For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

Shaheed Bhagat Singh State Technical Campus, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2018 Onwards)
3rd Semester (Second Year) -Curriculum

Total Contact Hours= 25

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credit
			L	T	P	Internal	External		
1.	BTCH-301B	Engineering & Solid Mechanics (SOM)	3	1	0	40	60	100	4
2.	BTCH-302B	Thermodynamics-I	3	1	0	40	60	100	4
3.	BTCH-303B	Transport Phenomena	3	1	0	40	60	100	4
4.	BTCH-304B	Material & Energy Balance Computations	3	1	0	40	60	100	4
5.	BTCH-305B	Fluid Mechanics	3	1	0	40	60	100	4
6.	BTCH-306B	Environmental Sciences (Mandatory Non-credit course)	2	-	-	40*	60*	100*	0 (*Sat/ Unsat)
7.	BTCH-307B	Chemical Engineering Lab-I (FF & SOM lab)	0	0	3	30	20	50	1
8	BTCH-308B	Training-I (Mandatory Non-credit course)	-	-	-	60*	40*	100*	0 (*Sat/ Unsat)
Total			**17**	**5**	**3**	**230**	**320**	**550**	**21**

*- marks are only given for awarding Satisfactory/Unsatisfactory grade

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

Shaheed Bhagat Singh State Technical Campus, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2018 Onwards)
4th Semester (Second Year) -Curriculum

Total Contact Hours= 26

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credit
			L	T	P	Internal	External		
1.	BTCH-401B	Heat Transfer	3	1	0	40	60	100	4
2.	BTCH-402B	Mass Transfer-I	3	1	0	40	60	100	4
3.	BTCH-403B	Thermodynamics-II	3	1	0	40	60	100	4
4.	BTCH-404B	Materials Science	3	0	0	40	60	100	3
5.	BTCH-405B	Numerical Methods in Chemical Engineering	3	1	0	40	60	100	4
6.	BTHU- 401B	HASS-II	3	0	0	40	60	100	3
7.	BTCH-406B	Numerical Methods in Chemical Engineering Lab	0	0	2	30	20	50	1
8.	BTCH-407B	Chemical Engineering Lab-II (Thermo & HT lab)	0	0	3	30	20	50	1
Total			**18**	**4**	**5**	**300**	**400**	**700**	**24**

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Shaheed Bhagat Singh State Technical Campus, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2018 Onwards)
5th Semester (Third Year) -Curriculum

Total Contact Hours= 25

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credit
			L	T	P	Internal	External		
1.	BTCH-501B	Chemical Reaction Engineering-I	3	1	0	40	60	100	4
2.	BTCH-502B	Mass Transfer-II	3	1	0	40	60	100	4
3.	BTCH-503B	Particle & Fluid Particle Processing	3	0	0	40	60	100	3
4.	Core Elective-I		3	0	0	40	60	100	3
	BTCH-511B	Optimization Techniques							
	BTCH-512B	Plant Utilities							
	BTCH-513B	Enzyme Tech.							
5.	BT-	Open Elective-I	3	0	0	40	60	100	3
6.	BTHU-501B	HASS-III (Project Management)	3	0	0	40	60	100	3
7.	BTCH-504B	Chemical Engineering Lab-III (MT lab)	0	0	3	30	20	50	1
8.	BTMC-501B/ BTMC-502B	Essence of Indian Traditional Knowledge / Constitution of India	2	0	0	50*	-	50	-
Total			**20**	**2**	**3**	**270**	**380**	**650**	**21**

*Satisfactory/ Unsatisfactory grade will be awarded based upon internal assessment

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Academic Autonomous Status vide letter No. 22-1/2015(AC)

Shaheed Bhagat Singh State Technical Campus, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2018 Onwards)
6th Semester (Third Year) -Curriculum

Total Contact Hours= 26

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credit
			L	T	P	Internal	External		
1.	BTCH-601B	Chemical Reaction Engineering-II	3	1	0	40	60	100	4
2.	BTCH-602B	Chemical Process Industries	3	0	0	40	60	100	3
3.	BTCH-603B	Energy Engg. & Pollution Control	3	1	0	40	60	100	4
4.	Core Elective-II		3	0	0	40	60	100	3
	BTCH-611B	Safety in Chemical Plants							
	BTCH-612B	Corrosion Engg.							
	BTCH-613B	Fluidization Tech.							
5.	BTHU- 601B	HASS-IV (Process Engg. Economics)	3	0	0	40	60	100	3
6.	BTCH-604B	Chemical Engineering Lab –IV (CRE & Mech. operations lab)	0	0	3	30	20	50	1
7.	BTCH-605B	Chemical Equipment Design	1	0	2	30	20	50	2
8.	BTCH-	Open Elective-II	3	0	0	40	60	100	3
Total			**19**	**2**	**5**	**300**	**400**	**700**	**23**

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

Shaheed Bhagat Singh State Technical Campus, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2018 Onwards)
7th Semester (Fourth Year) -Curriculum

Total Contact Hours= 25

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credit
			L	T	P	Internal	External		
1.	BTCH-701B	Process Instrumentation dynamics & Control	3	1	0	40	60	100	4
2.	Core Elective-III		3	0	0	40	60	100	3
	BTCH-711B	Polymer Science & Reactor Design							
	BTCH-712B	Heat Exchangers							
	BTCH-713B	Separation Processes							
3.	Core Elective - IV		3	0	0	40	60	100	3
	BTCH-714B	Petroleum Engg. & Tech							
	BTCH-715B	Biochemical Engg.							
	BTCH-716B	Fuel Cell Technology							
4.	BTCH-	Open Elective-III	3	0	0	40	60	100	3
5.	BTCH-702B	Chemical Engineering Lab –V (Process Simulation Lab)	0	0	3	30	20	50	1
6.	BTCH-703B	Chemical Engineering Lab –VI (Instrumentation, Dynamics & Control Lab)	0	0	3	30	20	50	1
7.	BTCH-704B	Chemical Process Plant Design	1	0	2	30	20	50	2
8.	BTCH-705B	Project	0	0	8	60	40	100	4
9.	BTCH-706B	Chemical Engineering Lab –VII (Chemical Technology & Enviro. Engg. Lab- Mandatory Non-Credit Course)	0	0	3	50*	-	50	0 (*Sat/ Unsat)
Total			**13**	**1**	**19**	**360**	**340**	**700**	**21**

*Satisfactory/ Unsatisfactory grade will be awarded based upon internal assessment

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

Shaheed Bhagat Singh State Technical Campus, Ferozepur Punjab
Department of Chemical Engineering
B.Tech. Chemical Engineering
Scheme of Syllabi (2018 Onwards)
8th Semester (Fourth Year) -Curriculum

Total Contact Hours= 00

Sr. No.	Course Code	Course Title	Hours per week			Marks Distribution		Total Marks	Credit
			L	T	P	Internal	External		
	BTCH-801B	Industry/Institutional internship Training				300	200	500	12
Total			**0**	**0**	**0**	**300**	**200**	**500**	**12**

3rd Semester
BTCH-301B Engineering and Solid Mechanics

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

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

Rigid body kinematics: **(4 hrs)**
Translation and rotation, relative motion, angular velocity, Laws of motion, (Euler's Axioms), General motion of a rigid body, General relative motion.

Simple Stresses & Strains: **(6 hrs)**
Simple stresses and strains : Concept of stress and strain; St. Vernants principle, stress and 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.

Slopes and Deflections of Beams: **(6 hrs)**
Slopes and deflections in beams and cantilevers, calculation of slopes and deflections using double integration moment area theorems and Macullay's method. Shear Force and Bending Moment diagram.

Theory of Bending: **(6 hrs)**
Compound stress and strains, the two dimensional system; stress at a point on a plane, principal stresses and principal planes; Mohr's circle of stress; ellipse of stress and their applications. Generalized Hook's Law, principal stresses related to principal strains

Analysis of Structures: **(4 hrs)**
Trusses, Equivalent force systems, Resultant forces, Linear and Angular Momentum, Free Body Diagrams, Equilibrium of rigid bodies, distributed forces.

Theories of failure: **(6 hrs)**
Strain energy, various theories of failure, their necessity and significance, graphical representation of theories of failure.

Torsion of shafts and springs: **(6 hrs)**
Torque, angle of twist and shear stresses in hollow and solid shafts with in elastic limit, assumptions intrusion, power transmitted by a shafts, analysis of close coil spring subjected to axial load couple. Shafts subjected to torsion.

