Shaheed Bhagat Singh State University, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2022 Batch Onwards)
3rd Semester (Second Year) -Curriculum

Total Contact Hours= 25

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credits
			L	T	P	Internal	External		
1.	BTCH-301C	Chemical Engineering Thermodynamics	3	1	0	40	60	100	4
2.	BTCH-302C	Fluid Mechanics	3	1	0	40	60	100	4
3.	BTCH-303C	Mechanical Operations	3	1	0	40	60	100	4
4.	BTCH-304C	Chemical Process Industries	3	0	0	40	60	100	3
5.	BTCH-305C	Engineering & Solid Mechanics	3	1	0	40	60	100	4
6.	BTCH-306C	Chemical Engineering Lab-I (FM & ESM lab)*	0	0	3	30	20	50	1.5
7.	BTCH-307C	Chemical Engineering Lab-II (Mechanical Operations lab)*	0	0	3	30	20	50	1.5
8	BTCH-308C	Training-I	-	-	-	60	40	100	2
Total			**15**	**4**	**6**	**320**	**380**	**700**	**24**

***Diploma course**

Shaheed Bhagat Singh State University, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2022 Batch Onwards)
4th Semester (Second Year) -Curriculum

Total Contact Hours= 27

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credits
			L	T	P	Internal	External		
1.	BTCH-401C	Chemical Reaction Engineering-I	3	1	0	40	60	100	4
2.	BTCH-402C	Mass Transfer-I	3	1	0	40	60	100	4
3.	BTCH-403C	Heat Transfer	3	1	0	40	60	100	4
4.	BTCH-404C	Materials Science*	3	0	0	40	60	100	3
5.	BTCH-407C	Plant Utilities	3	0	0	40	60	100	3
6.	BT-	Open Elective-I	3	0	0	40	60	100	3
7.	BTCH-405C	Chemical Engineering Lab-III (Heat & Mass Transfer lab)	0	0	3	30	20	50	1.5
8.	BTCH-406C	Chemical Engineering Lab-IV (CRE lab)	0	0	3	30	20	50	1.5
Total			**18**	**3**	**6**	**300**	**400**	**700**	**24**

***Diploma course**

Shaheed Bhagat Singh State University, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2022 Batch Onwards)
5th Semester (Third Year) -Curriculum

Total Contact Hours= 22

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credits
			L	T	P	Internal	External		
1.	BTCH-501C	Chemical Reaction Engineering-II	3	1	0	40	60	100	4
2.	BTCH-502C	Mass Transfer-II	3	1	0	40	60	100	4
3.	BTCH-503C	Industrial Pollution Control**	3	0	0	40	60	100	3
4.	Core Elective-I		3	0	0	40	60	100	3
	BTCH-511C	Mathematical Methods in Chemical Engg.							
	BTCH-512C	Corrosion Engg.							
5.	BT-	Open Elective-II	3	0	0	40	60	100	3
6.	BTCH-505C	Process Engineering & Economics	3	0	0	40	60	100	3
7.	BTCH-504C	Chemical Engineering Lab-V (C.T. & Environmental Engg. lab)	0	0	2	30	20	50	1
Total			**18**	**2**	**2**	**270**	**380**	**650**	**21**

****Advance Diploma**

Shaheed Bhagat Singh State University, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2022 Batch Onwards)
6th Semester (Third Year) -Curriculum

Total Contact Hours= 26

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credits
			L	T	P	Internal	External		
1.	BTCH-601C	Process Instrumentation, Dynamics & Control	3	1	0	40	60	100	4
2	BTCH-602C	Energy Technology	3	0	0	40	60	100	3
3.	BTCH-603C	Chemical Process Safety**	3	0	0	40	60	100	3
4.	Core Elective-II		3	0	0	40	60	100	3
	BTCH-611C	Polymer Science & Reactor Design							
	BTCH-612C	Optimization Techniques							
5.	BT-	Open Elective-III	3	0	0	40	60	100	3
6.	BTHU-	HASS-I***	3	0	0	40	60	100	3
7.	BTCH-604C	Chemical Equipment Design	1	0	3	30	20	50	2
8.	BTCH-605C#	Chemical Engg. & Polymer Processing lab (Mandatory Non-Credit Course)	0	0	3	50#	-	50	0 (#Sat/ Unsat)
Total			**19**	**1**	**6**	**320**	**380**	**700**	**21**

****Advance Diploma**

 # Mandatory Non-Credit lab (Satisfactory/ Unsatisfactory grade will be awarded based on securing 35% marks in internal exam)

Shaheed Bhagat Singh State University, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2022 Batch Onwards)
7th Semester (Fourth Year) -Curriculum

Total Contact Hours= 31

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credits
			L	T	P	Internal	External		
1.	BTCH-701C	Transport Phenomena	3	1	0	40	60	100	4
2.	Core Elective-III		3	0	0	40	60	100	3
	BTCH-711C	Petroleum Engineering & Technology							
	BTCH-712C	Fuel Cell Technology							
3	BT-	Open Elective-IV	3	0	0	40	60	100	3
4.	BTHU-	HASS-II***	3	0	0	40	60	100	3
5.	BTCH-702C	Chemical Engineering Lab –VI (Process Modeling & Simulation Lab)	0	0	3	30	20	50	1
6.	BTCH-703C	Chemical Engineering Lab –VII (Process Instrumentation, Dynamics & Control Lab)	0	0	3	30	20	50	1
7.	BTCH-704C	Chemical Process Plant Design	1	0	3	30	20	50	2
8.	BTCH-705C	Project	-	-	8	60	40	100	4
Total			**13**	**1**	**17**	**310**	**340**	**650**	**21**

Shaheed Bhagat Singh State University, Ferozepur Punjab

Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2022 Batch Onwards)
8th Semester (a) (Fourth Year) –Curriculum

Total Contact Hours= 14

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credits
			L	T	P	Internal	External		
1.	BTCH-802C	Heat Exchanger Networks	2	0	0	40	60	100	2
2.	Core Elective-IV		3	0	0	40	60	100	3
	BTCH-811C	Nano-Technology							
	BTCH-812C	Fluidization Engg.							
3	Core Elective-V		3	0	0	40	60	100	3
	BTCH-813C	Advanced Separation Processes							
	BTCH-814C	Bio-Chemical Engg.							
4.	Core Elective-VI		3	0	0	40	60	100	3
	BTCH-815C	Green Energy & Technologies							
	BTCH-816C	Bioenergy Engineering							
5.	BT-	Open Elective-V	3	0	0	40	60	100	3
Total			**14**	**0**	**0**	**200**	**300**	**500**	**14**

Shaheed Bhagat Singh State University, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2022 Batch Onwards)
8th Semester (b) (Fourth Year) -Curriculum

Total Contact Hours = 00

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credits
			L	T	P	Internal	External		
1.	BTCH-801C	Industry/ Institutional Internship Training	-	-	-	300	200	500	14
Total			**0**	**0**	**0**	**300**	**200**	**500**	**14**

*****List of Humanities and Social Sciences (HASS-I and II) subjects for 6th and 7th Sem.**

(i) BTHU-901C Personality Development

(ii) BTHU-902C Human Resource Management

(iii) BTHU-903C Project Management

(iv) BTHU-904C Applications of Psychology in Everyday Life

(v) BTHU-905C Entrepreneurship

BTCH-301C Chemical Engineering Thermodynamics

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

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 vapour/liquid systems and their applications to separation processes is included.

