B.Tech V Semester **CHEMICAL ENGINEERING**							
COURSE CONTENTS							
CM5301	**Mass Transfer - I**	**L**	**T**	**P**	**C**	**Max. Marks**	**Min. Marks**
Duration	3 Hours	3	1	2	5	70	22

Course Objectives:

The purpose of this course is to introduce the undergraduate students with the most important separation equipment in the process industry, and provide proper understanding of unit operations.

Unit I

Fundamentals of Mass Transfer: Introduction and classification of Mass transfer operations, Choice of separation method. Mass transfer coefficients: Individual and film coefficients, Overall mass transfer coefficient, Determination of mass transfer co-efficient. Interphase mass transfer. Analogies in transfer processes. Mass transfer theories: film, penetration and surface renewal theory.

Unit II

Diffusion Phenomena: Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, Diffusion coefficient: measurement and prediction, Diffusion in solids and its applications.

Unit III

Distillation: Vapour liquid equilibria: Boiling point diagram, Raoult's law, Relative volatility. Azeotropes: minimum and maximum boiling mixtures. Enthalpy concentration diagrams for binary systems. Methods of distillation: Flash, Differential and Steam Distillation; Azeotropic and Extractive Distillation;

Unit IV

Continuous Multistage Distillation: Multistage tray towers. Analysis of binary distillation in tray towers using graphical methods of McCabe-Thiele and Ponchon-Savarit: minimum reflux, total reflux and optimum reflux ratio, open steam, multiple feed and side stream. Multi component Calculations. Plate, point and overall efficiency in distillation columns.
Column internals. Loading, flooding, coning etc. phenomenon in columns.

Unit V

Absorption: Introduction, Types of tower packing's, Contact between liquid and gas, Pressure drop and limiting flow rates, Material balances, Limiting gas-liquid ratio, Rate of absorption, Calculation of tower height and number of transfer units (Concept of HTU and NTU), Alternate forms of transfer coefficients, Absorption in plate columns, Absorption with chemical reaction.

List of Experiment

1. To study the flooding and loading of packed columns using different types of packing.
2. To study different types of plates and packing.
3. To prepare the vapor-liquid equilibrium and Boiling point diagram for a binary liquid mixture.
4. Determination of relative volatility of a given system of acetic acid water.

B.Tech V Semester **CHEMICAL ENGINEERING**							
COURSE CONTENTS							
CM5302	**Chemical Reaction Engineering**	**L**	**T**	**P**	**C**	**Max. Marks**	**Min. Marks**
Duration	3 Hours	3	1	2	5	70	22

Course Objectives:

To apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems, To examine reaction rate data to determine rate laws, and to use them to design chemical reactors, To simulate several types of reactors in order to choose the most appropriate reactor for a given need, To design chemical reactors with associated cooling/heating equipment.

Unit I :

Classification of Reactions and Reactors: Definition of reaction rate, Variables affecting the rate, concept of reaction equilibria, order of reaction and its determination, theoretical study of reaction rates, collision and activated complex theory, Mechanism of reaction series, Parallel and consecutive reaction autocatalytic reactions, chain reaction polymerization reaction. Interpretation of kinetic data, Integral and differential method of analysis, variable volume reactions, total pressure method of kinetic analysis.

Concept of ideality, Development of design equations for batch, semi batch, tubular and stirred tank reactor, CSTR, PER, Combination of reactors, Reactors with recycle, yield and selectivity , reactor choice for single reaction.

Unit II

Multiple Reactions: Multiple Reactions in Batch, continuous stirred tank and Plug flow reactors uniqueness of steady state in continuous stirred tank reactor, optimum temperature progression, thermal characteristics of reactors. analysis of product distribution and determination of reactor size for different types of ideal reactors, selectivity and yield factors, Denbigh reactions, reactor choice for multiple reactions.

Unit III

Residence Time Distribution: Non ideal reaction, RTD dispersion model, Tank and series model, recycle model, segregated flow in mixed models, evaluation of RTD characteristics. , role of RTD in determining reactor behaviour, age distribution (E) of fluid, experimental methods for finding E, relationship between E and F curve.

Unit IV

Design of Reactors: Non-isothermal design of ideal reactors, hot spot in tubular reactor, auto-thermal process, steady state multiplicity and effect of operating variables on the stability of CSTR, optimal temperature progression for first order reversible reaction, and discussion of optimal policy for the operation of reactors with inter stage coolers.

