CURRICULUM
OF
M TECH (CHEMICAL ENGINEERING)

DEPARTMENT OF CHEMICAL ENGINEERING

DR B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY
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Scheme of Teaching and Examinations for M Tech (Chemical Engineering)

Semester-I

Course Code	Course	Hours/week			Credits
		L	T	P	
CHX-501	Computational Techniques in Chemical Engineering	3	0	0	3
CHX-503	Industrial Pollution Control Engineering	3	0	0	3
CHX-505	Process Modeling and Simulation	3	0	0	3
CHX-###	Elective-I	3	0	0	3
CHX-###	Elective-II	3	0	0	3
CHX-###	Elective-III	3	0	0	3
CHX-507	Computational Techniques in Chemical Engineering Lab	0	0	3	2
CHX-509	Industrial Pollution Control Lab	0	0	3	2
Total Credits					**22**

Semester-II

Course Code	Course	Hours/week			Credits
		L	T	P	
CHX-502	Transport Phenomena	3	0	0	3
CHX-504	Advanced Separation Techniques	3	0	0	3
CHX-506	Chemical Reactor Analysis and Design	3	0	0	3
CHX-###	Elective-IV	3	0	0	3
CHX-###	Elective-V	3	0	0	3
CHX-###	Elective-VI	3	0	0	3
CHX-508	Selected Experiments in Chemical Engineering	0	0	3	2
CHX-510	Process Modeling and Simulation Lab	0	0	3	2
Total Credits					**22**

Semester-III

Course Code	Course	Hours/week			Credits
		L	T	P	
CHX-601	Seminar	-	-	-	3
CHX-600*	Dissertation Phase-I	-	-	-	6
Total Credits					**09**

Semester-IV

Course Code	Course	Hours/week			Credits
		L	T	P	
CHX-600	Dissertation Phase-II	-	-	-	12
Total Credits					**12**

Grand total credits = 65

**The evaluation in respect of Dissertation Phase-I in Semester III will be sent along with the evaluation of Dissertation Phase-II after the completion of the Dissertation Semester IV*

LIST OF ELECTIVES

S.N.	Course Code	Course Title
1.	CHX-551	Petrochemical Technology
2.	CHX-552	Energy Management and Audit
3.	CHX-553	Introduction to Multiphase Flow
4.	CHX-554	Natural Gas Engineering
5.	CHX-555	Energy Efficiencies in Thermal Utilities
6.	CHX-556	Advanced Process Control
7.	CHX-557	Advanced Heat Transfer and Fluid Dynamics
8.	CHX-558	Rubber & Plastic Technology
9.	CHX-559	Polymer Technology
10.	CHX-560	Process Plant Design
11.	CHX-561	Industrial Rheology
12.	CHX-562	Membrane Separation Processes
13.	CHX-563	Fertilizer Technology
14.	CHX-564	Environment Impact Assessment
15.	CHX-565	New and Renewable Energy Sources
16.	CHX-566	Nanomaterials, Nanoscience& Nanotechnology
17.	CHX-567	Heat Exchanger Design
18.	CHX-568	Leather Fashion Design Technology
19.	CHX-569	Analytical Principles and instrumental Methods of Analysis
20.	CHX-570	Industrial safety and Hazard Management
21	CHX-571	Petroleum Engineering and Technology
22.	CHX-572	Computational Fluid dynamics
23.	CHX-573	Paint Technology
24.	ID-601	Research Methodology

CHX-501 Computational Techniques in Chemical Engineering [3 0 0 3]

Introduction to numerical computations in chemical engineering: General introduction to the subject of numerical analysis, Representing numbers, Polynomial curve fit by least squares method and its application to chemical processes. Newton's divided difference interpolation, Forward differences with equally space base points, Bisection method for one variable, Fixed point iteration for one variable, Newton's method for one variable, Secant method for one variable, Regula Falsi for one variable.

Linear equations. Solution of linear system by Gaussian elimination with backward substitution, The Gauss-Jordan modification (method), Iterative solution for linear systems, Iterative refinement for linear systems, Jacobi iterative method for linear systems, Gauss-Seidel iterative technique for linear systems, Convergence for the Jacobi method.

Nonlinear equations. Fixed point iteration for non-linear systems, Newton's method for non-linear systems, Evaluation of the Jacobian, Steepest decent techniques for non-linear systems,

First-order ordinary differential equations. Euler's and Taylor's method for single ODE, Runge-Kutta method for singe ODE, Predictory-corrector methods for single ODE, explicit and implicit methods (Adams-Bashforth and Adams-Moulton). Applications to rate equations

Higher-order ordinary differential equations. Higher order ODEs, R-K for systems of ODE's.

Statistics and data analysis.

Applications to Chemical Engineering: Applications of computational techniques to different chemical engineering problems eg. Calculation of specific volume of real gas binary mixtures, rate equations, material and energy balance, equipment design, handling of experimental data and curve fitting, bubble and dew point calculations, process control etc.

Books Recommended:

1. *Finlayson,B.A."Introduction to Chemical Engineering Computing"Wiley-Interscience(2006) .*
2. *Constantinides, A., "Applied Numerical Methods with personal computers"McGraw Hill (1987)*
3. *Jenson,V G, &Jeffereys, "Mathematical Methods in Chemical Engineering"Academic Press (1977)*
4. *Hanna and Sandall "Computational Methods in Chemical Engineering. Prentice Hall. (1995).*
5. *Burden, R. L., Faires J. D. "Numerical Analysis" 5th ed.,*

CHX-503 Industrial Pollution Control Engineering [3 0 0 3]

Air Pollution Control Engineering

Introduction, Definition, Sources, Characteristics and Perspective of Air Pollutants, Effects of Air Pollution on Biodiversity, Economic Effects of Air Pollution, Air Quality and Emission Standards, Engineering Systems of Control of Air Pollution by Equipment and by Process Changes, Air Pollution from Major Industrial Operations

Water Pollution Control Engineering

Introduction, Definition, Sources, Characteristics and Perspective of Water and Wastewater Pollutants, Effects of Water Pollution on Biodiversity, Economic Effects of Water Pollution, Water Quality and Emission Standards, Physical, Chemical and Biological Parameters, Engineering Systems of Control of Water and Wastewater Pollution by Primary, Secondary and Advance Treatment, Water Pollution from Major Industrial Operations

Solid Waste Management

Introduction, Definition, Sources, Characteristics and Perspective of Solid Waste, Generation, Separation, Handling, Storage and Transportation of Solid Waste, Waste Minimization of Solid

Waste, Physical, Chemical and Biological Treatment of Solid Waste, Reuse and Recycling of Solid Waste

Biomedical and Hazardous Waste Management

Introduction, Definition, Sources, Characteristics and Perspective of Biomedical and Hazardous Waste, Handling, Storage, Transportation of Biomedical and Hazardous Waste, Physical, Chemical and Biological Treatment of Biomedical and Hazardous Wastes

Books Recommended:

1. *Rao M. N. and Rao H. V. N., "Air Pollution", Tata McGraw Hill Publishing Company Ltd., (2005).*
2. *Peavy H. S., Rowe D. R. and Tchobanoglous G., "Environmental Engineering", McGraw Hill Book Company, International Edition (1985).*
3. *Metcalf and Eddy, Inc., "Wastewater Engineering-Treatment and Reuse", Tata McGraw Hill Publishing Company Ltd., Fourth Edition (2004).*
4. *Rittmann B. E. and McCarty P. L., "Environmental Biotechnology: Principles and Application", McGraw Hill International Editions, First Edition (2001).*
5. *Kiely G., "Environmental Engineering", Tata McGraw Hill Publishing Company Ltd, Special Indian Edition (2007).*

CHX- 505 Process Modeling and Simulation [3 0 0 3]

Process Model: Definition of mathematical model, Classification of models, uses of mathematical models, principles of formulation.

