COURSE STRUCTURE FOR M.E.CHEMICAL (For 2008 Course)
(w.e.f. June – 2008)

SEMISTER I

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Pr	Paper	TW	Oral	Pr	Total	
509101	Applied Statistics for Chemical Engineers	3	-	100	-	-	-	100	3
509102	Management of R&D in Chemical Industries	3	-	100	-	-	-	100	3
509103	Advanced Separation Processes	3	-	100	-	-	-	100	3
509104	Elective I	3	-	100	-	-	-	100	3
509105	Elective II	3	-	100	-	-	-	100	3
509106	Lab Practice I	-	6	-	50	-		50	3
509107	Seminar I	-	4	-	50	-	-	50	2
Total of First Term		15	10	500	100	-	-	600	20

SEMISTER II

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Pr	Paper	TW	Oral	Pr	Total	
509108	Process Modeling and Simulation	3	-	100	-	-	-	100	3
509109	Advanced Transport Phenomena	3	-	100	-	-	-	100	3
509110	Advanced Process Control	3	-	100	-	-	-	100	3
509111	Elective III	3	-	100	-	-	-	100	3
509112	Elective IV (Open)	3	-	100	-	-	-	100	3
509113	Lab Practice II	-	6	-	50	-		50	3
509114	Seminar II	-	4	-	50	-	-	50	2
Total of Second Term		15	10	500	100	-	-	600	20

SEMISTER III

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Pr	Paper	TW	Oral	Pr	Total	
609101	Seminar III(Based on Project)	-	4	-	50	-	-	50	2
609102	Project Stage I	-	18	-	50	-		50	6
Total of Third Term		-	22	-	100	-	-	100	08

SEMISTER IV

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Pr	Project	TW	Oral	Pr	Total	
609103	Project Stage II	-	18	150*	-	50		200	12
Total of Fourth Term		-	18	150	-	50	-	200	12

* The Term Work of Project stage II of semester IV should be assessed jointly by the pair of internal and external examiners. along with the oral examination of the same.

Note- The Contact Hours for the calculation of load of teacher Seminar- 1 Hr / week / student
Project - 2 Hr / week / student

LIST OF ELECTIVES

Elective I	Elective II	Elective III	Elective IV
1. Computational Fluid Dynamics	1. Industrial Pollution Control	1. Catalysis And Surface Phenomenon	**Open Elective**
2. Process Design And Synthesis	2.Process Optimization	2. Advanced Reaction Engineering	
3. Advanced Thermodynamics	3. Drugs and Pharmaceutical Engineering	3. Mathematical Methods In Chemical Engineering	
4. Computer Aided Design	4.Fluidization Engineering	4. Bioprocess Engineering	

SEMISTER I

M.E.CHEMICAL

509101 Applied Statistics for Chemical Engineers

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

EMPIRICAL STATISTICS: Measures of Central tendency, dispersion, skew ness and kurtosis Principle of least squares - Correlation and regression - rank correlation.

SAMPLING DISTRIBUTIONS AND ESTIMATION: Sampling distributions - Point and interval estimates for population proportions, mean and variance – Maximum likelihood estimate method - Method of moments.

TESTING OF HYPOTHESIS: Sampling distributions - Tests based on Normal, t, Chi-square and F distributions - Analysis of variance – oneway and two-way classifications.

DESIGN OF EXPERIMENTS: Completely randomized design - Randomized block design - Latin square design - 2 power 2 factorial design.

LINEAR PROGRAMMING: Basic concepts - Graphical and Simplex methods – Transportation problem - Assignment Problem.

Reference Books:

1. Freund, J.E. and Miller, I.R., “Probability and Statistics for Engineers ", Prentice – Hall of India, 5th Edition, New Delhi, 1994.
2. Gupta, S.C. and Kapur, V.K., “Fundamentals of Mathematical Statistics ", Sultan Chand & Sons, New Delhi, 1999.
3. Ang, A.H.S. and Tang W.H., “Probability concepts in Engineering Planning and Design – Basic Principles Vol.1 ", John Wiley and Sons, Inc. New Delhi, 1975.
4. Taha, H.A., " Operations Research: An Introduction ", Prentice - Hall of India, 6th Edition, New Delhi, 1997.
5. Berthouex, P.U., “Statistics for Environmental Engineers ", Lewis Publ., 1994

509102 Management of R&D in Chemical Industries

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Introduction. Nature of planning. Choice and Objectives of technological forecasting. Proposal preparation and motivative efforts, initiate the research and development programme. Concept of creativity, group approach to idea generation. Conditions for successful growth of creative ideas of realization. Quality of research personnel and staff selection. Organization and special problems of research and development. Conducting a research and development project. Scheduling, monitoring, and decision-making for cost effectiveness. Accountability and responsibility.

