Sixth Semester
Chemical Engineering

Branch: Chemical **Year**: Third **Semester**: Sixth

Sl. No.	Course No.	Subject	Periods			Evaluation Scheme					
Theory			**L**	**T**	**P**	**Sessional Exam**			**ESE**	**Subject Total**	**Credit**
						TA	**CT**	**Total**			
1	CH 681	Chemical Reaction Engg.-II	3	1		30	20	50	100	150	4
2	CH 682	Process Engg. Eco & Optimisation	3	1		30	20	50	100	150	4
3	CH 683	Mass Transfer Operations-I	3	1		30	20	50	100	150	4
4	CH 684	Heat Transfer Operations	3	1		30	20	50	100	150	4
5	CH 685	Petroleum Refining & Petrochemicals	3	1		30	20	50	100	150	4
6	CH 686	Process Dynamics and Control	3	1		30	20	50	100	150	4
Practicals											
7	CH 683L	Mass Transfer Operations Lab			3	30	20	50		50	2
8	CH 684 L	Heat Transfer Operations Lab			3	30	20	50		50	2
9	CH 685L	Petroleum Refining & Petrochemicals Lab			3	30	20	50		50	2
10	CH 686L	Process Dynamics and Control Lab			3	30	20	50		50	2
11	CH 687	General Proficiency							50	50	2
Total			18	6	12						

Total Marks: 1150 **Total Periods: 36** **Total Credits: 34**

TA: teachers assessment ***CT: Class Test*** ***ESE: End Sem Exam***

CH 684 HEAT_ TRANSFER-OPERATIONS

L – T -P
3- 1- 2

Time : 3 hrs
Theory :100 Marks
Sessional: 50 Marks
Practicals: 50 Marks

1.Heat transfer by conduction: One-dimensional Heat Conduction equation, Boundary conditions; One dimensional steady state heat conduction for slab, cylinder, sphere, composite medium, Thermal conduct resistance, critical thickness of insulation, Fourier law, Finned surfaces, temperature dependent K (T), Transient conduction and use of temperature charts. Lumped system analysis for slabs and long cylinder and spheres.

2. Heat Transfer by convection : Flow over a body, flow inside a duct. Forced Convection: Hydrodynamic and thermal boundary layer, simultaneously developing laminar flow, Turbulent flow inside ducts, Heat transfer to liquid metals. FreeConvection : Dimensionless parameters of Free Convection, Correlations of free convection on a vertical plate, Free Convection on a horizontal plate.

3. Condensation : Nusselt equation for horizontal and vertical condenser, Drop and film type condensation, Effect of non-condensable gases. Boiling: Boiling of liquids. Nucleate and film boiling.

4.Heat Transfer by Radiation: Concept of black body , Kirchoff's Law Emissivity, absorptivity, black body and grey body radiation. View factors, Radiation from non- luminous gases, radiation from flames, radiation errors in pyrometry.

5. Heat Exchanges: Classification, temperature distribution in heat exchangers, Overall heat transfer co-efficient, the LMTO method for heat exchanger analysis, correction for LMTD for use with cross flow and multipass exchanger. 6.Evaporation : Classification and application, operation of single and multiple effect evaporators.

6.Preliminary design aspect of heat transfer equipments: Heat Exchangers: Hair pin (double pipe exchangers) 1-2 shell and tube exchangers, Finned tube exchangers, LMTD, fouling factor, pressure drop considerations.

7.Heat transfer in packed and Fluidized bed: Brief introduction.

8.Furnaces: Classification, Constructional details, combustion, calculations.

Practical_ (sessional)

1. Thermal conductivity of solid materials.
2. Laminar and turbulent flow heat transfer I circular and noncircular ducts.
3. Heat transfer in pool boiling.
4. Condensation Heat transfers.
5. Heat transfer in extended surfaces.
6. Determination of view factor, emissivity.