Process Simulation: Scope of process simulation, Formulation of a problem, steady state simulation, Simulation strategies, Process simulator, Structure of process simulator.

Phenomenological Models for Chemical Engineering Systems: Series of isothermal constant holdup CSTRs, CSTRs with variable holdups, Isothermal/non-isothermal plug flow reactors, Two heated tanks, Gas phase pressurized CSTR, Non-isothermal CSTR, Single component vaporizer, Multi-component flash drum, Batch reactor, Reactor with mass transfer, Ideal binary distillation column, Multi-component non-ideal distillation column, Batch distillation with holdup, pH systems, Lumped parameter model of gas absorber, Lumped parameter model of liquid-liquid extraction column, Model foe heat exchanger, Model for interacting & non-intracting tanks, Model for biochemical reaction.

Data Driven Model for Chemical Engineering Systems (Black Box Model): Use of neural net statistical modeling, short review of artificial neural network, topology and threshold functions, Back propagation algorithms, Application of ANNs in Chemical Engineering, introduction to Genetic Algorithm.

Computer Simulation: Introduction, Computer programming, Newton- Raphson Method, False Position Methods, Euler Method, Runge-Kutta Method.

Books Recommended

1. *Luyben W L , "Process Modeling Simulation and Control for Chemical Engineers", international ed. McGraw Hill (1990).*
2. *Rose L M, " The Application of Mathematical Modeling to Process Development and Design", First Ed. Applied Science Publisher Limited., London (1974).*
3. *Bequette , " Process Dynamics- Modeling, Analysis and Simulation", PHI International (2003).*
4. *Rase H F, "Chemical Reactor Design for Process Plants, Vol II: Case Studies and Design Data", 1st Ed., John Wiley and Sons, New York (1997)*
5. *Denn M Morton, " Process Modeling", First Ed. Longman Publisher (1986).*

CHX-507 Computational Techniques in Chemical Engineering Lab [0 0 3 2]

1 To fit a best curve for the Re Vs Pr data (or Re vs f or growth of bacteria vs time data etc) using available software.
2 Estimation of specific volume of a non-ideal gas following Van der Waals equation by solving non-linear equation using trial and error Method.
3 Estimation of specific volume of a non-ideal gas following Van der Waals equation by solving non-linear equation using Newton Raphson Method.
4 Calculation of bubble point and dew point.
5 Numerical integration over batch reactor to find time using Simpson's rule/ trapezoidal rule
6 Numerical integration over plug flow reactor to find time using Simpson's rule/ trapezoidal rule
7 Calculation of adiabatic flame temperature
8 Solution of simultaneous material balance equations using Gauss Jordan elimination method
9 To study the transient behaviour of Continuous stirred tank reactor.

CHX-509- Industrial Pollution Control Laboratory [0 0 3 2]

To carry out following experiments in the laboratory:

1. To determine the Total Solids of a given sample.
2. To find out Total Dissolved Solids of a given sample.
3. To find out Fixed and Volatile solids of the given sample.
4. To determine Acidity of the given sample.
5. To determine the Alkalinity of the given sample.
6. To determine the Total Hardness of the given sample.
7. To find out amount of Sulphates in a given sample.
8. To estimate the content of Chlorides in the given water sample
9. To find the quantity of the Dissolved Oxygen present in the given sample
10. To determine the BOD of a given wastewater sample.
11. To determine the COD of a given wastewater sample.

CHX- 502 Transport Phenomena [3 0 0 3]

Introduction to Transport Processes
Basic Mass, Momentum and Energy transport processes; micro and macroscopic views; phenomenological laws; driving forces ; transport coefficients.
Definition of fluxes; conservation principles; differential elementary volumes and coordinate systems; boundary conditions; dimensionless numbers.
Molecular mass transport – Fick's law of binary diffusion; binary gaseous diffusion coefficient – kinetic theory; diffusion in liquids and solids.
Effective transport properties (diffusion in suspensions and through pack of spheres).
Steady and transient diffusion processes– examples and application to transport problems.

Momentum Transport and Viscous Flows
Newton's law of viscosity; molecular theory of viscosity of dilute gases and liquids; Couette and falling film flow; momentum as a flux and as a force – viscous stress tensor;

Shell momentum balance and laminar flows – principles; Poiseuille flow; flow in an annulus; creeping flow around a sphere.
Continuity and equations of change, Navier-Stokes equations.
Macroscopic balances for momentum transport
Turbulent flows, Reynolds experiment, drag forces; turbulence and eddy flow (similarities with molecular transport) and atmospheric fluxes (eddy covariance method).

Energy Transport – Heat, Radiation, Phase Change
Fourier's law of heat conduction; thermal conductivity - molecular and effective; heat flow in one and multi-dimensional geometries; steady state and transient analytical solutions to heat conduction; heat flow and convection; nonlinear cooling, macroscopic energy balance.
Radiative energy transport– Stefan-Boltzmann law; black body exchange, principles and examples ; radiation through the atmosphere and greenhouse effect.
Phase change and couple heat and mass transport (falling film, evaporating water drop)

Mass Transport in Solid and in Laminar Flow: Shell mass balances: boundary conditions, diffusion through a stagnant gas film, diffusion with heterogeneous chemical reaction, diffusion with homogeneous chemical reaction, diffusion into a falling liquid film l forced – convection mass transfer, diffusion and chemical reaction inside a porous catalyst: the "effectiveness factor".

Analogies between heat, mass and momentum and transfer.

Books Recommended

1. *Bird R B, Stewart W E and Light fort R N, "Transport Phenomena", John Wiley and Sons (2002).*
2. *Welty J R , Wilson R E and Wicks C E , "Fundamentals of Momentum , Heat and Mass Transfer", 4th ed,John Wiley and Sons (2001).*
3. *John C Slattery, "Momentum, Energy and Mass transfer in continua", McGraw Hill, Co. (1972).*
4. *Bennet C U and Myers J E, " Momentum, Heat and Mass Transfer" Tata McGraw Hill Publishing Co. (1975)*
5. *Robert S Brodkey and Harry C Hersing, " Transport Phenomena a Unified approach" McGraw Hill Book Co. (1988).*

CHX-504 Advanced Separation Techniques [3 0 0 3]

1. **Introduction of various separation techniques**
   Sedimentation, Fluidization, Centrifugal Separations, Leaching, Distillation, Multi Component Distillation, Absorption of gases, Liquid – Liquid extraction, Crystallization, Drying, Membrane separation and Adsorption.
2. **Liquid – Liquid Extraction:**
   Ternary phase diagrams & choice of solvent, single stage and multistage cross current, co-current and counter current extraction operation for immiscible and miscible solvents, related numerical problems, Batch and continuos contact extractors.
3. **Leaching:**
   Mass transfer in leaching, equipment for leaching, single stage and multistage cross current, co-current and counter current leaching operations, related numerical problems, Equipment for leaching.
4. **Adsorption:**
   Introduction and the nature of adsorbent, adsorption equilibria, the Langmuir isotherm, BET isotherm and Gibbs isotherm, potential theory and adsorption equipments.

