Curriculum Undergraduate Programme

B. Tech. Chemical Engineering

(2019 Batch onwards)

Department of Chemical Engineering

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Basis Structure of Curriculum for B.Tech in Chemical Engineering

Sr. No.	Course category	Number of Courses	Number of Credits
1	Common Institute Core Courses (CIC)	-	63
2	Programme Core -Theory and Laboratory (PC)	32	93
3	Programme Electives (PE)	05	15
4	Open Electives (OE)	03	09
Total Credits (I-VIII)		**180**	

III Semester

Code	Course Title	L	T	P	Contact hours	C
CHPC-201	Chemical Process Calculations	3	1	0	4	4
CHPC-203	Fluid Mechanics	3	1	0	4	4
CHPC-205	Chemical Technology-I	3	0	0	3	3
CHPC-207	Mechanical Operations	3	1	0	4	4
CHPC-209	Material Science for Chemical Engineers	3	0	0	3	3
CHPC-221	Fluid Mechanics Lab	0	0	3	3	2
CHPC-223	Mechanical Operations Lab	0	0	3	3	2
Total		**15**	**3**	**6**	**24**	**22**
Total Credits		**22 PC**	**0 PE**	**0 OE**	**0 CI**	**22**

IV Semester

Code	Course Title	L	T	P	Contact hours	C
MACI-202*	Probability and Statistics	3	1	0	4	4
CHPC-202	Chemical Engineering Thermodynamics	3	1	0	4	4
CHPC-204	Heat Transfer	3	1	0	4	4
CHPC-206	Chemical Technology-II	3	0	0	3	3
CHPC-208	Energy Technology	3	0	0	3	3
CHPC-210	Process Equipment Design	1	0	2	3	2
CHPC-222	Chemical Technology Lab	0	0	3	3	2
CHPC-224	Heat Transfer Lab	0	0	3	3	2
Total		**16**	**3**	**8**	**27**	**24**
Total Credits		**20 PC**	**0 PE**	**0 OE**	**4 CI**	**24**

* Syllabus will be provided by respective department.

V Semester

Code	Course Title	L	T	P	Contact hours	C
HMCI-202*	Entrepreneurship Development Management	3	0	0	3	3
CHPC-301	Mass Transfer- I	3	1	0	4	4
CHPC-303	Chemical Reaction Engineering - I	3	1	0	4	4
CHPC-305	Process Engineering and Economics	3	1	0	4	4
CHPC-307	Environmental Engineering	3	0	0	3	3
CHPE-XXX	Departmental Elective-I	3	0	0	3	3
CHPC-321	Environmental Engineering Lab	0	0	2	2	1
CHPC-323	Energy Technology Lab	0	0	2	2	1
CHCI-301	Minor Project, Phase-I	0	0	2	2	0**
Total		**18**	**3**	**6**	**27**	**23**
Total Credits		**17 PC**	**3 PE**	**0 OE**	**3 CI**	**23**

* Syllabus will be provided by respective department.

** Minor Project will be allotted in 5th Semester and evaluation at the end of 6th Sem.

VI Semester

Code	Course Title	L	T	P	Contact hours	C
CHPC-302	Mass Transfer- II	3	1	0	4	4
CHPC-304	Chemical Reaction Engineering-II	3	1	0	4	4
CHPC-306	Process Dynamics and Control	3	1	0	4	4
CHPE-XXX	Departmental Elective-II	3	0	0	3	3
CHOE-XXX	Open Elective -I	3	0	0	3	3
CHPC-322	Mass Transfer Lab	0	0	3	3	2
CHPC-324	Reaction Engineering and Thermodynamics Lab	0	0	3	3	2
CHCI-302	Minor Project, Phase-II	0	0	2	2	2
Total		**15**	**3**	**8**	**26**	**24**
Total Credits		**16 PC**	**3 PE**	**3 OE**	**2 CI**	**24**

VII Semester

Code	Course Title	L	T	P	Contact hours	C
CHPC-401	Transport Phenomena	3	1	0	4	4
CHPC-403	Industrial Safety and Hazards Management	3	0	0	3	3
CHPC-405	Process Plant Design	1	0	2	3	2
CHPE-XXX	Department Elective- III	3	0	0	3	3
CHOE-XXX	Open Elective-II	3	0	0	3	3
CHPC-421	Process Control Lab	0	0	3	3	2
CHPC- 423	Chemical Engineering Computing Lab	0	0	3	3	2
CHCI-425	Summer Training	-	-	-	-	2
CHCI-427	Major Project (Phase –I)	0	0	4	4	0*
Total		**13**	**1**	**12**	**26**	**21**
Total Credits		**13 PC**	**3 PE**	**3 OE**	**2 CI**	**21**

* Major Project will be allotted in 7th Semester and evaluation at the end of 8th semester

VIII Semester

Code	Course Title	L	T	P	Contact hours	C
CHPC-402	Modeling and Simulation	3	0	0	3	3
CHPE-XXX	Department Elective-IV	3	0	0	3	3
CHPE-XXX	Department Elective-V	3	0	0	3	3
CHOE-XXX	Open Elective-III	3	0	0	3	3
CHPC-422	Modeling and Simulation Lab	0	0	3	3	2
CHCI-424	Industrial Lecture	-	-	-	-	1*
CHCI-426	Major Project (Phase –II)	0	0	8	8	4
Total		**12**	**0**	**11**	**23**	**19**
Total Credits		**5 PC**	**6 PE**	**3 OE**	**5 CI**	**19**

* Minimum 4 industrial lecture will be organized by Department in final year of study. Grades to be awarded based upon Quiz test on the same day of lecture

Total Credits (III -VIII)	**93 PC**	**15 PE**	**9 OE**	**16 CI**	**133 Credits**
Total Credits (I-VIII)	**180**				

Note: In laboratory minimum 8 experiments will be conducted.

Program core courses to be offered by Department of Chemical Engineering for Department of Biotechnology:

Code	Course Title	L	T	P	Credit	Semester
CHPC-281	Fluid and Particle Mechanics	3	0	0	3	III
CHPC-282	Heat and Mass Transfer	3	1	0	4	IV
CHPC-481	Instrumentation and Process Control	3	0	0	3	VII
Total Credits		**10**				

DEPARTMENTAL ELECTIVES

Departmental Electives - I, II

Sr. No.	Code	Course Title	L	T	P	Credit
1.	CHPE-351	Computational Fluid Dynamics	3	0	0	3
2.	CHPE-352	Microbiology for Chemical Engineers	3	0	0	3
3.	CHPE-353	Biomass Conversion Processes	3	0	0	3
4.	CHPE-354	Nano Science and Technology	3	0	0	3
5.	CHPE-355	Environment Impact Assessment	3	0	0	3
6.	CHPE-356	Industrial Rheology	3	0	0	3
7.	CHPE-357	Optimization Techniques	3	0	0	3
8.	CHPE-358	Petroleum Recovery Technology	3	0	0	3
9.	CHPE-359	Petroleum Refining Technology	3	0	0	3
10.	CHPE-360	Polymer Science and Engineering	3	0	0	3
11.	CHPE-361	Process Plant Utilities	3	0	0	3
12.	CHPE-362	Process Intensification	3	0	0	3
13.	CHPE-363	Paint Technology	3	0	0	3

Departmental Electives - III, IV, V

Sr. No.	Code	Course Title	L	T	P	Credit
1.	CHPE- 451	Corrosion Engineering	3	0	0	3
2.	CHPE -452	Cement Technology	3	0	0	3
3.	CHPE -453	Energy Management and Audit	3	0	0	3
4.	CHPE- 454	Heterogeneous Catalysis and Reactor Design	3	0	0	3
5.	CHPE- 455	Hydrocarbon Engineering	3	0	0	3
6.	CHPE- 456	Industrial Environmental Management	3	0	0	3
7.	CHPE- 457	Introduction to Multiphase Flow	3	0	0	3
8.	CHPE- 458	Natural Gas Engineering	3	0	0	3

9.	CHPE- 459	New and Renewable Energy Resources	3	0	0	3
10.	CHPE- 460	Petrochemical Technology	3	0	0	3
11.	CHPE- 461	Biochemical Engineering	3	0	0	3
12.	CHPE- 462	Catalysis	3	0	0	3
13.	CHPE- 463	Pressure Driven Membrane Separation Processes	3	0	0	3
14.	CHPE-464	Process Instrumentation and Analytical Methods	3	0	0	3
15.	CHPE-465	Introduction to Colloids and Interfacial Science and Engineering	3	0	0	3
16.	CHPE-466	Fluidization Engineering	3	0	0	3
17.	CHPE-467	Fertilizer Technology	3	0	0	3
18.	CHPE-468	Biorefinery and Bioproducts Engineering	3	0	0	3

OPEN ELECTIVES

List of Open Electives

Sr. No.	Code	Course Title	L	T	P	Credit
1.	CHOE- 401	Hydrocarbon Engineering	3	0	0	3
2.	CHOE-402	Energy Management and Audit	3	0	0	3
3.	CHOE-403	Polymer Science and Engineering	3	0	0	3
4.	CHOE-404	Industrial Safety and Hazards Management	3	0	0	3
5.	CHOE-405	Environmental Engineering	3	0	0	3
6.	CHOE-406	Environment Impact Assessment	3	0	0	3
7.	CHOE-407	Oil and Natural Gas Economics	3	0	0	3
8.	CHOE-408	New and Renewable Energy Resources	3	0	0	3
9.	CHOE-409	Corrosion Engineering	3	0	0	3
10.	CHOE-410	Biorefinery and Bioproducts Engineering	3	0	0	3

Syllabus

Course Code	Course Title	L	T	P
CHPC-201	Chemical Process Calculations	3	1	0

Pre-requisites: Basic Knowledge on mathematics

Course objectives: This course will prepare students to make analysis of chemical processes through calculations, which need to be performed in the chemical processing operations. The students are introduced to the application of laws and also to formulate and solve material and energy balances in processes with and without chemical reactions.

Syllabus:

Introduction to Chemical Engineering Calculations

Units and dimensions, mole concept, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equations and stoichiometry, limiting and excess reactant, conversion and yield.

Material Balance

Material balance, program of analysis of material balance problems, solving material balance problems that do not involve chemical reactions, solving material balances problems involving chemical reactions, multiple subsystems, recycle, bypass, and purge calculations.

Gases Vapors, Liquids and Solids

Ideal gas law calculations, real gas relationships, vapor pressure and liquids, saturation, partial saturation and humidity.

Energy Balance

Concepts and units, calculation of enthalpy changes, application of the general energy balance without reactions occurring energy balances that account for chemical reaction, reversible processes and the mechanical energy balances, heats of solution and mixing, psychometric charts and their use.

Course Outcomes:

1. Understand the material and energy balances of chemical processes.
2. Able to perform material and energy balances on chemical processes/equipment without and with reactions.
3. Able to draw the flow diagram and solve the problems involving recycle, purge and bypass in a process or unit.
4. Understand the ideal and real behavior of gases, vapors and liquids.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√	√	√	√	√				
2	√	√					√	√			
3		√	√	√				√			
4	√	√	√	√	√	√					

Recommended books:

1. Himmelblau D. M., "Basic Principles and Calculations in Chemical Engineering", Prentice Hall, (1998).
2. Haugen O. A., Watson K. M. Ragatz R. A., "Chemical Process Principles (Part-I): Material and Energy Balances", Asia Publishing House, (1995).
3. Bhatt B. I., Vora S. M., "Industrial Stoichiometry", Tata McGraw Hill Publishing, New Delhi, (1987)
4. Reklaitis G. V., "Introduction to Material and Energy Balances", Wiley, New York, (1983)
5. Felder R. M., Rousseau R. W., "Elementary principles of Chemical Processes", 2nd Edition, Wiley, New York, (1986).

Course Code	Course Title	L	T	P
CHPC-203	Fluid Mechanics	3	1	0

Pre-requisites: None

Course objectives: To understand the fundamentals of fluid flow phenomena. Deriving the mass and momentum balance equations from first principles. To learn about the transportation of fluids and flow measuring devices.

Syllabus:

Introduction

Introduction, Ideal and real fluids, Extensive and Intensive Properties, Specific Weight, Mass density and Specific gravity, Viscosity, Surface Tension and Capillarity, Evaporability and Vapour pressure, Newtonian & Non Newtonian fluids.

