B. TECH. (CHEMICAL ENGG.)

Total Contact Hours = 25 Total Marks = 900 Total Credits = 24

SEMESTER 3rd		Contact Hrs			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BCHE1-301	Chemical Process Calculations	3	1	-	40	60	100	**4**
BCHE1-302	Fluid Flow	3	1	-	40	60	100	**4**
BCHE1-303	Mathematical Methods in Chemical Engg.	3	1	-	40	60	100	**4**
BCHE1-304	Mechanical Operations	3	1	-	40	60	100	**4**
BSOS0-F91	Soft Skills - I	-	-	2	40	60	100	**1**
BCHE1-305	Training-I	-	-	-	60	40	100	**2**
BCHE1-306	Fluid and Particle Mechanics Lab.	-	-	2	60	40	100	**1**
BCHE1-307	Numerical Methods in Chemical Engg. Lab.	-	-	2	60	40	100	**1**
Departmental Elective –I (Select any one)		3	-	-	40	60	100	**3**
BCHE1-356	Nanotechnology							
BCHE1-357	Corrosion Engineering							
BCHE1-358	Energy Engineering							
Total	**Theory = 6 Lab = 2**	**15**	**4**	**6**	**420**	**480**	**900**	**24**

**** Training-I (During summer vacation after 2nd semester)***

Total Contact Hours = 25 Total Marks = 800 Total Credits = 22

SEMESTER 4th		Contact Hrs			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BCHE1-408	Strength of Materials	3	1	-	40	60	100	**4**
BCHE1-409	Chemical Process Industries	3	1	-	40	60	100	**4**
BCHE1-410	Chemical Engineering Thermodynamics	3	1	-	40	60	100	**4**
BCHE1-411	Heat Transfer	3	1	-	40	60	100	**4**
BSOS0-F92	Soft Skills - II	-	-	2	60	40	100	**1**
BCHE1-412	Heat Transfer Lab.	-	-	2	60	40	100	**1**
BCHE1-413	Chemical Tech. Lab.	-	-	2	60	40	100	**1**
Departmental Elective –II (Select any one)		3	-	-	40	60	100	**3**
BCHE1-459	Plant Utilities							
BCHE1-460	Renewable Energy Resources							
BCHE1-461	Enzyme Technology							
Total	**Theory = 6 Lab = 2**	**15**	**4**	**6**	**380**	**420**	**800**	**22**

Total Contact Hours = 24 Total Marks = 800 Total Credits = 23

SEMESTER 5th		Contact Hrs			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BCHE1-514	Industrial Pollution Control	3	1	-	40	60	100	**4**
BCHE1-515	Chemical Reaction Engg. –I	3	1	-	40	60	100	**4**
BCHE1-516	Mass Transfer-I	3	1	-	40	60	100	**4**
BSOS0-F93	Soft Skills – III	-	-	2	60	40	100	**1**
BCHE1-517	Training – II	-	-	-	-	-	-	**2**
BCHE1-518	Chemical Reaction Engg. & Environmental Engg. Lab	-	-	2	60	40	100	**1**
BCHE1-519	Chemical Process Plant Design-I Lab.	-	-	2	60	40	100	**1**
Departmental Elective –III (Select any one)		3	-	-	40	60	100	**3**
BCHE1-562	Fluidization Tech.							
BCHE1-563	Project Management							
BCHE1-564	Polymer Science &Engineering							
Open Elective – I (Select any one)		3	-	-	40	60	100	**3**
Total	**Theory = 6 Lab = 2**	**15**	**3**	**6**	**380**	**420**	**800**	**23**

Total Contact Hours = 25 Total Marks = 800 Total Credits = 22

SEMESTER 6th		Contact Hrs			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BCHE1-620	Mass Transfer-II	3	1	-	40	60	100	**4**
BCHE1-621	Chemical Reaction Engg. –II	3	1	-	40	60	100	**4**
BSOS0-F94	Professional Skills – IV	-	-	2	60	40	100	**1**
BCHE1-622	Mass Transfer Lab.	-	-	2	60	40	100	**1**
BCHE1-623	Process Equipment Design Lab.	-	-	2	60	40	100	**1**
Departmental Elective –IV (Select any one)		3	1	-	40	60	100	**4**
BCHE1-665	Engineering Materials							
BCHE1-666	Petroleum Refining Engg							
BCHE1-667	Optimization Techniques							
Departmental Elective – V (Select any one)		3	1	-	40	60	100	**4**
BCHE1-668	Polymer Reactor Design							
BCHE1-669	Heat Exchangers							
BCHE1-670	Transport Phenomena							
Open Elective – II (Select any one)		3	-	-	40	60	100	**3**
Total	**Theory = 6 Lab = 2**	**15**	**4**	**6**	**380**	**420**	**800**	**22**

Total Contact Hours = 26 Total Marks = 700 Total Credits = 24

SEMESTER 7th		Contact Hrs			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BCHE1-724	Process Instrumentation, Dynamics & Control	3	1	-	40	60	100	**4**
BCHE1-725	Process Engineering & Economics	3	1	-	40	60	100	**4**
BCHE1-726	Project – I	-	-	8	60	40	100	**4**
BCHE1-727	Training – III	-	-	-	-	-	-	**4**
BCHE1-728	Chemical Process Plant Design-II Lab.	-	-	2	60	40	100	**1**
BCHE1-729	Process Instrumentation, Dynamics and Control Lab.	-	-	2	60	40	100	**1**
Departmental Elective –VI (Select any one)		3	-	-	40	60	100	**3**
BCHE1-771	Separation Processes							
BCHE1-772	Petrochemical Technology							
BCHE1-773	Biochemical Engg.							
Open Elective – II (Select any one)		3	-	-	40	60	100	**3**
Total	**Theory = 6 Lab = 2**	**12**	**2**	**12**	**240**	**360**	**700**	**24**

Total Contact Hours = 26 Total Marks = 400 Total Credits = 15

SEMESTER 8th		Contact Hrs			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BCHE1-830	Process Modelling & Simulation	3	1	-	40	60	100	**4**
BCHE1-831	Project – II	-	-	12	60	40	100	**6**
BCHE1-832	Process Simulation Lab.	-	-	2	60	40	100	**1**
Departmental Elective –VI (Select any one)		3	1	-	40	60	100	**4**
BCHE1-874	Chemical Process Safety							
BCHE1-875	Fuel Cell Technology							
BCHE1-876	Environmental Impact Assessment							
Total	**Theory = 2 Lab = 1**	**6**	**2**	**14**	**200**	**200**	**400**	**15**

Total Credits = 25 + 25 + 24 + 22 + 23 + 22 + 24 + 15 = 180

CHEMICAL PROCESS CALCULATIONS

Subject Code: BCHE1-301 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

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

UNIT-I (10 Hrs.)

