St. PETER'S UNIVERSITY

St. Peter's Institute of Higher Education and Research
(Declared under section 3 of UGC Act 1956)
Avadi, Chennai – 600 054.

M.Tech. (CHEMICAL ENGINEERING) PROGRAMME

(I TO IV SEMESTERS)

REGULATIONS AND SYLLABI

(REGULATIONS – 2013)

(With a retrospective amendment in the credits from the batch of students admitted in 2014-15)

M.Tech. (CHEMICAL ENGINEERING)
Regulations and Syllabi
(Effective from the Academic Year 2013-'14)

(With a retrospective amendment in the credits from the batch of students admitted in 2014-15)

1. Eligibility: Candidates who passed B.Tech. (Chemical Engineering) of the University or any other equivalent examination thereto are eligible for admission to Two Year M.Tech.(Chemical Engineering) Programme.

2. Duration: Two Years Comprising 4 Semesters. Each semester has a minimum 90 working days with a minimum of 5 hours a day and a minimum of 450 hours per Semester. Candidates who have completed the duration of the programme of study are permitted to appear for the arrear subjects, if any within two years after the duration of the programme.

3. Medium: English is the medium of instruction and examination.

4. Weightage for Internal and End Assessment: The weightage for Continuous Assessment (CA) and End Assessment (EA) is 25:75 unless the ratio is specifically mentioned in the scheme of Examinations. The Question Paper is to be set for a maximum of 100 Marks.

5. Choice Based Credit System: Choice Based Credit system is followed with one credit equivalent to one hour for a theory paper and two hours for a practical per week in a cycle of 18 weeks (that is, one credit is equal to 18 hours for each theory paper and one credit is equal to 36 hours for a practical in a semester) in the Time Table. The total credit for the programme (4 semesters) is 90.

6. Scheme of Examinations

SEMESTER I

Code No.	**Course Title**				
Theory		**L**	**T**	**P**	**C**
113CHPT01	Advanced Numerical Methods	3	0	0	4
113CHPT02	Catalytic Reaction Engineering	3	0	0	4
113CHPT03	Process Modeling and Simulation	3	0	0	4
113CHPT04	Advanced Thermodynamics	3	0	0	4
113CHPT06	**Elective I:** Energy Management	3	0	0	4
113CHPT13	**Elective II:** Safety and Hazard Control	3	0	0	4
Practical					
113CHPP01	Instrumental Methods of Analysis Laboratory	0	0	3	3
	Total	**18**	**0**	**3**	**27**

SEMESTER II

Code No.	**Course Title**				
Theory		**L**	**T**	**P**	**C**
213CHPT01	Advanced Separation Processes	3	0	0	4
213CHPT02	Advanced Process Control	3	0	0	4
213CHPT03	Chemical Process Design	3	0	0	4
213CHPT07	**Elective III:** Biochemical Engineering	3	0	0	4
213CHPT12	**Elective IV:** Total Quality Management	3	0	0	4
213CHPT23	**Elective V:** Environment, Health and Safety in Industries	3	0	0	4
Practical					
213CHPP01	Chemical Process Simulation laboratory	0	0	3	3
	Total	**18**	**0**	**3**	**27**

SEMESTER III

Code No.	Course Title				
Theory		**L**	**T**	**P**	**C**
313CHPT01	Advanced Transport Phenomena	3	0	0	4
313CHPT05	**Elective VI:** Process Optimization	3	0	0	4
313CHPT17	**Elective VII:** Green Chemistry and Engineering	3	0	0	4
Project					
313CHPP01	Project Work (Phase I)*	0	0	12	8
	Viva Voce				
	Total	**9**	**0**	**12**	**20**

***** Candidates who have completed Project work (Phase I) successfully are eligible for Project Work (Phase - II) Examination.

SEMESTER IV

Code No.	Course Title				
Project		**L**	**T**	**P**	**C**
413CHPP01	Project Work (Phase - II)*	0	0	24	16
	Viva Voce				
	Total	**0**	**0**	**24**	**16**

LIST OF ELECTIVES

Course Code	COURSE TITLE	L	T	P	C
SEMESTER I (ELECTIVE-I)					
113CHPT05	Solvent Extraction	3	0	0	4
113CHPT06	Energy Management	3	0	0	4
113CHPT07	Gas Transportation	3	0	0	4
113CHPT08	Petroleum Economics	3	0	0	4
113CHPT09	Enhanced Oil Recovery	3	0	0	4
113CHPT10	Multicomponent Distillation	3	0	0	4
ELECTIVE-II					
113CHPT11	Risk Analysis and Management	3	0	0	4
113CHPT12	Project Engineering of Process Plants	3	0	0	4
113CHPT13	Safety and Hazard Control	3	0	0	4
113CHPT14	Environmental Policies and Legislation	3	0	0	4
113CHPT15	Environmental Science	3	0	0	4
113CHPT16	Environmental Risk Assessment	3	0	0	4
113CHPT17	Waste Water Engineering	3	0	0	4
113CHPT18	Environmental Engineering	3	0	0	4
113CHPT19	Environmental Sustainability	3	0	0	4
113CHPT20	Ecology and Environment	3	0	0	4