Brief review **(10 hrs)**

Importance of thermodynamics in chemical engineering, State functions, types of systems, internal energy, heat and work reversible and irreversible processes. 1^{st} 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 2^{nd} and 3^{rd} Law of thermodynamics **(10 hrs)**

Concept o f E ntropy and lost work, Microscopic interpretation of entropy. Third law of thermodynamics and i t s applications, free energy functions and their significance in phase and chemical equilibria. Clapeyron equation and some important correlations for estimating vapour pressures. Estimation of t hermodynamic properties by using graphs and tables.

Equations of state **(6 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 **(14 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 coefficients. 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 **(8 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, 7^{th} 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-302C Fluid Mechanics

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: **(8 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: **(6 hrs)**

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

Dimensional Analysis of Fluid Flow: **(4 hrs)**

Problems using Rayleigh method and Buckingham π method, Dimensionless numbers and their significance

Flow of Incompressible Fluids: **(8 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, Turbine meters, Anemometer, Vortex meters.

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-303C Mechanical Operations

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

Objective: To introduce students to the numerous industrial operations dealing with the particulate solids, their handling in various unit operations, and those in which particle fluid interactions are important. The fundamentals of fluid-particle mechanics for various industrial processes like packed bed operation, fluidized operations, sedimentation, filtration, separation of solids and fluids has been emphasized etc.

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.

Screening*:* 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, mixers for cohesive solids, mixing index, axial mixing.

Size Reduction: (8 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.

Filtration: (8 hrs)

Classification of filtration*:* Cake filtration, Clarifying filters, liquid clarification, Gas cleaning, Cross flow Filtration, micro filtration
Filtration Equipment*:* Centrifuges and their selection.

Settling: (8 hrs)

Motion of particles through fluids*:* Terminal velocity, hindered settling, Stoke's law, Richardson-Zaki equation
Gravity settling processes*:* Classifiers, clarifiers, thickeners, flocculation, rate of sedimentation
Centrifugal Settling processes*:* Principles of centrifugal sedimentation, cyclones, hydroclones, tubular, disk and nozzle discharge centrifugal sludge separators, Centrifugal classifiers.

Flow through Packed Beds (2 hrs)

Ergunequation, Kozeny-Carmanequation, Blaine's apparatus.

Fluidization: (6 hrs)

Fluidization and fluidized bed, conditions for fluidization, minimum fluidization velocity, types of fluidization, expansion of fluidized beds and particulate fluidization, continuous fluidization, industrial applications.

BOOKS RECOMMENDED:

1. McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill.
2. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.
3. Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester; New York, 2008.
4. Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.
5. Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.
6. Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley, 2013.

COURSE OUTCOMES

Students will be able to: -

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

BTCH-304C 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 **(5 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.

Cement **(3 hrs)**

Types and properties of cement, Method of production of Portland cement, 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-305C Engineering and Solid Mechanics (ESM)

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

Objectives: Students would be introduced to fundamentals of Engineering Mechanics with emphasis on force systems. Second part of the course would be an introduction to Solid Mechanics, and students would be introduced to basic concepts of mechanics of deformable media: concept of stress tensor, strain tensor, strain rates, constitutive relations, and applicationsto one/two dimensional problems.

Rigid body kinematics: (4 hrs)

Translation and rotation, relative motion, angular velocity, Laws of motion, (Euler's Axioms), General motion of a rigid body, General relative motion.

Simple Stresses & Strains: (6 hrs)

Simple stresses and strains: Concept of stress and strain; St. Vernants principle, stress and straindiagram, 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.

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. Shear Force and Bending Moment diagram.

Theory of Bending: (6 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

Analysis of Structures: (4 hrs)

Trusses, Equivalent force systems, Resultant forces, Linear and Angular Momentum, Free BodyDiagrams, Equilibrium of rigid bodies, distributed forces.

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: (4 hrs)

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

Columns: **(6 hrs)**

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

BOOKS RECOMMENDED:

1. Timoshenko, S., Young D.H., Sukumar P., Rao J. V. Engineering Materials 5th Edition,McGraw Hill Education.
2. Timoshenko, S., Strength of Materials Vol-I: Elementary Theory and Problems, 3rd Edition,CBS Publishers, 2002
3. Vazirani V.N. & Ratwani, Analysis of Structures, Vol. I, 17th Ed., Khanna Publishers
4. Bansal, R.K., Strength of Materials, 4th Ed., Luxmi Publishers, 2010.
5. Popov E. P., Engineering Mechanics of Solids, 2nd Ed., Prentice Hall, 1999

COURSE OUTCOMES

Students will be able to:

1. Understand the basic concepts of rigid body kinematics.
2. Understand the concept of stress and strain at a point and stress analysis in various machine elements like thin cylinder, sphere, spring, beams and shafts.
3. Tackle the problems related to shearing Force, bending moment, slope and deflections indifferent 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-306C Chemical Engineering Lab – I
(FM & ESM lab)

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

LIST OF EXPERIMENTS

PART A*

1. Plot the characteristic curves for a centrifugal pump
2. Verification of Bernoulli's equation for a 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.

PART B*

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

***At least five experiments should be conducted from each part.

COURSE OUTCOMES:

Students will able to:

1. Demonstrate the understanding about the working of a centrifugal pump.
2. Demonstrate the practical understanding of Bernoulli's equation and different types of losses in pipe flow systems
3. Determine the coefficient of discharge for Venturimeter, Orifice meter, V-notch etc
4. Demonstrate understanding of different types of materials and their properties
5. Demonstrate practical understanding of behaviour of material under tensile/ compressive loading
6. Present results in the form of written reports.

BTCH-307C Chemical Engineering Lab-II (Mechanical Operations Lab)

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 its particle size distribution.
3. Determination of
   a) Variation in pressure drop & bed height with respect to superficial velocity for a bed of solids.
   b) Minimum fluidization velocity for a bed of solids.
4. Operating characteristics of crushing and grinding equipment (Jaw crusher, Ball mill).
5. Evaluation of the filtration constants for CaCO3 slurry in water and cake compressibility.
6. Determination of %age recovery of coal in froth from coal and sand mixture.
7. Determination of thickener capacity using batch sedimentation.
8. 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 equipment
3. Apply various principles of the filtration and analyse working of filtration equipment.
4. Calculate efficiency of various separating equipment.
5. Present results in form of written reports.

BTCH-308C Training -I

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

Each student is required to undergo Training in workshops/Chemical Engineering labs during the summer vacations after 1st year of study for a minimum period of 04 weeks. Students are required to gain hands on experience in the various workshops/ labs during the course of their training.

The objective of the training is to develop the ability of the student to work in the industrial environment by working in workshops/labs.

The students are required to present their work in the form of written reports and also appear in a Viva-Voce Examination.

