

M. Tech. DEGREE
(Chemical Engineering)



SYLLABUS FOR
CREDIT BASED CURRICULUM

2010 – 2011
onwards

Department of Chemical Engineering
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620 015.

M.TECH. Chemical Engineering

Course Structure and Scheme of Evaluation (Semester – wise)

[The total minimum number of credits = 61]

Course Structure and Scheme of Evaluation (Semester - wise)

Code	Name of the subject	Hours per week			Credits
		L	T	P	
SEMESTER I					
CL 601	Advanced Process Control	2	1	0	3
CL 603	Process Modelling & Simulation	2	1	0	3
CL 605	Bioprocess Engineering	3	0	0	3
CL 607	Chemical Reactor Analysis & Design	2	1	0	3
	Elective – I	3	0	0	3
	Elective – II	3	0	0	3
CL 625	Chemical Engineering Lab	2	0	0	2
	Total Credits in Semester I				20
SEMESTER II					
CL 602	Fluid Particle Technology	3	1	0	4
CL 604	Process Engineering Design	3	1	0	4
CL 606	Advanced Fluid Dynamics & Heat Transfer	2	1	0	3
	Elective – III	3	0	0	3
	Elective - IV	3	0	0	3
	Elective – V	3	0	0	3
	Total Credits in Semester II				20
SEMESTER – 3					
CL 647	PROJECT WORK	12			12
	Total Credits in Semester III				12
SEMESTER – 4					
CL 648	PROJECT WORK	12			12
	Total Credits in Semester IV				12
	Total Credits in the Course				64

Elective I & II:

CL 609	Computational Techniques in Engineering
CL 611	New Separation Techniques
CL 613	Nano Technology
ME 733	Analysis and Design of Pressure Vessels
	Any PG Elective from other Department

Elective III, IV & V

CL 608	Pinch Technology
CL 610	Principles & Practice of Energy Conservation
CL 612	Water and Land Pollution Control Plant Design
CL 614	Pharmaceutical Technology
CL 712	Computational Fluid Dynamics
MT 712	Corrosion Science & Engineering
	Any PG Elective from other Department

List of Reserved Electives:

CL 615	Scale - up Methods
CL 616	Food Processing
CL 617	Risk Analysis & HAZOPS
CL 618	Pollution Prevention Fundamentals
CL 619	Industrial Safety And Management
CL 620	Air Pollution Control Equipment Design
CL 621	Optimization Techniques
CL 622	Bio-energy Engineering
CL 623	Polymer Dynamics

CL 601 ADVANCED PROCESS CONTROL

Review of Systems: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Transient response. Block diagrams.

Stability Analysis: Frequency response, design of control system, controller tuning and process identification. Ziegler-Nichols and Cohen-Coon tuning methods, Bode and Nyquist stability criterion. Process identification.

Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, Smith predictor, internal model control.

Multivariable Control Analysis: Introduction to state-space methods, , Control degrees of freedom analysis and analysis, Interaction, Bristol arrays, Niederlinski index - design of controllers, Tuning of multivariable controllers.

Sample Data Controllers: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers. Introduction to PLC and DCS.

TEXT BOOKS:

1. D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.
2. D.E. Seborg, T.F. Edgar, and D.A. Millichamp, 'Process Dynamics and Control', John Wiley and Sons, 2nd Edition, 2004.

REFERENCES:

1. B.A.Ogunnaike and W.H.Ray, "Process Dynamics, Modelling and Control", Oxford Press, 1994.
2. W.L.Luyben, 'Process Modelling Simulation and Control for Chemical Engineers', McGraw Hill, 2nd Edition, 1990.
3. B.W. Bequette, 'Process Control: Modeling, Design and Simulation', PHI, 2006.
4. S. Bhanot, 'Process Control: Principles and Applications', Oxford University Press, 2008.

CL 603 PROCESS MODELLING AND SIMULATION

Introduction to modelling, a systematic approach to model building, classification of models. Conservation principles, thermodynamic principles of process systems.

Development of steady state and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems.

Development of grey box models. Empirical model building. Statistical model calibration and validation. Population balance models. Examples.

Solution strategies for lumped parameter models. Stiff differential equations. Solution methods for initial value and boundary value problems. Euler's method. R-K method, shooting method, finite difference methods. Solving the problems using *MATLAB/SCILAB*.

Solution strategies for distributed parameter models. Solving parabolic, elliptic and hyperbolic partial differential equations. Finite element and finite volume methods.

TEXT BOOKS:

1. K. M. Hangos and I. T. Cameron, "Process Modelling and Model Analysis", Academic Press, 2001.
2. W.L. Luyben, "Process Modelling, Simulation and Control for Chemical Engineers", 2nd Edn., McGraw Hill Book Co., New York, 1990.
3. W. F. Ramirez, "Computational Methods for Process Simulation", 2nd ed., Butterworths, 1997.