SEMESTER II

Course Code	COURSE TITLE	L	T	P	C
	ELECTIVE-III				
213CHPT04	Polymer Technology	3	0	0	4
213CHPT05	Industrial Instrumentation	3	0	0	4
213CHPT06	Industrial Pollution Prevention	3	0	0	4
213CHPT07	Biochemical Engineering	3	0	0	4
213CHPT08	Fundamentals of Nanoscience	3	0	0	4
213CHPT09	Drugs and Pharmaceutical Technology	3	0	0	4
213CHPT10	Membrane Technologies for Water and Wastewater Treatment	3	0	0	4
	ELECTIVE-IV				
213CHPT11	Operations Research	3	0	0	4
213CHPT12	Total Quality Management	3	0	0	4
213CHPT13	Supply Chain Management	3	0	0	4
213CHPT14	Intellectual Property Rights	3	0	0	4
	ELECTIVE-V				
213CHPT15	Atmospheric Science	3	0	0	4
213CHPT16	Environmental Reaction Engineering	3	0	0	4
213CHPT17	Advanced Oxidation Processes and Technology	3	0	0	4
213CHPT18	Pollution Abatement	3	0	0	4
213CHPT19	Environmental Nanotechnology	3	0	0	4
213CHPT20	Environmental Management	3	0	0	4
213CHPT21	Environmental Biotechnology	3	0	0	4
213CHPT22	Soil Pollution Engineering	3	0	0	4
213CHPT23	Environment, Health and Safety in Industries	3	0	0	4
213CHPT24	Remote Sensing and GIS Applications in Environmental Management	3	0	0	4
213CHPT25	Climate Change and Adaptation	3	0	0	4
213CHPT26	Waste Management and Energy Recovery	3	0	0	4

SEMESTER III

Course Code	COURSE TITLE	L	T	P	C
ELECTIVE-VI					
313CHPT02	Multiphase Flow	3	0	0	4
313CHPT03	Computational Fluid Dynamics	3	0	0	4
313CHPT04	Fluidization Engineering	3	0	0	4
313CHPT05	Process Optimization	3	0	0	4
313CHPT06	Design of Experiments	3	0	0	4
313CHPT07	Piping and Instrumentation	3	0	0	4
313CHPT08	Scale up Methods	3	0	0	4
ELECTIVE-VII					
313CHPT09	Bio - Energy Conservation Techniques	3	0	0	4
313CHPT10	Hydrogen and Fuel Cells	3	0	0	4
313CHPT11	Fuel Cell Technology	3	0	0	4
313CHPT12	Electrochemical Processes for Clean Technology	3	0	0	4
313CHPT13	Electrochemical Process Engineering for Chemical Engineers	3	0	0	4
313CHPT14	Electrochemical Engineering	3	0	0	4
313CHPT15	Electrochemical Environmental Technology	3	0	0	4
313CHPT16	Electrochemical Technology for Chemical Engineers	3	0	0	4
313CHPT17	Green Chemistry and Engineering	3	0	0	4

7. **Passing Requirements:** The minimum pass mark (raw score) be 50% in End Assessment (EA) and 50% in Continuous Assessment (CA) and End Assessment (EA) put together. No minimum mark (raw score) in Continuous Assessment (CA) be prescribed unless it is specifically mentioned in the scheme of Examination.

8. **Grading System:** Grading System on a 10 Point Scale be followed with 1 mark = 0.1 Grade point to successful candidates as given below.

CONVERSION TABLE

(1 mark = 0.1 Grade Point on a 10 Point Scale)

Range of Marks	Grade Point	Letter Grade	Classification
90 to 100	9.0 to 10.0	O	First Class
80 to 89	8.0 to 8.9	A	First Class
70 to 79	7.0 to 7.9	B	First Class
60 to 69	6.0 to 6.9	C	First Class
50 to 59	5.0 to 5.9	D	Second Class

0 to 49	0 to 4.9	**F**	**Reappearance**

Procedure for Calculation

Cumulative Grade Point Average (CGPA) = $\frac{\text{Sum of Weighted Grade Points}}{\text{Total Credits}}$

= $\frac{\sum (CA+EA)\ C}{\sum C}$

Where Weighted Grade Points in each Course = Grade Points (CA+EA) multiplied by Credits

= (CA+EA)C

Weighted Cumulative Percentage of Marks(WCPM) = CGPAx10

C- Credit, CA-Continuous Assessment, EA- End Assessment

9. Pattern of the Question Paper: The question paper for End Assessment will be set for three hours and for the maximum of 100 marks with following divisions and details.

Part A: 10 questions (with equal distribution to all units in the syllabus). Each question carries 2 marks.

Part B: 5 questions with either or type (with equal distribution to all units in the syllabus). Each question carries 16 marks. The total marks scored by the candidates will be reduced to the maximum prescribed in the Regulations.