Fluid statics

Pressure, Hydrostatics law, Pascal's Law, Different types of manometer, Continuous gravity Decanter, Centrifugal decanter and other pressure- measuring equipment's, Determination of meta centric height.

Fluid kinematics and Dynamics

Reynolds transport theorem, Classification of fluid flows, streamline, streak line, and Path lines, Flow rate & continuity equation, Bernoulli's Theorem, Kinetic energy correction factor and momentum correction factor in Bernoulli's equation.

Laminar viscous flow and Flow measurement devices

Flow regimes and Reynolds numbers, Laminar flow in circular pipes (Hagen Poiseuille Law), Orifice meter; Venturimeter; Weirs, concept of area meters: rotameter; Local velocity measurement: Pitot tube. Hot wire anemometer, mass flowmeter.

Hydraulic pumps

Pump Classification & Applications, Centrifugal pumps vs Reciprocating pumps, pump losses and Efficiencies, Multistage pumps, Work and power Input, Cavitation and maximum Suction lift, specific and minimum speed.

Flow around Immersed Bodies

Introducing the concepts of transition and turbulence. Drag force, lift and drag coefficients, drag on Flat Plate, Circular Cylinder and Sphere.

Course Outcomes:

1. After studying this subject, students would be able to measure pressure drop, flow rates etc. for incompressible and compressible fluids.
2. Ability to select pumps, valves, and would be able to calculate power requirement for pumping as well as agitation operations.
3. Ability to analyze the fluid flow problems with the application to the momentum balance.
4. Applying the principles of fluid mechanics to chemical engineering problems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√			√		√				
2	√	√	√		√			√			√
3	√		√					√			
4	√				√			√			√

Recommended books:

1. Smith J. C., McCabe W. L., Harriot P. H., "Unit Operations of Chemical Engineering", McGraw Hill (2001).
2. Frank M. White, "Fluid mechanics", 7th Edition, McGraw Hill (2010).
3. Kumar D. S., "Fluid Mechanics & Fluid power engineering", S. K. Kataria & Sons, (2004).
4. Timoshenko S. P. and Young D. H., "Engineering Mechanics", McGraw Hill, (1937).
5. Perry's, "Handbook of Chemical Engineering", 7th Edition, McGraw Hill, (1997).

Course Code	Course Title	L	T	P
CHPC-205	Chemical Technology -I	3	0	0

Pre-requisites: None

Course objectives: Students will have an insight to the various raw materials, reaction chemistry and processes for the manufacture of Soaps and Detergents, Fertilizers, Caustic soda, Chlorine, Hydrochloric acid, Soda ash, Cement and Glass.

Syllabus:

Soaps and Detergents

Raw materials and Reaction Chemistry, Continuous process for manufacture of fatty acids, soaps and glycerine, Classification of detergents, Builders and additives, Manufacture of detergents like alkyl benzene sulphonate, Sodium alkane sulphonate.

Fertilizers

Status of industry, grading and classification of fertilizers, raw materials, synthesis of ammonia based fertilizers, manufacture of phosphatic fertilizers and phosphoric acid, potash fertilizers, N-P-K values. Corrosion problems and materials of construction.

Chlor Alkali Industry

Electrochemistry of brine electrolysis, current efficiency, energy efficiency, diaphragm cells, mercury cells, mercury pollution and control, membrane cells, caustic soda, chlorine, hydrochloric acid; corrosion problems and materials of construction.

Soda Ash

Manufacturing, Solvay and modified Solvay process, materials of construction environmental considerations and corrosion problems.

Cement

Raw materials, Types of cement, Properties of cement, Manufacture of cement.

Glass

Types of glass, Raw materials and manufacture of glass.

Course Outcomes:

1. Able to analyze the flow of raw materials to finished products quantitatively and qualitatively in each step of process.
2. Able to understand the unit operations and unit processes involved.
3. Able to identify process flow diagrams of different chemical process industries and to understand the various associated engineering problems.
4. Ability to get knowledge on materials of construction and corrosion problems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√	√	√	√					
2	√		√	√	√						
3	√		√	√	√						
4	√	√	√	√	√	√					

Recommended books:

1. Austin G.T., Shreve's Chemical Process Industries - International Student Edition, 5th Edition, McGraw Hill Inc., 1998.
2. Sittig M. and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010.
3. W.V.Mark, S.C. Bhatia “Chemical Process Industries volume I and II”, 2nd Edition 2007
4. Shukla S. D., Pandey G. N., “A text book of Chemical Technology, Vol. I”, Vikas Publishing House Pvt. Ltd., New Delhi.
5. Jacob A. Moulijn, MichielMakkee and Annelies van Diepen , Chemical Process Technology, 1stEdn, 2001.

Course Code	Course Title	L	T	P
CHPC-207	Mechanical Operations	3	1	0

Pre-requisites: None

Course Objectives: The course aims at providing an overview of the approaches, methods and techniques of mechanical operations. The objectives include the understanding of concepts likephysical properties and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, sedimentation, agitation and mixing of liquids, and flow through packed and fluidized beds.

Syllabus:

Size Reduction

Particle size and shape, particle mass, size and shape distributions, measurement and analysis, concept of average diameter, size reduction, crushing, grinding and laws of grinding.

Screening

Screening equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen.

Settling

Flow around a single particle, drag force and drag coefficient, settling velocity of particles in a fluid, hindered and free settling of particles, thickening gravity separation.

Filtration

Classification of filters, various types of cake filters, principle of cake filtration, clarification filters, liquid clarification, centrifugal settling process.

Agitation & Mixing

Agitation of liquids, axial flow impellers, radial flow impellers, velocity and power consumption of agitated vessels, blending & mixing.

Fluidization

Packed beds, bed porosity, flow though a bed of particles, fluidization & fluidized bed, conditions for fluidization, minimum velocity, types of fluidization.

Solid Handling

Flow of solid by gravity, transport of solids by screw/ belt conveyers, cyclones, bag filters, electrostatic precipitators, particulate collection system.

Course Outcomes:

1. The student would understand the physical properties, property measurement and handling of solid-solid and solid-fluid mixtures.
2. The student would understand separation processes for solid-solid and solid-fluid mixtures.
3. To understand the processes involved in agitation and mixing of liquids
4. To understand the working and applications of solid-storage and conveying, and flow through packed and fluidized beds

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√		√	√		√					
2	√	√				√				√	
3	√	√									
4	√			√		√				√	

Recommended books:

1. Smith J. C., McCabe W. L., Harriot P. H., “Unit Operations of Chemical Engineering”, McGraw Hill, (2001).
2. Brown G. G. “Unit Operations”, 1st Edition, CBS Publisher, (2004).
3. Richardson and Coulson “Chemical Engineering Vol II”, 5th Edition, Butterworth–Heinemann, (2002).
4. Perry’s, “Handbook of Chemical Engineering”, 7th Edition, McGraw Hill, (1997).
5. Bhattacharya B. C., Narayanan C. M., “Mechanical Operation for Chemical Engineers”,Khanna Publishers, (1992).

Course Code	Course Title	L	T	P
CHPC-209	Material Science for Chemical Engineers	3	0	0

Pre-requisites: None

Course objectives: To impart the basic concept of material science. To understand the various properties, corrosion and heat treatment of engineering materials. To understand the engineering requirement and selections of materials based on the properties for various applications

Syllabus:

Introduction

Classes of engineering materials - engineering requirement of materials - selection of materials

Structure and Imperfections in Crystals

Crystal structure Crystal geometry, structure of solids, methods of determining structures. Imperfection in crystals - types of imperfection. Point imperfection, diffusion in solids - self diffusion Fick's law, Applications of diffusion.

Properties and Corrosion of Materials

Mechanical, Electrical and magnetic properties of materials - Deformation of materials - Heat Treatment techniques - corrosion, theories of corrosion - control and prevention of corrosion.

Metals

Engineering materials- ferrous metals - Iron and their alloys Iron and steel Iron carbon equilibrium diagram. Non-ferrous metals and alloys - Aluminium, copper, Zinc, lead, Nickel and their alloys with reference to the application in chemical industries. Material of Construction for various reactor vessels and other equipments.

Non Metals

Inorganic materials: Ceramics, Glass and refractories - organic materials: wood, plastics, and rubber and wood - Advanced materials-Biomaterials, nanomaterials and composites with special reference to the applications in chemical Industries.

Course Outcomes:

1. Understand the basics knowledge such as internal structure, crystal geometry, crystal imperfection of the engineering materials.
2. Understand the various properties and corrosion behavior of the selected materials in chemical industries.
3. Able to get experience in the metallic and nonmetallic material selection and handling material in chemical engineering in the areas of equipment design.
4. Able to get knowledge on advanced materials and their application.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√		√		√	√					
2	√	√	√	√	√	√	√				
3	√	√	√	√	√	√	√				
4	√		√	√	√						

Recommended books:

1. Lawrence H. Van Vlack, "Elements of Material Science and Engineering", 1971.
2. S. K. Hajra Choudhury, "Material Science and processes", 1st Edn. , 1977. Indian Book Distribution Co., Calcutta.
3. William D. Callister, "Materials Science and Engineering",7th edn, John Wiley & Sons, Inc.
4. V. Raghavan, Materials Science and Engineering, Prentice Hall.
5. Sidney H Avner, Introduction to Physical Metallurgy, 2nd edition, Mc Graw Hill..

Course Code	Course Title	L	T	P
CHPC-221	Fluid Mechanics Lab	0	0	3

Pre-requisites:	Basic knowledge of Fluid mechanics
Course objectives:	The course aims on the properties of fluids and the energy relationships in fluid systems. The fluid mechanics approach to solve typical problems in turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow, volumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps
List of Experiments:	1. To find coefficient of friction in pipes of different materials. 2. To verify Bernoulli's equation using hydraulic bench. 3. To find losses due to sudden expansion and sudden contraction in pipes. 4. To calculate Reynold's number for laminar and turbulent flow. 5. To calculate metacentric height. 6. To determine volumetric and mass flow rates through the Venturi meter. 7. To determine volumetric and mass flow rates using Orifice meter. 8. To determine the efficiency of a pump. 9. To calibrate and to find mass flow rate through Rotameter. 10. To find the discharge coefiicient of V-notch and rectangular notch.
Course Outcomes:	1. The student must be able to approach and solve typical problems in fluid dynamics at the appropriate level. 2. Students will be able to understand the fluid dynamics and also the principles of turbulent flow, calculation of turbulent boundary layers with pressure gradient, transition from laminar to turbulent flow. 3. Learn tomeasurevolumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pumps. 4. Ability to understand and analyze the applications to industrial flows.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√	√	√					√			√
2	√		√	√	√		√	√			√
3	√		√	√				√			√
4		√	√	√		√		√			√

Recommended books:

1. Smith J. C., McCabe W. L., Harriot P. H., "Unit Operations of Chemical Engineering", McGraw Hill (2001).
2. Lab Manual

Course Code	Course Title	L	T	P
CHPC-223	Mechanical Operations Lab	0	0	3

Pre-requisites: Basic knowledge of mechanical operations

Course Objectives: The course aims at performing the experiments and getting hands-on experience on concepts such as, the properties, size-reduction and handling of solids and solid-fluid mixtures, separation processes for solid-solid and solid-fluid mixtures, concepts of filtration, agitation and mixing of liquids, and packed and fluidized beds

List of Experiments:

1. Determination of power consumption and study of agitation and mixing characteristics of a fluid.
2. Determination of drag coefficient from the plot of drag coefficient vs modified Reynolds number
3. To determine pressure drop through a packed bed: To plot the graph between modified Reynolds no. vs. modified friction factor and verify Ergun Equation in packed column.
4. To find out the collection efficiency of a cyclone separator.
5. Determination of screening efficiency in a vibrating screen.
6. Plate and frame filter press: determination of cake resistance and filter medium resistance.
7. Determination of specific cake resistance in constant pressure vacuum filtrations.
8. To study filtration characteristics of a leaf filter.
9. To study the flow through a helical coil.
10. To study the crushing efficiency of a roll crusher.
11. To study the settling characteristics in a batch settling experiment and use the data to design a thickener for the given flow rate.
12. To determine the critical speed of a ball mill.

