UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY : : CHENNAI 600 025

REGULATIONS - 2013

I TO IV SEMESTERS CURRICULUM AND SYLLABUS (FULL TIME)

M.TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY

SEMESTER I

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
EV8101	Biological Waste Water Treatment	3	0	0	3
EV8102	Risk Analysis and Hazop	3	0	0	3
EV8103	Unit Operations and Unit Processes in Environmental Technology	3	0	0	3
MA8168	Advanced Numerical Methods	3	1	0	4
	Elective I	3	0	0	3
	Elective II	3	0	0	3
PRACTICAL					
EV8111	Environmental Engineering Lab	0	0	4	2
	TOTAL CREDITS	**18**	**1**	**4**	**21**

SEMESTER II

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
EV8201	Air and Noise Pollution Control	3	0	0	3
EV8202	Environmental Impact Assessment	3	0	0	3
EV8203	Separation Processes in Environmental Applications	3	0	0	3
EV8204	Solid Waste Management	3	0	0	3
	Elective III	3	0	0	3
	Elective IV	3	0	0	3
PRACTICAL					
EV8211	Seminar	0	0	2	1
	TOTAL CREDITS	**18**	**0**	**2**	**19**

SEMESTER III

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
EV8301	Modeling of Environmental Systems	3	0	0	3
	Elective V	3	0	0	3
	Elective VI	3	0	0	3
PRACTICAL					
EV8311	Project Work (Phase I)	0	0	12	6
	TOTAL CREDITS	**9**	**0**	**12**	**15**

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SEMESTER IV

COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL					
EV8411	Project Work (Phase II)	0	0	24	12
	TOTAL CREDITS	**0**	**0**	**24**	**12**

LIST OF ELECTIVES

{Common to M.TECH (CHEMICAL ENGG, PRPC & EST)}

CODE	COURSE TITLE	L	T	P	C
CL8068	Industrial Pollution Prevention	3	0	0	3
CL8069	Industrial Instrumentation	3	0	0	3
CL8070	Green Chemistry and Engineering	3	0	0	3
CL8071	Advanced Oxidation Processes and Technology	3	0	0	3
CL8072	Atmospheric Science	3	0	0	3
CL8073	Bio Energy Conservation Techniques	3	0	0	3
CL8074	Biochemical Engineering	3	0	0	3
CL8075	Climate Change and Adaptation	3	0	0	3
CL8076	Computational Fluid Dynamics	3	0	0	3
CL8077	Design of Experiments	3	0	0	3
CL8078	Drugs and Pharmaceutical Technology	3	0	0	3
CL8079	Ecology and Environment	3	0	0	3
CL8080	Electrochemical Engineering	3	0	0	3
CL8081	Electrochemical Environmental Technology	3	0	0	3
CL8082	Electrochemical Process Engineering for Chemical Engineers	3	0	0	3
CL8083	Electrochemical Processes for Clean Technology	3	0	0	3
CL8084	Electrochemical Technology for Chemical Engineers	3	0	0	3
CL8085	Energy Management	3	0	0	3
CL8086	Enhanced Oil Recovery	3	0	0	3
CL8087	Environment, Health and Safety in Industries	3	0	0	3
CL8088	Environmental Biotechnology	3	0	0	3
CL8089	Environmental Engineering	3	0	0	3
CL8090	Environmental Management	3	0	0	3
CL8091	Environmental Nanotechnology	3	0	0	3
CL8092	Environmental Policies and Legislation	3	0	0	3
CL8093	Environmental Reaction Engineering	3	0	0	3
CL8094	Environmental Risk Assessment	3	0	0	3
CL8095	Environmental Science	3	0	0	3
CL8096	Environmental Sustainability	3	0	0	3
CL8097	Fluidization Engineering	3	0	0	3
CL8098	Fuel Cell Technology	3	0	0	3
CL8099	Fundamentals of Nanoscience	3	0	0	3
CL8100	Gas Transportation	3	0	0	3
CL8104	Intellectual Property Rights	3	0	0	3
CL8105	Membrane Technologies for Water and Wastewater Treatment	3	0	0	3
CL8106	Multicomponent distillation	3	0	0	3

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CL8107	Multiphase Flow	3	0	0	3
CL8108	Petroleum Economics	3	0	0	3
CL8109	Piping and Instrumentation	3	0	0	3
CL8110	Pollution Abatement	3	0	0	3
CL8111	Polymer Technology	3	0	0	3
CL8112	Process Optimization	3	0	0	3
CL8113	Project Engineering of Process Plants	3	0	0	3
CL8114	Remote Sensing and GIS applications in Environmental Management	3	0	0	3
CL8115	Risk Analysis and Management	3	0	0	3
CL8116	Safety and Hazard Control	3	0	0	3
CL8117	Soil Pollution Engineering	3	0	0	3
CL8118	Solvent Extraction	3	0	0	3
CL8119	Supply Chain Management	3	0	0	3
CL8120	Total Quality Management	3	0	0	3
CL8121	Waste Management and Energy Recovery	3	0	0	3
CL8122	Waste Water Engineering	3	0	0	3
EY8077	Hydrogen and Fuel Cells	3	0	0	3
MG8071	Operations Research	3	0	0	3

A candidate will be permitted to register one elective course only under each group*, # and $.

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EV8101 BIOLOGICAL WASTE WATER TREATMENT L T P C
3 0 0 3

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

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.

EV8102 RISK ANALYSIS AND HAZOP L T P C
3 0 0 3

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

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.

EV8103 UNIT OPERATIONS AND PROCESSES IN ENVIRONMENTAL TECHNOLOGY

L	T	P	C
3	0	0	3

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

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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.

MA8168 ADVANCED NUMERICAL METHODS L T P C
3 1 0 4

UNIT I ALGEBRAIC EQUATIONS 12

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

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.

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EV8111 ENVIRONMENTAL ENGINEERING LAB L T P C
0 0 4 2

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

REFERENCES

1. Metcalf and Eddy. Inc. 'Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
2. Casey T.J., Unit Treatment Processes in Water and Wastewater Engineering, John Wiley Sons, London, 1993.
3. APHA, Standard methods for the examination of water and wastewater, American public health Association (22st edition) 2012.
4. H.H. and Krist, H, Laboratory Manual for the Examination of water, wastewater soil Rump, – Second Edition, VCH, Germany, 1992.
5. James P.LodgeJr(Editor), Methods of air sampling & analysis , 3rd Edition, Lewis publishers,Inc,USA,1989.

EV8201 AIR AND NOISE POLLUTION CONTROL L T P C
3 0 0 3

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

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.

EV8202 **ENVIRONMENTAL IMPACT ASSESSMENT** **L T P C**
3 0 0 3

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.

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UNIT IV **9**

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

UNIT V **9**

Case studies of EIA of developmental projects

TOTAL : 45 PERIODS

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.

EV8203 **SEPARATION PROCESSES IN ENVIRONMENTAL APPLICATIONS** **L T P C 3 0 0 3**

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.

NIT 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.

TOTAL : 45 PERIODS

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.