10. Effective Period of Operation for the Arrear Candidates : Two Year grace period is provided for the candidates to complete the arrear examination, if any.

Registrar

11. Syllabus

I Semester

113CHPT01-ADVANCED NUMERICAL METHODS

OBJECTIVES:

- To develop the ability to apply the concepts of Matrix theory and Liner programming in Electrical Engineering problems.
- To familiarize the students in calculus of variations
- To improve knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as precursor for further research.

UNIT I CALCULAS OF VARIATION

Introduction – Euler's equation – several dependent variables Lagrange's equation of Dynamics – Integrals involving derivatives higher that the first – Problem with constrains – Direct methods and eigen value problems.

UNIT II MATRIX THEORY

Eigen values using QR transformations – generalized eigenvectors – canonical forms – singular value decomposition and applications – pseudo inverse – least square approximations.

UNIT III LINEAR PROGRAMMING PROBLEM

Graphical method – simplex method – Big M Technique – Integer programming.

UNIT IV ALGEBRAIC EQUATIONS

Systems of linear equations – Jacabi, Gauss Seidel, Successive over Relaxation methods, Thomas algorithm for tridiagonal systems; Systems of non-linear equations – Sucessive approximation method, methods for improved convergence convergence, Muller method, Chebyshev third order method, Newton method and its variants, Continuation methods for multiple solutions.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS – IVPAs

RungeKutta methods, stip size control and estimates of error, stability of the steady state of a linear system, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations.

REFERENCES

1. Gupta, A.S, Calculus of variations with Applications, Prentice – Hall of India New Delhi, 1997.
2. Broson, R., Matrix operations, Schaum's outline series, McGraw Hill, New York, 1989.
3. Taha H.A, "Operation Research – An Introduction", Prentice Hall of India, 2001.
4. Numerical methods for Chemical Engineering by Kenneth J. Beers, Cambridge University Press, New York, 2007.
5. Gupta S.K.Numerical methods for Engineers, New age publishers 2003.
6. M.K.Jain. S.R.K.Iyengar, R.K.Jain Numerical methods: Problems and solutions, Wiley Eastern Limited, 2008

113CHPT02 - CATALYTIC REACTION ENGINEERING

UNIT I CATALYST AND ITS CHARACTERIZATION

General definition of catalysts, illustration of a catalytic a process, Design for catalysts – Primary constitutents, secondary constituents; Catalyst supports. Methods of determining catalysts activity – static methods, flow (dynamic) method; Study of structure – adsorption for determining catalsyst surface and pore radii; Mercury porosimetry, determination of true and apparent densities of catalysts; Structural study of electron microscopy, determination of mechanical strength of catalysts-static methods, dynamic methods; Methods of thermal analysis.

UNIT II KINETICS OF HETEROGENEOUS CATALYTIC REACTIONS.

Adsorption on Solid Catalysts. Rate Equations. Complex Catalytic Reactions. Experimental Reactors. Model Discrimination and Parameter Estimation. Sequential Design of Experiments. Physicochemical tests.

UNIT III TRANSPORT PROCESSES WITH REACTIONS CATALYZED BY SOLIDS.

Reaction of a component of a fluid at the surface of a solid. Mass and heat transfer resistances. Concentration or partial pressure and temperature differences. Molecular-, Knudsen-, and surface diffusion in pores. Diffusion in a catalyst particle. Diffusion and reaction in a catalyst particle. A continuum model. Falsification of rate coefficient and activation energy by diffusion limitations. Influence of diffusion limitations on the selectivities of coupled reactions. Criteria for the importance of intraparticle diffusion limitations. Multiplicity of steady states in catalyst particles. Combination of external and internal diffusion limitations. Diagnostic experimental criteria for the absence of internal and external mass transfer limitations. Nonisothermal particles.

UNIT IV CATALYST DEACTIVATION

Types of Catalyst Deactivation. Kinetics of Catalyst Poisoning. Kinetics of Catalyst Deactivation by Coke Formation.

UNIT V THE MODELING OF CHEMICAL REACTORS.

Approach. Aspects of Mass-, Heat- and Momentum Balances. The Fundamental Model equations. Fixed bed catalytic reactors. -The Importance and Scale of Fixed Bed Catalytic Processes. Factors of Progress: Technological Innovations and Increased Fundamental Insight. Factors Involved in the Preliminary Design of Fixed Bed Reactors. Modeling of Fixed Bed Reactors. Pseudohomogeneous Models-The Basic One-Dimensional Model. One-Dimensional Model with Axial Mixing. Two-Dimensional Pseudohomogeneous Models. Heteorgeneous Models- One-Dimensional Model Accounting for Interfacial Gradients. One-Dimensional Model Accounting for Interfacial and Intraparticle Gradients. Two-Dimensional Heterogeneous Models.
Fluidized bed and transport reactors -Introduction. Technological Aspects of Fluidized Bed and Riser Reactors. Some Features of the Fluidization and Transport of Solids. Heat Transfert in Fluidized Beds. Modeling of Fluidized Bed Reactors. Modeling of a Transport of Riser Reactor. Fluidized Bed Reactor Models Considering Detailed Flow Patterns. Catalytic Cracking of Vacuum Gas Oil.