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

UNIT-II (13 Hrs.)

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

With Chemical Reaction- Combustion, gas-synthesis, acid-alkali production recycle, purge, bypass in batch, stagewise and continuous operations in systems with or without chemical reaction.

UNIT-III (12 Hrs.)

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

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

UNIT-IV (10 Hrs.)

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

Recommended Books

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

FLUID FLOW

Subject Code: BCHE1-302 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

Learning Objectives: 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.

UNIT-I (15 Hrs.)

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

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

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

UNIT-II (10 Hrs.)

Basic Equations of Fluid Flow: Momentum Balance, Continuity equation, Bernoulli's Equations - Derivation and Application, Navier Stokes Equations. Dimensional Analysis of Fluid Flow Problems using Rayleigh method and Buckingham π method, Dimensionless numbers and their significance.

UNIT-III (10 Hrs.)

Flow of Incompressible Fluids: 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: Compressible flow, basic equation, Mach number and its significance and isentropic flow through nozzles.

UNIT-IV (10 Hrs.)

Flow Measurement: *In closed channels* - Pitot tube, Orifice meter, venturimeter, Rotameter, Hot wire Anemometers, Vortex meters**.** *In open channels*- Notches, Weirs, plumes.

Fluid Machinery: 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.

RECOMMENDED BOOKS

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

MATHEMATICAL METHODS OF CHEMICAL ENGG.

Subject Code: BCHE1-303 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

Learning Objectives: 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.

UNIT-I (12 Hrs.)

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

Nonlinear Algebraic Equation: Single variable successive substitutions (Fixed Point Method), Multivariable successive substitutions, single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique.

UNIT-II (11 Hrs.)

Eigen values and Eigen vectors of Matrices: Fadeev Leverrier's Method, Power Method.

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

UNIT-III (10 Hrs.)

Ordinary Differential Equations (ODE-IVPs) and partial differential Equations: The Finite Difference Technique, Runge-Kutta method.

UNIT-IV (12 Hrs.)

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

Recommended Books

1. S.K. Gupta, 'Numerical Methods for Engineers', 2nd Edn., New Age International Publishers, **2009.**
2. B.S. Grewal, 'Higher Engineering Mathematics',43rd Edn., Khanna Publishers, **2014**.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, 'Numerical Methods for Scientific and Engineering Computation', New Age International.
4. R.G. Rice and Do Duong D., 'Applied Mathematics and Modelling for Chemical Engineers', John Wiley & Sons, Inc., **1995.**
5. S.S. Sastry, 'Introductory Methods of Numerical Analysis', 4th Edn., Prentice Hall of India.
6. E. Kreyszig, 'Advanced Engineering Mathematics', 8th Edn., John Wiley, New Delhi.

MECHANICAL OPERATIONS

Subject Code: BCHE1-304 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

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

UNIT-I (11 Hrs.)

Characterization and Handling of Solids: Characterization of solid particles: Shape, size, specific surface, Particle size distribution**,** Properties of particulate masses: Major distinctive properties, pressures in masses of particles, angle of internal friction, angle of repose.
Storage and Conveying of Bulk Solids: Basic idea of conveyor, conveyor selection, screw, belt, vibrating, continuous flow and pneumatic conveyors, bulk storage, bin storage, feeders.
Screening: Capacity and Effectiveness of a screen, calculation of average size of particles in mixture by screen analysis, types of screens.

UNIT-II (10 Hrs.)

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

UNIT-III (12 Hrs.)

Size Reduction: Principles of Comminution: Criteria for comminution, characteristics of products, Energy and Power requirements, Bond's, Rittinger's and Kick's Law and Work Index. Size Reduction Equipment: Crushers, Grinders, and ultrafine grinders cutting machines, equipment operation.
Filtration: Classification of filters, various types of cake filters, principles of cake filtration, clarifying filters: liquid clarification, Gas cleaning, principles of clarification, Filtration Equipment and centrifuges and their selection, Cross flow Filtration, micro filtration.

UNIT-IV (12 Hrs.)

Settling: Motion of particles through fluids: Terminal velocity, hindered settling, Stoke's law,
Gravity settling processes: Classifiers, clarifiers, thickeners, flocculation, rate of sedimentation, Centrifugal Settling processes: Cyclones, hydroclones, decanters, tubular, disk and nozzle discharge centrifugal sludge separators, Centrifugal class fitters, principles of centrifugal sedimentation.
Fluidization: Fluidization and fluidized bed, conditions for fluidization, Ergun equation and Kozeny-Carman equation, minimum fluidization velocity, types of fluidization, expansion of fluidized beds and particulate fluidization, continuous fluidization; industrial applications.

Recommended Books

1. McCabe, L. Warren, Julian C. Smith and P. Harriot, 'Unit Operations of Chemical Engg.', 7th Edn., McGraw Hill, **2005.**
2. J.H. Harker, J.F. Richardson, J.R. Backhurst, 'Chemical Engg.' Vol.-2, 5th Edn., Butterworth-Heinemann, **2003.**

3. A.S. Foust, L.A. Wenzel, C.W. Clump, 'Principles of Unit Operations', 2nd Edn., John Wiley & Sons, **2008.**
4. W.L. Badger and J.T. Banchero, 'Introduction to Chemical Engg', McGraw Hill.
5. R.H. Perry, D.W. Green, 'Chemical Engineers Handbook', 8th Edn, McGraw Hill, **2008.**

FLUID AND PARTICLE MECHANICS LAB.