REFERENCES:

1. Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons, 1984.
2. Singiresu S. Rao, "Applied Numerical Methods for Engineers and Scientists" Prentice Hall, Upper Saddle River, NJ, 2001

CL 605 BIOPROCESS ENGINEERING

Introduction: Fermentation processes general requirements of fermentation processes - An overview of aerobic and anaerobic fermentation processes and their application in industry - Medium requirements for fermentation processes - examples of simple and complex media Design and usage of commercial media for industrial fermentation. Sterilization: Thermal death kinetics of micro-organisms - Batch and Continuous Heat-Sterilization of liquid Media - Filter Sterilization of Liquid Media and Air.

Enzyme technology, Enzymes: Classification and properties -Applied enzyme catalysis - Kinetics of enzyme catalytic reactions - Microbial metabolism - Metabolic pathways - Protein synthesis in cells.

Stoichiometry and Kinetics of substrate utilization and Biomass and product formation: Stoichiometry of microbial growth, Substrate utilization and product formation-Batch and Continuous culture, Fed batch culture Recovery and purification of products.

Bioreactor and product recovery operations: Operating considerations for bioreactors for suspension and immobilized cultures, Selection, scale-up, operation of bioreactors - Mass transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes; oxygen uptake rates and determination of oxygen transfer rates and coefficients; role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems.

Introduction to Instrumentation and Process Control in Bioprocesses: Measurement of physical and chemical parameters in bioreactors - Monitoring and control of dissolved oxygen, pH, impeller speed and temperature in a stirred tank fermenter.

TEXT BOOKS:

1. M.L. Shuler and F. Kargi, "Bio-process engineering", 2nd Edition, Prentice Hall of India, New Delhi. 2002.
2. J. E. Bailey and D.F. Ollis, "Biochemical Engineering Fundamentals", 2nd Ed., McGraw-Hill Publishing Co. New York. 1986.

REFERENCE:

1. P. Stanbury, A. Whitakar and S. J. Hall, "Principles of Fermentation Technology" 2nd Ed., Elsevier-Pergamon Press, 1999.

CL 607 CHEMICAL REACTOR ANALYSIS AND DESIGN

Analysis of Noncatalytic fluid solid reaction: Kinetics of non-catalytic fluid-particle reactions, various models, application to design.

Catalyst preparation and characterization: Catalysis - Nature of catalyses, methods of evaluation of catalysis, factors affecting the choice of catalysts, promoters, inhibitors, and supports, catalyst specifications, preparation and characterization of catalysts, surface area measurement by BET method, pore size distribution, catalyst, poison, mechanism and kinetics of catalyst, deactivation.

Physical adsorption and chemical adsorption: Fluid-fluid reactions different regimes, identification reaction regime, application to design. Physical absorption with chemical reaction, simultaneous absorption of two reacting cases consecutive reversible reactions between gas and liquid, irreversible reactions, estimation of effective interfacial area in absorption equipment.

Reaction kinetics, accounting porous nature of catalyst: Heterogeneous catalytic reactions - effectiveness factor, internal and external transport processes, non-isothermal reacting systems, uniqueness and multiplicity of steady states, stability analysis.

Modeling of chemical reactors: Modeling of multiphase reactors - Fixed, fluidized, trickle bed, and slurry reactors.

TEXT BOOKS:

1. G.F. Froment, K.B. Bischoff, "Chemical Reactor Analysis and Design", 2nd ed., John Wiley, New York, 1990.
2. O. Levenspiel, "Chemical Reaction Engineering", 3rd edition, Wiley Singapore, 2000.

REFERENCES:

1. J.J. Carberry "Chemical and Catalytic Reaction Engineering", McGraw Hill, New York, 1976.
2. R. Aris, "Elementary Chemical Reactor Analysis", Prentice Hall, 1969.

CL 602 FLUID PARTICLE TECHNOLOGY

Applications of fluidized beds: Introduction, Industrial application of fluidized beds, Physical operations and reactions.

Fluidization and analysis of different phases: Gross behavior of fluidized beds. Bubbles in dense beds. The emulsion phase in dense bubbling beds. Flow pattern of gas through fluidized beds.

Heat and Mass transfer in fluidized bed systems: Mass and heat transfer between fluid and solid. Gas conversion in bubbling beds. Heat transfer between fluidized bed and surfaces.

Elutriation and entrainment: TD and also distribution of solid in a fluidized bed. Circulation systems.

Design of fluidized bed systems: design of fluidization columns for physical operations, catalytic and non- catalytic reactions, three phase fluidization.

TEXT BOOK:

1. Diazo Kunji and O. Levenspiel, "Fluidization Engg". 2nd Ed., Butterworth Heinemann, 1991.

REFERENCE:

1. J. F. Davidson and Harrison, "Fluidization", 10th Ed, Academic Press, London, 1994.
2. Jackson, R., "The Dynamics of Fluidized Particles," Cambridge University Press, New York (2000).
3. Fan, L.-S. and C. Zhu, Principles of Gas-Solid Flows, Cambridge University Press, New York (1998).

CL 604 PROCESS ENGINEERING DESIGN

Phase separation equipment design: Design of filter press, Centrifuge, Cyclone (Hydro as well as air) Drier, and Crystallizer.