TEXT BOOKS

1. Chemical Reactor Analysis and Design, Gilbert F. Froment and Kenneth B. Bischoff, John Wiley & Sons, 2nd Edition, 1990.
2. Elements of Chemical Reaction Engineering, H. Scott Fogler, Prentice Hall International Series, 3rd Edition, 2000.

REFERENCES

1. Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, 3rd Edition, 1999.
2. Fundamentals of Chemical Reaction Engineering, Mark E. Davis and Robert J.Davis,

McGrawHill, 2003.
3. An Introduction to Chemical Engineering Kinetics & Reactor Design, Charles G. Hill, Jr., JohnWiley & Sons, 1977.

113CHPT03 - PROCESS MODELING AND SIMULATION

AIM
To understand the principles and applications of modeling and simulation.

OBJECTIVES
To impart to the student knowledge on modeling and simulation,classification of mathematical models,steady and unsteady state lumped and distributed systems and other modeling approaches

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

UNIT II STEADY STATE LUMPED SYSTEMS
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
Aharacteristics for through pipesnalysis 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
Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

UNIT V UNSTEADY STATE DISTRIBUTED SYSTEM
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.

UNIT VI OTHER MODELING APPROACHES
Empirical modeling, parameter estimation, population balance and stochastic modeling.

REFERENCES
1. Ramirez, W., "Computational Methods in Process Simulation", 2ndEdn., Butterworths, New York, 2000.
2. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill Book Co., 1990.
3. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", John Wiley, 2005.
4. Franks, R. G. E., "Mathematical Modelling in Chemical Engineering", John Wiley, 1967.

113CHPT04 - ADVANCED THERMODYNAMICS

UNIT I BASIC CONCEPTS
Energy and first Law; Reversibility and second Law; Review of Basic Postulates, equilibrium criteria, Legendre Transformation and Maxwell's relations

UNIT II STABILITY AND PHASE TRANSITION
Stability of thermodynamic systems, first order phase transitions and critical phenomenon, phase rule, single component phase diagrams, thermodynamic properties from volumetric and thermal data

UNIT III MULTICOMPONENT MIXTURES
Partial molar properties, fugacities in gas and liquid mixtures, activity coefficients, Ideal and Non-ideal solutions, Gibbs-Duhem equation, Wilson, NRTL, and UNIQUAC equations, UNIFAC method. Tutorials for application of principles.

UNIT IV PHASE EQUILIBRIUM
VLE - Equations of state, corresponding states, Henry's Law, lattice theory, criticality, high pressure VLE. Other phase equilibriums- SLE/LLE/VLLE. Tutorials for application of principles.

UNIT V CHEMICAL EQUILIBRIUM
Homogeneous gas and liquid phase reactions, heterogeneous reactions – phase and chemical equilibrium. Tutorials for application of principles.

REFERENCES
1. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad, 2005
2. Tester, J. W. and M. Modell, Thermodynamics and Its Applications. 3rd Edn. Prentice Hall, New Jersey, 1997.
3. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular thermodynamics of fluid-phase Equilibria, 3rd Edn, Prentice Hall Inc., New Jersey, 1999

113CHPP01 - INSTRUMENTAL METHODS OF ANALYSIS LAB

LIST OF EXPERIMENTS

1. UV-Visible spectrophotometer
2. Laser particle size diffraction analyzer
3. Gas chromatography
4. High performance liquid chromatography
5. Atomic absorption spectrophotometer.
6. Halogen moisture analyzer
7. Thermo gravimetric analyzer
8. Automated capillary micro flow porometer
9. Electrochemical workstation.
10. FTIR spectrophotometer.
11. Conductivity meter.
12. Polari meter.
13. Colorimeter.
14. PH meter.

*** Minimum experiments shall be offered.**

213CHPT01 - ADVANCED SEPARATION PROCESSES

UNIT I GENERAL

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

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

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

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

UNIT V OTHER SEPARATION TECHNIQUES

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.

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, 2009.
4. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997
5. Phillip C. Wankat , Separation Process Engineering (2nd Edition),Printice Hall,2007

213CHPT02 - ADVANCED PROCESS CONTROL

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

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

UNIT III MULTIVARIABLE CONTROL
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
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
Design of digital feedback controllers, digital approximation of classical, effect of sampling, Case study of Industrial Instrumentation and Control system, DCS, PLC, shutdown system.

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.
3. Kannan M. Moudgalya, Digital Process Control, John Wiley & Sons Ltd, 2007

213CHPT03 - CHEMICAL PROCESS DESIGN

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

UNIT II SYNTHESIS OF REACTION – SEPARATION SYSTEMS
Process recycle, Batch processes, Reaction path, reactor performance,

UNIT III DISTILLATION SEQUENCING
Using simple columns, using columns with more than two products, homogeneous fluid mixtures, Separation of Heterogeneous mixtures, Thermally coupled columns.