TEXT BOOKS:

1. Heat transfer- Principles and applications; B K Dutta, Prentice Hall India
2. Heat Transfer – A basic approach by M. Necati Ozisik
3. Heat Transfer by W. H. McAdams , Mcgraw-Hill.
4. Fundamentals of Heat Transfer by M. Mikheyev – Mir publications.

5. Unit operations of chemical Engg. W. L. cabe & J. C. Smith – Mcgraw – Hill Publication

CH 685 PETROLEUM REFINING AND PETROCHEMICALS

L – T -P
4- 1- 2

Time : 3 hrs
Theory :100 Marks
Sessional: 50 Marks
Practicals: 50 Marks

1. PRIMARY PROCESSING OF CRUDE OIL : Classification of crude oil, Atmospheric distillation .Vacuum distillation of residue-products and distillation practice.

2. SECONDARY PROCESSING OF CRUDE OIL : FCCU, Hydro cracking, Visbreaking, Thermal cracking. Coking, Reforming, Alkylation, Polymerization and Isomerisation process.

3. TREATMENT-TECHNIQUES : Treatment techniques for removal of objectionable gases. Odours, to improve performance, .Storage stability. Extraction of aromatics, Olefins and recovery operations from petroleum products.

4. PETROCHEMICALS : Chemicals from methane and synthetic gas: Ammonia, Methanol and Hydrogen Cyanide, Chemicals from olefins; Ethviene derivatives, Propylene derivatives and Butylene derivatives, Aromatics, intermediates for synthetic fibers. Plastics and rubber.

5. ENVIRONMENTAL AND SAFETY ASPECTS IN REFINERY AND PETROCHEMICALS : Waste water and effluent gases treatment from alkylation units and petrochemical units, safely aspects in the above industries.

TEXTBOOKS :

1. W.L. Nelson, "Petroleum Refinery Bn~meering"4"' Edn., McGraw Hill , New York 1985

2. B. K. Bhaskara Rao, "Modem Petroleum Refining Processes", 2nd' Edn., Oxford and IBH Publishing Company, New Delhi, 1990. Khanna Publishers.

REFERENCES :

1. G. D. Hobson and W.Pohl., " Modem Petroleum Technology", Gulf Publishers 2nd. Edn., 1990..

2. R. A. Meyers, "Hand book of Petroleum Refining Processes", McGraw Hill , 1st Edn., 1980.

3. F. Hatch md Sumi Malar, "From Hydrocarbons to Petrochemicals", Gulf Publishing Company, 1st Edn. 1981.

CH 681 CHEMICAL REACTION ENGINEERING-II

L-P-T
3-0-1
Theory : 100 marks
Sessional : 50 marks
Time : 3 hrs

1. Design for multiple reactions: Series and parallel reactions, Series-parallel reactions.

2. Temperature and pressure effects: Single reactions, multiple reactions.

3. No Ideal Flow: Residence time distribution of flow in vessels, models for non ideal flow, dispersion model, tanks in series model, multi parameter model, diagnosing ills of Operating equipment, Models for fluidized beds.

4. Mixing of fluids: Self-mixing of a single fluid, mixing of two miscible fluids.

5. Introduction to design for heterogeneous reacting systems: rate equations, contacting patterns.

6. Fluid-particle reactions: Un-reacted core model, shrinking core model, determination of rate-controlling step, application to design.

7. Fluid-Fluid reactions: rate equations, application to design.

8. Solid catalyzed reactions: rate equation, experimental methods for finding rates, Product distribution in multiple reactions, application to design.

9. Deactivating catalysts: Mechanism, rate equation, rate equation from experiment, design.

10. Introduction to reactor stability.

Books :-

1. Chemical Reaction Engineering by Levenspiel, Wiley Eastern.
2. Elements of Chemical Reaction engineering, Fogler, 3rd Ed.,Prentice hall
3. Chemical Engineering Kinetics by D.M. Smith, McGraw Hill Publication.
4. Reaction Kinetics for Chemical Engineers by Wales, McGraw Hill Publication.