COURSE OUTCOMES:

Students would be able to:

1. Apply techniques to perform basic operations with hand tools and power tools such as center lathe machine, drilling machine using given job drawing.
2. Report procedures followed for a given task in fitting, carpentry, foundry, sheet metals, welding and machine shops.
3. Apply safety consciousness and show team work.
4. Present results in form of written reports.

4th Semester
BTCH-401C 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 reactions.

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

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-402C 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 diffusion, mass transfer coefficients and gas-liquid mass transfer operations is developed.

Introduction **(2 hrs)**

Importance and classification of mass transfer operations in Chemical Engineering

Diffusion: **(8 hrs)**

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 Transfer correlations, Analogies between Mass, momentum and Heat transfer

Mass balance in co-current and counter-current operation, Concept of operating line, Multi-stage counter current operations, Concept of ideal stage, Stage efficiencies– local, overall and Murphree efficiency.

Gas- Liquid Operations

Gas absorption: **(8 hrs)**

Solubility of gases, ideal solutions, Roult's law & Henry's law, choice of solvent, Co-current & counter current operations, Calculation of stages, Absorption factor A, stripping, Non-isothermal absorption, Reactive Absorption.

Distillation: **(12 hrs)**

x-y & H-x-y diagrams, Flash vaporisation and condensation. Differential distillation, Batch distillation, Rayleigh equation, Binary fractionation, Steam distillation, Use of open steam, Azeotropic distillation, McCabe-Thiele and Ponchon-Savarit method, Total reflux, minimum and optimum reflux ratios, Efficiency. Introduction to multi-component distillation. partial condensers and total condensers

Design of G/L Equipments **(8 hrs)**

Introduction to column design - Stagewise and continuous contact equipment, HTU and NTU concepts

Design of plate and packed absorption columns, stripping columns and Distillation Column

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. Apply the concepts of Diffusion and various laws governing diffusion in solids, liquids & gases.
2. Apply the concept of mass transfer coefficients and analogies
3. Analyze processes involving Gas absorption/ Stripping.
4. Demonstrate the knowledge of distillation operations and analyze problems.
5. Apply the concepts for design of stagewise & continuous-contact columns.

BTCH-403C 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 charts.

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, NTU-Effectiveness for heat exchangers.

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 – Vol 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

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-404C Materials Science

External Marks: 60 **L T P**
Internal Marks: 40 **3 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: **(6 hrs)**
Review of bonding in solids, structure –property-processing relationship. Space lattice, FCC, HCC, crystal systems, Miller indices, effect of radius ratio on coordination, structures of common metallic, polymeric, ceramic, amorphous and partly crystalline materials.

Mechanical, Thermal and Electrical Properties: **(6 hrs)**
Methods of improving strength- reinforcement, additives, specific heat, glass transition temperature, crystalline melting temperature, thermal conductivity; dielectric strength, dielectric constant, power loss and electrical diffusivity.

Ferrous Metals: **(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).

Non Ferrous Metals: **(2 hrs)**
Aluminium, cobalt, copper, lead, magnesium, nickel, tin and zinc their properties and uses.

Alloys: **(4 hrs)**
Introduction to Phase-Diagrams of metals and its alloys; Fe-Fe3C; Cu-Ni, Cu-Zn, Al-Cu equilibrium diagrams, methods of improving strength, and applications of metals and alloys.

Ceramics: **(2 hrs)**
Definition of ceramic, clay: properties of clay, earthen wares and stonewares, uses of stonewares.

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

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

Polymers & Composites: **(3 hrs)**
Classification of polymers, Properties and engineering usage of Nylon-66, polyesters, polycarbonates, polyurethanes, PVC, polypropylene, polymer composites

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

The students 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 engineering 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 Engineering applications.

BTCH-407C Plant Utilities

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

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

Steam: **(6 hrs)**
Boilers- classification, various types, construction, boiler mountings & accessories, properties of steam-tables, Mollier Diagram.

Power Generation: **(6 hrs)**
Internal Combustion Engines- classification, two- stroke, four stroke petrol & diesel engine, valve timing diagram, carburetor, Combustion Phenomena.

Refrigeration: **(6 hrs)**
Air refrigeration cycles, vapour compression cycle, P-H diagram and liquefactions processes

Compressed Air and Vacuum: **(12 hrs)**
Use of compressed air. Classification of compressors, Reciprocating compressors-mechanical details, single stage and two stage reciprocating compressor, inter cooler, minimum work input in multistage.

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

Water: **(3 hrs)**
Cooling water, cooling towers, raw water, DM water, soft water

Waste Disposal: **(3 hrs)**
Plant sewer system and waste disposal

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students will be able to:

1. Classify and explain types of boilers, their components, and steam properties using steam tables and Mollier diagrams.
2. Compare two-stroke and four-stroke engines and interpret valve timing and combustion phenomena.
3. Illustrate refrigeration cycles and explain P-H diagrams and liquefaction processes.
4. Explain the working and performance of reciprocating and centrifugal compressors.
5. Describe types of industrial water and waste disposal systems.

BTCH-406C Chemical Engineering Lab-III
(Heat & Mass Transfer Lab)

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

LIST OF EXPERIMENTS

PART A

1. Determination of heat transfer coefficient for different types of heat transfer equipment.
2. Developing correlation of instantaneous heat transfer coefficients with time for steady deposition of scale on a heating surface.
3. Determination of heat losses from insulated pipes.
4. Performance characteristics of a shell and tube heat exchanger and an induced draft cooling tower.
5. Study and operation of long tube forced circulation and multiple effect evaporators.
6. To find the heat transfer coefficient of heat loss from a vertical cylinder by natural convection.
7. To find heat transfer coefficient for parallel flow and counter flow for double pipe heat exchanger.
8. To find heat transfer coefficient for heat loss by forced convection to air flowing through it for different air flow rates & heat flow rates.

PART B

1. Determinations of liquid hold up in a packed column.
2. To find the mass transfer coefficient for the vaporisation of organic vapour to air.
3. To verify the Rayleigh's equation for batch distillation.
4. To find the height equivalent to a theoretical plate and height of a transfer unit for the packed distillation column under total reflux.
5. To determine mass transfer coefficient from a wetted wall column.

At least four experiments should be conducted from each part.

COURSE OUTCOMES

Students will be able to:

1. Measure heat transfer coefficients of different flow geometries for different heat transfer conditions.
2. Measure the heat losses and effect of insulation during the heat transfer.
3. Perform the operation of different heat transfer equipment.
4. Apply the fundamental concepts of mass transfer and use those concepts to real engineering problems.
5. Apply the concepts of diffusion and various laws governing diffusion in solids, liquids & gases.
6. To present their results in written form of report.

BTCH-407C Chemical Engineering Lab-IV

(Chemical Reaction 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 Semi-batch reactor.
3. Study of Rate kinetics using an isothermal Plug flow reactor.
4. Study of Rate kinetics using an isothermal CSTR.
5. Study of Rate kinetics using three cascade CSTRs.
6. To determine the residence time distribution for a CSTR.
7. To determine the residence time distribution for Packed bed reactor.

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, Semi-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. Present results in form of written reports.

