Shaheed Bhagat Singh State Technical Campus, Ferozepur

B. Tech. Chemical Engineering

Scheme of Syllabi

3rd Semester

Total contact hours =30

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-301A	Mechanical Operations	3	1	---	40	60	100	4
BTCH-302A	Chemical Process Calculations	3	1	---	40	60	100	4
BTCH-303A	Fluid Flow	3	1	---	40	60	100	4
BTCH-304A	Chemical Engineering Thermodynamics	3	1	---	40	60	100	4
BTCH-305A	Chemical Process Industries	3	--	---	40	60	100	3
BTCH-306A	Chemical Technology lab	---	---	3	30	20	50	1
BTCH-307A	Fluid Flow Laboratory	---	---	3	30	20	50	1
BTCH-308A	Mechanical Operations Laboratory	---	---	3	30	20	50	1
BTCH-309A	Training-I*	---	---	---	60	40	100	2
BTHU-301A	Professional Skills-I	--	---	2	30	20	50	1
	Total	**15**	**4**	**11**	**380**	**420**	**800**	**25**

*** Training-I (6 weeks Institutional Training during summer vacation after 2nd semester)**

B. Tech. Chemical Engineering
Scheme of Syllabi
4th Semester

Total contact hours =26

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-401A	Mathematical Methods in Chemical Engg.	3	1	---	40	60	100	4
BTCH-402A	Heat Transfer	3	1	---	40	60	100	4
BTCH-403A	Energy Engineering	3	--	---	40	60	100	3
BTCH-404A	Strength of Materials	3	1	---	40	60	100	4
	Dept. Elective-I							
BTCH-411A	Corrosion Engg.	3	--	--	40	60	100	3
BTCH-412A	Plant Utilities							
BTCH-413A	Polymer Science & Engineering							
BTCH-414A	Enzyme Tech.							
BTCH-405A	Heat Transfer Laboratory	--	--	3	30	20	50	1
BTCH-406A	Numerical Methods in Chemical Engineering Laboratory	---	---	3	30	20	50	1
BTHU-401A	Professional Skills-II	--	---	2	30	20	50	1
	Total	**15**	**3**	**8**	**290**	**360**	**650**	**21**

B. Tech. Chemical Engineering
Scheme of Syllabi
5th Semester

Total contact hours =25

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-501A	Industrial Pollution Control	3	1	---	40	60	100	4
BTCH-502A	Chemical Reaction Engg. –I	3	1	---	40	60	100	4
BTCH-503A	Mass Transfer-I	3	1	---	40	60	100	4
	Dept. Elective –II							
BTCH- 511A	Fluidization Tech.	2	--	---	40	60	100	2
BTCH-512A	Project Management							
BTCH-513A	Engineering Materials							
	Open Elective –I	3	--	---	40	60	100	3
BTCH-504A	Chem Reaction Engg & Environmental Engg Laboratory	--	--	3	30	20	50	1
BTCH-505A	Chemical Process Plant Design-I	--	--	3	30	20	50	1
BTCH-506A	Training-II*	---	---	---	60	40	100	3
BTHU-501A	Professional Skills-III	--	---	2	30	20	50	1
		14	**3**	**8**	**350**	**400**	**750**	**23**

****<u>There should be Training-II of 6 weeks duration in the summer vacation after 4th semester</u>**

B. Tech. Chemical Engineering
Scheme of Syllabi
6th Semester

Total contact hours =26

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-601A	Mass Transfer-II	3	1	---	40	60	100	4
BTCH-602A	Chemical Reaction Engg. –II	3	1	---	40	60	100	4
	Dept. Elective –III							
BTCH-611A	Petroleum Refining Engg	3	--	---	40	60	100	3
BTCH-612A	Renewable Energy Sources							
BTCH-613A	Heat Exchangers							
	Dept. Elective –IV							
BTCH-616A	Optimization Techniques	3	1	---	40	60	100	4
BTCH-617A	Biochemical Engg.							
BTCH-618A	Transport Phenomena							
	Open Elective –II	3	--	---	40	60	100	3
BTCH-603A	Mass Transfer Laboratory	--	--	3	30	20	50	1
BTCH-604A	Process Equipment Design	--	--	3	30	20	50	1
BTHU-601A	Professional Skills-IV	--	---	2	30	20	50	1
		15	**3**	**8**	**290**	**360**	**650**	**21**

B. Tech. Chemical Engineering
Scheme of Syllabi
7th Semester

Total contact hours =29

Course		Contact Hours			Marks			Credits
Code	**Name**	**L**	**T**	**P**	**Internal**	**External**	**Total**	
BTCH-701A	Process Instrumentation, Dynamics & control	3	1	---	40	60	100	4
BTCH-702A	Process Engineering & Economics	3	1	---	40	60	100	4
	Dept. Elective –V							
BTCH-711A	Separation Processes	3	1	---	40	60	100	4
BTCH-712A	Petrochemical Technology							
BTCH-713A	Polymer Reactor Design							
	Open Elective –III	3	--	---	40	60	100	3
BTCH-703A	Process Instrumentation, Dynamics and Control Lab	--	--	3	30	20	50	1
BTCH-704A	Chemical Process Plant Design-II	--	--	3	30	20	50	1
BTCH-705A	Project-I	--	--	8	60	40	100	4
BTCH-706A	Training-III	--	--	--	60	40	100	4
		12	**3**	**14**	**340**	**360**	**700**	**25**

***<u>**There should be Industrial Training of 6 weeks duration in the summer vacation after 6th semester**</u>

B. Tech. Chemical Engineering
Scheme of Syllabi
8th Semester

Total contact hours =23

Course		Contact Hours			Marks			Credits
Code	**Name**	**L**	**T**	**P**	**Internal**	**External**	**Total**	
BTCH-801A	Process Modelling & simulation	3	1	---	40	60	100	4
	Dept. Elective –VII							
BTCH-811A	Chemical process Safety	3	1	---	40	60	100	4
BTCH-812A	Fuel Cell Technology							
BTCH-813A	Environmental Impact Assessment							
BTCH-802A	Process Simulation Laboratory	--	--	3	30	20	100	1
BTCH-803A	Project-II	--	--	12	60	40	100	6
		6	**2**	**15**	**170**	**180**	**350**	**15**

Syllabi (3rd Semester)
BTCH-301A MECHANICAL OPERATIONS

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Objective: The objective of this course is to develop the understanding of the students about solids, their characterization, handling and the various processes involving solids. The students are exposed to basic theory, calculations and machinery involved in various solid handling operations.

Characterization and Handling of Solids: (8 hrs)
Characterization of solid particles: Shape, size, specific surface, Particle size distribution
Properties of particulate masses: Major distinctive properties, pressures in masses of particles, angle of internal friction, angle of repose.
Storage and Conveying of bulk solids: Basic idea of conveyor, conveyor selection, screw, belt, vibrating, continuous flow and pneumatic conveyors, bulk storage, bin storage, feeders .

Screening: (4 hrs)
Capacity and Effectiveness of a screen, calculation of average size of particles in mixture by screen analysis, types of screens.

Agitation and Mixing: (8 hrs)
Agitation of low viscosity particle suspensions: axial flow impellers, radial flow impellers, close-clearance stirrer, unbaffled tanks, baffled tanks, basic idea for designing agitators. Power number, Froude number, power consumption in agitation
Mixing of Solids: Types of mixers, various mixers for cohesive solids, power requirements, mixing index, axial mixing.
Mixers for free flowing solids: ribbon blenders, screw mixers, tumbling mixers import wheels, mixing index in blending granular solids, mixing index at zero time, rate of mixing.

Size Reduction: (6 hrs)
Principles of Comminution: Criteria for comminution, characteristics of products, Energy and Power requirements, Bond's, Rittinger's and Kick's Law and Work Index.
Size Reduction Equipment: Crushers, Grinders, and ultrafine grinders cutting machines, equipment operation.

Filtration: (8 hrs)
Classification of filters, various types of cake filters, principles of cake filtration, clarifying filters: liquid clarification, Gas cleaning, principles of clarification.
Filtration Equipment and centrifuges and their selection, Cross flow Filtration, micro filtration

Settling: (8 hrs)
Motion of particles through fluids: Terminal velocity, hindered settling, Stoke's law,
Gravity settling processes: Classifiers, clarifiers, thickeners, flocculation, rate of sedimentation
Centrifugal Settling processes: Cyclones, hydroclones, decanters, tubular, disk and nozzle discharge centrifugal sludge separators, Centrifugal class fitters, principles of centrifugal sedimentation.

Fluidization: (6 hrs)
Fluidization and fluidized bed, conditions for fluidization, Ergun equation and Kozeny-Carman equation, minimum fluidization velocity, types of fluidization, expansion of fluidized beds and particulate fluidization, continuous fluidization; industrial applications.

BOOKS RECOMMENDED:

1. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005
2. Foust, A.S., Wenzel L.A., Clump C.W. Maus L., Anderson L. B., Principles of Unit Operations, 2nd Ed., John Wiley & Sons, 2008.
3. Harker J. H., Richardson, J. F., Backhurst J. R., Chemical Engg. Vol, 2, 5th Ed., Butterworth-Heinemann, 2003.
4. Badger, W.L. and Banchero, J.T, Introduction to Chemical Engg., McGraw Hill
5. Perry R.H., Green D. W., Chemical Engineers' Handbook, 8th ed., Mc-Graw Hill, 2008

COURSE OUTCOMES

Students will be able to:-

1. Characterize the particulate solids and demonstrate knowledge of its handling and conveying.
2. Demonstrate the knowledge of principles of size reduction and select the relevant equipment.
3. Analyze mixing processes and separation methods for solid-solid, solid-liquid and solid-gas mixtures.
4. Differentiate and analyze fluid flow through packed and fluidized beds.

BTCH-302A CHEMICAL PROCESS CALCULATIONS

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Objective: The objective of this course is to present to the students, an introduction to chemical engineering calculations, establish mathematical methodologies for the computation of material balances, energy balances and to present an overview of industrial chemical processes. It is prerequisite for several other courses in the curriculum, including courses in process dynamics, heat transfer and phase equilibrium.