UNIT IV HEAT EXCHANGER NETWORK & UTILITIES – ENERGY TARGETS
Heat recovery pinch, The Problem table Algorithm, Utilities Selection, Energy targets capital & total Cost targets.

UNIT V HEAT EXCHANGER NETWORK & **UTILITIES – CAPITAL AND TOTAL COST TARGETS**
Number of Heat Exchanger Units, Area Targets, Number of Shells Targets, Capital Cost Targets, Total Cost Targets.

REFERENCES
1. Smith, R., "Chemical Process Design", McGraw Hill, New York, 2005.
2. Douglas, J.M., "Conceptual Design of Chemical Process", McGraw Hill, New York, 1988.

213CHPP01 - CHEMICAL PROCESS SIMULATION LABORATORY

Matlab - Introduction of Matlab;Numerical Integration;Polynomial Curve fitting; simultaneous algebraic equations ; Matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++.

ASPEN- Introduction of Aspen Plus**;** Physical and thermodynamic property estimations; Mass and Energy balances; Simulation and design of reactors, distillation column, heat exchangers, absorbers; Simulation of flow in pipes, performing sensitivity analysis; analysis of pipeline hydraulics using Aspen Hysys Pipesys.

CFD - Introduction of CFD**,** Construction of geometry and grid generation ; Implementation of boundary conditions ;Fluid flow modeling; convection and diffusion problems ; pressure , velocity, temperature profile; Turbulence modeling; multiphase flow; Unsteady state simulations.

REFERENCES

1. Edgar, T.F. and Himmelblau, D.M.; "Optimization of Chemical Processes", McGraw-Hill Book Co. 2008.
2. Jana A.K., "Chemical Process Modelling and ComputerSimulation" Prentice Hall.2008
3. Jana A.K., "Process Simulation and Control using ASPEN" Prentice Hall.2009
4. Versteeg, H.K. and Malalasekera, W., " An Introduction to Computational Fluid Dynamics:
5. The Finite Volume Method", Prentice-Hall Inc.2008

313CHPT01 - ADVANCED TRANSPORT PHENOMENA

UNIT I INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS

Definition of Friction Factors, Friction Factors for Flow in Tubes, Pressure Drop Required for a Given Flow, Flow Rate for a Given Pressure Drop, Friction Factors for Flow around Spheres Determination of the Diameter of a Falling Sphere, Friction Factors for Packed Columns. Case studies.

UNIT II MACROSCOPIC BALANCES FOR ISOTHERMAL FLOW SYSTEMS AND POLYMERIC LIQUIDS

The Macroscopic Mass Balance , The Macroscopic Momentum Balance , The Macroscopic Mechanical Energy Balance , Estimation of the Viscous Loss , Power Requirement for Pipeline Flow , Use of the Macroscopic Balances for Steady-State**,** Pressure Rise and Friction Loss in a Sudden Enlargement , Isothermal Flow of a Liquid through an Orifice.

Examples of the Behavior of Polymeric Liquids, Rheometry and Material Functions, Non-Newtonian Viscosity and the Generalized Newtonian Models , , Laminar Flow of an compressible Power-Law Fluid in a Circular Tube , Flow of a Power-Law Fluid in a Narrow Slit , Tangential Annular Flow of a Power- Law Fluid , Elasticity and the Linear Viscoelastic Models, Molecular Theories for Polymeric Liquids. Practical applications. Case studies.

UNIT III INTERPHASE TRANSPORT IN NONISOTHERMAL SYSTEMS

Definitions of Heat Transfer Coefficients, Calculation of Heat Transfer Coefficients from Experimental Data **,** Analytical Calculations of Heat Transfer Coefficients for Forced Convection through Tubes and Slits **,** Heat Transfer Coefficients for Forced Convection in Tubes **,** Design of a Tubular Heater **,** Heat Transfer Coefficients for Forced Convection around Submerged Objects **,** Heat Transfer Coefficients for Forced Convection through Packed Beds **,** Heat Transfer Coefficients for Free and Mixed Convection, Heat Loss by Free Convection from a Horizontal Pipe , Heat Transfer Coefficients for Condensation of Pure Vapors on Solid Surfaces. Case studies

UNIT IV MACROSCOPIC BALANCES FOR NONISOTHERMAL SYSTEMS

The Macroscopic Energy Balance, The Macroscopic Mechanical Energy Balance, Use of the Macroscopic Balances to Solve Steady-State Problems with Flat Velocity Profiles, The Cooling of an Ideal Gas , Mixing of Two Ideal Gas Streams, Parallel- or Counter-Flow Heat Exchangers, Flow of Compressible Fluids through Head Meters. Case studies

