UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY:: CHENNAI 600 025

REGULATIONS - 2015

I TO IV SEMESTERS CURRICULUM AND SYLLABUS

M. TECH ENVIRONMENTAL SCIENCE AND TECHNOLOGY

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 students 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								✓	✓	✓	✓

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
YEAR 1	SEM 1	Advanced Numerical Methods	✓	✓	✓		✓	✓					
		Environmental Chemistry	✓	✓	✓			✓	✓				
		Unit Operations and Unit Processes in Environmental Technology	✓	✓	✓	✓							
		Biological Wastewater Treatment	✓		✓				✓				
		Environmental Engineering Lab		✓		✓		✓					
		Elective 1											
		Elective 2											
	SEM 2	Separation Processes in Environmental Applications	✓		✓			✓	✓				
		Environmental Impact Assessment			✓		✓			✓	✓		
		Air Pollution Control Engineering	✓		✓			✓	✓				
		Solid and Hazardous Waste Management	✓		✓						✓		✓
		Seminar						✓		✓		✓	✓
		Elective 3											
		Elective 4											
YEAR 2	SEM 1	Modeling of Environmental Systems				✓		✓					✓
		Elective 5											
		Elective 6											
		Project Work (Phase 1)				✓		✓				✓	✓
	SEM 2	Project Work (Phase 2)				✓		✓				✓	✓

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY:: CHENNAI 600 025

REGULATIONS - 2015

I TO IV SEMESTERS CURRICULUM AND SYLLABUS

M. TECH ENVIRONMENTAL SCIENCE AND TECHNOLOGY

SEMESTER – I

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	MA7155	Advanced Numerical Methods	FC	4	4	0	0	4
2.	EV7101	Biological Wastewater Treatment	PC	3	3	0	0	3
3.	EV7102	Environmental Chemistry	FC	3	3	0	0	3
4.	EV7103	Unit Operations and Unit Processes in Environmental Technology	PC	3	3	0	0	3
5.		Elective I	PE	3	3	0	0	3
6.		Elective II	PE	3	3	0	0	3
LABORATORY								
7.	EV7111	Environmental Engineering Lab	PC	4	0	0	4	2
			TOTAL	**25**	**19**	**0**	**4**	**21**

SEMESTER – II

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	EV7201	Air Pollution Control Engineering	PC	3	3	0	0	3
2.	EV7202	Environmental Impact Assessment	PC	3	3	0	0	3
3.	EV7203	Separation Processes in Environmental Applications	PC	3	3	0	0	3
4.	EV7204	Solid and Hazardous Waste Management	PC	3	3	0	0	3
5.		Elective I	PE	3	3	0	0	3
6.		Elective II	PE	3	3	0	0	3
LABORATORY								
7.	EV7211	Seminar	EEC	2	0	0	2	1
			TOTAL	**20**	**18**	**0**	**2**	**19**

SEMESTER – III

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	EV7301	Modeling of Environmental Systems	PC	3	3	0	0	3
2.		Elective I	PE	3	3	0	0	3
3.		Elective II	PE	3	3	0	0	3
LABORATORY								
1.	EV7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER – IV

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
LABORATORY								
1.	EV7411	Project Work Phase II	EEC	12	0	0	24	12
			TOTAL	**12**	**0**	**0**	**24**	**12**

TOTAL CREDITS : 67

Foundation Courses (FC)

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

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

Professional Core (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Unit Operations and Unit Processes in Environmental Technology	PC	3	3	0	0	3
2.		Biological Wastewater Treatment	PC	3	3	0	0	3
3.		Air Pollution Control Engineering	PC	3	3	0	0	3
4.		Separation Processes in Environmental Applications	PC	3	3	0	0	3
5.		Environmental Impact Assessment	PC	3	3	0	0	3
6.		Solid and hazardous Waste Management	PC	3	3	0	0	3
7.		Modeling of Environmental Systems	PC	3	3	0	0	3

Professional Electives (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CL7029	Industrial Pollution Prevention	PE	3	3	0	0	3
2.	CL7075	Industrial Instrumentation	PE	3	3	0	0	3
3.	CL7028	Green Chemistry and Engineering	PE	3	3	0	0	3
4.	CL7016	Advanced Oxidation Processes and Technology	PE	3	3	0	0	3
5.	CL7017	Atmospheric Science	PE	3	3	0	0	3
6.	CL7018	Biochemical Engineering	PE	3	3	0	0	3
7.	CL7019	Climate Change and Adaptation	PE	3	3	0	0	3