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EV8204 SOLID WASTE MANAGEMENT

L	T	P	C
3	0	0	3

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

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.

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EV8211 **SEMINAR**

L	T	P	C
0	0	2	1

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

EV8301 **MODELING OF ENVIRONMENTAL SYSTEMS**

L	T	P	C
3	0	0	3

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

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.

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EV8311 **PROJECT WORK (PHASE I)** **L T P C**
0 0 12 6

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

EV8411 **PROJECT WORK (PHASE II)** **L T P C**
0 0 24 12

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.

CL8068 **INDUSTRIAL POLLUTION PREVENTION** **L T P C**
3 0 0 3

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

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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.

CL8069 INDUSTRIAL INSTRUMENTATION L T P C
3 0 0 3

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

REFERENCES

1. Fribance, "Industrial Instrumentation Fundamentals" ,Mc Graw Hill Co. Inc. New York 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.

Attested

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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.

CL8070 GREEN CHEMISTRY AND ENGINEERING L T P C
3 0 0 3

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

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.

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CL8071 ADVANCED OXIDATION PROCESSES AND TECHNOLOGY L T P C
3 0 0 3

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

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.

CL8072 ATMOSPHERIC SCIENCE L T P C
3 0 0 3

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

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.

CL8073 BIO ENERGY CONSERVATION TECHNIQUES L T P C
3 0 0 3

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

TEXT BOOKS

1. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis HoknoodChichester, 1984.
2. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986

REFERENCES

1. Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997
2. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981
3. Best Practises Manual for Biomass Briquetting, I R E D A, 1997
4. Eriksson S. and M. Prior, The briquetting of Agricultural wastes for fuel, FAO Energy and Environment paper, 1990
5. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S

CL8074 BIOCHEMICAL ENGINEERING L T P C
3 0 0 3

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

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Anna University, Chennai-600 025.

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.

CL8075 CLIMATE CHANGE AND ADAPTATION L T P C
3 0 0 3

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

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

CL8076 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

UNIT I CONSERVATION LAWS AND TURBULENCE MODELS 9

Governing equations of fluid flow and heat transfer –mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form. Characteristics of turbulent flows, time averaged Navier Strokes equations, turbulence models-one and two equation, Reynolds stress, LES and DNS

UNIT II FINITE DIFFERENCE APPROXIMATION 9

Mathematical behaviour of PDE, finite difference operators, basic aspects of discretization by FDM, explicit and implicit methods, error and stability analysis

UNIT III FINITE VOLUME METHOD 15

Diffusion problems – explicit and implicit time integration; Convection-diffusion problems – properties of discretisation schemes, central, upwind, hybrid, QUICK schemes; Solution of discretised equations.

UNIT IV FLOW FIELD COMPUTATION 6

Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

UNIT V GRID GENERATION 6

Physical aspects, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping.

TOTAL : 45 PERIODS

REFERENCES

1. Anderson, J. D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw-Hill, 1995.
2. Fletcher, C. A. J., “Computational Techniques for Fluid Dynamics”, Springer Verlag, 1997.
3. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Pearson Education Ltd., 2007.
4. Chung T.J Computational Fluid Dynamics Cambridge University Press 2003.
5. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, NarosaPublishing House, New Delhi, 2001.
6. Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw – Hill Publishing Company Ltd. 1998.
7. Subas, V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.
8. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier Stock Equation”, Pineridge Press Limited, U.K., 1981.

CL8077 DESIGN OF EXPERIMENTS L T P C
3 0 0 3

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

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.

CL8078 DRUGS AND PHARMACEUTICAL TECHNOLOGY L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Development of drugs and pharamaceutical industry; organic therapeutic agents uses and economics

UNIT II DRUG METABOLISM AND PHARMACO KINETICS & MICROBIOLOGICAL AND ANIMAL PRODUCTS 9

Drug metabolism; physico chemical principles; pharma kinetics-action of drugs on human bodies. Antibiotics- gram positive, gram negative and broad spectrum antibiotics; hormones

UNIT III IMPORTANT UNIT PROCESSES AND THEIR APPLICATIONS 9

Chemical conversion processes; alkylation; carboxylation; condensation and cyclisation; dehydration, esterification, halogenation, oxidation, sulfonation; complex chemical conversions fermentation.

UNIT IV MANUFACTURING PRINCIPLES & PACKING AND QUALITY CONTROL 9

Compressed tablets; wet granulation; dry granulation or slugging; advancement in granulation; direct compression, tablet presses formulation; coating pills; capsules sustained action dosage forms; parential solutions, oral liquids; injections; ointments; standard of hygiene and manufacturing practice. Packing; packing techniques; quality control.

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UNIT V PHARMACEUTICAL PRODUCTS & PHARMACEUTICAL ANALYSIS **9**

Vitamins; cold remedies; laxatives; analgesics; nonsteroidal contraceptives; external antiseptics; antacids and others. Analytical methods and tests for various drugs and pharmaceuticals – spectroscopy, chromatography, fluorimetry, polarimetry, refractometry, pHmetry

TOTAL : 45 PERIODS

TEXT BOOK

1. Rawlines, E.A.; "Bentleys Text book of Pharmaceutics ", III Edition, Bailliere Tindall, London, 1977.46

REFERENCES

1. Yalkonsky, S.H.; Swarbick. J.; " Drug and Pharamaceutical Sciences ", Vol. I, II, III, IV, V,VI and VII, Marcel Dekkar Inc., New York, 1975.
2. "Remingtons Pharmaceutical Sciences ", Mack Publishing Co., 1975.

CL8079 ECOLOGY AND ENVIRONMENT L T P C
3 0 0 3

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

REFERENCES

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

CL8080 ELECTROCHEMICAL ENGINEERING L T P C
3 0 0 3

UNIT I **9**

Review basics of electrochemistry: Faraday's law -Nernst potential –Galvanic cells – Polarography, The electrical double layer: It's role in electrochemical processes –Electro capillary curve –Helmoltz layer –Guoy –Steven's layer –fields at the interface.

UNIT II **9**

Mass transfer in electrochemical systems: diffusion controlled electrochemical reaction – the importance of convention and the concept of limiting current. over potential, primarysecondary current distribution –rotating disc electrode.

UNIT III **10**

Introduction to corrosion, series, corrosion theories derivation of potential-current relations of activities controlled and diffusion controlled corrosion process. Potential-pH diagram, Forms of corrosion- definition, factors and control methods of various forms of corrosion-corrosioncontrol measures- industrial boiler water corrosion control –protective coatings – Vapor phase inhibitors –cathodic protection, sacrificial anodes –Paint removers.

UNIT IV **8**

Electro deposition –electro refining –electroforming –electro polishing –anodizing – Selective solar coatings, Primary and secondary batteries –types of batteries, Fuel cells.

UNIT V **9**

Electrodes used in different electrochemical industries: Metals-Graphite –Lead dioxide – Titanium substrate insoluble electrodes –Iron oxide –semi conducting type etc. Metal finishing- cell design. types of electrochemical reactors, batch cell, fluidized bed electrochemical reactor, filter press cell, Swiss roll cell, plug flow cell, design equation, figures of merits of different type of electrochemical reactors.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Picket, " Electrochemical Engineering ", Prentice Hall. 1977.
2. Newman, J. S., " Electrochemical systems ", Prentice Hall, 1973.

