UNIVERSITY OF PUNE
STRUCTURE T.E. (PETROCHEMICAL ENGINEERING)
2008 COURSE

Sub. No.	Subject	Teaching Scheme Hrs/Week			Examination Scheme (Marks)			
		Lect	Pr	Tut/Drg	Paper	TW	PR	OR
Term – I								
312401	Numerical and Statistical Methods	4	2	-	100	50	-	
312402	Applied Hydrocarbon Thermodynamics	4	-		100	-	-	
312403	Mass Transfer -I	4	2		100		50	
312404	Petrochemical Processes-I	4	2	-	100	50	-	
312405	Instrumentation and Instrumental Analysis	4	2	-	100	50	-	
312406	Chemical Engineering Laboratory I	--	2	-	-		50	
	Total	20	10		500	150	50	50
	Total Term – I	30			750			
Term – II								
312407	Transport Phenomena	4	-	-	100	-	-	
312408	Mass Transfer-II	4	2	-	100			50
312409	Reaction Engineering – I	4	-	-	100	-	-	
312410	Petrochemical Processes-II	4	2	-	100	-	50	
312411	Process Equipment Design and Drawing	4		2	100			50
312412	Computational Methods	-	2			50		
312413	Seminar	-	2		-	50		
	Total	20	08	02	500	100	50	100
	Total Term – II	30			750			
	Total for the year	60			1000	250	100 150	
	Grand Total				1500			

312401 NUMERICAL AND STATISTICAL METHODS
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:	**Examination Scheme:**
Lectures: 4 Hrs / week	Paper: 100 Marks
Practical: 2 Hrs / week	Term Work: 50 Marks

Objectives:

1. To get acquainted with operations research tools and statistical techniques required in petrochemical engineering practice.
2. To learn to apply numerical techniques in solving algebraic and differential equations usually encountered in petrochemical engineering practice.
3. To develop programming skills necessary for coding of algorithms.

SECTION – I

Unit 1: Operations Research: (08 Lect.)

Linear Programming, Formulation & Solution, Convex sets, Simplex method, duality. Applications of Linear Programming in Petrochemical Engineering..

Unit 2: Transportation and Assignment Problems: (08 Lect.)

Transportation problem, North-West corner rule, Vogel's Approximation Method, Balanced and Unbalanced transportation problems, Assignment problem, Hungarian method.

Unit 3: Statistics and Probability: (08 Lect.)

Correlation and Regression of data, Probability. Probability Distributions, Binominal, Normal and Poisson Distribution, Testing of Hypothesis, χ^2 Distribution

SECTION – II

Unit 4: Numerical Analysis: (08 Lect.)

Calculus of Finite difference, Finite difference Operators, Newton's, Lagrange's and Stirling's Interpolation formulae. Lagrange's method for interpolation

Numerical differentiation and Numerical Integration, Trapezoidal Rule, Simpson's 1/3 rd and 3/8th rules, weddle's rule, Error analysis.

Unit 5: Solutions of Equations: (08 Lect.)

Solution of Algebraic and Transcedental equations, Method of False Position, Newton-Raphson method, Method of Successive Approximation, Convergence and Stability Criteria.
Solution of System of Simultaneous Linear Equations, Gauss Elimination Method, Gauss-Seidel Method.
Method of Least Square for curve fitting.

Unit 6: Ordinary and Partial Differential Equations: (8 Lect.)

Solution of Ordinary differential equations, Euler's method, Modified Euler's method, Runge-Kutta method,.
Solution of Partial differential equations using finite difference technique. Explicit and Implicit methods. Solution of one dimensional unsteady state problems in heat and mass transfer.

Term Work:

Every student should carry out minimum ten exercises from the following list and submit the journal, which will form the term work.

List of Practical:

1. Numerical Analysis:

   a) Developing Computer Programmes using 'C' Language for following Numerical Methods.

      1. Regula Falsi Method.
      2. Newton-Raphson Method.
      3. Successive Approximation Method: Evaluation of Bubble and Dew Point.
      4. Newton's forward and backward difference interpolation methods.
      5. Lagrange's method for interpolation.
      6. Trapezoidal Rule.
      7. Simpson's 1/3rd Rule.
      8. Least Square Approximation for Curve Fitting.
      9. Modified Euler's Method: Determination of Optimal Residence Time for Batch Reactor.
      10. Runge-Kutta Method: Dynamic Response of CSTRS in Series.
      11. Guass Elimination Method.
      12. Guass-Seidel Method.
      13. Explicit Finite Difference Scheme.

   b) Solving preformulated mathematical models for Chemical Engineering operations using mathematical software packages such as fitting of kinetic parameters of a chemical reaction.

2. Assignments involving computer solutions of Chemical Engineering problems employing linear programming and statistical methods.

Reference Books:

1. Chapra S. C. and Canale R. D.; Numerical Methods for Engineers; WCB/McGraw-Hill Publications, 2001.
2. Gupta Santosh K.; Numerical Methods for Engineers, 2nd Edition, New Age International Publishers Ltd., Wiley Eastern Ltd., 2009.
3. Johnson Richard; Miller Irwin and Freund John's Probability and Statistics for Engineers; Seventh Edition, Prentice-Hall, 2004.

4. Taha H. A.; Operations Research-An Introduction; Seventh Edition, Prentice-Hall, 2002.
5. Beers, K. J.; Numerical Methods for Chemical Engineering: Applications in MATLAB; Cambridge University Press, 2007
6. M.E. Davis, "Numerical Methods & Modelling for Chemical Engineers", Wiley, 1984.

