U.P. TECHNICAL UNIVERSITY
LUCKNOW

Syllabus

[Effective from the session: 2007-08]

M.TECH. CHEMICAL ENGINEERING

(REGULAR)

Chemical Engineering
M.Tech.(Regular)
SCHEME OF EXAMINATION
(Revised : Effective from the Session 2007-08)
SEMESTER-I

S. No.	Course Code	Subject	Periods		Evaluation Scheme					Subject Total
					Sessional				Examination	
			L	T/P	CT	AT	TA	Total	ESE	
1	CH-11*	Advanced Separation Processes	3	1	30	10	10	50	100	150
2	CH-12	Advanced Chemical Engineering Thermodynamics	3	1	30	10	10	50	100	150
3	CH-13	Advanced Chemical Reaction Engg.	3	1	30	10	10	50	100	150
4	CH-14*	Modeling and Simulation of Chemical Engineering Systems	3	1	30	10	10	50	100	150
		Total	12	4				200	400	600

*15 Marks are for the class test and 15 marks for lab if any, otherwise 30 marks are for class tests

SEMESTER-II

S.No.	Course Code	Subject	Periods		Evaluation Scheme					Subject Total
					Sessional				Examination	
			L	T/P	CT	AT	TA	Total	ESE	
1	CH-21	Mathematical Methods in Chemical Engg.	3	1	30	10	10	50	100	150
2	CH-22	Advanced Transport phenomena	3	1	30	10	10	50	100	150
3	CH-23*	Advanced Process Dynamics and Control	3	1	30	10	10	50	100	150
4	CH-24	Statistical design of experiments	3	1	30	10	10	50	100	150
		Total	12	4				200	400	600

*15 Marks are for the class test and 15 marks for lab if any, otherwise 30 marks are for class tests

SEMESTER-III

S. No.	Course Code	Subject	Periods		Evaluation Scheme					Subject Total
					Sessional				Examination	
			L	T/P	CT	AT	TA	Total	ESE	
1	CH-31-33	Elective-I	3	1	30	10	10	50	100	150
2	CH-34-36	Elective-II	3	1	30	10	10	50	100	150
3		Seminar	-	2	-	-	-	100	-	100
4	CHD1		-	8				*		
		Total	6	12				200	200	400

* 100 marks of dissertation work will be awarded during fourth semester

Elective- 1 CH-31 Pollution Abatement and Control Equipments
CH-32 Safety Hazard and Risk Analysis
CH-33 Instrumental Methods of Analysis

Elective- II CH-34 Computer-aided design of chemical process plant
CH-35 Design of piping systems for chemical process plant
CH-36 Optimization of Chemical Processes

SEMESTER-IV

S. No.	Course Code	Subject	Periods		Evaluation Scheme		Subject Total
					Internal Assessment	Examination	
			L	T/P		ESE	
1	CHD2	Dissertation	-	18	200*	200	400
		Total		18	200	200	400

* 100 marks are for CHD1 and 100 marks are for CHD2

M. Tech Chemical Engineering Syllabus

SEMESTER-I

CH-11 : Advanced Separation Processes

Multicomponent distillation – Bubble point and dew point calculations, Lewis and Matheson calculation, Method of Thiele and Geddes; Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Classification of membrane processes; Liquid permeation membrane processes or dialysis – Series resistance in membrane processes, Dialysis processes, Types of equipment for dialysis; Gas permeation membrane processes – Types of membranes and permeability for separation of gases, Types of equipment for gas permeation membrane processes (flat membranes, spiral-wound membranes, hollow-fibre membranes); Types of flow in gas permeation; Complete-mixing model, cross-flow model and countercurrent flow model for gas separation by membranes; Effect of processing variables on gas separation by membranes

Reverse osmosis membrane processes – Osmotic pressure of solution, flux equation, Types of equipment and Complete mixing model; Effect of operating variables; Concentration polarization; Permeability constants

Ultra-filtration membrane processes – Types of equipment, flux equation, effects of processing variables

Supercritical fluid extraction – Supercritical fluids, Phase equilibria, Industrial applications; Important supercritical processes – Decaffination of coffee, Extraction of oil from seeds, Residuum oil supercritical extraction (ROSE), Supercritical fluid chromatography, Supercritical fluid reactions etc.