REFERENCES

1. Barak, M. and Stevenge, U. K., " Electrochemical Power Sources - Primary and Secondary Batteries" 1980
2. Mantell, C., " Electrochemical Engineering ", McGraw Hill, 1972.

CL8081 ELECTROCHEMICAL ENVIRONMENTAL TECHNOLOGY L T P C
3 0 0 3

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

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.

CL8082 ELECTROCHEMICAL PROCESS ENGINEERING FOR CHEMICAL ENGINEERS **L T P C 3 0 0 3**

UNIT I INTRODUCTION OF ELECTROCHEMICAL ENGINEERING **9**

Industrial importance of electrolytic processes, Basic concepts and definitions, Criteria for reactor performance, Electrochemical and catalytic reactions and reactors. Fundamentals of reaction kinetics, rate of electrochemical reaction, electrochemical thermodynamics, practical cell voltage requirements and polarization, single electrochemical reactions, potentiostatic operations of first order reaction and galvanostatic operation of first order reactions.

UNIT II ASPECTS OF MASS AND HEAT TRANSFER IN ELECTROLYTIC CELL SYSTEMS **9**

Basic aspects of fluid dynamics, mass transfer-mass flux in a fully developed turbulent regime, entrance and exit effects, obtaining numerical values of mass transfer coefficient by calculation and experiment, mass transfer in two phase flow, energetic and energy balances, CSTR with general order reactions, effect of mass transport and side reaction.

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UNIT III RATE PROCESSES AND REACTION MODELS 9

Rate processes, kinetics of elementary reactions, reaction mechanism and rate laws, transition state theory, derivation of kinetic relationships, reaction models.

UNIT IV REACTOR MODELS 9

General considerations, batch reactor and continuous reactor. Fed batch, continuous, cell recycle, plug flow reactor, two stage reactors,. Reactor dynamics and stability. Reactors with non ideal mixing. Other types of reactors- fluidized bed reactors; packed bed reactors, bubble column reactors, trickle bed reactors.

UNIT V ELECTROLYTIC REACTOR DESIGN, SELECTION AND SCALE UP 9

Electrolytic reactor designs, Electrolytic reactor selection, scale up of electrolytic reactors, effect of scale up on mass transfer, effect of scale up on current distribution, Multiple electrode models and time factors.

TOTAL : 45 PERIODS

TEXT BOOKS

1. F.Goodridge, K.Scott, Electrochemical process engineering. A guide to the design of electrolytic plant, Plenum Press, 1995.
2. Bockris, John O'M, Bockris, Ralph E.White, B.E. Conway, Modern aspects of electrochemistry, volume 28, Plenum Press, New York 1985.
3. Newman and Thomas- Alyea, Electrochemical systems, 3rd edition, Wiley & Sons, Hoboken, 2004.
4. Pletcher. D and Walsh F.C, Industrial electrochemistry, 2nd edition, Chapman and Hall, London, 1990.
5. Hartmut Wendt, Gerhard Kreysa, Electrochemical engineering, Science and technology in chemical and other industries, Springer, 1999.
6. Krishnan Rajeshwar, JORGE G. IBANEZ, Environmental Electrochemistry, Fundamentals and applications in Pollution Abatement, ACADEMIC PRESS, Inc, 1997.

CL8083 ELECTROCHEMICAL PROCESSES FOR CLEAN TECHNOLOGY

L T P C
3 0 0 3

UNIT I THE ELECTROCHEMICAL CELL AND REACTOR 9

The electrochemical cell, Faraday's Law and current efficiency, Electrode potential and current density, The Electrochemical reactor – Production Capacity, Energy Requirements and Cell Voltage, Temperature Control, Hydrodynamics and mass transport, Reactor Operating Factors. Electrode Materials – Chemical Suitability, Electrode Materials in Synthesis and Effluent treatment.

UNIT II ELECTROCHEMICAL CELL DESIGN AND ENGINEERING 9

Operating Factors in Electrochemical Reactor Design – Modes of Operation, In-cell and Ex-cell Reactions, Recycle Operation, Electrical Power supply, Distribution of Powers in Electrolysers. Cell Design, Design Concepts. Electrochemical Reactor Designs – Parallel Plate. Electrolysers, General Purpose Flow Electrolyser, Other Reactor Design, Reactor Design for Multiphase Reactions. Electrochemical Reactor Analysis, Mass Transport and Reactor Design.

UNIT III ELECTROCHEMICAL MEMBRANE PROCESS 9

Transport in Membranes and Diaphragms- Transport Process in Diaphragms, Membrane and the Transport of Ions. Ion-Selective Membranes in Salt Regeneration, Recycling and Effluent Treatment, Electrohydrolysis, Treatment of Plating Bath Rinse Waters and Waste Streams. Bipolar Membranes, Characterstics of Bipolar Membranes. Electrochemically enhanced Microfiltration and Ultrafiltration.

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UNIT IV THE TREATMENT OF INDUSTRIAL PROCESS STREAMS AND EFFLUENTS 9

Treatment of Organic Chemicals-Direct Anodic Oxidation, Chlorine and Chlorinated compounds, Indirect Oxidation Process. Treatment of Waste Water Containing Inorganic Compounds- Cyanides and Thiocynates, Chromium Liquors, Sterilisation of Water and Waste. Metal Recovery by Electrode position- Electrode position from Single Metal Ion Solutions, Metal separation from Mixed Metal Ion solutions, Combined Electrochemical Processes.

UNIT V ORGANIC AND INORGANIC ELECTROCHEMICAL SYNTHESIS 9

Types of Organic Electro synthesis, Limitations in Solubility, Indirect electro synthesis, Heterogeneous Redox Catalysis, Electrosorbed hydrogen, Direct electro organic Synthesis, Examples of electro organic Synthesis. Inorganic electrochemical Process- The Electro winning and Refining of Metals, Electrochemical Generation of Arsine, Other Processes, The scope for Inorganic Electro synthesis.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Scott.K, Electrochemical processes for clean technology, Standardsmedia, 1995.
2. F.Goodridge, K.Scott, Electrochemical Process Engineering. A guide to the design of electrolytic plant, Plenum press, 1995.
3. Cynthia, G.Zoski, Handbook of electrochemistry, 1st edition, Elsevier science, 2007.
4. Picket, Electrochemical Engineering, Prentice Hall, 1977.
5. Marcel Mulder, Basic Principles of Membrane Technology, 2nd edition, Kluwer Academic Publishers, 2003.
6. Krishnan Rajeshwar, JORGE G. IBANEZ, Environmental Electrochemistry, Fundamentals and applications in Pollution Abatement, ACADEMIC PRESS, Inc, 1997.
7. K. Scott, Electrochemical reaction engineering, London, ACADEMIC PRESS, 1991.