References:

1. NUTS AND BOLTS OF CHEMICAL EDUCATION RESEARCH**,** edited by Diane M. Bunce and Renée S. Cole, ACS Symposium Series 976, American Chemical Society, Washington, D.C.,
2. **Design of experiments (DOE) in chemical engineering ,** LAZIC Zivorad, Wiley-VCH, Weinheim
3. **Practical Process Research & Development,** Neal G. Anderson, Academic press
4. **Getting It Right: R&D Methods for Science and Engineering,** Peter Bock

509103 Advanced Separation Processes

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

GENERAL

Reveiw of conventional processes, Recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and equipment used in cross flow filtration, cross flow electro filtration, dual functional filter, Surface based solid - liquid separations involving a second liquid, Sirofloc filter.

MEMBRANCE SEPARATIONS

Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, Commercial, pilot plant and laboratory membranes permeators involving dialysis, reverse osmosis, Nanofiltration, ultrafiltration, Microfiltration and Donnan dialysis, Economics of membrane operations, Ceramic membranes.

SEPARATION BY ADSORPTION TECHNIQUES

Mechanism, Types and choice of adsorbents, Normal adsorption techniques, Affinity chromatography and
immuno chromatography. Types of equipment and commercial processes, Recent advances and process
economics.

IONIC SEPARATIONS

Controlling factors, Applications, Types of equipment employed for electrophoresis, Dielectrophoresis, Ion exchange chromatography and electro dialysis, Commercial Processes.

OTHER TECHNIQUES

Separations involving Iyophilisation, Prevaporation and permeation techniques for solids, liquids and gases. Industrial viability and examples, Zone melting, Addluctive crystallization, Other separation process, Supercritical fluid extraction, Oil spill Management, Industrial effluent treatment by modern techniques.

References:

1. Lacey, R.E. and S.Loaeb - " Industrial Processing with Membranes ", Wiley -Inter Science, New York, 1972.
2. King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd., 1982.
3. Schoew, H.M. - " New Chemical Engineering Separation Techniques ", Interscience Publishers, 1972.
4. Ronald W.Roussel - " Handbook of Separation Process Technology ", John Wiley, New York, 1987.
5. Kestory, R.E. - " Synthetic polymeric membrances ", Wiley, New York, 1987.
6. Osadar, Varid Nakagawa I - " Membrance Science and Technology ", Marcel Dekkar (1992).

Elective I

509104 Computational Fluid Dynamics

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Introduction to Fluid Dynamics

Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies.

Conjugate Heat Transfer (CHT)

Introduction to CHT, Fluid boundary conditions, CHT solid boundary conditions, CHT interface conditions, many to one CHT interface conditions, linear solver.

Geometric Modeling and CAD Repairing

Geometric transformations, Parametric representation of curves and surfaces, Concept of topology, Surface modeling, Faceted models, Solid modeling. Creation of water tight geometry, Faceted Boolean operations, Dependent and independent CAD errors.

Structured and Unstructured Grid Generation

Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination

Introduction to CFD

Philosophy of CFD, Governing equations of fluid dynamics and there physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition.

Numerical Methods in CFD

Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Study and transient solutions

Introduction to Turbulence Modeling

Introduction and background, Algebraic models, One equation models, Two equation models, Near wall treatment, Reynolds stress models, Eddy viscosity models (EVM),

Nonlinear eddy viscosity models, LES, RANS, and, hybrids, Direct numerical simulation (DNS)

Introduction to Multiphase Modeling

Fundamentals of multiphase flows, Eulerian-Lagrangian (ELAG) approach, Eulerian-Eulerian (E2P) approach, Volume Of Fraction (VOF) approach, Solving example problems

Chemical Fluid Mixing Simulation

Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples

Post-Processing of CFD results

contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.