312402 APPLIED HYDROCARBON THERMODYNAMICS
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:
Lectures: 4 Hrs / week

Examination Scheme:
Paper: 100 Marks

Objectives:

1. To be able to calculate heat and work effects associated with a process.
2. To understand treatment of experimental data in thermodynamics and to learn to predict and correlate important thermodynamics properties of fluids.
3. To gain insight into phase equilibria and chemical equilibria.

SECTION – I

Unit 1: Introduction and Basic Concepts: (08 Lect.)

Revision of basic terminology of thermodynamics. Applications of laws of thermodynamics to open and closed systems of practical interest in process industry. Irreversible vs reversible processes.Exergy analysis. Chemical potential with reference to single component open systems.

Unit 2: Properties of Fluids:Volumetric and Thermodynamic (08 Lect.)

(a) Volumetric Properties: P-V-T behaviour of pure substances, Critical properties. Concept of ideal gas. Equations of states for real gases.
(b) Thermodynamic properties: Property relations for homogeneous system. Residual properties. Thermodynamic network

Unit 3:Equilibrium and Stability (08 Lect.)

Criteria of equilibrium. Chemical potential. Application of equilibrium criteria.Stability.Phase diagram.Clapeyron equation. Solid-Liquid, Solid-Vapor and Liquid-Vapor equilibrium. Presentation of thermodynamic property data.

SECTION – II

Unit 4: Phase Equilibrium I (08 Lect.)

Determination and presentation of VLE data. Phase rule.Fugacity.Activity coefficients. Gibbs-Duhem equation. Experimental determination of activity coefficients. Henry's and Raoult's laws. Activity coefficient equations.

Unit 5: Phase Equilibrium II (08 Lect.)

Partial molar properties. Property changes on mixing for ideal and real solutions. Excess properties. Multicomponent phase equilibrium. Estimates from fragmentary data. Phase equilibrium via an equation of state.

Unit 6: Chemical Reaction Equilibria: (08 Lect.)

Generalized stoichiometry.The condition of equilibrium for a chemical reaction. Standard states and standard Gibbs free energy change. Temperature dependence of the equilibrium contant. Experimental determination of thermochemical data. Group contribution methods .Homogeneous and heterogeneous chemical equilibrium. Phase rule for reacting systems.

Reference Books:

1. Kyle B. G.; Chemical and Process Thermodynamics, Third Edition, Prentice Hall, 1999.
2. Sandler S. I.; Chemical Engineering Thermodynamics, Wiley, New York, 2001.
3. Smith J. M., Van Ness H. C. and Abbott M. M.; Introduction to Chemical Engineering Thermodynamics, Sixth Edition, Tata McGraw Hill, 2000.
4. Vidal Jean; Thermodynamics Applications in Chemical Engineering and Petroleum Industry; Editions Technip, Paris, 2003.

312403 MASS TRANSFER-I
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:
Lectures: 4 Hrs / week
Practicals: 2 Hrs / week

Examination Scheme:
Paper: 100 Marks
Practical: 50 Marks

Objectives:

1. To be familiar with equations describing molecular diffusion through gases, liquids, and solids.
2. To be familiar with techniques used to estimate mass transfer coefficients in laminar and turbulent flows.
3. To get acquainted with the general approach for the design of continuous contact and stage wise absorption towers.

SECTION - I

UNIT 1: Mass Transfer Operations and Molecular Diffusion: (08 Lect.)

General principles of mass transfer, Classification of mass-transfer operations, Choice of separation method, Methods of conducting the mass-transfer-operations, Design principles.

Principles, theory of diffusion, Fick's first law, steady state molecular diffusion in binary mixture of gases and liquids, diffusion coefficient in binary liquids and gases. Diffusion in solids, Multicomponent diffusion

UNIT 2: Interphase Mass Transfer (08 Lect)

Equilibrium, Diffusion between phases, Local and average phase /overall mass transfer coefficients, Material balances for steady-state co-current and countercurrent processes, Stage wise and differential contact, Theoretical stages, NTU, Stage, local and overall efficiency.

UNIT 3: Mass Transfer Coefficients (08Lect.)

Mass transfer coefficients in laminar and turbulent flow, Theories for mass transfer: Film Theory, Penetration theory, Surface renewal theory, Convective mass transfer, Dimensionless group of mass transfer and its applications, Analogies and correlations between heat, mass, and momentum transfer, Mass transfer data for simple situations.

SECTION – II

UNIT 4: Equipment for Gas-Liquid Operation (08 Lect.)

Gas dispersed: Sparged vessel/Bubble column, Mechanically agitated vessels for gas liquid contact, Tray Towers, Type Of trays, flow arrangements on tray, Tray efficiency, Sparged vessels, Gas hold up – concept of sleep velocity.

Liquid dispersed: Ventury Scrubber, Wetted wall tower, Spray tower, Spray chamber, Packed tower, Mass Transfer coefficients for packed tower, Types of packings, End effects and axial mixing, Tray tower Verses packed tower, Liquid hold up – determination of interfacial area based on hold up and mass transfer coefficients, Co-current flow of gas and liquid, hydrodynamic behavior of packed and tray towers.

UNIT 5: Humidification Operations (08 Lect.)

Concept of humidity and definitions, dry bulb temperature, wet bulb temperature, adiabatic Saturation temperature, adiabatic saturation, psychometric charts, adiabatic operations humidification operations and water-cooling operations, Humidification and dehumidification operations, Humidifier height calculations, cooling tower principle and operation, types of equipment, design calculation.

UNIT 6: Drying Operations (08 Lect.)

Moisture contents of solids, drying conditions – rate of batch drying under constant drying conditions, mechanism of batch drying, drying time, thorough circulation drying, Classification and selection of Industrial dryers, design of continuous counter current dryer.