8.	CL7021	Design of Experiments	PE	3	3	0	0	3
9.	CL7022	Electrochemical Environmental Technology	PE	3	3	0	0	3
10.	CL7023	Energy Management	PE	3	3	0	0	3
11.	CL7151	Environment Health and Safety in Industries	PE	3	3	0	0	3
12.	CL7025	Environmental Biotechnology	PE	3	3	0	0	3
13.	CL7026	Environmental Nanotechnology	PE	3	3	0	0	3
14.	CL7072	Environmental Policies and Legislation	PE	3	3	0	0	3
15.	CL7074	Fuel Cell Technology	PE	3	3	0	0	3
16.	CL7032	Remote Sensing and GIS applications in Environmental Applications Environmental Management	PE	3	3	0	0	3
17.	CL7034	Risk Analysis and Hazop	PE	3	3	0	0	3
18.	CL7080	Total Quality Management	PE	3	3	0	0	3

Employability Enhancement Courses (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Seminar	EEC	2	0	0	2	1
2.		Project Work Phase I	EEC	12	0	0	12	6
3.		Project Work Phase II	EEC	24	0	0	24	12

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

MA7155 ADVANCED NUMERICAL METHODS L T P C
4 0 0 4

OBJECTIVE:

- The course objective is to impart knowledge on advanced numerical methods for solving differential equations in science and engineering.
- Analysis and application of advanced numerical methods for solving Partial Differential Equations (PDEs).

UNIT I ALGEBRAIC EQUATIONS 1

Systems of linear equations – Jacobi, Gauss Seidel, SOR methods, Thomas algorithm for tridiagonal systems; Systems of nonlinear equations - successive approximation method, methods for improved convergence, Newton Method and its variants, continuation methods for multiple solutions.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS – IVPS 12

RungeKutta Methods, step size control and estimates of error, numerical stability, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations;

UNIT III ORDINARY DIFFERENTIAL EQUATIONS – BVPS 12

Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method, shooting technique.

UNIT IV PARTIAL DIFFERENTIAL EQUATIONS – FINITE DIFFERENCE METHOD 12

Parabolic equations – Different explicit and implicit methods, alternating direction explicit and implicit methods; Elliptic equations – Point iterative methods, line iterative methods, ADI methods; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines.

UNIT V PARTIAL DIFFERENTIAL EQUATIONS -FINITE ELEMENT METHOD 12

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

TOTAL : 60 PERIODS

OUTCOME:

- Be familiar with numerical solution of ODEs.
- Setup and solve partial differential equations numerically.

REFERENCES

1. Gupta, S.K., Numerical Methods for Engineers, New Age Publishers, 1995
2. Jain, M. K., S. R. Iyengar, M. B. Kanchi, R. K. Jain, Computational Methods for Partial Differential Equations, New Age Publishers, 2007.
3. Steven C. Chapra and Raymond P Canale, Numerical Methods for Engineers, 6th Edition, McGraw-Hill, 2010.

EV7101	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.

EV7102 **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. Sawyer C L McCarty P L and Parkin G E, Chemistry for Environmental Engineering. McGraw Hill, 1995
2. Rajeshwar, K. and Ibanez, J. G., Environmental Electrochemistry Academic Press, 1997.
3. VanLoon G W and S.J. Duffy, Environmental Chemistry, Oxford university press, 2005

EV7103 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.

UNIT III **9**

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

UNIT IV **9**

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

UNIT V **9**

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

TOTAL : 45 PERIODS

OUTCOME:

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

REFERENCES

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

EV7111 ENVIRONMENTAL ENGINEERING LAB **L T P C**
0 0 4 2

Course 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, SO2, NOX and CO).
3. Physiochemical analysis of solid wastes.

4. Design of clarifier by using the data obtained through batch sedimentation.
5. Coagulation and flocculation for removal of suspended solids from water.
6. Water softening.
7. Biological aerobic treatment for removal of organic 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.

EV7201 AIR 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

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

OUTCOME:

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

REFERENCES

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

EV7202 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.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT V **9**

Case studies of EIA of developmental projects

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

EV7203 SEPARATION PROCESSES IN ENVIRONMENTAL APPLICATIONS **L T P C 3 0 0 3**

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**

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**

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

UNIT III **9**

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

UNIT IV **9**

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

UNIT V **9**

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

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

TOTAL : 45 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. Treybal R E, Mass Transfer Operations, McGraw Hill 1981.
3. Seader J D and Henley E J, Separation Processes Principles, 3rd Edition, John Wiley&Sons, 2011.