References:

1.Computational Fluid Dynamics: The Basics with Applications, John D.Anderson, Mc Graw Hill, 1995

2.Computational Flow Moeling for Chemical Reactor Engineering, V. V. Ranade, Process Engineering Science, Volume 5, 2001,

3.Fundamentals of Grid Generation, Patrick Knupp and Stanly Steinberg, CRC Press, 1994,

4.Turbulence Modelling for CFD, D.C. Wilcox 1993,

5.An Introduction to Multigrid Methods, Pieter Wesseling, John Wiley & Sons, 1992,

6.Numerical Grid Generation: Foundations and Applications, J. F.Thompson, Z. U. A. Warsi and C. W. Mastin, North Holland, 1985,.

7. Numerical Heat Transfer and Fluid Flow, S.V. Patankar, McGraw-Hill,1981,

8.Simulation and Modelling of Turbulent Flows, Thomas B. Gatski, M. Yousuff Hussaini, John L. Lumley, Eds., Oxford University Press, 1996,

9. Computational Gas Dynamics, Laney, C. B., Cambridge Uni. Press, 1998.

Elective I

509104 Process Design And Synthesis

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist in process design.

Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization. **Product design** and developments, Process engineering economics and project evaluation

Life Cycle Assessments of process: From design to product development, Project costing and performance analysis, Environmental concerns, green engineering, engineering ethics, and health and safety.

Introduction to commercial process design and costing software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software

Heat Exchanger Network Synthesis:

Introduction & problem highlights ,HENS basics & graphics, The pinch point approach, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming

Ideal Distillation: Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor ow rates for single columns, Residue curve basics

Non-ideal Distillation: Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressure-swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE , Detailed Residue Curve Maps, Residue curve maps: Interior structure

Reactor Networks: Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps

References

Douglas, J. Conceptual Design of Chemical Processes. New York, NY: McGraw-Hill Science/Engineering/Math, 1988. ISBN: 0070177627.

Seider, W. D., J. D. Seader, and D. R. Lewin. Product and Process Design Principles: Synthesis, Analysis, and Evaluation. *2nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.*

Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz. Analysis, Synthesis, and Design of Chemical Processes, 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13-064792-6

L.T. Biegler, I.E. Grossmann and A.W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, 1997.

Elective I

509104 Advanced Thermodynamics

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Quantum Considerations

Introduction, Internal energy levels, Microstates, Macrostates and Probability, Case or repeated trials, Phase space, combinatorial problems with respects to particles and energy states.

Entropy and Probability

Thermodynamic probability, State of maximum Thermodynamic probability, Microscopic meaning of entroy, Use of Lagrangion multipliers, Stirling's approximation.

Statistical Mechanics

The statistical distribution laws, Maxwell - Boltzmann statistics, The Fermi-Dirac and Bose - Einstein Statistics, Partition functions, Transnational, Rotational etc., Applications of physical models.

Statistical Evaluation Of Thermodynamic Properties

Ideal Monatomic gas, Partition function, Calculation of the translational properties of an ideal monatomic gas, Sector - Tetrode equation, Potential energy function for a diatomic molecule, Rigid rotor harmonic – oscillator approximation, Rotational and vibrational partition functions of ideal polyatomic gases.

Thermodynamic Of Irreversible Processes

Irrevesible processes, Phenomenological laws, Application of onsager - reciprocal relations, Seebeek effect, Peltier effect, Thompson effect.

References:

1. Sonntag R.E. and G.I. Van wylen - " Fundamental of Statistical Thermodynamics ", John wiley and Sons, New York, 1966.
2. McQuarric D.A. - " Statistical Thermodynamics ", Harper and row Pub. New York, 1973.
3. Howerton M.T. - " Engineering Thermodynamics ", D. Van Nostrand Co., Inc., New York, 1962.
4. Tien C.L. and J.H. Lienhard - " Statistical Thermodynamics ", Halt Rinhart and Winston Inc., New York, 1971.
5. Otto Beran J., JulianaBoerio-Gates Vol I & II, “Chemical Thermodynamics: Advanced Applications”, Academic press, 2000.
6. Reid, Prausnitz and Poling, “The Properties of Gases and Liquids”,McGraw Hill Publication

Elective I
509104 Computer Aided Design

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

ELEMENTS OF COMPUTER SYSTEM
Central Processors, Data storage, Alphanumeric input and output, Graphical 1/0 Basic software, Operating system, Models of operation, Time sharing, Real time operation, Data and file management systems.