5. Membrane Separations

Types and choice of membranes, Nature of synthetic membranes, cross flow micro filtration, Ultra filtration, Reverse osmosis, Electrodialysis, Membrane fouling, Economics of membrane operations and Ceramic membranes.

Recent advances in separation techniques.

Books Recommended

1. *Geankopolis C J, "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)*
2. *Treybal R E , "Mass Transfer Operations" 3rd ed. , McGraw Hill (1980)*
3. *McCabe W L and Smith J C "Unit Operations of Chemical Engineering", McGraw Hill (2001).*
4. *Coulson J M and Richardson J F "Chemical Engineering , Vol. 2, 5", McGraw Hill (1999)*
5. *Walter L, Badger & Julius T.Banchero "Introduction to Chemical Engineering", McGraw Hill (1997).*

CHX-506 Chemical Reactor Analysis and Design [3 0 0 3]

Review of Kinetics of homogeneous and heterogeneous chemical and biochemical reactions, single and multiple reactions, order & molecularity, rate constant, elementary and non elementary reactions, Review of design of single and multiple reactions in batch reactor, plug flow reactor, C.S.T.R, and semi batch reactor, packed bed reactors and fluidized bed reactors.

Non isothermal reactor design: General design procedure, optimum temperature progression, adiabatic operation, non adiabatic operation, semi batch reactors. Steady state and unsteady state operations in C.S.T.R and Plug flow reactors, Reactor stability with special reference to C.S.T.R. Introduction to optimization of chemical reactors.

Non Ideal Flow: Residence time distribution of fluid in vessel, E,F & C Curve, Mean residence time, Models for non ideal flow, Dispersion model, N Tanks in series model, conversion in a reactor using RTD data.

Catalysts: Theories of heterogeneous catalysis, Classification of catalysts, catalyst preparation, Promoter and inhibitors, Catalysts Deactivation/Poisoning.

Heterogeneous Process: Effect of Intra Pellet and Mass Transfer on reaction rate, effect of heat transfer on rate of reaction. Gaseous diffusion in single cylindrical pore, Different modes of diffusion, Diffusion in Liquids, Diffusion in Porous Catalyst, Concepts of effective thermal conductivity and effective diffusivity, Effectiveness factors. Mechanism and kinetics of heterogeneous reactions.

Reactors: Fixed Bed Catalytic Reactor, Single and multibed adiabatic reactors, Multitubular fixed bed reactor, Monolith reactors.

Books Recommended

1. *Levenspiel O, "Chemical Reaction Engineering", 3rd Ed , John Wiley & Sons, Singapore (1999).*
2. *Fogler H Scott, "Elements of Chemical Reaction Engineering", 3rd ed, Prentice Hall Inc. (1999).*
3. *Smith J M , "Chemical Engineering Kinetics" , McGraw Hill , 3rd ed. (1981).*
4. *Hill, C G, "Chemical Engineering Kinetics and Reactor Design", John Wiley (1977).*
5. *Coulson J M and Richardson J F, "Chemical Engineering Volume 3", Pergamon Press (1999).*

CHX-508 Selected Experiments in Chemical Engineering (0 0 3 2)

1. To determine the mass transfer coefficient in a Packed Liquid Liquid Extraction Column.
2. To generate the VLE data for a binary mixture.
3. Determination of molecular weight of the given polymer sample.
4. Determination of specific cake resistance in a constant pressure vacuum filtration.
5. Regime Transition and Pressure drop studies in a Trickle bed reactor.
6. Studies on Residence Time Distribution in a packed bed reactor.
7. Dispersion studies using RTD data in a Multiphase Reactor.
8. To determine the smoke and flash point of a given diesel sample.

CHX-510 Process Modeling and Simulation Laboratory [0 0 3 2]

1. Introduction to CHEMCAD Software.
2. Simulation studies of various unit operations using CHEMCAD.
3. Modeling and Simulation of Isothermal CSTR.
4. Modeling and Simulation of non-isothermal CSTR.
5. Modeling and Simulation of isothermal batch reactor.
6. Modeling and Simulation of non-isothermal batch reactor.
7. Modeling and Simulation of distillation column.
8. Modeling and Simulation of heat exchanger.
9. Modeling and Simulation of cyclone separator
10. Modeling and Simulation of CSTRs in series.

Electives

CHX-551 Petrochemical Technology [3 0 0 3]

Petrochemicals: An overview. Growth of Global and Indian petrochemical industry. Petrochemical feed stock, Resources and generation of of different feedstocks-their purification, separation of individual components by adsorption, low temperature fractionation and crystallization.

Technologies for the manufacture of Bulk organic Chemicals: Steam Reforming, Syn gas manufacture, Steam Cracking, Olefin Separation, Separation of ethyl benzene, benzene, toluene, xylene.

Aromatic conversion process: Xylene Isomerisation.

Manufacture of the major downstream products and their uses, properties: Methanol, Formaldehyde, Ethylene oxide, Ethylene glycol, Etheylene amines from ethylene,acrylonitrile frm acetylene, Isopropanol, Acrylic acid, dutadiene by dehydrogenation of butane, Poly-vinyl chloride, Vinyl acetate monomer, LDPE and HDPE, Polymerization and their types, Polystyrene, Polybutadiene, Phenol formaldehyde resin, Styrene, Cumene, Isomerisation of o-xylene and m-xylene into p-xylene, Propylene oxide, Phthalic anhydride,Iso Phthalic acid, Iso-Propyl Alcohol, Butadiene, isobutylene, Acetic acid, Maleic anhydride, Nylon 6, Nylon 66, Polyethylene terepthalate, Formaldehyde resins, Styrene Butadiene Rubber, Alkyl Benzene Sulfonate, 1,4 Butanediol.

Synthetic Detergents: classification of detergents, production of Keryl benzene sulphonate etc, hard and soft detergents.

Books Recommended

1. *Chauvel A Lefebvre G, "Petrochemical Process Vol. I & II", Gulf Publishing Company (1989).*
2. *Rao G, Sitting "Dryden's Outline of Chemical Technology".*
3. *.Maiti Sukumar, "Introduction to Petrochemicals",Oxford & IBH Publishing Co. (1992).*
4. *Hatch L F, Matar S, "From Hydrocarbons to Petrochemicals," Gulf Publishing Company (1981)*
5. *Lee S, "Methane and its Derivaties", Marcel Dekker (1997).*

CHX-552 Energy Management and Audit [3 0 0 3]

Energy Scenario: Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, , Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features. Kyoto Protocol. Global warming.

