Punjab Technical University, Jalandhar

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-301	Mechanical Operations	3	1	---	40	60	100	4
BTCH-302	Chemical Process Calculations	3	1	---	40	60	100	4
BTCH-303	Fluid Flow	3	1	---	40	60	100	4
BTCH-304	Strength of Materials	3	1	---	40	60	100	4
BTCH-305	Chemical Engineering Thermodynamics	3	1	---	40	60	100	4
BTCH-306	Strength of Materials Laboratory	---	---	2	30	20	50	1
BTCH-307	Fluid Flow Laboratory	---	---	4	30	20	50	2
BTCH-308	Mechanical Operations Laboratory	---	---	4	30	20	50	2
BTCH-309	Institutional Practical Training*	---	---	---	60	40	100	---
	Total	**15**	**5**	**10**	**350**	**400**	**750**	**25**

*** Institutional Practical Training (During summer vacation after 2nd semester)**

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

Total contact hours =35

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTAM-201	Engineering Mathematics-III	4	1	---	40	60	100	5
BTCH-401	Chemical Process Industries	4	--	---	40	60	100	4
BTCH-402	Mass Transfer – I	3	1	---	40	60	100	4
BTCH-403	Heat Transfer	3	1	---	40	60	100	4
BTCH-404	Chemical Process Instrumentation	3	1	---	40	60	100	4
BTCH-405	Chemical Reaction Engineering - I	3	1	---	40	60	100	4
BTCH-406	Heat Transfer Laboratory	---	---	4	30	20	50	2
BTCH-407	Chemical Technology Laboratory	---	---	3	30	20	50	2
BTCH-408	CAD in Chemical Engineering Laboratory	---	---	3	30	20	50	2
	General Fitness	--	---	---	100	---	100	--
	Total	**20**	**5**	**10**	**430**	**420**	**850**	**31**

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

Total contact hours =32

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-501	Numerical Methods in Chemical Engineering	3	1	---	40	60	100	4
BTCH-502	Mass Transfer - II	3	1	---	40	60	100	4
BTCH-503	Process Dynamics & Control	3	1	---	40	60	100	4
BTCH-504	Industrial Pollution Control	3	1	---	40	60	100	4
BTCH	Elective - I	3	1	---	40	60	100	4
BTCH-505	Mass Transfer Laboratory	---	---	4	30	20	50	2
BTCH-506	Chemical Reaction Engineering & Pollution Control Laboratory	---	---	4	30	20	50	2
BTCH-507	Numerical Methods in Chemical Engineering Laboratory	---	---	4	30	20	50	2
BTCH-508	Industrial Practical Training**	--	--	--	60	40	100	2
	Total	**15**	**5**	**12**	**350**	**400**	**750**	**28**

****<u>There should be industrial/institutional training of 6 weeks duration in the summer vacation after 4th semester</u>**

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

Total contact hours =34

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-601	Chemical Reaction Engineering - II	3	1	---	40	60	100	4
BTCH-602	Optimization Techniques	3	1	---	40	60	100	4
BTCH-603	Energy Engineering	3	1	---	40	60	100	4
BTCH-604	Engineering Materials	3	---	---	40	60	100	3
BTCH-605	Transport Phenomenon	3	1	---	40	60	100	4
BTCH	Elective - II	3	1	---	40	60	100	4
BTCH-606	Process Instrumentation, Dynamics & Control Laboratory	---	---	4	30	20	50	2
BTCH-607	Chemical Process Plant Design-I	1	---	3	30	20	50	3
BTCH-608	Literature Survey & Seminar	---	---	3	30	20	50	2
	General Fitness	---	----	----	100	----	100	--
	Total	**19**	**5**	**10**	**430**	**420**	**850**	**30**

B. Tech. Chemical Engineering
Scheme of Syllabi
7th /8th Semester

Total contact hours = ----

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-701	Software Training@	---	---	---	150	100	250	10
BTCH-702	Industrial/ Institutional Training	---	---	---	300	200	500	20
	Total				**450**	**300**	**750**	**30**

@ the chemical engineering department in the college to provide software training to enhance the professional capabilities of students as Chemical Engineers like:

- **ASPEN**
- **CHEMCAD**
- **MATLAB**
- **PROSIM**
- **Any other relevant software**

B. Tech. Chemical Engineering
Scheme of Syllabi
7th /8th Semester

Total contact hours =35

Course Code	Course Name	Load Allocated			Marks Distribution		Total Marks	Credits
		L	T	P	Internal Marks	External Marks		
BTCH-801	Chemical Process Simulation	3	1	---	40	60	100	4
BTCH-802	Process Engineering & Economics	3	1	---	40	60	100	4
	Open Elective	3	---	---	40	60	100	3
BTCH	Elective-III	3	1	---	40	60	100	4
BTCH-803	Safety in Chemical Plants	3	1	----	40	60	100	4
BTCH-804	Chemical Equipment Design	---	---	3	30	20	50	2
BTCH-805	Process Optimization & Simulation Laboratory	---	---	3	30	20	50	2
BTCH-806	Chemical Process Plant Design-II	1	---	3	30	20	50	3
BTCH-807	Project	---	---	6	60	40	100	3
	General Fitness	---	----	----	100	----	100	--
	Total	**16**	**4**	**15**	**450**	**400**	**850**	**29**

LIST OF ELECTIVES

Elective - I		
Sr. no	**Course Code**	**Course Name**
1	BTCH-521	Polymer Science & Engineering
2	BTCH-522	Enzyme Technology
3	BTCH-523	Fluidisation Engineering
4	BTCH-524	Nano-Technology
5	BTCH-525	Separation Processes

Elective - II		
Sr. no	**Course Code**	**Course Name**
1	BTCH-621	Petroleum Refining Engineering
2	BTCH-622	New & Renewable Energy Sources
3	BTCH-623	Membrane Separations
4	BTCH-624	Fuel Cell Technology
5	BTCH-625	Corrosion Engineering
6	BTCH-626	Project Management

Elective - III		
Sr. no	**Course Code**	**Course Name**
1	BTCH-821	Bio-Chemical Engineering
2	BTCH-822	Polymer Reactor Design*
3	BTCH-823	Plant Utilities
4	BTCH-824	Heat Exchangers
5	BTCH-825	Petro-Chemical Technology

* Polymer Reactor Design Elective III is allowed only for students who have opted for Polymer Science & Engineering as Elective I.