Thin Cylinders/ spheres: **(4 hrs)**
Thin cylinders subjected to internal pressure, circumferential and longitudinal stress and strains, maximum shear stress, increase in diameter and volume, thin spheres subjected to internal pressure.

Columns: **(6 hrs)**
Columns under uniaxial loads, buckling of columns slenderness ratio, and conditions. Derivations of Euler's formula for elastic-buckling load, equivalent length,Rankine-Garden empirical formula.

BOOKS RECOMMENDED:

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

Course outcomes

Students will be able to:

1. Understand the basic concepts of rigid body kinematics.
2. Understand the concept of stress and strain at a point and stress analysis in various machine elements like thin cylinder, sphere, spring, beams and shafts.
3. Tackle the problems related to shearing Force, bending moment, slope and deflections in different types of beams subjected to various types of loadings.
4. Apply the knowledge of various theories of failures to design the various structural components subjected to different types of loadings.
5. Understand the concept of buckling of slender, long columns subjected to axial loads and be able to solve problems related to columns and struts.

BTCH-302B Thermodynamics-I

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

Objectives: This course covers the application of thermodynamic principles to chemical engineering problems. It involves principles and application of first, second and third laws of thermodynamics.

Introduction **(4 hrs)**
Scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy and Heat.

Energy conservation & first law of thermodynamics: **(6 hrs)**
State functions; Equilibrium; Phase Rule; Reversible process; Constant P, V, T processes; Mass and energy balances for open systems.

Phases: **(8 hrs)**
Phase transitions, PVT behaviour; description of materials – Ideal gas law, Vander Waals, virial and cubic equations of state; Reduced conditions & corresponding states theories; correlations in description of material properties and behaviour.

Heat effects: **(4 hrs)**
Latent heat, sensible heat, Standard heat of formation, reaction and combustion, flame temperature, Enthalpy for phase change etc.

Second law of thermodynamics: **(10 hrs)**
Statement of Second law of thermodynamics, Heat engines, Carnot's theorem, Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work. Throttling process, Joule-Thomson coefficient, Third law of thermodynamics and its applications

Thermodynamic property of fluids: **(4 hrs)**
Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties.

Thermodynamics of Process: **(6 hrs)**
Application of thermodynamics to flow processes-pumps, compressors and turbines, Thermodynamic analysis of Steam power plants and Rankine cycle.

Carnot refrigerator: **(6 hrs)**
Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes of gases.

BOOKS RECOMMENDED:

1. Smith J.M. and Van Ness, H.C, Introduction to Chemical Engineering Thermodynamics, 7th Ed., McGraw Hill Book Co., 2005
2. Dodge B.F., Chemical Engg. Thermodynamics, McGraw - Hill Book Company, Inc.
3. Balzhiser R., Samuels M., Eliassen J., Chemical Engineering Thermodynamics, PHI, 1972.
4. M J Moran, H N Shapiro, D D Boettner and M B Bailey, Principles of Engineering Thermodynamics, 8th Edition, Willey .

Course outcomes

Students should be able to

1. Apply the concept of Ist, IInd and the IIIrd laws of thermodynamics.
2. Apply mass and energy balances to closed and open systems.
3. Apply the heat effects to various sensible heat and latent heat processes.
4. Evaluate the properties of Gases, concept of non-ideal gases and its governing correlations.
5. Solve problems involving liquefaction, refrigeration and different power cycles.

BTCH-303B Transport Phenomena

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students are able to:

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

BTCH-304B Material & Energy Balance Computations

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

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

1. Introduction to Chemical Engineering Calculations: **(8 hrs)**
Units & Dimensions, Conversion of units, Mole concept, Basic Concept, Stoichiometric and composition relationship, limiting-excess- reactant, conversion and yield, "basis" of calculations Degrees of Freedom.

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

3. Energy Balance: **(14 hrs)**
Review: Standard heat of formation and combustion, standard heat of reaction, problems using Hess Law. open and closed system, heat capacity, calculation of enthalpy changes
Heat balances for non reacting processes and reaction processes. Theoretical flame temperature, Adiabatic reaction temperature, flame temperature, combustion calculation.

4. Gases, Vapors, Liquids and Solids: **(6 hrs)**
Equations of state, Vapor pressure, Clausius-Clapeyron equation, Cox chart, Duhring's plot, Raoult's law, Crystallization, Dissolution.

5. Humidity: **(4 hrs)**
Saturation, humid heat, humid volume, dew point, humidity chart and its use.

BOOKS RECOMMENDED:

1. Himmelblau, D. M., Riggs, J. B. "Basic Principles and Calculations in Chemical Engineering", Eighth Ed., Pearson India Education Services, 2015.
2. Bhatt, B. I., Vora, S. M., "Stoichiometry", Fourth Edition, Tata McGraw Hill Publishing Company Ltd, 2004.
3. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000
4. Hougen, O. A., Watson, K. M., Ragatz, R. A., "Chemical Process Principles, Part-I Material & Energy Balances", Second Edition, CBS Publishers & Distributors, 2004
5. Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, "Process Calculations" , Second Edition, Prentice Hall of India.
6. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.

COURSE OUTCOMES

Students would be able to:-

1. Demonstrate the knowledge of basic Chemical Engineering Calculations involving units & dimensions, stoichiometry and degree of freedom analysis.
2. Apply material balance on Chemical Engineering processes with & without chemical reaction.
3. Apply thermophysics and thermochemistry-laws for applying energy balance on Chemical Engineering processes.
4. Be familiar with equations of state and properties of gases and liquids, including phase transition, crystallization and dissolution operations.
5. Comprehend the concept of humidity and usage of psychometric charts.

BTCH-305B Fluid mechanics

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

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

Introduction **(2 hrs)**
Concept of fluid, difference between solids, liquids and gases; ideal and real fluids, Introduction to fluid statics and fluid flow

Fluid Statics **(4hrs)**
Normal forces in fluids, Manometers of different types, Forces on submerged bodies, Buoyancy and stability.

Fluid Properties **(8 hrs)**
Concept of capillarity, vapour pressure, compressibility and bulk modulus, Newtonian and non-Newtonian Fluids, Nature of turbulence, Eddy Viscosity, Flow in Boundary Layers.

Basic Equations of Fluid Flow **(6 hrs)**
Momentum Balance, Continuity equation, Bernoulli's Equations, Navier Stokes Equations, Derivation and Application,

Dimensional Analysis of Fluid Flow: **(4 hrs)**
Problems using Rayleigh method and Buckingham π method, Dimensionless numbers and their significance

Flow of Incompressible Fluids **(8 hrs)**
Concept of boundary layer, Laminar and Turbulent flow in pipes, Velocity distribution in pipes, Frictional Losses in pipes and fittings, effect of roughness, Fanning Equation, Estimation of Economic Pipe Diameter, Derivation of Hagen Poiseuille's equation and f =16/ Re.

Flow of Compressible Fluids **(4 hrs)**
Compressible flow, basic equation, Mach number and its significance and isentropic flow through nozzles

Flow Measurement **(6 hrs)**
In closed channels - Pitot tube, Orifice meter, venturimeter, Rotameter
In open channels- Notches, Weirs

Fluid Machinery **(6 hrs)**
Classification and performance of Pumps, Positive displacement pumps and its types, Centrifugal pumps- characteristic curves, Net positive Suction Head and cavitation, Turbines, Compressors, Blowers, Selection and specification.

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

Students would be able to:-

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

BTCH-306B Environmental Sciences (Mandatory Non-credit course)

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

Objective: The course provides a basic understanding of concept of multidisciplinary nature of Environmental Science & basic problems of exploitation & environmental effects of using Natural Resources. It provides an ability to identify threats to Bio-diversity, relationship among Social-issues, human population and their potential solutions. An awareness about causes, effects & control measures of various types of environmental Pollution.

Part A

Introduction: **(2 hrs)**

Definition and scope and importance of multidisciplinary nature of environment. Need for public awareness.

Natural Resources: **(2 hrs)**

Natural Resources and associated problems, use and over exploitation, case studies of forest resources and water resources.

Ecosystems: **(2 hrs)**

Concept of Ecosystem, Structure, interrelationship, producers, consumers and decomposers, ecological pyramids-biodiversity and importance. Hot spots of biodiversity.

Environmental Pollution: **(6 hrs)**

Definition, Causes, effects and control measures of air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards. Solid waste Management: Causes, effects and control measure of urban and industrial wastes. Role of an individual in prevention of pollution. Pollution case studies. Disaster Management : Floods, earthquake, cyclone and landslides.