Subject Code: BCHE1-306 **L T P C**
0 0 2 1

1. Characteristic curves of a centrifugal pump.
2. Verification of Bernoulli's equation for flow process.
3. Measurement of flow by a venturimeter/orifice meter
4. Measurement of flow by a V-notch in an open channel.
5. Measurement of losses in various fitting, valves and variation in cross section/ shapes.
6. Verification of Stokes Law.
7. Screen analysis of given sample for its particle size distribution.
8. Determination of variation in pressure drop & bed height w.r.t superficial velocity and minimum fluidization velocity for a bed of solids.
9. Operating characteristics of crushing and grinding equipment (Jaw crusher and Ball mill).
10. Evaluation of the filtration constants for $CaCO_3$ slurry in water and cake compressibility.
11. Determination of %age recovery of coal in froth from coal and sand mixture.
12. Determination of thickener capacity using batch sedimentation.
13. Determination of the separation efficiency of the classifier.

NUMERICAL METHODS IN CHEMICAL ENGINERING LABORATORY

Subject Code: BCHE1-307 **L T P C**
0 0 2 1

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

NANO-TECHNOLOGY

Subject Code: BCHE1-356 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

Introduction: Terminologies, History & Scope

Characterization: Contemporary Characterization Methods, top down & Bottom up Fabrication, Solution based Synthesis of Nanoparticles, Vapour Phase Synthesis & Synthesis with framework

UNIT-II

Fabrication: Nanolithography, Dip Pen Lithography. Artificially Layered Materials: Quantum Well, Quantum Dots, Super lattices & Layered Structures.

Self-Assembly: Supramolecular & dimension Control in Nanostructure, thermodynamics and coded self-assembly.

UNIT-III

Biomaterials: DNA & Nanomaterials, Bioanocomposites, Biometrics, molecular motor.

UNIT-IV

Nanoelectronics and Molecular Computing: Molecular wires, Nanowires, Nanotubes, Molecular switch, Molecular logic gates and molecular storage devices, DNA Computing Quantum Computing.

Recommended Books

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

CORROSION ENGINEERING

Subject Code: BCHE1-357 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

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

UNIT-II

Techniques for Corrosion Resistance: Higher corrosion resistance through proper selection of material, isolation of corrosion prone materials form destructive environment,

UNIT-III

Technologies of anodization, enamelling, rubber lining, glass lining, refractory lining, painting and other surface protective measures.

UNIT-IV

Corrosion engineering in special applications: Material transport, pumping, filtration, condensation, boiling, riveting, welding, high temperature environments etc. Cost factor in competitive corrosion prevention/inhibition techniques.

Recommended Books

1. H.H. Uhling, 'Corrosion Control', John Wiley & Sons, **1971.**
2. G. Butler & H.C.K. Ison, 'Corrosion 7 its prevention in Waters', Leonard Hill - London, **1966.**
3. P. Maslow, 'Chemical Materials for Construction', Structures Publishing Co., **1974.**
4. H.F. Payne, 'Organic Coatings Technology', John Wiley & Sons.
5. M.G. Fontance & N.D. Gtretrnee, 'Corrosion Engineering', McGraw Hill, **1967.**

ENERGY ENGINEERING

Subject Code: BCHE1-358 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

Learning Objectives: 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.

Unit – I

Introduction:
Energy crisis in the world and position in India
Conventional Sources of Energy:
Solid Fuels:
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.

Unit – II

Liquid Fuels:
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.

Unit – III

Gaseous Fuels:
Producer, water carburettor, water, coal, blast furnace and refinery gases, gases from biomass, LPG, CNG.
Combustion Process and Appliances:
Nature and types of combustion processes, mechanism of combustion reaction, spontaneous ignition temperature, gas and oil burners, coal burning equipment, fluidized bed combustion.

Unit – IV

Non- Conventional Sources of Energy:
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.
Recommended Books

1. Sarkar Samir, 'Fuels and Combustion', 2nd Edn., Orient Longman, **2003**.
2. O.P. Gupta, 'Elements of Fuels, Furnaces and Refractories', Khanna Publications, **1997.**
3. P.J. Wilson, G.H. Wells, 'Coal, Coke and Coal Chemicals', McGraw Hill, **1950.**
4. J. Griswold, 'Fuels, Combustion and Furnaces', McGraw Hill, **2006.**

STRENGTH OF MATERIALS

Subject Code: BCHE1-408 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

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

UNIT-I (10 Hrs.)

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

UNIT-II (12 Hrs.)

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

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

UNIT-III (11 Hrs.)

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

Torsion of shafts and springs: 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.

UNIT-IV (12 Hrs.)

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

Recommended Books

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

CHEMICAL PROCESS INDUSTRIES

Subject Code: BCHE1-409 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

Learning Objectives: 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.

UNIT-I (11 Hrs.)

Oils and Fats: 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: History and growth, raw material, manufacturing of detergents, biodegradability, Fat-splitting, purification of fatty acids, soap manufacture, glycerine manufacture, materials of construction.

UNIT-II (12 Hrs.)

Sugar: Manufacturing equipment and technology, cane sugar refining, bagasse utilization, energy requirements and conservation, environmental considerations.

Pulp and Paper: Growth of industry, raw materials, pre-treatment, pulping, manufacture of paper, recovery of chemicals.

Acids: Manufacture and uses of Phosphoric acid, hydrochloric acid, nitric acid, sulphuric acid, major engineering problems.

UNIT-III (11 Hrs.)

Fertilizers: 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: Manufacturing processes- Solvay and modified Solvay process, environmental considerations, corrosion problems and material of construction.

UNIT – IV (11 Hrs.)

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

Glass and Cement: Types and properties of cement, Method of production of Portland Cement, major engineering problems.

Types and properties of glass, Manufacturing process of glass, Applications, major engineering problems.