Syllabi (3rd Semester)

BTCH-301 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.

Conveying of bulk solids: Basic idea of conveyor, conveyor selection, screw, belt, vibrating, continuous flow and pneumatic conveyors.

Storage and weighing: bulk storage, bin storage, feeders (vibrating hopper, screw feeder, belt feeder), batch and continuous weighing.

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

BTCH-302 CHEMICAL PROCESS CALCULATION

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)**

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

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.

BTCH-303 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

Indroduction **(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 Equation 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.

BTCH-304 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.

Mechanical Properties and Testing: **(6 hrs)**
Concept of strength, yield strength, ultimate strength hardness, impact strength, ductility, britleness, tensile, compressive, bending, torsion, hardness and impact tests.

Theory of Bending: **(6 hrs)**
Review of bending moment, shear force, bending and shear stresses. Bending & shear stresses in composite beams.

Unsymmetrical Bending: **(6 hrs)**
Principal axes, analytical and graphical methods, stresses due to unsymmetrical bending 7-polygen deflections of beams under unsymmetrical bending.

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: **(6 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: **(6 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-305 CHEMCIAL 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

BTCH-306 STRENGTH OF MATERIALS LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 2**
Total Marks: 50	

1. Determination of yield points, tensile strength and ultimate strength of mild steel specimen.
2. Determination of compressive strength of mild steel specimen.
3. Bending test of mild steel specimen.
4. Tensile test of a specimen of brittle material.
5. Torsion test of a mild steel specimen.
6. Determination of Brinell hardness of ductile and brittle materials.
7. Determination of Rockwell Hardness of a hard material.
8. Performance of Vickers's Hardness test.
9. Determination of Impact strength of a specimen.

BTCH-307 FLUID FLOW LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 4**
Total Marks: 50	

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

BTCH-308 MECHANICAL OPERATIONS LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 4**
Total Marks: 50	

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 classifier.

Syllabi (4th Semester)

BTAM-201 ENGINEERING MATHEMATICS-III

External Marks: 60	**L T P**
Internal Marks: 40	**4 1 0**
Total Marks: 100	

Common to all (IV Semester)

PART-A

Fourier Series:
Periodic functions, Euler's formula. Even and odd functions, half range expansions, Fourier series of different wave forms.

Laplace Transforms:
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.

Special Functions:
Power series solution of differential equations, Frobenius method, Legendre's equation, Legendre polynomial, Bessel's equation, Bessel functions of the first and second kind. Recurrence relations, equations reducible to Bessel's equation.

PART-B

Partial Differential Equations:
Formation of partial differential equations, Linear partial differential equations, homogeneous partial differential equations with constant coefficients

Applications of PDEs:
Wave equation and Heat conduction equation in one dimension. Two dimensional Laplace equation in Cartesian Coordinates, solution by the method of separation of variables.

Functions of Complex Variable:
Limits, continuity and derivative of the function of complex variable, Analytic function, Cauchy-Riemann equations, conjugate functions, and harmonic functions;
Conformal Mapping: Definition, standard transformations, translation, rotation, inversion, bilinear. Complex Integration: Line integrals in the complex plane, Cauchy's theorem, Cauchy's integral formula and derivatives of analytic function. Taylor's and Laurent's expansions (without proofs), singular points, poles, residue,
Integration of function of complex variables using the method of residues.

BOOKS RECOMMENDED:

1. Kreyszig, E., Advanced Engineering Mathematics, Eighth edition, John Wiley, New Delhi
2. Grewal, B. S., Higher Engineering Mathematics, Khanna Publishers, New Delhi.
3. Ian N. Sneedon, Elements of Partial Differential Equations, McGraw- Hill, Singapore, 1957.
4. Peter. V. O'Nil, Advanced Engineering Mathematics, Wadsworth Publishing Company.
5. Taneja, H. C., Engineering Mathematics, Volume-I & Volume-II, I. K. Publisher.
6. Babu Ram, Advance Engineering Mathematics, Pearson Education.
7. Bindra, J. S., Applied Mathematics, Volume-III, Kataria Publications.

BTCH-401 CHEMICAL PROCESS INDUSTRIES

External Marks: 60	**L T P**
Internal Marks: 40	**4 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: **(6 hrs)**
Status and scope, major oil seeds production in India; solvent extraction, energy and solvent requirements, minor oil seeds and other oil bearing materials, 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: **(6 hrs)**
Manufacturing equipment and technology, cane sugar refining, baggase utilization, energy requirements and conservation, environmental considerations, khandsari – technology, molasses based industries, materials of construction.

PULP AND PAPER: **(4 hrs)**
Growth of industry, raw materials, pre-treatment, pulping, manufacture of paper, recovery of chemicals.

INDUSTRIAL GASES: **(4 hrs)**
Manufacture and uses of hydrogen, carbon dioxide, acetylene, oxygen, nitrogen, inert gases.

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

FERTILIZERS: **(7 hrs)**
Status of industry, grading and classification of fertilizers, raw materials, hydrogen production, fixation of nitrogen, synthesis- naphtha based and natural gas based, 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: **(5 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

BTCH-402 MASS TRANSFER-1

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 Publishing Co., 1985.
5. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005

BTCH-403 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

BTCH-404 CHEMICAL PROCESS INSTRUMENTATION

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 various types of instruments and their chemical process applications.

Introduction: **(5 hrs)**

Importance of instruments in Chemical Process industries, Classification of instruments, Static and Dynamic characteristics of instrument.

Instruments for Pressure Measurement: **(8 hrs)**

Use of manometers, Bourdon gauge, bellow type gauge, Measurement of vacuum and pressure, Transducers

Temperature Measurement: **(8 hrs)**

Thermocouples, resistance & filled thermometers, thermistors, optical and radiation pyrometers.