PART B

Social Issues and the Environment: **(8 hrs)**

Unsustainable to Sustainable development, Urban problems related to energy, Water conservation, rain water harvesting, watershed management. Resettlement and rehabilitation of people; its problems and concerns. Case studies. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies. Wasteland reclamation. Consumerism and waste products. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of pollution) Act. Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation Public awareness.

Human Population and the Environment: **(4 hrs)**

Population growth, variation among nations. Population explosion - Family Welfare Programme. Environment and human health, Human Rights, Value Education, HIV/AIDS. Women and child Welfare. Role of Information Technology in Environment and human health. Case studies.

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BTCH-307B Chemical Engineering Lab-I

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

LIST OF EXPERIMENTS

PART A*

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

PART B*

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

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

COURSE OUTCOMES:

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

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

BTCH-308B Training-I
(Mandatory Non-credit course)

External Marks: 4 0 **Grade Satisfactory- Pass**
Internal Marks: 6 0 **Unsatisfactory-Fail**
Total Marks: 100*

Each student will be required to submit a report after the completion institutional Workshop training. The reports will be assessed by Workshop in-charge. Students have to appear in Viva-Voce examination. Students have to secure passing marks in both and internal and external to secure them a Satisfactory grade.

***Marks are given for awarding Satisfactory/ Unsatisfactory grade.**

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4th Semester

BTCH-401B HEAT TRANSFER

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

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

Modes of Heat Transfer:

Conduction **(8 hrs)**

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

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

Convection **(10 hrs)**

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

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

Radiation **(6 hrs)**

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

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

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

Heat exchangers: **(10 hrs)**

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

Theory of Fins and their applications

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

Evaporators: **(8 hrs)**

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

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

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

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BTCH-402B Mass Transfer-I

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

Objective: The objective of this course is to present the principles of mass transfer and their application to separation and purification processes. The concept of diffusion, mass transfer coefficients and gas-liquid mass transfer operations is developed.

Introduction **(2 hrs)**

Importance and classification of mass transfer operations in Chemical Engineering.

Diffusion: **(8hrs)**

Diffusion in gases and liquids, Fick's First law of diffusion, Mass balance in simple situations - with and without chemical reaction.

Diffusion in solids, diffusion through porous solids and polymers, unsteady state diffusion

Interphase Mass transfer: **(10 hrs)**

Theories of Mass transfer, Individual and overall mass transfer coefficients, Convective mass transfer, Mass Transfer correlations, Analogies between Mass, momentum and Heat transfer

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

Gas- Liquid Operations

Gas absorption: **(8 hrs)**

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

Distillation: **(12 hrs)**

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students would be able to:

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

For Batches 2018 & Onwards
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BTCH-403B THERMODYNAMICS-II

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

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

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

Brief review: **(6 hrs)**

Review of 1^{st},2^{nd} and 3^{rd} Law of thermodynamics and its engineering applications, Clapeyron equation for estimating vapour pressures.

Solution Thermodynamics **(14 hrs)**

Fundamental property relationships, free energy and chemical potential, partial molar properties, ideal solution and excess properties, dependence of chemical potential on temperature and pressure. Definition of fugacity and fugacity coefficient of pure species and species in solution, Fugacity and its calculations. Dependence of fugacity on temperatures and pressure. Gibbs-Duhem equation

Phase Equilibria: **(12 hrs)**

Solution behaviour of real liquids and solids. Activity and activity coefficients. Variation of activity co- efficient with temperature and composition. Activity coefficients of electrolytes. Standard states. Properties of mixing. Application of Gibbs-Duhem equation to vapour- liquid equilibria, Ideal solutions (Lewis-Randall Rule).

Vapor-liquid equilibrium: **(6 hrs)**

Phase rule, simple models for VLE (UNIFAC/ UNIQUAC) and LLE, VLE by modified Raoult's law; VLE from K-value correlations; Flash calculations.

Chemical Equilibria: **(10 hrs)**

Equilibrium constant in terms of measurable properties, variations of equilibrium constant with temperature and pressure. Adiabatic reactions. Gibbs phase rule for reacting systems, equilibria in heterogeneous reactions. Multi-reaction equilibria.

BOOKS RECOMMENDED:

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

COURSE OUTCOMES:

The students will be able to:

1. Apply the laws of thermodynamics to chemical engineering processes.
2. Apply thermodynamic principles for analysis of solutions, ideal solutions, their excess properties.
3. Apply the knowledge of phase equilibria to chemical engineering problems.
4. Apply thermodynamics principles to VLE and LLE.
5. Apply Chemical Equilibria for solution to problems involving more than one phase and chemical reactions.

BTCH-404B Materials Science

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

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

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

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

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

Ferrous Metals: **(5 hrs)**
Important varieties of iron ores. Cast iron: types, properties and uses of cast iron; Pig iron: Types of pig iron. Wrought iron: properties and uses of wrought iron, Steel: factors affecting physical properties of steel and uses of steel (No manufacturing process).

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

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

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

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

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

Polymers & Composites: **(4 hrs)**
Classification of polymers, Properties and engineering usage of Nylon-66, polyesters, polycarbonates, polyurethanes, PVC, polypropylene, polymer composites.

Novel Materials: **(2 hrs)**
Introduction to nano materials and biomaterials and their uses.

BOOKS RECOMMENDED:

1. Patton W J, Materials in Industry, 2nd Ed., Prentice Hall, 1975.
2. Van Vlack L.H., Elements of Material Science & Engineering, 6th Ed., Pearson Education Inc., 2008.

3. Aggrawal B.K., Introduction to Engineering Materials, Tata McGraw Hill, 2008.
4. Narula G.S., Narual K. S., Gupta V.K., Material Science, Tata McGraw Hill, 2007.
5. Bawa HS, Materials and Metallurgy, Tata McGraw Hill, 1986.
6. Callister, W. D., Rethwisch D.G., Materials Science & Engineering- An introduction, 8th Ed., Wiley International, 2010.

COURSE OUTCOMES

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

1. Demonstrate the fundamental concepts of crystal structure.
2. Demonstrate the basic knowledge of ferrous and non-ferrous materials and advanced materials like nano-materials and biomaterials.
3. Distinguish the structure, properties and uses of various types of engineering materials like polymers, metals and ceramics.
4. Demonstrate the knowledge of phase diagrams and their relation to the material properties.
5. Make judicious choice among a range of materials, for various Chemical Engineering applications.

BTCH-405B Numerical Methods in Chemical Engineering

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

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

Introduction & Error analysis: **(3 hrs)**
Introduction to Numerical methods and its significance in chemical engineering, Classification of errors, significant digits and numerical stability.

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

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

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

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

Ordinary Differential Equations (ODE-IVPs) and partial differential Equations: **(8 hrs)**
Finite element method – Galerkin's mehod, Finite difference Technique,
Euler's method, Runge-Kutta method,

Laplace Transforms: **(5 hrs)**
Laplace transforms of various standard functions, properties of Laplace transforms, inverse Laplace transforms, transform of derivatives and integrals, Laplace transform of unit step function, impulse function, periodic functions, applications to solution of ordinary linear differential equations with constant coefficients.

BOOKS RECOMMENDED:

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

6. Rice R.G., Do Duong D., Applied Mathematics and Modelling for Chemical Engineers, John Wiley & Sons, Inc, 1995.
7. Sastry S.S., Introductory Methods of Numerical Analysis, 4th Ed., PHI.
8. Kreyszig, E., Advanced Engineering Mathematics, Eighth edition, John Wiley, New Delhi.

COURSE OUTCOMES

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

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

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BTHU-401B HASS-II

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

Any one subject from AICTE proposed list of Humanities, Social Science including Management Courses (HSMC-**).**

For Batches 2018 & Onwards
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BTHU-401B/HPY-303 APPLICATIONS OF PSYCHOLOGY IN EVERYDAY LIFE

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

COURSE TOPICS:

Unit 1: (4hrs)
Introduction: Nature and fields.

Unit 2: (6hrs)
Psychology in industries and organizations: Job analysis; fatigue and accidents; consumer behaviour.

Unit 3: (8hrs)
Psychology and mental health: Abnormality, symptoms and causes psychological disorders.

Unit 4: (8hrs)
Psychology and Counselling: Need of Counselling, Counsellor and the Counselee, Counselling Process, Areas of Counselling.

Unit 5: (10hrs)
Psychology and social behaviour: Group, group dynamics, teambuilding, Prejudice and stereotypes; Effective Communication, conflict and negotiation.