PROPERTIES ESTIMATION
Physical properties of compounds, Thermodynamic properties of gases and binary mixtures, Viscosity, Vapour pressure, Latent heat, Bubble point and drew point calculation, phase equilidria, Vapour-liquid equilibria, Liquid phase activity coefficients, K-values, Liquid phase activity coefficients, K-values, Liquid-Liquid equilidria, Gas solutions.

EQUIPMENT DESIGN
Computer aided design of reactors evaporators adsorption columns. Distillation columns (specific attention to multi components systems. Heat exchangers.

MASS AND ENERGY BALANCE COMPUTATIONS
Review of linear algebra, Spread sheets and its role in process calculation. Material balance and energy balance computation using spread sheets, Case studies.

DYNAMIC SIMULATION
Review on ordinary and partial differential equation, Boundary value problems, Stiff differential equation system, Dynamic simulation of stirred tanks system with heating Multi component system, Reactors, Absorption and distillation columns, Application of orthogonal collocation and weighted residuals techniques in heat and mass transfer systems, Introduction to special software for steady and dynamic simulation of Chemical engineering systems.

References:
1. James M.Deuglas, “Conceptual design of Chemical Processes", McGraw -Hill Book Company, New York, 1988.
2. Remirez, W.F. - " Computational methods for Process Simulations ", Butterworths, New York, 1989.
3. Sinnott R.K. " Chemical Engineering, Volume 6 ", Pergamon Press, New York, 1989.

Elective II

509105. Industrial Pollution Control

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Air pollutants, dynamics, plume behavior, dispersion of air pollutants, dynamics, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models.

Design concepts for pollution abatement systems for particulates and gases. These include gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.

Waster water treatment processes: Design concepts for primary treatment, grid chambers and primary sedimentation basins, biological treatment

Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and analysis, determination of kinetic coefficients, activated sludge process.

Design, trickling filter design considerations, advanced treatment processes.

Study of environment pollution from process industries and their abatement. Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.

Solid waste and Hazardous waster management: Sanitary land fill design, Hazardous waste classification and rules, management strategies. Treatment methods – component separation, chemical and biological treatment, incineration, solidification and stabilization, and disposal methods.

References:

1. C. S. Rao Environmental pollution control engineering, 2nd edition
2. S.P. Mahajan Pollution control in process industries .
3.N.L.Nemerow, “Liquid waste of industry- theories, Practices and Treatment”, Addison Wesley, New York, 1971.
4. W.J.Weber, “Physico-Chemical Processes for water quality control”, Wiley Interscience,. New York, 1969.
5. W.Strauss, “Industrial gas cleaning”, Pergamon, London, 1975.
6. A.C.Stern, “Air pollution”, Volumes I to VI, academic Press, New York, 1968.

Elective II
509105. Process Optimization

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Introduction to process optimization; formulation of various process optimization problems and their classification.

Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Optimization of one dimensional functions, unconstrained multivariable optimization- direct search methods. Bracketing methods: Exhaustive search method, Bounding phase method Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method. Point-Estimation method: Successive quadratic estimation method.

Indirect first order and second order method. Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cubic search method. Root-finding using optimization techniques.

Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method.

Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Sensitivity analysis, Direct search for constraint minimization: Variable elimination method, complex search method.

Successive linear and quadratic programming, optimization of staged and discrete processes.

Specialized & Non-traditional Algorithms: Integer Programming: Penalty function method, Non-traditional Optimization Algorithms: Genetic Algorithms: Working principles, differences between GAs and traditional methods, similarities between GAs and traditional methods, GAs for constrained optimization, other GA operators, Real-coded GAs, Advaced GAs.

Reference

1. Kalyanmoy Deb ,Optimization for engineering design, , Prentice Hall of India
2. T.F.Edgar and D.M.Himmelblau, optimization of chemical processes, Mc Graw Hill,
3. International editions, chemical engineering series, 1989.
4. G.S. Beveridge and R.S. Schechter, Optimization theory and practice, Mc Graw Hill, Newyork, 1970.
5. Rekllitis, G.V., Ravindran, A., and Ragdell, K.M., Engineering Optimization- Methods and Applications, John Wiley, New York, 1983.
6. SS Rao, Optimization Theory and Applications

Elective II
509105. Drugs and Pharmaceutical Engineering

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

INTRODUCTION
Development of pharmaceutical Industry, Organic therapeutic agents, uses and economics, Drug metabolism, Physic Chemical principles, Pharma Kinetics, Action of drugs on human bodies.

