AFFILIATED INSTITUTIONS

ANNA UNIVERSITY, CHENNAI

REGULATIONS - 2009

CURRICULUM II TO IV SEMESTERS (FULL TIME)

M.TECH. CHEMICAL ENGINEERING

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CH9321	Advanced Separation Processes	3	0	0	3
2.	CH9322	Advanced Process Control	3	0	0	3
3.	CH9323	Chemical Process Design	3	0	0	3
4.	E3	Elective III	3	0	0	3
5.	E4	Elective IV	3	0	0	3
6.	E5	Elective V	3	0	0	3
PRACTICAL						
7.	CH9327	Seminar	0	0	2	1
		TOTAL	**18**	**0**	**2**	**19**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CH9331	Process Modeling and Simulation	3	0	0	3
2.	E6	Elective VI	3	0	0	3
3.	E7	Elective VII	3	0	0	3
PRACTICAL						
4.	CH9334	Project Work (Phase I)	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
PRACTICAL						
1.	CH9341	Project Work (Phase II)	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

LIST OF ELECTIVES

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	CH9001	Multiphase Flow	3	0	0	3
2.	CH9002	Computational Fluid Dynamics	3	0	0	3
3.	CH9003	Fluidization Engineering	3	0	0	3
4.	CH9004	Risk Analysis and Management	3	0	0	3
5.	CH9005	Project Engineering and Process Plant	3	0	0	3
6.	CH9006	Process Optimization	3	0	0	3
7.	MA9219	Operations Research	3	0	0	3
8.	CH9008	Total Quality Management	3	0	0	3
9.	CH9009	Environmental Management	3	0	0	3
10.	CH9010	Green Chemistry and Engineering	3	0	0	3
11.	CH9011	Wastewater Engineering	3	0	0	3
12.	CH9012	Energy Management	3	0	0	3
13.	CH9013	Gas Transportation	3	0	0	3
14.	CH9014	Solvent Extraction	3	0	0	3

CH9321 ADVANCED SEPARATION PROCESSES L T P C
3 0 0 3

UNIT I GENERAL 12

Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances. process concept, theory and equipment used in cross flow filtration, cross flow electrofiltration, dual functional filter, surface based solid-liquid separations involving a second liquid, sirofloc filter.

UNIT II MEMBRANE SEPARATIONS 8

Types and choice of membranes, plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, commercial, pilot plant and laboratory membrane pemeators involving dialysis, reverse osmosis, nanofiltration, ultrafiltration, microfiltration and Donnan dialysis, economics of membrane operations, ceramic membranes.

UNIT III SEPARATION BY ADSORPTION TECHNIQUES 8

Mechanism, types and choice of adsorbents, normal adsorption techniques, affinity chromatography and immuno chromatography, types of equipment and commercial processes, recent advances and process economics

UNIT IV IONIC SEPARATIONS 8

Controlling factors, Applications, Types of equipment employed for electrophoresis, dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes

UNIT V OTHER TECHNIQUES 9

Separations involving lyophilization, pervaporation and permeation techniques for solids, liquids and gases, industrial viability and examples, zone melting, addiuctive crystallization, other separation processes, supercritical fluid extraction, oil spill management, industrial effluent treatment by modern techniques.

TOTAL : 45 PERIODS

REFERENCES:

1. King, C. J., “Separation Processes”, Tata McGraw Hill Co., Ltd., 1982.
2. Nakagawal, O. V., “Membrane Science and Technology”, Marcel Dekker, 1992.
3. Rousseau, R. W., “Handbook of Separation Process Technology”, John Wiley, New York, 1987.
4. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997

CH9322 ADVANCED PROCESS CONTROL L T P C
3 0 0 3

UNIT I ADVANCED CONTROL STRATEGIES 9
Feed forward, cascade, dead time compensation, split range, selective and override control; automatic tuning and gain scheduling

UNIT II INTERNAL MODEL CONTROL 9
Model based control – IMC structure – development and design; IMC based PID control

UNIT III MULTIVARIABLE CONTROL 9
Control loop interaction – general pairing problem, relative gain array and application, sensitivity. Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling

UNIT IV DISCRETE SYSTEMS 9
Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability.