Introduction to Chemical Engineering Calculations: **(10 hrs)**

Units & Dimensions, Conversion of units, Mole concept, Basic Concept, Stoichiometric and composition relationship, limiting-excess- reactant, conversion and yield, Degrees of Freedom.

Material Balance: **(16 hrs)**

Without Chemical reaction - Ideal gas-law calculations, real-gas relationships, vapour pressure of immiscible liquids, solutions and problems based on Raoult's, Henry & Dalton's Law. Absolute Humidity, Relative Humidity, Saturation, Dry bulb temperature, Wet bulb temperature, Adiabatic saturation temperature & use of psychometric Chart.

With Chemical Reaction- Combustion, gas-synthesis, acid-alkali production

recycle, purge, bypass in batch, stagewise and continuous operations in systems with or without chemical reaction.

Energy Balance: **(16 hrs)**

Review: Thermophysics, Thermochemistry-law of constant heat summation, Hess's Law, standard heat of reaction, combustion and formation, problems using Hess Law.

Heat balances for non reacting processes and reaction processes. Theoretical flame temperature, Adiabatic reaction temperature, flame temperature, combustion calculation.

Material and energy balances: **(6 hrs)**

Applied to industrial processes such as combustion and gasification of fuels, synthesis of ammonia, production of sulphuric acid, nitric acid, hydrochloric acid

BOOKS RECOMMENDED:

1. Hougen, P.A. Watson, K.M., Ragatz R.A Chemical Process Principles Part – I, John Wiley & Sons.
2. Himmelbleau, D. M., Riggs J.B., Basic Principles and Calculations of Chemical Engg., 7th Edition, Prentice Hall, 2004.
3. Bhatt B.L.Vora, S.M., Stoichiometry, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
4. Felder, R. M. & Rousseau, R.W., Elementary Principles of Chemical Processes, 2nd Edition, John Wiley & Sons.
5. Reklaitis G.V., Introduction to Material and Energy Balances, John Wiley & Sons.
6. Lewis W.K., Radasch A.H., Lewis H.C., Industrial Stoichiometry, McGraw Hill.

COURSE OUTCOMES

Students would be able to:-

1. calculate degree of freedom and its application
2. Implement material balance on various processes
3. Implement energy balance on various processes
4. Implement simultaneously energy balance and material balance.
5. Comprehend the concept of humidity and usage of psychometric charts.
6. Demonstrate the knowledge of simple phase equilibrium relationships.

BTCH-303A FLUID FLOW

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Objective: The course introduces the students to the principles of fluid mechanics that are of fundamental importance to chemical engineers i.e. fluid statics and dynamics, boundary layer, laminar and turbulent flows, fluid machinery etc. It is a prerequisite to Heat Transfer, Mass Transfer I & II

Introduction **(2 hrs)**

Concept of fluid, difference between solids, liquids and gases; ideal and real fluids, Introduction to fluid statics and fluid flow

Fluid Statics **(4hrs)**

Normal forces in fluids, Manometers of different types, Forces on submerged bodies, Buoyancy and stability.

Fluid Properties **(6 hrs)**

Concept of capillarity, vapour pressure, compressibility and bulk modulus, Newtonian and non-Newtonian Fluids, Nature of turbulence, Eddy Viscosity, Flow in Boundary Layers.

Basic Equations of Fluid Flow **(10 hrs)**

Momentum Balance, Continuity equation, Bernoulli's Equations, Navier Stokes Equations, Derivation and Application

Dimensional Analysis of Fluid Flow Problems using Rayleigh method and Buckingham π method, Dimensionless numbers and their significance

Flow of Incompressible Fluids **(10 hrs)**

Concept of boundary layer, Laminar and Turbulent flow in pipes, Velocity distribution in pipes, Frictional Losses in pipes and fittings, effect of roughness, Fanning Equation, Estimation of Economic Pipe Diameter, Derivation of Hagen Poiseuille's equation and f =16/ Re.

Flow of Compressible Fluids **(4 hrs)**

Compressible flow, basic equation, Mach number and its significance and isentropic flow through nozzles

Flow Measurement **(6 hrs)**

In closed channels - Pitot tube, Orifice meter, venturimeter, Rotameter

In open channels- Notches, Weirs

Fluid Machinery **(6 hrs)**

Classification and performance of Pumps, Positive displacement pumps and its types, Centrifugal pumps- characteristic curves, Net positive Suction Head and cavitation, Turbines, Compressors, Blowers, Selection and specification.

BOOKS RECOMMENDED:

1. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005
2. Backhurst J.R., Harker J.H., Coulson J.F., Richardson J.M., Chemical Engineering – Volume 1, 6th Ed., Butterworth Heinemann, 1999
3. Foust, A.S., Wenzel L.A., Clump C.W. Maus L., Anderson L. B., Principles of Unit Operations, 2nd Ed., John Wiley & Sons, 2008.
4. Raju K.S., Fluid Mechanics, Heat Transfer, and Mass Transfer: Chemical Engineering Practice, John Wiley and Sons, 2011
5. Badger, W.L. and Banchero, J.T, Introduction to Chemical Engg., McGraw Hill.
6. Philip J. Pritchard P. J., Fox and McDonald's Introduction to Fluid Mechanics, 8th Ed., John Wiley and Sons, 2011
7. Chattopadhyay, P., Unit Operations of Chemical Engg. Vol.1, 3rd Ed., Khanna Publishers.

COURSE OUTCOMES

1. Knowledge of basic principles of fluid mechanics
2. Ability to analyze fluid flow problems with the application of the momentum and energy equations.
3. Ability to decide when appropriate to use ideal flow concepts, continuity equation and Bernoulli equation
4. Understanding and analysis of problems using methodical dimensional analysis
5. Capability to analyze pipe flows as well as fluid machinery

BTCH-304A CHEMICAL ENGINEERING THERMODYNAMICS

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Prerequisite: The students should have studied Elements of Mechanical Engineering as a prerequisite to study this course

Objective: This course covers the application of thermodynamic principles to chemical engineering problems. The concept of equations of state, phase and chemical equilibrium with emphasis on vapor/liquid systems and their applications to separation processes is included.

Brief review: **(8 hrs)**

Importance of thermodynamics in chemical engineering, State functions, types of systems, internal energy, heat and work reversible and irreversible processes. 1st law of thermodynamic and its engineering applications, i.e., constant volume processes, constant pressure processes, isothermal and adiabatic processes, Throttling process, Joule-Thomson coefficient, liquefaction of gasses Standard heat of reaction, standard heat of formation, standard heat of combustion, flame temperature, enthalpy for phase change etc.

Review of 2nd and 3rd Law of thermodynamics: **(10 hrs)**

Concept of Entropy and lost work, Microscopic interpretation of entropy. Third law of thermodynamics and its applications, free energy functions and their significance in phase and chemical equilibria. Clapeyron equation and some important correlations for estimating vapour pressures. Estimation of thermodynamic properties by using graphs and tables.

Equations of state: **(7 hrs)**

Equation of state for real gases and their mixtures. Principle of corresponding states and generalized compressibility factor, H-x diagrams, heat of solution

Phase Equilibria: **(16 hrs)**

Partial molar properties, partial molar Gibbs free energy, chemical potential and its dependence on temperature and pressure. Ideal solutions (Lewis-Randall Rule).

Fugacity and its calculations. Dependence of fugacity on temperatures and pressure.

Solution behaviour of real liquids and solids. Activity and activity coeffiecients. Variation of activity co- efficient with temperature and composition. Activity coefficients of electrolytes. Standard states. Properties of mixing. Excess properties. Gibbs-Duhem equation and its application to vapour- liquid equilibria.

Chemical Equilibria: **(7 hrs)**

Equilibrium constant in terms of measurable properties, variations of equilibrium constant with temperature and pressure. Adiabatic reactions. Gibbs phase rule, equilibria in heterogeneous reactions. Electrochemical reactions.

BOOKS RECOMMENDED:

1. Smith J.M. and Van Ness, H.C, Introduction to Chemical Engineering Thermodynamics, 7th Ed., McGraw Hill Book Co., 2005
2. Dodge B.F., Chemical Engg. Thermodynamics, McGraw - Hill Book Company, Inc.
3. Balzhiser R., Samuels M., Eliassen J., Chemical Engineering Thermodynamics, Prentice Hall, 1972

COURSE OUTCOMES:
The students will be able to:

1. Apply the laws of thermodynamics to chemical engineering processes.
2. Apply thermodynamic principles for analysis of solutions, ideal solutions, their excess properties and residual properties.
3. Apply thermodynamic principles for different types of chemical engineering systems like Vapor/Liquid systems, Liquid/ Liquid systems and Solid/Liquid systems.
4. Analyze chemical reactions in relation to thermodynamic principles.
5. Apply Phase Equilibria and Chemical Equilibria for solution to problems involving more than one phase and chemical reactions.

BTCH-305A CHEMICAL PROCESS INDUSTRIES

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The main aim of this course is to acquaint the students with various broad categories of chemicals, their properties, usage and various technologies available for manufacture. The concept of flow diagrams and requirement of engineering materials for these technologies is included.

Oils and Fats: **(4 hrs)**
Status and scope, major oil seeds production in India; solvent extraction, energy and solvent requirements, hydrogenation of oils, Corrosion problems and materials of construction.

Soaps and Detergents: **(5 hrs)**
History and growth, raw material, manufacturing of detergents, biodegradability, Fat-splitting, purification of fatty acids, soap manufacture, glycerine manufacture, materials of construction.

Sugar: **(4 hrs)**
Manufacturing equipment and technology, cane sugar refining, baggase utilization, energy requirements and conservation, environmental considerations.

Pulp and Paper: **(4 hrs)**
Growth of industry, raw materials, pre-treatment, pulping, manufacture of paper, recovery of chemicals.

Acids **(3 hrs)**
Manufacture and uses of Phosphoric acid, hydrochloric acid, nitric acid, sulphuric acid, major engineering problems.