5th Semester

BTCH-501C Chemical Reaction Engineering-II

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 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-502C 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.

Simultaneous Heat & 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 of pure substances, 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: **(6 hrs)**

Types of membranes, permeate flux for ultra-filtration, concentration polarization, partial rejection of solutes, microfiltration, reverse osmosis and electro-dialysis.

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: **(6 hrs)**

Types, nature of adsorbents, Adsorption equilibria- single species- Langmuir, Freundlich isotherms, Adsorption operations –single stage and multi stage, Fixed bed absorbers, breakthrough

Crystallization: **(4 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 drying and humidification.
2. Analyze extraction and leaching operations.
3. Analyze the mass transfer operations of adsorption and crystallization.
4. Analyze the mass transfer operation of membrane separation

BTCH-503C Industrial Pollution Control

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

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: (8 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. The concept of Air Quality Index (AQI)

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: (12 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: (4 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 nonhazardous solid waste treatment and disposal.

BTCH- 504C Process Engg. & Economics

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

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

Cost Estimation: **(8 hrs)**

Factors affecting investment and production costs, Capital investments-fixed investments and working capital. Cost indices. Estimating equipment costs by scaling 6/10 factor rule. Methods for estimation capital investment. Estimation of total product cost, Break even analysis

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: **(2 hrs)**

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

Depreciation: **(4 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.

IPR and Patent Systems **(6 hrs)**

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

BOOKS RECOMMENDED:

1. Peters M.S., Timmerhaus K.D., Plant Design and Economics for Chemical Engg., 5th Ed., Tata McGraw Hill, 2005.
2. Ulrich,G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley, 1984

3. Guthrie, K.M., Process Plant Estimating, Evaluation and Control, Craftsman Solano Beach, CA.
4. 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/profitability analysis.
4. The students will be able to understand the concept of Intellectual Property Right (IPR) and Patent system.

Dept. Elective-I
BTCH-511C Mathematical Methods in Chemical Engineering

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

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

Introduction & Error analysis: **(3 hrs)**

Introduction to numerical methods and its significance in Chemical Engineering, Classification of errors, significant digits and numerical stability

Linear Algebraic Equations: **(5 hrs)**

Cramer's rule, Gauss Elimination and LU Decomposition, Gauss-Jordan elimination, Gauss-Seidel and Relaxation Methods

Non-Linear Algebraic Equations: **(5 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: **(3 hrs)**

Fadeev Leverrier's Method, Power Method

Function Evaluation: **(10 hrs)**

Least squares curve-fit (Linear Regression), Newton's interpolation formulae (equal intervals), Newton's Divided Difference Interpolation Polynomial, Langrangian Interpolation Unequal intervals. Extrapolation Technique of Richardson and Gaunt

Numerical Differentiation, Numerical Integration or Quadratures (Trapezoidal, Simpson's1/3 and 3/8 rules)

Ordinary Differential Equations (ODE-IVPs) and Partial Differential Equations: (4 hrs)

Finite element method – Galerkin’s method, Finite difference Technique, Euler’s method, Runge-Kutta method

Laplace Transforms: **(6 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.

BOOKS RECOMMENDED:

1. Gupta S.K., Numerical Methods for Engineers, 2nd Ed., New Age International Publishers, 2009
2. Grewal B.S., Higher engineering mathematics,43rd Ed., Khanna Publishers, 2014.
3. Jain M.K., Iyengar SRK and Jain R.K., Numerical Methods for Scientific and Engineering Computation, New Age International.
4. Finlayson, B.A. Nonlinear Analysis in Chemical Engineering, McGraw Hill, New York, 1980.
5. Villadsen J., and Michelsen, M.L. Solution of Differential Equation Models by Polynomial Approximation, Prentice Hall, N.J.,1978.
6. Rice R.G., Do Duong D., 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

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-512C Corrosion Engineering

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

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

Types of Corrosion **(8 hrs)**

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

Techniques for Corrosion Resistance **(16 hrs)**

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

Corrosion engineering in special applications **(12 hrs)**

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

Cost factor in competitive corrosion prevention/inhibition techniques.

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The student will be able to:

1. Recognise the different forms of corrosion
2. Identify likely forms of corrosion that a system could be susceptible.
3. Apply techniques for Corrosion Resistance to different systems.
4. Apply corrosion to specific Engineering applications and its economics.

BTCH-505C Chemical Engineering Lab – V
(Chemical Technology & Environmental Engg. Lab)

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

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. Preparation of urea/phenol -formaldehyde.
7. Preparation of soap by hot & cold process using Mustard oil.

Part-B**

1. To determine the Total Solids, Total Dissolved Solids, Fixed and Volatile solids of a given sample.
2. To determine conductivity and hardness of the given sample.
3. To determine pH, acidity and alkalinity of the given sample.
4. To find out amount of sulphates and chlorides in a given sample.
5. To find the quantity of the Dissolved Oxygen and BOD in the given sample.
6. To determine the COD of a given wastewater sample.
7. To determine the Most probable number (MPN) in a wastewater sample.
8. Analysis of particulate matter and gaseous pollutants using a High volume sampler.

**** At least four experiments have to be performed from each part of the Syllabi**

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. 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.

6th Semester

BTCH-601C 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 instruments

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: **(16 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: **(8 hrs)**

Feed forward, feedback, cascade, ratio, adaptive and digital computer control.

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. Demonstrate the knowledge of instruments for pressure, level and temperature measurement.
2. Analyze the utilization of recording, indicating, signaling, transmitting instruments.
3. Analyze 1st and 2nd order systems; linear and non-linear systems.
4. Demonstrate the knowledge of various types of controllers (P, PI & PID) and their transfer functions.
5. Analyze a given system for its frequency response and stability.
6. Demonstrate the knowledge of advanced control strategies like Cascade, Ratio and Feed forward Control

BTCH-602C Energy Technology

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, coal burning equipments, fluidized bed combustion.

Liquid Fuels: **(10 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 gas, water gas, coal gas, blast furnace and refinery gases, gases from biomass, LPG, CNG

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.

Hydrogen based Energy: **(4 hrs)**

Fuel cells, blue, grey, green hydrogen, hydrogen storage techniques and issues, National Green Hydrogen mission

BOOKS RECOMMENDED:

1. Sarkar Samir, Fuels and Combustion, 2nd Ed., Orient Longman, 2003.
2. Gupta O.P., Elements of Fuels, Furnaces and Refractories, Khanna Publications, 1997.
3. Wilson, P.J., Wells, G.H., Coal, Coke and Coal Chemicals, McGraw Hill, 1950.
4. Griswold, J. Fuels, Combustion and Furnaces, McGraw Hill, 2006.
5. Francis, W., Peters M.C., Fuels and Fuel Technology: a Summarized Manual, 2nd Ed.,

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 energy demand, energy crisis and identify available nonconventional (renewable) energy resources and techniques to utilize them effectively.
5. Demonstrate the knowledge of hydrogen based energy systems.