EV7204 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. Techobanoglous G, Integrated Solid Waste Management, McGraw- Hill Publication, 1993.
2. Wentz C A, Hazardous Waste Management, McGraw-Hill Publication, 1995.
3. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and Environmental
4. Resources Management, Hazardous waste Management, Mc-Graw Hill International edition, New York, 2001.
5. CPHEEO, "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation , Government of India, New Delhi, 2000.
6. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.

EV7211 **SEMINAR** **L T P C**
0 0 2 1

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

EV7301 MODELING OF ENVIRONMENTAL SYSTEMS L T P C

3 0 0 3

OBJECTIVE:

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

UNIT I **9**

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**

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**

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**

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**

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 : 45 PERIODS

OUTCOME:

- The students will be in a position to develop and construct models
- Be familiar with fuzzy logic based models.

REFERENCES

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

EV7311 **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.

EV7411 **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.

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

CL7029 **INDUSTRIAL POLLUTION PREVENTION** **L T P C**
3 0 0 3

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

CL7075 **INDUSTRIAL INSTRUMENTATION** **L T P C**
3 0 0 3

OBJECTIVES

To introduce control equipments used to control the production process of a chemical factory and the mechanism of control through automation and computers.

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

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

CL7028 GREEN CHEMISTRY AND ENGINEERING L T P C

3 0 0 3

OBJECTIVE:

- To make the students aware of global environmental issues, concepts behind pollution prevention, environmental risks, green chemistry.
- To make students understand the methods available 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

OUTCOME:

- Upon completion of this course, the students would understand the fundamentals of green Chemical 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. Mukesh Doble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007.

CL7016 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.
4. Harold J.Ratson, Odor and VOC control handbook, Newyork, Mcgraw-hill, 1998.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

CL7017 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. John.M.Wallace, Peter.V.Hobbs, Atmospheric science: An introductory survey, 2nd edition, Academic press, 2006.
2. C. N. Hewitt, Andrea V. Jackson, Handbook of Atmospheric Science: Principles and Applications, Blackwell Publishing, 2003.
3. John E. Frederick, Principles of Atmospheric Science, Jones & Bartlett Publishers, 2007.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

CL7018 **BIOCHEMICAL ENGINEERING** **L T P C**

3 0 0 3

OBJECTIVE:

- To discuss mainly on the role of enzymes and microbes in biotechnology sectors.
- To understand the design parameters in designing biochemical reactors.

UNIT I **9**

Introduction – principles of microbiology, structure of cells, microbes, bacteria, fungi, algae, chemicals of life – lipids, sugars and polysaccharides, amino acids, proteins, nucleotides, RNA and DNA, hierarchy of cellular organization, Principles of genetic engineering, Recombinant DNA technology, mutation.

UNIT II **9**

The kinetics of enzyme catalysed reactions – the enzyme substrate complex and enzyme action, simple enzyme kinetics with one and two substrates, determination of elementary step rate constants. Isolation and utilization of Enzymes – production of crude enzyme extracts, enzyme purification, applications of hydrolytic enzymes, other enzyme applications, enzyme production – intercellular and extra cellular enzymes.

UNIT III **9**

Metabolic pathways and energetics of the cell, concept of energy coupling, ATP and NAD, Photosynthesis, Carbon metabolism, EMP pathway, Tricarboxylic cycle and electron transport chain, aerobic and anaerobic metabolic pathways, transport across cell membranes, Synthesis and regulation of biomolecuels.

UNIT IV **9**

Typical growth characteristics of microbial cells, Factors affecting growth, Batch and continuous cell growth, nutrient media, enrichment culture, culture production and preservation Immobilization technology – Techniques of immobilization, Characterization and applications, Reactors for immobilized enzyme systems.

UNIT V **9**

Introduction to biological reactors, Continuously stirred aerated tank bioreactors, mixing power correlation, Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, heat transfer and power consumption, Multiphase bioreactors and their applications. Downstream processing and product recovery in bio processes.

TOTAL : 45 PERIODS

OUTCOME:

- The students would develop the ability to design novel bioprocesses for their research in various areas.
- The students will have the ability to find solutions to the problems which occur when materials and processes interact with the environment.

REFERENCES

1. Shuler M.L. and Kargi F. Bioprocess Engineering: Basic Concepts, 1st Edition, Prentice Hall, New Jersey, 1992.
2. Lee J., Biochemical Engineering, Prentice Hall Englewood Cliffs, 1992.
3. Blanch H.W and Clark D.S, Biochemical Engineering, Marcel Dekker, 1997.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

CL7019 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. Jan C. van Dam, Impacts of "Climate Change and Climate Variability on Hydrological Regimes", Cambridge University Press, 2003
2. Al core 'inconvenient truth" – video form
3. IPCC Fourth Assessment Report – The AR4 Synthesis Report,
4. Dash Sushil Kumar, "Climate Change – An Indian Perspective", Cambridge University Press India Pvt. Ltd, 2007

CL7021 **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

TEXT BOOK

1. Douglus C.Montgomery, Design and Analysis of Experiments, John Wiley & Sons,2005

REFERENCES

1. Angela M.Dean and Daniel Voss, Design and Analysis of Experiments, Springer texts in Statistics, 2000.
2. Philip J.Ross, Taguchi Techniques for Quality Engineering, Prentice Hall, 1989.