Fertilizers: **(4 hrs)**
Synthesis: naphtha, natural gas and ammonia based fertilizers, manufacture of phosphatic fertilizers and potash fertilizers, N-P-K values. Corrosion problems and materials of construction.

Soda Ash: **(4 hrs)**
Manufacturing processes- Solvay and modified Solvay process, environmental considerations, corrosion problems and material of construction.

Chlor Alkali: **(4 hrs)**
Electrochemistry of brine electrolysis, current efficiency, energy efficiency, diaphragm cells, mercury cells, mercury pollution and control, caustic soda, chlorine, corrosion problems and materials of construction.

Glass and Cement: **(4 hrs)**
Types and properties of cement, Method of production of Portland Cement, major engineering problems.
Types and properties of glass, Manufacturing process of glass, Applications, major engineering problems.

BOOKS RECOMMENDED:

1. Austin G., Shreve's Chemical Process Industries, 5th Ed., Tata McGraw Hill, 1990
2. Rao M.G., Sittig M, Dryden's Outlines of Chemical Technology- for 21st Century, 3rd Ed., Affiliated East West Press Pvt. Ltd., 2008
3. Pandey, G.N., Chemical Technology Volume-I and II, Vikas Publication, 2010
4. Moulijn J.A., Makkee M., Diepen A., Chemical Process Technology, John Wiley, 2001

COURSE OUTCOMES:

Students will be able to:-

1. Demonstrate the knowledge of various Chemical Industries and their status in India.
2. Demonstrate knowledge about process flow sheet of various organic and inorganic industries.
3. Demonstrate knowledge about history, current issues, and trends in process industries.
4. Demonstrate knowledge about MOC being used, environment and safety precautions in design and operations.
5. Demonstrate knowledge about chemical and physical processes involved including equipments and various alternative technologies being used in industries

BTCH-306A CHEMICAL TECHNOLOGY LABORATORY

	L	T	P
External Marks: 20			
Internal Marks: 30	**0**	**0**	**3**
Total Marks: 50			

LIST OF EXPERIMENTS

PART A

1. To perform proximate analysis of a given sample.
2. Determination of HCV and LCV of a given fuel by bomb calorimeter.
3. To determine the acid value of an oil/fat.
4. To determine the saponification value of an oil/fat.
5. To determine the iodine value of an oil/fat.
6. To estimate the given reducing/non-reducing sugar.
7. To determine the sediment in Crude Petroleum and Fuel oils .
8. To determine the viscosity of a given sample by Flow cup/Ostwald viscometer.

PART B

1. Preparation of an addition /condensation polymer.
2. Preparation of polymer product using injection moulding.
3. Preparation of compounded polymer sample using two roll mill.
4. Preparation of polymer product using compression moulding
5. Determination of performance of a given polymer sample under tensile loading like stress-strain curve, modulus of elasticity.
6. To find the cement composition in a given mortar sample.
7. To prepare soap by Hot and Cold process by mustard oil.

At least five experiments should be conducted from each part.

BTCH-307A FLUID FLOW LABORATORY

	L	T	P
External Marks: 20			
Internal Marks: 30	**0**	**0**	**3**
Total Marks: 50			

LIST OF EXPERIMENTS

1. Plot the characteristic curves of a centrifugal pump.
2. Verification of Bernoulli's equation for flow process.
3. Measurement of flow by a venturimeter
4. Measurement of flow by an orifice meter.
5. Measurement of flow by a rotameter
6. Measurement of flow by a V-notch in an open channel.
7. Measurement of losses in various fitting and valves.
8. Measurement of losses due to contraction and expansion.
9. Measurement of losses due to variation in cross section/ shapes.
10. Verification of laminar/ turbulent flow regime in a flow process.

BTCH-308A MECHANICAL OPERATIONS LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 3**
Total Marks: 50	

LIST OF EXPERIMENTS

1. Verification of Stokes Law.
2. Screen analysis of given sample for it's particle size distribution.
3. Determination of average size (different averages) from screen analysis.
4. Determination of variation in pressure drop & bed height With respect to superficial velocity for a bed of solids.
5. Determination of minimum fluidization velocity for a bed of solids.
6. Operating characteristics of crushing and grinding equipments (Jaw crusher, Roll crusher, Ball mill).
7. Evaluation of the filtration constants for $CaCO_3$ slurry in water and cake compressibility.
8. Determination of %age recovery of coal in froth from coal and sand mixture.
9. Determination of thickener capacity using batch sedimentation.
10. Determination of characteristics of centrifuge as a filter.
11. Determination of the separation efficiency of the cyclone separator.

(4th Semester)
BTCH-401A Mathematical Methods of Chemical Engg.

External Marks: 60 **L T P**
Internal Marks: 40 **3 1 0**
Total Marks: 100

Objective: This course is aimed at providing the students with knowledge about the numerical solutions to various mathematical expressions that they may come across in Chemical Engg. Practice, those are not easily solvable by conventional techniques. These techniques are very useful for the students for experimental data analysis, integration and differentiation of involved functions, solutions of certain implicit equations.

Linear Algebraic Equations: **(6 hrs)**
Cramer'srule, Gauss Elimination and LU Decomposition, Gauss-Jordan elimination, Gauss-Seidel and Relaxation Methods.

NonLinear Algebraic Equations: **(9 hrs)**
Single variable successive substitutions (FixedPoint Method), Multivariable successive substitutions, single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique.

Eigen values and Eigen vectors of Matrices: **(4 hrs)**
Fadeev Leverrier's Method, Power Method.

Function Evaluation: **(13 hrs)**
Least squares curve-fit (Linear Regression),Newton's interpolation formulae (equal intervals), Newton's Divided Difference Interpolation Polynomial, Lagrangian Interpolation Unequal intervals. Extrapolation Technique of Richardson and Gaunt.
Numerical Differentiation, Numerical Integration or Quadratures (Trapezoidal, Simpson's1/3and3/8 rules),

Ordinary Differential Equations (ODE-IVPs) and partial differential Equations: **(8 hrs)**
The Finite difference Technique, Runge-Kutta method

Laplace Transforms: **(8 hrs)**
Laplace transforms of various standard functions, properties of Laplace transforms, inverse Laplace transforms, transform of derivatives and integrals, Laplace transform of unit step function, impulse function, periodic functions, applications to solution of ordinary linear differential equations with constant coefficients, and simultaneous differential equations. .

BOOKS RECOMMENDED:
Text Books:

1. Gupta S.K., Numerical Methodsfor Engineers, 2nd Ed., New Age International Publishers, 2009
2. Grewal B.S., Higher engineering mathematics,43rd Ed., Khanna Publishers, 2014.

Reference Books

3. Jain M.K., Iyengar SRKand Jain R.K., Numerical MethodsforScientific andEngineeringComputation, NewAgeInternational.
4. Finlayson, B.A. Nonlinear Analysis in Chemical Engineering, MCGrawHill,NewYork,1980.
5. Villadsen J., and Michelsen, M.L. Solution of Differential Equation Models by Polynomial Approximation,PrenticeHall,N.J.,1978.
6. Rice R.G., Do DuongD.,Applied Mathematics and Modelling for Chemical Engineers, John Wiley & Sons, Inc, 1995.
7. Sastry S.S., Introductory Methods of Numerical Analysis, 4th Ed., PHI.
8. Kreyszig, E., Advanced Engineering Mathematics, Eighth edition, John Wiley, New Delhi

BTCH-402A HEAT TRANSFER

External Marks: 60 **L T P**
Internal Marks: 40 **3 1 0**
Total Marks: 100

Objective: The objective of the course is to introduce to students heat transfer mechanisms in solids and fluids and their chemical process applications. At the conclusion of the course, the student should possess the ability to model steady and unsteady heat transfer in simple systems and design heat exchangers. It requires use of thermodynamics and fluid mechanics and sets the basis for the design of reactors and separation processes.

Modes of Heat Transfer:

Conduction **(8 hrs)**

Fourier's law, one dimensional heat conduction through plane and composite structures having plane wall, spherical & cylindrical geometry. Steady state heat flow with heat source through plane wall and cylindrical surface. Thermal conductivity of materials. Insulating materials and critical thickness of insulation.

Unsteady-state conduction; Lumped heat capacity system, semi-infinite solid and Heisler chart.

Convection **(10 hrs)**

Free and forced convection, Concept of thermal boundary layer, concept of overall heat transfer coefficient for laminar and turbulent flow, Heat transfer inside & outside tubes with significance of Nusselt, Prandtl, Reynolds, Biot, Fourier and Peclet numbers.

Modelling of convective heat transfer coefficient by using dimensional analysis for natural convection.

Radiation **(6 hrs)**

Distribution of radiant energy, Definition of emissivity, absorptivity, Reflectivity and transmissivity, concept of Black and Grey bodies, Planck's law of monochromatic radiation, Kirchhoff's law, Wien's displacement law, Stefan-Boltzmann law, definition of intensity of radiation. Radiation formula for radiation exchange between simple bodies, two parallel surfaces and between any source and receiver, radiation shields

Condensation and Boiling Heat Transfer: **(6 hrs)**

Dropwise and Filmwise condensation of pure and mixed vapours, Convective, Nucleate & Film boiling, Theory and correlations, critical boiling flux

Heat exchangers: **(10 hrs)**

Heat exchangers - double pipe heat exchanger, Shell-and-Tube heat exchangers, plate type heat exchanger, concept and calculation of log mean temperature difference, temperature correction factor for shell & tube exchangers, fouling factors, overall heat transfer coefficient

Theory of Fins and their applications

Reboiler and Condensers, counter current dry contact Condenser, parallel current- wet contact Condenser.

Evaporators **(8 hrs)**

Various types of evaporators- Standard vertical tube evaporator, basket type vertical evaporator, forced circulation evaporator and horizontal tube evaporators.

Single effect evaporators and multi-effect evaporators and its various types of feed arrangements, boiling point elevation, capacity and economy of evaporators. Evaporation under vacuum.