Design of double heat exchangers, Shell and Tube Heat exchangers, Condensers and Evaporators

Design of storage tank and supports: Design of vertical and horizontal storage tank, Design of Saddle, Skirt, and Lug supports

Design of Reaction vessel, storage tank, Pressure vessel,

Design of mass transfer equipments: Design of distillation column, Absorption tower both plate as well as packed type, cooling tower and extraction columns

TEXT BOOKS:

1. *K.Q.Kern Process Heat transfer, McGraw-Hill, 1965*
2. *Coulson and Richardson Chemical Engineering Vol.VI, Pergamon Press, 1983*
3. *S.B.Thakore and B.I.Bhatt Introduction to Process Engineering and Design, McGraw-Hill, 2009*

REFERENCES:

1. *Perry Chemical Engineer's Hand book by Perry, McGraw-Hill, 2009*
2. *McCabe and Smith Unit operation of Chemical Engineering, McGraw-Hill, 2008*
3. *Christie John Geankopolis Transport process and Separation Process, Fourth Edition, PHI, 2004.*

CL 606 ADVANCED FLUID DYNAMICS & HEAT TRANSFER

Properties of fluids and multiphase flow: Introduction: Fluids and fluid properties, basic equations for flowing streams, flow of incompressible fluids, Newtonian, non-Newtonian and non-viscous fluids, determination of flow properties of fluids, flow in pipes and tanks, flow through packed bed and fluidized beds.

Boundary layer theory and statistical theory of turbulence: Laminar flow in closed conduits, Potential flow, Boundary layer theory, Hydrodynamic stability, Turbulence-Statistical theory, Measurement of turbulence intensity, Turbulent flow in closed conduits, Dimensional analysis in fluid dynamics.

Heat transfer in fluids: Combination of heat transfer resistance, Multidimensional Steady and Unsteady state heat conduction, Unsteady state heating and cooling of solid objects, Convection heat transfer coefficient, Heat transfer during Laminar and Turbulent flow in closed conduits-Empirical correlation for high Prandtl Number of fluids, Dimensional analysis in convection heat transfer

Analogy and recent developments in heat exchangers: Analogy between momentum and heat transfer. Recent developments in the design of compact heat exchangers, insulation-design and selection.

Heat transfer with phase change: Boiling and Condensation heat transfer, Heat transfer in Liquid metals, Flow in shell side of heat exchanger, Vibration analysis of heat exchangers

TEXT BOOKS:

1. *J.G. Knudsen and D.L. Katz, "Fluid Dynamics and Heat Transfer", McGraw Hill, New York, 1958.*

REFERENCES:

1. *Noel de Nevers, "Fluid Mechanics for Chemical Engineers", Second Edition, McGraw-Hill Inc, 1991.*
2. *Kern, D.Q., "Process Heat Transfer", McGraw-Hill - Revised Edition - 1999.*
3. *J.P. Holman, "Heat Transfer", 8th Edition, McGraw Hill, New York, 1997.*

ELECTIVES

CL 609 COMPUTATIONAL TECHNIQUES IN ENGINEERING

Design and analysis of experiments: Treatment and interpretation on engineering data: Curve fitting, Non-linear least square regression. Interpolation: Newton's Forward/Backward interpolation formula, Lagrange's interpolation formula and experiments their application. Tests of significance, Analysis of variance.

Formulation of physical problems: Mathematical statement of the problem, Representation of problems, Formulation on Solute extraction in single & multiple stages, Radial heat transfer through a cylindrical conductor, salt accumulation in stirred tank.

Numerical solution of linear & nonlinear algebraic equations: Linear systems of equations, solutions by Cramer's Rule, Matrix methods, Gaussian, Gauss-Jordan, Jacobean, Gauss-Seidel and Relaxation methods. Non-linear equations: Bisection, Regula-falsi, Secant and Newton-Raphson methods.

Numerical solution of ordinary differential equations: Ordinary differential equations: Runge-Kutta, Euler's and Milne's predictor corrector methods. Solution of boundary value problems.

Finite differences: Finite differences, Partial differential equations, Solutions of elliptic, parabolic, and hyperbolic types of equations.

TEXT BOOKS:

1. S. K. Gupta, "Numerical Techniques for Engineers", Wiley Eastern, 1995.
2. M.K. Jain, S.R.K. Iyengar and R. K. Jain, "Numerical Methods for Scientific and Engineering Computations", 1992.

REFERENCE:

1. H.S. Mickley, T.K. Sherwood and C.E. Reid, "Applied Mathematics in Chemical Engineering", II Edn., Tata McGraw Hill, New Delhi, 1978.

CL 611 NEW SEPARATION TECHNIQUES

General Review: Mechanisms: Separation factors and its dependence on process variables, classification and characterisation, thermodynamic analysis and energy utilization, kinetics and mass transport. Theory of cascades and its application in single and multistage operation for binary and multi component separations.

Membrane Separations: Types and choice of membranes, their merits, commercial, pilot plant polarization of membrane processes and laboratory membrane permeators, dialysis, reverse osmosis, ultra filtration, Concentration and economics of membrane operations, Design controlling factors.