Term work:

Every student should carry out minimum ten exercises from the following list and submit the journal, which will form the term work.

List of Experiments:

1. To determine diffusivity of acetone in air.
2. To determine mass transfer behavior in Surface evaporation
3. To determine mass transfer behavior of packed bed.
4. To determine mass transfer behavior of plate column.
5. To determine mass transfer behavior of wetted wall tower.
6. To determine mass transfer behavior of spray chamber.
7. To determine mass transfer behavior of a sparged vessel.
8. To determine mass transfer coefficient for surface evaporation.
9. To determine liquid hold up in packed tower.
10. To evaluate performance of humidification/ de-humidification column.
11. To determine drying characteristics of a wet solid material using tray dryer
12. To study hydrodynamic behavior of packed columns.
13. To study different types of packings
14. To study different types of trays

Reference Books:

1. Treybal, R.E.; Mass Transfer Operations; McGraw-Hill, Kogakusha, 1980
2. Thomas-K-Sherwood, Robert L. Pigford, Chorles R. Wilke, “Mass transfer” International Student Edition, McGraw Hill, Kogakusha Ltd., 1975.
3. Cussler E.L.; Diffusion: Mass transfer in fluid Systems; 2nd Edition, Cambridge University Press, 1998.
4. Geankoplis, C.J, Transport Processes and Unit Operations; PHI, 3rd Edition, 1993.
5. Hines A. L., R. N. Maddox; Mass Transfer Operations: Fundamentals and Applications; Prentice-Hall, Inc, Englewood Cliffs, New Jersey, 1985.

312404 PETROCHEMCIAL PROCESSES I

(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:
Lectures: 4 Hrs / week
Practicals: 2 Hrs / week

Examination Scheme:
Paper: 100 Marks
Term work: 50 Marks

Objectives:

1. To learn scientific and technological principles of Organic Synthesis and related Unit Processes.
2. To understand the role of Petrochemical Engineer in Unit Processes used for Organic Synthesis, biochemical processes, polymerization and nanotechnology.

SECTION – I

Unit 1: Nitration, Halogenation and Sulfonation (8 Lect.)

Overview of Organic Chemical Industry and Petrochemical Industry.
Overview of following Unit Processes with applications
Nitration - Nitrobenzene, Nitrotoluenes
Halogenation – DCM, MCA, VCM, Chlorobenzene
Sulfonation and Sulfation – BSA, DBS

Unit 2: Oxidation, Hydrogenation and Amination: (8 Lect.)

Overview of following Unit Processes with applications.
Oxidation – Formaldehyde, Acetic acid, Ethylene oxide
Hydrogenation –Catalysts and applications
Amination by Reduction and Ammnolysis – Anilines.

Unit 3: Alkylation, Esterification and Hydrolysis (08Lect.)

Overview of following Unit Processes with applications: Alkylation and Acylation- Cumene, Dodecyl benzene,Acetophenone Esterification – Ethyl acetate. Hydrolysis – Ethanol, Glycols

SECTION – II

Unit 4:Biochemical Processes (08 Lect.)

Important Industrial Fermentations such as ethanol manufacturing.
Engineering challenges in Bioprocesses and Bioseparations. New trends in Organic Synthesis. Asymmetric Synthesis. Photochemical Processes.

Unit 5: Polymerizarion Processes (08 Lect.)

Monomers and Polymers. Classification, types, properties and applications of polymers. Polymerization processes. Addition and condensation polymerization with examples.

Unit 6: Nanotechnology (08 Lect.)

Origin. Fundamental concepts. Nanomaterials such as carbon nanotubes and other fullerenes. Bottom up, Top down, Functional and Biomimetic approaches. Applications in petrochemical industry**.**

Term Work:

Every student should carry out minimum ten exercises from the following list and submit the journal, which will form the term work.

List of Experiments:

At least ten experiments from the following list should be performed

1. Conversion of Phenol to Anisole (O-Alkylation).
2. Conversion of Benzene to Nitrobenzene (Nitration).
3. Conversion of Nitrobenzene to Aniline (Amination by Reduction).
4. Conversion of Aniline to 2,4,6-Tribromoaniline (Halogention).
5. Conversion of Aldehyde to Carboxylic Acid (Oxidation).
6. Conversion of Carboxylic Acid to Ester (Esterification).
7. Conversion of Carboxylic Acid to Acid Chloride to Amide (F G Interconversion).
8. Conversion of Cinnamic Acid to Hydrocinnamic Acid (Hydrogenation).
9. Conversion of 2-Naphthol to Nerolene (O-Alkylation).
10. Conversion of Aldehyde of Alcohol (Reduction).
11. Oxidation of side chain of an aromatic substrate (Oxidation).
12. Experiment involving C – Alkylation.
13. Experiment involving N – Alkylation.
14. Experiment involving a Photochemical Conversion.
15. Experiment involving a Fermentation Process.