BTCH-603C Chemical Process Safety

External Marks: 60	**L T P**
Internal Marks: 40	**3 0 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 **(12 hrs)**

Concept of Loss prevention, acceptable risks, 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 **(6 hrs)**

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

Hazard identification **(6 hrs)**

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

Risk Assessment **(6 hrs)**

Probability theory, event tree, fault tree and QRA, Dow's fire and explosion index,

Accident Investigations **(6 hrs)**

Case Histories

Bhopal gas tragedy, Flix borough disaster, 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, 4^{th} Ed., Elsevier 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.

Dept. Electives-II
BTCH-611C Polymer Science & Reactor Design

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

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

Objective: The course will provide an overview of polymers and polymer reactor design, focusing on the various types of polymerization methods, polymerization techniques and their properties. The course will provide a detailed study of application of chemical engineering principles in the design and analysis of reactors for polymer production.

Introduction to Polymers: (4 hrs)

Classification of polymers, polymerization methods, kinetics of step growth and chain growth polymerization, polymerization techniques: Bulk, Solution, Suspension and Emulsion polymerisation

Polymer properties & their testing: **(10hrs)**

Number average and weight average molecular weight, significance of molecular weight, determination of molecular weight: viscosity method, light scattering method and gel permeation chromatography method. Glass transition temperature and associated properties, Tensile strength & impact strength and their determination, softening point, heat distortion temperature, resistivity, dielectric constant and electrical breakdown.

Introduction to polymer reactor design: (4 hrs)

Ideal Reactors: Design equations for batch, CSTR and plug flow reactor

Reactor Design: meaning, basic factors in reactor design and reactor selection

Design of Batch Reactors: (4 hrs)

Detailed design of polymerization reactors used for the production of following polymers: Polyvinyl chloride (PVC) and Phenol-formaldehyde

Reaction Engineering of step growth & chain growth polymerization: (10hrs)

Introduction, analysis of semi batch reactors, MWD of ARB polymerization in homogeneous continuous flow stirred-tank reactors (HCSTRs), advanced stage of polymerization, design of tubular reactors, copolymerization

Emulsion polymerization: (4 hrs)

Introduction, kinetics aspects of emulsion polymerization (Smith and Ewart model), emulsion polymerization in homogeneous continuous flow stirred tank reactors (HCSTRSs)

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. Sinha R., Outlines of Polymer Technology - Manufacture of Polymers, PHI
4. Kumar A. & Gupta R. K., Fundamentals of Polymers, 2nd edition, McGraw-Hill, 1998.
5. Kumar A. & Gupta R. K., Fundamentals of Polymer Science and Engineering, Tata McGraw-Hill, New Delhi, 1978.
6. Fogler H. S., Elements of Chemical Reaction Engineering, 4th Ed., Prentice Hall, 2006

COURSE OUTCOMES:

Students will be able to:

1. Demonstrate the knowledge of various types of polymers and polymerization methods, their properties and testing
2. Apply the fundamentals of kinetics to Chain growth, Step growth and Emulsion Polymerization
3. Quantitatively determine degree of polymerization and molecular weight distribution of ARB Polymers
4. Perform process design of batch, semi batch and continuous reactors for these polymerizations
5. Demonstrate the knowledge of fundamentals of Co-polymerization

BTCH-612C Optimization Techniques

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

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: **(8 hrs)**

Bracketing method (Bounding phase method).

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

Multivariable Optimization Techniques: **(8 hrs)**

Optimality criterion – Hessian Matrix and its use in optimization

1. Unidirectional search method.
2. Direct search method (Evolutionary method, Hooke-Jeeves Pattern Search method, Powell's conjugate direction method)
3. Gradient-based methods (Steepest descent method, Newton's method, Marquardt's methods)

Constrained Optimization Algorithms: **(8 hrs)**

Kuhn - Tucker conditions

1. Transformation method (penalty function method)
2. Direct search for constrained minimization (variable elimination method, complex search method.)

Linear Programming: **(4 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.

BTHU- *** HASS-I

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

Any one subject from the proposed list of Humanities, Social Science including Management Courses*.**

BTCH-604C Chemical Equipment Design

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

Prerequisite: The students should have studied Engineering & Solid Mechanics (ESM) 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.

BTCH-605C Chemical Engg. & Polymer processing lab#

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

1. Preparation of polymer product using Injection moulding.
2. Preparation of polymer product using Compression moulding.
3. Preparation of compounded polymer sample using two roll mill.
4. Determination of performance of a given polymer sample under tensile loading like stress-strain curve, modulus of elasticity.
5. 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.
6. To find the yield of crystals using batch crystallizer
7. To find the efficiency of rotary drier using a granular solid.
8. To study the adsorption characteristics and plot adsorption isotherm.
9. To find the yield of a natural oil by leaching from biomass.

 # Mandatory Non-Credit (Satisfactory/ Unsatisfactory grade will be awarded based on securing 35% marks in internal exam)

COURSE OUTCOMES

1. Prepare thermoset polymers and process polymers using compression moulding, Injection moulding and two roll mill.
2. Determine mechanical properties of polymers.
3. Operate equipment based upon processes involving Gas absorption, drying of solids, adsorption, crystallization, Distillation, Liquid-liquid extraction and leaching.
4. Present the work/results in form of written reports.

7th Semester
BTCH-701C Transport Phenomena

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

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

Review: (8 hrs)
Basic concepts of vector & tensor analysis and introduction to transport phenomena. Formulation of transport problems from nature, concept of boundary layer, laminar and turbulent flows.

Basics of Transport phenomena: (10hrs)
Basics of mass, energy and momentum transport. Newton's law of viscosity, Fourier's Law of heat conduction and Fick's law of diffusion.

Shell balances: (10 hrs)
Shell energy balance and shell mass balance for solving specific problems of transport of momentum, heat and mass in laminar flow or in solids in one dimension.

One dimensional transport problems: (8 hrs)
Development of general differential equations, one-dimensional steady state and unsteady state problems of momentum, heat and mass transfer.

Interphase transport: (6 hrs)
Interphase transport of Momentum, heat and mass and dimensionless correlations for each one of them.

Transport Analysis: (6 hrs)
Emphasis on analogies between momentum, heat and mass transfer with respect to transport mechanism and governing equations.

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students are able to:

1. Demonstrate the knowledge momentum, heat, mass transport and vector & tensor analysis.
2. Simplify the momentum transport problems using shell balances.
3. Apply the conservation principles for the microscopic analysis of the given situation and solve the same for heat transport.
4. Apply the conservation principles for the microscopic analysis of the given mass transport situation and solve the same.
5. Analyse the given situation on macroscopic scale for transport of momentum, heat and mass and their analogies.

Dept. Elective – III
BTCH-711C Petroleum Engg. & Technology

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

Objectives: The course provides a basic understanding of the properties and their significance of crude oils and petroleum fractions. It provides an ability to understand, design and analyze the various petroleum refinery processes. It also aims to provide the basic understanding of petrochemical industry which include the processes, products and their production technologies.

Introduction to Petroleum Industry (2 hrs)
World petroleum resources, Petroleum industry in India, Origin of petroleum, Brief of its Exploration, Integration of Refinery with Petrochemicals.

Refinery Feed Stocks (4 hrs)
Crude oil Classification, Composition and Properties Petroleum Crude, Evaluation of Crude Oils: ASTM, TBP and EFV Distillation.