CL8084 ELECTROCHEMICAL TECHNOLOGY FOR CHEMICAL ENGINEERS

L T P C
3 0 0 3

UNIT I FUNDAMENTAL CONCEPTS 9

Electron transfer, mass transport, interplay of electron transfer and mass transport, control adsorption, electro catalysis, phase formation in electrode reactions, chemical reactions, the properties of electrolytic solutions, assessment of cell voltage, electrochemistry at surfaces on open circuit.

UNIT II THE CHLOR-ALKALI INDUSTRY 9

General concepts of brine electrolysis, modern technological developments, chlorine cell technologies, production of potassium hydroxide. Production and consumption pattern, manufacture of Chlorine-caustic soda: Raw materials, principles of manufacture, Mercury-cathode & Membrane process: flow-sheet and sequence of operation, other processes, advancement of process technology and major engineering problems, uses.

UNIT III THE EXTRACTION, REFINING AND PRODUCTION OF METALS 9

Electro winning, cementation, electrore fining, electrode position of metal powders. Principles of mineral processing: comminution, physical separation techniques, flotation, dewatering. Selection of extraction processes. Hydrometallurgy and electrometallurgy including leaching, solution purification, solvent extraction, metal winning and refining. Pyrometallurgical operations including roasting, smelting, converting and refining and refractory issues.

Approved

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UNIT IV INORGANIC ELECTROLYTIC PROCESS 9

Fluorine, water electrolysis, sodium chlorate, sodium bromate, per acids and their salts, permanganate, potassium dichromate and chromic acid, hydrogen peroxide, ozone, manganese dioxide, synthesis of metal salts via anodic dissolutions.

UNIT V WATER PURIFICATION, EFFLUENT TREATMENT AND RECYCLING OF INDUSTRIAL PROCESS STREAMS 9

Metal ion removal and metal recovery, hypochlorite, and low tonnage chlorine electrolysis, electrodialysis. The treatment of liquors containing dissolved chromium, electrolytic methods of phase separation, flue gas desulphurisation, other electrochemical process.

TOTAL : 45 PERIODS

TEXT BOOKS

1. D.Pletcher and F.C.Walsh, Industrial electrochemistry, Chapman and Hall, London 1990.
2. K. Scott, Electrochemical reaction engineering, London, ACADEMIC PRESS, 1991.
3. Cynthia, G.Zoski, Handbook of electrochemistry, 1st edition, Elsevier science, 2007.
4. Thomas F.O'Brien, Tilak V. Bommaraju and Fumio Hine, Handbook of Chlor-alkali technology, Fundamentals, volume I, Springer, 2005.
5. John O'M, Bockris, Ralph E.White, B.E. Conway, Modern aspects of electrochemistry, volume 28, Plenum Press, New York, 1985.
6. Hartmut Wendt, Gerhard Kreysa, Electrochemical engineering, Science and technology in chemical and other industries, Springer, 1999.

CL8085 ENERGY MANAGEMENT L T P C
3 0 0 3

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

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.

CL8086 ENHANCED OIL RECOVERY L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF ENHANCED OIL RECOVERY 9

Pore Geometry, Microscopic aspects of displacement. Residual oil magnitude and mobilization. Buoyancy forces and prevention of trapping, Wettability, Residual oil and Oil recovery. Macroscopic aspect of displacement.

UNIT II WATER FLOODING 9

Properties, sampling and analysis of oil field water; Injection waters; Water flooding - Sweep efficiency, Predictive techniques, Improved water flood processes, Performance of some important water floods.

UNIT III ENHANCED OIL RECOVERY OPERATIONS-1 10

Flooding – miscible, CO_2, polymer, alkaline, surfactants, steam;

UNIT IV ENHANCED OIL RECOVERY OPERATIONS-2 10

Gas injection, in-situ combustion technology, microbial method.

UNIT V PROBLEMS IN ENHANCED OIL RECOVERY 7

Precipitation and deposition of Asphaltenes and Paraffins, Scaling problems, Formation of damage due to migration of fines, Environmental factors.

TOTAL : 45 PERIODS

REFERENCES

1. Donaldson, E.C. and G. V. Chilingarian, T. F. Yen, “Enhanced oil Recovery – I & II”, Fundamentals and Analysis, Elsevier Science Publishers, New York, 1985.
2. Lake, L.W., “Enhanced oil recovery”, Prentice Hall, 1989.
3. Schumacher, M.M., “Enhanced oil recovery: Secondary and tertiary methods”, Noyes Data Corp., 1978.
4. Van Poollen, H.K. “Fundamentals of enhanced oil recovery”, PennWell Books, 1980.

CL8087 ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES L T P C
3 0 0 3

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

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

CL8088 ENVIRONMENTAL BIOTECHNOLOGY L T P C
3 0 0 3

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.

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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

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

CL8089 **ENVIRONMENTAL ENGINEERING** **L T P C**
3 0 0 3

UNIT I ENVIRONMENT AWARENESS **9**

Environment – friendly chemical Process; Hazard and risk analysis; Environmental Audit.

UNIT II CHEMICAL ENGINEERING PROCESSES **9**

Unit Operations – application of - Abatement of water pollution; Current strategies to control air pollution; Disposal of solid wastes

UNIT III RECYCLING METHODOLOGY **9**

Economic recovery and recycling of waste; Transport fuel- Bio-diesel for a cleaner environment.

UNIT IV CLEAN TECHNOLOGY **9**

Towards Eco- friendly products of chemical industry; Pesticides –Their transfer and Transformation in the environment, Biological and electrochemical technology for effluent treatments

UNIT V POLLUTION PREVENTION **9**

Mass exchange network synthesis for pollution control and minimization Implications of environmental constraints for process design, policies for regulation of environmental impacts, Concept of common effluent treatment; Environmental legislations, Role of Government and Industries

TOTAL : 45 PERIODS

REFERENCES

1. Rao, C.S Environmental Pollution control Engineering, Wiley- Eastern Ltd. 1991.
2. Peavy H.S. Rowe D.R., and George Technologious, Environmental Engineering, Mc Graw Hill Book Company, Ny, 1985.
3. Rao M.N and H.V.N. Rao. "Air pollution" ,Tata McGraw Hill Publishing Co. Ltd.1989.
4. Theodore L and Buomlore A.J Air pollution control equipments. Prentice Hall Inc, NY. 1982.
5. Coulson, J.M. Richardson, J.F and R.K Sinnott, Chemical Engineering Vol. 6, Pergomon Press, 1989.
6. Gilbert M.Mastrs, Introduction to Environmental Engineering and Science, Prentice - Hall of India, New Delhi, 1994.
7. Wahi S.K., Agnihotri A.K and Sharmma J.S (Editors) Environmental Management in Petroleum Industry, Wiley Eastern Ltd., New Delhi 1996.
8. Smith, R., "Chemical Process Design", McGraw Hill, New York, 1995.
9. Paul L Bishop (2000) "Pollution Prevention Fundamentals and Practice", Mc Graw Hill, International.

