TEACHING SCHEDULE & STUDY SCHEME

M. TECH. PROGRAMME

(Chemical Engineering)

PUNJAB TECHNICAL UNIVERSITY, JALANDHAR

August, 2004
**DETAILED SYLLABUS AND OTHER CONDITIONS FOR THE PROPOSED COURSE**

**M.TECH. CHEMICAL ENGINEERING**

### Schedule of Teaching

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Tutorials (per week)</th>
<th>Total</th>
<th>Time (Hrs)</th>
<th>Theory Marks</th>
<th>Sessional Viva Marks</th>
<th>Total Marks</th>
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<td>4</td>
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<td>3</td>
<td>100</td>
<td>50</td>
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**SEMESTER -I**

- CH- 501 Mathematical Methods in Chemical Engineering
- CH- 502 Fluid Mechanics
- CH- 503 Mass Transfer Theory

**SEMESTER -II**

- CH- 504 Chemical Engg. Thermodynamics
- CH- 505 Environmental Engg.

**SEMESTER –III**

- CH- 506 Advanced Heat Transfer
- CH- 507 Chemical Reaction Engg.
- CH- Elective -I

**SEMESTER –IV**

- CH- 512 Process Dynamics & Control
- CH- Elective -II

**SEMESTER -V**

- CH- 517 Statistical Methods for Data Treatment
- CH- 518 Process Modelling and Simulation (Lab.)
- CH- 519 Graduate Seminar

**SEMESTER – VI**

- CH- 500 Dissertation

### LIST OF ELECTIVES

**ELECTIVE- I**

- CH- 508 Multi Component Distillation
- CH- 509 Adsorption Engg.
- CH- 510 Refrigeration Engg.
- CH- 511 Advanced Polymer Science & Engineering

**ELECTIVE- II**

- CH- 513 Colloid and Surface Chemistry
- CH- 514 Corrosion Engg.
- CH- 515 Bio Mass Utilization
- CH- 516 Advanced Energy Technology
Finite element analysis

Introduction to integral formulation of boundary value problems using variational methods, least square methods, Galerkin’s method, one dimensional linear elements with examples. Element matrices using Galerkin’s formulation.

Operation Research:

Duality theorem: Revised simple method

Transportation methods:

Introduction to the transportation model, Matrix terminology, Formulation and solution of transportation using various methods.

Assignment model:

Introduction to assignment model, Matrix Terminology, Comparison with Transportation model, Mathematical formulation and solution of assignment models.

Sequencing Models:

Introduction to sequencing models, processing of two jobs, through two machines, the travelling salesmen problem, Minimal path problem.

Z- Transforms:

Introduction, some standard Z- Transforms, linearity property, damping rule, some standard results, shifting rules, initial and final value theorems, convolution theorem, evaluation of inverse transforms, applications to difference equations.

Books Recommended:

8. B.S.Grewal : Higher engg mathematics, Khanna publishers, New Delhi
**Dimensional Analysis:** Buckingham Pi theorem, Reyleighs method, Geometric
Kinematic and dynamic similarity, scale up numerical problems on pumps, drag force
and agitation.

**Differential equation of fluid flow:** Continuity equation for one-dimensional and
three-dimensional flow. Deviation of momentum equation (Navier-stokes equation)
for three dimensional flow.

**Flow of non-Viscous flows:** Equation of motion (Euler equation) and its integration
to obtain Bernoulli’s equation, velocity potential and irrotational flow, streamlines
and stream functions for two dimensional incompressible flow, two dimensional
irrotational flow and flow nets.

**Laminar flow of viscous fluids:** Effect of viscosity on flow, pressure gradient in
steady uniform flow, poseuille’s equation and friction factor, Reynolds number,
Velocity profile in isothermal flow in circular tubes and annuli, and friction factor
relation. Flow in infinite parallel plates and shear stress.