Recommended Books

1. M.G. Rao, M. Sittig, 'Dryden's Outlines of Chemical Technology for 21st Century', 3rd Edn., Affiliated East West Press Pvt. Ltd., **2008.**
2. G.N. Pandey, 'Chemical Technology', Vol.-I & II, Vikas Publication, **2010.**
3. J.A. Moulijn, M. Makkee, A. Diepen, 'Chemical Process Technology', John Wiley, **2001.**

HEAT TRANSFER

Subject Code: BCHE1-410 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

Learning Objectives: The objective of the course is to introduce to students about 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.

UNIT-I (12 Hrs.)

Modes of Heat Transfer: ***Conduction*** - Fourier's law, one dimensional heat conduction through plane and composite structures having plane wall, spherical & cylindrical geometry. Steady state heat flow with heat source through plane wall and cylindrical surface. Thermal conductivity of materials. Insulating materials and critical thickness of insulation, Unsteady-state conduction; Lumped heat capacity system, semi-infinite solid and Heisler chart.

UNIT-II (12 Hrs.)

Convection: 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: 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.

UNIT-III (11 Hrs.)

Condensation and Boiling Heat Transfer: Dropwise and Filmwise condensation of pure and mixed vapours, Convective, Nucleate & Film boiling, Theory and correlations, critical boiling flux.

UNIT-IV (10 Hrs.)

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

Theory of Fins and their applications, Reboiler and Condensers, counter current dry contact Condenser, parallel current- wet contact Condenser.

Evaporators: 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.

Recommended Books

1. J.P. Holman, 'Heat Transfer', 10th Edn, McGraw Hill, **2010.**
2. J.R. Backhurst, J. H. Harker, J.F. Coulson, J.M. Richardson, 'Chemical Engineering', Vol.-1, 6th Edn., Butterworth Heinemann, **1999.**
3. W.H. McAdams, 'Heat Transmission', 3rd Edn., Kreiger Publishing Co, **1985.**
4. McCabe, L. Warren, C. Smith and P. Harriot, 'Unit Operations of Chemical Engg.', 7th Edn, McGraw Hill, **2005.**
5. D.Q. Kern, 'Process Heat Transfer', McGraw Hill.

CHEMICAL ENGINEERING THERMODYNAMICS

Subject Code: BCHE1-411 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

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

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

UNIT-I (12 Hrs.)

Brief Review: Importance of thermodynamics in chemical engineering, State functions, types of systems, internal energy, heat and work reversible and irreversible processes. 1st law of thermodynamic and its engineering applications, i.e., constant volume processes, constant pressure processes, isothermal and adiabatic processes, Throttling process, Joule-Thomson coefficient, liquefaction of gasses, Standard heat of reaction, standard heat of

formation, standard heat of combustion, flame temperature, enthalpy for phase change etc.

UNIT-II (11 Hrs.)

Review of 2nd and 3rd Law of thermodynamics: Concept of Entropy and lost work, Microscopic interpretation of entropy. Third law of thermodynamics and its applications, free energy functions and their significance in phase and chemical equilibria. Clapeyron equation and some important correlations for estimating vapour pressures. Estimation of thermodynamic properties by using graphs and tables.

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

UNIT-III (12 Hrs.)

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

UNIT-IV (10 Hrs.)

Chemical Equilibria: 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.

Recommended Books

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

HEAT TRANSFER LAB.

Subject Code: BCHE1-412 **L T P C**
0 0 2 1

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

CHEMICAL TECHNOLOGY LAB.

Subject Code: BCHE1-413 **L T P C**
0 0 2 1

LIST OF EXPERIMENTS

PART A

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

PART B

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

At least five experiments should be conducted from each part.

PLANT UTILITIES

Subject Code: BCHE1-459 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

Introduction: Importance of Process utilities in Chemical Plant.

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

UNIT-II

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

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

UNIT-III

Compressed Air and Vacuum: Use of compressed air. Classification of compressors. Reciprocating compressors-mechanical details, single stage and two stage reciprocating compressor, inter cooler, minimum work input in multistage. Centrifugal compressor-velocity diagram for centrifugal compressors, dimensional parameters, slip factor, impeller blade shapes, losses in axial flow compressors.

UNIT-IV

Water: Cooling water, cooling towers, raw water, DM water, soft water.

Waste Disposal: Plant sewer system and waste disposal.

Recommended Books

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

RENEWABLE ENERGY SOURCES

Subject Code: BCHE1-460 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

Introduction: Global and Indian scenario, sources, Energy conservation, types of NCES with applications

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

UNIT-II

Hydro electric Energy: Hydro-electric power plant, conversion of hydro energy into electricity.

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

UNIT-III

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

UNIT-IV

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

Ocean and Tidal Energy: Introduction and conversion technique, mini hydel power plants and their economics.

Recommended Books

1. G.D. Rai, 'Non-Conventional Energy Sources', 4th Edn., Khanna Publishers, **2009.**
2. Ashok V. Desai, D. Jhirad, M. Munasinghe, 'Non-Conventional Energy', New Age International, **1990.**
3. S.P. Sukhatme, 'Solar Energy: Principles of Thermal Collection and Storage', 3rd Edn, Tata McGraw-Hill Education, **2008.**
4. K.M. Mittal, 'Non-Conventional Energy System, Principles, Progress and Prospects', Wheeler Pub., **1997.**

ENZYME TECHNOLOGY

Subject Code: BCHE1-461 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

Kinetics and Mechanism of Enzyme Action: Nature and function of enzyme., classification of enzymes; quantification of enzyme activity and specific activity, Estimation of Michaelis Menten parameters, Effect of pH and temperature on enzyme activity, kinetics of inhibition. Modelling of rate equations for single and multiple substrate reactions.

UNIT-II

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

Mass transfer Effects in Immobilised Enzyme Systems: Analysis of film and Pore Diffusion Effects on kinetics of immobilised enzyme reactions; Formulation of dimensionless groups and calculation of Effectiveness Factors

UNIT-III

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

UNIT-IV

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

Recommended Books

1. H.W. Blanch, D.S. Clark, 'Biochemical Engineering', 1st Edn., Marcel Dekker, **1997.**
2. James M. Lee, 'Biochemical Engineering', PHI, USA, **2009.**
3. J.E. Bailey & D.F. Ollis, 'Biochemical Engineering Fundamentals', 2nd Edn., McGraw Hill, **1986.**

INDUSTRIAL POLLUTION CONTROL

Subject Code: BCHE1-514 **L T P C** **Duration: 46 Hrs.**
3 1 0 4

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

Learning Objectives: 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.