Petroleum Products Specifications (4 hrs)
Product specifications for LPG, Gasoline, Diesel fuels, Jet and turbine fuels, Lube oils, Heating oils, Residual fuel oils, Wax and Asphalt, Petroleum coke.

Crude Processing (4 hrs)
Desalters, Atmospheric and Vacuum Distillation Units, Pipe-Still Heaters, desulphurization

Finishing & Treatment processes
Different Hydrotreatment (eg. Hydro desulfurization) processes, Merox process, Doctor's sweetening, Smoke point improvement, etc. Octane Improver – TEL, MTBE, Viscosity Index Improver, Pour Point Depressor, Anti-Oxidants and others

Petrochemical Feed stocks and Targeted Products (4 hrs)
Raw Material for Petrochemical Industries, Intermediates feed stock, Desulphurization of Petrochemical Feedstock.

Conversion Processes for petrochemical feedstocks and refinery products (12 hrs)
Thermal & Catalytic Cracking Processes
Visbreaking, Fluid Catalytic cracking and Hydrocracking - Feed stocks — Catalysts - Process variables –Product Recoveries.
Cracking: Naphtha and Gas cracking for Production of Olefins.
Other Conversion Processes
Reforming, Alkylation, Polymerization and Isomerisation. Steam Reforming and Partial Oxidation: Synthesis Gas.

Manufacture of important petrochemicals (4 hrs)
Manufacture of LDPE, HDPE, PVC, PET etc.

Environmental Concerns (2 hrs)
Pollution Considerations in Refineries, Bio-refinery: A Sustainable Solution, Environmental Pollution Control in Petrochemical Industries.

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, 6th Edition, Oxford & IBH Publishing Co., 2018.
5. Rao B.K. B, A text on Petro Chemicals, 5th edition, Khanna Publisher, 2004
6.. Steiner H, Industries to Petroleum Chemicals, Pergammon Press,1992.
7 Waddone, A.C., Chemicals from Petroleum, John Murry, 1988.
8. Top Chev, A.V. Synthetic Materials from Petroleum, Pergammon Press, 1982.
9. Astle M.J., Synthetic Materials from Petroleum, Pergammon Press.

COURSE OUTCOMES

The students will be able to:

1. Demonstrate knowledge of various petroleum resources, Classify various crudes, Its composition.
2. Exhibit the knowledge of exploration and evaluation of crude & identify desirable properties of Petroleum fractions, the various pretreatment and refining processes like distillation etc.
3. Demonstrate knowledge of various conversion processes like Cracking, Reforming, Alkylation, Polymerization and Isomerization.
4. Demonstrate knowledge of various Petrochemical Feedstock, apply the knowledge of processing techniques for obtaining petrochemicals and manufacture of typical Petrochemicals and their commercial uses.
5. Analyze the effect of petroleum refining industries and petrochemical industries on Environment and its control strategies.

BTCH-712C Fuel Cell Technology

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

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

Introduction **(6 hrs)**
Fuel Cell definition and basics- cathode, anode, electrolyte, Difference between a fuel cell and a battery, Advantages and disadvantages, Basic fuel cell operation

Fuel Cell Fundamentals **(12hrs)**
Relationship between Gibb's free energy and electric work/ electric voltage, Reversible Voltage/ potential of fuel cell using standard electrode potentials, Effect of temperature and pressure on fuel cell potential, Nernst equation, Fuel cell efficiency, concept of OCV
Current density, Losses in fuel cell- activation loss, ohmic loss and concentration loss, Fuel cell performance curve
1-D model for a fuel cell, application of model to SOFC and PEMFC

Types of Fuel Cells **(12hrs)**
Construction, fuels and usage of Phosphoric Acid Fuel Cell, Polymer Electrolyte Membrane Fuel Cell, Alkaline fuel cell, Molten Carbonate Fuel Cell, Solid Oxide Fuel cell
Relative advantages and disadvantages of the various types of fuel cells

Fuel Cell Systems **(6 hrs)**
Fuel cell stack, engineering issues related to Fuel Cell Technology

Hydrogen as a fuel, availability and engineering issues

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students will be able to:

1. Analyze the different components of a fuel cell and its characteristics.
2. Apply fundamentals of electrochemistry, thermodynamics, fluid mechanics, and heat and mass transfer to design different components of fuel cells and fuel cell systems.
3. Understand and identify different types of Fuel Cells and their distinctive feature of each one
4. Comprehend the functioning of a typical fuel cell stack.

BTHU- *** HASS-II

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

Any one subject from the proposed list of Humanities, Social Science including Management Courses*.**

BTCH-704C Chemical Engineering Lab – VI
(Process Modeling & Simulation Lab)

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

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 ofthe semester.

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-703 C Chemical Engineering Lab – VII
(Process Instrumentation, Dynamics & Control Lab)

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/ pressure in a tank/ temperature using multi process trainer for different controller settings.
9. Study of control valve characteristics.
10. To control a system through cascade control.
11. To study ratio control, feed-forward control systems.
12. Study of Programmable Logic Control system.

COURSE OUTCOMES

The students will 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-704C Chemical Process Plant Design

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

1. Types of Flow Sheets
2. Overview of plant layout
3. Design of Sieve Tray Column and column internals
4. Design of Bubble Cap Column and column internals
5. Design of Packed Column and column internals
6. Specification sheet for tray type and packed columns.
7. Process Design of Shell and Tube Heat Exchanger
8. Process Design of Condensers
9. Introduction to plate heat exchangers and its design
10. Specification sheet for Heat exchangers
11. Selection, Preparation of specification sheet for a centrifugal pump

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

BOOKS RECOMMENDED:

1. Coulson, Richardson & Sinnott R.K., Chemical Engineering Volume-6 – an Introduction to Chemical Engineering Design, 4th Ed., Elsevier 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

Students would be able to:

1. Demonstrate the knowledge of standards, types and process design of equipments' like distillation columns, absorption columns, heat exchangers.
2. Perform process design of tray type and packed separation columns, heat exchangers.
3. Prepare the specification sheets for separation column and heat exchangers.
4. Demonstrate the knowledge of plant layout and flow sheets.
5. Present the work/results in form of written reports.

BTCH-705C Project

External Marks: 40 **L T P**
Internal Marks: 60 **0 0 8**
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.

BTHU-701C HASS-II

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

Any one subject from the proposed list of Humanities, Social Science including Management Courses*.**

8th Semester (a)
BTCH-802C Heat Exchanger Networks

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

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

Pinch Technology: **(12 hrs)**
Introduction, Basic concept, difference than energy auditing, Role of thermodynamic laws, Problem addressed by Pinch technology.
Key Steps of Pinch Technology: Data extraction, Targeting, Designing, Optimization- Super targeting.
Basic Elements of Pinch Technology: Grid diagram, Composite curve, Problem table algorithm, Grand composite curve.