Course Outcomes:

1. To experimentally analyze the properties, size-reduction, filtration and handling of solid-solid and solid-fluid mixtures
2. To experimentally analyze separation processes for solid-solid and solid-fluid mixtures
3. To experimentally analyze the parameters involved in agitation and mixing of liquids
4. To experimentally analyze the working and applications of packed and fluidized beds

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√		√			√					
2	√		√			√				√	
3	√		√	√							
4	√		√								

Recommended books:

1. Smith J. C., McCabe W. L., Harriot P. H., "Unit Operations of Chemical Engineering", McGraw Hill, (2001).
2. Lab manuals

Course Code	Course Title	L	T	P
CHPC-202	Chemical Engineering Thermodynamics	3	1	0

Pre-requisites: An introductory background in chemistry, physics and mathematics will be needed.

Course objectives: To introduce the principles of Chemical Engineering Thermodynamics and illustrate their application to design of chemical process plants. To understand the laws of thermodynamics and their applications in the flow/non-flow processes.To familiar with the estimation of volumetric and key thermodynamic properties of real fluids and mixtures, solution thermodynamics, phase and chemical reaction equilibria. To understand the applications phase and reaction equilibria which include liquid-liquid equlibria, vapour-liquid-liquid equlibria, solid-liquid, and solid-vapour equilibria.

Syllabus:

Introduction to Thermodynamics

Introductory concepts: Work, Heat, Reversible and Irreversible Processes; First law of Thermodynamics, Thermodynamics state and state functions, enthalpy, the steady state steady flow process, equilibrium, phase rule, Second law of thermodynamics, Heat engines, Entropy, Entropy changes of an ideal gas, Third law of thermodynamics.

Volumetric properties of pure fluids

PVT behaviour for an ideal gas, Virial equation of state, Applications of Virial equations, Cubic equation of state, Generalized correlations, Acentric factor.

Heat Effects

Sensible Heat Effects, Internal Energy of ideal gases, Latent heat of pure substances, Standard heat of reaction, formation, combustion, Heat of reaction at higher temperature, Heat effects of Industrial reactions.

Thermodynamic Properties of the fluid

Maxwell relations, Residual properties, two phase system, Thermodynamic diagram

Equilibrium and Stability

Criteria of equilibrium, Chemical Potential, Application of equilibrium criteria, Clausiusclapeyon equation.

Phase Equilibria

Fugacity, Determining of fugacity of pure substances, Fugacity in mixture, Ideal solution, Excess properties, andLiquid phase properties from VLE data, Activity coefficients, and coefficient equations.

Chemical Reaction Equilibria

Reaction ordinate for single & multiple reactions , condition of equilibrium for a chemical reactions, Standard states and G, Temperature dependence of the equilibrium constant, Estimation of equilibrium rate constant, Homogeneous gas phase reactions, Heterogeneous chemical equilibrium.

Course Outcomes:

1. Ability to understand the basic concepts of thermodynamic such as temperature, pressure, system, properties, process, state, cycles and equilibrium.
2. Ability to apply the laws of thermodynamics for solving problems related to flow processes and equilibrium systems.
3. Ability to define energy transfer through mass, heat and work for closed and control volume systems.
4. Ability to understand the homogeneous gas phase reactions and heterogeneous chemical equilibrium.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√			√			√		
2	√	√	√	√	√			√		√	
3	√	√	√		√		√				
4	√	√	√								√

Recommended books:

1. S.I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4th Edition, Wiley India, 2006.
2. J.M. Prausnitz, R.N. Lichtenthaler and E.G. Azevedo, Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed.,Prentice Hall, 1998.
3. J.W. Tester and M. Modell, Thermodynamics and its Applications, 3rd ed., Prentice Hall, 1999.
4. R.C. Reid, J.M. Prausnitz and B.E. Poling, Properties of Gases and Liquids, 4th ed., McGraw-Hill, 1987.
5. R. Balzheiser, M. Samuels, and J. Eliassen, Chemical Engineering Thermodynamics, Prentice Hall, 1972.

Course Code	Course Title	L	T	P
CHPC-204	Heat Transfer	3	1	0

Pre-requisites: Knowledge of differential equations.

Course objectives: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries. To learn about the design of heat exchangers and evaporators, reactor heating and cooling systems

Syllabus:

Conduction

Basic law of heat conduction-Fourier's law, thermal conductivity, its dependence on temperature, steady state heat conduction through a composite solid and its electric analogue, steady state heat conduction through cylinders, spheres and variable area of solids, different insulating materials and their applications for process equipment and pipelines, Fourier's law in three dimensions, lumped capacity method of unsteady state conduction.

Convection

Convection heat transfer and the concept of heat transfer coefficient, individual and overall heat transfer coefficient, heat transfer between fluids separated by plane wall, heat transfer between fluids separated by cylindrical wall (pipes), critical/ optimum insulation thickness, heat transfer through extended surfaces.

Forced Convection and Free Convection

Over a flat plate, thermal boundary layer, dimensionless groups and dimensional analysis, Buckingham Pi-theorem, heat transfer correlations- internal and external flows, laminar and turbulent flows. Heat transfer correlations for free convection, free convection from flat surfaces, free convection from a cylinder.

Heat Transfer with phase change

Boiling phenomena and analysis of boiling curve, correlation for nucleate boiling, critical heat flux, condensation phenomena, film condensation on a vertical surface (Nusselt equation, effect of non-condensable gases, drop wise condensation.

Radiation

Basic principle of radiation from a surface, blackbody radiation, Planck's law, Wien's displacement law, the Stefan Boltzmann law, Kirchhoff's law, gray body, radiation exchange between black bodies & gray bodies.

Evaporation

Types of evaporators, single and multiple effect evaporators, capacity and economy, boiling point elevation.

Course Outcomes:

1. Ability to understand and solve conduction, convection and radiation problems.
2. By the end of the subject, students should be able to perform heat flux calculations through constant and variable area elements and estimate optimum insulation thickness.
3. Develop correlations using elementary dimensional analysis and comprehend the laws governing radiation mode.
4. Ability to design and analyze the performance of heat exchangers and evaporators, reactor heating and cooling systems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√							√			√
2		√									
3		√			√			√			√
4					√	√		√	√	√	

Recommended books:

1. J. P. Holman, "Heat Transfer", 9th Edition, Tata McGraw-Hill, New Delhi, (2004).
2. Frank P. Incropera, "Fundamentals of heat and mass transfer" Volume 1, John Wiley, (2007).
3. Frank Kreith, Mark. S. Bohn, "Principles Of Heat Transfer", 4th Edition, Harper & Row Publishers, (1986).
4. D. Q. Kern, "Process Heat Transfer", McGraw Hill Book Co., (1997).
5. J. M. Coulson, J. F. Richardson, "Chemical Engineering" Volume 1, Pergamon Press, (1999).

Course Code	Course Title	L	T	P
CHPC-206	Chemical Technology - II	3	0	0

Pre-requisites:	In continuation with Chemical Technology-I
Course Objectives:	Students will have an insight to the various raw materials, reaction chemistry and processes for the manufacture of Paper, Cane sugar, Polymers, Agricultural residues, Sulphuric acid and Oils and Fats.
Syllabus:	**Regenerated Cellulose** Growth of industry, raw materials, pre-treatment, pulping, manufacture of paper, recovery of chemicals, environmental considerations, viscose rayon. **Cane sugar** Cane production and varieties, manufacturing equipment and technology, cane sugar refining, bagasse utilization, energy requirements and conservation, environmental considerations. **Polymers** Nomenclature of polymers and their classification, modes of polymerization i.e. addition, condensation, step growth and chain growth polymerization, methods of polymerization. Selected industrial polymerization, including plastics, synthetic fibers, synthetic and natural rubbers. **Agricultural Residue Utilization** Availability, Characteristics, energetic, and energy contents, modes of energy recovery, gasification, pyrolysis, deoxygenation, chemicals from agricultural residues. **Sulphuric acid** Raw materials and manufacture of sulphuric acid **Oils and Fats** Status and scope: Major oil seeds production in India; expression, solvent extraction, energy and solvent requirements, minor oil seeds and other oil bearing materials, Hydrogenation of oils.
Course Outcomes:	1. To understand the manufacturing processes in various chemical process industries. 2. To understand the different raw materials, process parameters and industrial variations. 3. Able to identify process flow diagrams of different chemical process industries and to understand the various associated engineering problems. 4. Ability to get knowledge on materials of construction and corrosion problems.

Mapping of course outcomes(CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√				√	√				√	√
2	√	√				√				√	√
3	√					√					√
4	√	√		√	√	√		√	√	√	√

Recommended books:

1. Dryden C. E., "Outlines of Chemical Technology", 2nd Edition, East–West Press Pvt. Ltd., New Delhi, (1973).Austin G. T., "Shreve's Chemical Process Industries", 5th Edition, McGraw Hill Book Company, New Delhi, (1986).
2. Chemical Engineering Education Development Centre "Chemical Technology I, II, III, IV, Manual of Chemical Technology, Indian Institute of Technology, Madras".
3. Shukla S. D., Pandey G. N., "A text book of Chemical Technology, Vol. I", Vikas Publishing House Pvt. Ltd., New Delhi. (1986).
4. Shukla S. D., Pandey G. N., "A text book of Chemical Technology, Vol. II", Vikas Publishing House Pvt. Ltd., New Delhi. (1986).

Course Code	Course Title	L	T	P
CHPC-208	Energy Technology	3	0	0

Pre-requisites: None

Course objectives: The course describes the fundamentals and main characteristics of fossil fuels and alternate energy sources along with their conversion processes.

Syllabus:

Introduction

Energy sources (conventional & non-conventional), renewable energy resources, primary & secondary energy sources, energy chain, energy demand, national energy strategy & plan, world energy scenario.

Solid Fuels

Coal, origin, composition & classification of coal, Properties of coal, classification of Indian coals, petrology of coal,washing of coal, storage of coal. Coal carbonisation, Combustion equipments- Fluidised bed combustion, different types of furnaces, gasification of coal, Lurgi process, Winkler process, Kopper–Totzek process, liquefaction of solid fuels, Overview of thermal plant.

Liquid Fuels

Petroleum and related products, origin, occurrence and reserves, nature of petroleum crudes, classification and characteristics of petroleum, Refining Unit Process: Cracking, Hydrocracking, Reforming, Alkylation, Polymerization, Isomerization. Petroleum products: naphtha, motor gasoline, aviation gasoline, kerosene, diesel oil, gas oil, fuel oil, lubricants, petroleum waxes, petroleum coke. Overview of petroleum refinery.

Gaseous Fuels

Gaseous fuels classification, Wobbe Index natural gas, methane from coal mines, producer, water, carburetted water gas, coal, blast furnace, refinery gases, and LPG.

Alternate Energy Technologies

Nuclear energy-Fission, fusion, nuclear fuel,fast breeder reactor. Solar energy-Solar radiation & related terms, measurement of solar radiation, solar energy collectors, applications & advantages of various collectors. Wind energy-Basic principles, site selection, basic components of wind energy conversion systems (WECS), classification of WECS, Bioenergy-Introduction, classification of biomass, biomass conversion technologies, Ocean energy, Geothermal energy ,Hydroenergy, fuel cell technology and Energy Storage Technologies

Course Outcomes:

1. The students will understand the concepts of coal origin, classification, preparation and their conversion technologies for energy production.
2. Ability to understand different types of unit process involved in petroleum refining.
3. Able to gain knowledge on manufacturing process of gaseous fuels and their utilization.
4. Able to acquire the knowledge on various alternate energy technologies and their importance in fulfilling the present day energy needs.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√			√					
2	√	√	√	√		√					
3	√	√	√	√		√					
4	√	√	√	√							

Recommended books:

1. Gupta O. P., "Elements of Fuels, Furnaces and Refractories", Khanna Publishers
2. Brame J. S., King J. C., "Fuels-Solid, Liquid and Gaseous", St. Martin Press
3. Sarkar S., "Fuels and combustion", Longman publishers India Ltd., 2nd Edition.
4. Energy Technology by Rao & Parulaker.
5. Energy Sources 2nd Ed. by G. D. Rai, Khanna Publications, New Delhi

Course Code	Course Title	L	T	P
CHPC-210	Process Equipment Design	2	0	0

Pre-requisites: Material science and strength of material, basic knowledge of engineering drawing.

Course objectives: This course is deals with the principals involved in the design and construction of equipment. It also provide knowledge of mechanical designs of various equipment.

Syllabus:

Introduction to principles of design

Nature of process equipment, general design procedure, basic considerations in design, standards, codes, and their significance, equipment classification and their selection, design pressure, design temperature, design stress, review of fabrication techniques and environmental considerations in design procedure. Principal stresses, theories of failure. Materials of construction and selection for process equipment, linings and coatings for equipment.