CL7022 ELECTROCHEMICAL ENVIRONMENTAL TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE:

- To understand the basics of electrochemistry and electrochemical engineering.
- To learn about the application of electrochemical process on environmental remediation.

UNIT I **9**

Definition and classification of pollutants, method of pollutants analysis, pollution monitoring, electrochemical monitoring, monitoring contaminated sites, seawater monitoring, rainfall monitoring, role of sensors in environmental pollution.

UNIT II **9**

Conventional methods for pollution control, incinerator, pyrolysis, air stripping, microbial treatment, precipitation coagulation, adsorption, membrane process. Advanced techniques of pollution treatment, treatment of polluted sites. Introduction to electrochemical systems, current charge transport potential, electrode interface, electrochemical kinetics. Water disinfections, general consideration, and chemical disinfections by products, taste and odour removal and indicator organism.

UNIT III **9**

Electrochemical treatment of waste water, direct electrolysis, indirect electrolysis, mechanism of electro oxidation, anodic oxidation of organic and inorganic pollutants, cathodic reduction, reversible, irreversible process, Fenton agents. Electrochemical reduction of metal ions, membrane assisted process, electro dialysis and electrochemical ion exchange process, electro chemical disinfections of water, UV dose and disinfection kinetics, photo electro chemical disinfection of water.

UNIT IV **9**

Electrochemical remediation of soil, photochemical treatment of organic pollutants, photo electro chemical reduction, electro chemical treatment of mixed and hazardous waste, electrochemical generation of hypochloric acid, photo electro chemical treatment of waste water.

UNIT V **9**

Materials for electrochemical treatment, electrodes used in different types of industries, type of electro chemical reactor, batch cell, fluidized bed electro chemical reactor, filter press cell, Swiss role cell, Plug flow cell, design equation, electrochemical reactors for [pollutant treatment, figure of merits of different types of electro chemical reactors.

TOTAL : 45 PERIODS

OUTCOME:

- The students will be in a position to develop electrochemical based treatment processes.
- Students will undertake projects related to electrochemical treatment of wastes.

REFERENCES

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

CL7023 **ENERGY MANAGEMENT** **L T P C**

3 0 0 3

OBJECTIVE

- To learn about various energy sources available and their application
- Impart knowledge on conservation of energy

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

CL7151 ENVIRONMENT HEALTH AND SAFETY IN INDUSTRIES **L T P C**
3 0 0 3

OBJECTIVE

- To give knowledge about occupational health, industrial hygiene, accidental prevention techniques to the students.
- To make the student aware about safety auditing and management systems,pollution prevention techniques etc.
- To train the students about risk assessment and management.

UNIT I INTRODUCTION **9**

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

UNIT II OCCUPATIONAL HEALTH AND HYGIENE **9**

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

UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS **9**

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

UNIT IV TECHNIQUES OF ENVIRONMENTAL SAFETY **9**

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

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

REFERENCES

1. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995
2. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.
3. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services 2005

CL7025 ENVIRONMENTAL BIOTECHNOLOGY 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. Wainwright, M, An Introduction to Environmental Biotechnology, 1999.
3. Martin, A.M., Biological Degradation of Wastes, Elsevier Appl. Science, New York, 1991
4. Gray, S.S., Fox, R and James W. Blackburn Environmental Biotechnology for Waste Treatment, Plenum Press, New York 1991.
5. Rittmann, B.E, Seagren, E., Wrenn, B. A and Valocchi A.J, Ray, C and Raskin, L Insitu Bioremediation (2nd Ed.) Nayes Publ. U.S.A. 1994.
6. Old, R.W., and. Primrose, S.B., Principles of Gene Manipulation (3rd Ed.), Blackwell Sci. Pub, Cambridge, 1985

CL7026 ENVIRONMENTAL NANOTECHNOLOGY L T P C
3 0 0 3

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

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-H_2 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, membrane process.

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, JeoYuesBolteru, 2007, McGraw Hill.
3. The Chemistry of Nanomaterials, Sysnthesis, Properties and applications. Edited by C.N.R.Rao. Mullller, A.K.Cheetham Copyright 8 2004 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim
4. Handbook of Nanotechnology, Edi-Bharat Bhushan, Springer, 2004.