UNIT V DIGITAL FEEDBACK CONTROLLERS 9
Design of digital feedback controllers, digital approximation of classical, effect of sampling, Dahlin's algorithms, Dead – beat algorithm, ringing, IMC algorithm, simplified model predictive algorithm.

TOTAL: 45 PERIODS

REFERENCES

1. Bequette, B. W., Process Control: Modeling, Design, and Simulation, Prentice Hall, 2003
2. Stephanopolous, G., "Chemical Process Control", Prentice Hall of India, New Delhi, 1985.

CH9323 CHEMICAL PROCESS DESIGN L T P C
3 0 0 3

UNIT I INTRODUCTION 9
The Hierarchy of Chemical process Design- Overall process Design, approaches to design.

UNIT II CHOICE OF REACTORS AND SEPARATOR 9
Reaction path, reactor performance, practical reactors, Separation of Heterogeneous mixtures, homogeneous fluid mixtures.

UNIT III SYNTHESIS OF REACTION – SEPARATION SYSTEMS 9
Process recycle, Batch processes, process yield

UNIT IV DISTILLATION SEQUENCING 9
Using simple columns, using columns with more than two products, Distillation Sequencing Using thermal coupling.

UNIT V HEAT EXCHANGER NETWORK & UTILITIES – ENERGY TARGETS 9

Heat recovery pinch, The Problem table Algorithm, Utilities Selection, Energy targets capital & total Cost targets -Number of Heat Exchanger Units, Area Targets, Number of Shells Targets, Capital Cost Targets, Total Cost Targets.

TOTAL: 45 PERIODS

REFERENCES

1. Smith, R., "Chemical Process Design", McGraw Hill, New York, 1995.
2. Douglas, J.M., "Conceptual Design of Chemical Process", McGraw Hill, New York, 1988.

CH9327 SEMINAR L T P C
0 0 2 1

Students are expected to present two seminars along with report on any recent topic in chemical engineering.

CH9331 PROCESS MODELLING AND SIMULATION L T P C
3 0 0 3

UNIT I INTRODUCTION 5

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

UNIT II STEADY STATE LUMPED SYSTEMS 9

Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flowsheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations.

UNIT III UNSTEADY STATE LUMPED SYSTEMS 9

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems.

UNIT IV STEADY STATE DISTRIBUTED SYSTEM 9

Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

UNIT V UNSTEADY STATE DISTRIBUTED SYSTEM 13

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations - Empirical modeling, parameter estimation, population balance and stochastic modeling.

TOTAL: 45 PERIODS

REFERENCES:

1. Ramirez, W., "Computational Methods in Process Simulation", 2nd Edn., Butterworths, New York, 2000.
2. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill Book Co., 1973.
3. Felder, R. M. and Rousseau, R. W., “Elementary Principles of Chemical Processes“, John Wiley, 2000.
4. Franks, R. G. E., “Mathematical Modelling in Chemical Engineering“, John Wiley, 1967.

CH9334 PROJECT WORK (PHASE I) L T P C
0 0 12 6

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

CH9341 PROJECT WORK (PHASE II) L T P C
0 0 24 12

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

CH9001 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, calculation and measurement of particle size, size distributions 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, effects of acceleration, effects of coupling; Interaction between particles – mechanisms of interaction, interparticle forces, hard sphere model, soft sphere model, discrete element modeling, semi-empirical methods, kinetic theory, force chains.

UNIT III MODELLING 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.

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, 1978.
2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 1998
3. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 1998
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. 1998.
7. Wallis, G.B., “One Dimensional Two Phase Flow”, McGraw Hill Book Co., New York, 1969.

CH9002 COMPUTATIONAL FLUID DYNAMICS L T P C
3 0 0 3

UNIT I CONSERVATION LAWS 9

Governing equations of fluid flow and heat transfer –mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form

UNIT II TURBULENCE 9

Characteristics of turbulent flows, Time averaged Navier Stokes equations, Turbulence models – one and two equation, Reynolds stress, LES and DNS

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.

CH9003 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 SOLIDS MIXING AND SEGREGATION 8

Phase juxtapositions operation shifts, Reversal points, Degree of segregation, Mixing Segregation equilibrium, and 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, 1992.
3. Kunii, D. and Levenspiel, O., "Fluidization Engineering", 2nd Edn., Butterworth-Heinemann, London, 1991.