Energy Management & Audit: Definition, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

Energy Action Planning: Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification, Organizing - location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager, Accountability. Motivating-motivation of employees: Information system designing barriers, Strategies; Marketing and communicating-training and planning.

Financial Management: Investment-need, Appraisal and criteria, Financial analysis techniques-Simple pay back period, Return on investment, Net present value, Internal rate of return, Cash

flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs.

Project Management: Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification.

Energy Monitoring and Targeting: Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Techniques -energy consumption,
Production, Cumulative sum of differences (CUSUM).

Books Recommended:

1. *Capehart, Barney L., Wayne C. Turner and William J. Kennedy, "Guide to Energy Management" , Third Edition, Fairmont Press, Atlanta, GA, 2000;*
2. *Albert Thumann and D. Paul Mehta "Handbook of Energy Engineering", by. 4th ed. Lilburn, GA: Fairmont Press; 1997*
3. *Loftness, Robert L. "Energy Handbook." 2d ed. New York: Van Nostrand Reinhold Co., 1984.*
4. *Turner W. "Energy Management Handbook", Ed., John Wiley &. Sons, New York, 1982*
5. *Lapedes, DN " Encyclopedia of Energy", McGraw-Hill, New York, (1976)*

CHX-553 Introduction to Multiphase Flow [3 0 0 3]

Flow past immersed bodies: Drag and drag coefficients, flow through beds of solids, motion of particles through fluids, fluidization, types of fluidization and applications.

Two-phase flow: Two–phase flow through pipes. Lockhart-Martinelli parameters and their application in analysis of two-phase flows.

Interaction of fluids: Mixing of a single fluid; degree of segregation, early and late mixing of fluids, models for partial segregation, mixing of two miscible fluids. Gas-liquid flow phenomenon, Types of regimes formation – trickle, pulse, bubble, dispersed bubble, spray regime etc.

Types of Multiphase-Reactors: Various types of multiphase reactors. eg. Packed bed, packed-bubble column, trickle bed reactor, three phase fluidized bed reactor, slurry bubble column, stirred tank reactor. Characteristics of above mentioned reactors such as; fluid flow phenomena and flow regimes, flow charts/ correlations, pressure drop, liquid hold up etc. Reactors involving Newtonian and non-Newtonian fluids.

RTD in Multiphase Flow systems: Non Ideal Flow: Residence time distribution of fluid in vessel, E, F & C Curve, Mean and variance, the Dirac delta function, residence time, linear and non-linear processes, models for non ideal flow, dispersion model, N tanks in series model, model for small deviations from plug flow and long tails, conversion in a reactor using RTD data, diagnosing ills of operating multiphase reactors, models for multiphase reactors. Two parameter model; PD model; three parameter models; PE Model.

Books Recommended

1 *Levenspiel O, "Chemical Reaction Engineering", 3rd Ed , John Wiley & Sons, Singapore (1999).*
2 *Fogler H Scott, "Elements of Chemical Reaction Engineering", 3rd ed, Prentice Hall Inc. (1999).*
3 *Shah Y.T., "Gas-Liquid-Solid Reactor Design", McGraw Hill Int. New York, 1979.*
4 *Westerterp K.R., van Swaaij W.P.M., and Beenackers A.A.C.M., "Chemical Reactor Design and Operation", John Wiley & Sons, 1993.*
5 *Doraiswamy L.K., and Sharma M.M., "Heterogeneous Reactions: Volume 2 Fluid-Fluid-Solid Reaction", John Wiley & Sons, 1984, Singapore*

CHX-554 Natural Gas Engineering [3 0 0 3]

Introduction: Gas from condensate and oilfields. Scope of Natural gas industry. Basic thermodynamic and system energy concepts in Natural Gas Engineering.
Review of physical and chemical properties of natural gas and associate hydrocarbons. Phase behaviour studies of two phase hydrocarbon systems, equations of states, multiple flashes. Water-hydrocarbon system. Vapour liquid equilibria.
Flow of fluids. Compression calculations. Heat Transfer and Mass Transfer principles and applications in Natural Gas Engineering.
Gas flow measurement. Process control and instrumentation in natural gas processing plants.
Natural Gas Processing. Field separation and oil absorption process. Refrigeration and low temperature processing. Liquification process. Dehydration of Natural Gas sweetening of Natural gas and sulphur recovery, Processing for LPG, LNG, CNG system.
Transmission of Natural Gas. Specifications. Utilization of Natural Gas. Underground storage and conservation of Natural Gas.
Unconventional Gas: Coal Bed Methane, Natural Gas Hydrate.
Conversion of gas to liquid.
Economic consideration for development of gas fields.

Books Recommended

1 *Kumar S, "Gas Production Engineering", Gulf Publishing Co. (1987)*
2 *Beggs H D, "Gas Production Operations", OGCI Publication (1984).*
3. *Ikoku C K, "Natural Gas Engineering" – John Wiley (1984).*
4. *Alexandre R, "Natural Gas : Production, Processing and Transport" – Hyperion Books (1995).*
5. *Donald L Katz, "Hand Book of Natural Gas Engineering" Mc Graw Hill*

CHX-555 Energy Efficiencies in Thermal Utilities [3 0 0 3]

Introduction: Fuels, Properties of Fuel oil, Coal and Gas, Storage, handling andpreparation of fuels, Principles of Combustion, Combustion of Oil, Coal, and Gas
Boilers: Types, Combustion in boilers, Performances evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities.
Steam System: Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings.
Furnaces: Classification, General fuel economy measures in furnaces, distribution, Temperature control, Draft control, Waste heat recovery.
Insulation and Refractories: Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory-types, selection and application of refractories, Heat loss.
FBC boilers: Introduction, Mechanism of fluidised bed combustion, Advantages, Types of FBC boilers, Operational features, Retrofitting FBC system to conventional boilers, Saving potential.
Cogeneration: Definition, Need, Application, Advantages, Classification, Saving potentials
Waste Heat Recovery: Classification, Advantages and applications, Commercially viable waste heat recovery devices, Saving potential.

Books Recommended:

1 *A.K.Shaha, Combustion Engineering and Fuel Technology, Oxford & IBH Publishing Company.*
2 *James J.Jackson ,Steam Boiler Operation, Prentice-Hall Inc, New Jersey, 1980.*
3 *Fuel Economy in furnaces and Waste heat recovery-PCRA*

4 *D N Nandi,Handbook on Refractories , Tata McGraw-Hill Publishing Company*
5 *Limited, New Delhi.*
6 *Douglas M.Considine Energy Technology Handbook, McGraw Hill Inc, New York, 1977.*
7 *George Polimeros,Energy Cogeneration handbook Criteria for Central Plant Desing Industrial Press Inc, N.Y.*
8 *D.A.Reay, E & F.N.Span, Heat Recovery Systems London, 1979.*

CHX- 556 Advanced Process Control [3 0 0 3]

Review of process control. Concept of stability, Stability Criteria, Routh test for stability
Introduction to frequency response, block diagrams, transient response frequency response and other methods of approach.
Control System Design by frequency response: Bode stability criteria, Gain and phase Margin, Ziegler Nichols Controller settings,
Advance Control Strategies: Cascade control, Feed forward control, Ratio control, Dead time compensation
Mathematical analysis of automatic process control. Analysis and synthesis of linear and non-linear feed back control systems. Introduction to computer aided control. Digital simulation and computation of control systems. Computer solutions to optimum control and control problems.