Storage tanks

Various types of storage tanks and applications, Atmospheric tanks, tanks for storing volatile and nonvolatile liquids, storage of gases, Losses in storage tanks, Various types of roofs used for storage tanks, manholes, nozzles and mountings. Design of cylindrical and spherical storage tanks, base plates, shell plates, roof plates, wind girders, curb angles for self-supporting and column supported roofs

Mechanical design

Mechanical design of tall vessels for distillation and absorption columns.

Design of supports

Introduction and classification of supports, design of skirt supports, stresses due to dead weight, wind load, seismic load, and period of vibration, design of base plate, skirt, bearing plate, anchor bolts, bolting chairs, design of bracket supports. Design of saddle supports, ring stiffeners, etc.

Agitators and Reaction Vessels

Types of agitators, their selection, applications, baffling, power consumption which includes twisting moment, equivalent bending moment, design of blades etc.

Reaction vessels

Introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil. Study and design of internal coil reaction vessels, Heat transfer coefficients in coils.

Course Outcomes:

1. Introduce to standards for the mechanical design of equipment used in the process industry.
2. This course enables the students to use the design codes.
3. The students would demonstrate general understanding of fabrication techniques and equipment testing as a designer.
4. Students will able to design, fabricate and identify design problems in industrial equipment based on the knowledge obtained from this course.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓					✓				✓	✓
2	✓	✓		✓		✓		✓	✓	✓	✓
3	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
4	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓

Recommended books:

1. Bhattacharya B. C., "Chemical Equipment Design", CBS Publisher, (1985).
2. Ulrich G. D., "A Guide to Chemical Engineering Process Design and Economics", John Wiley, (1984).
3. Ludwig E. E., "Applied Process Design for Chemical and Petrochemical Plants, Vol. 1, 2 and 3", 3rd Edition, Gulf Publishing Company, Houston, (1995).
4. Perry's, "Handbook of Chemical Engineering", 7th Edition, McGraw Hill, (1997).
5. Sinnott R. K., "Coulson & Richardson's Chemical Engineering, Vol.6", 2nd Edition, Butterworth Heinemann, Oxford, (1998).

Course Code	Course Title	L	T	P
CHPC-222	Chemical Technology Lab	0	0	3

Pre-requisites: Basics knowledge of chemical process

Course objectives: To expose the students on how raw materials are converted into useful products.

List of Experiments:

1. To determine the acid value of a vegetable oil and lubricating oil
2. To determine the saponification value of vegetable oil.
3. To standardize the given Fehling's solution.
4. To estimate the given reducing sugar.
5. To estimate the given non reducing sugar.
6. To analyze the given cement sample.
7. To determine the corrosion rate of a metal using electrochemical method.
8. To determine the viscosity of a given sample by Redwood Apparatus
9. To determine the molecular weight of the given polymer using Ostwald viscometer.
10. To determine adulterants in given food sample.
11. To synthesize urea fertilizer.
12. To determine the potential for electrodeposition of copper.

Course Outcomes:

1. Acquire the knowledge to determine acid and saponification value of given oil sample
2. Able to understand the measurement of various properties like viscosity, Molecular weight using viscometer
3. Acquire knowledge in analysis of cement and preparation of urea**.**
4. Ability to estimate the reducing and non reducing nature of sugar sample, adulteration of food samples and corrosion rate of a metals.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√					√		√			
2	√					√		√			
3	√	√	√			√		√			
4	√	√	√								

Recommended books

1. Lab manuals
2. Dryden C E, "Outlines of Chemical Technology", East –West Press Pvt. Ltd., New Delhi, 2 nd Edition (1973)

Course Code	Course Title	L	T	P
CHPC-224	Heat Transfer Lab	0	0	3

Pre-requisites: Knowledge of heat transfer.

Course objectives: This lab is designed to develop among the students the skills to perform experiments related to the application of heat transfer concepts is conduction, convection and radiation. The students learn about operation of heat exchangers and evaporators. The students learn to record and present their observations in reports.

List of experiments:

1. Determination of thermal conductivity of insulating powder.
2. Determination of thermal conductivity of the given liquid.
3. Determination of heat transfer coefficient by forced convection.
4. Determination of heat transfer coefficient for pin fin by forced convection.
5. Determination of heat transfer coefficient for pin fin by natural convection.
6. Determination of emissivity of the given test plate.
7. To conduct test on heat pipe and comparison of the temperature distribution.
8. Determination of heat transfer coefficient in shell & tube heat exchanger.
9. Determination of overall heat transfer for parallel flow in double pipe heat exchange.
10. Determination of overall heat transfer coefficient for counter flow in double pipe heat exchanger
11. Determination of overall heat transfer coefficient in an open pan evaporator
12. Determination of heat transfer coefficient by drop wise and film wise condensation

Course Outcomes:

1. The students will exhibit the skills of handling equipment at laboratory scale and co-relate the theoretical aspects by performing experiments related to heat transfer.
2. The students will develop the hand experience for industry.
3. Ability to understand, explain and select instrumental for heat transfer analysis.
4. The students will develop the skill of presenting the results in form of written reports.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√						√	√			√
2			√		√			√			
3		√				√		√			√
4									√		

Recommended books:

1. J. P. Holman, "Heat Transfer", 9th Edition, Tata McGraw-Hill, New Delhi, (2004).
2. Lab Manual

Course Code	Course Title	L	T	P
CHPC-301	Mass Transfer- I	3	1	0

Pre-requisites: None

Course objectives: To understand the principles of diffusion, gas absorption, drying and theories of inter phase mass transfer. This basic knowledge will be useful to design various mass transfer equipments.

Syllabus:

Diffusion

Classification of mass transfer operation, choice of separation methods. Diffusion in Mass Transfer: Steady state molecular diffusion in fluids at rest and in laminar flow, molecular diffusion in gases, molecular diffusion in liquids, diffusivity in liquids and gases, momentum and heat transfer in laminar flow.

Mass Transfer Coefficient

Local and overall mass transfer coefficient, heat and mass transfer analogy, eddy diffusivities, film theory, penetration theory, surface renewal theories, combination film theory and surface stretch theory.

Inter phase Mass Transfer

Equilibrium, local two phase mass transfer coefficients, Local overall Mass Transfer coefficients, material balance for co current & counter current processes, cascades and concept of Ideal stage and stage efficiencies, continuous contact equipment's

Gas Absorption

Choice of solvent, Estimation of number of ideal stages – Graphical and Analytical methods, Minimum solvent flow rate, Significance of absorption factor, number of transfer units and height of a transfer unit (NTU & HTU) concepts, packed column for absorption, rate of absorption, height of column based on condition in gas film and liquid film, height based on overall coefficients, equipment for gas absorption.

Drying

Equilibrium in drying, batch drying and rate of batch drying, time of drying, Through circulations drying & continuous drying, batch & continuous drying equipment's.

Course Outcomes:

1. Ability to understand theprinciples of mass transport.
2. The students are able to comprehend the concepts of co current & counter current processes, cascades and concept of Ideal stage and stage efficiencies, continuous contact equipment's.
3. Ability to perform calculations of number of transfer units and height of a transfer unit (NTU & HTU) concepts, packed column for absorption, equipment for gas absorption and batch & continuous drying equipment's .
4. Applying the concepts to mass transport to industrial flows.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√			√	√	√				√
2	√	√			√	√	√				√
3	√	√	√								√
4	√	√	√			√	√				

Recommended books:

1. Treybal R. E., "Mass Transfer Operations" 3rd Edition, McGraw Hill, (1980).
2. Geankopolis C. J., "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition, (2004).
3. Seader J. D., Ernest, J. Henley, "Separation process principles" 2nd Edition, Wiley, (2005).
4. McCabe W. L., Smith J. C. "Unit Operations of Chemical Engineering", McGraw Hill, (2001).
5. Coulson J. M., Richardson J. F. "Chemical Engineering, Vol. 2", McGraw Hill, (1999).

Course Code	Course Title	L	T	P
CHPC-303	Chemical Reaction Engineering - I	3	1	0

Pre-requisites: None

Course Objectives: The course aims to understand the basic concepts of chemical kinetics for different types of reactions. Design of the reactors for homogeneous reactions such as batch, plug-flow and mixed-flow reactors. To understand the effect of temperature and pressure on reaction kinetics. The students learn about the fluid-solid non-catalytic reactions and their reactor design.

Syllabus:

Introduction

Kinetics of homogeneous chemical and biochemical reactions, single and multiple reactions, order & molecularity, rate constant, elementary and non-elementary reactions, temperature dependent term of rate equation.

Interpretation of Batch Reactor Data

Constant volume batch reactor, integral method of analysis of data, series and parallel reactions, reversible reactions, Variable volume batch reactor, Differential methods of analysis, Temperature and reactions rate.

Introduction to Homogeneous Reactor Design

Ideal batch reactor, mixed flow reactor, plug flow reactor, holding and space time, design for single reactions, size comparison (analytical and graphical method, plug flow reactors in series & parallel, mixed reactor in series, recycle reactors.

Design for Multiple Reactions

Reactions in parallel and series in CSTR, reactions in parallel and series in Plug flow reactor, yield & selectivity.

Temperature and Pressure Effects

General design procedure, optimum temperature progression, adiabatic operation, non adiabatic operation.

Non Catalytic Fluid Solid Reactions

Kinetics and Mass transfer, Selection of model, PCM and SCM models, diffusion through gas film control, diffusion through ash layer control, chemical reaction control, Reactor Design.

Course Outcomes:

1. To understand the mechanism of chemical kinetics for different types of reactions
2. To design batch and flow reactors for single homogeneous reactions
3. To understand the factors affecting the conversion, yield and selectivity in multiple reactions
4. To understand solid-fluid non-catalytic reaction kinetics and design of reactors

Mapping of course outcomes(CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		√	√	√							
2	√	√	√	√				√		√	
3		√		√						√	
4	√	√	√	√				√		√	

Recommended books:

1. Levenspiel O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., “Elements of Chemical Reaction Engineering”, 3rd Edition, Prentice Hall Inc., (1999)
3. Smith J. M., “Chemical Engineering Kinetics”, 3rd Edition, McGraw Hill, (1981).
4. Hill C. G., “Chemical Engineering Kinetics and Reactor Design”, John Wiley, (1977).
5. Coulson J. M., Richardson J. F., “Chemical Engineering, Volume 3”, Pergamon Press, (1999). Sons, NY, (1990).

Course Code	Course Title	L	T	P
CHPC-305	Process Engineering and Economics	3	1	0

Pre-requisites: None

Course Objectives: The course aims at understanding the basics of accounting, cost-factors involved in process plant planning, concepts like interests, investments, taxes and insurance, depreciation, profitability, optimum design of operations in chemical plants.

Syllabus:

Cost and Asset Accounting

Assets and Equities, Balance sheet, Income statement, Debits and Credits, Cost accounting methods.

Cost Estimation

Factors affecting investment & production costs, Capital investments (Fixed and working capital), Types of capital cost estimates, Cost Indexes, Estimating equipment costs by scaling 6/10 Factor Rule, Purchase Equipment Installation , Insulation costs, Instrumentation & Control, Piping , Electrical Installation , Service facilities, Land, Engineering & Supervision, Start–up expenses. Methods of Estimating Capital Investment, Estimation of total product cost, Different costs involved in the total product for a typical Chemical Process plant.

Interest and Investment Costs

Types of interest (simple & compound interest), Nominal & Effective Rates of interest, Continuous interest, Present worth & discounts, Annuities, perpetuities, capitalized costs, Interest & Investment costs.

Taxes and Insurance

Types of taxes, Property taxes, excise taxes, income taxes, Types of Insurance & Legal Responsibility.

Depreciation

Purpose of Depreciation as cost, Types of Depreciation, Depletion, Service life., Salvage value, Present value, Methods of determining Depreciation, Straight-line method, Declining Balance Method, Sum of the years Digits method, Sinking Fund Method, Single Unit & Group Depreciation.

Profitability, Alternative Investments & Replacement

Profitability standards, Mathematical methods of profitability evaluation: Rate of return on investment, Discounted cash flow method, Net Present worth, Capitalised costs, pay out period. Determination of Acceptable investment, Alternatives when an investment must be made, Alternative analysis by method of return on incremental investment, Alternative analysis incorporating minimum return as a cost, Replacements.