Separation by Sorption Techniques: Types and choice of adsorbents, chromatographic techniques, Types, Retention theory mechanism, Design controlling factors ion exchange chromatography equipment and commercial processes, recent advances and economics.

Ionic Separations: Controlling factors, applications, Theory mechanism and - equipments for electrophoresis, dielectrophoresis and electro dialysis - commercial applications - Design considerations.

Thermal Separation: Thermal diffusion: Basic rate law, phenomenological theories of thermal diffusion for gas and liquid mixtures, Equipments design and applications. Zone melting: Equilibrium diagrams, Controlling factors, Apparatus and applications.

Other Techniques: Adductive crystallization molecular addition compounds, Clathrate compounds and adducts, Equipments, Applications, Economics and commercial processes. Foam Separation: Surface adsorption, Nature of foams, Apparatus, Applications, and Controlling factors.

TEXT BOOKS:

1. H.M. Schoen, "New Chemical Engineering Separation Techniques", Wiley Interscience, New York, 1972.
2. C.J. King, "Separation Processes", Tata McGraw Hill, New Delhi, 1982.
3. B. Sivasankar, "Bioseparations – Principles and Techniques", Prentice Hall of India Pvt. Ltd, New Delhi, 2005.

REFERENCES:

1. R.E. Lacey and S. Loeb, "Industrial Processing with Membranes," Wiley-Inter sciences, New York, 1972.
2. Ronald W. Roussel, Hand book of Separation Process Technology, John Wiley, New York, 1987.
3. H.R.C. Pratt, "Counter-Current Separation Processes," Elsevier, Amsterdam, 1967.

CL 613 NANO TECHNOLOGY

Supramolecular Chemistry: Definition and examples of the main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems. Main supramolecular structures.

Physical Chemistry of Nanomaterials: Students will be exposed to the very basics of nanomaterials; a series of nanomaterials that exhibit unique properties will be introduced.

Methods of Synthesis of Nanomaterials. Equipment and processes needed to fabricate nano devices and structures such as bio-chips, power devices, and opto-electronic structures. Bottom-up (building from molecular level) and top-down (breakdown of microcrystalline materials) approaches.

Biologically-Inspired nanotechnology basic biological concepts and principles that may lead to the development of technologies for nano engineering systems. Coverage will be given to how life has evolved sophisticatedly; molecular nanoscale engineered devices, and discuss how these nanoscale biotechnologies are far more elaborate in their functions than most products made by humans.

Instrumentation for nanoscale characterization. Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range.

TEXT BOOKS:

1. *Supramolecular Chemistry* by Jean-Marie Lehn, Wiley VCH, 1995
2. *Supramolecular Chemistry* by Jonathan Steed & Jerry Atwood, John Wiley & Sons, 2004
3. *Intermolecular and Surface Forces* by Jacob Israelachvili, Academic Press, London, 1992.

CL 608 PINCH TECHNOLOGY

Pinch Location: Locating the pinch, significance of pinch, pinch in grid representation, Threshold problems, capital cost implication of the pinch.

Targeting: Heat exchanger networks, energy targeting, area targeting, unit targeting, shell targeting, cost targeting, super targeting, continuous targeting.

Pinch Methodology: Problem representation, temperature enthalpy diagram, simple match matrix. Heat content diagram, Temperature interval diagram, Heuristic approach & PDM, weighted flow rate specific heat method (WFCPM), Tree searching.

Pinch Design and Optimization: Networks for maximum energy recovery, Pinch design method, Flexibility criteria of the pinch, cp table, the tick of heuristic, case studies, optimization of heat exchanger network optimality for a minimum area network, Sensitivity analysis.

Energy and Resource Analysis of various processes and Mass Exchange Network: Batch process, flexible process, distillation process, evaporation process, reaction process, process using mass separating agent. Heat pipes and Heat pumps, MEN Network, Waste minimization by using mass separating agents.

TEXT BOOKS:

1. V. Uday Shenoy "Heat Exchanger network synthesis" Gulf Publishing Co, USA, 1995
2. D.W. Linnhoff et al., "User Guide on Process Integration for the efficient use of Energy", Institution of Chemical Engineers, U.K., 1994.

REFERENCES:

1. James M. Douglas "Conceptual Design of Chemical Process", McGraw Hill, New York, 1988.
2. Anil Kumar, "Chemical Process Synthesis and Engineering Design", Tata McGraw Hill New Delhi, 1977.

CL 610 PRINCIPLES AND PRACTICE OF ENERGY CONSERVATION

Introduction: General principles of energy conservation. Sectorial energy conservation possibilities, electricity conservation, industrial transportation and residential sectors.