BOOKS RECOMMENDED:

1. Holman, J.P., Heat Transfer, 10th Ed., McGraw Hill, 2010.
2. McAdams W.H., Heat Transmission, 3rd Ed., Kreiger Publishing Co, 1985
3. Backhurst J.R., Harker J.H., Coulson J.F., Richardson J.M., Chemical Engineering – Volume 1, 6th Ed., Butterworth Heinemann, 1999
4. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005
5. Kern D.Q., Process Heat Transfer, McGraw Hill.
6. Kreith F., Manglik R.M., Bohn M.S., Principles of Heat Transfer, 7th Ed., Brooks Cole Thomson Learning Publication, 2010
7. Incopera F.P., DeWitt D.P., Bergman T.L., Lavine A.S., Fundamentals of Heat and Mass Transfer, 7th Ed., John Wiley, 2011

COURSE OUTCOMES

Upon successful completion of this course, the student will be able to:

1. Demonstrate the basic laws of heat transfer.
2. Solve problems involving steady and unsteady state heat conduction in simple geometries with and without heat generation.
3. Evaluate the heat transfer in natural and forced convection.
4. Solve simple radiation heat transfer problems
5. Perform the analysis of heat transfer processes involved in evaporation, condensation and boiling.

BTCH-403A ENERGY ENGINEERING

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The objective of this course is to teach the students about the various options available to meet the ever growing demand of energy by the industry. It includes both the conventional and non-conventional energy sources.

Introduction: **(2 hrs)**

Energy crisis in the world and position in India

Conventional Sources of Energy:

Solid Fuels: **(6 hrs)**

Composition and classification of coals, analysis and properties of coal, characteristics and distribution of Indian coals, coal carbonization, briquetting, gasification and liquefaction of solid fuels.

Liquid Fuels: **(8 hrs)**

Petroleum and Related Products:

Introduction: Origin, occurrence and reserves, reserves, Production and consumption, classification and characteristics of Petroleum properties and characteristics, petroleum refining in India.

Petroleum Products - Naphtha, motor gasoline, aviation gasoline, kerosene, diesel oil, gas oils, fuel oils, lubricants, petroleum waxes, Petroleum coke.

Gaseous Fuels: **(6hrs)**

producer, water carburettor, water, coal, blast furnace and refinery gases, gases from biomass, LPG, CNG,.

Combustion Process and Appliances: **(6 hrs)**

Nature and types of combustion processes, mechanism of combustion reaction, spontaneous ignition temperature, gas and oil burners, coal burning equipments, fluidized bed combustion.

Non- Conventional Sources of Energy: **(8 hrs)**

Nuclear energy: - Nuclear reactions, fuel materials, moderators and structural materials, reactors Energy by bio-processes-bio-gas, Solar Energy - Photovoltaic cells, solar collectors, wind Energy and biofuels.

BOOKS RECOMMENDED:

Text Books:

1. Sarkar Samir, Fuels and Combustion, 2nd Ed., Orient Longman, 2003.
2. Gupta O.P., Elements of Fuels, Furnaces and Refractories, Khanna Publications, 1997.

Reference Books:

3. Wilson, P.J., Wells, G.H., Coal, Coke and Coal Chemicals, McGraw Hill, 1950.
4. Griswold, J. Fuels, Combustion and Furnaces, McGraw Hill, 2006.
5. Francis, W., Peters M.C., Fuels and Fuel Technology: a Summarized Manual, 2nd Ed., Pergarmon Press, 1980.

BTCH-404A STRENGTH OF MATERIALS

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Objective: This course is aimed at giving an insight to students about the behaviour of materials under external forces. The concept of stress, strain, elasticity etc. as applied to various structural members under loading are included.

Simple Stresses & Strains: **(8 hrs)**

Simple stresses and strains : Concept of stress and strain; St. Vernants principle, stress and strain diagram, Hooke's law, Young's modulus, Poisson ratio, stress at a point, stress and strains in bars subjected to axial loading. Modulus of elasticity, stress produced in compound bars subject to axial loading .Temperature, stress and strain calculations due to applications of axial loads and variation of temperature in single and compound bars.

Theory of Bending: **(8 hrs)**

Compound stress and strains, the two dimensional system; stress at a point on a plane, principal stresses and principal planes; Mohr's circle of stress; ellipse of stress and their applications. Generalized Hook's Law, principal stresses related to principal strains

Slopes and Deflections of Beams: **(6 hrs)**

Slopes and deflections in beams and cantilevers, calculation of slopes and deflections using double integration moment area theorems and Macullay's method.

Theories of failure: **(6 hrs)**

Strain energy, various theories of failure, their necessity and significance, graphical representation of theories of failure.

Torsion of shafts and springs: **(6 hrs)**

Torque, angle of twist and shear stresses in hollow and solid shafts with in elastic limit, assumptions intrusion, power transmitted by a shafts, analysis of close coil
spring subjected to axial load couple. Shafts subjected to torsion.

Thin Cylinders/ spheres: **(7 hrs)**

Thin cylinders subjected to internal pressure, circumferential and longitudinal stress and strains, maximum shear stress, increase in diameter and volume, thin spheres subjected to internal pressure.

Columns: **(7 hrs)**

Columns under uniaxial loads, buckling of columns slenderness ratio, and conditions. Derivations of Euler's formula for elastic-buckling load, equivalent length, Rankine-Garden empirical formula.

BOOKS RECOMMENDED:

1. Timoshenko, S., Strength of Materials Vol-I: Elementary Theory and Problems, 3rd Edition, CBS Publishers, 2002
2. Vazirani V.N. & Ratwani, Analysis of Structures, Vol. I, 17th Ed., Khanna Publishers
3. Bansal, R.K., Strength of Materials, 4th Ed., Luxmi Publishers, 2010.
4. Popov E. P., Engineering Mechanics of Solids, 2nd Ed., Prentice Hall, 1999

BTCH-405A HEAT TRANSFER LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 3**
Total Marks: 50	

LIST OF EXPERIMENTS

1. Determination of heat transfer coefficient for different types of heat transfer equipments.
2. Wilson Plots for unsteady state heat transfer in jacketed vessels.
3. Developing correlation of instantaneous heat transfer coefficients with time for steady deposition of scale on a heating surface.
4. Determination of heat losses from insulated pipes.
5. Performance characteristics of a shell and tube heat exchanger and an induced draft cooling tower.
6. Study and operation of long tube forced circulation and multiple effect evaporators.
7. Duhring's plot for solutions involving non-volatile solutes.
8. To find the heat transfer coefficient of heat loss from a vertical cylinder by natural convection.
9. To find heat transfer coefficient for parallel flow and counter flow for double pipe heat exchanger.
10. To find heat transfer coefficient for heat loss by forced convection to air flowing through it for different air flow rates & heat flow rates.

BTCH-406A NUMERICAL METHODS IN CHEMICAL ENGINERING LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 3**
Total Marks: 50	

1. Solution of a system of linear equations in unknowns by Gaussian elimination.
2. Gauss-Seidel iterative method to solve a linear system of equations.
3. To find the inverse of matrix by Gauss-Jordan method.
4. Application of Faddeev-Leverrier's method.
5. Method for finding dominant Eigen value and corresponding Eigen vectors by power method.
6. Solution of nonlinear equation by Newton Raphson method.
7. Application of Newton's formulae for interpolation.
8. Application of Lagrange polynomial interpolation formula.
9. Application of Newton's formula for numerical differentiation.
10. Numerical integration by Trapezoidal rule.
11. Numerical integration by Simpson's rules.
12. Solution of an O.D.E. by Runge Kutta Methods.
13. Application of finite difference technique.

BTCH-411A CORROSION ENGINEERING

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The course will provide an overview of corrosion effects, the various processes and applications where corrosion is dominant and mitigation strategies.

Corrosion (10 hrs)

Direct & two stage attack, electrochemical attack, environment conditioning.

Techniques for Corrosion Resistance (14 hrs)

Higher corrosion resistance through proper selection of material, isolation of corrosion prone materials form destructive environment, Technologies of anodization, enamelling, rubber lining, glass lining, refractory lining, painting and other surface protective measures.

Corrosion engineering in special applications (12 hrs)

Material transport, pumping, filtration, condensation, boiling, riveting, welding, high temperature environments etc.

Cost factor in competitive corrosion prevention/inhibition techniques.

BOOKS RECOMMENDED:

1. Uhling, H.H., Corrosion Control, John Wiley & Sons, 1971
2. Butler, G. & Ison, HCK, Corrosion 7 its prevention in waters, Leonard Hill - London, 1966
3. Maslow, P., Chemical Materials for construction, structures publishing co. 1974
4. Rajagopalan, K S., Corosion and its Prevention, Chemical Engineering Education Development
   Centre, IIT Madras, 1975
5. Payne, H. F., Organic Coatings Technology, John Wiley & Sons.
6. Fontance, M.G. & Gtretrnee, N.D., Corrosion Engineering, McGraw Hill, 1967.

BTCH-412A PLANT UTILITIES

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The aim of this course is to familiarize the students with utility services required in chemical process industries, their importance and fundamental principles.

Introduction: Importance of Process utilities in Chemical Plant. (2 hrs)

Steam: (8 hrs)

Boilers- classification , various types, construction, boiler mountings & accessories, properties of steam-tables, Mollier Diagram.

Power Generation: (6 hrs)

Internal Combustion Engines- classification, two- stroke, four stroke petrol & diesel engine, valve timing diagram, carburetor, Combustion Phenomena .

Refrigeration: (6 hrs)

Air refrigeration cycles, vapour compression cycle, P-H diagram, liquefactions processes

Compressed Air and Vacuum: (8 hrs)

Use of compressed air. Classification of compressors.

Reciprocating compressors-mechanical details, single stage and two stage reciprocating compressor, inter cooler, minimum work input in multistage.

Centrifugal compressor- velocity diagram for centrifugal compressors, dimensional parameters, slip factor, impeller blade shapes, losses in axial flow compressors.

Water: (4 hrs)

Cooling water, cooling towers, raw water, DM water, soft water

Waste Disposal: (2 hrs)

Plant sewer system and waste disposal.