CL8090 ENVIRONMENTAL MANAGEMENT L T P C
3 0 0 3

UNIT I **8**

Environmental Legislations in India, Europe, USA and Canada – Development of Legislations, Standards and Guidelines

UNIT II **5**

Water (Prevention and control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981, Environmental Protection Act 1986, Hazardous Waste management Rules and Guidelines for siting of industries. Standards for discharge of treated liquid effluent into water bodies, including inland water bodies, and sea, standards for disposal of air emissions (SO_2,SPM,NH_3, H_2S and HC) into atmosphere.

UNIT III **8**

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

UNIT IV **10**

Principles of Environmental impact assessment and audit guidelines and legislature requirements for siting of industrial units in estates/complex. Preparatory procedures for EIA study, Evaluation of impact on air, water and land environment.

UNIT V **14**

Principles of Environmental Auditing, Cleaner Technologies in Industrial Processes and evaluation of processes Auditing techniques in Preparing EA.Monitoring of ambient environment, including air, water and land, noise, liquid and solid waste management.

TOTAL : 45 PERIODS

REFERENCES

1. Mike Russo., Environmental Management: Readings and Cases, 2 nd Edition, Sage Publications, 2008.
2. Canter, W.L., Environmental Impact Assessment, McGraw-Hill Inc., 1992
3. Rau, J.G and Wooten, D.C., Environmental Impact Analysis Handbook, McGraw-Hill, 1980.
4. Jain, R.K., Urban, L.V., Stacey, G.S. and Balbach, H.E., Environmental Assessment, McGraw-Hill, 1993.
5. UNEP/IED Technical Report Serial No.2., Environmental Auditing, 1990.

CL8091 ENVIRONMENTAL NANOTECHNOLOGY L T P C
3 0 0 3

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

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.

CL8092 ENVIRONMENTAL POLICIES AND LEGISLATION L T P C
3 0 0 3

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

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.

CL8093 ENVIRONMENTAL REACTION ENGINEERING L T P C
3 0 0 3

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

REFERENCES

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

CL8094 ENVIRONMENTAL RISK ASSESSMENT L T P C
3 0 0 3

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

REFERENCES

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

CL8095 ENVIRONMENTAL SCIENCE L T P C
3 0 0 3

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 co-factors, 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

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, 2008.
3. VanLoon G W and S.J. Duffy, Environmental Chemistry, Oxford university press, 2005

CL8096 **ENVIRONMENTAL SUSTAINABILITY** **L T P C**
3 0 0 3

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

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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.

CL8097 FLUIDIZATION ENGINEERING L T P C
3 0 0 3

UNIT I INTRODUCTION 5

The Fluidized state, Nature of hydrodynamic suspension, particle forces, species of Fluidization, Regimization of the fluidized state, operating models for fluidization systems, Applications of fluidization systems.

UNIT II HYDRODYNAMICS OF FLUIDIZATION SYSTEMS 12

General bed behaviour, pressure drop, Flow regimes, Incipient Fluidization, Pressure fluctuations, Phase Holdups, Measurements Techniques, Empirical Correlations for Solids holdup, liquid holdup and gas holdup. Flow models – generalized wake model, structural wake model and other important models.

UNIT III SOLID MIXING AND SEGREGATION 8

Phase juxtapositions operation shifts, Reversal points, Degree of segregation, Mixing Segregation equilibrium, Generalised fluidization of poly disperse systems, liquid phase Mixing and gas phase mixing.

UNIT IV HEAT AND MASS TRANSFER IN FLUIDIZATION SYSTEMS 12

Mass transfer – Gas Liquid mass transfer, Liquid Solid mass transfer and wall to bed mass transfer, Heat transfer – column wall – to – bed heat transfer, Immersed vertical cylinder to bed heat transfer, Immersed horizontal cylinder to bed heat transfer.

UNIT V MISCELLANEOUS SYSTEMS 8

Conical Fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Two phase and Three phase inverse fluidized bed, Draft tube systems, Semifluidized bed systems, Annular systems, Typical applications, Geldart's classification for power assessment, Powder characterization and modeling by bed collapsing.

TOTAL : 45 PERIODS

REFERENCES

1. Fan, L. S., "Gas- liquid Solid Fluidization Engineering", Butterworths, 1989,
2. Kwauk, M., "Fluidization - Idealized and Bubbleless, with applications", Science Press, 2009.
3. Kunii, D. and Levenspiel, O., "Fluidization Engineering", 2nd Edn., Butterworth-Heinemann, London, 1991.

CL8098 FUEL CELL TECHNOLOGY L T P C
3 0 0 3

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

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.

CL8099 FUNDAMENTALS OF NANOSCIENCE L T P C
3 0 0 3

UNIT I INTRODUCTION **10**

Nanoscale Science and Technology- Implications for Physics, Chemistry, Biology and Engineering-Classifications of nano structured materials- nano particles quantum dots, nanowires-ultra-thin films-multilayered materials. Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties. Introduction to properties and motivation for study (qualitative only).

UNIT II PREPARATION METHODS **10**

Bottom-up Synthesis-Top-down Approach: Precipitation, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.

UNIT III PATTERNING AND LITHOGRAPHY FOR NANOSCALE DEVICES **5**

Introduction to optical/UV electron beam and X-ray Lithography systems and processes, Wet etching, dry (Plasma /reactive ion) etching, Etch resists-dip pen lithography.

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UNIT IV PREPARATION ENVIRONMENTS 10

Clean rooms: specifications and design, air and water purity, requirements for particular processes, Vibration free environments: Services and facilities required. Working practices, sample cleaning, Chemical purification, chemical and biological contamination, Safety issues, flammable and toxic hazards, biohazards.

UNIT V CHARECTERISATION TECHNIQUES 10

X-ray diffraction technique, Scanning Electron Microscopy – environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques- AFM, SPM, STM, SNOM, ESCA, SIMS Nano indentation

TOTAL : 45 PERIODS

TEXT BOOKS

1. A.S. Edelstein and R.C. Cammearata, eds., "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Publishing, Bristol and Philadelphia, 1996.
2. N John Dinardo, "Nanoscale charecterisation of surfaces & Interfaces", 2nd Edition, Weinheim Cambridge, Wiley-VCH, 2000.

REFERENCES

1. G Timp (Editor), "Nanotechnology", AIP press/Springer, 1999
2. Akhlesh Lakhtakia (Editor), "The Hand Book of Nano Technology, Nanometer Structure", Theory, Modeling and Simulations", Prentice-Hall of India (P) Ltd, New Delhi, 2007.

CL8100 GAS TRANSPORTATION L T P C
3 0 0 3

UNIT I 9

Introduction, widespread use, the various types, the advantages and the special features of pipelines.

UNIT II 9

The fluid mechanics of various types of pipe flow including incompressible and compressible flows of Newtonian fluids, non-Newtonian fluids, flow of solid/liquid mixture (slurry), flow of solid/air mixture (pneumatic transport), and flow of capsules (capsule pipelines).