Heat Exchanger Network (HEN): **(12 hrs)**
Targeting of Energy, Area targeting, Number of units targeting, Shell targeting, cost targeting.
Designing of HEN: Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches, Design for threshold problem, Loops and Paths.
Heat Integration of Equipments

BOOKS RECOMMENDED:

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

COURSE OUTCOMES:
The student would be able to
1. Understand the pinch concept and process thermodynamics
2. Identify minimum energy targets
3. Identify different choices and constraint during heat exchange networking
4. Apply strategies for retrofitting existing process plant, integration of energy demands of multiple processes

BTCH-811C Nano- Technology

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

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

Introduction: **(4 hrs)**
Terminologies, History & Scope

Characterization & Fabrication: **(12hrs)**
Contemporary Characterization Methods, top down & Bottom up Fabrication, Solution based Synthesis of Nanoparticles, Vapour Phase Synthesis & Synthesis with framework, Nanolithography, Dip Pen Lithography. Artificially Layered Materials: Quantum Well, Quantum Dots, Super lattices & Layered Structures.

Self-Assembly: **(8 hrs)**
Supramolecular & dimension Control in Nanostructure, thermodynamics and coded self-assembly.

Biomaterials: **(12hrs)**
DNA & Nanomaterials, Bio-nanocomposites, Biometrics, molecular motor.
Nano-electronics and Molecular Computing: Molecular wires, Nanowires, Nanotubes, Molecular switch, Molecular logic gates and molecular storage devices, DNA Computing Quantum Computing.

BOOKS RECOMMENDED:

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

COURSE OUTCOMES:
The student would be able to
1. To understand different techniques for synthesis of nanomaterials.
2. To provide scientific understanding of application of nanomaterials and nanotechnology in health and environmental conservation.
3. Familiarity with working principles, tools and techniques in the field of nanomaterials.
4. Understanding of the strengths, limitations and potential uses of nanomaterials.

BTCH-812C Fluidization Engineering

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

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

Introduction and applications **(6 hrs)**
Introduction to fluidised bed systems, Fundamentals of fluidisation, Industrial applications of fluidised beds - Physical operations. Synthesis reactions, cracking and reforming of hydrocarbons, Gasification, Carbonisation, Gas-solid reactions, calcining and clinkering.

Behaviour of Fluidised beds **(12hrs)**
Gross behaviour of fluidised beds, Minimum and terminal velocities in fluidised beds, Types of fluidisation.
Design of distributors, Voidage in fluidised beds, TDH, variation in size distribution with height, viscosity and fluidity of fluidised beds, Power consumption.
Analysis of bubble and emulsion Phase: Davidson's model, Frequency measurements, bubbles in ordinary bubbling bed model for bubble phase.
Emulsion phase: Experimental findings, Turnover rate of solids. Bubbling bed model for emulsion phase Interchange coefficients.

Flow pattern of Gas and heat & mass transfer in Fluidised beds **(12hrs)** Flow pattern of gas through fluidised beds, Experimental findings, the bubbling bed model for gas interchange, Interpretation of Gas mixing data
Heat and Mass Transfer between fluid and solid: Experiment findings on Heat and Mass Transfer, Heat and mass transfer rates from bubbling bed model.
Heat transfer between Fluidised beds and surface- Experiment finding theories of bed heat transfer, comparison of theories.

Entrainment & Elutriation **(6 hrs)**
Entrainment of or above TDH, model for Entrainment and application of the entrainment model to elutriation. High velocity fluidized beds, Circulating fluidized beds, Design of fluidized bed reactors.

BOOKS RECOMMENDED:
1. Kunii D. & Levenspiel O., Fluidization Engineering, *2*nd Ed., Butterworth Heinemann, 1991
2. D. Gidaspow, Multiphase flow and fluidization: continuum and kinetic theory description, Elsevier Science & Technology Books, 1993
3. L.G. Gibilaro, Fluidization-dynamics, Butterworth-Heinemann, 2001
4. S. K. Majumder, Hydrodynamics and Transport Processes of Inverse Bubbly Flow, 1st ed. Elsevier, Amsterdam (2016)

COURSE OUTCOMES:

The student would be able to

1. Explain the fundamentals and industrial applications of fluidized beds.
2. Assess parameters like velocities, voidage, and power consumption using models and data.
3. Apply bubble and emulsion phase models to describe gas-solid dynamics in fluidized beds.
4. Analyze heat and mass transfer between phases in fluidized beds based on experimental findings.
5. Design and optimize fluidized bed reactors, considering factors like entrainment and high-velocity fluidization.

BTCH-813C Advanced Separation Processes

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 separation techniques used in industry. It includes the study of details of techniques like membrane separations, adsorption, chromatography.

Separation Processes **(6 hrs)**
Industrial chemical processes, Mechanism of separation, separation power, selection of feasible separation processes.

Membrane Separations **(12hrs)**
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 Electro-dialysis, Reverse Osmosis, Gas Permeation, Pervaporation, Ultrafiltration, Microfiltration.

Adsorption, Ion Exchange, and Chromatography **(18hrs)**
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

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:

The student would be able to

1. Explain the fundamentals of industrial separation processes, including mechanisms of separation, separation power, and criteria for selecting feasible separation techniques.
2. Describe membrane materials, membrane modules, and transport phenomena in porous and nonporous membranes for liquid and gas separations.
3. Analyze membrane-based separation processes such as dialysis, electrodialysis, reverse osmosis, gas permeation, pervaporation, ultrafiltration, and microfiltration.
4. Understand equilibrium, kinetic, and mass-transfer principles governing adsorption, ion exchange, and chromatographic separation processes.
5. Apply concepts of sorption systems to analyze and design batch and continuous adsorption, ion-exchange cycles, pressure- and thermal-swing adsorption, and chromatographic separation systems.

BTCH-814C Bio-Chemical Engineering

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

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

Biochemistry: **(8 hrs)**
Structure and function of carbohydrates, lipids, amino acids and peptides, nucleic acid and nucleotides, proteins, enzymes.

Classification of microorganisms: **(8 hrs)**
Morphological, structural and biochemical characteristics of prokaryotes and eukaryotes. Microbial nutrients and growth media. Microbial reproduction and growth.

Kinetics of microbial growth **(4 hrs)**
Enzyme kinetics including enzyme inhibition.

Nutrient transport across cell membrane **(2 hrs)**

Sterilization of air and media

Mass transfer and microbial respiration: **(6 hrs)**
Mass transfer resistance, physical and enzymatic considerations, critical value of dissolved oxygen concentration, respiration of mycelial pellet

Bubble aeration and mechanical agitation **(6 hrs)**
Single bubbles, series of bubbles, power number versus Reynolds number, decrease of power requirement in aeration.