Books:

1. C.J.Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi (2000).
2. T.K.Sherwood, R.L.Pigford and C.R.Wilke, Mass Transfer, McGraw-Hill, New York (1975).
3. R.E.Treybal, Mass-Transfer Operations, McGraw-Hill, New York (1980).

CH-12 : Advanced Chemical Engineering Thermodynamics

Basic concepts of thermodynamics

Applications of thermodynamics to flow processes: Compression processes, Duct flow of compressible fluids, Expanders

Applications of solution thermodynamics: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing, Heat effects of mixing processes

Chemical reaction equilibria: Multi-reaction equilibria, Fuel cells

Topics in phase equilibria: Gamma/phi formulation of VLE, VLE from cubic equation of state, Equilibrium and stability, Liquid-liquid equilibrium, Vapour-liquid-liquid equilibrium, Solid-liquid equilibrium, Solid-vapour equilibrium, Equilibrium adsorption of gases on solids, Osmotic equilibrium and osmotic pressure

Thermodynamic analysis of steady-state flow processes: Concept of ideal work, lost work, thermodynamics efficiency, availability

Introduction to molecular thermodynamics: Molecular theory of fluids, Second virial coefficients from potential functions, Internal energy of ideal gases: microscopic view, Thermodynamic properties and statistical mechanics, Hydrogen bonding and charge transfer complexing, Behaviour of excess properties, Molecular basis for mixture behaviour and VLE by molecular simulation

Books:
Smith, Van Ness and Abbott, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill (2001)

CH-13 :Advanced Chemical Reaction Engineering

Basic principles, rate controlling steps, Thermodynamic aspects of chemical equilibrium calculations, Intrinsic and Global rates. Heterogeneous reactor design. Non-catalytic and catalytic heterogeneous reaction and reactor design, axial mixing phenomenon, Fluidized bed reactors, Analysis of real reactors.

Multiphase flow reactors, Stirred vessel reactors, miscellaneous reactors, Multiphase flow regimes, Gas-liquid, Solid-gas, Gas-solid, liquid-solid reactors, Isothermal and adiabatic fixed bed reactors, Non-isothermal and non adiabatic fixed bed reactors, fixable bed reactors.

Classification, characterization, preparation and application of catalysts, activation & deactivation catalysts, Specific design aspects and the typical industrial reactors with their performance, Reactor stability and optimization, Scale up of reactors.
Books:

1. Levenspeil, Chemical Reaction Engineering,
2. J.M.Smith, Chemical Engineering Kinetics,

CH-14 :Modeling and Simulation of Chemical Engineering Systems

Fundamentals of mathematical modeling-Principles of formulations, Fundamental laws: Continuity equations, energy equation, equation of motion, transport equations, equation of state, equilibrium, chemical kinetics; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models-Simple vs. rigorous, lumped parameter vs. distributed parameter, Steady state vs. dynamic, Transport phenomena based vs. Statistical; Concept of degree of freedom for steady state and unsteady state systems.
Mathematical models of heat-transfer equipments: Shell & tube heat exchangers, Evaporators, Fired heaters, Partial condensers
Mathematical models of mass-transfer equipments: Batch and continuous distillation columns, Reactive distillation columns, Packed absorption columns, Dehumidifiers
Mathematical models of reactors: Batch reactors, Continuous-stirred tank reactors, Plug-flow reactors, Industrial reactors-Ammonia converter, Sulphuric acid converter, Methanol reactor, FCC reactor, Claus reactor, etc.
Numerical methods: Linear and non-linear simultaneous algebraic equations, Ordinary-differential equations-Initial-value problems & boundary-value problems, Partial-differential equations
Different approaches to flow sheet simulation- Sequential modular approach, Simultaneous modular approach, Equation oriented approach; Review of thermodynamic procedures and physical property data banks.
Books:

1. W.L.Luyben, Process Modeling, Simulation and Control for Chemical Engineers, McGraw-Hill, New York (1990).
2. M.M.Denn, Process Modeling,
3. C.D.Holland, Fundamentals and Modeling of Separation Processes,

4. Asghar Hussain, Chemical Process Simulation, Wiley Eastern Ltd., New Delhi (1986).
5. M.E.Davis, Modeling and Numerical Methods in Chemical Engineering
6. B.Carnahan, H.A.Luther and J.O.Wilkes, Applied Numerical Methods, McGraw-Hill, New York (1969).

SEMESTER-II

CH-21 :Mathematical Methods in Chemical Engineering

Formulation of linear and non-linear first and second order ordinary differential equations, higher order linear, differential equations for systems involving momentum, heat and mass transfer with and without chemical reactions and their analytical solutions.

Matrix, Principal types of matrix, Introduction to eigen values, bilinear forms and positive-definiteness, Cholesky decomposition, Gershorgin's theorem eigen values of diagonal and triangular matrices, similarity, transforms, decomposition, iteratively, estimating the leading eigen value, Linear transformations and linear operators, eigenvector expansion, matrices as representations of linear operators Zero eigen values, null spaces, and operator inversion, singular value decomposition.

Infinite series, Power series, Applications of series in chemical engineering, Simple series solutions, Method of Frobenius, Bessel's equation, Properties of Bessel functions.

Diffusion/convection form of PDE's in chemical engineering, characteristics and PDE types (elliptic, parabolic, and hyperbolic) and their analytical solution.

Difference operators, operator E, Formulation of linear and non-linear finite difference equations, differential-difference equations for multistage separation units and chemical reactors in series and their analytical solution.

Books:

1. Jenson and Jeffery, Mathematical Methods in Chemical Engineering,
2. Mickley, Reid and Sherwood, Applied Mathematics in Chemical Engineering, Tata-McGraw-Hill, New Delhi

CH-22 : Advanced Transport Phenomena

Development of momentum, mass and energy balance equations: Equations of change for isothermal systems, Velocity distributions in flow systems, Interphase transport, Microscopic and macroscopic balances

Theories of turbulence-Phenomenological and statistical, Turbulent transfer processes in single and multiphase systems, Temperature distribution in turbulent flow, Concentration fluctuation and time-smoothed concentration, Turbulent mixing with first and second-order reactions

Boundary-layer theory: Steady state transport in boundary layer, Taylor dispersion in laminar tube flow

Interphase transport in non-isothermal systems

Equation of change for entropy, Application of generalized Maxwell-Stephan equation, Mass transport across selectively permeable membrane and porous media

Books:

1. Bird, Stewart and Lightfoot, Transport Phenomena, Wiley, New York

CH-23 : Advanced Process Dynamics and Control

Process dynamics: Laplace transforms, response of lumped parameter systems (first order systems, higher order systems, staged systems), response of distributed parameter systems, dynamic analysis of non-linear systems, inverse response systems, time delay systems, stability.

Advance control strategies: Cascade control, feed forward control, ratio control, adaptive and inferential control, model based control (internal model control, generic model control).

State space methods- State space representation of physical systems, Transfer function matrix, multi variable process control, interaction analysis, stability.

Sampled data control systems: Sampling and Z-transforms, open loop and closed loop response, modified Z-transforms, design of sampled data controllers.