Optimum Design

General procedure for Determining optimum conditions, Procedure with one variable, Procedure with Two or More variables, Break even chart for production schedule and its significance.

Course Outcomes:

1. To understand the contributing factors leading to cost-estimation of a process plant.
2. To understand concepts like interests, investments, taxes and insurance, depreciation, profitability, and alternative investments.
3. To understand profitability concept and use for alternative investments.
4. To be able to optimally design the plant operation conditions.

Mapping of course outcomess (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√				√				√	
2					√		√			√	√
3				√	√					√	√
4		√		√	√	√				√	√

Recommended books:

1. Douglas, James M., Conceptual Design of Chemical Processes, McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (1988).
2. Biegler, L.T., I.E. Grossmann and A.W. Westerberg, Systematic Methods of Chemical Process Design,
3. Prentice Hall (Pearson Education), New Jersey, USA (1997).
4. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers (5th Ed), McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (2003).
5. Smith, R., Chemical Process: Design and Integration, John Wiley and Sons, WestSussex, UK (2005).

Course Code	Course Title	L	T	P
CHPC-307	Environmental Engineering	3	0	0

Pre-requisites: None

Course objectives:
This course aims at developing the students the environmental impacts of air, water and solid pollution.
This course also aims to develop the basic knowledge about the biomedical, hazardous, and waste management.

Syllabus:

Air Pollution Control Engineering:
Introduction, Definition, Sources, Characteristics and Perspective of Air Pollutants, Effects of Air Pollution on Biodiversity, Economic Effects of Air Pollution, Air Quality and Emission Standards, Engineering Systems of Control of Air Pollution by Equipment and by Process Changes.

Water Pollution Control Engineering:
Introduction, Definition, Sources, Characteristics and Perspective of Water and Wastewater Pollutants, Effects of Water Pollution on Biodiversity, Economic Effects of Water Pollution, Water Quality and Emission Standards, Physical, Chemical and Biological Parameters, Engineering Systems of Control of Water and Wastewater Pollution by Primary, Secondary and Advance Treatment.

Solid Waste Management:
Introduction, Definition, Sources, Characteristics and Perspective of Solid Waste, Generation, Separation, Handling, Storage and Transportation of Solid Waste, Physical, Chemical and Biological Treatment of Solid Waste.

Biomedical and Hazardous Waste Management:
Introduction, Definition, Sources, Characteristics and Perspective of Biomedical and Hazardous Waste, Handling, Storage, Transportation of Biomedical and Hazardous Waste, Physical, Chemical and Biological Treatment of Biomedical and Hazardous Wastes.

Course Outcomes:

1. The students are able to understand the impact of air, water and solid pollution effects on the environment.
2. The students are able to design various engineering systems of control of air, water and solid waste pollution by equipment and by process changes.
3. The students gain the knowledge of different standards for the measure and control of air, water and solid waste pollution in the environment.
4. The students exhibit the skill to solve the problems related to the environmental engineering.

Mapping of course objectives (CO) & program outcomes (PO)

	Program Outcomes										
Course Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√	√	√				√			√	
2	√	√			√			√			√
3	√	√				√			√		
4	√	√		√					√		

Recommended Book

1. Rao M. N., Rao H. V. N., "Air Pollution", Tata McGraw Hill Publishing Company Ltd., (2005).
2. Peavy H. S., Rowe D. R., Tchobanoglous G., "Environmental Engineering", McGraw Hill Book Company, International Edition, (1985).
3. Metcalf and Eddy, Inc., "Wastewater Engineering-Treatment and Reuse", Tata McGraw Hill Publishing Company Ltd., Fourth Edition, (2004).
4. Rittmann B. E., McCarty P. L., "Environmental Biotechnology: Principles and Application", McGraw Hill International Editions, First Edition, (2001).
5. Kiely G., "Environmental Engineering", Tata McGraw Hill Publishing Company Ltd, Special Indian Edition, (2007).

Course Code	Course Title	L	T	P
CHPC-321	Environmental Engineering Lab	0	0	2

Pre-requisites: Basic knowledge of environmental science and technology.

Course objectives: This particular laboratory will give students, the practical knowledge of pollution control measures by performing the experiments in the laboratory.

List of Experiments:

1. To determine the pH of a water sample.
2. To determine the total solids (TS) of a given sample.
3. To find out total dissolved solids (TDS) of a given sample.
4. To find out total fixed solid (TFS) and total volatile solids (TVS) of the given sample.
5. To determine the acidity of the given sample.
6. To determine the alkalinity of the given sample.
7. To determine the total hardness of the given sample.
8. To find out amount of sulfates in a given sample.
9. To estimate the content of chlorides in the given water sample
10. To find the quantity of the dissolved oxygen (DO) present in the given sample.
11. To determine the biochemical oxygen demand BOD of a given wastewater sample.
12. To determine the chemical oxygen demand COD of a given wastewater sample.
13. Determination of dye concentration using UV-VIS spectrometer.
14. Determination of Cr ions concentration in the water sample using double UV-VIS spectrometer.
15. Determination of particulate matter (PM) from air sample.

Course Outcomes:

1. Students will develop the skills to co-relate the theoretical aspects by performing experiments.
2. Students can able to determining various properties contributing towards the water quality such as acidity, alkalinity, hardness, dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand(COD) present in the given sample.
3. Students will be able to distinguish between the poor and good quality of life sustaining elements (water, air and soil).
4. The students will develop the skill of presenting the results in form of written reports.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓	✓		✓	✓	✓	✓				✓
2	✓	✓	✓				✓	✓			✓
3			✓			✓	✓	✓			
4	✓							✓	✓	✓	✓

Recommended books

1. Lab manuals
2. Guide Manual: Water and Waste Water Analysis, Central Pollution Control Board, A Government of India Organization.

Course Code	Course Title	L	T	P
CHPC-323	Energy Technology Lab	0	0	2

Pre-requisites:	Basic knowledge on conventional fuels
Course objectives:	The students will get the practical exposure of calculating different properties like smoke point, flash point, cloud point, pour point, and melting point of the various fuels. Students can also able characterise the solid fuels based on proximate analysis.
List of Experiments:	1. To determine the fire and flash point, of a given sample 2. To determine the Smoke Point of a given sample 3. To study the Distillation of Petroleum Products 4. To determine the calorific value of a fuel using Peroxide Bomb Calorimeter 5. To determine the Cloud Point and Pour Point of a given sample 6. To determine the Melting Point of Petroleum wax 7. To determine the moisture content and Volatile Matter of given solid fuel sample 8. To determine the Ash content and fixed carbon and calculate higher heating value from proximate analysis of given solid fuel sample. 9. To analyze the dry exhaust gas from a combustion system using the Orsat apparatus. 10. To determine the carbon residue using Carbon Residue Apparatus. 11. To determine the Aniline point of liquid fuels. 12. To determine the characteristics of carbonization process with given samples. 13. To determine the characteristics of hydrothermal liquefaction process with given samples. 14. To determine the burning properties of different fuels.
Course Outcomes:	1. The students will able to measure various properties of fuels like flash , fire ,smoke, melting, aniline, cloud and pour point 2. Able to understand the importance of proximate analysis for solid fuels 3. Able to gain knowledge on the application of distillation process 4. Able to analyze the flue gases and determine carbon residue

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√		√	√		√		√			
2	√		√	√		√		√			
3	√		√	√		√		√			
4	√		√	√		√		√			

Recommended books:

1. Gupta O. P., “Elements of Fuels, Furnaces and Refractories”, Khanna Publishers
2. Lab manuals

Course Code	Course Title	L	T	P
CHPC-302	Mass Transfer - II	3	1	0

Pre-requisites: None

Course objectives: To understand the principles of mass transfer operations such as distillation, extraction, leaching, adsorption which has high relevance to industrial applications. This basic knowledge will be useful to design various mass transfer equipment's.

Syllabus:

Distillation

Mass Transfer equilibria for vapour-liquid, liquid-liquid, solid-liquid and solid-gas systems, Raoult's Law and Dalton's law, partial vaporisation and partial condensation, relative volatility, differential distillation & flash distillation, steam distillation, Lewis Sorel and McCabe–Thiele methods & numerical, Ponchon-Savarit method, Underwood and Fenske equations, total reflux , minimum and optimum reflux ratios, multiple feeds and side streams, Azeotropic and Extractive distillation.

Liquid-Liquid Extraction

Ternary phase diagrams & choice of solvent, single stage and multistage cross current, co-current and counter current extraction operation for immiscible and miscible solvents, related numerical problems, continuous contact extractors

Leaching

Mass transfer in leaching, equipment for leaching, single stage and multistage cross current, co-current and counter current leaching operations, related numerical problems.

Adsorption

Introduction and the nature of adsorbent, adsorption equilibria, the Langmuir isotherm, BET isotherm and Gibbs isotherm, potential theory and adsorption equipment

Crystallization

Formation of nuclei, nuclei growth and properties of crystals, effect of impurities on crystals formation, effect of temperature on solubility, caking of crystals, yield of crystals, crystallisers, related numerical problems.

Course Outcomes:

1. Ability to understand the basic principles of distillation, methods and types of distillation
2. The students will be able to apply McCabe Thiele method for determination of number of stages in a distillation column.
3. The students will be able to calculate percentage recovery of solute and number of stages for liquid –liquid extraction operation.
4. Ability to perform calculations of HETP and NTU for the adsorption equipments.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√			√	√					√
2	√	√	√		√			√			√
3	√	√	√			√	√	√			√
4	√	√	√		√	√					√

Recommended books:

1. Treybal R. E., "Mass Transfer Operations" 3rd Edition, McGraw Hill, (1980).
2. Geankopolis C. J., "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition, (2004).
3. Seader J. D., Ernest, J. Henley, "Separation process principles" 2nd Edition, Wiley, (2005).
4. McCabe W. L., Smith J. C. "Unit Operations of Chemical Engineering", McGraw Hill, (2001).
5. Coulson J. M., Richardson J. F. "Chemical Engineering, Vol. 2", McGraw Hill, (1999)

Course Code	Course Title	L	T	P
CHPC-304	Chemical Reaction Engineering - II	3	1	0

Pre-requisites: None

Course Objectives: The course aims to understand the non-ideal flow patterns in reactors, physical properties of solid catalysts, catalytic and non-catalytic heterogeneous systems, effect of external and internal transporton reaction rates and kinetic regimes for fluid-fluid reactions

Syllabus:

Non Ideal Flow

Non-ideal flow patterns, E, F & C Curve, Mean residence time, Models for non-ideal flow, N Tanks in series model, conversion in a reactor using RTD data.

Heterogeneous Processes

Global rates of reaction, Types of Heterogeneous reactions, Catalysis, The nature of catalytic reactions, Mechanism of catalytic reactions. Physical Adsorption and Chemisorption, Adsorption isotherms, Rates of adsorption isotherm.

Solid Catalysts

Determination of surface area, Void volume and solid density, Pore volume distribution, Theories of heterogeneous catalysis, Classification of catalysts, catalyst preparation, Promoter and inhibitors, Catalysts Deactivation

Rate Equations for Fluid solid catalytic reactions

Rates of Adsorption, Surface reaction, Desorption, Rate limiting step, Power Law, Langmuir Hinshelwood rate, Eley-Rideal mechanism, Packed bed reactor and fluidized bed reactor, Numerical Problems

Intra Pellet Mass Transfer

Gaseous diffusion in single cylindrical pore, Different modes of diffusion: Bulk diffusion, Knudsen diffusion and surface diffusion, Diffusion in Liquids, Diffusion in Porous Catalyst, Concepts of effective thermal conductivity and effective diffusivity, Effectiveness factors

Reactors

Types of Packed-Bed, Fluidized-Bed, Slurry and Trickle-Bed Catalytic Reactors, Effect of external mass and heat transfer processes, Global reaction rates

Introduction to Fluid-Fluid Reactions

Kinetic Regimes for Mass Transfer and Reaction, Film Conversion parameter, Clues to the kinetic Regime from solubility data, Clues to the Kinetic Regime from equipment, Applications to design

Course Outcomes:

1. To understand and analyze the non- ideal flow behavior in reactors
2. To understand and analyze the external and internal transport in catalytic reactionsystems
3. To understand physical properties and preparation of solid catalysts.
4. To understand and analyze kinetic regimes in Fluid-Fluid reactions and reactor design

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		√	√								
2	√	√		√							
3		√	√	√		√					
4	√	√		√						√	

Recommended books:

1. Levenspiel O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., “Elements of Chemical Reaction Engineering”, 3rd Edition, Prentice Hall Inc., (1999)
3. Smith J. M., “Chemical Engineering Kinetics”, 3rd Edition, McGraw Hill, (1981).
4. Hill C. G., “Chemical Engineering Kinetics and Reactor Design”, John Wiley, (1977).
5. Froment, G.F. and Bischoff, K. B., “Chemical Reactor Analysis and Design”, 2nd Edition, John Wiley and Sons, NY, (1990).