Reference Books:

1. Rao M Gopala, Marshall Sittig; Dryden's Outlines of Chemical Technology; East West Press; Third edition, 1997.
2. Groggins P H; Unit Processes in Organic Synthesis; Tata McGraw Hill; Fifth Edition, 1995.
3. Wittcoff H. A. and Reuben B. G.; Industrial Organic Chemicals; Wiley Interscience Publication; Fifth Edition, 1996.
4. Chauvel A and Lefebvre G.; Petrochemical Processes – I; Gulf Publication; First Edition, 1989
5. Mall I.D. "Petrochemical Process Technology", Macmillan India Ltd,2007
6. Wiseman P., "Petrochemicals," Ellis Horwood Ltd., 1986
7. Shuler Michael L and Kargi F,"Bioprocess Engineering Basic Concepts",Prentice Hall India, 2004

312405 Instrumentation and Instrumental Analysis
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:	**Examination Scheme:**
Lectures: 4 Hrs / week	Paper: 100 Marks
Practicals: 2 Hrs / week	Term Work: 50 Marks

Objectives

1. To understand the fundamentals and working principles of instrumentation and instrumental analysis
2. To understand and interpret the results of various analyzers
3. To understand various quality control norms and specifications related to refining and petrochemical industry

SECTION ONE

Unit 1 Introduction to Instruments, Characteristics and Signal conditioning (8Lect)

Introduction to Instruments and Their representation: Introduction, Elements, Classification, Standards, Calibration procedures

Static and Dynamic Characteristics of Instruments, Specification of static characteristics, Selection of instruments, Forcing functions, Formulation of First order and second order system equations, Dynamic response

Principals of Analog signal conditioning, converters, guidelines for analog signal conditioning design , Principles of digital signal conditioning, computer interface, DACs, ADCs, DAS hardware, DAS software, characteristics of digital data

Unit 2 Temperature, Pressure, Level measurements (8Lect)

Temperature measurement: Temperature scales, Non electrical methods, Electrical methods, Radiation methods

Pressure measurement: Moderate pressure measurement, High pressure measurement, vacuum measurement

Level measurement: measurement techniques for Liquids and slurries, advance measurement techniques

Unit 3 Flow measurements and study of Valves (8Lect)

Flow measurement: Introduction, Review of Venturimeter, orifice meters, rotameters, Pitot tube, working of turbine, vortex shedding, electromagnetic flow meters

Introduction to Advanced flow measurement techniques: Hot Wire anemometer, Laser Doppler anemometer, Ultrasound, Particle image Velocimetry

Study of Valves: Types of Valves, Actuators, Positioners, Valve characteristics, Controllability and Rangeability, Cavitation, Flashing, choking, Valve Sizing for incompressible fluids, compressible fluids, Two phase flows

SECTION II

Unit 4 Introduction to Quality control and Analytical Techniques (8Lect)

Need for Chemical analysis in Petroleum industry. Crude Assay. Standard Test Methods. Introduction to principles of Analytical techniques: Spectroscopic Techniques, Chromatographic techniques, Crystallography, electrochemical analysis, thermal analysis, electrophoresis, calorimetery, Hybrid techniques

Unit 5 Working and Interpretation of Instrumental analytical methods : I (8Lect)

Spectroscopic techniques: Atomic Absorption, X-ray, inductively coupled argon plasma (ICAP), ultraviolet – visible (UV-VIS), fluorescence, infrared (IR), Raman spectroscopy, mass spectrometry (MS),nuclear magnetic resonance (NMR)

Chromatographic Techniques: gas chromatography (GC), high pressure liquid chromatography, gel permeation chromatograpghy (GPC) , thin layer chromatograpghy (TLC), super criticle fluid chromatography (SFC)

Classification of spectroscopic and chromatographic techniques for Analysis of fuels

UNIT 6 Working and Interpretation of Instrumental analytical methods: II (8Lect)

Lubricant Analysis: constituents of lubricants, characterization of lubricants by analytical techniques, importance of elemental analysis in lubricants

Miscellaneous measurements and analysis: density, viscosity, Refractormeter, pH and redox potential measurements. Thermal conductivity gas analyzers. Oxygen determination. Orsat analysis

Term work:

Every student should carry out minimum ten exercises from the following list and submit the journal, which will form the term work

List of Experiments:

To Study working, characteristics and applications of following instruments and analyzers

1. Temperature measurements
2. Pressure measurements
3. Flow measurements
4. Level measurements
5. Types of Valves and valve Characteristics
6. Sizing of valves : incompressible fluids, compressible fluids, Two phase flows
7. Working of feedback loop, its components and data acquisition hardware components
8. First and Second order Response and characteristics
9. To separate and isolate the components of a given sample mixture using column chromatography.
10. To analyze and compare the given hydrocarbon and related samples with standards using GC.
11. Analysis of samples by Refractometer
12. Study experiments on HPLC, GPC,SFC

13. Interpretation of UV, IR and NMR spectra of standard hydrocarbon and related samples.
14. Interpretation of Mass Spectra of standard hydrocarbon and related samples.
15. Force, torque and power measurement techniques
16. Density, viscosity measurement techniques

Reference Books:

1. Eckman, D. P.; Industrial Instrumentation; Wiley Eastern, 1991.
2. Johnson, C.; Process Control Instrumentation Technology; 4th ed., Prentice-Hall International.
3. Liptak, B. G., Venczel, K.; Instrument Engineer's Handbook, Process Measurement; Chiltan Book Company.
4. Nakra, B. C.; Chaudhary K. K.; Instrumentation Measurement and Analysis; Tata McGraw Hill, New Delhi, 1998.
5. Patranabis, D.; Principles of Industrial Instrumentation; Tata McGraw Hill, New Delhi, 1996.
6. Silverstein, Bassler, Morrill; Spectrometric Identification of Organic Compounds; John-Wiley Publication, 1991.
7. Gary J.H. and Handework G.E., "Petroleum Refining Technology and Economics", Marcel Dekker, Inc., 1984.

312406 CHEMICAL ENGINEERING LABORATORY-I

(T. E. Petrochemical Engineering, 2008 Course)

Teaching Scheme:
Practical: 2 Hrs / week

Examination Scheme:
Practical: 50 Marks

Course Objectives

To gain an integrated understanding of the fundamental concepts from stoichiometry, thermodynamics, reaction kinetics, and transport phenomena

Term work:

Every student should carry out minimum twelve exercises from the following list and submit the journal, which will form the term work.