Text

1. Schultz, D. & Schultz, S.E. (2009). Psychology and Work Today (10th ed.). New Jersey: Pearson/Prentice Hall.
2. Butcher J. N., Mineka S., & Hooley, J. M. (2010). Abnormal psychology (14th ed.). New York: Pearson
3. Gladding, S. T. (2014). Counselling: A comprehensive profession. New Delhi: Pearson Education
4. Aronson, E., Wilson, T. D., & Akert, R. M. (2010). Social Psychology (7th Ed.) Upper Saddle River, NJ: Prentice Hall.

COURSE OUTCOMES

The students would be able to
1) Apply different applications of psychology in industries and organizations,
2) Resolve different social issues, workplace issues, and behavioural issues, and
3) Apply the knowledge gained from this course for enhancing their own personal and professional work life
4) To improve the mental health through counselling.
5) Understand group dynamics and team-work and also to develop ability for effective conflict management .

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BTCH-406B Numerical Methods in Chemical Engineering Lab

LIST OF PROGRAMs:

1. Introduction to use of Software Packages: Matlab for numerical calculations. (2 practical turn)
2. Solution of linear algebraic equations using Gauss elimination, Gauss-Siedel etc. (1 practical turns)
3. Solution of a non-linear equations using bracketing and Newton-Raphson method (1practical turn)
4. Newton forward /backward, Lagrange's interpolation and Approximation (2 practical turns)
5. Numerical integration using Trapezoidal rule, Simpson's 1/3 rule. (1 practical turns)
6. Numerical solution of Algebraic Equation by Regular-falsi and Newton Raphson methods. (2 practical turns)
7. Solution of (IVPs) ODE's using Euler, Predictor-corrector and Runge-Kutta methods (2 practical turn)
8. Solution of simple (BVPs) using finite difference technique (1 practical turns)

Suggested Text Books

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.

Suggested References Books

1. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.
2. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.
3. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.
4. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Course Outcomes

Students will be able to

1. Use programming languages to solve chemical engineering problems involving Linear and non-linear equations.
2. Use programming languages to solve chemical engineering problems involving ODEs and PDEs.
3. Use programming languages to solve chemical engineering problems involving numerical integration and interpolation.
4. To present their results in written form of report.

For Batches 2018 & Onwards
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BTCH-407B Chemical Engineering Lab-II (Thermo & HT lab)

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

LIST OF EXPERIMENTS:

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

COURSE OUTCOMES

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

1. Measure heat transfer coefficients of different flow geometries for different heat transfer conditions.
2. Measure the heat losses and effect of insulation during the heat transfer.
3. Perform the operation of different heat transfer equipments.
4. Measure partial molar properties and validate laws of thermodynamics.
5. To present their results in written form of report.

5th Semester
BTCH-501B Chemical Reaction Engineering-I

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

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

Introduction: **(8 hrs)**
Introduction & importance of Chemical Reaction Engineering, kinetics of homogeneous reactions, concepts of reaction rates, rate equation, rate constant, order & molecularity, mechanism for elementary & non-elementary reactions.

Design for Single Reactions: **(16 hrs)**
Material balance equation for ideal batch reactor and its use for kinetic interpretation of data and isothermal reactor design for simple & complex rate equation. Performance equations for CSTR and PFR and their use for kinetic interpretation and design. Comparison of batch reactor, CSTR & PFR, Recycle reactor, concept of yield & selectivity. Reactor combinations of CSTR and PFR.

Design for Multiple Reactions: **(8 hrs)**
Quantitative treatment of Series & parallel multiple reaction in a batch reactor, CSTR & PFR, Concept of product distribution for multiple reactions.

Temperature & Pressure effects: **(6 hrs)**
Concept of adiabatic & non-isothermal operations, Energy balance equation for Batch, CSTR & PFR and their application to design of reactors, optimal temperature progression, multiple steady states in CSTR.

Non –Ideality: **(10 hrs)**
Basics of non-ideal flow, residence time distribution, States of segregation
Measurement and application of RTD, E-Age distribution function & F-curve and inter-relationship between them, Conversion in non-ideal reactors.

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

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

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

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

BTCH-502B Mass Transfer-II

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

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

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

Simultaneous Heat & Mass Transfer (14 hrs)

Drying of solids:

Rate of drying curves, through circulation drying, Continuous drying, Types of dryers.

Humidification operations:

VLE & Enthalpy of pure substances, Reference substance plots, vapour gas mixtures, concept of adiabatic saturation, psychometric charts, adiabatic operations-humidification water cooling & dehumidification operations.

Equipments: water cooling towers & spray chambers.

Membrane Separations: (6hrs)

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

Liquid-liquid extraction: (10 hrs)

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

Leaching: (8 hrs)

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

Adsorption: (6 hrs)

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

Crystallization: (4 hrs)

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

BOOKS RECOMMENDED:

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

8. Holland, Charles D., Fundamentals and Modelling of Separation Processes, Prentice Hall, Inc. New Jersey.

COURSE OUTCOMES

The students would be able to

1. Apply the concepts of mass transfer to the analysis of drying and humidification.
2. Analyse extraction and leaching operations.
3. Analyse the mass transfer operations of adsorption and crystallization.
4. Analyse the mass transfer operation of membrane separation

BTCH-503B Particle & Fluid Particle Processing

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

Objective: To introduce students to the numerous industrial operations dealing with the particulate solids, their handling in various unit operations, and those in which particle fluid interactions are important. The course addresses fundamentals of fluid-particle mechanics, such as the notion of drag, and builds on those fundamentals to develop design concepts for various industrial processes like packed bed operation, fluidized operations, sedimentation, filtration, separation of solids and fluids, etc..

Characterization and Handling of Solids: (6 hrs)
Characterization of solid particles: Shape, size, specific surface, Particle size distribution. ***Properties of particulate masses:*** Major distinctive properties, pressures in masses of particles, angle of internal friction, angle of repose.
Screening: Capacity and Effectiveness of a screen, calculation of average size of particles in mixture by screen analysis, types of screens.

Agitation and Mixing: (6 hrs)
Agitation of low viscosity particle suspensions: axial flow impellers, radial flow impellers, close-clearance stirrer, unbaffled tanks, baffled tanks, basic idea for designing agitators. Power number, Froude number, power consumption in agitation
Mixing of Solids: Types of mixers, various mixers for cohesive solids, mixing index, axial mixing.

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

Filtration: (6 hrs)
Classification of filtration: Cake filtration, Clarifying filters, liquid clarification, Gas cleaning, Cross flow Filtration, micro filtration
Filtration Equipment: Centrifuges and their selection.

Settling: (6 hrs)
Motion of particles through fluids: Terminal velocity, hindered settling, Stoke's law, Richardson-Zaki equation.
Gravity settling processes: Classifiers, clarifiers, thickeners, flocculation, rate of sedimentation
Centrifugal Settling processes: Principles of centrifugal sedimentation, cyclones, hydroclones, tubular, disk and nozzle discharge centrifugal sludge separators, Centrifugal classifiers.

Flow through Packed Beds (2 hrs)
Ergun equation, Kozeny-Carman equation, Blaine's apparatus.

Fluidization: (4 hrs)
Fluidization and fluidized bed, conditions for fluidization, minimum fluidization velocity, types of fluidization, expansion of fluidized beds and particulate fluidization, continuous fluidization, industrial applications.

Suggested Text Books

1. McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill.
2. Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.

Suggested References Books

1. Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester ; New York, 2008.
2. Allen, T., Powder Sampling and Particle Size Determination, Elsevier, 2003.
3. Masuda, H., Higashitani, K., Yoshida, H., Powder Technology Handbook, CRC, Taylor and Francis, 2006.
4. Vollath, D. Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd Ed., Wiley, 2013.

COURSE OUTCOMES

Students will be able to:-

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

BTCH-504B Chemical Engineering lab-III (Mass Transfer lab)

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

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

COURSE OUTCOMES

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

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

BTMC-501B Essence of Indian Traditional Knowledge

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

The detailed syllabus & course outcomes are same as that specified for Subject Essence of Indian Traditional Knowledge in AICTE model Curriculum for 2018 Batch

*** Satisfactory/Unsatisfactory grade is awarded based upon passing marks scored by the student.**

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

BTMC-502B Constitution of India

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

The detailed syllabus & course outcomes are same as that specified for Subject Constitution of India in AICTE model Curriculum for 2018 Batch

*** Satisfactory/Unsatisfactory grade is awarded based upon passing marks scored by the student.**

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21

BTHU-501B HASS-III (Project Management)

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

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

Small Scale Industries: **(8 Hrs.)**
Definition of Small and Medium enterprises ,Product Range, Relative merits and demerits of SSI and large/medium industries, Characteristics of SSI, Classification and its Importance and advantages.