Energy Audit and Energy Cycles: Energy Audit – Characteristic methods employed in certain Energy Intensive Industries – various energy conservation measures - Energy conservation in steam systems – Importance of correct pressure, Temperature, & Quality of steam - Condensate recovery - Co-generation – in-plant power generation systems – co-generation schemes and configuration – Design considerations – Heat rate improvement. Case studies- Gas & steam turbine combined cycle: Simple Gas-Steam combined cycles - Repowering cycles - Combined cycles with PFBC and PFBG systems - Thermodynamic analysis for Optimum design - Advantages of combined cycles

Energy conservation in boilers: Practical applications of energy conservation: steam balances using the steam turbine, returning the condensate to boilers, flashing condensate to lower pressure, Furnace efficiency: effect of flue gas and combustion air temperature, reducing flue gas temperature, steam tracing, Heat recovery.

Energy conservation in pumps including Variable Drives and Variable Frequency Drives, Piping systems, Dryers and evaporators: Pumps, Fans and blowers, Piping systems design for energy efficiency, Multiple effects, gravity feed evaporators, thermo-compression, vapour - recompression systems - Drying: Convective dryers.

Energy Conservation: Case studies Ceramic industry (Glass, porcelain), Cement, Refineries, Iron and steel, Pulp and Paper

TEXT BOOKS:

1. M. Chiogioji, "Industrial Energy Conservation", McGraw Hill, New York, 1979.
2. "Optimizing Energy Efficiency In Industry", G. G. Rajan, Tata McGraw-Hill publishing Co., N. Delhi, 2001

REFERENCES:

1. T.N. Veziroglu "Alternative Energy sources", Vol. V, Elsevier Pub., Amsterdam, 1983.
2. S.D. Huo, " Hand book of Industrial Energy Conservation", Van Nostrand Reinhold Publishers, New York, 1983.

CL 612 WATER AND LAND POLLUTION CONTROL PLANT DESIGN

Water Pollutants, Effects, Monitoring and Quality standards: Pollution of water and soil, effect of pollutants on environment and health, monitoring water pollution, water pollution laws and minimum national standards, monitoring, compliance with standards, Latest norms for effluent treatment.

Water Pollution Sources, Analysis and Methods of control: Water pollution sources and classification of water pollutants - Wastewater sampling and analysis. Treatment of water-pollution: BOD, COD of wastewater and its reduction – Fundamentals of Anaerobic digestion and Aerobic digestion.

Wastewater Treatment Plant Design: Physical unit operations: Screening, Flow equalization, sedimentation etc., Chemical Unit Processes: chemical precipitation, dis-infection, colour removal by adsorption Biological unit processes: Aerobic suspended - growth treatment processes, aerobic attached-growth treatment processes, anaerobic suspended - growth treatment processes, anaerobic attached-growth treatment processes.

Advanced Wastewater and Water Treatment: Carbon adsorption - Ion exchange - Membrane processes - Nutrient (nitrogen and phosphorus) removal - Design of plant for treatment and disposal of sludge

Solids Waste and Landfill Management: Sources and classification - methods of solid waste disposal - Composting (natural) - Accelerated composting with industrial sludge - Landfill technology - Methods adopted for municipal solid waste - Toxic-waste management, Incineration of industrial waste, Design aspects, economics.

TEXT BOOKS:

1. C.S. Rao, "Environmental Pollution Control Engineering", Wiley 2nd Edition, New Age International Publishers, 2006.
2. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, New Delhi, 1985

REFERENCES:

1. P. Sincero and G.A. Sincero, *Environmental Engineering: A Design Approach* Prentice Hall of India pvt Ltd, N.Delhi. 1996
2. Tchbanoglous and F.L. Burton, *Metcalf and Eddy's Wastewater Treatment-Disposal And Reuse (Third Ed.)*, TMH publishing Co Ltd, N. Delhi. (1996)

CL 614 PHARMACEUTICAL TECHNOLOGY

Introduction to Physical Pharmaceutics - Metrology and calculations, Molecular structure, properties and states of matter, Solutions, Phase equilibria, Micromeritic and Powder Rheology, Surface and Interfacial phenomena, Dispersion systems, Diffusion & Dissolution, Kinetics and drug stability, Viscosity & Rheology, and Polymer science and applications.

Formulations and Development

Packaging

Introduction to Industrial Processing

Transport Phenomena (Fluid Flow, Heat Transfer and Mass Transfer)

Particulate Technology (Particle Size, Size reduction, Size Separation, Powder Flow and Compaction)

Unit Operations (Mixing, Evaporation, Filtration, Centrifugation, Extraction, Distillation, and Drying)

Materials of Pharmaceutical Plant Construction

Good Manufacturing Practice (GMP's) Guideline

TEXT BOOKS:

1. *Remington's Pharmaceutical Sciences, 18th ed., Mach Publishing Co, 1990*

REFERENCE BOOKS:

1. *Physical Pharmacy by Alfred Martin, Lippincott Williams & Wilkins, 2006*

2. *Bentley's Pharmaceutics by E A Rawlins, 8th ed., ELBS Publication London, 1987*

3. *Cooper and Gunn's Tutorial Pharmacy, C. B. S. Publishers & Distributors, N. Delhi 1986*

CL 712 COMPUTATIONAL FLUID DYNAMICS

Conservation Laws of Fluid Motion and Boundary Conditions: Governing equations of fluid flow and heat transfer, Equations of state, Navier-Stokes equations for a Newtonian fluid, Classification of physical behaviour, Classification of fluid flow equations, Auxiliary conditions for viscous fluid flow equations