**Turbulent flow of viscous fluids:** Prantyl mixing length theory, Reynolds equation
for in compressible flow. Reynold stresses, Statistical theory of turbulence.
Measurement of turbulence, hot wire anemometer and its use in turbulence
parameters.

**Flow in compressible fluid passed immersed bodies:** Von- Karman integral
momentum equation, boundry layer on immersed bodies, equation of two dimensional
flow in boundary layer, local and total drag coefficient. Transition from laminar to
turbulent flow on the flat plate.

**Pumping and piping:** pumps for pumping all types of liquid/slurries their design
consideration. Process plant piping, piping network and design.

**General topics:**
(a) Non Newtonian flow in lamina flow.
(b) Velocity measurement techniques for fluids.

**Books Recommended:**
   1974
2) Mc Cabe, Smith and Harriot, Unit operations of chemical Engg, Mc Graw Hill
   Book Co., 1993
3) Gupta Santosh K., momentum transfer operations, Tata McGraw Hill
4) Sissen, L.E., Pitts D.R., Elements of transport phenomenon, McGraw Hill.
   1972
5) Nevers Noel de, fluid mechanics for chemical Engg, 2nd edition, Mc Graw
   Hill, 1991
6) Streeter V.L., Fluid mechanics Mc Graw Hill
General methods of solution of problem in unsteady-state molecular diffusion in isotropic media. Derivation of equations of unsteady-state diffusion for typical cases of mass-transfer in infinite semi-infinite and finite plane media and in spherical and cylindrical media.

Mechanism of turbulent diffusion in fluids: applications of the concept of boundary layers theory and of analogies of momentum heat and mass transfer to turbulent range diffusional phenomena. A theoretical treatment of interrelation ship of mass transfer coefficient and heat transfer coefficient.

Interphase diffusional phenomena: steady state and unsteady state theories of diffusion in two phase systems, significance of hydrodynamic factor in mass transfer between two phases in relative motion.

Mass transfer with Chemical Reaction: Diffusion reaction equations, slow reactions, fast reactions, transition from low to fast reaction, problems in practice.

Books Recommended:

1. Review & Applications of Laws of Thermodynamics and other basic concepts.

**Thermodynamic Properties:**
Inter-relationship of properties; Equations of States; Law of corresponding states with practical examples; Maxwell’s relations; Mathematics of property changes, Jacobian Method.

**Solution Thermodynamics**

**Thermodynamic Properties and VLE from Equations of State:**
The nature of equilibrium, The Phase Rule, The Gamma/ Phi Formulation of VLE, Dewpoint and Bubblepoint Calculations, Flash Calculations; solute(1)/ solvent(2) systems; properties of Fluids from the Various Equations of State; VLE from Cubic Equations of State.

**Phase Equilibria**
Equilibrium and Stability; Liquid/ Liquid Equilibrium( LLE), Vapour/ Liquid/ Liquid Equilibrium( VLLE); Solid/ Liquid Equilibrium( SLE); Solid/ Vapour Equilibrium(SVE); VLE by Molecular Simulation

**Chemical- Reaction Equilibria**
The Reaction Coordinate; Application of Equilibrium Criteria to Chemical Reactions; The Standard Gibbs Energy Change and the Equilibrium Constants; Effect of Temperature on the Equilibrium Constant; Evaluation of Equilibrium Constants; Relation of equilibrium constants to composition; Equilibrium Conversions for single Reactions; Phase rule & Duhem’s Theorem for reacting systems; multireaction equilibria.

**Introduction to irreversible thermodynamics .**

**BOOKS RECOMMENDED**

**CH-505 ENVIRONMENTAL ENGINEERING**

**Air Pollution :**
1. Inter-relation ship between energy and pollution, global warning, effect of change in climate on eco-systems and world economy, clean and green technologies, pollution by automobiles and aircrafts.