Course Code	Course Title	L	T	P
CHPC-306	Process Dynamics and Control	3	1	0

Pre-requisites: Basic knowledge of mathematics, mass and energy Balance

Course objectives: The course aims to analyse of the response of chemical process systems in terms of block diagram and the stability of the process. The students will be able to analyse the dynamic behaviour of first and second order processes and various controllers used in chemical process industries.

Syllabus:

Modeling Tools for Process Dynamics

Process Dynamics of Chemical Process, Mathematical Tools for Modeling: Transforms of Simple Function, Transforms of Derivative, Initial Value Theorem and Final Value Theorem, Transform of Integral.

First Order Systems

Mercury Thermometer & Its Transfer Function, Transient Response, Forcing Functions, Liquid Level System, Liquid Level Process with Constant Flow Outlet, Mixing Process, Linearization, Response of First Order System in Series: Non-Interacting and Interacting Systems.

Higher Order Systems and Transportation Lag

Transfer Function of Second Order System, Response of Second Order System to Forcing Functions Namely Step, Impulse and Sinusoidal. Transportation Lag.

Controllers and Final Control Elements

Mechanisms of Control Valve, Proportional Controller, Integral & Derivative Controller.

Control System

Components of a Control System: Process, Measuring Element, Controller and Final Control Element, Development of Block Diagram.

Transient Response of Simple Control System

Proportional Control for Set Point Change, Proportional Control for Load Change, Proportional Integral Control for Load Change, Proportional Integral Control for Set Point Change, Proportional Control System With Measurement Lag

Stability of the System

Concept of Stability, Stability Criteria, Routh Test for Stability. Introduction to Frequency Response: Bode Diagram for First Order, Bode Diagram for Proportional, Integral and Derivative Control, Second Order System. Control System Design by Frequency Response: Bode Stability Criteria, Gain and Phase Margin, Ziegler Nichols Controller Settings.

Introduction to Advanced Control

Feed Forward Control, Cascade Control, Dead Time Compensation, Controller Tuning

Course Outcomes:

1. To understand the chemical process in terms of block diagram
2. The students will able to understand the effect of various forcing function on first and higher order systems.
3. The students will able to understand the transient response of various controllers.
4. The students can identified the stability of control systems and be able to design the control system for chemical and allied industries.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓					✓	✓	✓			
2		✓		✓		✓	✓	✓			
3		✓		✓				✓			
4	✓			✓				✓			

Recommended books:

1. Coughanower D. R., "Process System Analysis and Control", 2nd Edition, McGraw Hill. (1991).
2. Seborg, E., Mellichamp, "Process Dynamics & Control", 2nd Edition, John Wiley, (2004).
3. Stephanopoulos, "Chemical Process Control-An Introduction To Theory & Practice",1st Edition, Prentice Hall Inc.
4. Eckman D. P., "Industrial Instrumentation", Wiley Eastern Ltd., (1975).
5. Kerk F. W., Rimboi W., Tarapore R., "Instrumentation", Wiley and Sons, (1983).

Course Code	Course Title	L	T	P
CHPC-322	Mass Transfer Lab	0	0	3

Pre-requisites: Basic knowledge of mass transfer operations

Course objectives: The course aims that thestudents will get the experimental exposure of different mass transfer operations such as diffusion, extraction, drying, etc. In addition, the students learn to record and present the observations made through experiments.

List of experiments:

1. To plot the ternary phase diagram for acetic-acid–water Toluene.
2. To draw the tie line and to determine plait point for ternary system.
3. To determine the diffusivity of acetone in air.
4. To study the drying characteristics of the given wet material (Natural Convection).
5. To determine the Mass Transfer Coefficient for vaporization of naphthalene in air..
6. To verify Rayleigh's Equation for Batch distillation**.**
7. To find HETP and HTU for packed distillation column.
8. To purify turpentine oil having high boiling point using steam distillation.
9. To determine VLE data for methanol–water and to compare it with literature data.
10. **10.** To determine the mass transfer coefficient by carrying out liquid-liquid extraction in a packed column using acetic acid- toluene-water system.
11. To study the drying characteristics of the given wet material (forced convection).
12. To study the process of crystallization in an agitated batch crystallizer and to plot a graph between weight of crystals vs. temperature.
13. To find out mass transfer coefficient in a drop wise liquid–liquid extraction.
14. To Study the Heat and Mass Balance in Cooling Tower.

Course Outcomes:

1. The students will develop the skills to handle the equipment's at laboratory scale.
2. Ability to co-relate the theoretical aspects by performing experiments related to mass transfer operations.
3. The knowledge related to distillation column, liquid-liquid extraction in a packed column, agitated batch crystallize, liquid-liquid extraction and heat and mass balance in cooling tower can lead to design of the experiments.
4. Ability to understand and analyze the applications to industrial flows.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√	√	√		√	√	√	√			√
2	√	√	√		√	√		√			
3		√	√			√		√			
4	√	√	√				√	√			√

Recommended books:

1. Treybal R. E., "Mass Transfer Operations" 3rd Edition, McGraw Hill, (1980).
2. Lab manuals

Course Code	Course Title	L	T	P
CHPC-324	Reaction Engineering and Thermodynamics Lab	0	0	3

Pre-requisites:	Knowledge of chemical reaction engineering and thermodynamics
Course Objectives:	The course aims at performing the experiments, estimation of reaction kinetics, porosity and sphericity of catalyst, residence time distribution, and validation of adsorption isotherms.
List of Experiments:	1. Determination of rate constant for saponification reaction in a batch reactor. 2. Determination of rate constant for saponification reaction in a plug-flow reactor. 3. Determination of porosity and sphericity of the given catalyst. 4. RTD study in a packed bed reactor. 5. To study the adsorption of acetic acid on charcoal and prove the validity of Freundlich and Langmuir adsorption isotherm. 6. To study the adsorption of oxalic acid on charcoal and prove the validity of Freundlich and Langmuir adsorption isotherm. 7. To analyse the effect of temperature on rate constant in a batch reactor 8. To study the kinetics for dissolution of benzoic acid in water 9. To determine the rate constant for hydrolysis of ethyl acetate using hydrochloric acid as a catalyst 10. To study the kinetics of methanol oxidation in a methanol-based fuel cell. 11. To study the kinetics of water splitting in a photo-electrochemical cell. 12. To determine VLE data for methanol–water and to compare it with literature data. 13. To find the dryness fraction of steam using calorimeter 14. To study the effect of molar ratio on rate kinetics for a second order reaction in a batch reactor
Course Outcomes:	1.Ability to understand and analyze the rate kinetics for the given reaction 2. Ability to analyze the properties of solid catalyst particles 3. To analyze the residence time distribution curve in a packed-bed reactor 4.To experimentally verify the adsorption isotherms 5. To study the reaction kinetics in a fuel cell and a photo-electrochemical cell.

Mapping of course outcomes(CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		✓	✓	✓				✓			
2		✓	✓	✓				✓			
3	✓	✓	✓	✓				✓			
4		✓	✓	✓				✓			

Recommended books:

1. Levenspiel O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley & Sons, Singapore, (1999).
2. Lab manuals

Course Code	Course Title	L	T	P
CHPC-401	Transport Phenomena	3	1	0

Pre-requisites: Knowledge of fluid mechanics, heat transfer, mass transfer and engineering mathematics.

Course objectives: Transport phenomena is the subject which deals with the different transport processes such as momentum, energy and mass, ubiquitous in industry as well as in nature. Momentum, heat and mass transfer are taught together due to the underlying similarities of the mathematics tools and molecular mechanisms describing such processes. The students will be made aware of the core scientific connections and will be encouraged to solve problems based on relevant analogies.

Syllabus:

Momentum transport

Viscosity and the mechanism of momentum transport, Newton's law of viscosity, non-Newtonian fluids, pressure and temperature dependence of viscosity, theory of viscosity of gases at low density, theory of viscosity of liquids.

Velocity distributions in laminar Flow

Shell momentum balances: boundary conditions, flow of a falling film, flow through a circular tube, flow through an annulus, adjacent flow of two immiscible fluids.

The Equations of change for isothermal systems

To equation of continuity, the equation of motion, the equation of mechanical energy.

Thermal conductivity and the mechanism of energy transport

Fourier's Law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids, theory of thermal conductivity of gases at low density, theory of thermal conductivity of liquids, thermal conductivity of solids.

Temperature distributions in solids and in laminar flow

Shell energy balances; boundary conditions, heat conduction with an electrical heat source, heat conduction with a chemical heat source, heat conduction through composite walls: Addition of Resistance, Forced Convection, Free Convection.

The Equations of change for non-isothermal systems

The equations of energy, the energy equation in curvilinear coordinates, the equations of motion for forced and free convection in nonisothermal flow, summary of the equations of change, use of equation of change to set up steady–state heat transfer problems.

Diffusivity and the mechanism of mass transport

Definition of concentrations, velocities and mass fluxes, fick's law of diffusion, theory of ordinary diffusion in gases at low density, theory of ordinary diffusion in liquids.

Concentration distributions in solid and in laminar flow

Shell mass balances: boundary conditions, diffusion through a stagnant gas film, diffusion with heterogeneous chemical reaction, diffusion with homogeneous chemical reaction, diffusion into a falling liquid film l forced–convection mass transfer, Analogies between Heat, mass and momentum and transfers.

Course Outcomes:

1. Understanding of transport processes.
2. Ability to do heat, mass and momentum transfer analysis.
3. Ability to analyze industrial problems along with appropriate boundary conditions.
4. Ability to develop steady and time dependent solutions along with their limitations.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√				√		√		√		√
2	√	√					√	√	√		√
3				√		√				√	
4								√	√		

Recommended books:

1. R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, 'Transport Phenomena', 2nd Edition., John Wiley & Sons, (2002).
2. Christie John Geankoplis, "Transport Processes and Separation Process Principles", 4th Edition, PHI Learning Private Limited., (2013).
3. K. S. Gandhi, "Heat and Mass Transfer A Transport Phenomena Approach" New age international (P) Limited (2012).
4. J. R. Welty, R. E. Wilson, C. E. Wicks, "Fundamentals of Momentum, Heat and Mass Transfer", 4th Edition, John Wiley and Sons (2001).
5. W. J. Thomson, "Introduction to Transport Phenomena", Pearson Education Asia, (2001).

Course Code	Course Title	L	T	P
CHPC-403	Industrial Safety and Hazards Management	3	0	0

Pre-requisites:	Transport Phenomena, Mechanical Unit Operation, Process Control
Course objectives:	The objective of the course is to impart knowledge to the students about source of hazards and control techniques. The course briefs the basics of fire, explosion and toxic dispersion modeling.
Syllabus:	**Introduction** Concept of Loss Prevention, Acceptable Risks, Accident And Loss Statistics, Nature of Accident Process, Inherent Safety. **Toxicology** Dose Vs. 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** Fire Triangle, Flammability Characteristics of Liquid and Vapors, LOC and Inerting, Types of Explosions, Designs for Fire Prevention and Control **Hazard Identification** Hazard Survey, Checklist, HAZOP, Safety Reviews, Reliefs and Relief Sizing **Risk Assessment** Probability Theory, Event Tree, Fault Tree, QRA and LOPA, Dow's Fire and Explosion Index, Mond Index, Dow's Chemical Release Model **Accident Investigations and Case Histories** Bhopal Gas Tragedy, Flixborough Disaster, Fukushima Daiichi Explosion, IOCL Jaipur Fire
Course Outcomes:	1. The students are able to understand the concept of loss prevention in Chemical Process Industries, hazard models such as pool fire, fireball, toxic dispersion etc. 2. Able to calculate the accident and loss statics for the real plant units. 3. The students learn to exhibit the skill of performing risk assessment such as conducting Dow's fire and Explosion index for the real plant units. 4. Able to design the fire prevention and control systems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	✓					✓					✓
2	✓	✓				✓					✓
3		✓		✓		✓					✓
4		✓				✓					✓

Recommended books:

1. Crowl D. A., Louvar J. F., "Chemical Process Safety Fundamentals with applications", 2nd Edition, Prentice Hall, NJ (2002),
2. Coulson J. M., Richardson J. F., "Chemical Engineering", 2nd Edition, Vol. 6, Pergamon Press (1999).
3. Lees F. P., Loss Prevention in Process Industries, 2nd Edition, Butterworth, London, (1996).
4. Dow's Chemical Exposure Index Guide, Dow Chemical Company, New York, (1993).
5. Wells G. L, Safety in Process Plant Design, George Godwin Ltd., New York, (1980).