UNIT-I (11 Hrs.)

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

UNIT-II (12 Hrs.)

Air Pollution: Principal air pollutants and their usual sources, Effects of air pollution on human health, animals and vegetation and materials, Atmospheric dispersion of air pollutants, Temperature inversions. Ambient air sampling, dust fall jar and high volume sampler, stack sampling

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

UNIT-III (12 Hrs.)

Water Pollution: 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 equipment like flocculation, skimming, flotation.

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

UNIT-IV (11 Hrs.)

Solid Waste: Control and disposal, sanitary landfill, incineration, pyrolysis gasification and recycling.

Recommended Books

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

CHEMICAL REACTION ENGINEERING-I

Subject Code: BCHE1-515 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

Learning Objectives: 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.

UNIT-I (11 Hrs.)

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

UNIT-II (12 Hrs.)

Design for Single Reactions: 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

UNIT-III (12 Hrs.)

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

Temperature & Pressure effects: 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.

UNIT-IV (10 Hrs.)

Non–Ideality: 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.

Recommended Books

1. O. Levenspiel, 'Chemical Reaction Engineering', 3rd Edn., John Willey, **2004.**
2. J.M. Smith, 'Chemical Engineering Kinetics', 3rd Edn., McGraw Hill, **1981**.
3. D.G. Peacock, J.F. Richardson, 'Chemical Engineering', Vol.-3, 3rd Edn., Butterworth Heinemann, **1994.**
4. S.M. Walas, 'Reaction Kinetics for Chemical Engineers', 3rd Edn., McGraw Hill Book Co,, Inc.
5. K.G. Denbigh, J.C.R. Turner, 'Chemical Reactor Theory-An Introduction', 3rd Edn., Cambridge Univ. Press London, **1984.**

MASS TRANSFER-I

Subject Code: BCHE1-516 **L T P C** **Duration: 46 Hrs.**
3 1 0 4

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

UNIT-I (11 Hrs.)

Introduction: Importance and classification of mass transfer operations in Chemical Engineering.

Diffusion: 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

UNIT-II (12 Hrs.)

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

UNIT-III (11 Hrs.)

Gas Absorption: Design of plate and packed absorption columns, Scrubbers, Non-isothermal absorption, Simultaneous heat and mass transfer.

Drying of Solids: Rate of drying curves, through circulation drying, Continuous drying, Types of dryers.

UNIT-IV (12 Hrs.)

Humidification Operations: VLE & Enthalpy, Reference substance plots, vapour gas mixtures, concept of adiabatic saturation, psychometric charts, adiabatic operations-humidification operations and water cooling operations. Dehumidification Equipment: water

cooling towers & spray chambers

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

Recommended Books

1. Treybal Robert E., 'Mass Transfer Operations', 3rd Edn., McGraw Hill, **2001.**
2. T.K. Sherwood, R.L. Pigford, C.R. Wilke, 'Mass Transfer', Chemical Engineering Series, McGraw Hill, **1975.**
3. J.R. Backhurst, J.H. Harker, J.F. Coulson, J.M. Richardson, 'Chemical Engineering', Vol.-1, 6th Edn., Butterworth Heinemann, **1999.**
4. A.H.P. Skelland, 'Diffusional Mass Transfer', Kreiger Publishing Co., **1985**.
5. McCabe, L. Warren, Julian C. Smith P. Harriot, 'Unit Operations of Chemical Engg.', 7th Edn., McGraw Hill, **2005.**

CHEMICAL REACTION ENGINEERING ENVIRONMENTAL ENGG LAB.

Subject Code: BCHE1-518 **L T P C**
0 0 2 1

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

CHEMICAL PROCESS PLANT DESIGN-I LAB.

Subject Code: BCHE1-519 **L T P C**
0 0 2 1

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

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

Recommended Books

1. Coulson, Richardson & R.K. Sinnott, 'Chemical Engineering', Vol.-6 – An Introduction to Chemical Engineering Design', 4th Edn., Elsevier Butterworth Heinemann, **2005.**

2. R.H. Perry, D.W. Green, 'Chemical Engineers Handbook', 8th Edn., McGraw Hill, **2008.**
3. A.K. Coker, 'Ludwig's Applied Process Design in Chemical & Petrochemical Plants', Vol.-1, 4th Edn., Gulf Publication- Butterworth Heinemann, **2007.**
4. F. C. Vilbrandt, C.E. Dryden, 'Chemical Engg. Plant Design', 4th Edn., McGraw Hill, **1959.**
5. M.S. Peters, K.D. Timmerhaus, 'Plant Design and Economics for Chemical Engg.', 5th Edn., McGraw Hill, **2003.**

FLUIDIZATION TECHNOLOGY

Subject Code: BCHE1-562 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

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

UNIT-II

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

UNIT-III

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

UNIT-IV

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

Recommended Books

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

PROJECT MANAGEMENT

Subject Code: BCHE1-563 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

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

UNIT-II

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

UNIT-III

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

UNIT-IV

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

Recommended Books

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

POLYMER SCIENCE & ENGINEERING

Subject Code: BCHE1-564 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

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

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

UNIT-II

Polymer Properties & their Testing: Glass transition temperature and associated properties, Tensile strength & impact strength and their determination, softening point, heat distortion dielectric and power factor.

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

UNIT-III

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

UNIT-IV

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

Recommended Books

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

MASS TRANSFER - II

Subject Code: BCHE1-620 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

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

Learning Objectives: 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.

UNIT-I (12 Hrs.)

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

UNIT-II (10 Hrs.)

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

UNIT-III (11 Hrs.)

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

Leaching: Leaching equipment and equilibrium. Single stage and multistage cross current and counter current leaching.