Growth of SSI: **(12 Hrs.)**
Present status of small scale industry in the country, Trends of growth in India and abroad, Export Potential of SSI, Marketing mechanism of SSI, Future Growth fields of SSI, Problems of SSI, Industry- Academia R&D Regimes in IITs, CSIR etc., Patent Ecosystem in India , Science Parks.

Policies Governing SSI: **(6 Hrs.)**
Resolutions of 1956 and 1977, New Policies for small and Tiny sector, Govt. Incentives, Finance of SSI, Taxation Benefits , Turnkey and other projects , Registration process of SSI.

Feasibility Report Preparation of SSI: **(4 Hrs.)**
Market Analysis, Financial Analysis, Technical Analysis , Economic Analysis , Ecological Analysis and Legal and Administrative Analysis.

Entrepreneurship: **(6 Hrs.)**
Definition of Entrepreneur, Characteristics of Entrepreneurs, Classification of Entrepreneurs, Institutions in Aid of Entrepreneurship development.

BOOKS RECOMMENDED:
1. Geoffery G. Mcredity, Nerson, R.E, Neck, P.A, The Practice of Entrepreneurship, Dialogue Publication, 1982.
2. Chaudhary S., Project Management, Tata McGraw Hill Publishing Co., Ltd., 2004.
3. Desai V., Small Scale Industries and Entrepreneurship Development, Himalaya Publishing House, 2017.
4. Aswathappa, Factory Organisation and Management, Himalya Publishing House.
5. Bhojwani Ramesh, Small, Medium & Large Scale Industries Vol. I & II , Small industry Research Institute Delhi

Course outcomes
Students should be able to
1. Understand the detailed concept of Small Scale Industry (SSI).
2. Analyse and understand the Growth of SSI at Indian and Global level.
3. Understand the policies governing SSI.
4. Apply the knowledge of feasibility report to various SSI.
5. Understand and apply the concept of Entrepreneurship

(Dept. Electives)
BTCH-511B Optimization Techniques

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

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

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

Introduction: **(8 hrs)**
Engineering application of optimization, Design variables, constraints, objective function, variable bounds, statement and formulation of an optimization problem, Examples of chemical engineering Optimization problems, Classification of optimization problems, different optimization algorithms.Optimal Point: Local optimal point, global optimal point and inflection point, Optimality criterion.

Single variable Optimization Techniques: **(8 hrs)**
1. Bracketing method (Bounding phase method).
2. Region elimination methods (Internal halving method, Fibonacci search method, Golden section search method).
3. Point estimation method (Successive quadratic estimation methods).
4. Gradient-based methods (Newton-Raphson method, Bisection method, Secant, Cubic search method.)
5. Root finding using optimization techniques.

Multivariable Optimization Techniques: **(8 hrs)**
1. Optimality criterion – Hessian Matrix and its use in optimization
2. Unidirectional search method.
3. Direct search method (Evolutionary method, Hooke-Jeeves Pattern Search method, Powell's conjugate direction method)
4. Gradient-based methods (Steepest descent method, Newton's method, Marquardt's methods)

Constrained Optimization Algorithms: **(7 hrs)**
1. Kuhn - Tucker conditions
2. Transformation method (penalty function method)
3. Direct search for constrained minimization (variable elimination method, complex search method.)

Linear Programming: **(5 hrs)**
Linear programing problems, Degeneracy, Simplex method of linear programming, dual phase simplex method.

BOOKS RECOMMENDED:
1. Deb K., Optimization for Engg. Design Algorithms and Examples , Prentice Hall of India, 2005.
2. Edgar T.I. & Himmelblau D.M., Lasdon L.S., Optimization of Chemical Processes, McGraw Hill, 2001.

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

COURSE OUTCOMES

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

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

BTCH-512B Plant Utilities

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

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

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

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

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

Compressed Air and Vacuum: **(12 hrs)**
Use of compressed air. Classification of compressors.
Reciprocating compressors-mechanical details, single stage and two stage reciprocating compressor, inter cooler, minimum work input in multistage.
Centrifugal compressor- velocity diagram for centrifugal compressors, dimensional parameters, slip factor, impeller blade shapes, losses in axial flow compressors.

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

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

BOOKS RECOMMENDED:

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

BTCH-512B Enzyme technology

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

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

Kinetics and Mechanism of Enzyme Action: **(10 hrs)**
Nature and function of enzyme., classification of enzymes; quantification of enzyme activity and specific activity. Estimation of Michaelis Menten parameters, Effect of pH and temperature on enzyme activity, kinetics of inhibition. Modeling of rate equations for single and multiple substrate reactions.

Immobilised Enzyme Reactions: **(8 hrs)**
Techniques of enzyme immobilisation-matrix entrapment, ionic and cross linking, column packing; Analysis of mass transfer effects of kinetics of immobilised enzyme reactions; Analysis of Film and Pore Diffusion Effects on Kinetics of immobilized enzyme reactions; calculation of Effectiveness Factors of immobilized enzyme systems; Bioconversion studies with immobilized enzyme packed - bed reactors.

Mass transfer Effects in Immobilised Enzyme Systems: **(12 hrs)**
Analysis of film and Pore diffusion Effects on kinetics of immobilised enzyme reactions; Formulation of dimensionless groups and calculation of Effectiveness Factors Reactor design and analysis for immobilized enzyme reactors

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

Enzyme Biosensors: **(6 hrs)**
Applications of enzymes in analysis; Design of enzyme electrodes and case studies on their application as biosensors in industry, healthcare and environment.

BOOKS RECOMMENDED:

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

6th Semester
BTCH-601B Chemical Reaction Engineering-II

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

The students would be able to:

1. Apply the basics of catalysis and the principles of Reaction Engineering, mass transfer and heat transfer to heterogeneous reactions.

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

BTCH-602B Chemical Process Industries

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

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

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

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

1. Austin G., Shreve's Chemical Process Industries, 5th Ed., Tata McGraw Hill, 1990
2. Rao M.G., Sittig M, Dryden's Outlines of Chemical Technology- for 21st Century, 3rd Ed., Affiliated East West Press Pvt. Ltd., 2008

3. Pandey, G.N., Chemical Technology Volume-I and II, Vikas Publication, 2010
4. Moulijn J.A., Makkee M., Diepen A., Chemical Process Technology, John Wiley, 2001

COURSE OUTCOMES:

Students will be able to:-

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

BTCH-603B Energy Engg. & Pollution Control

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

Conventional Sources of Energy: **(2 hrs)**
Fossil Fuels and their derivative fuels: Coal, Crude, Natural Gas, Shale oil & gas

Solid Fuels- coal: **(6 hrs)**
Classification of coal based upon rank, Seylor's classification, Indian classification
Proximate & ultimate analysis, caking/ coking coals, effect of coal constituents on its properties, carbonization of coal, briquetting, liquefaction of coal- Bergius & Fischer Tropsch process, fluidized bed combustion of coal.

Liquid Fuels- Petroleum Products: **(6 hrs)**
Production and consumption, classification and characteristics of Petroleum crude, Refining products, refining processes – pre-treatment, stabilization, cracking, reforming, petroleum refining in India.
properties and characteristics of Petroleum Products - motor gasoline, aviation gasoline, kerosene, diesel oil.

Gaseous Fuels: **(4hrs)**
Production of producer gas, water gas, coal gas, CNG.
Blast furnace and refinery gases, gases from biomass, LPG.

Non- Conventional Sources of Energy: **(6 hrs)**
Nuclear energy: - Nuclear reactions, fuel materials, moderators, reactors
Solar Energy - Photovoltaic cells, solar collectors, Overview of wind Energy, biofuels- Bio-ethanol & Biodiesel.

Air Pollution: **(12 hrs)**
Ambient air standards
Principal air pollutants and their usual sources, 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 air pollutants- equipment efficiency, gravity settler, cyclone separator, fabric filters, Electrostatic precipitators, scrubbers.

Water Pollution: **(10 hrs)**
Standards *for disposal of* water
Types of water pollutants, their sources BOD and COD, oxygen sag curve, waste water sampling- grab and composite sample.
Waste water treatment:
Primary Treatment through settling techniques and equipments like flocculation, skimming, flotation.
Secondary Treatment: aerobic and anaerobic digestion, activated sludge process, trickle filter and oxidation ponds.