Fermenter design **(2 hrs)**
Cardinal rules for design of fermenter, materials of construction

BOOKS RECOMMENDED:

1. Pelzer M.J., Chan E.C.S. and Kerig N.R., Microbiology, 3rd edition, McGraw Hill Book Co., 1993
2. Stryer L, Freeman W.H., Biochemistry, 5th edition, W.H.Freeman and co, 2002
3. Bailey J.E. & Ollis, D.F., Biochemical Engineering Fundamentals, 2nd edition, McGraw Hill, 1986.
4. Shuler M.L., Kargi F., Bioprocess Engineering: Basic Concepts, 2nd Ed., Prentice Hall, 2000
5. Shuichi Aiba, Biochemical Engineering, 2nd edition, Academic Press Inc. New York, 1973

COURSE OUTCOMES:

The student would be able to

1. Explain the structure and biological functions of carbohydrates, lipids, proteins, enzymes, nucleic acids, and other essential biomolecules.
2. Classify microorganisms based on morphological, structural, and biochemical characteristics, and describe microbial nutrition, growth media, and reproduction.
3. Analyze microbial growth kinetics, enzyme kinetics, and enzyme inhibition mechanisms relevant to biochemical processes.
4. Understand nutrient transport across cell membranes, sterilization of air and media, and mass transfer aspects in microbial respiration systems.
5. Apply principles of aeration, agitation, and fermenter design, including power requirements and materials of construction, for efficient bioprocess operations.

BTCH-815C Green Energy & Technologies

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

Objectives: To demonstrate the importance of solar energy collection and storage, the principles of wind energy and biomass energy, geothermal and ocean energy, energy efficient systems and the concepts of green manufacturing systems.

Solar energy: **(8 hrs)**
Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems and coordinates of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems. Photo voltaic energy conversion – types of PV cells. Flat plate and concentrating collectors, classification of concentrating collectors, orientation. Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

Wind energy: **(4 hrs)**
Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

Bio-mass: **(3 hrs)**
Principles of bio-conversion, anaerobic/aerobic digestion, types of bio-gas digesters, gas yield, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.

Geothermal energy: **(2 hrs)**
Resources, types of wells, methods of harnessing the energy.

Ocean energy: **(3 hrs)**
OTEC, Principles of utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques.

Energy efficient systems: **(8 hrs)**
(A) Electrical systems: Energy efficient motors, energy efficient lighting and control, selection of luminaire, variable voltage variable frequency drives (adjustable speed drives), controls for HVAC (heating, ventilation and air conditioning), demand site management.
(B) Mechanical systems: Fuel cells- principle, thermodynamic aspects, selection of fuels & working of various types of fuel cells, Environmental friendly and Energy efficient compressors and pumps**.**

Green manufacturing systems: **(8 hrs)**
Environmental impact of the current manufacturing practices and systems, benefits of green manufacturing systems, selection of recyclable and environment friendly materials in manufacturing, design and implementation of efficient and sustainable green production systems with examples like environmental friendly machining, vegetable based cutting fluids, alternate casting and joining techniques, zero waste manufacturing.

BOOKS RECOMMENDED:

1. Solar Energy – Principles of Thermal Collection and Storage/Sukhatme S.P. and J.K. Nayak/TMH.
2. Non-Conventional Energy Resources- Khan B.H/ Tata McGraw Hill, New Delhi, 2006.
3. Green Manufacturing Processes and Systems - J. Paulo Davim/Springer 2013.
4. Alternative Building Materials and Technologies - K.S Jagadeesh, B.V Venkata Rama Reddy and K.S Nanjunda Rao/New Age International.
5. Principles of Solar Engineering - D.Yogi Goswami, Frank Krieth & John F Kreider /Taylor & Francis.
6. Non-Conventional Energy - Ashok V Desai /New Age International (P) Ltd.
7. Renewable Energy Technologies -Ramesh & Kumar /Narosa.
8. Non-conventional Energy Source- G.D Roy/Standard Publishers.
9. Renewable Energy Resources-2nd Edition/ J.Twidell and T. Weir/ BSP Books Pvt.Ltd.
10. Fuel Cell Technology -Hand Book / Gregor Hoogers / BSP Books Pvt. Ltd.

COURSE OUTCOMES:

The student would be able to

1. Explain the importance of solar energy collection and storage.
2. Apply the principles of wind energy and biomass energy.
3. Analyze knowledge on geothermal and ocean energy.
4. Learn about energy efficient systems.
5. Discuss the concepts of green manufacturing systems.

BTCH-816C Bio-Energy Engineering

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

Objectives: To learn different technologies for production of energy from different biomass waste materials in an efficient and eco-friendly manner. To generate awareness in the society for the environmental and social problems

Energy concepts: **(8hrs)**
Fundamental concepts in understanding biofuel/bioenergy production, Renewable feedstock and their production, Feedstock availability, characterization and attributes for biofuel/bioenergy production.

Biomass feedstocks and processing : **(8hrs)** Biomass Conversion Technologies – Biorefinery Concept , Hydrolysis, enzyme & acid hydrolysis - Fermentation,Anaerobic digestion – Trans-esterification, Various biofuels/bioenergy from biomass

Biogas production: **(6hrs)**
Biomass processing for gaseous fuel production, effect of parameters, Microbial and biochemical aspects for biogas production, Kinetics and mechanism of the process.

Biodiesel : **(6hrs)**
Biodiesel production from oil seeds, waste oils and algae, Environmental impacts of biofuel production Value-added processing of biofuel residues and co-products, Emissions of biomass

Waste to energy: **(8hrs)**
Waste composition and Classification: Organic municipal waste, clinical waste, sewage sludge, agricultural waste, Waste& biomass materials handling. Energy processing from waste/biomass, Bio-energy policies & legislation at national and international level.

BOOKS RECOMMENDED

1. Jianzhong Sun, Shi-You Ding, Joy D. Peterson, Laurie Peter, Heinz Frei, Ferdi Schuth, Tim S. Zhao, Tao Ling. Biological Conversion of Biomass for Fuels and Chemicals: Explorations from Natural Utilization Systems. Royal Society of Chemistry; 1 edition (2013).
2. Jens Holm-Nielsen, Ehiaze Augustine Ehimen Biomass Supply Chains for Bioenergy and Biorefining.. Woodhead Publishing (2016).

COURSE OUTCOMES:

The students will be able to

1. Understand the fundamental concepts of bio-energy
2. Relate the principles underlying the design and operation of biomass to energy
3. Identify the bioconversion techniques and limitations in Biomass processing
4. Compare Biomass conversion processes
5. Analyze research issues in biodiesel production
6. Measure the Environmental impacts of biofuels and legislation

8th Semester (b)
BTCH-801C Industry/Institutional Internship Training

External Marks: 200	**L T P**
Internal Marks: 300	**0 0 0**
Total Marks: 500	

Each student is required to undergo Industrial/Institutional internship Training in a Chemical Engineering based industry/institute for a minimum period of 18 weeks. Students are required to work on Chemical Engineering based projects during the course of their training.
The objective of the Industry/institutional internship training to test the ability of the student to work in the industrial environment by application of the Chemical Engineering principles learnt during the course of their study.

The students are required to present their projects undertaken during their industrial/institutional training in form of presentation and also appear in a Viva-Voce Examination to defend their work.

COURSE OUTCOMES:
Students will be able to
1) Apply theoretical principles and practical aspects of chemical engineering to industrial problems
2) Evaluate performances of an industrial unit and analyse troubleshooting problems.
3) Apply technical knowledge, management, leadership and entrepreneurship skills as a Chemical engineer.
4) Demonstrate their drive to serve community
5) Organize and demonstrate the results obtained during the projects undertaken during their training.
6) Deliver well organized technical presentations.
7) Present the findings in written format.