UNIT V INTERPHASE TRANSPORT IN NONISOTHERMAL MIXTURES

Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Evaporation from a Freely Falling Drop, Mass Transfer in Creeping Flow through Packed Beds, Mass Transfer to Drops and Bubbles, Definition of Transfer Coefficients in Two Phases, Determination of the Controlling Resistance, Estimation of the Interfacial Area in a Packed Column, Estimation of Volumetric Mass Transfer Coefficients. Case studies

TEXT BOOK

1. Bird R.B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd Edn., John Wiley and Sons, 2007.

REFERENCES

2. Welty, J.R., Wicks, C. E. and Wilson, R. E., "Fundamentals of Momentum, Heat Mass Transfer", 5th Edn., John Wiley and Sons, 2010.
3. Brodkey, R. S. and Hershey, H. C., "Transport Phenomena – A Unified Approach", Brodkey Publishing, 2004.

113CHPT05 - SOLVENT EXTRACTION

UNIT I EQUILIBRIUM IN LIQUID-LIQUID SYSTEM

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

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

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

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.

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.

113CHPT06 - ENERGY MANAGEMENT

UNIT I

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

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

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

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

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.

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.

113CHPT07 - GAS TRANSPORTATION

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

UNIT II
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
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
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
Structural design of pipelines —load considerations and pipe deformation and failure.
Economics of pipelines including life-cycle, Cost analysis and comparison of the costeffectiveness of pipelines with alternative modes of transport such as truck or railroad.
Legal, safety and environmental issues about pipelines.

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.

113CHPT08 - PETROLEUM ECONOMICS

UNIT I

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

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

UNIT III

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

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

UNIT V

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

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.

113CHPT09 - ENHANCED OIL RECOVERY

UNIT I FUNDAMENTALS OF ENHANCED OIL RECOVERY
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
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
Flooding – miscible, CO2, polymer, alkaline, surfactants, steam;

UNIT IV ENHANCED OIL RECOVERY OPERATIONS-2
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.

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.

113CHPT10 - MULTICOMPONENT DISTILLATION

UNIT I HERMODYNAMIC PRINCIPLES

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

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

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

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

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

TEXT BOOK

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

113CHPT11 - RISK ANALYSIS AND MANAGEMENT

UNIT I

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

UNIT II

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

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

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

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.

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.

113CHPT12 - PROJECT ENGINEERING OF PROCESS PLANTS

UNIT I

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

UNIT II

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

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

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

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.

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

113CHPT13 - SAFETY AND HAZARD CONTROL

UNIT I

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

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

UNIT III

Safety in plant design and layout. Risk Assessment.

UNIT IV

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

UNIT V

Disaster mitigation, Emergency Preparedness plans.

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.

113CHPT14 - ENVIRONMENTAL POLICIES AND LEGISLATION

UNIT I INTRODUCTION

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

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

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

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

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

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.

113CHPT15 - ENVIRONMENTAL SCIENCE

UNIT I

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

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

UNIT III

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

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

UNIT V

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.

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

113CHPT16 - ENVIRONMENTAL RISK ASSESSMENT

UNIT I

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

UNIT II

Risk assessment – introduction and available methodologies, Risk assessment steps, Hazard identification, Hazard assessment (consequence analysis), probabilistic hazard assessment (Fault tree analysis)

UNIT III

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

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

UNIT V

Past accident analysis: Flux borough – Mexico – Bhopal analysis. Government policies to manage environmental risk

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.

113CHPT17 - WASTE WATER ENGINEERING

UNIT I INTRODUCTION

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

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

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

UNIT IV RESIDUALS MANAGEMENT

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

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.

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.

113CHPT18 - ENVIRONMENTAL ENGINEERING

UNIT I ENVIRONMENT AWARENESS
Environment – friendly chemical Process; Hazard and risk analysis; Environmental Audit.

UNIT II CHEMICAL ENGINEERING PROCESSES
Unit Operations – application of - Abatement of water pollution; Current strategies to control air pollution; Disposal of solid wastes

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

UNIT IV CLEAN TECHNOLOGY
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
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

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.

113CHPT19 - ENVIRONMENTAL SUSTAINABILITY

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

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

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

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

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

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.

113CHPT20 - ECOLOGY AND ENVIRONMENT

UNIT I

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

Classification of ecotechnology - Principles and components of Systems and Modeling - Structural and functional interactions in environmental systems - Human modifications of environmental systems.

UNIT III

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

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

Case studies of integrated ecological engineering systems

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.

213CHPT04 - POLYMER TECHNOLOGY

UNIT I GENERAL ASPECTS OF POLYMERS
Classification, mechanisms and methods of polymerization, properties-molecular weight, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II APPLICATION ORIENTED POLYMERS
Resins-PVC-Silicon oil and resin, fibrous polymers-nylon 66, polyacrylonitrile, adhesivesepoxides, phenol formaldehyde, urea formaldehyde.

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

UNIT IV PROCESSING OF POLYMERS
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
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.