UNIT III 9

Various types of pipes (steel, concrete, PE, PVC, etc.), valves (gate, globe, ball, butterfly, etc.) and pressure regulators in pipelines. Blowers and compressors (for gases). Various kinds of flowmeters, sensors, pigs (scrapers) and automatic control systems used in pipelines.

UNIT IV 9

Various means to protect pipelines against freezing, abrasion and corrosion, such as cathodic protection, Planning, construction and operation of pipelines, including modern use of advanced technologies such as global positioning systems (GPS), directional drillings, automatic control using computers, and pipeline integrity monitoring such as leak detection.

UNIT V 9

Structural design of pipelines —load considerations and pipe deformation and failure. Economics of pipelines including life-cycle, Cost analysis and comparison of the cost-

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effectiveness of pipelines with alternative modes of transport such as truck or railroad. Legal, safety and environmental issues about pipelines.

TOTAL : 45 PERIODS

REFERENCES

1. Liu, H., R. L. Gandhi, M. R. Carstens and G. Klinzing, "Freight pipelines: current status and anticipated use,"(Report of American Society of Civil Engineers (ASCE) Task Committee on freight Pipelines), ASCE J. of Transportation Engr., vol. 124, no. 4, pp.300-310, Jul/Aug 1998.
2. Liu, H and T. Marrero, "Pipeline engineering research and education at universities in the United States," C.D. Proc. of Intl. Conf. on Engr. Education (ICEE-98), Rio de Janeiro Brazil, 15 pages, August 17-20, 1998.

CL8104 INTELLECTUAL PROPERTY RIGHTS L T P C
3 0 0 3

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 PERIODS

TEXT BOOK

1. Subbaram N.R. “Handbook of Indian Patent Law and Practice “, S. Viswanathan Printers and Publishers Pvt. Ltd., 1998.

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. Using the Internet for non-patent prior art searches, Derwent IP Matters, July 2000.

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CL8105 MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT

L T P C
3 0 0 3

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

REFERENCES

1. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005
2. Symon Jud, MBR Book – Principles and application of MBR in water and wastewater treatment,Elservier, 2006
3. K. Yamamoto and Urase T, Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000
4. Jorgen Wagner, Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision2, Osmonics Inc., 2001
5. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
6. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elservier, 1995

CL8106 MULTICOMPONENT DISTILLATION L T P C
3 0 0 3

UNIT I THERMODYNAMIC PRINCIPLES 9

Fundamental Thermodynamic principles involved in the calculation of vapor – liquid equilibria and enthalpies of multi component mixtures – Use of multiple equation of state for the calculation of K values – Estimation of the fugacity coefficients for the vapor phase of polar gas mixtures – calculation of liquid – phase activity coefficients.

UNIT II THERMODYNAMIC PROPERTY EVALUATION 9

Fundamental principles involved in the separation of multi component mixtures – Determination of bubble-point and Dew Point Temperatures for multi component mixtures – equilibrium flash distillation calculations for multi component mixtures – separation of multi component mixtures at total reflux.

UNIT III MINIMUM REFLUX RATIO FOR MCD SYSTEM 9

General considerations in the design of columns – Column sequencing – Heuristics for column sequencing – Key components – Distributed components – Non-Distributed components – Adjacent keys. Definition of minimum reflux ratio – calculation of Rm for multi component distillation – Underwood method – Colburn method.

UNIT IV VARIOUS METHODS OF MCD COLUMN DESIGN 9

Theta method of convergence – Kb method and the constant composition method – Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Stage and reflux requirements – Short cut methods and Simplified graphical procedures.

UNIT V VARIOUS TYPES OF MCD COLUMNS 9

Design of sieve, bubble cap, valve trays and structured packing columns for multi component distillation – computation of plate efficiencies.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Holland, C.D., “Fundamentals of Multi Component Distillation”, McGraw Hill Book Company,1981
2. Van Winkle, “Distillation Operations”, McGraw Hill Publications, 1987.

CL8107 MULTIPHASE FLOW L T P C
3 0 0 3

UNIT I CHARACTERISTICS OF MULTIPHASE FLOWS 9

Significance of multiphase flows, important non-dimensional numbers, parameters of characterization, particle size measurement, size distribution and moments, size distribution models

UNIT II PARTICLE FLUID INTERACTION 9

Equation of motion for a single particle, calculation of drag, motion of a particle in two-dimensions, effects of unsteady and non-uniform flow fields, effect of acceleration, effect of coupling; Interaction between particles, mechanism of interaction, interparticle forces, hard sphere model, soft sphere model, discrete element modeling, semi-empirical methods, kinetic theory, force chains.

UNIT III MODELING OF MULTIPHASE FLOWS 9

Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models - correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows

UNIT IV CONSERVATION EQUATIONS 9

Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling.

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UNIT V MULTIPHASE SYSTEMS **9**

Flow regime and hydrodynamic characteristics of packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds; Conventional and novel measurement techniques for multiphase systems including CARPT, Laser Doppler anemometry, Particle Image Velocimetry.

TOTAL : 45 PERIODS

REFERENCES

1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 2005.
2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 2011
3. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 2005
4. Govier, G. W. and Aziz. K., "The Flow of Complex Mixture in Pipes", Van Nostrand Reinhold, New York, 1972.
5. Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003
6. Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York. 2008.
7. Wallis, G.B., "One Dimensional Two Phase Flow", McGraw Hill Book Co., New York, 1969.

CL8108 PETROLEUM ECONOMICS **L T P C**
3 0 0 3

UNIT I **9**

Introduction to upstream economics analysis, energy overview of India – Time value of money, cash flow analysis, capital budgeting techniques, general probability, elements of oil and gas project cash flows.

UNIT II **9**

Reserves classification methods, quantification, assessment of geoscience and reservoir engineering uncertainties – Assessment of reserves, production and demand in international market.

UNIT III **9**

Inflation and cost escalation, oil market and OPEC, share of non OPEC countries in oil production – International oil and gas pricing mechanism – Geopolitics.

UNIT IV **9**

Petroleum Fiscal system, classification and analysis – Reserves Auditing – Accounting systems for oil and gas.

UNIT V **9**

Project Economic Evaluation and petroleum economic models – Decision analysis – Valuation of petroleum properties.

TOTAL : 45 PERIODS

REFERENCES

1. Abdel-Aal, H. K. Bakr, A. B. Al-Sahlawi. A : Petroleum Economics and Engineering, Dekrer Publication, 1992
2. Cronquist, C., Estimation and classification of Reserves of Crude oil, Natural Gas, and Condensate, SPE (2001)
3. Johnston, D, "International Exploration Economics, Risk, and Contract Analysis", Pennwell Books, 2003.

4. Seba R. D., “Economics of Worldwide Petroleum Production”, OGCL Publications, USA, 1998.
5. Thompson R. S. and Wright J. D., “Oil Property Evaluation”, 2nd Edition, Thompson-Wright Associates, 1985.

CL8109 PIPING AND INSTRUMENTATION L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF PIPING ENGINEERING 9

Definitions, Piping Components their introduction, applications. Piping MOC, Budget Codes and Standards, Fabrication and Installations of piping.