Unit V

Heterogeneous Processes and non- catalytic reaction: Heterogeneous processes: Catalysis and adsorption; Classification of catalysts, Preparation of catalysts, Promoters and Inhibitors, General

mechanism of catalytic reactions surface area and pore size distribution Rate equation of fluid solid catalytic reactions, Hougen - Watson & Poinule law models, Procurement and analysis of kinetic data, kinetics of catalyst deactivation. Models for fluid - solid non-catalytic reactions, controlling mechanisms, Diffusion through gas film controls. Diffusion through ash layer controls, Chemical reaction controls, fluidized bed reactors with and without elutriation.

List of Experiments:

1. To determine velocity rate constant of the hydrolysis of ethyl acetate by sodium hydroxide.
2. To study the rate constant of hydrolysis of an ester-catalyzed by acid.
3. Determine the rate constant and order of reaction between Potassium per sulphate and Potassium iodide.
4. To study temperature dependency of rate constant, evaluation of activation energy and verification of Arrhenious law.
5. To study a consecutive reaction system(hydraulic model)
6. To study a parallel reaction system (hydraulic model)
7. Study of non-catalytic homogeneous saponification reaction in CSTR.
8. To study a non-catalytic homogeneous reaction in a plug flow reactor.
9. To study the residence time distribution
10. Behavior of a back mix reactor.
11. To study the RTD behavior of a tubular reactor.
12. To study the RTD behavior of a packed bed reactor.
13. To study the behavior of a continuous flow reactor system-three reactor in series.
14. To study the kinetics of thermal decomposition of calcium carbonate.
15. Study of non-catalytic saponification reaction in a tubular flow reactor.

Note: Each student should perform at least eight experiments out of the above list.

Course Outcomes:

- Develop rate laws for homogeneous reactions
- Design of ideal reactors for single and complex reactions
- Develop skills to choose the right reactor among single, multiple, recycle reactor, etc. schemes.
- Design of non-isothermal reactors and the heat exchange equipment required.

Suggested Readings:

1. J.M. Smith – CHEMICAL ENGINEERING KINETICS – 3rd Ed. Mc Graw Hill.
2. K.G. Denbigh & K.G. Turner – CHEMICAL REACTION THEORY AN INTRODUCTION – 2nd Ed. United Press and ELBS 1972
3. G. Copper & GVJ Jeffery's – CHEMICAL KINETICS AND REACTOR ENGINEERING – Prentice Hall 1972
4. O. Levenspiel – CHEMICAL REACTION ENGG. – 2nd Ed. Willey Eastern, Singapore.
5. Houghen Watson & Ragatz – CHEMICAL PROCESS PRINCIPLES PART III – (Kinetics & Catalysis) 2nd Ed. Asian Publishing House Bombay.
6. Fogler, H.S. – ELEMENTS OF CHEMICAL REACTION ENGINEERING – 2nd Ed. Prentice Hall of India Pvt. Ltd. New Delhi. -1999

B.Tech V Semester **CHEMICAL ENGINEERING**							
COURSE CONTENTS							
CM5303	**Process Equipment Design Mechanical Aspects**	**L**	**T**	**P**	**C**	**Max. Marks**	**Min. Marks**
Duration	3 Hours	3	1	0	4	70	22

Course Objectives:

To design process equipment , vessels with associated cooling/heating equipment.

Unit I

Mechanics of Materials:

Stress- Strain relationships of elastic materials subjected to tensile, compressive and shear forces, Elastic and plastic deformation, General design considerations; Design of shell, bottom plates, self supported, and column supported roofs, wind girder, nozzles and other accessories.

Unit II

Unfired Pressure Vessel:

Pressure vessel codes, classification of pressure vessels, Design of cylindrical and spherical shells under internal and external pressures; Selection and design of flat plate, tore-spherical, ellipsoidal, and conical closures, compensations of openings. High pressure Vessels: Stress analysis of thick walled cylindrical shell, Design of monobloc and multilayer vessels.

Unit III

Tall Vertical & Horizontal Vessels:

Pressure, dead weight, wind, earthquake and eccentric loads and induced stresses; combined stresses, Shell design of skirt supported vessels. Vessel supports; Design of skirt, lug, and saddle supports.

Unit IV

Bolted Flanges:

Types of Flanges, and selection, Gaskets, Design of non- standard flanges, specifications of standard flanges. Fabrication of Equipment; major fabrication steps; welding, non-destructive tests of welded joints, inspection and testing, vessel lining, materials used in fabrication of some selected chemical industries.