UNIT-IV (12 Hrs.)

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

Crystallization: Equilibria and yields, Methods of forming nuclei in solution and crystal growth, equipment - vacuum crystallizer, Draft tube-baffle crystallizer.

Recommended Books

1. Treybal Robert E., 'Mass Transfer Operations', 3rd Edn., McGraw Hill, **2001.**
2. T.K. Sherwood, R.L. Pigford, C.R. Wilke, 'Mass Transfer', Chemical Engineering Series, McGraw Hill, **1975**.
3. J.R. Backhurst, J.H. Harker, J.F. Coulson, J.M. Richardson, 'Chemical Engineering', Vol.-1, 6th Edn., Butterworth Heinemann, **1999.**
4. A.H.P. Skelland, 'Diffusional Mass Transfer', Kreiger Publishing Co., **1985.**
5. McCabe, L. Warren, Julian C. Smith and P. Harriot, 'Unit Operations of Chemical Engg.', 7th Edn., McGraw Hill, **2005.**
6. J.H. Harker, J.F. Richardson, J.R. Backhurst, 'Chemical Engg.', Vol.-2, 5th Edn., Butterworth-Heinemann, **2003.**

CHEMICAL REACTION ENGINEERING –II

Subject Code: BCHE1-621 **L T P C** **Duration: 46 Hrs.**

3 1 0 4

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

Learning Objectives: 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.

UNIT-I (11 Hrs.)

Kinetics of Heterogeneous Reactions: 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.

UNIT-II (12 Hrs.)

Diffusion through Porous Catalyst Particles: 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.

UNIT-III (11 Hrs.)

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

UNIT-IV (12 Hrs.)

K**inetics & Design of Fluid-Fluid Reactions:** 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: 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.

Recommended Books

1. J.M. Smith, 'Chemical Engineering Kinetics', 3rd Edn., McGraw Hill, **1981.**
2. O. Levenspiel, 'Chemical Reaction Engineering', 3rd Edn., John Willey, **2004.**
3. D.G. Peacock, J.F. Richardson, 'Chemical Engineering' Vol.-3, 3rd Edn., Butterworth Heinemann, **1994.**
4. S.M. Walas, 'Reaction Kinetics for Chemical Engineers', 3rd Edn., McGraw Hill Book Co, Inc.
5. H.S. Fogler, 'Elements of Chemical Reaction Engineering', 4th Edn., Prentice Hall, **2006.**
6. J.J. Carberry, 'Chemical and Catalytic Reaction Engineering', McGraw Hill, New York, **1976.**

MASS TRANSFER LAB.

Subject Code: BCHE1-622 **L T P C**
0 0 2 1

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

PROCESS EQUIPMENT DESIGN LAB.

Subject Code: BCHE1-623 **L T P C**
0 0 2 1

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

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

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

Recommended Books

1. L.E. Brownell and E.H. Young, 'Process Equipment Design', Wiley Interscience, **1959**.
2. R.C. Bhattacharya, 'An Introduction to Chemical Equipment Design-Mechanical Aspects', 1st Edn., CBS Publication, **1985.**
3. V.V. Mahajani, S.B. Umarji, 'Joshi's Process Equipment Design', 4th Edn., Macmillan Indian Ltd., **2009.**

ENGINEERING MATERIALS

Subject Code: BCHE1-665 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

Learning Objectives: 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 equipment being used in a particular processing technology.

UNIT-I

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

UNIT-II

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

UNIT-III

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

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

UNIT-IV

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

Novel Materials: Introduction to nano materials and biomaterials and their uses

Recommended Books

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

OPTIMIZATION TECHNIQUES

Subject Code: BCHE1-666 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

Learning Objectives: 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.

UNIT-I

Introduction: 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.

UNIT-II

Single variable Optimization Techniques:

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

UNIT-III

Multivariable Optimization Techniques:

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

UNIT-IV

Constrained Optimization Algorithms:

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

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

Recommended Books

1. K. Deb, 'Optimization for Engg. Design Algorithms and Examples', Prentice Hall of India, **2005.**
2. T.I. Edgar & D.M. Himmelblau, L.S. Lasdon, 'Optimization of Chemical Processes', McGraw Hill, **2001.**
3. S.S. Rao, 'Engineering Optimization Theory and Practice', 4th Edn., John Wiley and Sons,

2009.
4. W.H. Ray & J. Szekely, 'Process Optimization with Applications to Metallurgy & Chemical Engg.' Wiley Interscience, **1973.**
5. S.G. Beveridge & R.S. Schechter, 'Optimization: Theory & Practice', McGraw Hill, **1970**.
6. B.S. Grewal, 'Numerical Methods in Engineering and Science', Khanna Publishers, **1991.**

PETROLEUM REFINING ENGINEERING

Subject Code: BCHE1-667 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

UNIT-I

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

Crude Pre-treatment: Composition and classification of crudes, methods of evaluation: ASTM, TBP and EFV distillation.

UNIT-II

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

Testing of petroleum products:

(i) Physical test: Density and specific gravity, viscosity.

(ii) Chemical test: Organic and inorganic constituents.

(iii) Flammability Test: Flash point, volatility.

(iv) Knock Rating Test: For Gasoline Octane Number.

UNIT-III

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

UNIT-IV

Conversion Process: Thermal cracking, visbreaking and coking processes, Catalytic cracking, reforming, hydro processing, alkylation, polymerization and isomerisation. Safety and pollution considerations in refineries.

Recommended Books

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

POLYMER REACTOR DESIGN

Subject Code: BCHE1-668 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

Learning Objectives: The course will provide a detailed study of application of chemical

engineering principles in the design and analysis of reactors for polymer production.

UNIT-I

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

UNIT-II

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

UNIT-III

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

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

UNIT-IV

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

Recommended Books

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

HEAT EXCHANGERS

Subject Code: BCHE1-669 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

Learning Objectives: 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 equipment to yield better performance.