UNIT II PIPE HYDRAULICS AND SIZING 9

Pipe sizing based on velocity and pressure drop consideration cost, least annual cost approach, pipe drawing basics, development of piping general arrangement drawing, dimensions and drawing of piping.

UNIT III PLOT PLAN 9

Development of plot plan for different types of fluid storage, equipment layout, process piping layout, utility piping layout. Stress analysis -Different types of stresses and its impact on piping, methods of calculation, dynamic analysis, flexibility analysis.

UNIT IV PIPING SUPPORT 9

Different types of support based on requirement and its calculation.

UNIT V INSTRUMENTATION 9

Final Control Elements; measuring devices, instrumentation symbols introduction to process flow diagram (PFD) and piping & instrumentation diagram (P&ID)

TOTAL : 45 PERIODS

TEXT BOOKS

1. Piping Handbook, 6 th edition, M.L. Nayyar, P.E., Mc Graw-Hill, Inc
2. Piping Design Handbook edited by Johan J McKetta, CRC Press, 1992.
3. Luyben, W. L.," Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.

CL8110 POLLUTION ABATEMENT L T P C
3 0 0 3

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- radioactive 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

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.

CL8111 POLYMER TECHNOLOGY **L T P C**
3 0 0 3

UNIT I GENERAL ASPECTS OF POLYMERS **9**

Classification, mechanisms and methods of polymerization, properties-molecular weight, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II APPLICATION ORIENTED POLYMERS **9**

Resins-PVC-Silicon oil and resin, fibrous polymers-nylon 66, polyacrylonitrile, adhesives-epoxides, phenol formaldehyde, urea formaldehyde.

UNIT III ELASTOMERS **9**

Natural rubber, styrene-butadiene, poly isopropane-neoprene, silicon rubber, thermoplastic elastomer.

UNIT IV PROCESSING OF POLYMERS **9**

Processing additives, plasticzer, antiaging additives, surface and optical properties, modifiers, fire retardants, additives for rubber and elastomer, various molding techniques.

UNIT V PHYSICAL AND CHEMICAL TESTING OF PLASTICS **9**

Mechanical properties, tensile strength and hardness, electrical properties, volume resistivity, dielectric strength, optical properties glass, light transmission and refractive index, chemical analysis-elemental and functional analysis.

TOTAL : 45 PERIODS

REFERENCES

1. Miles, D.C & Briston, J.H. Polymer Technology, Chemical publishing Co: Inc: NY: 1979
2. Maturine Morton, "Rubber Technology", 3rd Edition, Van Nostrand Re Inhold, NY: 1987
3. Masic, L. "Thermoplastics Materials Engineering", Applied science publishers Ltd, NY: 1986
4. Raymond E.Seymour, "Engineering Polymer Source Book", Mc Graw Hill

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Anna University, Chennai-600 025.

CL8112 PROCESS OPTIMIZATION L T P C
3 0 0 3

UNIT I INTRODUCTION 5

Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, Types of optimization problem.

UNIT II LINEAR PROGRAMMING 10

Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III NONLINEAR UNCONSTRAINED OPTIMIZATION 10

Convex and concave functions unconstrained NLP, Newton's method Quasi-Newton's method, Examples.

UNIT IV CONSTRAINED OPTIMIZATION 10

Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

UNIT V MULTI OBJECTIVE OPTIMIZATION 10

Weighted Sum of Squares method, Epsilon constrain method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization.

TOTAL : 45 PERIODS

REFERENCES

1. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
2. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer, 2003.
3. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
4. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers, 2000

CL8113 PROJECT ENGINEERING OF PROCESS PLANTS L T P C
3 0 0 3

UNIT I 9

Project definition, Project Profile and standards, Feed back information (MIS), Evaluation and Modification, Selection, Criteria.

UNIT II 9

Planning the process, Strategic and Managerial Planning, Organising the process planning, cost and costing, Cost Control systems, Economic Balancing, Network Planning, Methods (PERT/CPM), Engineering Flow Diagrams, Cost requirements, Analysis and Estimation of Process Feasibilities (Technical/Economical) Analysis, Cost – Benefit Ratio Analysis, Project Budgeting, Capital Requirements, capital Market, Cash Flow Analysis, Break even strategies.

UNIT III 9

Plant Engineering Management, Objectives, Programme, Control, Plant Location and Site Selection, Layout diagrams, Selection and procurement of equipment and machineries, Installation, Recommission, Commissioning and performance appraisal, Strategies choice and Influence, Product planning and development, Provision and maintenance of service facilities.

UNIT IV **9**

Process safety, Materials safety and Handling regulations, Safety in equipment and machinery operations, Design considerations of safety organization and control, Pollution, Pollution control and Abatement, Industrial Safety Standard Analysis.

UNIT V **9**

Government regulations on procurement of raw materials and its allocation. Export – Import regulations, Pricing policy, Industrial licensing procedure, Excise and other commercial taxes, Policies on depreciation and corporate tax, Labour laws, Social welfare legal measurements, Factory act, Regulations of Pollution Control Board.

TOTAL : 45 PERIODS

REFERENCES

1. Cheremisinoff, N. P., Practical Guide to Industrial Safety: Methods for Process Safety Professionals, CRC Press, 2001
2. Couper, J. R., Process Engineering Economics, CRC Press, 2003.
3. Perry, J. H. "Chemical Engineer's Hand Book", 8th Ed., McGraw Hill, New York, 2007.
4. Peters, M. S., Timmerhaus, C. D. and West, R. E., "Plant Design and Economics for Chemical Engineers", 5th Edn., McGraw Hill, 2003.
5. Silla, H., Chemical Process Engineering: Design and Economics, CRC Press, 2003
6. Vinoski, W., Plant Management Handbook, Pearson Education, Limited, 1998
7. Watermeyer, P., Handbook for Process Plant Project Engineers, John Wiley and Sons, 2002

CL8114 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

L T P C
3 0 0 3

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

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TOTAL : 45 PERIODS

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.

CL8115 RISK ANALYSIS AND MANAGEMENT L T P C
3 0 0 3

UNIT I **9**

General: Risk types, Completion, Permitting, Resource, Operating, Environmental, Manageable, Insurable, Risk Causes, Risk Analysis types and causes.

UNIT II **9**

Techniques: General, Risk adjusted discounted rate method, Certainty Equivalent Coefficient method, Quantitative Sensitivity analysis, Probability distribution, Coefficient of variation method, Simulation method, Crude Procedures, Payback period, Expected monetary value method, Refined procedures, Shackle approach, Hiller's model, Hertz model, Goal programming.

UNIT III **9**

Risk Management: Emergency relief Systems, Diers program, Bench scale experiments, Design of emergency relief systems, Internal emergency planning, Risk management plan, mandatory technology option analysis, Risk management alternatives, risk management tools, risk management plans, Risk index method, Dowfire and explosion method, Mond index Method.

UNIT IV **9**

Risk Assurance and Assessment: Property Insurance, Transport insurance, Liability insurance, Pecunious insurance, Risk Assessment, Scope Canvey study, Rijimond pilot study, Low Probability high consequence events. Fault tree analysis, Event tree analysis, Zero Infinity dilemma.