3. Metrological aspects of air pollution, inversion, types of plumes and their behavior and different atmospheric stability conditions, plume dispersion, Gaussian model, buoyant plumes (Temperature profile of earth’s atmosphere and its role in air pollution)

4. Types of smogs, photo-Chemical and Classical, fog, mist aerosol diffusion coefficient, air quality and emission standards.

5. Particulate matter as air pollutant, its sources and effects, its removal equipments: setting chambers, cyclone, electrostatic precipitators filter bags, venture scrubbers - their advantages and disadvantages and selection of equipments Types of cyclones; Stairmand design of cyclones, grade efficiency curves, pressure drop measurement.

6. Removal of Sox and Nox from stack gases (mainly from thermal plants and chemical industries)

**Water Pollution**

7. Types of water pollutants, their sources and effects (mainly from chemical industry)

8. Primary, Secondary and tertiary treatment of waste water, thickening of sludge, activated sludge process, sludge processes, sludge digester. Treatment of low POD and BOD waste waters. Trickling filters their working and design, some tertiary treatment methods.

**Solid Pollution**


10. Disposal of solid waste.

11. Solid waste management, Reuse of Solid waste materials, Recovery of materials & metals, Conversion into useful products

**BOOKS RECOMMENDED**


Application of Dimensional Analysis to Convection Problems


**Natural Convection Heat Transfer**: Free Convection Heat Transfer on a Vertical Flat Plate, Empirical Relations for Free Convection, Free Convection from Vertical Planes and Cylinders, Free Convection from Horizontal Cylinders, Free Convection from Inclined Surfaces, Non-Newtonian Fluids, Simplified Equations for Air, Free Convection from Spheres, Free Convection in Enclosed Spaces, Combined Free and Forced Convection,

**Analogies Between Momentum Heat and Mass Transfer**

**Heat Transfer in Packed Fluidized Beds**


**BOOKS RECOMMENDED**:

Review of fundamental concepts in kinetics, design equation for single and multiple reactions in isothermal batch, semi – batch, stirred tank and plug –flow reactors.


Introduction to optimization of Chemical Reactors.

Non – ideality in reactors: Its effects on conversion and one parameter models for non – ideal flow, Multi parameter models for real reactors, Mixing of fluids in reactors and its effect on chemical conversion, Characterization of micro and macro mixing.

Kinetics and its application to design of isothermal fixed bed and fluidized reactors for fluid- solid catalytic reactions. Catalyst deactivation. One dimensional; and two dimensional models for non – isothermals, non- adiabatic fixed- bed reactors. design of Slurry and trickle – bed reactors. Design of slurry and trickle bed reactors.

BOOKS RECOMMENDED


ELECTIVE – I

CH-508   MULTI-COMPONENT DISTILLATION

Binary Vapour – liquid Equilibria: P-x-y diagram, T-x-y diagram, X-y diagram,
Nonideal Vapour – Liquid Equilibrium : Activity Coefficient (Various Correlation),
K- Factor, Relative Volatility.

Different methods of flash vaporization calculations including empirical co-relations,
Analytical (Fensky, Underwood & Smoker equations) and graphical methods for
calculation of stage requirement for binary and multi-component systems for constant
and varying flow rates for varying relative volatilities for complex columns involving
multiple feeds, side streams, open stream and like, for other special cases.

Methods for estimation of minimum reflux requirements, optimum, feed stage
locations and minimum number of stages. Extractive and Azeotropic distillations,
general considerations for the choice of separating agents and methods of
calculations.

Unsteady state distillation, single and multistage processes, effect of column hold
up, Contacting efficiencies in distillation, different methods for estimation of
efficiencies, effect of liquid mixing.

Distillation trays, Hydraulic and other design considerations.

BOOKS RECOMMENDED

   International Editions.

2. McCabe & Smith : Unit Operations of Chemical Engineering,
Adsorption vs distillation, Selectivity’s, Practical Adsorbents, Zeolites, Commercial Molecular Sieve Adsorbent.