Special control topics: Non linear control: phase- plane analysis, Introduction to statistical process control-Emerging technologies for advanced process control.
Books:

1. Coughanowr and Koppel, Process Systems Analysis and Control,
2. Stephnopolous, Chemical Process Control
3. W.L.Luyben, Process Modeling, Simulation and Control for Chemical Engineers, McGraw-Hill,

CH-24 : Statistical Design Of Experiments

Introduction to Statistics for Engineers: Simplest discrete and continuous distributions, Statistical inference, Statistical estimation, tests and estimates on statistical variance, Analysis of variance, Regression analysis (Simple linear, multiple, polynomial, nonlinear), Correlation analysis (Correlation in linear regression, correlation in multiple linear regression)
Design and Analysis of Experiments: Introduction to design of experiments, Preliminary examination of subject of research, Screening experiments
Basic Experiment-Mathematical Modeling: Full factorial experiments and fractional factorial experiments, Second-order rotatable design (Box-Wilson design), Orthogonal second order design (Box Benken design), D-optimality, B_k-designs and Hartleys second order design
Statistical Analysis: Determination of experimental error, Significance of the regression coefficients, Lack of fit of regression models
Experimental Optimization Of Research Subject: Problem of optimization, Gradient optimization method, Nongradient method of optimization, simplex sum rotatble design
Canonical Analysis Of Response Surface
Mixture Design `Composition-Property': Screening design `composition-property', Simplex lattice design, Scheffe simplex lattice design, Simplex centroid design, Extreme vertices design, D-optimal design, Draper-Lawrence design, Factorial experiments with mixture, Full factorial combined with mixture design
Books:

1. Z.R.Lazic, Design of experiments in chemical engineering: A practical guide, Wiley (2005).

SEMESTER-III

Elective-I

CH-31 : Pollution Abatement & Control Equipments

Waste water treatment and disposal, Elements of plant analysis and design, Facilities for physical and chemical treatment of wastewater, screening, comminuting, flow equalization, sedimentation, chemical precipitation, filtration, chlorination and odour control,
Biological treatment of wastewater: activated sludge process, aerated lagoons, trickling filter, and stabilization ponds treatment and disposal of sludge, advanced wastewater treatment processes,
Air pollution control techniques, particulate emission control by inertial impaction, interception, stacks and chimneys, exhaust systems, dispersion heights and plume characteristics, gravity settling chambers, centrifugal collectors, wet collectors, bag filters, electrostatic precipitators, Pollution control by absorption, adsorption, combustion, condensation, oxidation and catalytic conversion, automotive emission control devices
Solid waste management, pyrolysis, combustion, biodegradation, land fills.
Noise pollution control techniques.

Books
1. K.B.Schnelle & C.A.Brown, Air Pollution Control Technology Handbook, CRC Press
2. H.S. Peavy, Donald R Rowe &George Tchobanoglous, "Environmental Engineering", McGraw-Hill
3. R .K.Trivedy& P.K.Goel,An Introduction to Air Pollution, Technoscience Pub.

CH-32 : Safety Hazards and Risk Analysis

Safety legislations: Safety programmes, Public perceptions, Engineering ethics, Government policy on safety hazard identification, preliminary hazard analysis, hazard and operability (HAZOP) analysis, event tree, fault tree analysis.

Toxic releases, to phase phenomenon, emission and dispersion models, estimation and prevention.

Fire and explosions, chemistry of fire, fire triangle, fire and explosion index (FEI), estimation, heat effects, vapor cloud explosion (VCE), boiling liquid expanding vapor explosions (BLEVE) and prevention.

Industrial hygiene, health hazards, evaluation of worker's exposure to toxicants, control methods.

Hazard management safety system, relief systems, risk management routines, emergency plans, and disaster control ergonomics.

Case histories of some major accidents.

Nuclear radiation hazards and safety from these.

Books:
1. G.L.Wells,Safety in Process Plant Design
2. Sanjoy Banerjee, Industrial Hazard & Plant Safety

3. Daniel A. Crowl, Joseph F. Louvar, Chemical Process Safety: Fundamentals with Applications, Prentice Hall
4. Frank P. Lees, Loss Prevention in the Process Industries, Butterworths ,London

CH-33 :Instrumental Methods of Analysis

Analog and digital signals, concepts of signal noise sensitivity, detection limit, resolution, dynamic range and selectivity to an instrumental analysis, calibration of an instrumental method, electromagnetic sources and detection systems used in instrumental method of chemical analysis, selection of suitable instrumental method for a given analysis.