Solid Waste Management: **(2 hrs)**
Sanitary landfill, incineration, pyrolysis.

BOOKS RECOMMENDED:

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

4. Francis, W., Peters M.C., Fuels and Fuel Technology: a Summarized Manual, 2nd Ed., Pergamon Press, 1980.
5. Rao C.S., Environmental Pollution Control Engineering, 2nd Edition, New Age International Pvt. Ltd., 2006
6. Perkins H. C., Air Pollution, McGraw Hill, N.Y., 1974
7. Liptak B.G., Liu D. H. F., Environmental Engineers Handbook, 2nd Ed., CRC Press, 1999
8. Willisamson S.J., Fundamentals of Air Pollution, Addison Wesley Co. N.Y.,1973
9. Nemerow N.L., Liquid Wastes of Industry: Theory, Practices and Treatment, Addison Wesley Co. N.Y., 1971
10. Metcalf and Eddy, Waste-Water Engineering, 4th Edition, Tata McGraw Hill, 2007.
11. Mahajan S. P., Pollution Control in Process Industries, Tata McGraw Hill, 2008.
12. Sincero, A.P., Sincero, G.A., Environmental Engineering, Prentice-Hall of India, 1999.

COURSE OUTCOMES

Students are able to:

1. Demonstrate the knowledge of various conventional fossil fuels and their derivative fuels.
2. Demonstrate the knowledge of nonconventional (renewable) energy resources and techniques to utilize them effectively.
3. Describe the atmospheric dispersion of air pollutants, and perform process calculations of air pollution control devices.
4. Differentiate various types of water pollutants and describe various methods for waste water treatment.
5. Demonstrate the knowledge of the different types of wastes generated in industry, their standards including solid waste management.

BTCH-611B Safety in Chemical Plants

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

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

Introduction **(12 hrs)**
Concept of Loss prevention, acceptable risks, nature of accident process, inherent safety.
Toxicology: Dose versus response, toxicants entry route, models for dose and response curves, TLV and PEL
Industrial Hygiene: Identification, Material safety data sheets, Industrial hygiene evaluation and control

Basics of Fires and Explosion **(6 hrs)**
Fire triangle, definitions, flammability characteristics of liquid and vapours, LOC and inerting, types of explosions, Designs for fire prevention

Hazard identification **(6 hrs)**
Hazard survey, checklist, HAZOP, safety reviews, what if analysis

Risk Assessment **(6 hrs)**
Probability theory, event tree, fault tree and QRA , Dow's fire and explosion index,

Accident Investigations **(6 hrs)**
Case Histories
Bhopal gas tragedy, Flix borough disaster, IOCL disaster, nuclear disaster in Japan in 2011.

BOOKS RECOMMENDED:

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

Course Outcomes:

Students would be able to:-

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

BTCH-612B Corrosion Engg.

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

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

Corrosion **(8 hrs)**
Direct & two stage attack, electrochemical attack, environment conditioning.

Techniques for Corrosion Resistance **(16 hrs)**
Higher corrosion resistance through proper selection of material, isolation of corrosion prone materials form destructive environment, Technologies of anodization, enamelling, rubber lining, glass lining, refractory lining, painting and other surface protective measures.

Corrosion engineering in special applications **(12 hrs)**
Material transport, pumping, filtration, condensation, boiling, riveting, welding, high temperature environments etc.
Cost factor in competitive corrosion prevention/inhibition techniques.

BOOKS RECOMMENDED:

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

BTCH-613B Fluidization Tech.

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

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

Introduction and applications (8 hrs)

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

Behaviour of Fluidised beds (12 hrs)

Gross behaviour of fluidised beds, Minimum and terminal velocities in fluidised beds, Types of fluidisation.

Design of distributors, Voidage in fluidised beds, TDH, variation in size distribution with height, viscosity and fluidity of fluidised beds, Power consumption.

Analysis of bubble and emulsion Phase: Davidson's model, Frequency measurements, bubbles in ordinary bubbling bed model for bubble phase.

Emulsion phase: Experimental findings, Turnover rate of solids. Bubbling bed model for emulsion phase Interchange coefficients.

Flow pattern of Gas and heat & mass transfer in Fluidised beds (10 hrs)

Flow pattern of gas through fluidised beds, Experimental findings, The bubbling bed model for gas interchange, Interpretation of Gas mixing data

Heat and Mass Transfer between fluid and solid: Experiment findings on Heat and Mass Transfer, Heat and mass transfer rates from bubbling bed model.

Heat transfer between Fluidised beds and surface- Experiment finding theories of bed heat transfer, comparison of theories.

Entrainment & Elutriation (6 hrs)

Entrainment of or above TDH, model for Entrainment and application of the entrainment model to elutriation.

High velocity fluidized beds, Circulating fluidized beds, Design of fluidized bed reactors.

BOOKS RECOMMENDED:

1. Kunii D. & Levenspiel O., Fluidization Engineering , 2nd Ed., Butterworth Heinemann, 1991

BTHU- 601B HASS-IV (Process Engg. Economics)

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

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

Cost Estimation: **(7 hrs)**
Factors affecting investment and production costs, Capital investments-fixed investments and working capital. Cost indices. Estimating equipment costs by scaling 6/10 factorrule. Methods for estimation capital investment. Estimation of total product cost, Break even analysis.

Balance sheet and income statement: **(4 hrs)**
Concept of Gross Profit, Net Profit, Return on Investment, Current Ratio, Quick Ratio, Debt-equity ratio

Interest and investment costs: **(5 hrs)**
Simple and compound interest, Nominal and effective rates of interest. Continuous interest, Annuity, Perpetuity and capitalized costs.

Taxes and Insurance: **(3 hrs)**
Types of taxes and tax returns, types of insurance and legal responsibility.

Depreciation: **(5 hrs)**
Types of depreciation, service life, salvage value, present value and methods of determining depreciation, single unit and group depreciation.

Profitability: **(8 hrs)**
Alternative Investments and Replacements: Mathematical methods of profitability evaluation, Cash flow diagrams, Determination of acceptable investments alternative when an investment must be made and analysis with small increment investment, replacement.

IPR and Patent Systems **(4 hrs)**
Intellectual property, IPRs and its types, Patent claims, legal decision making process and ownership of tangible and intellectual property. Indian patent system, current IPR laws and legislations in India for IPR. Documents required for filing patent, infringement of patents and remedies

BOOKS RECOMMENDED:

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

Course Outcomes:

1. The students will be able to prepare and analyze the balance sheet, income statement and estimation of capital investment, total product costs.

2. The students will be able to understand the concept of interest cost, depreciation and taxes.
3. The students will be able to perform profitability and replacement analysis and calculation of single variable optimum cost/profitabilty analysis.
4. The students will be able to understand the concept of Intellectual Property Right (IPR) and Patent system.

BTCH-604B Chemical Engineering Lab –IV
(CRE & Mech. Operations lab)

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

LIST OF EXPERIMENTS

PART A

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.

PART B

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

At least five experiments should be conducted from each part.

COURSE OUTCOMES

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

1. Perform kinetic analysis of reactions using various types of reactors like Batch, PFR and CSTR.
2. Determine the Residence Time Distribution for PFR and Packed Bed Reactor.
3. Determine the operating characteristics of crushing and grinding equipment.
4. Apply various principles of the filtration and analyze working of filtration equipment.
5. Calculate efficiency of various separating equipment.
6. Present results in form of written reports.

BTCH-605B Chemical Equipment Design

External Marks: 20 **L T P**
Internal Marks: 30 **1 0 2**
Total Marks: 50

Prerequisite: The students should have studied Engineering & Solid Mechanics (SOM) as a prerequisite to study this course

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

Students would be able to:

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

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

(7thSemester)

BTCH-701B Process Instrumentation, Dynamics & Control

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

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

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

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

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

Different modes of control and their basic characteristics: **(15 hrs)**
Proportional, Integral and Derivative Control action, Controller characteristics- P, PI & PID controllers, process characteristics and choice of indicating, recording& controlling instruments for chemical industries, Feedback control servo and regulation control. Time domain-closed loop frequency response, optimization of control system response, stability analysis – Routh criteria, Bode plots

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

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

BOOKS RECOMMENDED:

1. Eckman D.P., Industrial Instrumentation, Wiley Eastern, 1974
2. Patranabis D., Principles of Process Control, 2nd Ed., Tata McGraw Hill, 2001
3. Coughanowr D.R., Leblanc S., Process System Analysis and Control, 3rd Ed., McGraw Hill, 2009
4. Stephanopoulos, G., Chemical Process Control - An Introduction to Theory and Practice, 1st Ed., Prentice Hall of India, 1990
5. Peacock D.G., Richardson J.F., Chemical Engineering – Volume 3, 3rd Ed., Butterworth Heinemann, 1994
6. Bequette B.W., Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall, 1998
7. Bequette B. W., Process Control: Modeling, Design and Simulation, Prentice Hall, 2003
8. Pollard, Process Control for Chemical and Allied Industries, Butterworth Heinnemann, 1971.
9. Weber T. W., An Introduction to Process Dynamics &Control, Kreiger Publishing Co, 1988
10. Harriott, P., Process Control, TMH Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2001.