CL7072 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. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford University Press, New Delhi, 2001.
3. GregerI.Megregor, “Environmental law and enforcement”, Lewis Publishers, London. 1994.

CL7074 **FUEL CELL TECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVE
To understand about fuel cells, their working principle, Types, Design and performance analysis.

UNIT I **9**
Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

UNIT II **9**
Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

UNIT III **9**
Fuel cell characterization - in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modelling and system integration: - 1D model – analytical solution and CFD models.

UNIT IV **9**
Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

UNIT V **9**
Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications

TOTAL : 45 PERIODS

OUTCOMES
After completing the course, student should have learnt
- Basics and workingprinciples 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 and velocity distribution in single cell as well as stack.
- Design and stack making process for real field applications

REFERENCES

1. O'Hayre, R.P.,S. Cha,W. Colella, F.B.Prinz, Fuel Cell Fundamentals,Wiley, NY (2006).
2. Bard,A. J. , L. R., Faulkner,Electrochemical Methods, Wiley, N.Y.(2004) Ref Book.
3. Basu,S.(Ed) Fuel Cell Science and Technology,Springer, N.Y.(2007).
4. Liu, H.,Principles of fuel cells, Taylor & Francis, N.Y. (2006).
5. Fuel cell technology handbook, edited by Gregor Hoogers, CRC Press 2003.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

CL7032 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. Lillesand, T.M. and Kiefer, R.W, Remote sensing and image interpretation, John Wiley and sons, New York, 2004.
2. GolfriedKonechy, Geoinformation: Remote sensing, Photogrammetry and Geographical Information Systems, CRC press, 1st Edition, 2002.
3. Burrough, P.A. and McDonnell, R.A., Principles of Geographic Information systems Oxford University Press, New York, 2001.
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.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

CL7034 **RISK ANALYSIS AND HAZOP** **L T P C**
3 0 0 3

OBJECTIVE

- To impart knowledge on risk analysis and HAZOP and their importance
- To teach about methods followed for HAZOP analysis

UNIT I **9**

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

UNIT II **9**

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

UNIT III **9**

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

UNIT IV **9**

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

UNIT V **9**

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

TOTAL : 45 PERIODS

OUTCOME

- Students will be in a position analyse the risk and HAZOP involved in the processes
- Students may undertake project related to risk analysis and HAZOP

REFERENCES

1. Crowl,D.A and Louvar,J.F., Chemical process saftery; Fundamentals with applications, prentice hall publication inc., 2002.
2. Marcel, V.C., Major Chemical Hazard-Ellis Harwood Ltd., Chi Chester, UK, 1987.
3. Skeleton, B., Process Safety Analysis, Institution of Chemical Engineers, U.K., 1997.
4. Khan,F.I and Abbasi,S.A., Risk assessment of chemical process industries; Emerging technologies, Discovery publishing house, New Delhi, 1999.
5. Houstan,H.B., Process safety analysis, Gulf publishing company, 1997.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

CL7080 TOTAL QUALITY MANAGEMENT L T P C
3 0 0 3

OBJECTIVE

To provide comprehensive knowledge about the principles, practices, tools and techniques of Total quality management.

UNIT I CONCEPTS OF TQM 5

Philosophy of TQM, Customer focus, organization, top management commitment, team work, quality philosophies of Deming, Crosby and Muller.

UNIT II TQM PROCESS 12

QC Tools, Problem solving methodologies, new management tools, work habits, quality circles, bench marking, strategic quality planning.

UNIT III TQM SYSTEMS 8

Quality policy deployment, quality function deployment, Standardization, designing for quality, manufacturing for quality.

UNIT IV QUALITY SYSTEM 10

Need for ISO 9000 system, Advantages, clauses of ISO 9000, Implementation of ISO 9000, quality costs, quality, auditing, case studies.

UNIT V IMPLEMENTATION OF TQM 10

Steps, KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.

TOTAL : 45 PERIODS

OUTCOMES

- To under the various principles, practices of TQM to achieve quality
- To learn the various statistical approaches for quality control.
- To understand the TQM tools for continuous process improvement.
- To learn the importance of ISO and Quality systems

REFERENCES

1. Rose J. E., “Total quality Management”, Kogan Page Ltd, 1999.
2. Bank, J., “The essence of Total Quality Management”, Prentice Hall of India, 1993.
3. Bonds, G., “Beyond Total Quality Management”, McGraw Hill, 1994.
4. Osada, T., “The 5S’s, The Asian Productivity Organisation”, 1991.