CH9004 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

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.

CH9005 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

CH9006 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

MA9219 OPERATIONS RESEARCH L T P C
3 1 0 4

UNIT I QUEUEING MODELS 9

Poisson Process – Markovian Queues – Single and Multi-server Models – Little's formula – Machine Interference Model – Steady State analysis – Self Service Queue.

UNIT II ADVANCED QUEUEING MODELS 9

Non- Markovian Queues – Pollaczek Khintchine Formula – Queues in Series – Open Queueing Networks –Closed Queueing networks.

UNIT III SIMULATION 9

Discrete Even Simulation – Monte – Carlo Simulation – Stochastic Simulation – Applications to Queueing systems.

UNIT IV LINEAR PROGRAMMING 9

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Problems.

UNIT V NON-LINEAR PROGRAMMING 9

Lagrange multipliers – Equality constraints – Inequality constraints – Kuhn - Tucker conditions – Quadratic Programming.

L : 45 T: 15 TOTAL : 60 PERIODS

TEXT BOOKS:

1. Winston.W.L. "Operations Research", Fourth Edition, Thomson – Brooks/Cole, 2003.
2. Taha, H.A. "Operations Research: An Introduction", Ninth Edition, Pearson Education Edition, Asia, New Delhi, 2002.

REFERENCES:

1. Robertazzi. T.G. "Computer Networks and Systems – Queuing Theory and Performance Evaluation", Third Edition, Springer, 2002 Reprint.
2. Ross. S.M., "Probability Models for Computer Science", Academic Press, 2002.

CH9008 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, 1993.
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.

CH9009 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. Canter, W.L., Environmental Impact Assessment, McGraw-Hill Inc., 1992
2. Rau, J.G and Wooten, D.C., Environmental Impact Analysis Handbook, McGraw-Hill, 1980.
3. Jain, R.K., Urban, L.V., Stacey, G.S. and Balbach, H.E., Environmental Assessment, McGraw-Hill, 1993.
4. UNEP/IED Technical Report Serial No.2., Environmental Auditing, 1990.

CH9010 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

REFERENCE

1. Allen, D.T., Shonnard, D.R, Green Engineering: Environmentally Conscious Design of Chemical Processes. Prentice Hall PTR 2002

CH9011 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.

CH9012 **ENERGY MANAGEMENT** **L T P C**
3 0 0 3

UNIT I **9**
Energy Resources – Conventional – Non conventional, Energy Reserves and Depletion, Non renewable energy sources.

UNIT II **9**
Power generation by steam, Hydroelectric, Diesel oil, Nuclear fission and Natural gas, Co-generation of power. Selection of power generation process, Economical and technical efficiency of power generation, Socio economic factor affecting consumption of power by various methods, Design and safety equipments

UNIT III **9**
Renewable sources of energy, Thermal and power generation using water, wind, seawave, Solar energy, Geothermal and biomass utilization.

UNIT IV **9**
Energy consumption, Demand pattern, energy planning – Short term and long term, Energy conservation – need for, Energy recovery, various types of Energy audit – advantages

UNIT V **9**
Recovery of waste heat, optimum shell and tube heat exchanger, heat exchanger network, evaporator systems, boiler, turbo generator system

TOTAL : 45 PERIODS

REFERENCES

1. Francis, W. and M.C. Peter – Fuels and fuel technology, Pergamon Press, 1980.
2. Nagpal, G.R – Power Plant Engineering, Khanna Publishers, 1973.
3. Loftiness, R.L. – Energy Hand Book, Van Nostrand Reinhold Company, New York, 1978.
4. Edgar R.F. and Himmelblau, Optimization of Chemical Process, McGraw Hill Book Co., NY, 1989.

CH9013 **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-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.

CH9014 **SOLVENT EXTRACTION** **L T P C**
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UNIT I EQUILIBRIUM IN LIQUID-LIQUID SYSTEM **9**

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 interphase 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 9

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 9

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.

UNIT V APPLICATIONS 9

Solvent Extraction in hydrometallurgical Processing and puntication of metals – Computation of extraction equilbria – Modeling and optimization in Solvent extraction – New materials in solvent extraction.

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.