Books Recommended

1. *Coughanower D R, "Process System Analysis and Control", McGraw Hill, 2nd ed. (1991)*
2. *Seborg, Edgar, and Mellichamp, "Process Dynamics & Control", John Wiley 2nd. Ed. (2004)*
3. *Harriot, " Process Control", Tata Mcgraw Hill (2000)*
4. *Stephanopoulos," Chemical Process Control - An Introduction To Theory & Practice", Ist Ed., Prentice Hall of India Private Limited (2003).*
5. *Luyben W L, "Essentials Of Process Control" McGraw Hill (1997).*

CHX-557 Advanced Heat Transfer and Fluid Dyamics [3 0 0 3]

Heat Transfer

Application of dimensional analysis to convection problems Heat Transfer in laminar turbulent and flow in closed conduits. Natural Convection heat transfer. Analogies between momentum heat and mass transfer. Heat transfer in packed fluidized beds.
Condensing heat transfer co-efficients. Condensation of mixed vapours in presence of non-condensible cases. Boiling liquid heat transfer.

Fluid Dynamics
Dimensional Analysis: Buckingham Pi-theorem, Rayleigh method, Geometric Kinematic and dynamic similarity, scale up numerical problems on pumps, drag force, and agitation.

Differential Equation of fluid flow: Continuity equation for one dimensional and three dimensional flow. Derivation of momentum equation (Navier-Stoke's equation) for three dimensional flow.

Laminar flow of viscous fluids: Effects of viscosity on flow, pressure gradient in steady uniform flow, Poseuille equation and friction factor, Reynolds number, velocity profiles in isothermal flow in circular tube and annuli and friction factor relations. Flow in infinite parallel plates and shear stress.

Turbulent flow of viscous fluids: Prandtl mixing length theory, Reynolds equation for in compressible turbulent flow. Reynolds stresses, Statistical theory of turbulence Measurement of turbulence, Hot wire anemometer and its use in turbulence parameters.

Turbulent flow in closed conditions: Logarithmic and universal velocity distribution for turbulent flow in smooth tubes. Friction factor for rough and smooth tubes.

Book Recommended

1. *Holman J P, "Heat Transfer", McGraw Hill Book Co. (1992).*
2. *Incropera F P and DeWitt D P, "Introduction to Heat Transfer," 2nd Ed John Wiley New York (1996).*
3. *Knudsen, &Katz "Fluid Dynamics and Heat Trasnfer" McGrawHill Book Co.(1974)*
4. *McCabe, Smith & Harriat, "Unit Operations of Chemical Engineering"McGraw HillBook Co. (1993)*
5. *Gupta,Santhosh K, "Momentum Transfer Operative" Tata McGraw Hill.*

CHX-558 Rubber and Plastic Technology [3 0 0 3]

Rubber & elastomers, natual & synthetic chlorinated, oxygenated, cycle rubber, Runa S. Buna N, Butyl rubber, neoprene, thiokols, polyisoprene rubber, polyurethane, Fillers, accelerators, activators, antioxidants & other additives, mastication & compounding, vulcanization theory & technology, Latex testing, formulation, fabrication, rubbers of commercial importance.
Introduction to Plastics, Polythene, LDPE, Poly Propylene, Copolymers of ethylene, polystyreme, acrylic plastics, Polyvinyl acetate, PVC, Polytetrafluoro ethylene (PTFE), Polymidesm, Polyesters, Polyurethanes, Polycarbonates, cellulose plastics, phenolic resins, Plastic material processing technology; mouldings, extrusion, injection, blow & compression moulding, vaccum forming, compounding, designing with plastics, plastics of commercial importance.

Books Recommended

1. Polymer Science & Technology of Plastics Rubber by P. Ghosh
2. Text book of polymer science by f.w.Billmeyer.
3. Polymer Science by V.R. Gowariker, N.V. Viswanathan & J. Sreedharan.
4. Introduction to Polymer chemistry by R.B. Seymour.
5. P.J. Flory, Inter Science, Principles of Polymer Chemistry, Cornell University Press 1953.
6. Text book of Polymer Science &Engg. By Anil Kumar & S. Gupta

CHX-559 Polymer Technology [3 0 0 3]

Introduction: Concepts and classification of polymers, Functionality , Glass transition temperature, Addition, condensation , step- growth and chain –growth polymerization
Molecular weight estimation: Average molecular weight – Number and weight average, Sedimentation and viscosity average molecular weights, Molecular weight and degree of polymerization, Significance of molecular weight.
Polymerization Processes: Bulk , solution, emulsion and suspension polymerization, Comparison of polymerization processes.

Polymerization Kinetics: Chemistry of step reaction polymerization, Mechanism and kinetics of polycondensation reactions and free- radical chain polymerization.
Synthetic Fibres: Types of Fibres, Spinning Techniques, Manufacturing Technology and Applications of different types of fibres: cellulosic fibres, polyamides, acrylics, vinyls and vinylidines, fluorocarbons.
Plastics: Manufacturing Technology and applications of different types of plastics: Polyester, polyethylene, Phenolics**,**
Rubbers: Structure, properties and preparation natural rubber , synthetic rubbers: SBR, rubber compounding and reclaiming.

Books Recommended

1. *Gowariker V R , Viswanathan N V and Sreedhar J "Polymer Science" New Age International Publishers (1996)*
2. *Billmeyer F W "Text Book of Polymer Science" Wiley Tappers (1994)*
3. *Ghosh P, "Polymer Science and Technology of plastics and rubber" Tata McGraw Hill (2001).*
4. *Gupta R K and Anil Kumar, " Fundamentals of Polymer Engineering", 2nd Ed., Marcel Dekkar (2003)*
5. *Fried J R "Polymer Science and Technology" PHI*

CHX-560 Process Plant Design [3 0 0 3]

Introduction to principles involved in the design and construction of plant, plant layout, auxiliaries, offsite facilities. Introduction to Indian standards for storage tanks and their use to design cylindrical and spherical vessels under internal pressure, fixed roof and open roof tanks. Mechanical design of tall vessels for distillation and absorption columns. Design of supports for vertical and horizontal vessels. Classification of shell and tube heat exchanger, material of construction, cleaning of heat exchangers, heat transfer fluid, agitated vessels, description of shell, tubes, bonnet and channel, pass partition plate, nozzle, baffles, tie rods, baffle spacers, flanges, gaskets and expansion joints. Process design of double pipe and shell and tube heat exchangers. Types of mass transfer equipments, packed and tray type towers. Tray Hydraulics: Bubble cap columns, perforated plate columns and packed towers Process design of tray and packed towers. Design of other process equipments.