UNIT-I

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

UNIT-II

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

UNIT-III

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

UNIT-IV

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

Recommended Books

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. R. Smith, 'Chemical Process Design', McGraw Hill, **1995.**

TRANSPORT PHENOMENA

Subject Code: BCHE1-670 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

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

Learning Objectives: 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.

UNIT-I

Review: Transport of momentum, heat and mass by molecular Motion-Newton's law of Viscosity, Fourier's law of heat conduction, Fick's law of diffusion.

UNIT-II

Transport Properties: Viscosity, thermal conductivity and mass diffusivity. Emphasis on the analogy between momentum, heat and mass transfer with respect to transport mechanism and governing equations.

UNIT-III

Development of Mathematical Models of Transfer Process by Shell Momentum Balance: 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.

UNIT-IV

Development of General Differential Equations of Fluid Flow: Heat transfer and mass transfer and their applications in solving one-dimensional steady state and unsteady state problems of momentum, heat and mass transfer.

Interphase Transport: Interphase transport of Momentum, heat and mass and dimensionless correlations for each one of them.

Transport Analysis: Momentum, heat and mass transfer analysis and analogies.

Recommended Books

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

PROCESS INSTRUMENTATION, DYNAMICS & CONTROL

Subject Code: BCHE1-724 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

Learning Objectives: The course is devoted to the analysis of the various types of instruments used in chemical processes, dynamical behavior of systems and the mathematical

tools used in their analysis. Further, the control of these processes by using various types of controllers and their design is included in the course.

UNIT-I (11 Hrs.)

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

Instruments for Pressure, Temperature & Level Measurement: 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.

UNIT-II (12 Hrs.)

General Principles of Process Control: 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.

UNIT-III (12 Hrs.)

Different Modes of Control and their Basic Characteristics: 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.

UNIT-IV (10 Hrs.)

Introduction to Advanced Control Techniques: Feed forward, feedback, cascade, ratio, adaptive and digital computer control.

Process Identification and Applications: Process identification of systems with unknown transfer functions.

Recommended Books

1. D.P. Eckman, 'Industrial Instrumentation', Wiley Eastern, **1974.**
2. D. Patranabis, 'Principles of Process Control', 2nd Edn., Tata McGraw Hill, **2001.**
3. G. Stephanopoulos, 'Chemical Process Control - An Introduction to Theory and Practice', 1st Edn., Prentice Hall of India, **1990.**
4. D.G. Peacock, J.F. Richardson, 'Chemical Engineering', Vol.-3, 3rd Edn., Butterworth Heinemann, **1994.**
5. B.W. Bequette, 'Process Dynamics: Modelling, Analysis and Simulation', Prentice Hall, **1998.**
6. Pollard, 'Process Control for Chemical and Allied Industries', Butterworth Heinemann, **1971.**
7. T.W. Weber, 'An Introduction to Process Dynamics & Control', Kreiger Publishing Co., **1988.**
8. P. Harriott, 'Process Control', Tata McGraw Hill Publishing Co. Ltd., New Delhi, **2001.**

PROCESS ENGINEERING & ECONOMICS

Subject Code: BCHE1-725 **L T P C** **Duration: 46 Hrs.**
3 1 0 4

Learning Objectives: 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.

UNIT-I (12 Hrs.)

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

Balance Sheet and Income Statement: Concept of Gross Profit, Net Profit, Return on Investment, Current Ratio, Quick Ratio, Debt-equity ratio

UNIT-II (11 Hrs.)

Interest and Investment Costs: Simple and compound interest, Nominal and effective rates of interest. Continuous interest, Annuity, Perpetuity and capitalized costs.

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

UNIT-III (12 Hrs.)

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

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

UNIT-IV (11 Hrs.)

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

IPR and Patent Systems: 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

Recommended Books

1. M.S. Peters, K.D. Timmerhaus, 'Plant Design and Economics for Chemical Engg.', 5th Edn., Tata McGraw Hill, **2005.**
2. G.D. Ulrich, 'A Guide to Chemical Engineering Process Design and Economics', John Wiley, 1**984.**
3. K.M. Guthrie, 'Process Plant Estimating, Evaluation and Control', Craftsman Solano Beach, California,
4. Couper James R., 'Process Engineering Economics', Marcel Dekker, NY, **2003.**

CHEMICAL PROCESS PLANT DESIGN –II LAB.

Subject Code: BCHE1-728 **L T P C**
0 0 2 1

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

The student is to appear in a viva-voce examination based on design report.

Recommended Books

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

PROCESS INSTRUMENTATION, DYNAMICS & CONTROL LAB.

Subject Code: BCHE1-729 **L T P C**
0 0 2 1

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

SEPARATION PROCESSES

Subject Code: BCHE1-771 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

Learning Objectives: 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.

UNIT-I

Separation Processes: Industrial chemical processes, Mechanism of separation, separation power, selection of feasible separation processes.

UNIT-II

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

UNIT-III

Dialysis and Electro dialysis, Reverse Osmosis, Gas Permeation, Pervaporation, Ultrafiltration, Microfiltration.

Ion Exchange, and Chromatography: 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

UNIT-IV

Adsorption 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

Recommended Books

1. J.D. Seader & E.J. Henley, 'Separation Processes Principles', 2nd Edn, John Wiley & Sons, **2006.**
2. R.W. Rousseau, 'Handbook of Separation Process Technology', Wiley-Interscience, **1987.**
3. H. Strathmann, 'Ion Exchange Membrane Separation Processes', Elsevier Science.

PETROCHEMICAL TECHNOLOGY

Subject Code: BCHE1-772 **L T P C** **Duration: 34 Hrs.**

3 0 0 3

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

UNIT-I

Introduction: Petro chemicals; Definition, importance and growth potential of the field. Concepts of quality and environmental pollution control in petrochemical industries.

UNIT-II

Petrochemical Feed Stocks: Raw material for petrochemical industries, sources, economics and advantage, Production of olefin containing gases; various purification and separation processes. Important intermediate material for petrochemical industry e.g. Aromatic, Ammonia, Butadiene, Alcohol, synthesis gas.

UNIT-III

Processes for Petrochemical Feed Stock: Cracking- thermal and catalytic, polymerization and isomerisation. Desulphurization of petrochemical feed stock.