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

213CHPT05 - INDUSTRIAL INSTRUMENTATION

UNIT I

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

UNIT II

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

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

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

UNIT V

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.

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.
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.

213CHPT06 - INDUSTRIAL POLLUTION PREVENTION

UNIT I

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

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

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

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

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

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.

213CHPT07 - BIOCHEMICAL ENGINEERING

UNIT I

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

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

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

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

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.

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.

213CHPT08 - FUNDAMENTALS OF NANOSCIENCE

UNIT I INTRODUCTION

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

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

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.

UNIT IV PREPARATION ENVIRONMENTS

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

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

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.

213CHPT09 - DRUGS AND PHARMACEUTICAL TECHNOLOGY

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

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

UNIT V PHARMACEUTICAL PRODUCTS & PHARMACEUTICAL ANALYSIS
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

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.
"Remingtons Pharmaceutical Sciences ", Mack Publishing Co., 1975.

213CHPT10 - MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT

UNIT I INTRODUCTION

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

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

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

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

UNIT V CASE STUDIES

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

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

213CHPT11 - OPERATIONS RESEARCH

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

UNIT IV ELEMENTS OF QUEUING THEORY
Basic elements of the Queuing model, M/M/1 and M/M/C Queues.

UNIT V ELEMENTS OF RELIABILITY THEORY
General failure distribution, for components, Exponential failure distributions, General model, Maintained and Non-maintained systems, Safety Analysis.

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.

213CHPT12 - TOTAL QUALITY MANAGEMENT

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

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

UNIT III TQM SYSTEMS
Quality policy deployment, quality function deployment, Standardization, designing for quality, manufacturing for quality.

UNIT IV QUALITY SYSTEM
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
Steps, KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.

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.

213CHPT13 - SUPPLY CHAIN MANAGEMENT

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

UNIT II LOGISTICS MANAGEMENT
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
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
Supplier selection and Contracts - Design collaboration - Procurement process. Revenue management in supply chain.

UNIT V COORDINATION AND TECHNOLOGY IN SUPPLY CHAIN
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.

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.

213CHPT14 - INTELLECTUAL PROPERTY RIGHTS

UNIT I

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

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

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

UNIT IV

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

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.

TEXT BOOKS

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.

213CHPT15 - ATMOSPHERIC SCIENCE

UNITI INTRODUCTION

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

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

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

UNIT IV ATMOSPHERIC DYNAMICS

Kinematics of the large-scale horizontal flow – Dynamics of horizontal flow – primitive equations – atmospheric general circulation – numerical weather prediction.

UNIT V CLIMATE

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.

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.

213CHPT16 - ENVIRONMENTAL REACTION ENGINEERING

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

UNIT IV
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
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.

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, P enosil 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.

213CHPT17 - ADVANCED OXIDATION PROCESSES AND TECHNOLOGY

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

UNIT II
Photoinduced AOP, UV Photolysis H2O2, UV/O3 processes, Ozonation, Fenton processes, Ultrasound processes and principles of sonochemistry.

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

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.

213CHPT18 - POLLUTION ABATEMENT

UNIT I

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

UNIT II

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

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

UNIT IV

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

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

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.

213CHPT19 - ENVIRONMENTAL NANOTECHNOLOGY

UNIT I GENERAL

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

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

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

UNIT IV OTHER FEATURES OF NANO PARTICLES

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

UNIT V ENVIRONMENTAL APPLICATIONS

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

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.

213CHPT20 - ENVIRONMENTAL MANAGEMENT

UNIT I

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

UNIT II

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 (SO2,SPM,NH3, H2S and HC) into atmosphere.

UNIT III

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

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

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.

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.

213CHPT21 - ENVIRONMENTAL BIOTECHNOLOGY

UNIT I

Principles and concepts of environmental biotechnology - usefulness to mankind.

UNIT II

Degradation of high concentrated toxic pollutants - non-halogenated, halogenated - petroleum hydrocarbons - metals. Mechanisms of detoxification, oxidation reactions, dehalogenation - biotransformation of metals. Microbial cell/enzyme technology - adapted microorganisms - biological removal of nutrients – microalgal biotechnology and applications in agriculture- role of extra cellular polymers.

UNIT III

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

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

UNIT V

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

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

213CHPT22 - SOIL POLLUTION ENGINEERING

UNIT I PHYSICS AND CHEMISTRY OF SOIL

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

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

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

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

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.

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.

213CHPT23 - ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES

UNIT I INTRODUCTION

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

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

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

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

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.

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

213CHPT24 - REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

UNIT I OVERVIEW OF REMOTE SENSING

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

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

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

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

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

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.

213CHPT25 - CLIMATE CHANGE AND ADAPTATION

UNIT I EARTH'S CLIMATE SYSTEM

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

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

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

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

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.

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

213CHPT26 - WASTE MANAGEMENT AND ENERGY RECOVERY

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES
Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES
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
Basics, types, working and typical conversion efficiencies of composting – anaerobic digestion – RDF – combustion – incineration – gasification – pyrolysis

UNIT IV HAZARDOUS WASTE MANAGEMENT
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
Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for Land Fill Gases.