Books Recommended

1. *Bhattacharya B C, "Chemical Equipment Design", CBS Publisher (1985).*
2. *Kern D Q, "Process Heat Transfer", McGraw Hill (2001)*
3. *Perry's, "Handbook of Chemical Engineering" McGraw Hill, 7th Ed (1997).*
4. *Ludwig E E, "Applied Process Design for Chemical and Petrochemical Plants (Vol. 1,2 and 3)", 3rd Ed., Gulf Publishing Company, Houston (1995)*
5. *Ulrich, G D, "A Guide to Chemical Engineering Process Design and Economics", John Wiley (1984).*

CHX-561 Industrial Rheology [3 0 0 3]

Introduction: Introduction to non Newtonian fluids, time independent fluid behavior, power law model, ellis fluid model, introduction to viscoplastic fluids, Bingham plastic model, Herschel bulkley model, casson fluid model, dilatent fluid behaviour, time dependent fluid behavior (thixotropy and rheopexy), visco elastic fluids, dimensional considerations.
Rheometry: Introduction and working of Capillary viscometers, rotational viscometers, stress rheomters.

Flow in pipes and in conduits of non circular cross section: Fluid flow in laminar flow in circular tubes, power law fluids, bingham plastic, yield pseudo plastic fluids, etc., generalized Reynolds no for time independent fluids, laminar flow in two infinite parallel plates, laminar flow in concentric annulus.

Heat Transfer Characteristics of non Newtonian fluids in pipes: Laminar flow in circular tubes, full developed heat transfer to power law fluids in laminar flow.

Momentum heat and Mass transfer in boundary layers

Liquid mixing: liquid mixing, scale up of stirred vessels, power consumptions in stirred vessels.

Books Recommended

1. *Chabra and Richardson, Non Newtonian fluids in Process Industries, Butterworth, Melbourne, (1999)*
2. *Bird, Stewart W E and Light fort, "Transport Phenomena", John Wiley and Sons (2002).*
3. *Welty J R , Wilson R E and Wicks C E , "Fundamentals of Momentum , Heat and Mass Transfer",4th ed, John Wiley and Sons (2001).*
4. *Tanners R I, "Rheology: An Historical perspective", Elsevier, Amsterdam (1998).*
5. *Skelland, A H P, Non Newtonian flow and heat transfer, Wiley, New York (1967)*

CHX-562 Membrane Separation processes [3 0 0 3]

Introduction: introduction to membrane and membrane process, historical developments in membranes, Commercial membrane separation processes, new membrane separation process under development

Membrane Transport Theory: introduction, solution diffusion model, three parameter models, pore flow membranes, concentration polarization.

Membranes and Modules: Isotropic and Anisotropic membranes, liquid membrane, metal and ceramic membrane, hollow fibre, spiral wound, plate and frame, and tubular modules.

Reverse Osmosis: Introduction and definition, theory and design, different membrane modules, selected applications and economics.

Ultra filtration: Introduction and definition, theory and design, membrane module and process configuration, applications and economics.

Micro filtration: Introduction and definition, theory of cross flow filtration, dead end micro filtration, applications and economics.

Emulsion liquid membranes: Introduction and definition, theory and design,
selected applications and economics

Dialysis, Electodialysis, Pervaporation, Gas permeation: brief introduction and applications.

Books Recommended

1. *Wilson & Sirkar, Membrane Handbook, Mc grawhill, London, (2001).*
2. *Nune and Peinemann, Membrane Technology in chemical industries, Wiley, New York, (2000).*
3. *Cheryan Munir, Ultra filtration Handbook, Technomic, New York, (1985)*
4. *Noble and Stern, Membrane separation and technology, principles and applications, Elsevier, (1995)*
5. *Baker R W, Membrane technology and applications, Wiley, New York, (2000).*

CHX-563 Fertilizer Technology [3 0 0 3]

Elements required for plants growth, Classification of fertilizers, Compound, Complex & bulk blended fertilizers. N-P-K values & calculations.

Nitrogenous Fertilizers: Manufacturing Processes for Ammonia, Effects of various factors on the process. Manufacture of ammonium sulphate, ammonium chloride, Ammonium phosphate, Ammonium nitrate, nitric acid, Urea etc.Economics & other strategies, Material of construction & corrosion problem.

Phosphatic fertilizers: Calculation of percentage tricalcium phosphate of lime in phosphatic rock. Manufacture of triple super phosphate & single super phosphate, Nitrophosphate, Sodium phosphate, phosphoric acid & other phosphatic fertilizers.

Potash Fertilizers: Manufacture of potash fertilizers like potassium sulphate, potassium chloride etc.

Books Recommended

1. *Dryden C E, "Outlines of Chemical Technology", East –West Press Pvt. Ltd., New Delhi, 2nd Edition (1973)*
2. *Austin G T, "Shreve's Chemical Process Industries", McGraw Hill Book Company, New Delhi 5th Edition (1986)*
3. *Chemical Engineering Education Development Centre– "Chemical Technology I, II, III , IV , Manual of Chemical Technology, Indian Institute of Technology , Madras".*
4. *Shukla S D and Pandey G N, "A text book of Chemical Technology Vol I", Vikas Publishing House Pvt. Ltd., New Delhi*
5. *Shukla S D and Pandey G N, "A text book of Chemical Technology Vol lI", Vikas Publishing House Pvt. Ltd., New Delhi*

CHX-564 Environment Impact Assessment [3 0 0 3]

Environment Impact Assessment (EIA)

Concept of EIA, Origin of EIA, Procedure of EIA, Evaluation Methodology for EIA, Scope Studies, Preparation and Review of Environment Impact Statement (EIS)

Life Cycle Assessment (LCA)

Introduction of LCA, Importance of LCA, Environmental Parameters in LCA, Documentation in LCA

Waste Minimization

Introduction, Types of Waste, Benefits of Waste Minimization, Elements of Waste Minimization Programme, Integrated System for Waste Management, Case Studies

Environmental Audit (EA)

Concept of EA, Necessity and Importance of EA, Audit Items, Audit Procedures

Environmental Management System (EMS)

Introduction, Terminology and Certification, Environmental Standards, the International Standard Organization (ISO), the ISO 9000 and the ISO 14000 Family of Standards, Guides and Technical Reports, ISO 14001 Certification as a Tool for Sustainable Development

Case Studies

Discussion and analysis of various Case studies of environmental engineering projects

Books Recommended:

1. *Anjaneyulu Y., "Environment Impact Assessment Methodologies", B S Publications (2002).*
2. *Canter L. W., Environment Impact Assessment", McGraw Hill, Second Edition (2005).*
3. *Garg S. K., Garg R. and Garg R., "Ecological and Environmental Studies", Khanna Publishers, First Edition (2006).*

4. *Santra S. C., "Environmental Science", New Central Book Agency (P) Ltd., Second Edition (2006).*
5. *Uberoi N. K., "Environmental Management", Excel Books, Second Edition (2006).*

CHX- 565 New and Renewable Energy Sources [3 0 0 3]

Introduction: Global and Indian scenario, sources, Energy conservation, types of NCES with applications

Solar Energy: Role and development of new renewable energy sources, instruments for measuring solar radiations, solar radiation data, Flat plat and concentrating collectors, classification of concentrating collectors, advanced collectors, different methods of solar energy storage, solar ponds, solar applications: Solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion.