BOOKS RECOMMENDED:

1. Yadav B, Thermodynamics & Heat Engines, Central Publishing House, Allahabad, 2000.
2. Vasandani, Treatise on Heat Engines, 4th edition, Metropolitan Book Co. Pvt Ltd, New Delhi, 2008
3. Lyle O, The efficient Use of Steam, Her Majesty's Stationary Office, London, 1974.
4. Baasal W D, Preliminary Chemical Engineering Plant Design, 2nd edition, New York, 1989.
5. Dodge B F, Chemical Engineering Thermodynamics, 2nd edition, McGraw Hill, 1967

BTCH-413A POLYMER SCIENCE & ENGINEERING

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The course will provide an overview of Polymers, focusing on the various types of polymers, polymerization processes, their properties and characterization.

Introduction to Polymers: (6 hrs)
Classification of polymers, polymerization process, Kinetics of step growth and chain growth polymerization, polymerization techniques: Bulk, Solution, Suspension and Emulsion Polymerisation.

Molecular weight & Size of Polymers: **(6 hrs)**
Number average and weight average molecular weight, significance of molecular weight, determination of molecular weight, viscosity method, osmotic pressure, light scattering method, gel permeation chromatography method.

Polymer properties & their testing: **(6 hrs)**
Glass transition temperature and associated properties, Tensile strength & impact strength and their determination, softening point, heat distortion dielectric and power factor.

Synthesis & Properties of Commercial Polymers: **(6 hrs)**
Manufacture, processing and properties of resins and fibre forming polymers such as phenol formaldehyde, LDPE, HDPE, polypropylene, polyvinyl chloride, polystyrene, polyurethane and polyamides.

Introduction to Rubber & Elastomers (6 hrs)
Natural & synthetic rubber, Buna S, Buna N, Butyl rubber, neoprene, thiokols, , polyurethane, Fillers, accelerators, activators, antioxidants & other additives.

Polymer Degradation: **(6 hrs)**
Thermal, Mechanical and by ultrasonic waves, photo degradation, heat energy radiation, oxidation and hydrolysis.

BOOKS RECOMMENDED:

1. Gowariker V.L., Viswanathan N.V. and Sreedhar J., , Polymer Science, 1st Ed., New Age International
2. Ghosh P., Polymer Science & Technology of Plastics & Rubber, 3rd edition, Tata McGraw Hill New Delhi, 2010
3. Billmeyer F.W., Text Book of Polymer Science, 3rd edition, John Wiley,
4. Sinha R., Outlines of Polymer Technology - Manufacture of Polymers, PHI
5. Kumar A., Gupta R.K., Fundamentals of Polymers, McGraw Hill, 1998.
6. Kumar A., Gupta R.K. , Fundamentals of Polymer Science and Engineering, Tata McGraw Hill New Delhi, 1978.

COURSE OUTCOMES

Upon successful completion of this course, the student will be able to:

1.Demonstrate the knowledge of various types of Polymers and rubbers, their characteristics and synthesis .

2.Comprehend the concept of polymerization methods and structure- property relationships of polymers.

3.Differentiate various processing & manufacturing techniques of polymers and their testing.

4.Demonstrate the knowledge of polymer degradation .

BTCH-414A ENZYME TECHNOLOGY

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The course is aimed at enabling the students to understand the enzymatic reactions, their importance and the various fundamentals involved in enzymatic reactions.

Kinetics and Mechanism of Enzyme Action (8 hrs)

Nature and function of enzyme., classification of enzymes; quantification of enzyme activity and specific activity.

Estimation of Michaelis Menten parameters, Effect of pH and temperature on enzyme activity, kinetics of inhibition. Modeling of rate equations for single and multiple substrate reactions.

Immobilised Enzyme Reactions (6 hrs)

Techniques of enzyme immobilisation-matrix entrapment, ionic and cross linking, column packing; Analysis of mass transfer effects of kinetics of immobilised enzyme reactions;

Mass transfer Effects in Immobilised Enzyme Systems (7 hrs)

Analysis of film and Pore diffusion Effects on kinetics of immobilised enzyme reactions; Formulation of dimensionless groups and calculation of Effectiveness Factors

Applications of Enzymes (8 hrs)

Extraction of commercially important enzymes from natural sources; Commercial applications of enzymes in food, pharmaceutical and other industries; enzymes for diagnostic applications. Industrial production of enzymes. Case studies on application - chiral conversion, esterification etc.

Enzyme Biosensors (7 hrs)

Applications of enzymes in analysis; Design of enzyme electrodes and case studies on their application as biosensors in industry, healthcare and environment.

BOOKS RECOMMENDED:

1. Blanch, H.W., Clark, D.S., Biochemical Engineering, 1st Ed., Marcel Dekker, 1997
2. Lee, James M. Biochemical Engineering, PHI, USA,2009
3. Bailey J.E. & Ollis, D.F., Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill, 1986
4. Wiseman, Alan, Hand book of Enzyme Biotechnology, Ellis Harwood, 1995.

(5th Semester)
INDUSTRIAL POLLUTION CONTROL

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Prerequisite: The students should have studied Mechanical Operations as a prerequisite to study this course

Objective: The course aims at giving the students an insight into the environmental issues related to chemical process industries in terms of their impact on land, water and air and the possible mitigation techniques to reduce this effect for sustainable processing.

Introduction: (12 hrs)

Ambient air and water standards, principle sources of pollution, Inter relationship between energy and environmental pollution, Prevention of environmental pollution through conservation.

Air Pollution: (12 hrs)

Principal air pollutants and their usual sources, Effects of air pollution on human health, animals and vegetation and materials, Atmospheric dispersion of air pollutants, Temperature inversions.

Ambient air sampling, dust fall jar and high volume sampler, stack sampling

Air pollution control techniques –

Process and equipment's used for the control of gaseous pollutants- equipment efficiency, gravity settler, cyclone separator, fabric filters, Electrostatic precipitators, scrubbers.

Water Pollution: (16 hrs)

Types of water pollutants, their sources and effects. BOD and COD, BOD_5, oxygen sag curve, waste water sampling- grab and composite sample.

Waste water treatment:

Primary Treatment through settling techniques and equipments like flocculation, skimming, flotation.

Secondary Treatment: aerobic and anaerobic digestion, activated sludge process, trickle filter and oxidation ponds.

Solid Waste: (8 hrs)

Control and disposal, sanitary landfill, incineration, pyrolysis gasification and recycling.

BOOKS RECOMMENDED:

1. Perkins H. C., Air Pollution, McGraw Hill, N.Y., 1974
2. Liptak B.G., Liu D. H. F., Environmental Engineers Handbook, 2nd Ed., CRC Press, 1999
3. Willisamson S.J., Fundamentals of Air Pollution, Addison Wesley Co. N.Y.,1973
4. Nemerow N.L., Liquid Wastes of Industry: Theory, Practices and Treatment, Addison Wesley Co. N.Y., 1971
5. Rao C.S., Environmental Pollution Control Engineering, 2nd Edition, New Age International Pvt. Ltd., 2006
6. Metcalf and Eddy, Waste-Water Engineering, 4th Edition, Tata McGraw Hill, 2007.
7. Mahajan S. P., Pollution Control in Process Industries, Tata McGraw Hill, 2008.
8. Sincero, A.P., Sincero, G.A., Environmental Engineering, Prentice-Hall of India, 1999.

CHEMICAL REACTION ENGINEERING-I

External Marks: 60	**L**	**T**	**P**
Internal Marks: 40	**3**	**1**	**0**
Total Marks: 100			

Objective: This course teaches the principles of reaction engineering and reactor design for homogeneous reactions. It is one of the core subjects in the chemical engineering curriculum. The course integrates fluid mechanics and heat transfer to the design and analysis of isothermal, non-isothermal, ideal and non-ideal reactors. Students learn the application of stoichiometry and rate law to design a chemical reactor that produces the desired conversion of reactants.

Introduction: (8 hrs)

Introduction & Importance of Chemical Reaction Engineering, Kinetics of homogeneous reactions, Concepts of reaction rates, rate equation, rate constant, order & molecularity, Mechanism for Elementary & Non-elementary reaction.

Design for Single Reactions: (16 hrs)

Material balance equation for ideal batch reactor and its use for kinetic interpretation of data and isothermal reactor design for simple & complex rate equation.

Performance equations for CSTR and PFR and their use for kinetic interpretation and design

Comparison of batch reactor, CSTR & PFR, Recycle reactor, concept of yield & selectivity

Reactor combinations of CSTR and PFR

Design for Multiple Reactions: (8 hrs)

Quantitative treatment of Series & parallel multiple reaction in a batch reactor, CSTR & PFR, Concept of Product distribution for multiple reactions.

Temperature & Pressure effects: (6 hrs)

Concept of adiabatic & non-isothermal operations, Energy balance equation for Batch, CSTR & PFR and their application to design of reactors, optimal temperature progression, multiple steady states in CSTR.

Non –Ideality: (10 hrs)

Basics of non-ideal flow, residence time distribution, States of segregation

Measurement and application of RTD, E-Age distribution function & F-curve and inter-relationship between them, Conversion in non-ideal reactors.

BOOKS RECOMMENDED:

1. Levenspiel O., Chemical Reaction Engineering, 3rd Ed., John Willey, 2004.
2. Smith J.M., Chemical Engineering Kinetics, 3rd Ed., McGraw Hill, 1981.
3. Peacock D.G., Richardson J.F., Chemical Engineering – Volume 3, 3rd Ed., Butterworth Heinemann, 1994
4. Walas S.M., Reaction Kinetics for Chemical Engrs, 3rd Ed., McGraw Hill Book Co, Inc.
5. Denbigh K.G. , Turner J.C.R., Chemical Reactor Theory –an Introduction, 3rd Ed., Cambridge Univ. Press London, 1984.
6. Fogler H. S., Elements of Chemical Reaction Engineering, 4th Ed., Prentice Hall, 2006

MASS TRANSFER-I

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Objective: The objective of this course is to present the principles of mass transfer and their application to separation and purification processes. The concept of mass transfer coefficients, rate expressions and some mass transfer operations is developed.

Introduction **(2 hrs)**
Importance and classification of mass transfer operations in Chemical Engineering.