Flow & level measurements: **(8 hrs)**

Liquid level measurement-Direct and differential method and Flow measuring devices, Use of obstruction type meters, Variable area meters. Pressure probes, positive displacement type meters

Instruments for Miscellaneous Measurements : **(14 hrs)**

Measurement of Nuclear Radiation, Viscosity, Conductivity, Humidity and pH value, Industrial weighing and feeding systems, Instrument for gas analysis, gas chromatography, mass spectroscopy. Process instrumentation, Recording instruments, indicating and signalling instruments, Transmission of instrument reading, control centre, Instrumentation diagram, Instrumentation in modern plant.

Controls: **(5 hrs)**

Introduction to the concept of Automatic process control and Process and Instrumentation diagrams of typical units like Reactors and Evaporators.

BOOKS RECOMMENDED:

1. Eckman D.P., Industrial Instrumentation, Wiley Eastern, 1974
2. Harriott P., Process Control, Tata McGraw Hill, 2001.
3. Patranabis D., Principles of Process Control, 2nd Ed., Tata McGraw Hill, 2001
4. Pollard, Process Control for Chemical and Allied Industries, Butterworth Heinnemann, 1971.
5. Weber T. W., An Introduction to Process Dynamics & Control, Kreiger Publishing Co, 1988
6. Coughanour, D. R., Process System Analysis & Control, McGraw Hill.
7. Coughanowr D. R., Leblanc S., Process System Analysis and Control, 3rd Ed., McGraw Hill, 2009

BTCH-405 CHEMICAL REACTION ENGINEERING-1

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: **(8 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: **(8 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

BTCH-406 HEAT TRANSFER LABORATORY

External Marks: 20 **L T P**
Internal Marks: 30 **0 0 4**
Total Marks: 50

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-407 CHEMICAL TECHNOLOGY LABORATORY

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

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 determine the neutralisation no. of an oil/fat.
7. Preparation of phenol-formaldehyde.
8. Preparation of urea-formaldehyde.
9. Preparation of polymer product using compression moulding, Injection moulding.
10. Preparation of compounded polymer sample using two roll mill.
11. Determination of performance of a given polymer sample under tensile loading like stress-strain curve, modulus of elasticity.
12. Determination of N-P-K value of a fertilizer

BTCH-408 CAD IN CHEMICAL ENGINEERING LABORATORY

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

1. Traditional drafting of various assemblies, pipe joints, sectional views and valves.
2. Introduction to various Computer Softwares and Computer Aided Drafting. Study and use of various commands from Menus, Command Tool Box and Command prompt area.
3. Applications of Auto – CAD
    - Drawing of Process and Flow Sheets.
    - X-Y Graphs, Heat Exchangers.
    - Columns: Packed Columns, Plate Columns.
    - Jacketed vessels, Boiler parts like spring loaded steam stop valve.
    - Cut View of Centrifugal pump and rotary compressor to show internal details.

BOOKS RECOMMENDED:

1. Rakar, A., Inside Auto Cad, B.P.B. Publications, New Delhi.
2. Omura, G., Mastering Auto Cad, P.B.S. Publications, New Delhi.
3. Voisinet, D.D., Computer Aided Drafting & Design.
4. Rogers, D.F., Procedural Elements for Computer Graphics, McGraw Hill, N.Y.

Syllabi (5th Semester)

BTCH-501 NUMERICAL METHODS IN CHEMICAL ENGINEERING

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.

Introduction & Error analysis: **(5 hrs)**
Introduction to Numerical methods and its significance in chemical engineering, Classification of errors, significant digits and numerical stability.

Linear Algebraic Equations: **(7 hrs)**
Cramer's rule, Gauss Elimination and LU Decomposition, Gauss-Jordan elimination, Gauss-Seidel and Relaxation Methods.

Non Linear Algebraic Equations: **(10 hrs)**
Single variable successive substitutions (Fixed Point Method), Multivariable successive substitutions, single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique.

Eigen values and Eigen vectors of Matrices: **(6 hrs)**
Faddeev Leverrier's Method, Power Method.

Function Evaluation: **(12 hrs)**
Least squares curve-fit (Linear Regression), Newton's interpolation formulae (equal intervals), Newton's Divided Difference Interpolation Polynomial, Lagrangian Interpolation Unequal intervals).
Numerical Differentiation, Numerical Integration or Quadratures (Trapezoidal, Simpson's 1/3 and 3/8 rules), Extrapolation Technique of Richardson and Gaunt.

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

BOOKS RECOMMENDED:

1. Gupta S.K., Numerical Methods for Engineers, 2nd Ed., New Age International Publishers, 2009
2. Jain M.K., Iyengar SRK and Jain R.K., Numerical Methods for Scientific and Engineering Computation, New Age International.
3. Finlayson, B.A. Nonlinear Analysis in Chemical Engineering, MCGraw Hill, New York, 1980.
4. Villadsen J, and Michelsen, M.L. Solution of Differential Equation Models by Polynomial Approximation, Prentice Hall, N.J., 1978.
5. Rice R. G., Do Duong D., Applied Mathematics and Modelling for Chemical Engineers, John Wiley & Sons, Inc, 1995.
6. Sastry S.S., Introductory Methods of Numerical Analysis, 4th Ed., PHI.

BTCH-502 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: (18 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, 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.

BTCH-503 PROCESS DYNAMICS & CONTROL

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

Objective: The course is devoted to the analysis of the dynamical behavior of systems and the mathematical tools used in their analysis. Further, the control of these processes by using various types of controllers and their design is included ion the course.

General Principles of Process Control: **(12 hrs)**
Basic control elements, degree of freedom and fixing of control parameters, Simple system analysis, Laplace transformation and transfer functions, block diagrams, linearization. First and higher order systems, interacting and non-interacting systems, distributed and lumped parameter systems, dead time.

Different modes of control and their basic characteristics: **(18 hrs)**
Proportional, Integral and Derivative Control action, Controller characteristics- P, PI & PID controllers, process characteristics and choice of indicating , recording & controlling instruments for chemical industries, Feedback control servo and regulation control. Time domain-closed loop frequency response, optimization of control system response, stability analysis – Routhe criteria, Bode plots

Introduction to advanced control techniques: **(8 hrs)**
Feed forward, feed back, cascade, ratio, adaptive and digital computer control.