MANUFACTURING PRINCIPLES
Compressed tablets, Wet granulation, Dry granulation or slugging, Direct compression, Tablet formulation, coating pills, capsules oral liquids, injections and ointments.

PHARMACEUTICAL PRODUCTS
Vitamins, cold remedies, Laxatives, Analgesics, Nonsterodial conceptives, External antiseptics, Antacids and others.

MICROBIOLOGICAL AND ANIMAL PRODUCTS: Antibiotics, Biological, Harmones, Vitamins, preservation.

PHARMACEUTICAL ANALYSIS: Analytical methods and tests for various drugs and pharmaceuticals.

PACKING AND QUALITY CONTROL: Packing, Packing techniques, Quality control.

References:
1. Rawlines, E.A., " Bentleys Textbook of Pharmaceuticals ", III Edition, Bailliere Tindall, London, 1977.
2. Yalkonsky, S.H., Swarbrick, J., " Drug and Pharmaceutical Sciences ", Vol. I, II, III, IV, V, VI and VII, Marcel Deker Inc., New York 1975.
3. " Remingtons Pharmaceutical Sciences ", Mack Publishing Co., 1975.

Elective II
509105. Fluidization Engineering

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

INTRODUCTION

The fluidized state, Nature of hydro dynamic suspension particle-particle forces, species of fluidization, Regimization of the fluidized state, operating models for fluidizations systems, Application of fluidization systems.

HYDRODYNAMICS OF FLUIDIZATION SYSTEMS

General bed behavior pressure drop, Flow regimes, Incipient fluidization, pressure fluctuations, phase holdups, Measurement techniques, Empircial correlations for soilds holdup, liquid holdup and gas holdup, Flow models - generalized wake model, structural wake model and other imporatant models.

SOLIDS MIXING AND SEGREGATION

Phase juxtaposition operation shifts, Reversal points, Degree of segregation, Mixing - segregation equilibrium, Generalized fluidization of poly disperse systems, liquid phase mixing and gas phase mixing.

HEAT AND MASS TRANSFER FLUIDIZATION SYSTEMS

Mass transfer - gas-liquid mass transfer, Liquid soild mass transfer and wall to bed mass transfer, Heat transfer - column wall - to - bed heat transfer, Immersed vertical cylinder-to-bed heat transfer, Immersed horizontal cylinder to-bed heat transfer.

MISCELLANEOUS SYSTEMS

Conical fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Two phase and three phase inverse fluidized bed, Draft tube systems, Semi fluidized bed systems, Annular systems, typical applications, Geldart's classification for power assessment, Powder characterization and modeling by bed collapsing.

References:

1. Gas-Liquid-Solid Fluidization Engineering, Liang-Shih Fan, Butterworths, 1989.
2. Fluidization Idealized and Bubbleless, with Applications, Mosoon Kwauk, Science Press, 1992.
3. Fluidization Engineering, O. Levenspiel and D. Kunii, John Wiley, 1972.

509106 Lab Practice I

Teaching Scheme	Examination Scheme
Practical: 6 Hrs/Week	T.W. : 50 marks

Each student should perform at least 8 experiments/ assignments from the list given below and submit the journal which will form the term-work for the subject

1. To study the performance of an ion exchange resin in a packed bed.
2. To study the effect of operating variable in Reverse Osmosis.
3. To study the effect of operating variables in Ultra filtration
4. Breakthrough Analysis of Ion Exchange Column.
5. To determine the effect of specific parameters on the adsorption i.e. temperature and concentration.
6. To Study the Supercritical Extraction
7. Computer Aided Design of Reactive Distillation Column
8. Computer Aided Design of Heat Exchanger
9. Computer Aided Design of Absorption Column
10. Computer Aided Design of CSTR /PFR/Trickle Bed Reactor

509107 Seminar I

Teaching Scheme	**Examination Scheme**
Practical : 4 Hr/Week	T.W. : 50 marks

Each student is required to deliver a seminar in first semester on the state of the art of the topic of his/her choice, preferably the topic of his/her dissertation and submit it in form of a short report.

SEMISTER II

509108 Process Modeling and Simulation

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

BASIC MODELLING

Introduction to modeling, Application and scope of coverage, Formulation, Review of algebraic equators, Ordinary and partial differential equation. Analytical and numerical techniques, Smoothing techniques, Spline function approximations.