Turbulence and its Modelling: Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model, The k-e model, Reynolds stress equation models, Algebraic stress equation models

The Finite Volume Method for Diffusion Problems: Introduction, one-dimensional steady state diffusion, two-dimensional diffusion problems, three-dimensional diffusion problems, discretised equations for diffusion problems

The Finite Volume Method for Convection-Diffusion Problems: Steady one-dimensional convection and diffusion, The central differencing scheme, Properties of discretisation schemes-Conservativeness, Boundedness, Transportiveness, Assessment of the central differencing scheme for convection-diffusion problems, The upwind differencing scheme, The hybrid differencing scheme, The power-law scheme, Higher order differencing schemes for convection-diffusion, Quadratic upwind differencing scheme

The Finite Volume Method for Unsteady Flows and Implementation of Boundary Conditions: One-dimensional unsteady heat conduction, Discretisation of transient convection-diffusion equation, Solution procedures for unsteady flow calculations, Implementation of Inlet, outlet and wall boundary conditions, constant pressure boundary condition.

TEXT BOOKS:

1. H. K. Versteeg and W. Malalasekera, *An introduction to computational fluid dynamics: the finite volume method*, Longman scientific & technical publishers, 2007
2. John D. Anderson, *Computational fluid dynamics: The Basics with Applications* McGraw-Hill, New York, 1995.

REFERENCE BOOKS:

1. Vivek V. Ranade, *Computational flow modeling for chemical reactor engineering* Academic Press, San Diego, 2002

CL 615 SCALE -UP METHODS

Principals of Similarity, Pilot Plants & Models: Introduction to scale-up methods, pilot plants, models and principles of similarity. Industrial applications.

Dimensional Analysis and Scale-Up Criterion: Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering.

Scale-Up of Mixing and Heat Transfer Equipment: Typical problems in scale-up of mixing equipment and heat transfer equipment

Scale-Up of Chemical Reactors: Kinetics, reactor development & scale-up techniques for chemical reactors.

Scale-Up of Distillation Column & Packed Towers: Scale-up of distillation columns and packed towers for continuous and batch processes

TEXT BOOKS:

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

REFERENCE:

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

CL 616 FOOD PROCESSING

Food Process Engineering - Fundamentals: Raw material and the process-Geometric, Functional and Growth properties of the raw material, Mechanization and the raw material, cleaning - contaminants in food raw materials, function of cleaning and cleaning methods, sorting and Grading of Foods.

Unit Operations in Food Processing: Fluid flow, thermal process calculations, refrigeration, evaporation and dehydration operations to food processing. Heat processing of foods - modes of heat transfer involved in heat processing of foods.

Food Canning Technology: Fundamentals of food canning technology, Heat sterilization of canned food, containers - metal, glass and flexible packaging, Canning procedures for fruits, vegetables, meats, poultry and marine produces.

Separation And Mixing Process In Food Industries: Conversion operations. Size reduction and screening of solids mixing and emulsification, filtration and membrane separation, centrifugation, crystallization, extraction.

Food Biotechnology: Food Biotechnology. Dairy and cereal products. Beverages and food ingredients. High fructose corn syrup. Single cell protein.

TEXT BOOK:

1. R.T. Toledo, *"Fundamentals of Food Process Engineering"*, AVI Publishing Co., New York, 1980.

REFERENCES:

1. J.M. Jackson & B.M. Shinn, *"Fundamentals of Food Canning Technology"*, AVI Publishing Co., New York, 1978.
2. J.G. Bernnan, J. R .Butters, N.D. Cowell & A. E. V. Lilley, *"Food Engineering Operations"*, 2nd Edn., Applied Science, New York, 1976.

CL 617 RISK ANALYSIS & HAZOPS

Introduction to Consequence Analysis - Dispersion and Toxic models: Risk analysis introduction - Rapid risk analysis - Comprehensive risk analysis - Failure types and release rate calculation - Emission and dispersion - Dispersion models for dense gas - Plume dispersion - Jet dispersion - Toxic dispersion model - Evaluation of risk contours.

Consequence Analysis - Fire and Explosion models: Radiation - Tank on fire - Flame length - Radiation intensity calculation and its effect to plant, people & property, UCVCE - Explosion due to - Deflattration - Detonation - TNT, TNO & DSM model - Over pressure - Effects of explosion - Risk contour - Flash fire - Jet fire - Pool fire - BLEVE - Fire ball.

Risk Management & Iso14000: Overall risk analysis - Generation of Meteorological data - Ignition data - Population data - Overall risk contours for different failure scenarios - Disaster management plan - Emergency Planning - on site & offsite emergency planning - Risk management & ISO14000 - EMS models - Case studies - Marketing terminal, gas processing complex, refinery.

Past Accident Analysis: Hazard identification - Safety Audits - Checklists - What if Analysis - Vulnerability models - Event tree and Fault tree Analysis - Past accident analysis Flixborough - Mexico - Bhopal - Madras - Vizag accident analysis.