List of Experiments:

1. Analogy between heat and momentum transfer
2. Mixing Performance of Mechanically Agitated Contactor
3. Multicomponent VLE studies
4. Heat transfer in fluidized bed
5. Studies in liquefaction
6. Studies in absorption refrigeration
7. Hydrodynamics of packed bed.
8. Hydrodynamics of sieve tray
9. Joule Thomson Effect
10. Carnot Cycle
11. Heat transfer in Packed Bed
12. Simultaneous heat and mass transfer
13. Benard cells as a model of dissipative structures
14. Fluidized bed drying
15. Organic Rankine Cycle
16. Flow through Piping Network
17. Kinetics of a (Solid-Liquid) Esterification Reaction
18. Interfacial (Liquid-Liquid) Nitration
19. Interfacial Polymerization
20. Energy storage systems

312407 TRANSPORT PHENOMENA
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:
Lectures: 4 Hrs / week

Examination Scheme:
Paper: 100 Marks

Objective:

1. Develop an understanding of the conservation laws that govern mass momentum, and heat transfer
2. Develop the ability to formulate and solve mathematical models for physical situations.

SECTION I

Unit 1 Introduction to Transport Phenomena (8Lect)

Transport Phenomena and Unit Operations. Equilibrium and Rate Processes. Role of Intermolecular Forces. Analogous Forms of Heat Transfer Mass Transfer Momentum Transfer equations. Heat, Mass and Momentum Diffusivities. Estimation of transport properties

Unit 2 Molecular transport and the general property balance (8Lect)

Conservation of mass and energy. Coordinate systems Balance equation in differential form, One directional balance equation including molecular and convective transport.
Three dimensional Balance equations, The continuity equation, The Energy Equation, The Navier Stokes equations.

Unit 3 Flow turbulence (8Lect)

Laminar and turbulent flows. Fully developed turbulent flow
The equations for transport under turbulent conditions: Reynolds rules of averaging, Reynolds equation for incompressible turbulent flow, Reynolds stresses, turbulent flow through pipe. Boussinesq theory. Prandtl mixing length.

SECTION II

Unit 4 Agitation and mixing (8Lect)

Introduction to agitation, types of impellers and their flow patterns, torque measurement, Dimensionless power and pumping numbers, design variables, Scale up with and without geometric similarity, constituent equations and numerical techniques for flow in stirred tanks

Unit 5 : Numerical Heat Transfer (8Lect)

Derivation of basic equation, Unsteady state heat conduction, Numerical finite difference methods for unsteady state conduction, differential equation for energy change, boundary layer flow and turbulence in heat transfer, Dimensional analysis in Heat transfer

Unit 6 Numerical Mass transfer (8Lect)

Review of Mass transfer and diffusion in gases, liquids and solids, unsteady state diffusion, convective mass transfer coefficients, Molecular diffusion Plus convection and chemical reaction, Numerical methods for unsteady state molecular diffusion, Dimensional Analysis in mass transfer, Boundary layer flow and turbulence in mass transfer

References:

1. Robert S Brodkey; Transport Phenomena: A Unified Approach, McGraw Hill,1988
2. Bird R. W. Stewart and E. Lightfoot; Transport Phenomena, Second Edition; John Wiley and Sons Inc., 2002.
3. Geankoplis C. J.; Transport Processes and Separation Process Principles, Fourth Edition; Prentice Hall India, 2003.
4. Noel de Nevers; Fluid Mechanics for Chemical Engineers, Third Edition; McGraw Hill, 2005
5. Kern D. Q.; Process Heat Transfer; McGraw Hill, 1965.
6. Versteeg H.K, Malalasekara W, An introduction to computational fluid dynamics, 1995, Longman Scientific and Technical publications

312408 MASS TRANSFER –II
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:
Lectures: 4 Hrs / week
Practicals: 2 Hrs / week.

Examination Scheme:
Paper: 100 Marks
Oral: 50Marks

Objectives:

1. Be familiar with principles underlying and the derivation of the design equations for basic mass transfer operations.
2. To learn basic design principles and applications relevant to stage-wise operations.
3. To be able to perform design calculations for equilibrium staged separation processes.
4. To use a simulation package (Aspen Plus/Hysys) for processes involving multiple equilibrium-stage and rate-based unit operations.

SECTION-I

Unit 1: Gas Absorption (08 Lect.)

Choice of solvent, Equilibrium and operating line concept in absorption calculations; Absorption factor and stripping factor types of contactors, design of packed and plate type absorbers; Operating characteristics of stage wise and differential contactors, Absorption factor, Kremser equation, concepts of NTU, HTU and overall volumetric mass transfer coefficients, concept of HETP.

Unit 2: Distillation -I (08 Lect.)

Vapor-liquid equilibria, Relative volatility, Ideal Solutions, Relative volatility, Azeotropic mixtures, Raoult's law and deviations from ideality, methods of distillation; fractionation of binary and multicomponent system.

Principle of distillation - flash distillation, differential or simple distillation, steam distillation, multistage continuous rectification, Total reflux, minimum reflux ratio, optimum reflux ratio.

Unit 3: Distillation –II (08 Lect.)