Course Code	Course Title	L	T	P
CHPC-405	Process Plant Design	1	1	0

Pre-requisites: Basic knowledge of Fluid flow, heat transfer and engineering mathematics.

Course objectives: The course objective is to give knowledge to the students about design of various equipment's like heat exchangers, distillation columns, packed towers and other process equipment's. It also helps the students in design and construction of the newly designed plants

Syllabus:

Introduction

Basic considerations in chemical engineering plant design, optimization and feasibility of plant design.

Process Design Aspects

Selection of process-factors affecting process selection. Types of project design, Importance of Laboratory development pilot plant, safety factors, types of flow diagrams.

Selection of Process Equipment's

Standard versus special equipment-material of construction for process equipment's, selection criteria, and specification sheets.

Heat Exchanger Design

Classification of shell and tube heat exchanger, material of construction, cleaning of heat exchangers, heat transfer fluid, agitated vessels, description of shell, tubes, bonnet and channel, pass partition plate, nozzle, baffles, tie rods, baffle spacers, flanges, gaskets and expansion joints. Design of heat exchangers: Energy balance, heat duty consideration and process design of double pipe and shell and tube heat exchangers.

Mass Transfer Equipment's

Types of mass transfer equipment, packed and tray type towers. Tray Hydraulics : Bubble cap columns, perforated plate columns and packed towers. Process Design **:** Process design of tray and packed towers.

Course Outcomes:

1. The students are able to handle the design of various typical chemical based equipment's like heat exchangers, distillation columns etc.
2. The students would also able to make plant layout of the newly developed plants and prepare written reports of design problems.
3. Ability to understand, explain chemical process plant.
4. The students will develop the skill of presenting the data in correct form.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√					√					√
2		√	√	√					√		√
3			√	√	√	√	√	√			
4									√	√	

Recommendedbooks:

1. D. Q. Kern, "Process Heat Transfer", McGraw Hill, (2001).
2. E. E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Vol. 1, 2 and 3, 3rd Edition, Gulf Publishing Company, (1995).
3. J. M. Coulson, R. E. Richardson, "Chemical Engineering" Vol. 2 and 6, Pergamon Press, (1998).
4. M. Van Winkle, "Distillation", 1st Edition, McGraw Hill Company, New York, (1967).
5. Robert H Perry's, "Handbook of Chemical Engineering" McGraw Hill, 7th Edition, (1997).

Course Code	Course Title	L	T	P
CHPC-421	Process Control Lab	0	0	3

Pre-requisites:	None
Course objectives:	The students will get the experimental exposure of chemical processes like mercury thermometer, liquid level tank, non-interacting and interacting tanks, controllers etc and their analysis.
List of experiments:	1. Determination of first order response of the given mercury thermometer 2. Determination of time constant of U tube manometer 3. Determination of first order response in a liquid level tank 4. Determination of time constant in a non-interacting tank 5. Determination of time constant in a interacting tank 6. To study the ON/OFF characteristics of Control valve 7. To study the Linear characteristics of Control valve 8. To study the Equal Percentage characteristics of Control valve 9. To study the P,PI,PID controller with liquid level control trainer 10. To study the P,PI,PID controller with temperature control trainer
Course Outcomes:	1. The students will develop the skills to handle the equipments at laboratory scale. 2. Able to co-relate the theoretical aspects by performing experiments of process control i.e. liquid level tank and control valve characteristics. 3. Experimental exposure to the first and second order process systems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	✓		✓					✓			✓
2	✓	✓	✓	✓				✓			✓
3	✓		✓					✓			✓

Recommended books:

1. Coughanower D. R., "Process System Analysis and Control", 2nd Edition, McGraw Hill. (1991).
2. Lab manuals

Course Code	Course Title	L	T	P
CHPC-423	Chemical Engineering Computing Lab	0	0	3

Pre-requisites: Knowledge of differential equations.

Course objectives: This course has been designed to develop the understanding the computational methods to solve the problems related to the chemical engineering applications. The students are exposed to learn the basic principles, and logical skills in solving the problems using computational methods.

Syllabus:

1. Estimation of Molar Volume and Compressibility Factor from Van Der Waals.
2. Estimation of Molar Volume and Compressibility Factor from Redlich-Kwong.
3. Fitting Polynomials and Correlation Equations to Vapor Pressure Data.
4. Fitting Parameters in the Monod Equation for a Batch Culture.
5. Estimation of Vapor Pressure Correlation by Clapeyron and Antoine Equations.
6. Gas Volume Calculations Using Various Equations of State.
7. Estimation of specific volume of a non-ideal gas following Van der Waals equation by solving non-linear equation using Newton Raphson Method.
8. Bubble Point Calculation for an Ideal Binary Mixture.
9. Dew Point Calculation for an Ideal Binary Mixture.
10. Estimation of Adiabatic Flame Temperature in Combustion.
11. Estimation of Antoine Equation Parameters Using Nonlinear Regression.
12. Calculations involving Flash Evaporation of an Ideal Multicomponent Mixture.
13. Solution of simultaneous material balance equations using Gauss Jordan elimination method.
14. To study the transient behaviour of Continuous stirred tank reactor.
15. Numerical integration over batch reactor to find time using Simpson's rule/ trapezoidal rule.

Course Outcomes:

1. The students would be well versed with the principles of computing methods with the theory involved in the solving the chemical engineering problems.
2. The students would be able to independently solve the problems in the chemical engineering and would be aware about its applications.
3. Able to convert any chemical engineering problems in mathematical forms.
4. Ability to understand and solve the numerically chemical engineering problems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√			√	√			√			√
2		√					√				√
3									√		
4			√	√				√	√		

Recommendedbooks:

1. S. K. Gupta," Numerical Methods for Engineers", Wiley Eastern, (1995).
2. P. Abuja, "Introduction to Numerical methods for chemical engineering", PHI learning Pvt, (2006).
3. S. C. Chapra, R.P. Canale, "Numerical Methods for Engineers", 5th Edition; McGraw Hill(2006).
4. A. Gourdin, M Boumhrat; "Applied Numerical Methods" Prentice Hall India, (2000).
5. .G. M. Philips, P. J. Taylor, "Theory and Applications of Numerical Analysis",2nd Edition., Academic Press (1996).

Course Code	Course Title	L	T	P
CHPC-402	Modeling and Simulation	3	0	0

Pre-requisites: Knowledge of Chemical Process Calculations, Heat Transfer, Mass Transfer, Chemical Reaction Engineering

Course Objectives: The course aims at developing the ability of students in mathematical treatment of chemical engineering processes. The objective is to understand the basic concepts of process modeling and simulation. Starting from formulation of the model, the course presents several processes from chemical engineering, where simulation approaches and mathematical tools are discussed.

Syllabus:

Introduction

Definition of mathematical model, lumped parameter models, distributed parameter models, uses of mathematical models, scope of coverage, principles of formulation.

Fundamental laws

Continuity equations, energy equations, equation of motion, equations of state, equilibrium, chemical kinetics

Mathematical Models for Chemical Engineering Systems

Series of isothermal constant holdup CSTRs, CSTRs with variable holdups, Two heated tanks, Non-isothermal CSTR, Single component vaporizer, Batch reactor, Ideal binary distillation column, Batch distillation with holdup, pH systems, Lumped parameter model of gas absorber, Model for heat exchanger, Model for interacting & non-interacting tanks, Model for biochemical reaction.

Simulation

Approach and common numerical methods, simulation examples of isothermal CSTR, non-isothermal CSTR, Batch reactor

Course Outcomes:

1. The student would understand the basic concepts of process model formulation, analysis of variables, parameter estimation and simulation with mathematical techniques
2. The student would understand the basic laws of chemical engineering and their mathematical treatment, leading to model development.
3. The student would get familiar with common mathematical and computational tools for simulation of different chemical engineering processes

Mapping of course outcomes(CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√		√				√		√	√
2		√		√							√
3		√		√				√		√	√

Recommended books:

1. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", International Edition, McGraw Hill, (1990).
2. Rose L. M., "The Application of Mathematical Modelling to Process Development and Design", First Edition Applied Science Publisher Limited, London, (1974).
3. Bequette, "Process Dynamics- Modelling, Analysis and Simulation", PHI International, (2003).
4. Rase H. F., "Chemical Reactor Design for Process Plants, Vol II: Case Studies and Design Data", 1st Edition, John Wiley and Sons, New York, (1997).
5. Morton D. M., "Process Modelling", First Edition, Longman Publisher, (1986).

Course Code	Course Title	L	T	P
CHPC-422	Modeling and simulation Lab	0	0	3

Pre-requisites:	Fluid mechanics, Heat Transfer, Mass Transfer and Chemical Reaction Engineering
Course objectives:	This course aims at developing amongst the students the simulation techniques for solving mathematical models of chemical engineering processes by means of computer programming. These models are reduced into set of equations solvable by numerical methods and then solved with the help of software packages.
List of experiments	1. Modeling and Simulation of Isothermal CSTR 2. Modeling and Simulation of non-isothermal CSTR 3. Modeling and Simulation of isothermal batch reactor 4. Modeling and Simulation of non-isothermal batch reactor 5. Modeling and Simulation of distillation column 6. Modeling and Simulation of heat exchanger 7. Modeling and Simulation of cyclone separator 8. Modeling and Simulation of CSTRs in series 9. Simulation of pipe flow problem 10. Simulation of heat transfer in metal pipe/blocks for various types of boundary conditions. 11. Simulation of settling of solid particle in fluid. 12. Generation of velocity profile and shear stress profile for various fluids under laminar conditions. 13. Simulation of 2-dimensional heat transfer in metal block. 14. Simulation of drying behaviour of wet solid.
Course Outcomes:	1. The student is able to incorporate his entire knowledge of chemical engineering principles to an industrial or academic problem. 2. The students to show their abilities to exhibit experimental, analytical and communication skills and make a record of the findings in the form of a report or thesis. 3. The knowledge from this course can lead to design of the equipments. 4. Ability to design unit processes which can yield best results.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√	√	√	√			√	√			√
2	√	√		√			√		√		
3	√	√		√			√				√
4	√	√		√							√

Recommended books:

1. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", International Edition, McGraw Hill, (1990).
2. Lab manuals

DEPARMENTAL ELECTIVES

Course Code	Course Title	L	T	P
CHPE-351	Computational Fluid Dynamics	3	0	0

Pre-requisites: Knowledge of fluid dynamics, heat transfer, partial differential equation and numerical method.

Course objectives: This course aims to develop an understanding of complex energy, mass and momentum equations for fluid flow, heat transfer and mass transfer. This course also aims to make the students familiar with the numerical techniques required to solve the partial and differential equations of conservation of mass, energy and momentum.

Syllabus:

Introduction to Computational Fluid Dynamics

Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation.

Classification of Partial Differential Equations and Physical Behavior

Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations.

Fundamentals of Discretization

Discretization principles: Pre-processing, Solution, Post-processing, finite difference methods(FDM), finite element method (FEM), finite volume method(FVM), Finite well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM).

Solution of Systems of Linear Algebraic Equations

Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search method, Elimination method: Forward elimination and backward substitution, Assessment of number of computations, L-U decomposition technique, Tridiagonal matrix algorithm (TDMA)

Discretization of Convection-Diffusion Equations: A Finite Volume Approach

Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme. Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

Grid Generation

Physical aspects, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping.

Course Outcomes:

1. To understand mathematical characteristics of partial differential equations.
2. To understand basic properties of computational methods–accuracy, stability, consistency.
3. To learn computational solution techniques for various types of partial differential equations.
4. To learn how to computationally solve Euler and Navier-Stokes equations.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√					√		√	√		√
2		√									
3		√			√		√	√		√	√
4	√			√			√	√			

Recommended books:.