UNIT-IV

Manufacture of Important Petrochemicals: Plastics, Fertilizer, Carbon Black, Synthetic fibers, Synthetic Rubber, Synthetic Detergents.

Recommended Books

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

BIOCHEMICAL ENGINEERING

Subject Code: BCHE1-773 **L T P C** **Duration: 34 Hrs.**
3 0 0 3

Learning Objectives: 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.

UNIT-I

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

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

UNIT-II

Kinetics of Microbial Growth: Enzyme kinetics including enzyme inhibition. **Sterilization of air and media.**

UNIT-III

Nutrient Transport across Cell Membrane.

Mass Transfer and Microbial Respiration: Mass transfer resistance, physical and enzymatic considerations, critical value of dissolved oxygen concentration, respiration of mycelial pellet.

UNIT-IV

Bubble Aeration and Mechanical Agitation: Single bubbles, series of bubbles, power number versus Reynolds number, decrease of power requirement in aeration.

Cardinal rules for Fermenter design, materials of construction.

Recommended Books

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

CHEMICAL PROCESS SIMULATION

Subject Code: BCHE1-830 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

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

UNIT-I (11 Hrs.)

Introduction: Concept of Dynamics, Variables and Degrees of freedom, Definition of mathematical model, Classification of models - lumped parameter model & distributed parameter model, uses of mathematical models, principles of formulation of models, parametric sensitivity.

UNIT-II (11 Hrs.)

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

Mathematical Models of Chemical Reaction Engg. System

1. Model for Series of isothermal CSTRs
2. Model for an Isothermal/non-isothermal plug-flow reactor.
3. Model for a gas phase pressurized CSTR
4. Model for a Non isothermal CSTR
5. Model for a Jacketed Batch reactor
6. Model for Biochemical reactor.

UNIT-III (12 Hrs.)

Mathematical Models of Chemical Engg. Systems:

1. Model for a Single component vaporizer
2. Model for Multi component flash drum
3. Model for Ideal/ Non-ideal distillation column
4. Model for batch distillation column
5. Equilibrium-constant & titration curve models for pH systems
6. Lumped parameter model of a gas absorber
7. Lumped parameter model of a liquid-liquid extraction column
8. Model involving energy equation of heated tanks.
9. Model for Heat-exchangers
10. Model for a system of interacting & non-interacting tanks.
11. Model for a Reactor along with Mass Transfer

UNIT-IV (11 Hrs.)

Simulation: Meaning of simulation; simulation strategy for simple isothermal CSTR, simple non-isothermal CSTR and simple isothermal batch reactor.

Recommended Books

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

PROCESS SIMULATION LAB.

Subject Code: BCHE1-832 **L T P C**
0 0 2 1

1. Program involving Simulation of Bubble point calculations
2. Program involving Simulation of Dew Point Calculations.
3. Program involving Simulation of Gravity Flow tank using C++/MATLAB
4. Program involving Simulation of three isothermal CSTRs in series using C++ /MATLAB.
5. Program involving Simulation of non- isothermal CSTR using C++/MATLAB.
6. Program involving Simulation of isothermal batch reactor using C++/MATLAB.
7. Program involving Simulation of non - isothermal batch reactor using C++/MATLAB.
8. Program involving Simulation of isothermal of distillation column using C++/MATLAB.
9. Program involving Simulation of Multi-Component Flash Drum.
10. Program involving Simulation of a Heat Exchanger.

CHEMICAL PROCESS SAFETY

Subject Code: BCHE1-874 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

Learning Objectives: 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.

UNIT-I (11 Hrs.)

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

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

UNIT-II (12 Hrs.)

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

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

UNIT-III (12 Hrs.)

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

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

UNIT-IV (10 Hrs.)

Accident Investigations: *Case Histories* - Bhopal gas tragedy, Flixborough disaster, Pasadena accident, IOCL disaster, nuclear disaster in Japan in 2011.

Recommended Books

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

FUEL CELL TECHNOLOGY

Subject Code: BCHE1-875 **L T P C** **Duration: 45 Hrs.**
3 1 0 4

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

UNIT-I (12 Hrs.)

Introduction: Fuel Cell definition and basics- cathode, anode, electrolyte, Difference between a fuel cell and a battery, Advantages and disadvantages, Basic fuel cell operation. Relationship between Gibb's free energy and electric work/ electric voltage, Reversible Voltage/ potential of fuel cell using standard electrode potentials,

UNIT-II (12 Hrs.)

Fuel Cell Fundamentals: 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.

UNIT-III (11 Hrs.)

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

UNIT-IV (10 Hrs.)

Fuel Cell Systems: Fuel cell stack, engineering issues related to Fuel Cell Technology**,** Hydrogen as a fuel, availability and engineering issues.

Recommended Books

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

ENVIRONMENT IMPACT ASSESSMENT

Subject Code: BCHE1-876 **L T P C** **Duration: 45 Hrs.**

3 1 0 4

UNIT-I (12 Hrs.)

Environment Impact Assessment (EIA): Concept of EIA, Origin of EIA, Procedure of EIA, Evaluation Methodology for EIA, Scope Studies, Preparation and Review of Environment Impact Statement (EIS), Introduction of Life Cycle Assessment, Environmental Parameters in LCA.

UNIT-II (11 Hrs.)

Environment Audit: Concept of Environmental Audit, Necessity and Importance of EA, Audit Procedures.

UNIT-III (12 Hrs.)

Environmental Management System (EMS): Introduction, Terminology and Certification, Environmental Standards, the International Standard Organization (ISO), the ISO 9000 and the ISO 14000 Family of Standards, Guides and Technical Reports, ISO 14001 Certification as a Tool for Sustainable Development.

UNIT-IV (10 Hrs.)

Case Studies Discussion and analysis of various Case studies of environmental engineering projects.

Recommended Books

Vijay Kulkarni and T.V. Ramachandra, 'Environmental Management, Commonwealth of Learning', Canada and Indian Institute of Science, Bangalore, **2006.**