Diffusion: **(6hrs)**
Diffusion in gases and liquids, Fick's First law of diffusion, Mass balance in simple situations - with and without chemical reaction.
Diffusion in solids, diffusion through porous solids and polymers, unsteady state diffusion

Interphase Mass transfer: **(10 hrs)**
Theories of Mass transfer, Individual and overall mass transfer coefficients, Convective mass transfer.
Mass balance in concurrent and counter-current continuous contact equipment, Concept of operating line, Multi-stage counter current operations, Concept of ideal stage, Stage efficiencies, Design of continuous contact equipments, HTU and NTU concepts.

Gas absorption: **(10 hrs)**
Design of plate and packed absorption columns, Scrubbers, Non-isothermal absorption, Simultaneous heat and mass transfer.

Drying of solids: **(6 hrs)**
Rate of drying curves, Through circulation drying, Continuous drying, Types of dryers.

Humidification operations: **(8 hrs)**
VLE & Enthalpy, Reference substance plots, vapour gas mixtures, concept of adiabatic saturation, psychometric charts, adiabatic operations-humidification operations and water cooling operations.
Dehumidification Equipments: water cooling towers & spray chambers

Membrane Separations: **(6hrs)**
Types of membranes, permeate flux for ultra filtration concentration polarization, partial rejection of solutes, microfiltration, Reverse Osmosis and Electro-dialysis.

BOOKS RECOMMENDED:

1. Treybal Robert E., Mass Transfer Operations, 3rd Ed., McGraw Hill, 2001
2. Sherwood T. K., Pigford R.L., Wilke C.R., Mass Transfer, Chemical Engineering Series, McGraw Hill, 1975.
3. Backhurst J.R., Harker J.H., Coulson J.F., Richardson J.M., Chemical Engineering – Volume 1, 6th Ed., Butterworth Heinemann, 1999
4. Skelland, A.H.P, Diffusional Mass Transfer, Kreiger Pub. Co., 1985.
5. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005

Dept. Elective –II

FLUIDIZATION TECH.

External Marks: 60	**L T P**
Internal Marks: 40	**2 0 0**
Total Marks: 100	

Objective: The aim of this course is to present to the students, the importance of fluidization and the fundamental principles involved in fluidization engineering.

Introduction and applications
Introduction to fluidised bed systems, Fundamentals of fluidisation, Industrial applications of fluidised beds - Physical operations. Synthesis reactions, cracking and reforming of hydrocarbons, Gasification, Carbonisation, Gas-solid reactions, calcining and clinkering.

Behaviour of Fluidised beds
Gross behaviour of fluidised beds, Minimum and terminal velocities in fluidised beds, Types of fluidisation.
Design of distributors, Voidage in fluidised beds, TDH, variation in size distribution with height, viscosity and fluidity of fluidised beds, Power consumption.
Analysis of bubble and emulsion Phase: Davidson's model, Frequency measurements, bubbles in ordinary bubbling bed model for bubble phase.
Emulsion phase: Experimental findings, Turnover rate of solids. Bubbling bed model for emulsion phase Interchange coefficients.

Flow pattern of Gas and heat & mass transfer in Fluidised beds
Flow pattern of gas through fluidised beds, Experimental findings, The bubbling bed model for gas interchange, Interpretation of Gas mixing data
Heat and Mass Transfer between fluid and solid: Experiment findings on Heat and Mass Transfer, Heat and mass transfer rates from bubbling bed model.
Heat transfer between Fluidised beds and surface- Experiment finding theories of bed heat transfer, comparison of theories.

Entrainment & Elutriation
Entrainment of or above TDH, model for Entrainment and application of the entrainment model to elutriation.
High velocity fluidized beds, Circulating fluidized beds, Design of fluidized bed reactors.

BOOKS RECOMMENDED:

1. Kunii D. & Levenspiel O., Fluidization Engineering , 2nd Ed., Butterworth Heinemann, 1991
2. Maria Laura Passos, Marcos Antonio S. Barrozo Arun S. Mujumdar, Fluidization Engineering, Laval – Canada December, 2014
3. Perry R.H., Green D. W., Chemical Engineers' Handbook, 8th ed., Mc-Graw Hill, 2008
4. Backhurst J.R., Harker J.H., Coulson J.F., Richardson J.M., Chemical Engineering – Volume 1, 6th Ed., Butterworth Heinemann, 1999

Dept. Elective –II

PROJECT MANAGEMENT

External Marks: 60	**L T P**
Internal Marks: 40	**2 0 0**
Total Marks: 100	

Objective: The aim of this course is to provide an overview of project management for small scale and medium scale industries and the regulations relevant to these industries.

Small Scale Industries and Government Policies
Small scale industries and list of products reserved under it. Relative merits and demerits of SSI and large/medium policy resolutions of 1956 and 1977.
Mini plants and Govt. Incentives, Present status of small scale industry in the country.

Small Scale Industry-Requirements and trends
Types of product and standardization of their qualities, Raw materials requirements, Utilities services, market survey, economic viability, employment potential, promotion of regional development
Trends of growth in India and abroad

Project management of SSI
Feasibility report, patterns of financial assistance, available from state/central government and financial institutions. Exploitation of R & D work from technological pools like patent office, CSIR, IIT, NRDC. Technical tie-up. Turnkey and other projects.

Legal Obligations
Import license, marketing techniques, product identification and selling, Promotion of export and legal obligations.

BOOKS RECOMMENDED:

1. Geoffery G. Mcredity, Nerson, R.E, Neck, P.A, The Practice of Entrepreneurship, Dialogue Publication, 1982
2. Chaudhary S., Project Management, Tata McGraw Hill Publishing Co., Ltd., 2004
3. Aswathappa, Factory Organisation and Management, Himalya Publishing House.
4. Bhojwani Ramesh, Small, Medium & Large Scale Industries Vol. I & II , Small industry Research Institute Delhi

Dept. Elective – II

ENGINEERING MATERIALS

External Marks: 60	**L T P**
Internal Marks: 40	**2 0 0**
Total Marks:100	

Objective: This course is aimed at giving the students information about the availability of various types and classes of materials for engineering usage as per the demands of the end use. This course will help the students in choosing a suitable material of construction for various equipments being used in a particular processing technology.

Crystal Structure
Review of bonding in solids, structure –property-processing relationship. Miller indices, effect of radius ratio on coordination, structures of common metallic, polymeric, ceramic, amorphous and partly crystalline materials. Mechanical and Thermal Properties. Methods of improving strength- reinforcement, additives.

Ferrous Metals & Non Ferrous Metals
Important varieties of iron ores. Cast iron: types, properties and uses of cast iron; Pig iron: Types of pig iron. Wrought iron: properties and uses of wrought iron. Steel: factors affecting physical properties of steel and uses of steel (No manufacturing process) Aluminium, cobalt, copper, nickel, and zinc their properties and uses.

Alloys
Introduction to Phase-Diagrams of metals and its alloys; Fe-Fe3C; Cu-Ni, equilibrium diagrams

Ceramics
Definition of ceramic, clay: properties of clay, earthen wares and stonewares, uses of stonewares. Definition, classification, composition, types and properties of glass. Definition of refractory, classification of refractories, properties of refractories. Common refractory bricks like silica bricks, fire clay bricks, dolomite bricks and high alumina bricks

Polymers & Composites
Classification of polymers, Properties and Engineering Usage of Nylon-66, nylon-6, polyesters, polycarbonates, polyurethanes, rubber, polymer composite blends

Novel Materials
Introduction to nano materials and biomaterials and their uses

BOOKS RECOMMENDED:

1. Patton W J, Materials in Industry, 2nd Ed., Prentice Hall, 1975.
2. Van Vlack L.H., Elements of Material Science & Engineering, 6th Ed., Pearson Education Inc., 2008.
3. Aggrawal B.K., Introduction to Engineering Materials, Tata McGraw Hill, 2008.
4. Narula G.S., Narual K. S., Gupta V.K., Material Science, Tata McGraw Hill, 2007.
5. Bawa HS, Materials and Metallurgy, Tata McGraw Hill, 1986.
6. Callister, W. D., Rethwisch D.G., Materials Science & Engineering- An introduction, 8th Ed., Wiley International, 2010.

CHEMICAL REACTION ENGINEERING ENVIRONMENTAL ENGG Lab

External Marks: 20 **L T P**
Internal Marks: 30 **0 0 3**
Total Marks: 50

1. Study of Rate kinetics and temperature dependency using an isothermal batch reactor.
2. Study of Rate kinetics using an isothermal Plug flow reactor
3. Study of Rate kinetics using an isothermal CSTR
4. Study of Rate kinetics using a cascade CSTR
5. To find the residence time distribution for a CSTR.
6. To find the residence time distribution for Packed bed reactor
7. To determine the Total Solids, Total Dissolved Solids, Fixed and Volatile solids of a given sample.
8. To determine conductivity, alkalinity and hardness of the given sample.
9. To find out amount of Sulphates and chlorides in a given sample.
10. To find the quantity of the Dissolved Oxygen and BOD in the given sample
11. To determine the COD of a given wastewater sample.
12. Analysis of Particulate matter and gaseous pollutants using a High volume sampler.

Chemical Process Plant Design-I

External Marks: 20 **L T P**
Internal Marks: 30 **0 0 3**
Total Marks: 50

1. Selection, Preparation of specification sheet for a centrifugal pump
2. Design of piping and piping networks
3. Process design of gravity chambers
4. Process design of cyclones
5. Process Design of Shell and Tube Heat Exchanger
6. Process Design of Condensers
7. Process Design of Agitated vessels
8. Introduction to plate heat exchangers and its design
9. Specification sheet for Heat exchangers

The students are to appear in a viva-voce examination based on design report.