MODELLING OF HEAT, MASS AND MOMENTUM TRANSFER OPERATIONS

Review of heat, mass and momentum transfer operations, Modeling ar exchangers, Evaporators, Absorption columns, Extractors, Distillation columns, Membrane processes.

MODEL DISCRIMINATION AND PARAMETER ESTIMATION

Rate equations, Linear and non-linear regression analysis, Design of experiments, Factorial, Central, fractional design, Evolutionary operation techniques, Case studies.

OPTIMIZATION TECHNIQUES

Function, Analysis and numerical methods for single variable and multivariable system, constrained optimization problems.

APPLICATION OF OPTIMIZATION

Heat transfer and energy conservation, Separation techniques, Fluid flow systems, Chemical Reactor design.

References:

1. Edgar, T.F. and D.M. Himmelblau - “Optimization of Chemical Processes ", McGraw Hill Book Co., New York, 1989.
2. Lubeyn W.L. “Process Modeling, Simulation and Control Engineering ", McGraw Hill Book Co., New York, 1990.
3. " Chemical Engineering Tutorial Numerical methods, Chemical Engineering ", August 17, October 26, 1987 Feb. 15, April 25, July 18, Nov. 21, 1988, July 14, 1989.
4. " Chemical Engineering Tutorial Statistics for Chemical Engineers ", Chemical Engg., July 23, 1985, Feb. 3, April 14, June 23, Sept. 1, 1986.

509109 Advanced Transport Phenomena

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Basic concept and review of classical flow problems using shell balances.

Review of mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems, frame of reference (Eularian and Lagrangian).

The equations of change for isothermal flow: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non-Newtonian fluids.

The equations of change for non-isothermal flow: Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems.

The equations of change for multi component systems: The equations of continuity for a binary mixture, the equation of continuity of A in curvilinear coordinates, the multicomponent equations of change in terms of the flows, the multi component fluxes in terms of the transport properties, use of equations of change to setup diffusion problems.

Velocity, temperature and concentration distributions with more than one independent variables, unsteady flow, stream function, potential flow, boundary layer theory, steady state two dimensional flow for momentum, heat and mass.

Turbulent flow: Introduction, fluctuations and time smoothened equations for velocity, temperature and concentration, time smoothing of equation of change , equation of energy, equation of continuity of A, Reynolds stresses.

Dimensional Analysis: Introduction, momentum, heat and mass transfer.

References

1. R.B. Bird, W. E. Stewart and E. N. Light foot Transport Phenomena Wiley international Edition, New York 2002.
2. G.K. Batchelor An introduction to fluid dynamics, Cambridge university press, Cambridge, 1967.
3. J.C. Salterry momentum Energy and mass transfer in continua Robert e. Kridger publishing company. New York 1981.
4. James R.Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, , John Wiley & sons, Inc New York.

509110 Advanced Process Control

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Brief review of – dynamic behavior of processes, single-loop feedback control systems, stability analysis and design of feedback control systems, Process identification

Multiloop control systems (cascade, selective, split- range), PID enhancements (feed-forward, ratio, adaptive, inferential, anti-reset windup, auto-tuning, gain scheduling)

Multivariable Control Systems:
MIMO control systems, input-output pairing, loop interaction, controllability and observability, transfer function model, open-loop dynamic analysis in state-space, transient response, stability analysis, synthesis of alternative control configurations, RGA analysis and loop pairing, design of non-interacting control loops, centralized MVC systems.

Advanced Process Control Systems:
Introduction to model-based control (MBC), real-time optimization, MPC, IMC base PID, statistical process control, batch process control, state estimation, robust controller design, distributed parameter controllers.

Plant wide Control Systems:
Issues, internal feedback of material and energy, interaction of plant design and control system design, design of plant wide control systems, effect of control structure on closed-loop performance, use of APC soft wares for plant wide control..

ANN and Fuzzy logic Control Systems (FLC), need, classification, design, development, estimator, multilevel control systems, , fuzzy logic tuned set-point weight PID controller, FLC of semi batch reactors and bioreactors.