BOOKS RECOMMENDED

**Introduction and Basic Concepts:** Introduction; Various Methods of Refrigeration; Unit of Refrigeration and Coefficient of Performance; Carnot Refrigeration Cycle; Difference between Heat Engine, Refrigerator and Heat Pump

**Vapour Compression Refrigeration Systems:** Carnot Vapour Compression Cycle; Simple Vapour Compression System; Wet Compression Versus Dry Compression; Expansion Process; Simple Vapour Compression Cycle; Ewing’s Method for Suction State with respect to Maximum COP; Use of p-h Chart; Effect of Condenser Pressure, Evaporator Pressure, Super Heating of Refrigerant Vapour before Suction And Sub cooling of Refrigerant Before Expansion on Performance of Vapour Compression Cycle; Actual Vapour Compression Cycle

**Multi-Pressure Vapour Compression Systems:** Multi-Pressure Vapour Compression Systems in Industrial Refrigeration; Multistage Vapour Compression Systems; Necessity of Multistage Vapour Compression System; Optimum Inter-stage Pressure; Removal of Flash Gas; Inter-cooling; Multistage Vapour Compression Systems with Multi-Evaporators ,Multi-Compressors with or without Flash Gas Removal and Flash Gas Inter-cooling; Cascade Refrigeration System

**Vapour Absorption Refrigeration System:** Principle of Vapour Absorption Refrigeration System; Comparison of Vapour Absorption Refrigeration System with Vapour Compression Refrigeration System; Aqua-Ammonia Vapour Absorption Refrigeration System; Temperature-Concentration Diagram; Temperature-Enthalpy Diagram; Lithium-Bromide Water-Vapour Absorption Refrigeration System; Three Fluid Absorption Refrigeration System; Multi-Stage Vapour Absorption System

**Refrigerants:** Primary and Secondary Refrigerants; Halocarbon Compounds; Inorganic Compounds; Hydrocarbons; Azeotropes; Nomenclature of Refrigerants; Thermodynamic, Chemical and Physical Properties of Refrigerants; Common Refrigerants; Environmental Aspects of Refrigerants; Alternative Refrigerants; Comparative Study of Refrigerants

**Refrigeration Equipments:** Compressors; Condensers; Evaporators; Expansion Devices; Selection of Capillary Tube; Drier, Receiver, Oil Separator and Electric Controls

**Low Temperature Refrigeration:** Applications; Joule-Thomson Coefficient and Irreversible Expansion of Gases; Liquification of Gases, Linde or Linde-Hampson System; Claude Liquification System; Helium Liquification; Refrigeration System for Solid CO₂; Magnetic Cooling

**Non-Conventional Methods of Refrigeration:** Steam Jet Refrigeration; Vortex Tube Refrigeration; Pulse Tube Refrigeration; Thermo-Electric Refrigeration

**BOOKS RECOMMENDED**

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<tr>
<th>Reference</th>
<th>Author</th>
<th>Publisher</th>
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<tr>
<td>(1)</td>
<td>Principles of Refrigeration</td>
<td>Dossat John</td>
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<td>(2)</td>
<td>Mechanical Refrigeration</td>
<td>Sparks &amp; Dillo</td>
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<td>(4)</td>
<td>Refrigeration &amp; Air-Conditioning</td>
<td>Jordan &amp; Priester</td>
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<td>(5)</td>
<td>Air-Conditioning &amp; Refrigeration</td>
<td>Jennings &amp; Lewis</td>
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<td>(7)</td>
<td>Refrigeration &amp; Air-Conditioning</td>
<td>Manohar Prasad</td>
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<td>Refrigeration &amp; Air-Conditioning</td>
<td>Arora &amp; Doam-</td>
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<td>(9)</td>
<td>Refrigeration &amp; Air-Conditioning</td>
<td>P.L. Ballani</td>
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**ELECTIVE - I**

**CH-511 Advanced Polymer Science & Engg.**

**Introductory Survey:** Definition and Concept of polymers, Classification of polymers, Structure-Properties relationship, configuration and conformation, solubility parameter, intrinsic viscosity, diffusion and permeability in polymers, crystallization from melt, Kinetics of crystallization, Theory of glass transition.