Design calculations by McCabe-Thiele and Ponchon-Savarit methods; continuous contact distillation tower (packed tower) design; extractive and azeotropic distillation, low-pressure distillation; steam distillation, reactive distillation, membrane distillation, effect of operating conditions on the number of ideal stages, Murphree stage and overall efficiency, calculation of actual number of stages, batch distillation with reflux, packed bed distillation, NTU and HTU calculations, Introduction to Multicomponent distillation

SECTION –II

Unit 4: Liquid-Liquid Extraction and Leaching Operations (08 Lect.)

Liquid-Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and countercurrent extraction with and without reflux, Different types of extractors: Selection construction, sizing and operation, Introduction to Solid-liquid extraction (Leaching), Various Types of Leaching Operations with application, Method of Calculations, Leaching equipment.

Unit 5: Adsorption and Ion Exchange (08 Lect.)

Adsorption **–** Types of adsorption, nature of adsorbents, adsorption equilibria, Adsorption isotherms, effect of pressure and temperature on adsorption isotherms, Freundlich equation, Langmuir equation, Break through curve, adsorption equipment for batch and continuous operation.

Ion exchange **–** Principle of Ion exchange, techniques and applications, industrial equipment.

Unit 6: Membrane Separation Processes (08 Lect.)

Membrane separation process, classification of membrane separation processes, solid and liquid membranes, Ultra and Nano filtration, concept of osmosis, reverse osmosis, Electrodialysis, their applications; foam separation process, thermal and sweep diffusion process.

Term work:

Every student should carry out minimum ten exercises from the following list and submit the journal, which will form the term work.

Oral examination will be based on the list of experiments performed during practical.

List of Experiments:

1. To determine the mass transfer coefficient and number of plate in a sieve plate absorption column
2. To carry out gas liquid absorption of CO_2 in aqueous NaOH solution in packed bed column and to determine mass transfer coefficient
3. T-x-y diagram for water-acetone system
4. To generate VLE data for Methanol-Water system in the laboratory
5. To carry out simple distillation for a binary system and verify Rayleigh equation
6. To carry out batch distillation in packed column under variable reflux packed column distillation.
7. To carry out steam distillation.
8. To carry out Liquid –Liquid Extraction in a packed column.
9. To collect liquid – liquid equilibrium data for liquid – liquid extraction.
10. To carry out cross current leaching.
11. To carry out counter current leaching.
12. To determine binodal curve.
13. To carry out and compare single stage and multistage extraction.
14. To carry out batch crystallization and to compare yield obtained with theoretical yield.
15. To study adsorption in packed bed for a solid-liquid system and plot breakthrough curve.
16. To carry out solute-solvent separation using membrane (RO, MF and NF)
17. To study Batch Reactive Distillation operations in Laboratory.

Reference Books:

1. Treybal, R.E.; Mass Transfer Operations; McGraw-Hill, 1980.
2. Coulson J.M., Richardson J.F.; Chemical Engineering; Volume I and II, Pergamon Press, 1977.
3. Foust A.S., Wenzel L.A., Clump C.W., Naus L., and Anderson L.B.; Principles of Unit Operations; Second Edition, Wiley, 1980.
4. Seader J.D., Henley E.J; Separation Process Principles; John Wiley and sons, 1998.

312409 REACTION ENGINEERING - I
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:	**Examination Scheme:**
Lectures: 4 Hrs / week	Paper: 100 Marks

Objectives:

1. To learn classification and characteristics of various ideal reactors.
2. To learn design, operation and selection of ideal reactor systems

SECTION-I

Unit 1: Introduction to chemical kinetics (08 Lect)

General mole balance equation, Homogeneous and Heterogeneous Reaction rates, rate constants, stoichiometry, and reactor mass balance. Temperature and concentration dependence of rate of reaction. Constant-volume and Varying-volume systems, Search for a reaction mechanism and consequent deduction of rate expression.

Unit 2:**Batch Reactor** (08 Lect)

Constant pressure and constant volume batch reactor. Interpretation of batch data. Differential and integral methods of analysis. Regression analysis in fitting kinetic models.

Unit 3: Continuous reactors (08 Lect)

CSTR and PFR. Performance equations. Space velocity and space time, Comparison between batch reactor, CSTR and PFR.Recycle reactor. Reactor design for a Single Reaction. Multiple-Reactor Systems

SECTION-II

Unit 4: **Design for Single and multiple Reactions** (08 Lect)

Design for Parallel Reactions, Successive irreversible reactions of different orders, Irreversible series-parallel reactions. Denbeigh reactions and its special cases.

Unit 5: **Energy balance for reactors** (08 Lect)

Energy balance equation.. Non-isothermal reactions. Qualitative discussion of optimum temperature progression.Simultaneous solution of material and energy balances for reactor design. Multiple steady states of adiabatic CSTR.

Unit 6:Basics of Non-Ideal Flow (08 Lect)

Residence Time Distribution.RTD of ideal reactors. Earliness of mixing, Segregation and RTD.Conversion in non-ideal flow reactors. Tanks-in-series model.

Reference Books:

1. Levenspiel O.; Chemical Reaction Engineering; Third Edition, John Wiley and Sons., 2003.
2. Fogler H. S.; Elements of Chemical Reaction Engineering; Prentice Hall, India, 1997.
3. Denbeigh K. and Turner J.; Chemical Reactor Theory- An Introduction; Cambridge University Press, 1984.
4. Smith J. M.; Chemical Engineering Kinetics; 3rd Edition, McGraw-Hill, 1981.

312410 PETROCHEMICAL PROCESSES II
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:	**Examination Scheme:**
Lectures: 4 Hrs / week	Paper: 100 Marks
Practical: 2 Hrs / week	Practical: 50 Marks

Objectives:

- To gain an understanding of origin, evaluation of and refining processes for crude petroleum and characterization methods for crude and crude fractions
- To get acquainted with the product profile of national and international petrochemical industry and the emerging scenario in hydrocarbon sector.