Course Outcomes:

Students will be able to

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

For Batches 2018 & Onwards
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Core Electives-III

BTCH-711B Polymer Science & Reactor Design

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

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

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

Introduction to Polymers: **(4 hrs)**
Classification of polymers, polymerization methods, kinetics of step growth and chain growth polymerization, polymerization techniques: Bulk, Solution, Suspension and Emulsion polymerisation

Polymer properties & their testing: **(10 hrs)**
Number average and weight average molecular weight, significance of molecular weight, determination of molecular weight: viscosity method, light scattering method and gel permeation chromatography method. Glass transition temperature and associated properties, Tensile strength & impact strength and their determination, softening point, heat distortion temperature, resistivity, dielectric constant and electrical breakdown.

Introduction to polymer reactor design: **(4 hrs)**
Ideal Reactors: Design equations for batch, CSTR and plug flow reactor
Reactor Design: meaning, basic factors in reactor design and reactor selection

Reaction Engineering of step growth & chain growth polymerization: **(10 hrs)**
Introduction, analysis of semi batch reactors, MWD of ARB polymerization in homogeneous continuous flow stirred-tank reactors (HCSTRs), advanced stage of polymerization, design of tubular reactors, copolymerization

Emulsion polymerization: **(4 hrs)**
Introduction, kinetics aspects of emulsion polymerization (Smith and Ewart model), emulsion polymerization in homogeneous continuous flow stirred tank reactors (HCSTRSs)

Design of Batch Reactors: **(4 hrs)**
Detailed design of polymerization reactors used for the production of following polymers: Polyvinyl chloride (PVC) and Phenol-formaldehyde

BOOKS RECOMMENDED:

1. Gowariker V.L., Viswanathan N.V. and Sreedhar J., Polymer Science, 1st Ed., New Age International
2. Ghosh P., Polymer Science & Technology of Plastics & Rubber, 3rd edition, Tata McGraw Hill New Delhi, 2010
3. Sinha R., Outlines of Polymer Technology - Manufacture of Polymers, PHI
4. Kumar A. & Gupta R. K., Fundamentals of Polymers, 2nd edition, McGrawHill, 1998.
5. Kumar A. & Gupta R. K., Fundamentals of Polymer Science and Engineering, TataMcGrawHill, New Delhi, 1978.
6. Fogler H. S., Elements of Chemical Reaction Engineering, 4th Ed., Prentice Hall, 2006

Course Outcomes:

Students will be able to:

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

For Batches 2018 & Onwards
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BTCH-712B Heat Exchangers

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

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

Pinch Technology: **(8 hrs)**
Introduction, Basic concept, How it is different than energy auditing, Role of thermodynamic laws, Problem addressed by Pinch technology.

Key Steps of Pinch Technology: **(6 hrs)**
Data extraction, Targeting, Designing, Optimization- Super targeting.

Basic Elements of Pinch Technology: **(6 hrs)**
Grid diagram, Composite curve, Problem table algorithm, Grand composite curve.

Heat Exchanger Network (HEN): **(6 hrs)**
Targeting of Energy, Area targeting, Number of units targeting, Shell targeting, cost targeting.

Designing of HEN: **(8 hrs)**
Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches, Design for threshold problem, Loops and Paths.

Heat Integration of Equipments **(2 hrs)**

BOOKS RECOMMENDED:

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

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

BTCH-713B SEPARATION PROCESSES

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

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

Introduction to Separation Processes **(4 hrs)**

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

Membrane Separations **(8 hrs)**

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

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

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

Sorbents: Adsorbents, Ion Exchangers, Sorbents for Chromatography

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

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

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

Multi component Distillation: **(6 hrs)**

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

BOOKS RECOMMENDED:

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

Course Outcomes

Students will be able to

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

For Batches 2018 & Onwards
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Core Elective - IV

BTCH-714B Petroleum Engg. & Tech

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

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

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

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

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

Crude Distillation (4 hrs)
Atmospheric and Vacuum Distillation Units, Auxiliary equipment such as Desalters, Pipe-Still Heaters etc.

Thermal & Catalytic Cracking Processes (6 hrs)
Visbreaking, Fluid Catalytic cracking and Hydrocracking - Feed stocks — Catalysts - Process variables –Product Recoveries.

Other Conversion Processes (6hrs)
Reforming, Alkylation, Polymerization and Isomerisation .

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

Basic building Block Processes : (4 hrs)
Cracking: Naphtha and Gas cracking for Production of Olefins.
Steam Reforming and Partial Oxidation: Synthesis Gas.
Manufacture of important petrochemicals: LDPE, HDPE, PVC, PET etc.

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

BOOKS RECOMMENDED

1. Nelson, W.L., Petroleum Refinery Engineering, 5th Edition, McGraw Hill, 1985.
2. Hobson, G.D., Pohl. W., Modern Petroleum Technology, 5th Edition, John Wiley, 1984.
3. Guthrie, V.B., Petroleum Products Handbook, McGraw Hill, 1960.
4. Rao, B.K., Modern Petroleum Refining Processes, 6th Edition, Oxford & IBH Publishing Co., 2018.
5. Rao B.K. B, A text on Petro Chemicals, , 5th edition, Khanna Publisher, 5th Edition, , 2004
6.. Steiner H, Industries to Petroleum Chemicals, Pergammon Press,1992.
7 Waddone, A.C. , Chemicals from Petroleum, John Murry, 1988.
8. Top Chev, A.V. Synthetic Materials from Petroleum, Pergammon Press, 1982.

9. Astle M.J., Synthetic Materials from Petroleum, Pergammon Press.

COURSE OUTCOMES

The students will be able to:

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

BTCH-715B Biochemical Engg.

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

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

Introduction to Biochemistry : **(6 hrs)**
Structure and function of carbohydrates, lipids, amino acids and peptides, nucleic acid and nucleotides, proteins, enzymes.

Classification of microorganisms: **(6 hrs)**
Morphological, structural and biochemical characteristics of prokaryotes and eukaryotes.
Microbial nutrients and growth media. Microbial reproduction and growth.

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

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

Sterilization of air and media **(2 hrs)**

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

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

Cardinal rules for Fermentor design, materials of construction. **(4 hrs)**

BOOKS RECOMMENDED:

1. Pelzer M.J., Chan E.C.S. and Kerig N.R., Microbiology, 3rd edition, McGraw Hill Book Co., 1993
2. Stryer L, Freeman W.H., Biochemistry, 5th edition, W.H.Freeman and co, 2002
3. Bailey J.E. & Ollis, D.F., Biochemical Engineering Fundamentals, 2nd edition, McGraw Hill, 1986.
4. Shuler M.L., Kargi F., Bioprocess Engineering: Basic Concepts, 2nd Ed., Prentice Hall, 200
5. Shuichi Aiba, Biochemical Engineering, 2nd edition, Academic Press Inc. New York, 1973

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

BTCH-716B Fuel Cell Technology

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

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

Introduction **(8 hrs)**

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

Fuel Cell Fundamentals **(12 hrs)**

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

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

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

Types of Fuel Cells **(10 hrs)**

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

Relative advantages and disadvantages of the various types of fuel cells

Fuel Cell Systems **(6 hrs)**

Fuel cell stack, engineering issues related to Fuel Cell Technology

Hydrogen as a fuel, availability and engineering issues

BOOKS RECOMMENDED:

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

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

BTCH-702B Chemical Engineering Lab –V
(Process Simulation Lab)

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

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

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

Course Outcomes:

The students will be able to:

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

For Batches 2018 & Onwards
Academic Autonomous Status vide letter No. 22-1/2015(AC)

BTCH-703B Chemical Engineering Lab –VI
(Instrumentation, Dynamics & Control Lab)

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

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

Course Outcomes:

The students would be able to

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

BTCH-704B Chemical Process Plant Design

External Marks: 20 **L T P**
Internal Marks: 30 **1 0 2**
Total Marks: 50

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

Students would be able to:

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

BTCH-705B Project

External Marks: 40	**L T P**
Internal Marks: 60	**0 0 8**
Total Marks: 100	

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

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

The student is to appear in a Viva-Voce Examination

Course Outcomes

The student would be able to

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

For Batches 2018 & Onwards
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BTCH-706B Chemical Engineering Lab –VII
(Chemical Technology & Environmental Engg. Lab)
(Mandatory Non-Credit Course)

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

***Satisfactory/Unsatisfactory grade will be awarded based upon scoring passing marks in the internal assessment.**

Part-A**

1. To perform proximate analysis of a given sample.
2. Determination of HCV and LCV of a given fuel by bomb calorimeter.
3. To determine the acid value of an oil/fat.
4. To determine the saponification value of an oil/fat.
5. To determine the iodine value of an oil/fat.
6. Preparation of urea/phenol -formaldehyde.
7. Preparation of polymer product using Injection moulding.
8. Preparation of compounded polymer sample using two roll mill.
9. Determination of performance of a given polymer sample under tensile loading like stress-strain curve, modulus of elasticity.
10. Preparation of soap by hot & cold process using Mustard oil.