References:

1. Seborg, Edgar, Mellichamp, 'Process Dynamics and Control', Wiley student edition
2. Bequette, 'Process Control', Prentice Hall Publications
3. Stephanopoulos, 'Chemical Process Control', Prentice Hall Publications.
4. Marlin, 'Process Control', Mc Graw Hill Publication.
5. Ogunike, Ray, 'Process Dynamics, Modelling and Simulation', Mc Graw Hill Publication
6. M. Chidambaram, 'Computer Control of Processes', Alpha Science.

Elective III

509111 Catalysis And Surface Phenomenon

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Introduction of Catalysis

Classification of Catalysis - Homogeneous, Heterogeneous, Biocatalysts, Preparation of catalysis - Laboratory Techniques, Industrial methods, Transition models, Dual functional catalysts, Zeolites, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active ingredients, Supportive materials, Catalysts activation.

Catalysts Characterization

Surface area measurements, BET Theory, Pore size distribution, Porosimetry Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques, XRD, XPS, ESCA, ESR, NMR, Raman and Masbauar spectroscopies, Surface acidity and toxicity, Activity, Life time, Bulk density, Thermal stability etc.

Theories of Catalysts

Crystal structure and its defects, Geometric and electronic factors, Analysis of transition model catalysis, Chemistry and thermodynamics of adsorption, Adsorption isotherms - Langmuir model, Tempkin model, Freundich model, Elovich equation, Langmiur Hinshel - wood model, Rideal - Eely mechanism, Reversible - irreversible mono and bimolecular reactions with and without inerts, Determination of rate controlling steps, Inhibition, parameter estimation.

Mass and Heat Transport in Porous Catalysts

Internal and external transport, fixed bed, Fluidized bed reactors, Effect of internal transport on selectivity. Effectiveness factor and Thiele modulus.

Catalyst Deactivation

Poisons, sintering of catalysts, Pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration.

Industrial Catalysis

Industrial catalysts preparation methods, Typical industrial catalytic processes, Case studies, Catalytic deactivation prevention methods, New techniques for catalyst characterization, Overall study.

References:

1. Emmett, P.H. - “Catalysis Vol. I and II, Reinhold Corp.", New York, 1954.
2. Smith, J.M. - “Chemical Engineering Kinetics ", McGraw Hill, 1971.
3. Thomas and Thomas - “Introduction to Heterogeneous Catalysts ", Academic Press, London 1967.

Elective III

509111 Advanced Reaction Engineering

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Kinetics Of Heterogeneous Reactions

Catalytic Reactions, Rate controlling steps**,** Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Steady State approximation, Noncatalytic fluid - solid reactions, Shrinking and unreacted core model.

Population Balance Models

Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non-ideal reactors.

External Diffusion Effects In Heterogeneous Reactions

Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modelling diffusion with and without reaction.

Internal Transport Processes In Porous Catalysts

Intrapellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.

Design Of Heterogeneous Catalytic Reactors

Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors.

Introduction to multiphase reactor design, Two phase fluidized bed model, slurry reactor model, Trickle bed reactor model.

References:

1. Smith J.M. - " Chemical Engineering Kinetics ", McGraw-Hill, 1981.
2. Bischoff and Fromment - " Chemical Reactor Design and Analysis ", Addision - Wesley, 1982.
3. Fogler H.S - " Elements of Chemical Reaction Engineering ", Prentice - Hall 1986.

Elective III

509111 Mathematical Methods In Chemical Engineering

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Tensors, Matrices and Their Applications, Tensor Algebra and Elements of Tensor Calculus, Numerical Linear Algebra: Solution of Systems of Linear and Nonlinear Algebraic Equations and the Algebraic Eigenvalue Problem

Advanced Topics in ODEs: General Results for Systems of Linear First Order ODEs, Phase Portraits of multi-dimensional Linear Systems, Nonlinear Systems, Elementary Stability and Bifurcation Analysis, Green's Function, Series Solutions and Special Functions, Orthogonal Polynomials, Differential Eigenvalue Problems, Sturm-Liouville Problems

PDEs: Classification and General Results including the Maximum Principle, Detailed discussion of Laplace's, Wave and Diffusion Equations (class notes and handouts); Boundary Conditions; External vs. Internal Problems; Finite, Semi-Infinite and Infinite Spatial Domains; Solution in Different Coordinate Systems

Analytical Methods for Partial Differential Equations: PDEs arising from models for Reaction-Diffusion-Convection Phenomena, Instability and Pattern Formation in Systems Governed by PDEs.

Numerical Solution to ODEs and PDEs: Finite Difference Method, Method of Weighted Residuals, Pseudo-Spectral Methods, Introduction to Finite Element Method and Femlab

Perturbation Methods: Regular and Singular Perturbation, Method of Multiple Scales, Homogenization
Introduction to Lattice Methods, Stochastic Simulation Techniques

References:

1. Mathematical Methods in Chemical Engineering by Arvind Varma and Massimo Morbidelli, Oxford University Press, New York, 1997.
2. Mathematical Methods in Chemical Engg. S.Pushpavanam, Prentice Hall of India.
3.

Elective III

509111 Bioprocess Engineering

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

Advance Enzyme Kinetics: Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

How cell work- the central dogma, DNA replications, sending the messages, genetic code, translation, posttranslational processing, sensing of extra cellular environment, roll of cell receptors.

Major metabolic pathways, bioenergetics, Glucose metabolism, metabolism of nitrogenous compounds, respiration, metabolism of hydrocarbons, anaerobic metabolism, autotrophic metabolism.

Bioreactors: modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid state fomenters.

Homogeneous and heterogeneous reactions in bioprocesses: reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Biological waste water treatment : microbial participation in natural cycle of matter, activated sludge process, design and modeling of activated sludge process, Nitrification, anaerobic digestion, mathematical modeling of anaerobic digester, anaerobic denitrification, phosphate removal.

References

1) Biochemical Engineering Fundamentals – J. E. Bailey and D. F. Ollis – McGraw-Hill
2) Bioprocess Engineering Principles – P. M. Doran – Academic Press
3) Bioprocess Engineering – M. L. Shuler, F. Kargi , Prentice -Hall

509112 Elective IV (Open)

Teaching scheme	Examination Scheme
Lecture: - 3h/week	Theory: - 100 Marks

509113 Lab Practice II

Teaching Scheme	**Examination Scheme**
Practical: 6 Hrs/Week	T.W. : 50 marks

Each student should perform at least 8 experiments/ assignments from the list given below and submit the journal which will form the term-work for the subject

1. Stability analysis using Bode diagrams for control systems.
2. Simulation of Non Isothermal CSTR.
3. Simulation of Batch Reactor.
4. Dynamic modeling of Binary Distillation column control using Matlab/Simulink
5. Dynamic modeling of Non Isothermal CSTR using Matlab/ Simulink
6. Dynamic modeling of Single Component Vaporizer using Matlab/ Simulink
7. Design of a Flow network containing Pumps, fittings and Piping (horizontal, vertical, inclined)
8. Computer Aided Process design of simple reactors (CSTR, Tubular) with or without heat transfer.
9. Computer Aided Process design & Rating of stand alone Multi-component Distillation columns.
10. Process design & Rating of TEMA Type Shell &Tube Heat exchangers.
11. Steady state flow sheeting of acyclic processes.
12. Steady state flow sheeting of Processes with recycles /Purge/Bypass etc.
13. Study of dynamic behavior of simple systems such as tank in series, double effect evaporators,etc.
14. Study of coupling of manipulated and controlled variables using relative gain analysis (RTA).
15. Dynamic simulation of Simple process systems with controllers
16. Dynamic simulation & controllability analysis of Binary distillation column .
17. Controller Tuning of Multiple Input-Multiple out put system.
18. To determine Close Loop Time Constant for Distillation Column Control

509114 Seminar II

Teaching Scheme | **Examination Scheme**
Practical : 4 Hr/Week | T.W. : 50 marks

Each student is required to deliver a seminar in first semester on the state of the art of the topic of his/her choice, preferably the topic of his/her dissertation and submit it in form of a short report.

609101 Seminar III (Based on Project)

Teaching Scheme | **Examination Scheme**
Practical : 4 Hr/Week | T.W. : 50 marks

Each student is required to deliver a seminar in third semester on the state of the art of the topic of his/her choice, preferably the topic of his/her dissertation and submit it in form of a short report.

609102 Project Stage I

Teaching Scheme | **Examination Scheme**
Practicals: 18 Hrs/Week

Students are required to prepare a report based on project of their choice.

609103 : Project Stage II

Teaching Scheme | **Examination Scheme**
Practical : 18 Hrs/Week | T.W.:50marks /
Project 200 Marks

Students are required to prepare report on project of their choice. They are required to submit project report and appear for the oral examination