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SECTION – I

UNIT 1: Origin, Formation and Composition of Petroleum (08 Lect.)

Origin and formation of petroleum. Reserves and deposits of world. Petroleum industry in India. Composition and evaluation of crude. Important products, properties and test methods. Brief overview of emerging scenario in alternative feedstock sector and nonconventional sources of energy.

UNIT 2: Refinery Processes: Fuels and Lubes (08 Lect.)

Dehydration,Desalting, Distillation of crude . Alkylation and Isomerization..Preparation of Lube Oil Base Stocks.Hydroprocessing. Blending

UNIT 3: Refinery Processes: Resid Processing Options (08 Lect.)

Catalytic cracking. Hydrocracking. Delayed coking. Bitumen blowing.Gasification. Sulphur recovery.

SECTION – II

UNIT 4: Petrochemical Products and Feedstocks (08 Lect.)

Petrochemical product profile..Petrochemical base intermediates. Catalytic reforming. Aromatics separation. Aromatics conversion processes. Steam cracking process technology for olefins.Hydrogen production.

UNIT 5: Polymers, Elastomers and Resins (08 Lect.)

Characteristics and classification of polymers. Process technologies for Polyethylene,Polypropylene,Polyvinyl Chloride,Polystyrene and Formaldehyde Resins.

UNIT 6: Fibres (08 Lect.)

Process technologies for Caprolactum, Adipic acid, Terephthalic acid and Dimethyl Terephthalate, Polyethylene Terephthalate,Nylon 66,Nylon 6.

Term Work:

Every student should carry out *minimum ten* experiments from the following list and submit the journal, which will form the term work.

List of Practicals:

1) To characterize given crude sample for ^{0}API, TBP, Viscosity Gravity Constant, Pour Point, Water and Salt Content, Conradson Carbon and Asphaltenes.
2) To determine characteristics of a given lube oil sample viz:
   i) Viscosity. ii) Viscosity index. iii) Demulsibility
3) To determine following properties for a given sample of solvent naphtha.
   i) Kauri Butanol Number ii) Refractive Index iii) Interfacial tension
4) To determine following properties for a given sample of bitumen.
   i) Penetration ii) Softening Point
5) To determine following properties for a given sample of wax.
   i) Melting point ii) Freezing point, iii) Congealing Temperature
6) To analyze a typical LPG (bottled) for complete analysis inclusive of additives using gas chromatograph.
7) To verify blending charts reported in literature by carrying out product mix to meet desired specifications.
8) To determine the following characteristics for a sample of gasoline.
   (i) Reid Vapor Pressure (ii) Distillation Curve
9) To determine the following characteristics for a sample of diesel oil.
   (i) Aniline Point (ii) Pour Point (iii) Copper Corrosion Number (iv) Kinematic Viscosity (v) Distillation (vi) Sulfur (vii) Flash Point (viii) Cloud Point
10) To verify relation between Smoke Point, Aromatic Content and Aniline Point for a artificially prepared hydrocarbon mixture.
11) To characterize a given polymer material.
12) To develop TBP and EFV curves for a given petroleum product from laboratory ASTM distillation.

Reference Books:

1) Nelson N.L., “Petroleum Refinery Engineering”, McGraw Hill Book Co., 1985.
2) Gary J.H. and Handework G.E., “Petroleum Refining Technology and Economics”, Marcel Dekker, Inc., 1984.
3) Waquier, J.P., “Petroleum Refining” Vol .I and II, Second Editions Technip, 1995
4) Mcketta S.S., Ed., “Petroleum Processing Handbook”, Marcell Dekker, Inc., 1992.
5) Chauvel A. and Lefebvre G., “ Petrochemical Processes”, Vol. I and II, Gulf Publishing Company, 1989.
6) Mall I. D., “Petrochemical Process Technology”, Macmillan India Ltd., 2007.

312411 PROCESS EQUIPMENT DESIGN and DRAWING
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:	**Examination Scheme:**
Lectures: 4 Hrs / week	Paper: 100 Marks
Drawing: 2 Hrs / week	Oral: 50 Marks

Objectives:

1. To be familiar with process and mechanical aspects of equipment design.
2. To be exposed to various design codes used in mechanical design of equipment.
3. To learn to draw various process equipments and Mechanical components as per calculated design.

SECTION – I

Unit 1: Introduction to Design: (08 Lect.)

General Design procedure, Design Methodology, Steps in Design Activity, Creative Design, Process design and mechanical design, Mechanical Properties of Material, Stress concentration, Factor of safety, Material Selection, Fabrication techniques, Codes and standards, ASME and TEMA codes in design. Use of Computer in Design activity.

Unit 2: Design of Mechanical Components: (08 Lect.)

Theories of failure, Design of mechanical components, Types of drive systems, Design of belt drives, Selection of bearings.

Unit 3: Design of Pressure Vessel: (08 Lect.)

A brief overview of process design aspects of pressure vessel (as a reactor for example). Design of unfired pressure vessel shell, head, flange joint, nozzle and supports. selection of corrosion allowance and weld joint efficiency. Design of heating and cooling arrangement (jackets and coil) for reaction vessel, over pressure protection devices such as blow down, Pressure relief valves, rupture disc, steam trap etc.

SECTION – II

Unit 4: Design of Heat Exchanger: (08 Lect.)

A brief overview of process design aspects of heat exchanger. Codes and standards for heat exchangers, Design of heat exchanger (U tube and fixed tube) i.e. shell, head, channel, tubes, tube sheet, tie rods & baffles. Design consideration of condensers and evaporators.