BOOKS RECOMMENDED:

1. Coulson, Richardson &Sinnott R.K., Chemical Engineering Volume-6 – an Introduction to Chemical Engineering Design, 4th Ed., Elseveir Butterworth Heinemann, 2005
2. Perry R.H., Green D. W., Chemical Engineers' Handbook, 8th ed., Mc-Graw Hill, 2008
3. Coker A.K., Ludwig's Applied Process Design in Chemical & Petrochemical Plants- Vol 1, 4th Ed., Gulf Publication- Butterworth Heinemann, 2007
4. Siddiqui S., Ludwig's Applied Process Design in Chemical & Petrochemical Plants – Volume 2, 4th Ed., Gulf Publication, 2010
5. Ludwig E.E., Applied Process Design in Chemical & Petrochemical Plants- Vol 3, 3rd Ed., Gulf Publication- Butterworth Heinemann, 2001
6. Vilbrandt F.C., Dryden C. E., Chemical Engg. Plant Design, 4th Ed., McGraw Hill, 1959
7. Peters M.S. , Timmerhaus K.D., Plant Design and Economics for Chemical Engg., 5th Ed., McGraw Hill, 2003
8. Molyneux F., Chemical Plant Design –I, Butterworth Heinemann, 1963

Professional Skills-III

External Marks: 2 0	**L T P**
Internal Marks: 3 0	**0 0 1**
Total Marks: 50	

(Course to be handled by Dept. Of Humanities)

6th Sem
MASS TRANSFER - II

External Marks: 60 **L T P**
Internal Marks: 40 **3 1 0**
Total Marks: 100

Prerequisite: The students should have studied Mass Transfer-I as a prerequisite to study this course

Objective: The objective of this course is to present the principles of mass transfer and their application to separation and purification processes. The concept of various mass transfer operations is developed which are extensively used.

Distillation: **(10 hrs)**
Roult's law, ideal solutions, x-y & H-x-y diagrams, Flash vaporisation and condensation. Differential distillation, Batch distillation, Rayleigh equation, Steam distillation, Binary distillation, McCabe-Thiele and Ponchon-Savarit method, Total reflux, minimum and optimum reflux ratios, Efficiency – local, overall and Murphree efficiency.

Distillation Column Design **(8 hrs)**
Introduction to distillation column design, Design of distillation columns with open steam, partial condensers and total condensers. Approximate plate to plate calculations for multi-component distillation.

Liquid-liquid extraction: **(10 hrs)**
Extraction equipment, equilibrium diagram. Choice of solvent. Single stage and multistage counter-current extraction with/without reflux. Continuous contact extractors.

Leaching: **(8 hrs)**
Leaching equipment and equilibrium. Single stage and multistage cross current and counter current leaching.

Adsorption: **(7 hrs)**
Types, nature of adsorbents, Adsorption equilibria- single species- Langmuir, Freundlich isotherms, Adsorption operations –single stage and multi stage, Adsorption column sizing

Crystallization: **(5 hrs)**
Equilibria and yields, Methods of forming nuclei in solution and crystal growth, equipments- vacuum crystallizer, Draft tube-baffle crystallizer.

BOOKS RECOMMENDED:

1. Treybal Robert E., Mass Transfer Operations, 3rd Ed., McGraw Hill, 2001
2. Sherwood T. K., Pigford R.L., Wilke C.R., Mass Transfer, Chemical Engineering Series, McGraw Hill, 1975.
3. Backhurst J.R., Harker J.H., Coulson J.F., Richardson J.M., Chemical Engineering – Volume 1, 6th Ed., Butterworth Heinemann, 1999
4. Skelland, A.H.P, Diffusional Mass Transfer, Kreiger Publishing Co., 1985.
5. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005
6. Harker J. H., Richardson, J. F., Backhurst J. R., Chemical Engg. Vol, 2, 5th Ed., Butterworth-Heinemann, 2003.
7. King C.J, Separation Process, Tata McGraw Hill Pub.
8. Holland, Charles D., Fundamentals and Modelling of Separation Processes, Prentice Hall, Inc. New Jersey.

CHEMICAL REACTION ENGINEERING –II

External Marks: 60 **L T P**
Internal Marks: 40 **3 1 0**
Total Marks: 100

Prerequisite: The students should have studied Chemical Reaction Engg. – I as a prerequisite to study this course

Objective: This course teaches the principles of reaction engineering and reactor design for heterogeneous reactions. It is one of the core subjects in the chemical engineering curriculum. The course includes the use of mass transfer and heat transfer principles as applicable to heterogeneous reactions and their application to reactor design.

Kinetics of heterogeneous reactions: (10 hrs)
Introduction to catalysts & their classification, Concepts of physical absorption and Chemisorption, Preparation of solid catalysts, Deactivation of Catalysts, Synthesis of rate law, mechanism & rate limiting step for catalytic reactions, Langmuir Hinshelwood rate equations and parameter estimation.

Diffusion through porous catalyst particles: (10 hrs)
Effectiveness factor for pore diffusion resistance through a single cylindrical pore, Significance of Thiele modulus, Heat effects during reaction, Performance equations for solid- gas reactions for different reactor types & determination of controlling resistance.

Kinetics of Fluid-Particle Reactions: (10 hrs)
Modelling of gas-solid non-catalytic reactions and determination of parameters, Combination of resistances & determination of rate controlling step.

Kinetics & Design of Fluid-Fluid Reactions: (10 hrs)
Interface behaviour for liquid-phase reaction, Regimes for different reaction kinetics for liquid-liquid reactions, Determination of reaction rate & tower height based on film and penetration theories, Concept of Enhancement factor & Hatta Number.

Design of heterogeneous reactors: (8 hrs)
Analysis of rate data design outline and selection of fixed bed, fluid bed and slurry reactors, Reactor systems and design for gas-liquid-solid non-catalytic system.

BOOKS RECOMMENDED:

1. Smith J.M., Chemical Engineering Kinetics, 3rd Ed., McGraw Hill, 1981.
2. Levenspiel O., Chemical Reaction Engineering, 3rd Ed., John Willey, 2004.
3. Peacock D.G., Richardson J.F., Chemical Engineering – Volume 3, 3rd Ed., Butterworth Heinemann, 1994
4. Walas S.M., Reaction Kinetics for Chemical Engrs, 3rd Ed., McGraw Hill Book Co, Inc.
5. Denbigh K.G. , Turner J.C.R., Chemical Reactor Theory –an Introduction, 3rd Ed., Cambridge Univ. Press London, 1984.
6. Fogler H. S., Elements of Chemical Reaction Engineering, 4th Ed., Prentice Hall, 2006
7. Carberry, J.J. Chemical & Catalytic Reaction Engineering, McGraw Hill, NY, 1976.

PETROLEUM REFINING ENGINEERING

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The course is aimed at providing the understanding of petroleum refining industry. It includes the characterization of crude and petroleum products and their usage and the various processes involved.

Introduction to petroleum industry:
World petroleum resources, petroleum industry in India. Origin, exploration, drilling and production of petroleum crudes, Transportation of crudes and products.

Crude pretreatment:
Composition and classification of crudes, methods of evaluation: ASTM, TBP and EFV distillation.

Petroleum Products

Properties and specifications of petroleum products such as LPG, gasoline, naphtha, kerosene, diesel oils, lubricating oils, waxes and the like.

Testing of petroleum products:
(i) Physical test: Density and specific gravity, viscosity.
(ii) Chemical test: Organic and inorganic constituents.
(iii) Flammability Test: Flash point, volatility.
(iv) Knock Rating Test: For Gasoline Octane Number.

Separation Processes:
Design and operation of topping and vacuum distillation units, Tube still furnaces, Solvent extraction processes for lube oil base stock and for aromatics from naphtha and kerosene steams, solvent dewaxing.

Conversion Process:
Thermal cracking, visbreaking and coking processes.
Catalytic cracking, reforming, hydroprocessing, alkylation, polymerization and isomerisation.

Safety and pollution considerations in refineries.

BOOKS RECOMMENDED:

1. Nelson, W.L., Petroleum Refinery Engineering, 5th Edition, McGraw Hill, 1985.
2. Hobson, G.D., Pohl. W., Modern Petroleum Technology, 5th Edition, John Wiley, 1984.
3. Guthrie, V.B., Petroleum Products Handbook, McGraw Hill, 1960.
4. Rao, B.K., Modern Petroleum Refining Processes, 5th Edition, Oxford & IBH Publishing Co., 2009.

RENEWABLE ENERGY SOURCES

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The objective of this course is to acquaint the students with the renewable energy sources available to supplement and augment the energy requirements.

Introduction: **(2 hrs)**
Global and Indian scenario, sources, Energy conservation, types of NCES with applications

Solar Energy: **(12 hrs)**
Role and development of new renewable energy sources, instruments for measuring solar radiations, solar radiation data, Flat plat and concentrating collectors, classification of concentrating collectors, advanced collectors, different methods of solar energy storage, solar ponds
solar applications: Solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion.

Hydro electric Energy: **(3 hrs)**
Hydro-electric power plant, conversion of hydro energy into electricity.

Wind Energy: **(5 hrs)**
Sources and potentials, horizontal and vertical axis, wind mills, wind regime analysis and evaluation of wind mills.

Biomass and Biofuels: **(8 hrs)**
Recycling of agricultural waste, anaerobic/ aerobic digestion and types of biogas digesters; gas yield, and combustion characteristics of bio gas, design of biogas system for heating, lighting and running IC engines. Introduction to Biofuels such as biodiesel, ethanol, biobutanol etc., their production and present status.

Geothermal Energy: Resources, types of wells, methods of harnessing the energy **(3 hrs)**

Ocean and Tidal Energy:
Introduction and conversion technique, mini hydel power plants and their economics **(3 hrs)**

BOOKS RECOMMENDED:

1. Rai G D, Non-Conventional Energy Sources, 4th edition, Khanna Publishers, 2009
2. Kumar Ramesh editor, Udayakumar K., Anandakrishnan M., Renewable Energy Technologies: Ocean Thermal Energy Conversion and Sustainable Energy Options, Narosa Publication, 1997
3. Desai Ashok V, Jhirad D., Munasinghe M., Non-Conventional Energy, New Age International, 1990
4. Sukhatme S. P. , Solar Energy: Principles of Thermal Collection and Storage, 3rd Edition, Tata McGraw-Hill Education, 2008
5. Mittal K.M., Non-Conventional Energy System, Principles, Progress and Prospects, Wheeler Pub, 1997

HEAT EXCHANGERS

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 0**
Total Marks: 100	

Objective: The course will provide an overview of analysis of heat exchange equipment in an industry based on pinch technology and minimization of utilities, number of heat exchangers etc. It includes the networking of heat exchange equipments to yield better performance.