Hazops: Hazops - Principles - Risk ranking - Guide word - Parameter - Deviation - Causes - Consequences - Recommendation - Coarse HAZOP study - Case studies - Pumping system - Reactor System - Mass transfer system.

TEXT BOOKS:

1. *K.V. Raghavan and A A. Khan, "Methodologies in Hazard Identification and Risk Assesment", Manual by CLRI, 1990.*
2. *V. C. Marshal, "Major Chemical Hazards", Ellis Horwood Ltd., Chichester, United Kingdom. 1987.*

REFERENCES:

1. *Frank P. Less, "Loss Prevention in Process Industries", Vol. I, II & III Butterworth, London, 1980.*
2. *"A Guide to Hazard Operability Studies", Chemical Industry Safety and Health Council, 1977.*

CL 618 POLLUTION PREVENTION FUNDAMENTALS

Pollution Prevention in industries: Environment friendly chemical processes - Properties and fates of environmental contaminants - Regulations for clean environment and implications for industries - Improved manufacturing operations.

Life Cycle Assessment and Environmental Audit: Life cycle assessment and pollution prevention economics - Hazard and risk Analysis - Pollution prevention planning - Design for the environment.

Conservation of Materials and Energy: Water energy and reagent conservation – Residuals management – Economic Recovery and Recycling of Wastes - Case studies.

Total Quality Environment Management and Ems 14000: Municipal pollution prevention Programmes – Environment Management System-14000-Systematic, Structured and Documented Response to Environmental Issues - Auditable and Time Targeted Environmental Improvement Programs.

Hierarchy of Environment Management Practices: Waste-specific pollution prevention: waste pre - generation focus on minimization / recycling, Waste-specific pollution control treatment: pre - generation focus on disposal/recycling- Waste-specific Post-release-to environment focus: recycling/remediation

TEXT BOOKS:

1. Bishop P., *Pollution Prevention: Fundamentals and Practice*, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000
2. T.K. Roy, (Editor), *Chemical Technology for better Environment*, Allied publishers Ltd, Chennai 1998

REFERENCES:

1. El Halwagy, M. M, *Pollution Prevention through Process Integration : Systematic Design Tools*, Academic Press, N.Y. (1997)
2. P.T. Anastas and J.C. Warner, *Green Chemistry: Theory and Practice*, Oxford University Press. N.Y. 1998

CL 619 INDUSTRIAL SAFETY AND MANAGEMENT

Hazards: Chemical hazards classification. Radiation hazards and control of exposure to radiation. Types of fire and fire prevention methods. Mechanical hazards. Electrical hazards

Psychology and Hygiene: Industrial psychology Industrial hygiene. Safety in plant site selection and plant layout. Industrial lighting and ventilation. Industrial noise.

Occupational diseases and control: Occupational diseases and prevention methods. Safe housekeeping Instrumentation for safe operation. Personal protective equipments. Safety in chemical operations and processes.

Management: Safety organization – safety committee – safety education and training. Management process. Philosophy and need for Industrial safety. Role of Government in Industrial safety.

Laws: Factory Act. ESI Act, Environmental Act. Workment - comperation Act. Advantages of adopting safety laws.

TEXT BOOKS:

1. *H.H. Fawcett & W. S .Wood, "Safety and Accident Prevention in Chemical Operation", 2nd Ed, Wiley Interscience, 1982.*

REFERENCES:

1. *Guide for Safety in the Chemical laboratory Second edition 1977, Manufacturing Chemists Association. Van Nostrand Reinhold Company, New York.*
2. *Industrial Safety and Laws, 1993, by Indian School of Labour Education, Madras.*

CL 620 AIR POLLUTION CONTROL EQUIPMENT DESIGN

Air Pollutant Sources, Effects and Clean Air Acts: Pollution of air: Sources and effects of air pollutants on physical environment and living systems, Monitoring air pollution, Air pollution Laws and Minimum national standards.

Air Pollutant Formation, Dispersion, Analysis: Formation of pollutants through large-scale combustion of fossil fuels, mineral processing, automobiles in urban areas and at source minimisation of release - Meteorological aspects of air pollutant dispersion. Chemical reactions in a contaminated atmosphere, urban air pollution, acid rain Air sampling and measurement, Analysis of air pollutants

Air Pollution Control Methods for Particulates Removal: Control Methods - Source Correction methods - Particulate emission control: Dry techniques industrial dust collectors, cyclone and multiclone separators, bag filters, electrostatic precipitators, relative merits and demerits, choice of equipments, design aspects economics. Wet techniques wet dust collection, wet cyclone, empty scrubber, column (packed) scrubber, ventury scrubber, suitability, merits and demerits, design aspects and economics.

Control of Specific Gaseous Pollutants: Cleaning of Gaseous effluents - Control of sulphur dioxide emission by various methods - Control of nitrogen oxides in combustion products - Control of release of carbon monoxide and hydrocarbons to the atmosphere.