****

CH 683 MASS_TRANSFER_OPERATION-I

Theory : 100 marks
Sessional : 50 marks
Practical: 50 Marks
Time : 3 hours

L – T – P
3 – 1 – 2

Molecular Diffusion and Eddy Diffusions: Maxwell Stefan law , Fick's law , steady state diffusion through a stagnant fluid, diffusivity of gaseous and liquid systems, Analogy between momentum, Heat and mass transfer. Eddy Diffusion.

Interphase Masss transfer : Mass transfer coefficients, Two-film theory, Idea about penetration and surface renewal theory , Correlations between transfer coefficients, Equilibrium relationship between gas-liquid and liquid-liquid systems.

Steady state co-current and counter current process in gas absorption, Minimum gas-liquids ratio for absorption. Packed absorption tower, liquid hold up, loading and flooding of packed tower, packing materials, graphical design method of packed column, the H.T.U. and N.T.U. Comparison of packed and plate column.

Simultaneous absorption and chemical reaction, effect of chemical reaction on absorption rate. Theory of the stagnant film of finite thickness (steady state rapid 2^{nd} order irreversible reaction and slow first order reaction)

Humidification and Dehumidfication : Vapor – liquid equilibria , Enthalpy of saturated and unsaturated vapor –liquid mixtures , adiabatic saturation curves . concept of wet bulb and dry bulb temperature , Lewis relationship, water cooling with air , Dehumidification of air water vapor, water cooling towers.

Drying: Equilibrium relationship, drying rate curve , batch and continuous drying , mechanism of drying , calculation on batch and continuous drying , continuous drying equipments – Tunnel dryers. Rotary dryers, Spray dryers etc.

Crystallization: Saturation nucleation, crystallization rate , effect of impurities , effect of temperature on solubility, caking of crystals, Batch crystallizers, continuous crystallizers.

Absorption and Ion Exchange: Types of absorption , nature of absorbents, absorption equilibria absorption of single gas/vapor from gaseous mixture dilute and concentrated liquid solutions , fixed bed , ion-bed absorbers, principles of ion exchange, equilibria and rate of ion exchange.

Less Conventional Operations : Introduction to fractional crystallization , sublimation , foam separation , membrane separation , thermal diffusion , reverse osmosis, electro dialysis.

Principles of Process design of absorption and extraction towers.

BOOKS:

1. R.C. Treybal . Mass Transfer Operation , McGraw –Hill Kogakusha, 3^{rd} Edition
2. G. Astavita "Mass Transfer with Chemical Reaction" Elsevier Co.
3. Foust & Wenzel . "principles of Unit Operations" Wiley International.
4. Unit Operations in chemical Engg Ed2 by McCabe and Smith
5. Chemical Engineering Vol 2 Ed2 Pergamon Press by Coulson and Rechardson.
6. N Anantharaman & K M Sheriffa Begum, Elements of mass Transfer, Part-I, Prentice Hall India

Practical :

1. Study of Flooding and Laoding Characteristics in packed bed
2. Experiment on a Fluidized dryer
3. Determination of mass transfer co-efficient in wetted wall column.
4. Equilibrium flash Distillation

5. Diffusivity in still air
6. Bubble cap distillation column.

CH 686 **PROCESS DYNAMICS AND CONTROL (3-1-2)**

Time : 3 hrs.
Theory : 100 marks

Sessional : 50 marks

Practicals: 50 Marks

1. The control of a chemical process : Its characteristics and associated problems. Process control, Process variables, Design elements of a control system, Control aspects of a complete Chemical plant, List of digital computer in process control, Laplace transformation and its application.

2. Modeling the dynamic and static behavior of Chemical Processes : Development of a Mathematical model, Modeling considerations for control purposes, the input output models, Transfer functions, Linear open loop systems, Degrees of freedom and its applications.