Pinch Technology:
Introduction, Basic concept, How it is different than energy auditing, Role of thermodynamic laws, Problem addressed by Pinch technology.
Key Steps of Pinch Technology: Data extraction, Targeting, Designing, Optimization-Super targeting.

Basic Elements of Pinch Technology: Grid diagram, Composite curve, Problem table algorithm, Grand composite curve.

Heat Exchanger Network (HEN):
Targeting of Energy, Area targeting, Number of units targeting, Shell targeting, cost targeting.
Designing of HEN: Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER).

Design of multiple utilities and pinches, Design for threshold problem, Loops and Paths.
Heat Integration of Equipments

BOOKS RECOMMENDED:

1. Kumar, Chemical Synthesis and Engineering Design, Tata McGraw Hill
2. V. Uday Sheno, Heat Exchanger network synthesis, Gulf Publishing Co, USA, 1995
3. James M. Douglas Conceptual Design of Chemical Process, McGraw Hill, New York, 1988.
4. Linnhoff, B. Townsend D.W., Boland D., Hewitt G.F., Thomas, B.E.A., Guy, A.R. and Marsland, R.H., "A User's Guide on Process Integration for the Efficient Use of Energy", Inst. of Chemical Engineers, London, 1982.
5. Smith, R., "Chemical Process Design", McGraw Hill, 1995.

OPTIMIZATION TECHNIQUES

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Prerequisite: The students should have studied Numerical Methods in Chemical Engg. as a prerequisite to study this course

Objective: This course aims at training the students in the use of various optimization techniques for finding the best operating conditions or values for design variables such that some objective is justified. It includes the optimization of linear, non-linear, single variable and multivariable problems.

Introduction: **(8 hrs)**

Engineering application of optimization, Design variables, constraints, objective function, variable bounds, statement and formulation of an optimization problem, Examples of chemical engineering Optimization problems, Classification of optimization problems, different optimization algorithms.

Optimal Point: Local optimal point, global optimal point and inflection point.

Optimality criterion.

Single variable Optimization Techniques: (10 hrs)

1. Bracketing method (Bounding phase method).
2. Region elimination methods (Internal halving method, Fibonacci search method, Golden section search method).
3. Point estimation method (Successive quadratic estimation methods).
4. Gradient-based methods (Newton-Raphson method, Bisection method, Secant, Cubic search method.)
5. Root finding using optimization techniques.

Multivariable Optimization Techniques: (12 hrs)

1. Optimality criterion – Hessian Matrix and its use in optimization
2. Unidirectional search method.
3. Direct search method (Evolutionary method, Hooke-Jeeves Pattern Search method, Powell's conjugate direction method)
4. Gradient-based methods (Steepest descent method, Newton's method, Marquardt's methods)

Constrained Optimization Algorithms: (12 hrs)

1. Kuhn - Tucker conditions
2. Transformation method (penalty function method)
3. Direct search for constrained minimization (variable elimination method, complex search method.)

Linear Programming: (7 hrs)

Linear programing problems, Degeneracy, Simplex method of linear programming, dual phase simplex method.

BOOKS RECOMMENDED:

1. Deb K., Optimization for Engg. Design Algorithms and Examples , Prentice Hall of India, 2005.
2. Edgar T.I. & Himmelblau D.M., Lasdon L.S., Optimization of Chemical Processes, McGraw Hill, 2001.
3. Rao S.S., Engineering Optimization Theory and Practice, 4th Ed., John Wiley and Sons, 2009.
4. Ray W.H., & Szekely J., Process Optimization with Applications to Metallurgy & Chemical Engg. Wiley Interscience, 1973.
5. Beveridge S.G. & Schechter R.S., Optimization: Theory & Practice, McGraw Hill, 1970.
6. Grewal B.S., Numerical Methods in Engineering and Science, Khanna Publishers, 1991.

BIOCHEMICAL ENGINEERING

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Objective: This course is aimed at giving the students an insight into biochemical processes, their importance and fundamentals in these processes like biochemistry, kinetics and transport.

Biochemistry :
Structure and function of carbohydrates, lipids, amino acids and peptides, nucleic acid and nucleotides, proteins, enzymes.

Classification of microorganisms:
Morphological, structural and biochemical characteristics of prokaryotes and eukaryotes. Microbial nutrients and growth media. Microbial reproduction and growth.

Kinetics of microbial growth,
Enzyme kinetics including enzyme inhibition.

Sterilization of air and media

Nutrient transport across cell membrane.

Mass transfer and microbial respiration:
Mass transfer resistance, physical and enzymatic considerations, critical value of dissolved oxygen concentration, respiration of mycelial pellet

Bubble aeration and mechanical agitation
Single bubbles, series of bubbles, power number versus Reynolds number, decrease of power requirement in aeration.

Cardinal rules for Fermentor design, materials of construction.

BOOKS RECOMMENDED:

1. Pelzer M.J., Chan E.C.S. and Kerig N.R., Microbiology, 3rd edition, McGraw Hill Book Co., 1993
2. Stryer L, Freeman W.H., Biochemistry, 5th edition, W.H.Freeman and co, 2002
3. Bailey J.E. & Ollis, D.F., Biochemical Engineering Fundamentals, 2nd edition, McGraw Hill, 1986.
4. Shuler M.L., Kargi F., Bioprocess Engineering: Basic Concepts, 2nd Ed., Prentice Hall
5. Shuichi Aiba, Biochemical Engineering, 2nd edition, Academic Press Inc. New York, 1973

TRANSPORT PHENOMENA

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 0**
Total Marks: 100	

Objective: This course introduces the student to the rigorous formulation of transport problems using the conservation principles and flux expressions, and identifies the similarities and differences among the transport processes for momentum, heat and mass. The main focus of the course is on microscopic treatment of transport problems, with particular emphasis on proper use of dimensional analysis and scaling arguments.

Review: **(8 hrs)**
Transport of momentum, heat and mass by molecular motion-Newton's law of Viscosity, Fourier's law of heat conduction, Fick's law of diffusion.

Transport properties: **(10 hrs)**
Viscosity, thermal conductivity and mass diffusivity.
Emphasis on the analogy between momentum, heat and mass transfer with respect to transport mechanism and governing equations.

Development of mathematical models of transfer process by shell momentum balance: **(12 hrs)**
Shell energy balance and shell mass balance for solving specific problems of transport of momentum, heat and mass in laminar flow or in solids in one dimension.

Development of general differential equations of fluid flow: **(8 hrs)**
Heat transfer and mass transfer and their applications in solving one-dimensional steady state and unsteady state problems of momentum, heat and mass transfer.

Interphase transport: **(5 hrs)**
Interphase transport of Momentum, heat and mass and dimensionless correlations for each one of them.

Transport Analysis: **(5 hrs)**
Momentum, heat and mass transfer analysis and analogies

BOOKS RECOMMENDED:

1. Bird R.B., Stewart, W.E. and Lightfoot, E.N., Transport Phenomena, 2nd Ed., John Wiley& Sons, 2005.
2. Geankoplis C.J., Transport Processes and Separation Process Principles (Includes Unit Operations), 4th Ed., Prentice Hall, 2003
3. Weity, J.R. Wilson, R.E. and Wicks, C.E., Fundamentals of Momentum Heat and Mass Transfer, 4thEd., John Wiley & Sons.
4. Bennett.C.O. and Myres J.E., Momentum Heat and Mass Transfer, 3rd Ed., McGraw Hill, 1982.

MASS TRANSFER LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 3**
Total Marks: 50	

1. To find out the critical moisture content of the given material and to find out the equations for constant and falling rate period of drying.
2. Determination of liquid hold up in a packed column.
3. To find the mass transfer coefficient for the vaporisation of organic vapour to air.
4. To verify the Rayleigh's equation for batch distillation.
5. To find the height equivalent to a theoretical plate and height of a transfer unit for the packed distillation column under total reflux.
6. To find the yield of crystals using batch crystallizer
7. To find the efficiency of rotary drier using a granular solid
8. To find the efficiency of a distillation column.
9. To study the adsorption characteristics and plot adsorption isotherm.
10. To find the yield of a natural oil by leaching from biomass.
11. To study liquid-liquid extraction in a packed column.
12. To determine mass transfer coefficient from a wetted wall column.

PROCESS EQUIPMENT DESIGN

External Marks: 20 **L T P**
Internal Marks: 30 **0 0 3**
Total Marks: 50

Prerequisite: The students should have studied Strength of Materials as a prerequisite to study this course

1. Mechanical Design of Process Equipment: Introduction, Classification of pressure vessels, pressure vessel codes and standards, Fundamental Principles and equations review
2. Design Considerations: Design Pressure, Design Temperature, Materials of construction, Weld joint efficiency, corrosion allowance, Design loads.
3. Design of thin walled vessels under Internal Pressure: Cylindrical and spherical vessels
4. Design of heads and closures – design of flat head, conical head, dished heads, hemispherical and elliptical heads
5. Design of thick walled vessels under Internal Pressure
6. Design of Vessels subject to External Pressure: Cylindrical& spherical vessels, Stiffening rings, vessel heads
7. Design of vessels under combined loading: Dead Weight, wind load
8. Design of supports: Skirt support, lug support

The examination shall include a viva-voce examination based on the design report.

BOOKS RECOMMENDED:

1. Brownell L.E. and Young E. H., Process Equipment Design, Wiley Interscience, 1959.
2. Bhattacharya, R.C., An Introduction to Chemical Equipment Design- Mechanical Aspects, 1st Ed., CBS Publication, 1985

Mahajani V.V., Umarji S.B., Joshi's Process Equipment Design, 4th Ed., Macmillan Indian Ltd., 2009

Professional skills -IV

External Marks: 2 0	**L T P**
Internal Marks: 3 0	**0 0 1**
Total Marks: 50	

(Course to be handled by Dept. Of Humanities)