Geothermal Energy: Resources, types of wells, methods of harnessing the energy

Wind Energy: Sources and potentials, horizontal and vertical axis, wind mills, wind regime analysis and evaluation of wind mills.

Biomass and Biofuels: Recycling of agricultural waste, anaerobic/aerobic digestion, and types of biogas digesters, gas yield, and combustion characteristics of bio gas, design of biogas system for heating, lighting and running IC engines. Introduction to Biofuels such as biodiesel, ethanol, biobutanol etc. and their production and present status.

Ocean Energy: OTEC, settling of OTEC plants, thermodynamic cycles

Tidal Energy: Potential and conversion technique, mini hydel power plants and their economics

Books Recommended

1. *Rai G D, "Non-conventional energy sources"*
2. *Kumar Ramesh and Narosa, "Renewable Energy Technologies"*
3. *Ashok V Desai, "Non-convetional energy", Wiley Eastern*
4. *Sukahme, "Solar energy"*
5. *K. Mittal and Wheeler, "Non-conventional energy system"*

CHX-566 Nanomaterials, Nanoscience & Nanotechnology [3 0 0 3]

Introduction: Terminologies, History & Scope

Characterization &Fabrication: Contemporary Characterization Methods, Top down & Bottom up Fabrication, Solution based Synthesis of Nanoparticles, Vpour Phase Synthesis & Synthesis with framework, Nanolithography, Dip Pen Lithography.

Artificially Layered Materials: Quantum Well, Quantum Dots, Super lattices & Layered Structures.

Self Assembly: Supramolecular & Dimension Control in Nanostructure, thermodynamic and coded self assembly.

Biomaterial: DNA & Nanomaterials. Bionanocomposites, Biometrics, Molecular Motors.

Nanoelectronics and Molecular Computing: Molecular wires, Nanowires, Nanotubes, Molecular switch, Molecular logic gates and molecular storage devices, DNA Computing Quantum Computing.

Books Recommended

1. *Poole, C. P. and Owens F. J., Introduction to Nanotechnology, Wiley, 2003.*
2. *Understanding Nanotechnoogy, Scientific American, 2002*
3. *Ratner M & Ratne D, Nanotechnology, Prentice Hall, 2003*
4. *Wilson, Kannagara, Smith, Simmons & Raguse, Nanotechnology, CRC Press Boca Raton, 2002.*
5. *Foster Lynn, Nanotechnology: Sceince innovation and opportunity, Prentice Hall, 2005.*

CHX-567 Heat Exchanger Design [3 0 0 3]

Basic design methods for heat exchanger- Design of shell and tube type heat exchanger, TEMA code. Plate type heat exchanger, compact heat exchanger, Codes of mechanical design of heat exchanger.Computerized methods for design and analysis of heat exchanger. Performance enhancement of heat exchanger, fouling of heat exchanger, Testing, evalution and maintenance of heat exchanger. Power plant heat exchanger, heat exchanger for recovery at low, medium and high pipe exchanger. Regenerators, Principles of boiler design, recuperators, matrix heat exchanger and heat pipe exchanger.
Methodology for thermal design of heat exchangers. Rating and sizing problems. Pressure drop calculations. Furnaces, Radiative heat exchangers. Optimization of heat exchangers; modeling and commercial codes. Recent developments in heat exchangers.

Books Recommended

1. *Heat Transfer by F. Incropera and D. De Witt or other basic undergraduate heat transfer textbook.*
2. *Compact Heat Exchangers by W. Kays and A. London, National Press.*
3. *Compact Heat Exchangers by R. Shah, A. Kraus, D. Metzger, Hemsisphere Publishing Corporation.*
4. *Heat Exchanger Design By Fraas, Arthur P. Fraas, M Necati Özisik, Wiley-IEEE.*
5. *Heat exchanger, Design, rating and Selection, Sadik Kakac, CRC Press*
6. *Heat Exchangers Thermal Hydraulic Fundamentals and Design by S. Kakac, A. , Bergles, F. Mayinger, McGraw-Hill Book Company. Automotive Heating and Air Conditioning by Tom Birch, Prentice*

CHX –568 Leather Fashion Design Technology [3 0 0 3]

Leather Manufacture: Introduction to the manufacture of leather from different hides and skins. Chemistry and Mechanisms of various Pre-tanning, Tanning and Post tanning and Finishing processes.
Tannages: Principles involved in Inorganic and Organic tanning.
Leather Auxiliaries: Introduction to the Auxiliaries used during Leather processing.
Leather Machinery: Study of various types of Leather, Footwear, Garment and Leather Goods Machinery.
Footwear: Anatomy of Human Foot, Foot Comfort and Foot care, Footwear Materials, Footwear Manufacture, Final Inspection and Packages.
Leather Garments and Goods: Classification of Leather Garments and Goods, Material Selection, Designing and Styling, Pattern Production.
CAD of Leather Products: Introduction to general CAD, Design methods using CAD for leather products. Grading of patterns for footwear and garments, International Fashion Trends, Colour Characteristics,
Decorative Styling Techniques

Books Recommended:

1. *Thornton J H, "Textbook of Footwear Manufacture", Heywood, London, 1964.*
2. *Harvey A J, "Footwear Materials and Process Technology", Lasra Publications, New Zealand.*
3. *"Fashion Drawing Method", ESMOD, Paris, 1992.*
4 *Radhakrishnan P and Kothandaraman C P, "Computer Graphics and Design".*
5. *"American Shoe Making", Shoe Trades Publishing Co. , Cambridge, USA.*

CHX-569 Analytical Principles and instrumental methods of Analysis [3 0 0 3]

Atomic Absorption Spectroscopy: General principles, instrumental set up and analytical procedures and applications.
Flame photometry: Principles of flame photometry, type of instruments, experimental technique, applications.
Thermo-Analytical method: Theory, instrumental requirements and methodology for thermogravimetric analysis (TG), differential thermal analysis (DTA) and differential scanning calorimetry (DSC), applications.
Chromatographic Methods: Classification of chromatographic methods according to separation and development procedure, instrumentation and applications.
Solvent Extraction: Distribution law, techniques for solvent extraction and application.
Turbidimetry: Principles of turbidimetry, instrumental set up and applications.
Polarography and Amperometric Titrations: General principles and instrumental set up and application.
Electrochemical Techniques: Conductometry, pH metry, cyclic voltametry.
Data Analysis: Uncertainties, Errors, calibrations, Mean, Standard Deviation, Least square fit.