UNIT V **9**

Risk Analysis in Chemical Industries: Handling and storage of Chemicals, Process plants, Personnel protection equipments. Environmental risk analysis, International environmental management system, Corporate management system, Environmental risk assessment, Total quality management, Paradigms and its convergence.

TOTAL : 45 PERIODS

REFERENCES

1. Srivastav, S., "Industrial Maintenance Management", Sultan Chand & Co., 1998.
2. Rao, P. C. K., "Project Management and Control", Sultan Chand & Co., Ltd., 1996

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Anna University, Chennai-600 025.

3. Sincero, A. P. and Sincero, G. A., “Environmental Engineering – A Design Approach”, Prentice Hall of India, 1996.
4. Pandya, C. G., “Risks in Chemical Units”, Oxford and IBH Publishers, 1992.
5. Fawcett, H. H., “Safety and Accident Prevention in Chemical Operations by John Wiley & Sons, 1982.
6. Kind, R. W., “Industrial Hazard and Safety Handbook” Butterworth, 1982.
7. Steiner, H. M., “Engineering Economic Principles”, McGraw Hill Book Co., New York, 1996.

CL8116 SAFETY AND HAZARD CONTROL L T P C
3 0 0 3

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

REFERENCES

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

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CL8117 SOIL POLLUTION ENGINEERING L T P C
3 0 0 3

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 soil-pollutant 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

REFERENCES

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

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CL8118 SOLVENT EXTRACTION L T P C
3 0 0 3

UNIT I EQUILIBRIUM IN LIQUID-LIQUID SYSTEM 12

Binary and ternary liquid equilibria, Tie-lines, Critical solution temperature, Tie line correlations ,Contour/prism diagrams, Binary / Ternary prediction methods of activity coefficient, Theory and Prediction of diffusivity in liquids, Theory of inter phase mass transport, Estimation and prediction of mass transport coefficients.

UNIT II DIFFERENTIAL / STAGE-WISE EQUILIBRIUM CONTACT OPERATIONS 9

Equilibrium stage-wise contact, Single and multiple contacts with co-current and counter current flow of phases for immiscible and partially miscible solvent phases , Calculation methods, Fractional extraction with reflux of raffinate and extract. Differential contact, HETS, NETS, HTU, NTU concepts and Estimation of these parameters, Mass transfer efficiency, Axial mixing and Residence time distribution in extractors and their estimation.

UNIT III DISPERSION AND COALESCENCE IN EXTRACTORS 12

Characteristics of dispersion involving single and multiple nozzle distributors, Drop size and formation and coalescence, Mean drop size at dispersion and their settling velocities/relative characteristics velocities. Effect of drop oscillation ,wobbling and Internal circulation, Effect of surface active agents, Prediction of drop size and characteristics velocity in spray , packed and mechanically agitated contactors as in RDC, pulsed columns, solute transfer effects on drop dynamics.

UNIT IV DESIGN OF LIQUID EXTRACTION COLUMNS 12

Design of extractor height and diameter, Prediction of flow capacities in terms of flooding rates, Regime of operating envelops, Hydrodynamic design variables such as hold up, characteristic velocities, pressure drop, Effect of direction of solute transfer on these variables and their prediction methods, Correction of mass transfer data, Axial mixing correction for column height, Interfacial area estimations, using slow, fast and instantaneous reactions and their application with models for mass transfer coefficients.

TOTAL : 45 PERIODS

REFERENCES

1. Laddha, G. S. and Degaleesan, T. E., "Transport Phenomena in Liquid Extraction", Tata McGraw Hill, New Delhi, 1976.
2. Hanson, C., Baird, M. H. I. and Lo, T. C., "Hand Book of Solvent Extraction", Wiley – International, New York, 1983.
3. Hanson, C., "Recent Advances in Liquid Extraction", Pergamon Press, London, 1972.
4. Treybal, R. E., "Liquid Extraction", McGraw Hill, New York, 1963.

CL8119 SUPPLY CHAIN MANAGEMENT L T P C
3 0 0 3

UNIT I INTRODUCTION 6

Definition of Logistics and SCM: Evolution, Scope, Importance& Decision Phases – rivers of SC Performance and Obstacles.

UNIT II LOGISTICS MANAGEMENT 10

Factors – Modes of Transportation - Design options for Transportation Networks-Routing and Scheduling – Inbound and outbound logistics- Reverse Logistics – 3PL- Integrated Logistics Concepts- Integrated Logistics Model – Activities - Measuring logistics cost and performance – Warehouse Management - Case Analysis.

UNIT III SUPPLY CHAIN NETWORK DESIGN 10

Distribution in Supply Chain – Factors in Distribution network design –Design options-Network Design in Supply Chain – Framework for network Decisions - Managing cycle inventory and safety.

UNIT IV SOURCING, AND PRICING IN SUPPLY CHAIN 9

Supplier selection and Contracts - Design collaboration – Procurement process. Revenue management in supply chain.

UNIT V COORDINATION AND TECHNOLOGY IN SUPPLY CHAIN 10

Supply chain coordination - Bullwhip effect – Effect of lack of co-ordination and obstacles – IT and SCM - supply chain IT frame work. E Business & SCM. Metrics for SC performance – Case Analysis.

TOTAL : 45 PERIODS

REFERENCES

1. Supply Chain Management, Strategy, Planning, and operation – Sunil Chopra and Peter Meindl- PHI, Second edition, 2007.
2. Logistics, David J.Bloomberg, Stephen Lemay and Joe B.Hanna, PHI 2002.
3. Logistics and Supply Chain Management –Strategies for Reducing Cost and Improving Service. Martin Christopher, Pearson Education Asia, Second Edition.
4. Modeling the supply chain, Jeremy F.Shapiro, Thomson Duxbury, 2002.
5. Handbook of Supply chain management, James B.Ayers, St.Lucle Press, 2000.

CL8120 TOTAL QUALITY MANAGEMENT L T P C

3 0 0 3

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

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.

CL8121 WASTE MANAGEMENT AND ENERGY RECOVERY L T P C
3 0 0 3

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

TEXT BOOKS

1. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed. McGraw-Hill, New York, 1993.
2. Howard S. Peavyetal, Environmental Engineering, McGraw Hill International Edition, 1985

REFERENCES

1. LaGrega, M., et al., Hazardous Waste Management, McGraw-Hill, c. 1200 pp., 2nd ed., 2001.
2. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990
3. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
4. ManojDatta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.

CL8122 WASTE WATER ENGINEERING L T P C
3 0 0 3

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

REFERENCES

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

EY8077 HYDROGEN AND FUEL CELLS L T P C
3 0 0 3

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

TEXT BOOKS

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)

REFERENCES

1. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996).
2. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork Ltd., London (1989)
3. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).
4. Viswanathan, B and M AuliceScibioh, Fuel Cells – Principles and Applications, Universities Press (2006)

MG8071 OPERATIONS RESEARCH L T P C
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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 time-chart 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

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.

Attested

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