Process dynamics and applications: **(10 hrs)**
Process identification, dynamics and control of chemical equipment's such as exchangers, distillation columns.

BOOKS RECOMMENDED:

1. Coughanowr D. R., Leblanc S., Process System Analysis and Control, 3rd Ed., McGraw Hill, 2009
2. Stephanopoulos, G., Chemical Process Control - An Introduction to Theory and Practice, 1st Ed., Prentice Hall of India, 1990
3. Peacock D.G., Richardson J.F., Chemical Engineering – Volume 3, 3rd Ed., Butterworth Heinemann, 1994
4. Bequette B.W., Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall, 1998
5. Bequette B. W., Process Control: Modeling, Design and Simulation, Prentice Hall, 2003
6. Pollard, Process Control for Chemical and Allied Industries, Butterworth Heinnemann, 1971.
7. Weber T. W., An Introduction to Process Dynamics & Control, Kreiger Publishing Co, 1988
8. Harriott, P., Process Control, TMH Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2001.

BTCH-504 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.

BTCH-505 MASS TRANSFER LABORATORY

	L	T	P
External Marks: 20			
Internal Marks: 30	**0**	**0**	**4**
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.

BTCH-506 CHEMICAL REACTION ENGINEERING & POLLUTION CONTROL LABORATORY

	L	T	P
External Marks: 20			
Internal Marks: 30	**0**	**0**	**4**
Total Marks: 50			

1. Study of Rate kinetics using an isothermal batch reactor.
2. Study of Rate kinetics using an isothermal flow reactor PFR/CSTR
3. To find the residence time distribution for PFRs of different lengths.
4. To find the residence time distribution for Packed bed reactor
5. Experiments based on CSTRs in series.

Environmental pollution Analysis

6. Analysis of gaseous pollution as SO_2, H_2S, NO-NOx, CO-CO_2, O_3, NH_3.
7. Determination of TDS, SS, Dissolved solids of a water sample
8. Determination of COD of a water sample
9. Determination of BOD of a water sample
10. Domestic effluent Analysis.

BTCH-507 NUMERICAL METHODS IN CHEMICAL ENGINERING LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 4**
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.

6th Semester

BTCH-601 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 and Catalytic Reaction Engineering, McGraw Hill, New York, 1976.

BTCH-602 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: **(5 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.

Single variable Optimization Techniques: **(12 hrs)**

1. Optimality criterion.
2. Bracketing method (Bounding phase method).
3. Region elimination methods (Internal halving method, Fibonacci search method, Golden section search method).
4. Point estimation method (Successive quadratic estimation methods).
5. Gradient-based methods (Newton-Raphson method, Bisection method, Secant, Cubic search method.)
6. 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.

BTCH-603 ENERGY ENGINEERING

External Marks: 60 **L T P**
Internal Marks: 40 **3 1 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: **(10 hrs)**
Principal solid fuel-coal, origin, composition and classification of coal, origin, composition and classification of coals, analysis and properties of coal, characteristics and distribution of Indian coals, coal preparation, Storage of coal, coal carbonization, briquetting, gasification and liquefaction of solid fuels.
Liquid Fuels: **(12 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.
Refining Unit Processes: Cracking, thermal cracking, catalytic cracking, hydrocraking, reforming thermal and catalytic reforming, alkylation, and polymerization, Isomerization.
Petroleum Products - Naphtha, motor gasoline, aviation gasoline, kerosene, diesel oil, gas oils, fuel oils, lubricants, petroleum waxes, Petroleum coke.
Gaseous Fuels: **(6hrs)**
Types, natural gas, methane from coal mines, producer, water carburettor, water, coal, blast furnace and refinery gases, gases from biomass, LPG, gasification of coal and oil, purification of gaseous fuels.
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.
Furnaces: General classification and description of different types of furnaces with special reference to furnaces used in ceramic, petroleum and pharmaceutical industries.

Non- Conventional Sources of Energy: **(12hrs)**
Nuclear energy: - Nuclear reactions, fuel materials, moderators and structural materials, reactors Energy by bio-processes-bio-gas Solar Energy - Photovoltaic cells, solar collectors, wind, tidal and geothermal energy, biofuels.

BOOKS RECOMMENDED:

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

6. Haslam R.T. Russal, R.P, Fuels and their Combustion, McGraw Hill.
7. Brame, J.S. and King, J.C, Fuels-Solid Liquid and Gaseous, St. Martin Press, 1967.
8. Rai G D, Non-Conventional Energy Sources, 3rd Ed., Khanna Publishers, 1994.
9. Rao, S., Parulekar, B.B., Energy Technology – Non-conventional, Renewable & Conventional, 3rd Edition, Khanna Publishers, 2007

BTCH-604 ENGINEERING MATERIALS

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

Prerequisite: The students should have studied Chemical Process Industries as a prerequisite to study this course

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: **(5 hrs)**
Review of bonding in solids, structure –property-processing relationship. Space lattice, FCC, HCC, crystal systems, Miller indices, effect of radius ratio on coordination, structures of common metallic, polymeric, ceramic, amorphous and partly crystalline materials.

Mechanical, Thermal and Electrical Properties: **(5 hrs)**
Methods of improving strength- reinforcement, additives. specific heat, glass transition temperature, crystalline melting temperature, thermal conductivity; dielectric strength, dielectric constant, power loss and electrical diffusivity.

Ferrous Metals: **(5 hrs)**
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).

Non Ferrous Metals: **(3 hrs)**
Aluminium, cobalt, copper, lead, magnesium, nickel, tin and zinc their properties and uses.

Alloys: **(5 hrs)**
Introduction to Phase-Diagrams of metals and its alloys; Fe-Fe_3C; Cu-Ni, Cu-Zn, Al-Cu equilibrium diagrams, methods of improving strength, and applications of metals and alloys.

Ceramics: **(3 hrs)**
Definition of ceramic, clay: properties of clay, earthen wares and stonewares, uses of stonewares.

Glass: **(2 hrs)**
Definition, classification, composition, types and properties of glass.

Refractories **(3 hrs)**
Definition of refractory, classification of refractories, properties of refractories. Common refractory bricks like silica bricks, fire clay bricks, dolomite bricks, high alumina bricks and carbon bricks.

Polymers & Composites: **(5 hrs)**
Classification of polymers, Properties and Engineering Usage of Nylon-66, nylon-6, polyesters, polycarbonates, polyurethanes, PVC, polypropylene, 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.

BTCH-605 TRANSPORT PHENOMENA

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

Prerequisite: The students should have studied Heat Transfer, Fluid Flow and Mass Transfer I, as a prerequisite to study this course

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.

BTCH-606 PROCESS INSTRUMENTATION, DYNAMICS & CONTROL LABORATORY

	L	T	P
External Marks: 20			
Internal Marks: 30	**0**	**0**	**4**
Total Marks: 50			

1. Calibration of temperature, pressure, flow and composition measuring instruments.
2. Study of process dynamics of a liquid level tank
3. Study of process dynamics of interacting / non-interacting tank
4. Study of process dynamics of some processes.
5. Investigation of the operation of pneumatic and electronic controllers with proportional integral derivative action.
6. To determine the best setting of a controllers with controlling an actual process.
7. To solve first order or higher order differential equations with the help of an analog computer/ computer and to study control problems by simulation.
8. To control the level of liquid in the process tank using multi process trainer for different controller settings.
9. Study of control valve characteristics.
10. Study of Programmable Logic Control system.

BTCH-607 CHEMICAL PROCESS PLANT DESIGN-1

	L	T	P
External Marks: 20			
Internal Marks: 30	**1**	**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 student is to appear in a viva-voce examination.

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. Ludwig E.E., Applied Process Design in Chemical & Petrochemical Plants- Vol 3, 3rd Ed., Gulf Publication- Butterworth Heinemann, 2001
5. Vilbrandt F.C., Dryden C. E., Chemical Engg. Plant Design, 4th Ed., McGraw Hill, 1959
6. Peters M.S. , Timmerhaus K.D., Plant Design and Economics for Chemical Engg., 5th Ed., McGraw Hill, 2003
7. Molyneux F., Chemical Plant Design –I, Butterworth Heinemann, 1963

BTCH-608 LITERATURE SURVEY & SEMINAR

External Marks: 20
Internal Marks: 30
Total Marks: 50

L	T	P
0	0	3

The students will be introduced to and made conversant with

1. Availability of literature, journals and patents
2. Concept of impact factor of journals
3. Presentation of bibliography and referencing of information

Each student will have to prepare and deliver a seminar based on literature survey and to attend the seminars, regularly. Depending on his/her performance in seminar he/she will be evaluated. Main aim is to develop presentation skills in the students.

7th/ 8th Semester

BTCH-702 INDUSTRIAL/ INSTITUTIONAL TRAINING

External Marks: 375
Internal Marks: 375
Total Marks: 750

Each student will be required to submit a report after the completion of factory/ institutional training. The reports will be assessed by teachers in-charge of the training. The student has to appear in Viva-Voce examination.

8th Semester
BTCH-801 CHEMICAL PROCESS SIMULATION

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

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

Objective: This course aims at developing the ability of the students in the mathematical treatment of chemical engineering processes. This course includes the concept of models, variables, parameters, parametric sensitivity and model formulation and their solution through simulation.

Introduction: **(10 hrs)**
Concept of Dynamics, Variables and Degrees of freedom, Definition of mathematical model, lumped parameter model, distributed parameter model, uses of mathematical models, principles of formulation of models, parametric sensitivity.

Fundamental Laws: **(8 hrs)**
Continuity equations, energy equations, equations of motion, transport equations, equations of state, equilibrium, chemical kinetics.

Mathematical Models of Chemical Engg. Systems: **(24hrs)**
1. Model for Series of isothermal CSTRs
2. Model for an Isothermal/non-isothermal plug-flow reactor.
4. Model involving energy equation of heated tanks.
5. Model for a gas phase pressurized CSTR
6. Model for a Non isothermal CSTR
7. Model for a Single component vaporizer
8. Model for Multi component flash drum
9. Model for a Jacketed Batch reactor
10. Model for a Reactor along with Mass Transfer
11. Model for Ideal/ Non-ideal distillation column
12. Model for batch distillation column
14. Equilibrium-constant & titration curve models for PH systems
15. Lumped parameter model of a gas absorber
16. Lumped parameter model of a liquid-liquid extraction column
17. Model for Heat-exchangers
18. Model for a system of interacting & non-interacting tanks.
19. Model for Biochemical reactor.

Simulation: **(6 hrs)**
Meaning of simulation; simulation strategy for simple isothermal CSTR, simple non-isothermal CSTR and simple isothermal batch reactor

BOOKS RECOMMENDED:

1. Luyben W.L., Process Modelling and Simulation and Control for Chemical Engineers, McGraw Hill
2. Husain, Chemical Process Simulation, 1st edition, Wiley Eastern, 1986
3. Ramirez F. W., Computational Methods in Process Simulation, 2nd Ed., Butterworth Heinemann, 1998
4. Bequette B.W., Process Control: Modeling, Design and Simulation, Prentice Hall, 2003
5. Suryanarayana A., Chemical Instrumentation & Process Control, Khanna Pub.

BTCH-802 PROCESS ENGINEERING ECONOMICS

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

Objective: The objective of this course is to enable the students to make an economic analysis of different technologies or operations based on understanding of various costs involved. A brief introduction to patents and IPRs is also included to give an insight to the students in this field.

Cost Estimation: **(8 hrs)**

Factors affecting investment and production costs, Capital investments - fixed investments and working capital. Cost indices. Estimating equipment costs by scaling 6/10 factor rule. Methods for estimation capital investment. Estimation of total product cost. Different costs involved in the total product for a typical chemical process plant.

Balance sheet and income statement: **(6 hrs)**

Concept of Gross Profit, Net Profit, Return on Investment, Current Ratio, Quick Ratio, Debt-equity ratio

Interest and investment costs: **(6 hrs)**

Simple and compound interest, Nominal and effective rates of interest. Continuous interest, Annuity, Perpetuity and capitalized costs.

Taxes and Insurance: **(4 hrs)**

Types of taxes and tax returns, types of insurance and legal responsibility.

Depreciation: **(6 hrs)**

Types of depreciation, service life, salvage value, present value and methods of determining depreciation, single unit and group depreciation.

Profitability: **(8 hrs)**

Alternative Investments and Replacements: Mathematical methods of profitability evaluation, Cash flow diagrams, Determination of acceptable investments alternative when an investment must be made and analysis with small increment investment, replacement, Break even analysis.

Optimum Design: **(3 hrs)**

Procedure with one variable, Optimum reflux ratio in distillation and optimum pipe diameter.

IPR and Patent Systems **(7 hrs)**

Intellectual property, IPRs and its types, Patent claims, legal decision making process and ownership of tangible and intellectual property. Indian patent system, current IPR laws and legislations in India for IPR

Documents required for filing patent, infringement of patents and remedies

BOOKS RECOMMENDED:

1. Peters M.S. , Timmerhaus K.D., Plant Design and Economics for Chemical Engg., 5th Ed., Tata McGraw Hill, 2005
2. Ulrich, G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley, 1984
3. Guthrie, K.M., Process Plant Estimating, Evaluation and Control, Craftsman Solano Beach, Calif,
4. Couper James R, Process Engineering Economics, Marcel Dekker, NY, 2003

BTCH-803 SAFETY IN CHEMICAL PLANTS

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

Objective: The course will provide an overview of Process Safety in the Chemical Industry, focusing on the nature of chemical plant accidents, their causes, and steps to eliminate them, with emphasis on inherently safe designs. The students are expected to have active participation through case studies of disasters in the past.

Introduction **(10 hrs)**

Concept of Loss prevention, acceptable risks, accident and loss statistics, nature of accident process, inherent safety.

Toxicology: Dose versus response, toxicants entry route, models for dose and response curves, TLV and PEL

Industrial Hygiene: Identification, Material safety data sheets, Industrial hygiene evaluation and control

Basics of Fires and Explosion **(8 hrs)**

Fire triangle, definitions, flammability characteristics of liquid and vapours, LOC and inerting, types of explosions, Designs for fire prevention

Hazard identification **(6 hrs)**

Hazard survey, checklist, HAZOP, safety reviews, what if analysis

Risk Assessment **(8 hrs)**

Probability theory, event tree, fault tree, QRA and LOPA, Dow's fire and explosion index, Mond's index, Dow's Chemical release model

Accident Investigations **(4 hrs)**

Case Histories

Bhopal gas tragedy, Flixborough disaster, Pasadena accident, IOCL disaster, nuclear disaster in Japan in 2011.

BOOKS RECOMMENDED:

1. Crowl D.A., Louvar J.F., Chemical Process Safety: Fundamentals with Applications, 3rd Ed., Prentice Hall, 2011
2. Coulson, Richardson & Sinnott R.K., Chemical Engineering Volume-6 – an Introduction to Chemical Engineering Design, 4th Ed., Elseveir Butterworth Heinemann, 2005
3. Dow Chemical Company, Dow's Chemical Exposure Index Guide, 1993
4. Lees F P , Loss Prevention in Process Industries, 2nd ed, Butterworth, London, 1996
5. Wells G L, Safety in Process Plant Design, George Godwin ltd., New York, 1980

BTCH-804 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
3. Mahajani V.V., Umarji S.B., Joshi's Process Equipment Design, 4th Ed., Macmillan Indian Ltd., 2009

BTCH–805 PROCESS OPTIMIZATION & SIMULATION LABORATORY

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

1. Application of Bounding Phase Method.
2. Application of Fibonacci search method.
3. Application of Golden Section Search Method.
4. Application of Newton-Raphson method
5. Application of Secant Method.
6. Application of Root Finding Technique.
7. Application of Evolutionary Method.
8. Application of Steepest Descent Method.
9. Application of Marquardt's method.
10. Application of Penalty Function Method.
11. Simulation for calculation of Bubble point & Dew point of mixtures.
12. Program involving Simulation of Gravity Flow tank using C++.
13. Program involving Simulation of isothermal CSTR using C++.
14. Program involving Simulation of non- isothermal CSTR using C++.
15. Program involving Simulation of isothermal batch reactor using C++.
16. Program involving Simulation of non - isothermal batch reactor using C++.
17. Program involving Simulation of isothermal of distillation column using C++.

BTCH-806 CHEMICAL PROCESS PLANT DESIGN –II

External Marks: 20	**L T P**
Internal Marks: 30	**1 0 3**
Total Marks: 50	

1. Design of Sieve Tray Column and column internals
2. Design of Bubble Cap Column and column internals
3. Design of Packed Column and column internals
4. Specification sheet for fractionating column
5. Design of Homogeneous Reactors
6. Design of Heterogeneous reactors – Fixed bed
7. Design of Heterogeneous reactors – fluidised bed
8. Types of Flow Sheets
9. Overview of plant layout

The student is 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

BTCH-807 PROJECT

External Marks: 40	**L T P**
Internal Marks: 60	**0 0 6**
Total Marks: 100	

Each student is required to submit 3 bound type written copies of a project report on a proposed research oriented work :- either theoretical or practical (e.g design of sophisticated process plant, modelling & simulation of sophisticated chemical process, optimization of sophisticated of chemical process, chemical process experimentation & data analysis)

The object is to test the ability of the student to incorporate his entire knowledge of chemical engineering principles, to judge his knowledge, originality and capacity for application of laboratory data in designing chemical plants and to determine the level of his proficiency at the end of the course.

The student is to appear in a Viva-Voce Examination

ELECTIVE - I

BTCH-521 POLYMER SCIENCE & ENGINEERING

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 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:
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:
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:
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:
Manufacture, processing and properties of resins and fibre forming polymers such as phenol formaldehyde, epoxy resins and silicon polymers, LDPE, HDPE, polypropylene, polyvinyl chloride, polystyrene, polyurethane and polyamides.

Introduction to Rubber & Elastomers
Natural & synthetic rubber, Buna S, Buna N, Butyl rubber, neoprene, thiokols, , polyurethane, Fillers, accelerators, activators, antioxidants & other additives, mastication & compounding, vulcanization theory & technology.

Polymer Degradation:
Thermal, Mechanical and by ultrasonic waves, photo degradation, heat energy radiation, oxidation and hydrolysis.

Polymer Reactor Design:
Meaning, general design procedure. Detailed Design of ideal batch reactor for the production of Phenol-formaldehyde (novolac) starting from phenol & formaldehyde as raw materials.

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

BTCH-522 ENZYME TECHNOLOGY

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

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

Techniques of enzyme immobilisation-matrix entrapment, ionic and cross linking, column packing; Analysis of mass transfer effects of kinetics of immobilised enzyme reactions; Analysis of Film and Pore Diffusion Effects on Kinetics of immobilized enzyme reactions; calculation of Effectiveness Factors of immobilized enzyme systems; Bioconversion studies with immobilized enzyme packed -bed reactors**.**

Mass transfer Effects in Immobilised Enzyme Systems

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

Reactor design and analysis for immobilized enzyme reactors

Applications of Enzymes

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. Use of enzymes in analysis-types of sensing-gadgetry and methods.

Case studies on application - chiral conversion, esterification etc.,

Enzyme Biosensors

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.

BTCH-523 FLUIDIZATION ENGINEERING

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

BTCH-524 NANO-TECHNOLOGY

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

Objective: The course will provide an overview of Nano materials, their characterization, usage and use in biomaterials.

Introduction :
Terminologies, History & Scope
Characterization & Fabrication:
Contemporary Characterization Methods, top down & Bottom up Fabrication, Solution based Synthesis of Nanoparticles, Vapour Phase Synthesis & Synthesis with framework, Nanolithography, Dip Pen Lithography. Artificially Layered Materials: Quantum Well, Quantum Dots, Super lattices & Layered Structures.
Self Assembly:
Supramolecular & dimension Control in Nanostructure, thermodynamics and coded self assembly.
Biomaterials:
DNA & Nanomaterials, Bioanocomposites, Biometrics, molecular motor.
Nanoelectronics and Molecular Computing: Molecular wires, Nanowires, Nanotubes, Molecular switch, Molecular logic gates and molecular storage devices, DNA Computing Quantum Computing.

BOOKS RECOMMENDED:

1. Poole C.P., Owens F.J., Introduction to Nanotechnology, Wiley, 2003.
2. Understanding Nanotechnology, Scientific American 2002.
3. Ratner M & Ratner D, Nanotechnology : A Gentle Introduction To The Next Big Idea, Prentice Hall, 2003
4. Wildon M., Kannagara K., Smith G, Simmons M. & Raguse B, Nanotechnology, CRC

BTCH-525 SEPARATION PROCESSES

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

Objective: The course is aimed at providing the understanding of separation techniques used in industry. It includes the study of details of techniques like membrane separations, adsorption, chromatography.

Separation Processes

Industrial chemical processes, Mechanism of separation, separation power, selection of feasible separation processes.

Membrane Separations

Membrane Materials, Membrane Modules, Transport in Membranes – Porous Membranes, Bulk Flow, Liquid Diffusion in Pores, Gas Diffusion, Nonporous Membranes, Solution-Diffusion for Liquid Mixtures, Solution-Diffusion for Gas Mixtures, Module Flow Patterns, Cascades, External Mass-Transfer Resistances, Concentration Polarization and Fouling.

Dialysis and Electrodialysis, Reverse Osmosis, Gas Permeation, Pervaporation, Ultrafiltration, Microfiltration.

Adsorption, Ion Exchange, and Chromatography

Sorbents: Adsorbents, Ion Exchangers, Sorbents for Chromatography

Equilibrium Considerations: Pure Gas Adsorption, Liquid Adsorption, Ion Exchange Equilibria, Equilibria in Chromatography

Kinetic and Transport Considerations: External Transport, Internal Transport, Mass Transfer in Ion Exchange and Chromatography

Sorption Systems: Adsorption, Ion Exchange, Chromatography, Slurry Adsorption (Contact Filtration), Fixed-Bed Adsorption (Percolation), Thermal-Swing Adsorption, Pressure-Swing Adsorption, Continuous, Countercurrent Adsorption Systems, Simulated-Moving-Bed Systems, Ion-Exchange Cycle, Chromatographic Separations

BOOKS RECOMMENDED:

1. Seader J D & Henley E J, Separation processes principles, 2nd edition, John Wiley & sons, 2006
2. Rousseau R W, Handbook of separation process technology, Wiley-Interscience, 1987
3. Strathmann H, Ion exchange membrane separation processes, Elsevier Science.

ELECTIVE-II

BTCH-621 PETROLEUM REFINING ENGINEERING

External Marks: 60	**L**	**T**	**P**
Internal Marks: 40	**3**	**1**	**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. 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.

BTCH-622 NEW AND RENEWABLE ENERGY SOURCES

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 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:
Global and Indian scenario, sources, Energy conservation, types of NCES with applications

Solar Energy:
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.

Geothermal Energy:
Resources, types of wells, methods of harnessing the energy

Wind Energy:
Sources and potentials, horizontal and vertical axis, wind mills, wind regime analysis and evaluation of wind mills.

Biomass and Biofuels:
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.

Ocean Energy:
OTEC, settling of OTEC plants, thermodynamic cycles

Tidal Energy:
Potential and conversion technique, mini hydel power plants and their economics

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

BTCH-623 MEMBRANE SEPARATION PROCESSES

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

Objective: The course will provide an overview of membrane processes used in separations in the chemical industry and their applications.

Introduction:
Definition of membrane and membrane process, Commercial membrane separation processes, new membrane separation process under development

Reverse Osmosis:
Introduction and definition, theory and design, different membrane modules, selected applications and economics.

Ultra filtration:
Introduction and definition, theory and design, membrane module and process configuration, applications and economics.

Micro filtration:
Introduction and definition, theory of cross flow filtration, dead end micro filtration, applications and economics.