Books Recommended:

1. *Instrumental Methods of Analysis, Willard, Merritt, Dean and Settle, CBS Publisher and Distributors., 1986*
2. *Therma Analysis, W W Wendlandt and L W Collins, Dowden Hutechin and Ross.*
3. *Basic Concepts of Analytical Chemistry, S M Khopkar, Wiley Eastern.*
4. *Thermal methods of Analysis, Principles, Application and Problems, J Haines, Blackie Academic and Professional, 1994.*
5. *Chromatographic Methods, A Braithwaite and F J Smith, 5th edn. Blackie Academic and Professional, London, 1996.*
6. *Principles of Instrumental Analysis, Skoog, Holder, Nieman, Fifth edition, Thomson Books, 1998.*

CHX-570 Industrial Safety and Hazard Management [3 0 0 3]

Introduction: Concept of Loss prevention, types of process hazards, acceptable risks, accident and loss statistics, nature of accident process, concepts of inherent safety.
Inherent safer Designs: Concepts of inherent safety in chemical plants, concept of dilution, substitution, moderation and
Toxicology: brief introduction to Dose vs response curve, toxicants entry route, threshold limit values, and regulatory bodies in safety
Fires and Explosion: Fire triangle, definitions, flammability characteristics of liquid and vapors, LOC, models of pool fire and fire ball, confined and unconfined vapor explosions, BLEVE.
Fire prevention: Engineering aspects of fire prevention and control, inerting procedure, static electricity, charge accumulation, static electricity control techniques, , flame arrestors their design, design of sprinkler systems, flare design, fire extinguishment,, Recent advances in fire prevention in control systems.
Hazard Management: Basic components of hazard management, Risk control, Domino effect, Hazard survey, checklist, HAZOP, safety reviews, what if analysis.
Risk Assessment: Reliability theory, event tree, fault tree, QRA, LOPA, Dow's fire and explosion index, Mond index, Dow's Chemical release model.
Security Risk Assessment: Security vulnerability methodology, brief review of important SVA's by ACC, API and USDOJ, Introduction to Security Risk Factor Tables, Case studies.

Books Recommended

1. *Crowl D A, Louvar J F, " Chemical Process Safety Fundamentals with applications", 2nd Prentice Hall, NJ (2002).*

2*. Coulson J M and Richardson J F , "Chemical Engineering",2nd , Vol 6, Pergamon, press (1999).*

3. *Dow Chemical Company, Dow's Chemical Exposure Index Guide, New York, (1993).*

4. *Lees F P, Loss prevention in process Industries, 2nd ed, Butterworth, London, (1996.)*

5*. Wells G L, Safety in process Plant Design, George godwin ltd., New York, (1980)*

6*. Bajpai S and Gupta J. P., Site Security for Chemical Process Industries, Journal of Loss Prevention in Process Industries, 18 (2005), 301-309.*

CHX-571 Petroleum Engineering and Technology [3 0 0 3]

Scope and Purpose of Refining: Global and Indian refining scenario, Petroleum refining industry in India practice and prospects, An overview of the entire spectrum of the refinery products, refinery configuration development, Physio chemical characteristics of Petroleum and Petroleum products.

Refinery Distillation Processes: Desalting and Stabilization of crude, Process description of typical simple distillation, Fractional distillation, crude oil distillation, vaccum distillation etc. Degree of separation (5-95 gap) and degree of difficulty of separation (Δ t 50), Packie charts, ASTM, TBP and EFV Distillation.

Fuel Refining: Cracking, coking, reforming, alkylation, isomerisation polymerization, sweetening, visbreaking. Thermal and Catalytic solvent extraction and adsorption w.r.t refining industry.

Lube Refining: Solvent extraction, dewaxing propane deasphalting.

Wax Refining: Deoiling of crude wax, crystallization, catalytic, sweating microcrystalline and petroleum wax applications.

Hydro processing: Hydro cracking, hydro treating, hydro finishing.

Refinery Feedstock: Nature and effect of different types of refinery feedstock and their impurities on refinery configuration and operation.

Refinery Gas Processing: Process description of typical light ends unit, acid gas removal using gas treating processes. Hydrogen Production and Hydrogen Management in refineries.

Two Phase Oil and Gas Separation equipment: Types, their description, vessel sizing. Theory of separation and separator design.

Three Phase Oil Gas and Water Separators: Types of separators, their description. Various control and vessel internals, theory and sizing of three phase separator. LACT units. Application of thermodynamics of Refining process.

Books Recommended

1. *Nelson W L, "Petroleum Refinery Engineering", Mc Graw Hill Book Co., 1985.*
2. *Watkins R N, "Petroleum Refinery Distillation", Gulf Publishing Co.*
3. *Gary J H and Handework G E, "Petroleum Refining Technology and Economics", Marcel Dekker, Inc., 2001.*
4. *Jones D S J, "Elements of Petroleum Processing", John Willey & Sons, 1995*
5. *Waquier J P, "Petroleum Refining" Vol. I & II Editions, Technip, 1995.*

CHX-572 Computational Fluid Dynamics [3 0 0 3]

CONSERVATION LAWS

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

BASICS OF NUMERICS
Basic aspects of discretization, finite differences, dfference equations, explicit and implicit approaches.
FLOW FIELD COMPUTATION
Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows
GRID GENERATION
Physical aspects, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping.

Books Recommended

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.

CHX-573 Paint Technology [3 0 0 3]

Introduction: History and development of paint industry, paint its definition, function and classification.
Raw Materials: Raw material for industry, drying oils, bodied oils natural and synthetic resins, pigments and extenders.
Paint Auxiliaries: Auxiliaries like driers, plasticsers, softeners, dispersing and flatting agents varnishes and lacquers,
Manufacturing of paints: formulation and manufacturing of paints, machinery used in paint
manufactures, methods of application, applications of industrial and architectural finishes. . Common defects in paint and varnishes.

Books Recommended

1. Payne H F , Organic coating technology Vol. I & II , Wiley, New York, (1954)
2. Morgans H M , Outlines of Paint technology, 3e, CBS, New Delhi, (2001)
3. Joseph Bijos , Good Painting Practices, Wiley, New York, (1967)
4. Bentley and Turner, Introduction to Paint Chemistry and principles of paint technology, fourth Edition, CRC publisher, Austria, (1997)

CHX 600 Project-Phase I [0 0 0 6]

The project work shall be extended into two phases i.e 3rd & 4th semester. In phase-I (3rd semester), the student shall identify his/her supervisor and submit a project proposal to the concern HOD with in 8 weeks in the start of 3rd semester. One presentation of the work shall be made by individual student by the end of 3rd semester. The awards ***of Ist phase evaluation*** shall be retained in the Department.

CHX 600 Project-Phase II [0 0 0 12]

In Project-Phase–II, the student shall continue his/her project work (Phase-I). Before submission of his/her final report, he/she shall deliver a pre-submission seminar in the

Department. The awards of ***1st phase evaluation*** (3rd Sem), pre-submission (4th sem), evaluation of phase –I & II (combine) shall be used cumulatively for final evaluation of the M.Tech project by an external examiner.

Criteria for evaluation of M.Tech project

Ist phase	100
Pre-submision	100
Evalaution of project work	150
Final presentation	150
Total	500