Noise Pollution and Control: Sound pressure, Power and Intensity - Measures of Noise- Outdoor noise propagation- Indoor Noise propagation- Noise Control

Hazardous Waste Management and Risk Assessment: Types of hazardous Wastes-Health effects - Nuclear fission and radioactive waste treatment and disposal methods. Risk assessment

TEXT BOOKS:

1. Y.B.G. Verma, H. Brauer, "Air Pollution Control Equipments", Springer, Verlag Berlin, 1981.
2. M.N. Rao and H.V.N. Rao, "Air Pollution", Tata McGraw Hill, New Delhi, 1993.

REFERENCES:

1. Rao C.S. "Environmental Pollution Control Engineering," 2nd Edition, New Age International Publishers, 2006.
2. A. P. Sincero and G.A. Sincero *Environmental Engineering: A Design Approach*, Prentice Hall of India pvt Ltd, N.Delhi.1996

CL 621 OPTIMIZATION TECHNIQUES.

General: Functions of single and multiple variables - optimality criteria, direct and indirect search methods.

Linearization: Constraint optimality criteria, transformation methods based on linearization.

Quadratic and Geometric Programming: Quadratic and geometric programming problems, calculus of variations.

Optimality Criteria & Optimal Control Problems: Euler-Lagrange optimality criteria, Pontryagin's maximum principle, optimal control problems. Numerical methods.

Artificial Intelligence in Optimization: Introduction to Artificial Intelligence in optimization.

TEXT BOOK:

1. T.F. Edgar and D.M. Himmelblau, " *Optimization Techniques for Chemical Engineers*", McGraw-Hill, New York, 1985.

REFERENCE:

1. K. Deo, " *Optimization Techniques*", Wiley Eastern, 1995.

CL 622 BIOENERGY ENGINEERING

Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification - Chemical composition and properties of different biomass materials and bio-fuels – Sugar cane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels-Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass.

Biogas, Technology: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues. Microbial and biochemical aspects- Operating parameters for biogas production. Kinetics and mechanism - Dry and wet fermentation. Digesters for rural application - High rate digesters for industrial waste water treatment.

Bio-Ethanol and Bio-Diesel Technology: Production of Fuel Ethanol by Fermentation of Sugars. Gasohol as a Substitute for Leaded Petrol. - Trans-Esterification of Oils to Produce Bio-Diesel.

Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass - Biomass processing for liquid fuel production - Pyrolysis of biomass - Pyrolysis regime, effect of particle size, temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, temperature and of introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers.

Combustion of Biomass and Cogeneration Systems: Combustion of Woody Biomass: Theory, Calculations and Design of Equipments. Cogeneration in Biomass Processing Industries. Case Studies: Combustion of Rice Husk, Use of Bagasse for Cogeneration.

TEXT BOOKS:

1. Chakraverthy A, “*Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes*”, Oxford & IBH publishing Co, 1989.
2. D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, “*Principles of Solar Engineering*”, 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003 [chapter 10]
3. Mital K.M, “*Biogas Systems: Principles and Applications*”, New Age International publishers (P) Ltd., 1996.4. Nijaguna, B.T., *Biogas Technology*, New Age International publishers (P) Ltd., 2002

REFERENCES:

1. Venkata Ramana P and Srinivas S.N, “Biomass Energy Systems”, Tata Energy Research Institute, 1996.
2. Rezaian. J and N. P. Cheremisinoff, “Gasification Technologies, A Primer for Engineers and Scientists”, Taylor & Francis, 2005
3. Khandelwal. K.C. and Mahdi S. S., “Bio-Gas Technology”, Tata McGraw-Hill Pub. Co, 1986.

CL 623 POLYMER DYNAMICS

Introduction to Polymers: Polymer Melts and Solution.

Description Viscosity of Polymer Melts and Solution: Viscosity of Concentrated Solutions and Melts, Effect of Branching on Viscosity, Elasticity and Viscoelasticity, Maxwell Model for Viscoelasticity, Flow phenomena in polymeric liquids, Brownian Motion, Smoluchowski and Langevin Equation, Autocorrelation and Cross-Correlation functions, Response Function, Fluctuation Dissipation Theorem, Interacting Brownian Particles, Oseen Tensor, microscopic basis of viscoelasticity.

Dilute Solutions: Elastic Dumbbell Model and bead-rod-spring model for polymer chain, the Rouse and Zimm Models

Visco-elasticity and Birefringence. Semidilute and Concentrated Solutions and melts: Effective Medium Theory, Entanglement Effect, Tube Model and Reptation Model, Network theories, Linear Viscoelasticity, Stress Relaxation, Non-Linear Viscoelasticity, Dynamics of Rigid Rodlike Polymers.

REFERENCES:

1. *Theory of Polymer Dynamics*, M. Doi and S. F. Edwards, Clarendon Press, Oxford, 1986.
2. *Dynamics of Polymeric Liquids*, 2nd Edition vols. 1 & 2, R. B. Bird, R. C. Armstrong, O. Hassager, John Wiley and Sons, NY, 1987.
3. *Structure and Rheology of Complex Fluids*, R. G. Larson, Oxford University Press, 1999.