Course outcomes:

After the course student should able to:

- Knowledge of basics of process equipment design and important parameters requires
- Design of internal and external pressure vessels
- Design of tall and horizontal vessels and its supports
- Knowledge of equipment fabrication and testing methods

Suggested Readings:

1. Brownell, N.E and Young, H.E; Process Equipment Design; John Wiley.
2. Bhattacharya, B.C; Introduction of Chemical Equipment Design; CBS Publishers, Delhi.
3. Perry RH; Hand book of Chemical Engineers; Mc Graw Hill Pub.

B.Tech V Semester **CHEMICAL ENGINEERING**							
COURSE CONTENTS							
CM5304	**Petroleum Technology**	**L**	**T**	**P**	**C**	**Max. Marks**	**Min. Marks**
Duration	3 Hours	3	1	0	4	70	22

Course objectives: Studying this subject the students will learn about the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Unit-I

Origin of Petroleum:

Origin and occurrence of petroleum crude, status of petroleum refining in India. Composition of petroleum, classification and physical properties of petroleum. Evaluation of crude oil and petroleum products, future refining trends.

Unit –II

Distillation of Crude

Crude oil Distillation Process, Pretreatment of crude, atmospheric and vacuum distillation process. Secondary conversion processes: Catalytic reforming, catalytic cracking and deep catalytic cracking.

Unit - III

Heavy Residue Up gradation:

Hydro cracking, Hydro treating, visbreaking and delayed coking alkylation, isomerisation, dehydrogenation processes, polymerization.

Unit - IV

Lubricating Oil, Grease and Bitumen:

Dewaxing and deoiling, deasphalting, lube hydro-finishing, bitumen air blowing, Sweetening and Desulphurization. Hydro-desulphurisation of petroleum products.

Unit - V

Solvent Extraction:

Solvent furfural process, refinery gas utilization: LPG, propylene and hydrogen recovery, Reformulated Gasoline: Present and future requirements.

Course Outcomes:

- Introduction with the petroleum refinery worldwide.
- Develop knowledge of different refining processes.
- Develop knowledge of safety and pollution control in the refining industries.
- To find the suitable refining technology for maximizing the gasoline yield.

Suggested Readings:

1. Nelson W.L. - PETROLEUM REFINERY ENGINEERING - 4th ed. McGraw Hill . (1987)
2. Hobson G.D. et al. - MODERN PETROLEUM TECHNOLOGY - Part I & II 9th ed. 1986. John Willy & Sons.

B.Tech V Semester **CHEMICAL ENGINEERING**							
COURSE CONTENTS							
CE535X (1)	**Biochemical Engineering**	**L**	**T**	**P**	**C**	**Max. Marks**	**Min. Marks**
Duration	3 Hours	3	0	2	4	70	22

Course objective : Studying this subject the students will learn about the enzymes and production of bioreactors and biofuels to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Unit I

Introduction to Bio-Processes: Aspects of microbiology, cell theory structure of microbial cells, classification of microorganism, Essential chemicals of life lipids, Sugars and Polysaccharides, RNA and DNA, Amino acids and proteins.

Unit II

Bio-Processes Mechanism: Metabolic mechanism of the cells. Biochemical Kinetics, Simple enzyme kinetics with one or two substrates, Modulation and regulation of enzymatic activity, immobilized enzyme, enzyme reactions in heterogeneous systems. Sterilization, filtration

Unit III

Growth & Cultivation: Growth cycle, phases for Batch cultivation, mathematical modeling of batch growth, products synthesis Kinetics, overall kinetics and thermal death kinetics of cells and spores.

Unit IV

Genetic Engineering: Application of genetic engineering, agitation and aeration, Determination of oxygen transfer rate, determination of Kga and KLa scaling of mass transfer equipment

Unit V

Design of Bioreactors: Classification and characterization of different bioreactors. Batch and continuous reactors, tubular, CSTR and tower reactors. Aerobic and anaerobic fermentation - process, design and operation of typical aerobic and anaerobic fermentation processes, Manufacture of microbial products e.g. antibiotics alcohol/wine etc. and whole cells for industrial processes.

List of Experiments:

1. To carry out the isolation and identification of microorganism from a soil sample.
2. To examine and study the effectiveness of various techniques used for the preservation of microorganisms.
3. To study the kinetics of ethanol fermentation.
4To determine the kinetic constants l.1max and Km for the growth of microorganisms.
5. To identify bacterial species using Gram staining tests.
6. To determine the biochemical oxygen demand of the given wastewater sample.
7. To determine the chemical oxygen demand of the given wastewater sample.