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

313CHPT02 - MULTIPHASE FLOW

UNIT I CHARACTERISTICS OF MULTIPHASE FLOWS
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
Equation of motion for a single particle, calculation of drag, motion of a particle in twodimensions, 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
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
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
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.

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.

313CHPT03 - COMPUTATIONAL FLUID DYNAMICS

UNIT I CONSERVATION LAWS AND TURBULENCE MODELS
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 DIFFERNCE APPROXIMATION
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
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
Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

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

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.

313CHPT04 - FLUIDIZATION ENGINEERING

UNIT I INTRODUCTION

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

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

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

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

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.

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.

313CHPT05 - PROCESS OPTIMIZATION

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

UNIT II LINEAR PROGRAMMING
Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III NONLINEAR UNCONSTRAINED OPTIMIZATION
Convex and concave functions unconstrained NLP, Newton's method Quasi-Newton's method, Examples.

UNIT IV CONSTRAINED OPTIMIZATION
Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

UNIT V MULTI OBJECTIVE OPTIMIZATION
Weighted Sum of Squares method, Epsilon constrain method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization.

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

313CHPT06 - DESIGN OF EXPERIMENTS

UNIT I CONCEPTS AND TERMINOLOGY

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

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

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

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

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.

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.

313CHPT07 - PIPING AND INSTRUMENTATION

UNIT I FUNDAMENTALS OF PIPING ENGINEERING
Definitions, Piping Components their introduction, applications. Piping MOC, Budget Codes and Standards, Fabrication and Installations of piping.

UNIT II PIPE HYDRAULICS AND SIZING
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
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
Different types of support based on requirement and its calculation.

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

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.

313CHPT08 - SCALE-UP METHODS

AIM

To understand the principles and applications of scale up methods in chemical Engineering

OBJECTIVE:

- To impart knowledge on scale up techniques
- To understand the application of scale up of Chemical equipments

UNIT I PRINCIPALS OF SIMILARITY, PILOT PLANTS & MODELS

Introduction to scale-up methods, pilot plants and models and principles of similarity.

UNIT II DIMENSIONAL ANALYSIS AND SCALE-UP CRITERION

Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering.

UNIT III SCALE-UP OF HEAT TRANSFER EQUIPMENT

Typical problems in scale-up of mixing equipment and heat transfer equipment

UNIT IV SCALE-UP OF MASS TRANSFER EQUIPMENT

Scale-up of distillation columns and packed towers for continuous and batch processes

UNIT V SCALE-UP OF CHEMICAL REACTORS

Kinetics, reactor development & scale-up techniques for chemical reactors.

TEXT BOOKS

1. Marko Zlokarnik, "Dimensional Analysis and Scale-up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986.
2. Johnstone and Thring ," Pilot Plants Models and Scale-up methods in Chemical Engg.", McGraw Hill, New York, 1962.

REFERENCE

1. Donald G. Jordan,"Chemical Process Development" (Part 1 and 2), Interscience Publishers, 1988.

313CHPT09 - BIO - ENERGY CONSERVATION TECHNIQUES

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

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

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

313CHPT10 - HYDROGEN AND FUEL CELLS

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES

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

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

UNIT III FUEL CELLS

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

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

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS

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.

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)

313CHPT11 - FUEL CELL TECHNOLOGY

UNIT I

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

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

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

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

UNIT V

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

REFERENCES

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

313CHPT12 - ELECTROCHEMICAL PROCESSES FOR CLEAN TECHNOLOGY

UNIT I THE ELECTROCHEMICAL CELL AND REACTOR

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

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

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.

UNIT IV THE TREATMENT OF INDUSTRIAL PROCESS STREAMS AND EFFLUENTS

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

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.

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.

313CHPT13 - ELECTROCHEMICAL PROCESS ENGINEERING FOR CHEMICAL ENGINEERS

UNIT I INTRODUCTION OF ELECTROCHEMICAL ENGINEERING

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

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.

UNIT III RATE PROCESSES AND REACTION MODELS

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

UNIT IV REACTOR MODELS

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

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.

TEXT BOOK

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.

313CHPT14 - ELECTROCHEMICAL ENGINEERING

UNIT I

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

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

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

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

UNIT V

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.

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.

313CHPT15 - ELECTROCHEMICAL ENVIRONMENTAL TECHNOLOGY

UNIT I

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

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

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

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

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.

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.

313CHPT16 - ELECTROCHEMICAL TECHNOLOGY FOR CHEMICAL ENGINEERS

UNIT I FUNDAMENTAL CONCEPTS
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.

UNITII THE CHLOR-ALKALI INDUSTRY
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
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.

UNIT IV INORGANIC ELECTROLYTIC PROCESS
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
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.

TEXT BOOK
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.

313CHPT17 - GREEN CHEMISTRY AND ENGINEERING

UNIT I

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

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

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

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

UNIT V

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.

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.