Basic principles of Instrumental methods- IR, UV, Visible, Fluorescence spectroscopy, mass spectrometry, Nuclear magnetic resonance, gas and liquid chromatography, X-ray analysis and electron spectroscopy (surface analysis).

Physical characteristic of the analytical Instruments- UV-Visible, IR, Fluorescence, Atomic Absorption, NMR Spectrophotometers, Gas chromatograph, High performance liquid chromatograph, Electrochemistry- Glucose sensors, HPTLC, SEM, GCMS, Mass spectrometer.

Books: H. Williard, L. Merrlt, J. Dean,F. Settle, Instrumental Methods of Analysis

Elective II:

CH-34 : Computer-Aided Design of Chemical Process Plants

Elements of computer-aided system design, Interactive methods, Computer graphics, Database technology, Application to property estimation.

Steady state and dynamic simulation, process synthesis and flow sheeting, executed programs for plants like sulphuric acid, ammonia etc.

Introduction to computer aided chemical processes analysis, modeling concepts and system analysis, software architectures, network decomposition mathematical algorithms, design criteria in process design, decision and state variables, control functions, information and data structure.

Modular programs for design of pressure vessel, shell and tube heat exchanger, multiple effect evaporators, plate and packed towers, fixed and fluidized bed reactor.
Costing and project evaluation.

Books:
1. M.S Peter and K.D. Timmer haus, R.E West , Plant design and economics for chemical engineers Mc Graw Hill (2002)
2. M.E. Leesley , Computer aided process plant design, Gulf Pub. Co.(1982)

CH- 35 : Design Of Piping Systems For Chemical Plants

Fundaments of fluid flow through pipes-Calculation of pressure drop for Newtonian & non-Newtonian fluids, incompressible & compressible fluids and two-phase flow, Calculation of

economic pipe diameter, insulation thickness, equivalent length, Slurry transport and pipelines
Engineering flow diagram, nomenclature and equipment elevation
Piping layout, line pressure drop, piping analysis, stress analysis of curved pipelines, yard piping
Piping codes, standards and specifications-ASME, ASTM, API
Piping components-pipes, pipe ends, pipe fittings, end fittings, flanged joints, valves, valve codes and standards, valve classification, valve components, bolts, gaskets (fasteners and sealing elements)
Piping materials-selection, cost and installation
Design of heat exchanger piping, Thermosyphon reboiler piping, Pressure relief piping
Steam tracing design, Thermowell design, Expansion loops and expansion joints
Design of pipeline network-Pinch analysis
Pipeline operation and maintenance-friction reduction, cleaning, coating, wear, leak detection, water hammer
Books:

1. Peter Smith, Fundamentals of piping design, Gulf Publishing House
2. Kellog, Design of pipeline systems

CH- 36 : Optimization Of Chemical Processes

Introduction to optimization; formulation of objective function; Basic concept-function, regions, necessary and sufficient conditions for an extremum of an unconstrained function.
One dimensional search: Scanning and breaking; Newton, quasi-Newton and secant method; Region elimination method; Polynomial approximation method.
Unconstrained multivariable optimization: Direct methods- random search, grid search, univariate search, simplex method, conjugate search direction and Powell's method; indirect method-gradient and conjugate gradient method, Newton's method, movement in search direction, secant method.
Linear programming: Basic concepts in linear programming; Graphical solution, simplex method, Standard LP form; obtaining first feasible solution; sensitivity analysis.
Non linear programming: Lagrange multiplier method; Quadratic programming; Penalty function and augmented Lagrangian method; Successive quadratic programming; Optimization of dynamic processes.
Optimization of staged and discrete processes: Dynamic programming; integer and mixed integer programming.
Non traditional optimization techniques: Simulated annealing; Genetic algorithms; Differential evolution.
Application of optimization in the design of separation process, chemical reactor and large scale process plant.

Books:

1. Edgar and Himmelblau, Optimization of Chemical Processes, McGraw-Hill