**Polymerization:** Step polymerization (Carothers equation, reactivity of functional groups, kinetics of step polymerization), accessibility of functional groups in polymerization reaction, cross linking technology, distribution of molecular weight in bi-function polymerization, prediction & practical consideration of gel point; Free Radical polymerization (Kinetics rate & nature), Determination of absolute rate constant; Nature of termination and its effect on distribution on molecular weight; auto-acceleration & its kinetic study; Process condition; Relation between chain length & D.P.; Thermodynamic Consideration; Living Polymers; Ionic Chain Polymer; Comparison between Radical and ionic polymerisation; Cationic co-polymerization of C-C bond; Anionic polymers of C-C double bond; copolymerization; kinetics of copolymers; monomers reactivity ratio; significance of co-polymerization; block & graft copolymers; copolymer composition; kinetics of stereo regular polymerization; detailed study of kinetics & mechanism of polymerisation involving Ziegler Natta catalysts & metallocene catalysts; ring opening polymerization; group transfer polymerisation: detailed study of kinetics & mechanism of formation of inorganic polymers.

**Techniques of polymers:** Design criterion of polymerisation system; brief introduction & comparison of various techniques of polymerisation; bulk polymerisation; solution polymerisation (description of process, effect of process, parameter of polymerisation kinetics and distribution on molecular weight of polymers) emulsion polymerisation; (description of process, effect of process parameter on polymerisation kinetics and distribution on molecular weight of polymers); inverse emulsion polymerisation (description of process, effect of process parameter on polymerisation kinetics and distribution on molecular weight of polymers); suspension polymerisation (description of process, effect of process parameter on polymerisation kinetics and distribution on molecular weight of polymers).

**BOOKS RECOMMENDED**

2. ‘Outlines of Polymers Technology’ by Sinha PHI.
3. ‘Poly Science’ by Joel R Fried PHI.
4. ‘Poly Science’ by Billimeyar Jr.
5. ‘Principles of Polymerisation’ by G. Odian.
6. ‘Momentum Heat & Mass to fundamentals, by Kcssler, DI publication by Decker.'
CH-512 PROCESS DYNAMICS & CONTROL


**Stability** : Concept of Stability, Routh Test for Stability, Concepts of Root Locus & their plotting.

**Frequency Response** : Introduction to Frequency Response. Control System Design by Frequency Response.


**State – Space Methods** : State-Space Representation of Physical Systems, Transfer Function Matrix, Multivariable Control.


**BOOKS RECOMMENDED** :

Energy Classification, Sources, Utilization, Economics and Terminology


Nuclear Power Reactor System

Production of Energy from Biomass: Gasification, Pyrolysis and Combustion Technology.


BOOKS RECOMMENDED:

3. Armando Caccres, Cemat Apartado Postal 1160, Gutamala City, Gautamala.
5. Samir Sarkar; Fuel and Combustion.
CH-517 STATISTICAL METHODS FOR DATA TREATMENT

1. Introduction: Modern Statistics. The Role of Scientists and Engineers in Quality Improvement.


3. Sampling Distributions: Populations and Samples: The sampling distribution of the Mean; The Sampling Distribution of the Variance.

4. The Mean, Median Mode and Other Measures of Central Tendency.

5. The Standard Deviation and other Measures of Dispersions.


7. Proportions: Estimations of Proportions, Bayesian Estimation, Hypothesis concerning one proportion, Hypothesis concerning several Proportions, The Analysis of r x c tables, Goodness of Fit.


9. Curve Fitting: The Method of Least Squares, Curvilinear Regression, Multiple Regression, Checking the Adequacy of the Model, Correlation, Multiple Linear Regression.


Books Recommended:


