Shaheed Bhagat Singh State Technical Campus, Ferozepur

B. Tech. Chemical Engineering

Scheme of Syllabi

3rd Semester

Total contact hours =30

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

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

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

Total contact hours =26

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

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

Total contact hours =25

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

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

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

Total contact hours =26

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

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

Total contact hours =29

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

***__**There should be Industrial Training of 6 weeks duration in the summer vacation after 6th semester**__

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

Total contact hours =23

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

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

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

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

1. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005
2. Foust, A.S., Wenzel L.A., Clump C.W. Maus L., Anderson L. B., Principles of Unit Operations,

2nd Ed., John Wiley & Sons, 2008.
3. Harker J. H., Richardson, J. F., Backhurst J. R., Chemical Engg. Vol, 2, 5th Ed., Butterworth-Heinemann, 2003.
4. Badger, W.L. and Banchero, J.T, Introduction to Chemical Engg., McGraw Hill
5. Perry R.H., Green D. W., Chemical Engineers' Handbook, 8th ed., Mc-Graw Hill, 2008

COURSE OUTCOMES

Students will be able to:-

1. Demonstrate the knowledge of characterization the particulate solids and its screening.
2. Demonstrate the working principles of size reduction and the relevant equipment.
3. Analyze the processes involving agitation and mixing of low viscosity particle suspensions and separation methods for solid-liquid and solid-gas mixtures using various filtration techniques.
4. Analyze the processes involving motion of particles through fluids though Sedimentation and Fluidization and the relevant equipment.

BTCH-302A CHEMICAL PROCESS CALCULATIONS

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

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

Introduction to Chemical Engineering Calculations: **(10 hrs)**
Units & Dimensions, Conversion of units, Mole concept, Basic Concept, Stoichiometric and composition relationship, limiting-excess- reactant, conversion and yield, Degrees of Freedom.

Material Balance: **(16 hrs)**
Without Chemical reaction - Ideal gas-law calculations, real-gas relationships, vapour pressure of immiscible liquids, solutions and problems based on Raoult's, Henry & Dalton's Law. Absolute Humidity, Relative Humidity, Saturation, Dry bulb temperature, Wet bulb temperature, Adiabatic saturation temperature & use of psychometric Chart.
With Chemical Reaction- Combustion, gas-synthesis, acid-alkali production
recycle, purge, bypass in batch, stagewise and continuous operations in systems with or without chemical reaction.

Energy Balance: **(16 hrs)**
Review: Thermophysics, Thermochemistry-law of constant heat summation, Hess's Law, standard heat of reaction, combustion and formation, problems using Hess Law.
Heat balances for non reacting processes and reaction processes. Theoretical flame temperature, Adiabatic reaction temperature, flame temperature, combustion calculation.

Material and energy balances: **(6 hrs)**
Applied to industrial processes such as combustion and gasification of fuels, synthesis of ammonia, production of sulphuric acid, nitric acid, hydrochloric acid

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

Students would be able to:-

1. Demonstrate the knowledge of basic Chemical Engineering Calculations involving units & dimensions, stoichiometry and degree of freedom analysis.
2. Apply material balance on Chemical Engineering processes with & without chemical reaction.
3. Apply thermophysics and thermochemistry-laws for applying energy balance on Chemical Engineering processes.
4. Comprehend the concept of humidity and usage of psychometric charts.
5. Demonstrate the knowledge material balance and energy balance for solving problems based upon Combustion.

BTCH-303A FLUID FLOW

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

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

Introduction **(2 hrs)**

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

Fluid Statics **(4hrs)**

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

Fluid Properties **(6 hrs)**

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

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

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

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

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

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

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

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

Flow Measurement **(6 hrs)**

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

In open channels- Notches, Weirs

Fluid Machinery **(6 hrs)**

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

Students would be able to:-

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

BTCH-304A CHEMICAL ENGINEERING THERMODYNAMICS

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

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

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

Brief review: **(8 hrs)**

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

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

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

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

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

Phase Equilibria: **(16 hrs)**

Partial molar properties, partial molar Gibbs free energy, chemical potential and its dependence on temperature and pressure. Ideal solutions (Lewis-Randall Rule).
Fugacity and its calculations. Dependence of fugacity on temperatures and pressure.
Solution behaviour of real liquids and solids. Activity and activity coeffiecients. Variation of activity co- efficient with temperature and composition. Activity coefficients of electrolytes. Standard states. Properties of mixing. Excess properties. Gibbs-Duhem equation and its application to vapour- liquid equilibria.

Chemical Equilibria: **(7 hrs)**

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES:

The students will be able to:

1. Apply the laws of thermodynamics to chemical engineering processes.
2. Apply thermodynamic principles for analysis of solutions, ideal solutions, their excess properties and residual properties.

3. Apply thermodynamic principles for different types of chemical engineering systems like Vapor/Liquid systems, Liquid/ Liquid systems and Solid/Liquid systems.
4. Analyze chemical reactions in relation to thermodynamic principles.
5. Apply Phase Equilibria and Chemical Equilibria for solution to problems involving more than one phase and chemical reactions.

BTCH-305A CHEMICAL PROCESS INDUSTRIES

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

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

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

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES:
Students will be able to:-

1. Demonstrate the knowledge of various Chemical Industries and their status in India.
2. Demonstrate knowledge about process flow sheet of various organic and inorganic industries.
3. Demonstrate knowledge about history, current issues, and trends in process industries.

4. Demonstrate knowledge about MOC being used, environment and safety precautions in design and operations.
5. Demonstrate knowledge about chemical and physical processes involved including equipments and various alternative technologies being used in industries

BTCH-306A CHEMICAL TECHNOLOGY LABORATORY

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

LIST OF EXPERIMENTS

PART A

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

PART B

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

At least five experiments should be conducted from each part.

COURSE OUTCOMES:

At the end of the course the student will be able to:

1. Determine the characteristic values of oil/fat samples.
2. Characterize solid fuels.
3. Prepare thermoset polymers and process polymers using compression moulding, Injection moulding and two roll mill.
4. Determine mechanical properties of polymers.
5. Present results in form of written reports.

BTCH-307A FLUID FLOW LABORATORY

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

LIST OF EXPERIMENTS

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

COURSE OUTCOMES:

At the end of the course the student will able to:

1. Demonstrate the working of a centrifugal pump.
2. Demonstrate practical understanding of Bernoulli's equation
3. Determine coefficient of discharge of fluids by Venturimeter, Orifice meter and V-notch etc
4. Demonstrate practical understanding of friction losses due to various fitting and valves, contraction and expansion or due to variation in cross section/ shapes.
5. Present results in form of written reports.

BTCH-308A MECHANICAL OPERATIONS LABORATORY

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

LIST OF EXPERIMENTS

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

COURSE OUTCOMES:

Students would be able to:-

1. Demonstrate the concept of fluidization.
2. Determine the operating characteristics of crushing and grinding equipments
3. Apply various principles of the filtration and analyze working of filtration equipments.
4. Calculate efficiency of various separating equipments.
5. Present results in form of written reports.

BTHU – 301A PROFESSIONAL SKILLS - I

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

Personality Development: General overview of Personality, Understanding Self Concept and Self Esteem, Building Self Esteem, Self Confidence, Assertiveness (Activity based training) Understanding assessment of Personality.
Mental Abilities: Understanding Intelligence, emotional intelligence, successful intelligence, Development of emotional intelligence.
Social Etiquettes and Personal Grooming: Importance of social image, Dos and Don'ts in dressing up, Developing an Understanding of Social Etiquettes.
Communication Skills: Features of an effective Communication. Verbal and Non-verbal Communication, Understanding role of body language in effective communication.

Recommended Books:

1. Personality Development by Harold Wallace and L.Ann Masters, Cengage Learning
2. Psychology By Baron_____
3. Educational Psychology by Anita Woolfolk, Pearson.
4. Organizational Behaviour by Stephen Robbins, Pearson Education.
5. Organizational Behaviour by J. W. Newstrom and Keith Davis, Tata McGraw Hills
6. Nonverbal Communication_____
7. Effective Technical Communication by M. Ashraf Rizvi, Tata McGraw Hill.

Course Outcomes:

CO No.	After undergoing this course, students must be able to:
1	Acquire the understanding of the multifaceted aspects of Personality, their significance and assessment
2	Understand the different aspects of intelligence and their relative relevance in effective utilization of one's abilities in diversified situations.
3	Recognize the significance of social image and personal grooming.
4	Develop a knack for effective communication by understanding its both verbal and non-verbal aspects.
5	Demonstrate various acquired professional skills with a sense of confidence

(4th Semester)

BTCH-401A Mathematical Methods of Chemical Engg.

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:
Text Books:

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

Reference Books

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

COURSE OUTCOMES

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

1. Apply numerical methods to obtain solutions of linear and non-linear algebraic equation.
2. Derive and apply numerical methods for various mathematical operations and tasks, such as interpolation, differentiation and integration.
3. Evaluate eigen values and eigen vectors of matrices and demonstrate understanding and implementation of numerical solution algorithms applied to ODE-IVPs and PDEs.
4. Apply Laplace Transform technique to the solution of linear ODEs and simultaneous ODEs.

BTCH-402A HEAT TRANSFER

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

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

Modes of Heat Transfer:

Conduction **(8 hrs)**

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

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

Convection **(10 hrs)**

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

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

Radiation **(6 hrs)**

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

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

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

Heat exchangers: **(10 hrs)**

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

Theory of Fins and their applications

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

Evaporators **(8 hrs)**

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

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

BOOKS RECOMMENDED:

1. Holman, J.P., Heat Transfer, 10th Ed., McGraw Hill, 2010.
2. McAdams W.H., Heat Transmission, 3rd Ed., Kreiger Publishing Co, 1985
3. Backhurst J.R., Harker J.H., Coulson J.F., Richardson J.M., Chemical Engineering – Volume 1, 6th Ed., Butterworth Heinemann, 1999

4. McCabe, Warren L., Smith, Julian C. and Harriot, P., Unit Operations of Chemical Engg., 7th Ed., McGraw Hill, 2005
5. Kern D.Q., Process Heat Transfer, McGraw Hill.
6. Kreith F., Manglik R.M., Bohn M.S., Principles of Heat Transfer, 7th Ed., Brooks Cole Thomson Learning Publication, 2010
7. Incopera F.P., DeWitt D.P., Bergman T.L., Lavine A.S., Fundamentals of Heat and Mass Transfer, 7th Ed., John Wiley, 2011

COURSE OUTCOMES

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

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

BTCH-403A ENERGY ENGINEERING

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

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

Introduction: **(2 hrs)**
Energy crisis in the world and position in India

Conventional Sources of Energy:

Solid Fuels: **(6 hrs)**
Composition and classification of coals, analysis and properties of coal, characteristics and distribution of Indian coals, coal carbonization, briquetting, gasification and liquefaction of solid fuels.

Liquid Fuels: **(8 hrs)**
Petroleum and Related Products:
Introduction: Origin, occurrence and reserves, reserves, Production and consumption, classification and characteristics of Petroleum properties and characteristics, petroleum refining in India.
Petroleum Products - Naphtha, motor gasoline, aviation gasoline, kerosene, diesel oil, gas oils, fuel oils, lubricants, petroleum waxes, Petroleum coke.

Gaseous Fuels: **(6hrs)**
producer, water carburettor, water, coal, blast furnace and refinery gases, gases from biomass, LPG, CNG.

Combustion Process and Appliances: **(6 hrs)**
Nature and types of combustion processes, mechanism of combustion reaction, spontaneous ignition temperature, gas and oil burners, coal burning equipments, fluidized bed combustion.

Non- Conventional Sources of Energy: **(8 hrs)**
Nuclear energy: - Nuclear reactions, fuel materials, moderators and structural materials, reactors Energy by bio-processes-bio-gas, Solar Energy - Photovoltaic cells, solar collectors, wind Energy and biofuels.

BOOKS RECOMMENDED:

Text Books:

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

Reference Books:

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

COURSE OUTCOMES

Students are able to:-

1. Demonstrate the knowledge of various conventional solid fossil fuels energy resources and their effective utilization.
2. Demonstrate the knowledge of naturally occurring Petroleum and its products upon refining and their commercial applications.
3. Demonstrate the knowledge of various naturally occurring and synthesized gaseous fuels and efficient utilization.
4. Demonstrate the knowledge of various types of liquid and gaseous fuel burners and applying combustion principles for solution of problems based upon combustion.
5. Demonstrate the knowledge of energy demand, energy crisis and identify available nonconventional (renewable) energy resources and techniques to utilize them effectively.

BTCH-404A STRENGTH OF MATERIALS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Columns: **(7 hrs)**

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES:

After studying this course, the students must be able to:

1.Understand the concept of stress and strain at a point and stress analysis in various machine elements like thin cylinder, sphere, spring, beams etc.

2.Analyze and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behavior of materials.

3.Tackle the problems related to shearing Force, bending moment, slope and deflections in different types of beams subjected to various types of loadings.

4.Apply the knowledge of various theories of failures to design the various structural components subjected to different types of loadings.
5.Understand the concept of buckling of slender, long columns subjected to axial loads and be able to solve problems related to columns and struts.

BTCH-405A HEAT TRANSFER LABORATORY

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

LIST OF EXPERIMENTS

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

COURSE OUTCOMES

Students will be able to develop the following skills/understanding upon the successful completion of this course:

1. Measure heat transfer coefficients of different common materials and different flow geometries like shell & tube and double pipe heat exchangers.
2. Measure the heat losses and effect of insulation during the heat transfer.
3. Perform the operation of open pan/single effect/multi-effect evaporators.
4. Measure radiative heat transfer, condensation and boiling heat transfer.
5. To present their results in written form of report.

BTCH-406A NUMERICAL METHODS IN CHEMICAL ENGINERING LABORATORY

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

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

COURSE OUTCOMES

Students would be able to:-

1. Develop a logic for solving linear and non-linear algebraic equations.
2. Develop a logic for numerical integration and differentiation.
3. Develop a logic to calculate eigen values of a matrix and interpolation of data.
4. Convert the logic into codes of computation and solve a given problem.
5. Present results in form of written reports

BTCH-413A POLYMER SCIENCE & ENGINEERING

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

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

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

2. Comprehend the concept of polymerization methods and structure- property relationships of polymers.
3. Differentiate various processing & manufacturing techniques of polymers and their testing.
4. Demonstrate the knowledge of polymer degradation

BTHU – 401A PROFESSIONAL SKILLS - II

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

Inter-personal Skills: Introduction to Interpersonal Relations, Transactional analysis, Understanding Emotions, Emotional empathy and Sensitivity Training.
Mental Abilities: Numerical Ability, Inductive Reasoning and Deductive Reasoning.
Stress Management: Introduction to Stress, Causes of Stress, Impact of Stress, and Managing Stress, Coping strategies (Individual and Group).
Communication Skills: Public speaking, Impromptu, Introducing Yourself and Telephone Etiquettes.

Recommended Books:

1. Stress, Appraisal, and Coping by Richard S. Lazarus and Susan Folkman by Springer Publishing Company.
2. Emotion in Social Relations: Cultural, Group and Interpersonal Processes by Brian Parkinson; Agneta H. Fisher; Antony S. R. Manstead Psychology Press.
3. Social Psychology by Robert Baron and Donn Irwin Byron_____.
4. Handbook of Practical Communication Skills by Chrissie Wright, Jaico Publications, Mumbai.
5. Effective Technical Communication by M. Ashraf Rizvi, Tata McGraw Hill.
6. Communication Skills for Engineers: Sunita Mishra and C. Muralikrishna, Pearson Education, New Delhi.

Course Outcomes

CO No.	After undergoing this course, students must be able to:
1	Understand varied aspects of interpersonal -relations and develop ability for creating harmonious relations.
2	Sharpen and demonstrate Numerical Ability and Reasoning Abilities.
3	Apply stress management techniques after going through the knowledge of Stress and its coping strategies.
4	Develop and Demonstrate Speaking skills in various contexts such as Public speaking, Impromptu, Introducing Oneself and Telephonic conversation.

(5th Semester)

BTCH-501A 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.

COURSE OUTCOMES

Students would be able to:-

1. Demonstrate the knowledge of the different types of wastes generated in industry, their standards, classification and their effects.
2. Characterize various waste water samples.
3. Differentiate various unit operation and unit processes involved in conversion of highly polluted water to potable standards.
4. Describe the atmospheric dispersion of air pollutants, and perform process design calculations of air pollution control devices.
5. Analyze and quantify hazardous and non hazardous solid waste treatment and disposal.

BTCH-502A CHEMICAL REACTION ENGINEERING-I

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

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

Introduction: **(8 hrs)**

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

Design for Single Reactions: **(16 hrs)**

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

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

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

Reactor combinations of CSTR and PFR

Design for Multiple Reactions: **(8 hrs)**

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

Temperature & Pressure effects: **(6 hrs)**

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

Non –Ideality: **(10 hrs)**

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

At the end of the course the student will be able to:

1. Demonstrate the basic concepts of chemical reaction Engg and develop rate laws for homogeneous reactions

2. Perform design calculations of ideal reactors for single and complex reactions for isothermal and non-isothermal reactors.
3. Compare the relative performance of different reactors.
4. Distinguish between various RTD curves and predict the conversion from a non ideal reactor using tracer information.
5. Determine optimal reactor configurations and operating policies for systems involving multiple reactions .

BTCH-503A MASS TRANSFER-I

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

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students would be able to:

1. Demonstrate knowledge of the principles of mass transfer.
2. Apply the concepts of Diffusion and various laws governing diffusion in solids,

liquids & gases.

3. Apply the concept of mass transfer coefficients in designing of Co-current, counter-current & continuous-contact columns.
4. Analyse processes involving Gas absorption, drying of solids, Humidification operations & membrane separation.

BTCH-513A ENGINEERING MATERIALS

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

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

Crystal Structure **(5 hrs)**

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

Ferrous Metals & Non Ferrous Metals **(6 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) Aluminium, cobalt, copper, nickel, and zinc their properties and uses.

Alloys **(2 hrs)**

Introduction to Phase-Diagrams of metals and its alloys; Fe-Fe_3C; Cu-Ni, equilibrium diagrams

Ceramics **(6 hrs)**

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

Polymers & Composites **(3 hrs)**

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

Novel Materials **(2 hrs)**

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.

COURSE OUTCOMES

At the end of the course the student will be able to:

1. Demonstrate the fundamental concepts of crystal structure.
2. Demonstrate the basic knowledge of ferrous and Non-Ferrous materials and advanced materials like Nano-materials and Biomaterials.

3. Distinguish the structure, properties and uses of various types of Engg. Materials like Polymers, Metals and Ceramics.
4. Demonstrate the knowledge of Phase Diagrams and their relation to the material properties.
5. Make judicious choice among a range of materials, for various Chemical Engg applications.

BTCH-504A CHEMICAL REACTION ENGINEERING ENVIRONMENTAL ENGG Lab

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

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

COURSE OUTCOMES

At the end of the course the student will be able to:

1. Perform kinetic analysis of reactions using various types of reactors like Batch , PFR and CSTR.
2. Determine the Residence Time Distribution for PFR and Packed Bed Reactor.
3. Measure the conc. of gaseous pollutants in air.
4. Measure the TDS, SS, COD&BOD of water sample.
5. Present results in form of written reports.

BTCH-505A Chemical Process Plant Design-I

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students will be able to

1. Demonstrate the knowledge of standards and process design of equipments like heat exchangers and cyclone separator.
2. Perform process design shell & tube heat exchanger, condenser, plate heat exchanger.
3. Prepare the specification sheets for heat exchangers.
4. Demonstrate the knowledge of various types of pumps and prepare pump specifications.
5. Present the work/results in form of written reports.

BTCH-506A Training-II

Internal Marks: 6 0
External Marks: 4 0
Total Marks: 100

Each student would have to undergo six weeks industrial/ institutional training and will be required to submit a report after the completion of training. The reports will be assessed by teachers-in-charge of the training. The student has to appear in Viva-Voce/Presentation for internal as well as external evaluation.

Course Outcomes

1. Apply various concepts learnt in Chemical Engineering in understanding of various industrial operations being carried out in Chemical industry.
2. Handle/analyze and solve live projects/problems giving their solutions with mathematical consistency & most economical & efficient way.
3. Demonstrate the skill of using literature / resources for solution of such problems in Chemical Industry.
4. Represent the results of industrial/ institutional training in written form as a report.

BTHU – 501A PROFESSIONAL SKILLS - III

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

Concepts of Groups and Teams: Groups and Group dynamics, Group cohesiveness, compliance and conformity. Team building, Team work, Conflict: types and resolutions.
Mental Abilities: Verbal Ability, Spatial Ability, Memory.
Attitude: Meaning of attitude, link between attitude and behavior, Persuasion, attitude towards work environment, Work-force Diversity. Significance of Happiness, Optimism, Wellbeing.
Communication Skills: Job Application Writing, Resume Writing, email writing, Group Discussion, Power Point Presentation.

Recommended Books:

1. Organizational Behaviour by Stephen Robbins, Pearson Education
2. Positive Psychology: The Scientific and Practical Explorations of Human Strengths, C R Snyder and Shane J. Lopez, Jennifer, Pedrotti, Sage Publications.
3. Social Psychology by Robert Baron and Donn Irwin Byron , Prentice Hall India.
4. Handbook of Practical Communication Skills by Chrissie Wright, Jaico Publications, Mumbai.
5. Effective Technical Communication by M. Ashraf Rizvi, Tata McGraw Hill.
6. Model Business Letters, E-mails & Other Business Documents, 6th Edition, by Shirley Taylor, Pearson Education.
7. Communication skills for Engineers by Sunita Mishra and C. Muralikrishna, Pearson Education, 2004.

Course Outcomes

CO No.	After undergoing this course, students must be able to:
1	Understand nuances of group dynamics and team-work and also to develop ability for effective conflict management .
2	Sharpen and demonstrate Verbal Ability, Spatial Ability and Memory skills.
3	Understand the linkage between attitude and behaviour and its role in professional and personal well- being.
4	Develop and demonstrate oral and written communication skills such as Oral presentations, Group discussion, Resume writing, job application writing, email writing.

(6th Semester)

BTCH-601A MASS TRANSFER - II

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

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

Hall, Inc. New Jersey.

COURSE OUTCOMES

The students would be able to

1. Apply the concepts of mass transfer to the analysis of various types of distillation.
2. Analyse extraction and leaching operations.
3. Analyse the mass transfer operations of adsorption and crystallization.
4. Provide solution to problems related to distillation, extraction etc.

BTCH-602A CHEMICAL REACTION ENGINEERING –II

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students would be able to:

1. Apply the basics of catalysis and the principles of Reaction Engineering, mass transfer and heat transfer to heterogeneous reactions.
2. Analyse the kinetics of Fluid-particle non-catalytic reactions & determination of the rate-controlling step for these reactions.
3. Apply the concepts of film & penetration theories for design of columns involving Fluid-fluid reactions.
4. Analysis of rate data for heterogeneous reactions to design of fixed bed, fluidized bed & slurry type reactors.

BTCH-611A PETROLEUM REFINING ENGINEERING

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

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

Introduction to petroleum industry: **(04 hrs)**
World petroleum resources, petroleum industry in India. Origin, exploration, drilling and production of petroleum crudes, Transportation of crudes and products.

Crude pretreatment: **(06 hrs)**
Composition and classification of crudes, methods of evaluation: ASTM, TBP and EFV distillation.

Petroleum Products **(08 hrs)**
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: **(10 hrs)**
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: **(08 hrs)**
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.

COURSE OUTCOMES

The students will be able to:

1. Demonstrate knowledge of various petroleum resources, drilling techniques for obtaining crude petroleum & various regulations for crude oil production
2. Classify various crudes & identify desirable properties of Petroleum fractions and testing methods.
3. Exhibit the knowledge of the various pretreatment and refining processes like distillation, extraction, de-waxing etc.
4. Exhibit the knowledge of the various conversion processes like cracking, reforming, alkylation, polymerization and isomerization.

BTCH-616A OPTIMIZATION TECHNIQUES

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

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

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

Introduction: **(8 hrs)**

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

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

Optimality criterion.

Single variable Optimization Techniques: **(10 hrs)**

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

Multivariable Optimization Techniques: **(12 hrs)**

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

Constrained Optimization Algorithms: **(12 hrs)**

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

Linear Programming: **(7 hrs)**

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

BOOKS RECOMMENDED:

1. Deb K., Optimization for Engg. Design Algorithms and Examples , Prentice Hall of

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

COURSE OUTCOMES

At the end of this course, students will be able to:

1. Formulate optimization problem and interpret the results of a model and present the insights (sensitivity, duality etc.)
2. Perform analysis and optimization of a given single variable, constrained and unconstrained problems using various optimization techniques.
3. Analyze and optimize a given multivariable, constrained and unconstrained problems using various optimization techniques.
4. Optimize linear programming problem.

BTCH-603A MASS TRANSFER LABORATORY

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

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

COURSE OUTCOMES

Students will be able to develop the following skills/understanding upon the successful completion of this course:

1. Apply the fundamental concepts of mass transfer and use those concepts to real engineering problems.
2. Apply the concepts of diffusion and various laws governing diffusion in solids, liquids & gases.
3. Operate equipments based upon processes involving Gas absorption, drying of solids, adsorption, crystallization, Distillation, Liquid-liquid extraction and leaching
4. To present their results in written form of report

BTCH-604A 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.

COURSE OUTCOMES

Students would be able to:

1. Demonstrate knowledge about important parameters and codes of equipment design.
2. Perform mechanical design for thin & thick internal and external pressure vessels and tall vessels.
3. Perform mechanical design for various parts of vessels, heads, supports.
4. Perform mechanical design various types of bottoms and roofs for cylindrical vessels.
5. Present the work/results in form of written reports.

BTHU – 601A PROFESSIONAL SKILLS – IV

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

Motivation: Introduction to Motivation, Relevance and Intrinsic and Extrinsic Motivation, Achievement motivation, Assessment of Motivation.

Leadership: Characteristics of a good leader. Styles of leadership (Transformational, Transactional, Charismatic).

Aptitude: Meaning and measurement, problem solving abilities, logical reasoning skills, verbal and numerical reasoning, Pictorial comparison, shapes and symbols.

Communication Skills: Report Writing, Negotiation Skills, Meeting Skills, Interview Skills.

Recommended Books:

1. Organizational Behaviour by Stephen Robbins, Pearson Education.
2. Organizational Behaviour by Fred Luthans, Tata McGraw Hill.
3. Handbook of Technical Writing by David A.McMurrey and Joanne Buckley by Cengage Learning.
4. Handbook of Practical Communication Skills by Chrissie Wright, Jaico Publications, Mumbai.
5. Effective Technical Communication by M. Ashraf Rizvi, Tata McGraw Hill.
6. Model Business Letters, E-mails & Other Business Documents, 6th Edition, by Shirley Taylor, Pearson Education.
7. Communicative English for Engineers and Professionals by Nitin Bhatnangar and Mamta Bhatnagar, Pearson Education.

Course Outcomes of Professional Skills (BTHU-601A)

CO No.	After undergoing this course, students must be able to:
1	Understand implications of varied aspects of Motivation and its assessment.
2	Understand and imbibe leadership skills and various styles of leadership.
3	Sharpen and demonstrate problem solving abilities, logical reasoning skills, verbal and numerical reasoning, Pictorial comparison, shapes and symbols
4	Develop and Demonstrate oral and written communication Skills such as Negotiation Skills, Meeting Skills, Interview Skills, Report Writing.

(7th Semester)

BTCH-701A PROCESS INSTRUMENTATION, 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 various types of instruments used in chemical processes, dynamical behaviour 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 in the course.

Introduction: **(2 hrs)**
Importance of instruments in Chemical Process industries, Static and Dynamic characteristics of instrument.

Instruments for Pressure, Temperature & Level Measurement: **(10 hrs)**
Bourdon gauge, bellow type gauge, Measurement of vacuum and pressure, Transducers Thermocouples, resistance & filled thermometers, thermistors, optical and radiation pyrometers.
Liquid level measurement-Direct and differential method, positive displacement type meters

General Principles of Process Control: **(12 hrs)**
Basic control elements, degree of freedom and fixing of control parameters, Simple system analysis, 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: **(15 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 – Routh criteria, Bode plots

Introduction to advanced control techniques: **(6 hrs)**
Feed forward, feedback, cascade, ratio, adaptive and digital computer control.

Process Identification and applications: **(3 hrs)**
Process identification of systems with unknown transfer functions.

BOOKS RECOMMENDED:

1. Eckman D.P., Industrial Instrumentation, Wiley Eastern, 1974
2. Patranabis D., Principles of Process Control, 2nd Ed., Tata McGraw Hill, 2001
3. Coughanowr D.R., Leblanc S., Process System Analysis and Control, 3rd Ed., McGraw Hill, 2009
4. Stephanopoulos, G., Chemical Process Control - An Introduction to Theory and Practice, 1st Ed., Prentice Hall of India, 1990
5. Peacock D.G., Richardson J.F., Chemical Engineering – Volume 3, 3rd Ed., Butterworth Heinemann, 1994
6. Bequette B.W., Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall, 1998
7. Bequette B. W., Process Control: Modeling, Design and Simulation, Prentice Hall, 2003

8. Pollard, Process Control for Chemical and Allied Industries, Butterworth Heinnemann, 1971.
9. Weber T. W., An Introduction to Process Dynamics &Control, Kreiger Publishing Co, 1988
10. Harriott, P., Process Control, TMH Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2001.

Course Outcomes:

Students will be able to

1. Analyse 1st and 2nd order systems
2. Analyse linear and non-linear systems.
3. Demonstrate the knowledge of various types of controllers (P, PI& PID) and their transfer functions.
2. Analyse a given system for its frequency response and stability.
3. Demonstrate the knowledge of Process Identification and advanced control strategies like Cascade, Ratio and Feed forward Control

BTCH-702A 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: (12 hrs)
Factors affecting investment and production costs, Capital investments-fixed investments and working capital. Cost indices. Estimating equipment costs by scaling 6/10 factorrule. 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: (4 hrs)
Concept of Gross Profit, Net Profit, Return on Investment, Current Ratio, Quick Ratio, Debt-equity ratio

Interest and investment costs: (4 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: (2hrs)
Procedure with one variable, Optimum reflux ratio in distillation and optimum pipe diameter.

IPR and Patent Systems (8 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
1. Ulrich,G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley, 1984
2. Guthrie, K.M., Process Plant Estimating, Evaluation and Control, Craftsman Solano Beach, Calif,
3. Couper James R, Process Engineering Economics, Marcel Dekker, NY, 2003

Course Outcomes:

1. The students will be able to prepare and analyze the balance sheet, income statement and estimation of capital investment, total product costs.
2. The students will be able to understand the concept of interest cost, depreciation and taxes.
3. The students will be able to perform profitability and replacement analysis and calculation of single variable optimum cost/profitabilty analysis.

4. The students will be able to understand the concept of Intellectual Property Right (IPR) and Patent system.

Dept. Elective –V

BTCH-711A 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, and chromatography.

Introduction to Separation Processes (4 hrs)
Industrial chemical processes, Mechanism of separation, separation power, selection of feasible separation processes.

Membrane Separations (12 hrs)
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 (24 hrs)
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, Counter-current Adsorption Systems, Simulated-Moving-Bed Systems, Ion-Exchange Cycle, Chromatographic Separations

Multi component Distillation: (8 hrs)
Introduction to Multi-component Distillation, Estimation of Minimum number of trays: Fenske Equation, Minimum Reflux: Underwood Equations, Estimation of Numbers of Stages at Finite Reflux: Gilliland Correlation, Concept of divided walled distillation columns.

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.

Course Outcomes
Students will be able to
1. Demonstrate knowledge of various chemical engineering separation processes.
2. Apply knowledge of membrane separation for phenomena
3. Ability to analyze the separation system for multi-component mixtures
4. Ability to design separation system for the effective solution of intended problem

BTCH-712A PETRO CHEMICAL TECHNOLOGY

ExternalMarks:60 **L TP**
Internal Marks:40 **3 1 0**
TotalMarks: 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 **(8 hrs)**
Petrochemicals: Definition, importance and growth potential of the field.
Petrochemical Feed stocks **(16 hrs)**
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 feedstock **(12 hrs)**
Cracking- thermal and catalytic, polymerization and isomerisation.
Desulphurization of petrochemical feedstocks
Manufacture of important petrochemicals: **(12 hrs)**
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

Course Outcomes:

The students will be able to:

1. Demonstrate knowledge of various petrochemicals.
2. Demonstrate knowledge of various Petrochemical Feed stocks and their purification for commercial production of petrochemicals.
3. Apply the knowledge of processing techniques for obtaining petrochemicals from various Petroleum products.
4. Manufacture of typical Petrochemicals and their commercial uses.
5. Analyze the effect of petrochemicals and petrochemical industries on environment and its control strategies.

BTCH-713A 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: **(12 hrs)**
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: **(12 hrs)**
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: **(8 hrs)**
Introduction, design of tubular reactors, copolymerization, solution of equations describing isothermal radical polymerization.

Emulsion polymerization: **(8 hrs)**
Introduction, emulsion polymerization in homogeneous continuous flow strirred tank reactors (HCSTRSs)

Design of Batch Reactors: **(8 hrs)**
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, McGrawHill, 1998.
2. Kumar A. & Gupta R. K., Fundamentals of Polymer Science and Engineering, TataMcGrawHill, New Delhi, 1978.
3. Fogler H. S., Elements of Chemical Reaction Engineering, 4th Ed., Prentice Hall, 2006

Course Outcomes:

Students will be able to:

1. Apply the fundamentals of kinetics to Chain growth, Step growth and Emulsion Polymerisation.
2. Formulate mathematical models for different types of polymerizations.
2. Quantitatively determine degree of polymerization and molecular weight distribution of ARB Polymers.
3. Perform process design of batch, semi batch and continuous reactors for these polymerizations
4. Demonstrate the knowledge of fundamentals of Co-polymerisation.

BTCH-703A PROCESS INSTRUMENTATION, DYNAMICS & CONTROL LABORATORY

External Marks: 20	**L T P**
Internal Marks: 30	**0 0 3**
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 tanks in series.
4. Study of process dynamics of some processes like heat exchangers.
5. Investigation of the operation of pneumatic and electronic controllers with proportional integral derivative action.
6. To determine the best setting of a controller for 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.

Course Outcomes:

The students would be able to

1. Calibrate instruments involving process variables used for controlling chemical process plants.
2. Analyze the dynamics of various Ist & IInd order systems and develop their transfer functions.
3. Analyze the characteristics of pneumatic and electronic controllers.
4. Compare the characteristics of various types of Control valves & Interpret operation of a Programmable Logic Control (PLC) system.
5. Present the results in form of written reports.

BTCH-704A CHEMICAL PROCESS PLANT DESIGN –II

ExternalMarks:20	**L TP**
Internal Marks:30	**1 03**
TotalMarks: 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 tray type and packed columns.
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 the design report.

BOOKS RECOMMENDED:

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

Course Outcomes:

1. The students will be able to demonstrate the knowledge of standards, types and process design of equipments like distillation columns, absorption columns and reactors.
2. The students will be able to perform process design of tray type distillation column, packed absorption column and reactors.
3. The students will be able to prepare the specification sheets for distillation column and absorption column.
4. The students will be able to demonstrate the knowledge of plant layout and flow sheets.
5. The students will be able to present the work/results in form of written reports.

BTCH-705A PROJECT -I

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

Each student will have to perform literature survey and plan the course of action for the final project (Project-II) and submit a report and deliver a presentation based on the work done.
The main aim is to develop an understanding of literature survey, its analysis and presentation skills in the students. Depending on his/her performance in the presentation he/she will be evaluated. The student will also have to appear in a Viva-Voce Examination justifying the work being carried out.

Course Outcomes

The student would be able to

1. Demonstrate the intensive literature survey for any Chemical Engineering related problem.
2. Deliver well organized technical presentations of on the literature survey performed.
3. Write an efficient and effective report.

BTCH-706A Training-III
INDUSTRIAL/ INSTITUTIONAL TRAINING

External Marks:4 0
Internal Marks: 6 0
Total Marks: 100

Each student would have to undergo eight weeks industrial/ institutional training and will be required to submit a report after the completion of training. The reports will be assessed by teacher in-charge of the training. The student has to appear in Viva-Voce/Presentation for internal as well as external evaluation.

Course Outcomes

1. Apply various concepts learnt in Chemical Engineering in understanding of various industrial operations being carried out in Chemical industry.
2. Handle/analyze and solve live projects/problems giving their solutions with mathematical consistency & most economical & efficient way.
3. Demonstrate the skill of using literature / resources for solution of such problems in Chemical Industry.
4. Represent the results of industrial/ institutional training in written form as a report.

(8th Semester)
BTCH-801A PROCESS MODELING & SIMULATION

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 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: **(12 hrs)**

Concept of Steady state, Dynamics, Variables and Degrees of freedom, Definition of mathematical model, Classification of models – Simple and rigorous, lumped and distributed parameter model, uses of mathematical models, principles of formulation of models, advantages and limitations of mathematical modeling; parametric sensitivity.

Review of Fundamental Laws and Numerical methods: **(6 hrs)**

Continuity equations, energy equations, equations of motion, transport equations, equations of state, equilibrium, chemical kinetics.

Review of numerical methods used for solution of linear and nonlinear equations, ODE's and PDE's.

Process modeling:

Steady state models **(10 hrs)**

-Model of three isothermal CSTRs in series -constant & variable hold-up.
- Model for an Isothermal/non-isothermal plug-flow reactor.
- Model of equilibrium staged processes Distillation columns, Gas Absorbers & Strippers.
- Model of flash vessels
- Model for various types of heat exchangers
- Model of evaporators
- Equilibrium-constant & titration curve models for PH systems.

Unsteady state models

Lumped parameter systems **(8 hrs)**

- Model for a gravity flow liquid level tank.
- Model for a system of interacting & non-interacting tanks.
- Model of jacketed stirred tank heater
- Model of jacketed stirred tank reactor
- Model of flash separation column
- Model of multistage batch and continuous distillation column.
- Model for liquid-liquid extraction columns.

Distributed parameter systems: **(8 hrs)**

- Model of laminar flow in pipe, heat exchanger
- Model of packed columns
- Model of packed bed reactor.

Simulation: **(4 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 Modeling Simulation and Control for Chemical Engineers, 2nd Edition, McGraw Hill Book Co., 1990.
2. Franks, R.G.E., Mathematical Modeling in Chemical Engineering, John Wiley, 1967.
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

Course Outcomes:

The students will be able to:

1. Apply the concepts of model formulation, an analysis of variables and parameters, and degree of freedom analysis for the solution of mathematical model.
2. Develop steady state models of typical chemical engineering processes like reactors, columns, heat exchangers etc.
3. Develop unsteady state models of typical chemical engineering processes like reactors, columns, heat exchangers etc.
4. Apply the knowledge of numerical methods and simulate simple Chemical Engineering problems involving lesser no. of equations and variables.

Dept. Elective –VII

BTCH-811A Chemical Process Safety

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 **(16 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 **(8 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 **(8 hrs)**
Case Histories
Bhopal gas tragedy, Flix borough 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

Course Outcomes:
Students would be able to:-
1. Demonstrate the knowledge of safety principles in Chemical Industry.
2. Apply the knowledge of various hazard identification techniques.
3. Exhibit the knowledge of various types of fires and explosions; and design for fire protection.
4. Analyze and apply the various risk assessment methods to Chemical Engineering scenario.
5. Analyze case histories of industrial disasters.

BTCH-802A PROCESS SIMULATION LABORATORY

Objectives: The objective of the lab is to introduce students to solving process simulation problems using MATLAB / Simulink. A basic background in Numerical Methods and Chemical Engineering is expected, though all the key concepts required for the lab will be reviewed during the course of the semester.

External Marks:20	**L TP**
Internal Marks:30	**0 03**
Total Marks: 50	

1. Program involving Simulation for calculation of Bubble point & Dew point of mixtures using MATLAB/ Simulink.
2. Program involving Simulation of Lumped Gravity Flow tank model using MATLAB/ Simulink.
3. Program involving Simulation of Steady state three isothermal CSTRs in series -constant & variable hold-up using MATLAB/ Simulink.
4. Program involving Simulation of Steady state Plug flow reactor using MATLAB/ Simulink.
5. Program involving Simulation of Steady state Gas Absorber using MATLAB/ Simulink.
6. Program involving Simulation of a Steady state Shell and tube type heat exchanger using MATLAB/ Simulink.
7. Program involving Simulation of lumped Jacked non-isothermal CSTR using MATLAB/ Simulink.
8. Program involving Simulation of isothermal batch reactor using MATLAB/ Simulink.
9. Program involving Simulation of lumped model liquid-liquid extraction columns using MATLAB/ Simulink.
10. Program involving Simulation of isothermal distillation column using MATLAB/ Simulink.
11. Program involving Simulation of distributed Model of laminar flow in pipe using MATLAB/ Simulink.
12. Program involving Simulation of distributed Model of packed bed reactor using MATLAB/ Simulink.

Course Outcomes:

The students will be able to:

1. Apply single and multi-variable optimizations techniques for developing mathematical models and numerical analysis of Chemical Engineering problems.
2. Develop mathematical models of chemical engineering processes and numerical implementation by using various numerical methods like Bisection Method, Newton Raphson method & Euler's Method.
3. The students exhibit the skill of usage of programming language for Simulation of Models developed for Chemical Engineering Problems.
4. Present results in the form of written reports both Analytical and graphical form.

BTCH-803A Project-II

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 objective 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

Course Outcomes

The student would be able to

1. Apply chemical engineering principles for solution of a given problem.
2. Perform experiments/ data collection necessary for solution and arrive at solution of any Chemical Engineering related problem.
3. Deliver well organized technical presentations.
4. Present the findings in written format.