3. Analysis of the Dynamic behavior of Chemical Processes: Transfer functions and the input-output models, Dynamic behavior of 1^{st} order systems, Dynamic behavior of 2^{nd} order systems, Dynamic behavior of higher order systems, Interacting and non interacting systems, Dynamic systems with dead time.

4. Linear closed loop systems : Analysis and design of feedback control systems, Feed back control, types of feed back controllers, Associated problems, Block diagram of feed back controlled processes and closed loop response, Effect of proportional, integral, derivative and composite control actions.

5. Stability analysis of Feed back Systems : The characteristics equation, Routh-Hurwitz Criterion for stability, Root locus analysis, Controller design and tuning, Frequency response analysis of linear processes, Bode diagrams, Design of feed back control systems using frequency response techniques, Bode stability criterion, Gain and phase margins, Ziegler-Nichols tuning techniques.

6. Controllers and Final control elements: Self operated, Pneumatic, Hydraulic, Electric power employed.

7. Advanced control systems : Large dead time, dead time compensation, Cascade control, Split-range control, feed forward control, Ratio control, Adaptive control, Digital computer control.

8. Process dynamics and applications: Process identification, Dynamics and control of chemical equipments such as heat exchangers, distillation columns, reactors etc.

9. Computer simulation of control systems.

Practicals

Experiments on
1. Temperature control.
2. Flow control.
3. Level control. with respect to a chemical reactor.

Books :

1. Automatic Process Control by D.P. Eckman.
2. Chemical Process Control by George Stephanopoulos, Prentice – Hall of India.
3. Process System Analysis & Control by Coughanuer & Koppel, Tata-McGraw Hill publication.
4. Process Control by Peter Harriat, McGraw Hill Chemical Engg. Series.
5. Industrial Control and Instrumentation by W. Bolton, Orient Lougman.

6. Process Control by Patranabs.

CH 682 : PROCESS ENGINEERING ECONOMICS & OPTIMISATION

L – T – P
3 – 1 – 0
Theory : 100 marks

Sessional ; 50 marks

Time : 3 hours

- **Feasibility Analysis** : Technology of project. Market Survey analysis.
- **Interest and Economic Equivalence** – Simple interest, Compound interest, Present Worth and Discount, Nominal & Effective interest rates, Uniform annual end of the year amount, i.e. unacost, Uniform annual beginning of year amount, Applications in cost comparison, Cost comparison by present worth for unequal duration of service lives, Cost comparison by unacost, Cost comparison by Capitalized cost.
- **Depreciation & Taxes :** What is depreciation, Depreciation terms and depreciation relationships, Methods of determining depreciation – Straight Line Method, declining Balance Method, Sum-of-the-year Digits Method, Sinking Fund method.
- **Cost Estimation :** Types of Cost Estimation, Process Equipment Cost Estimation, Cost Index, Equipment Cost Size relationship, Production Cost.
- **Profitability :** Introduction, Methods of profitability evaluation – rate of return on investment, rate of return on average investment, Payout time, Payout time with interest, Discounted Cash Flow (DCF) method, venture worth method, Application of profitability relation in alternative investment analysis, cost factor in profitability evaluation.
- **Break Even Analysis :** Introduction, Relation between costs and production. Economic Production chart, Break even chart, Economic Production cost vs rapidity variation, capacity factor, demand factor, load factor, diversity factor, application of break even analysis for project improvement.
- **Financial Statements,** financial analysis and Financial Institutions.
- **Optimization :** Introduction, optimization techniques, nature of optimization, unvariable systems – analytical methods of solution, multivariable systems, method of Lagrangian Multipliers, Search Method, Time Programming.

BOOKS :

1. Chemical Engineering Economics and Division Analysis, Chemical Engineering Education Development Centre, IIT, Madras.
2. Pradip Kumar, Financial Accountancy.
3. Process Plant and Equipment Cost Estimation, Sevak Publication, Mumbai.
4. Jelen, F.C., Cost and Optimization Engineering, McGraw-Hill.