Part-B**

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

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

8th Semester

BTCH-801B Industry/Institutional Internship Training

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

Each student is required to undergo Industrial/Institutional internship Training in a Chemical Engineering based industry/institute for a minimum period of 18 weeks. Students are required to work on Chemical Engineering based projects during the course of their training.

The objective of the Industry/institutional internship training to test the ability of the student to work in the industrial environment by application of the Chemical Engineering principles learnt during the course of their study.

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

List of Open Elective Courses

(i) BTCH-901B Polymer Science & Engineering

(ii) BTCH-902B Project Management

(iii) BTCH-903B Engineering Materials

(iv) BTCH-904B New & Renewable Energy Sources

(v) BTCH-905B Environmental Impact Assessment

BTCH-901B Polymer Science & Engineering

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

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

Introduction to Polymers: **(6 hrs)**

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

Molecular weight & Size of Polymers: **(6 hrs)**

Number average and weight average molecular weight, significance of molecular weight, determination of molecular weight, viscosity method, osmotic pressure, light scattering method, gel permeation chromatography method.

Polymer properties & their testing: **(6 hrs)**

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

Synthesis & Properties of Commercial Polymers: **(6 hrs)**

Manufacture, processing and properties of resins and fibre forming polymers such as phenol formaldehyde, LDPE, HDPE, polypropylene, polyvinyl chloride, polystyrene, polyurethane and polyamides.

Introduction to Rubber & Elastomers **(6 hrs)**

Natural & synthetic rubber, Buna S, Buna N, Butyl rubber, neoprene, thiokols, polyurethane, Fillers, accelerators, activators, antioxidants & other additives.

Polymer Degradation: **(6 hrs)**

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

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

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

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

BTCH-902B Project Management

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

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

Small Scale Industries: **(8 Hrs.)**
Definition of Small and Medium enterprises ,Product Range, Relative merits and demerits of SSI and large/medium industries, Characteristics of SSI, Classification and its Importance and advantages.

Growth of SSI: **(12 Hrs.)**
Present status of small scale industry in the country, Trends of growth in India and abroad, Export Potential of SSI, Marketing mechanism of SSI, Future Growth fields of SSI, Problems of SSI, Industry- Academia R&D Regimes in IITs, CSIR etc., Patent Ecosystem in India , Science Parks.

Policies Governing SSI: **(6 Hrs.)**
Resolutions of 1956 and 1977, New Policies for small and Tiny sector, Govt. Incentives, Finance of SSI, Taxation Benefits , Turnkey and other projects , Registration process of SSI.

Feasibility Report Preparation of SSI: **(4 Hrs.)**
Market Analysis, Financial Analysis, Technical Analysis , Economic Analysis , Ecological Analysis and Legal and Administrative Analysis.

Entrepreneurship: **(6 Hrs.)**
Definition of Entrepreneur, Characteristics of Entrepreneurs, Classification of Entrepreneurs, Institutions in Aid of Entrepreneurship development.

BOOKS RECOMMENDED:
1. Geoffery G. Mcredity, Nerson, R.E, Neck, P.A, The Practice of Entrepreneurship, Dialogue Publication, 1982.
2. Chaudhary S., Project Management, Tata McGraw Hill Publishing Co., Ltd., 2004.
3. Desai V., Small Scale Industries and Entrepreneurship Development, Himalaya Publishing House, 2017.
4. Aswathappa, Factory Organisation and Management, Himalya Publishing House.
5. Bhojwani Ramesh, Small, Medium & Large Scale Industries Vol. I & II , Small industry Research Institute Delhi

Course outcomes
Students should be able to
1. Understand the detailed concept of Small Scale Industry (SSI).
2. Analyse and understand the Growth of SSI at Indian and Global level.
3. Understand the policies governing SSI.
4. Apply the knowledge of feasibility report to various SSI.
5. Understand and apply the concept of Entrepreneurship

BTCH-903B Engineering Materials

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

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

Crystal Structure **(8 hrs)**

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

Ferrous Metals & Non Ferrous Metals **(8 hrs)**

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

Alloys **(4 hrs)**

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

Ceramics **(8 hrs)**

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

Polymers & Composites **(5 hrs)**

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

Novel Materials **(3 hrs)**

Introduction to nano materials and biomaterials and their uses

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

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

1. Demonstrate the fundamental concepts of crystal structure.
2. Demonstrate the basic knowledge of ferrous and Non-Ferrous materials and advanced materials like Nano-materials and Biomaterials.
3. Distinguish the structure, properties and uses of various types of Engg. Materials like Polymers, Metals and Ceramics.
4. Demonstrate the knowledge of Phase Diagrams and their relation to the material properties.
5. Make judicious choice among a range of materials, for various Chemical Engg applications.

BTCH-904B New & Renewable Energy Sources

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

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

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

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

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

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

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

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

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

BOOKS RECOMMENDED:

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

COURSE OUTCOMES

1. The students will get acquainted with Non-Conventional sources of energy technologies.
2. The students will be able to demonstrate the knowledge of various renewable energy technologies and systems.

3. The students will be able to exhibit the knowledge of principles and phenomenon to generate energy from Biomass, Oceans and Wind.
4. The students will be able to elaborate the technologies that are used to harness the power of solar energy, hydel energy, and geothermal energy.

BTCH-905B Environmental Impact Assessment

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

Objective: The objective of this course is to acquaint the students about various types of environmental pollutants, their impact and their assessment technique.

Introduction: **(6 hrs)**
Classification of Pollution and Pollutants, – Evolution of EIA (Global and Indian Scenario)- Elements of EIA — Screening – Scoping - Public Consultation - Environmental Clearance process in India

Air Pollution: **(6hrs)**
Primary and Secondary Types of Pollutants, sulfur dioxide- nitrogen dioxide, carbon monoxide, WATER POLLUTION: Point and Non-point Source of Pollution, Major Pollutants of Water, Impact of pollutants

Solid Waste: **(4 hrs)**
Classification and sources of Solid Waste, Characteristics, effects, e waste, Effects of urbanization on land degradation, pesticide pollution

Noise Pollution: **(4 hrs)**
Sources of Noise, Effects of Noise, Control measures

Impacts of pollutants, types, scale of impact: **(6 hrs)**
Global, local pollutants. Climate change, Ozone layer depletion, Deforestation, land degradation , Impact of development on vegetation and wild life.

Socio-economic impacts: **(6 hrs)**
Impact assessment Methodologies Overlays, Checklist, Matrices, Fault Tree Analysis, Event Tree Analysis- Role of an Environmental Engineer- Public Participation

Standards for Water, Air and Noise Quality: **(4 hrs)**
Environmental Management Plan- EIA- Case studies of EIA

BOOKS RECOMMENDED:

1. A K Srivastava, Environment impact Assessment, APH Publishing, 2014
2. John Glasson, Riki Therivel & S Andrew Chadwick “Introduction to EIA” University College London Press Limited, 2011
3. Larry W Canter, “Environmental Impact Assessment”, McGraw Hill Inc. , New York, 1995.
4. Ministry of Environment & Forests, Govt. of India 2006 EIA Notification
5. Rau G J and Wooten C.D “EIA Analysis Hand Book” Mc Graw Hill
6. Robert A Corbett “Standard Handbook of Environmental Engineering” McGraw Hill, 1999.