Unit 5: Design of Storage Vessel: (08 Lect.)

Storage of volatile and Non-volatile fluid. Design of fixed roof cylindrical storage tank. Pipeline design consideration, stress analysis and types of pipe supports.

Unit 6: Piping Engineering (08 Lect.)

Pipe thickness, pipe diameter, condensate piping, steam piping, pipe support. Design of piping for natural gas, crude oil, sea water pipe line. Pipe line design on fluid dynamic parameter. Piping coding.

Oral:

Oral examination will be based on above syllabus and the design assignments carried out during semester.

List of Design Assignments:

Minimum three design assignments and respective drawings should be drawn on full empirical drawing sheets from the following list.

1. Design of mechanical component such as protected flange couplings.
2. Design of pressure / reaction vessel including shell, heads, supports, nozzles etc.
3. Design of shell and tube heat exchanger including channels, baffles, tube sheets, tie rods supports etc.
4. Design of storage tank including design of each course at different heights, rooftop, bottoms, vents etc.
5. Design of distillation / absorption tower, including tall tower considerations, eccentrically loaded joints, supports, manholes reinforcement rings etc.
6. Optimum design of pressure vessel using design software such as Designer Desktop and IS Code 2825.

Reference Books:

1. Joshi M. V., Mahajani V. V.; Process Equipment Design; MacMillan, 2003.
2. Spolts M. F.; Mechanical Design Analysis; Prentice Hall, 1964.
3. Bhattacharya B. C.; Introduction to Chemical Equipment Design Mechanical Aspects; CBS Publishers, Delhi, 1991.
4. Moss Dennis R.; Pressure Vessel Design Manual; 3rd Edition; Gulf Professional Publishing, 2003.
5. Walas S.; Chemical Equipment Design; Butterworth-Heinemann, 1988.
6. Evans Frank L Jr.; Equipment Design Handbook for Refineries and Chemical Plants; Vol.-I & II, Gulf Publication Co., 1979.
7. J.M. Coulson, J.F. Richardson and R.K. Sinott, “Chemical Engineering Vol.6” by, Pergamon Press.

312412 COMPUTATIONAL METHODS
(T. E. Petrochemical Engineering 2008 Course)

Teaching Scheme:
Practicals: 2 Hrs / week

Examination Scheme:
Term Work: 50 Marks

Objectives:

1. To learn the basic principles of computer programming using EXCEL and MATLAB.
2. To learn the principles associated with some of the common computer based techniques used to solve Chemical Engineering problems.
3. To learn to represent a process flow sheet as a computer program.
4. To gain hands-on experience in using commercial software to simulate a process.

Term work:

Every student should carry out minimum ten exercises from the following list and submit the journal, which will form the term work.

List of Practicals:

1. Process Calculations with spreadsheet like MS Excel, (3 separate problems):
   1. Material Balance without reaction.
   2. Material Balance with reaction.
   3. Energy Balance.

2. Presentation with Word, Excel, Power Point:
   1. Technical Communication.
   2. Presentation of engineering calculations.
   3. Graphical presentations of data using Pie chart, bar chart, line curve.

3. Process Flow Diagram using packages like Paintbrush, AutoCAD and standard process design software:
   1. Block flow diagram of a process.
   2. Process flow diagram of a process.
   3. Heat exchanger calculations.

4. Solving simulataneous ODEs together for complex reaction network.
5. Compressibility factor determination from van der Waal equation
6. Molar volume determination using ideal gas law, van der Waal, Redlich-Kwon equation
7. Calculation of Bubble point and Dew point of a multi-component mixture.
8. Regression of Rate data – checking dependency among variables.
9. Concept of Unstable Steady State (USS) – Autocatalytic reactions, Chemical Oscillations and Chaos.
10. Long assignment to model a system using a commercial flow sheet simulator
11. (For example, Steady state flow sheeting by Hysys. Process).

312413 SEMINAR

Teaching Scheme:	**Examination Scheme**
Tutorial: 2 Hrs / Week	Term Work: 50 marks

Seminar should be based on a detailed study of any topic related to Petroleum Engineering (preferably the advanced areas / application) and the topic should preferably be relevant to the curriculum.

It is expected that the student collect information from reference books, journals and Internet. The report submitted should reveal the student's internalization of the collected information. Mere compilation from the net and other resources is discouraged.

Format of the Seminar report should be as follows:

1. The report should be neatly written or typed on white paper. The typing shall be with normal spacing and on one side of the paper (A-4 size).
2. The report should be submitted with front and back cover of card paper neatly cut and bound or spirally together with the text.
3. Front cover: This shall have the following details.

a. Title of the seminar report.
b. The name of the candidate with roll number examination seat number at the middle.
c. Name of the guide below the candidate's details.
d. The name of the institute and year of submission on separate lines at the bottom.

4. Seminar approval sheet.
5. The format of the text of the seminar reports:

The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow.

The discussion and conclusions shall form the last part of the text. They should be followed by nomenclature and symbols used followed by acknowledge the bibliography should be at the end. References should be written in the standard format. SPE format for Petroleum Engineering be followed in giving references.

The total number of typed pages, excluding cover shall be about 25 to 30 only. All the pages should be numbered. This includes figures and diagrams.

Two copies of the seminar report shall be submitted to the college. The candidate shall present the seminar before the examiners. The total duration of presentation and after-discussion should be about 30 minutes. (25 min + 5 min. Audience can ask questions only if the examiner permits. Such questions will not have any bearing on marks).

The assessment for the subject shall be based on

1. Report submitted.
2. Presentation.
3. Discussion.