Emulsion liquid membranes:
Introduction and definition, theory and design, selected applications and economics

Dialysis, Electodialysis, Pervaporation, Gas permeation:
Brief introduction and applications**.**

BOOKS RECOMMENDED:

1. Wilson & Sirkar, Membrane Handbook, Mc grawhill, London, 2001
2. Nune and Peinemann, Membrane Technology in Chemical Industries, Wiley, New York, 2000
3. Cheryan Munir, Ultra Filtration Handbook, Technomic, New York, 1985
4. Noble and Stern, Membrane Separation and Technology, principles and applications, Elsevier, 1995
5. Baker R W, Membrane Technology and Applications, Wiley**,** New York, 2000

BTCH-624 FUEL CELL TECHNOLOGY

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

Objective: The course is aimed at providing the information about fuel cells, their types, fundamentals, technology and the problems associated with fuel cell technology.

Introduction

Fuel Cell definition and basics- cathode, anode, electrolyte, Difference between a fuel cell and a battery, Advantages and disadvantages, Basic fuel cell operation

Fuel Cell Fundamentals

Relationship between Gibb's free energy and electric work/ electric voltage, Reversible Voltage/ potential of fuel cell using standard electrode potentials, Effect of temperature and pressure on fuel cell potential, Nernst equation, Fuel cell efficiency, concept of OCV

Current density, Losses in fuel cell- activation loss, ohmic loss and concentration loss, Fuel cell performance curve

1-D model for a fuel cell, application of model to SOFC and PEMFC

Types of Fuel Cells

Construction, fuels and usage of Phosphoric Acid Fuel Cell, Polymer Electrolyte Membrane Fuel Cell, Alkaline fuel cell, Molten Carbonate Fuel Cell, Solid Oxide Fuel cell

Relative advantages and disadvantages of the various types of fuel cells

Fuel Cell Systems

Fuel cell stack, engineering issues related to Fuel Cell Technology

Hydrogen as a fuel, availability and engineering issues

BOOKS RECOMMENDED:

1. Hayre R.O., Cha S., Colella W., Prinz F. B., Fuel Cell Fundamentals, John Wiley and Sons, 2006
2. Berger E. D., Handbook of Fuel Cell Technology, Prentice-Hall, 1968
3. Vielstich W., Lamm A., Gasteiger H. A., Handbook of Fuel Cells, Vol. 2, Wiley, 2003

BTCH-625 CORROSION ENGINEERING

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 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
Direct & two stage attack, electrochemical attack, environment conditioning.
Techniques for Corrosion Resistance
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
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-626 PROJECT MANAGEMENT

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 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.

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

ELECTIVE-III

BTCH-821 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.

Nutrient transport across cell membrane.

Sterilization of air and media

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, 200
5. Shuichi Aiba, Biochemical Engineering, 2nd edition, Academic Press Inc. New York, 1973

BTCH-822 POLYMER REACTOR DESIGN

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

Prerequisite: The students should have studied Polymer Science and Engineering as Elective-1, Chemical Reaction Engg. I as a prerequisite to study this course

Objective: The course will provide a detailed study of application of chemical engineering principles in the design and analysis of reactors for polymer production.

Introduction:
A brief introduction to various types of polymers, polymerization methods and their importance. Reactors: Definition, types, application-fields.
Reactor Design: meaning, general design procedure

Reaction Engineering of step growth polymerization:
Introduction, analysis of semi batch reactors, MWD of ARB polymerization in homogeneous continuous flow stirred-tank reactors (HCSTRs), advanced stage of polymerization, similarity solution of step growth polymerization in films with finite mass transfer.

Reaction engineering of chain growth polymerization:
Introduction, design of tubular reactors, copolymerization, solution of equations describing isothermal radical polymerization.

Emulsion polymerization:
Introduction, emulsion polymerization in homogeneous continuous flow strirred tank reactors (HCSTRSs)

Design of Batch Reactors:
Detailed Design of ideal batch reactor for the production of Phenol-Formaldehyde (novolac) starting from phenol & formaldehyde as raw materials.

BOOKS RECOMMENDED:

1. Kumar A. & Gupta R. K., Fundamentals of Polymers, 2nd edition, McGraw Hill, 1998.
2. Kumar A. & Gupta R. K., Fundamentals of Polymer Science and Engineering, Tata McGraw Hill, New Delhi, 1978.
3. Fogler H. S., Elements of Chemical Reaction Engineering, 4th Ed., Prentice Hall, 2006

BTCH-823 PLANT UTILITIES

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 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.

Importance of Process utilities in Chemical Plant.

Steam:

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

Power Generation:

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

Refrigeration:

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

Compressed Air and Vacuum:

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:

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

Waste Disposal:

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-824 HEAT EXCHANGERS

External Marks: 60	**L T P**
Internal Marks: 40	**3 1 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.

BTCH-825 PETRO CHEMICAL TECHNOLOGY

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

Objective: The course aims at providing the knowledge of petrochemical industry to the students which includes the processes, products and their production in petrochemical industry.

Introduction
Petro chemicals; Definition, importance and growth potential of the field.
Petrochemical Feed stocks
Raw material for petrochemical industries, sources, economics and advantage
Production of olefin containing gases; various purification and separation processes.
Important intermediate material for petrochemical industry e.g. Aromatic, Ammonia, Butadiene, Alcohol, synthesis gas
Processes for petrochemical feed stock
Cracking- thermal and catalytic, polymerization and isomerisation.
Desulphurization of petrochemical feedstocks
Manufacture of important petrochemicals:
Plastics, Fertilizer, Carbon Black, Synthetic fibers, Synthetic Rubber, Synthetic Detergents.

Concepts of quality and environmental pollution control in petrochemical industries.

BOOKS RECOMMENDED:

1. Rao B.K. B, Modern Petroleum Refinery Processes, 5th edition, Oxford & IBH Publishing Co. Pvt. Ltd., 2009
2. Steiner H, Industries to Petroleum Chemicals, Pergammon Press,1992
3. Waddone, A.C. , Chemicals from Petroleum, John Murry, 1988
4. Top Chev, A.V. Synthetic Materials from Petroleum, Pergammon Press, 1982
5. Astle M.J., Synthetic Materials from Petroleum, Pergammon Press