1. H. K. Versteeg, W. Malalasekera, "An Introduction to Computational Fluid Dynamics: The finite volume method", Longman Scientific & Technical, (1995).
2. S. V. Patankar, "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, (1980).
3. T. J. Chung, "Computational Fluid Dynamics", Cambridge University Press, (2002).
4. J. Blazek, "Computational Fluid Dynamics:Principles and Applications", Elsevier, (2001).
5. John D. Anderson Jr, "Computational Fluid Dynamics", McGraw Hill Book Company, (2002).

Course Code	Course Title	L	T	P
CHPE-352	Microbiology for Chemical Engineers	3	0	0

Pre-requisites:	Basic knowledge of physics and chemistry
Course objectives:	The students will be made aware of fundamental and applied microbiology. They will learn the use of microbiology in the field of chemical engineering.
Syllabus:	**Scope and History of Microbiology** Scope and History of Microbiology, Classification, Characterization, Identification and Nomenclature of Microorganisms, Microscopy, Morphological, Structural and Biochemical characteristics of prokaryotes and eukaryotes (bacteria , yeast, mold, algae, protozoa, actinomycetes) **Cultivation of Microorganisms** Microbiological media, physical conditions required for growth. Reproduction and Growth of Microorganism: Modes of cell division, growth curve of microbes, Quantitative measurement of growth. **Methods in Microbiology** Chemical, Physical and Biological methods of selection of microorganisms, Methods of isolating pure cultures, Maintenance and preservation of pure cultures, microbial mutation. **Microbial Metabolism** Metabolic pathways and Bioenergetics, Aerobic and Anaerobic growth, Transport of nutrients across cell membranes **Physical and Chemical Control of Microorganism** Major groups of antimicrobial agents, Mode of action and practical applications **Energy Transduction Mechanisms in Microbial Cell** Aerobic and anaerobic respiration, Microbial photosynthesis, Transduction, Transformation, Conjugation **Microbial Interaction** Roles of microbes in Nitrogen, Carbon and Sulphur cycle **Application of Microorganism in various Field** Agriculture, food, environment, medicine, public health and industry.
Course Outcomes:	1. Understanding of fundamentals of microbiology. 2. Be familiar with cultivation, growth and control of microorganism. 3. Be familiar with advantages and disadvantages of microorganisms. 4. Understanding of application of microbiology in chemical engineering

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√	√				√	√			√	√
2	√	√	√			√	√			√	√
3	√	√			√	√	√			√	√
4	√	√		√	√	√	√			√	√

Recommended books:

1. Pelczar M J, Chan E C S and Krieg N R “Microbiology, 5th Edition, ” Mc Graw Hill, New York (1995)
2. Davis B D, “Microbiology”, Harper and Row Publications, Hageston (1980)
3. Salle A J, “Fundamental Principles of Bacteriology” , 7th Edition, Tata McGraw Hill, New Delhi (1984)
4. Stanier R Y, “Text in Microbiology” McMillan Press London (1995)
5. Casida L E, “Industrial Microbiology”, New Age International Publishers, New Delhi (2003)

Course Code	Course Title	L	T	P
CHPE-353	Biomass Conversion Processes	3	0	0

Pre-requisites:	None
Course objectives:	Characterize different biomass feedstocks based on its constituents and properties • Understand the analytical techniques to characterize biomass• Understand and evaluate various biomass pretreatment and processing techniques in terms of their applicability for different biomass type for biomass conversion processes; combustion, pyrolysis, gasification and liquefaction for production of value added bio-products.
Syllabus:	**Introduction:** Importance of Bioenergy and bio-fuels,Global and Indian scenario, Types of biomass, characterization-proximate and ultimate analysis, determination of structural components of biomass. **Pretreatment of biomass:** Pretreatment processes specific to various conversion processes for production of targeted products, Physical treatment processes, thermal, biological, chemical, physiochemical treatment processes **Conversion processes:** Biochemical conversion processes, Thermochemical conversion processes-Combustion, gasification, pyrolysis, hydrothermal liquefaction. Catalytic processes-types of catalysts, their influence on product quality. Reaction kinetics-thermogravimetric study, determination of kinetic parameters using various models. Various types of bio-fuels and bio-products-importance, characterization, properties, life cycle analysis and their environmental impacts. Integrated hybrid conversion processes.Design of a biorefinery by incorporating various unit operations, mass and energy balance, sustainability aspects using Aspen plus and other simulation packages.
Course Outcomes:	1. Understand basic concepts about biomass derived energy. 2. Understand and evaluate various biomass pretreatment and processing techniques. 3. Able to understand the various biomasses to energy conversion processes. 4. Ability to design a sustainable biorefinery for biofuels and bioenergy production by combining various processes

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√		√		√	√					
2	√	√	√	√	√	√	√				
3	√	√	√	√	√	√	√				
4	√		√	√	√						

Recommended books:

1. Pandey, A., Larroche, C., Ricke, S.C., Dussap, C.-G., Gnansounou, E., Biofuels: Alternative feedstocks and conversion processes, Academic Press, U.S.A., 2011.
2. Brown, R.C. (Ed.) Thermochemical processing of biomass into fuels, chemicals and power, Wiley, 2011.
3. Clark, J., Deswarte, F. (Ed.) Introduction to chemicals from biomass, John Wiley and Sons, U.K., 2008.
4. Basu, Prabir. Biomass gasification, pyrolysis and torrefaction: practical design and theory. Academic press, 2013.
5. Chen, Hongzhang, and Lan Wang. Technologies for biochemical conversion of biomass. Academic Press, 2016.

Course Code	Course Title	L	T	P
CHPE-354	Nano Science and Technology	3	0	0

Pre-requisites:	Engineering chemistry and physics
Course Information:	The course aims at understanding the bottom-up(includes both chemical and physical methods) and the top-down methods(mainly physical methods) for the synthesis of nanostructured materials. The course also focuses on different type of nanostructures such as carbon nanotubes(CNT), metal and metal oxide nanoparticles, self-assembly of these nanostructures.The devices developed out of these nanostructures shall be also discussed.
Syllabus:	**Introduction** Nano technology, history, motivation, materials, devices and systems. **Fabrication of Nanomaterials** Top down & Bottom up Fabrication, Solution based Synthesis of Nanoparticles, Vapour Phase Synthesis & Synthesis with framework, Lithography and Chemical Patterning, Nanolithography, Dip Pen Lithography, e-beam lithography, Liftoff lithography. **Quantum Structures** Quantum Well, Quantum wires, Quantum Dots, Super lattices & Layered Structures, Quantum Computing. **Self Assembly** Supramolecular& Dimension Control in Nanostructures, thermodynamics and coded self-assemblies. **Carbon Nanostructures and Biomaterials** Carbon molecules, clusters, carbon nanotubes and their applications DNA & Nanomaterials, Bionanocomposites, Biometrics, molecular motors. DNA Computing, Biophotonics. **Nanodevices** Electronic, Magnetic, Mechanical, Photonic, Fluidic and Biomedical devices.
Course Objectives:	1. To understand the basic concepts of nanostructures and their properties. 2. To study the synthesis processes, for the manufacture of nanomaterials. 3. To understandthe structure and property relationship of various nanomaterials. 4. To get familiar with latest devices and technologies based on nanomaterials.

Mapping of course objectives (CO) & program outcomes (PO)

Course Objectives	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓					✓					✓
2	✓								✓		
3	✓										
4	✓	✓			✓	✓				✓	✓

Recommended books:

1. Poole, C. P., Owens, F. J., “Introduction to Nanotechnology”, Wiley, (2003).
2. Ratner, M., Ratner, D., “Nanotechnology”, Prentice Hall, (2003).
3. Wilson, M., Kannagara, K., Smith, G., Simmons, M., Raguse, B., “Nanotechnology”, CRC Press, (2002).
4. Ozin, G. A., Andre, C. A., “Nanochemistry: A Chemical approach to Nanomaterials”, Royal society of Chemists. (2005)
5. Foster, L. E., “Nanotechnology, Science Innovation & Opportunity”, Pearson Education, (2007).

Course Code	Course Title	L	T	P
CHPE-355	Environment Impact Assessment	3	0	0

Pre-requisites: Knowledge of Environment Science & Technology

Course objectives:

The objective of the course is to introduce students to the process of Environmental Impact Assessment (EIA) and the procedures that are followed in environmental management in industry.

Students are introduced with some of the basic environmental assessment techniques

Through case studies, students will learn to present and explain the components and decision making processes involved in environmental assessment.

Students will create a visual representation of data that comprises an environmental impact statement

Syllabus:

Environment Impact Assessment (EIA)

Concept of EIA, Origin of EIA, Procedure of EIA, Evaluation Methodology for EIA, Scope Studies, Preparation and Review of Environment Impact Statement (EIS).

Life Cycle Assessment (LCA)

Introduction of LCA, Importance of LCA, Environmental Parameters in LCA, Documentation in LCA.

Waste Minimization

Introduction, Types of Waste, Benefits of Waste Minimization, Elements of Waste Minimization Programme, Integrated System for Waste Management.

Environmental Audit (EA)

Concept of EA, Necessity and Importance of EA, Audit Items, Audit Procedures.

Environmental Management System (EMS)

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

Case Studies

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

Course Outcomes:

1. Ability to understand the current EIA methods and the techniques and tools used
2. Ability to understand the current assessment methods and legislation
3. Ability to understand the current environmental monitoring systems
4. Ability to apply knowledge acquired to the process of environmental impact modeling and prediction as a design tool with application to a number of case studies

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√			√			√		√	
2	√	√	√	√			√	√			
3	√	√	√			√					√
4	√	√	√		√				√		

Recommended books:

1. Anjaneyulu Y., “Environment Impact Assessment Methodologies”, B S Publications, (2002).
2. Canter L. W., “Environment Impact Assessment”, McGraw Hill, Second Edition, (2005).
3. Garg S. K., Garg R., Garg R., “Ecological and Environmental Studies”, Khanna Publishers, First Edition, (2006).
4. Santra S. C., “Environmental Science”, New Central Book Agency (P) Ltd., Second Edition, (2006).
5. Uberoi N. K., “Environmental Management”, Excel Books, Second Edition, (2006).

Course Code	Course Title	L	T	P
CHPE-356	Industrial Rheology	3	0	0

Pre-requisites: Undergraduate level courses in Fluid Mechanics, Heat Transfer, Mass Transfer and Transport phenomena.

Course objectives: Rheology is the subject which deals with the rheological properties (viscosity, shear modulus, loss modulus etc) of solids, fluids, viscoelastic fluids and solids. Most of the industrial flows are non-Newtonian in nature and are not studied enough in the undergraduate courses and with this course; students will be able to understand the importance of rheology and the working principles of different kinds of rheometer. Finally, students will be able to understand and analyze the industrial flows.

Syllabus:

Introduction

Introduction to rheology, solid and fluid behavior, time independent fluid behavior, time dependent fluid behavior (thixotropy and rheopexy), linear viscoelasticity, nonlinear viscoelasticity, dimensional considerations.

Rheometry for Non Newtonian Fluids

Shear flow rheometry- Capillary viscometers, rotational viscometers, normal stress measurements, Introduction and working of Capillary viscometers, rotational viscometers, stress rheometers, basics of elongation flow rheometry.

Rheology of Polymeric Liquids

Polymer chain conformation, different regimes of polymeric solutions-dilute, semi-dilute and concentrated, effect of temperature.

Flow in Pipes and in Conduits of Non-Circular Cross Section

Fluid flow in laminar flow in circular tubes, power law fluids, Bingham plastic, yield pseudo plastic fluids, generalized Reynolds no for time independent fluids, laminar flow in two infinite parallel plates, and laminar flow in concentric annulus.

Momentum and Heat Transfer In Boundary Layer Flows

Laminar flow in circular tubes, full-developed heat transfer to power law fluids in laminar flow, laminar flow of power law liquids over a plate.

Course Outcomes:

1. Understanding the importance of Rheology.
2. Introducing the theories of linear and nonlinear viscoelasticity.
3. Exposure to complex fluids and their behavior in stress and strain controlled experiments.
4. Ability to analyze the industrial non-Newtonian flows.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√					√	√			√
2	√	√		√				√			√
3		√	√	√			√	√			√
4				√	√			√			√

Recommended books:

1. Christopher W. Macosko, 'RHEOLOGY principles, measurements and applications',1st ed., Wiley-VCH, (1994).
2. Bird, Stewart W. E. and Lightfoot, "Transport Phenomena", John Wiley and Sons, (2002).
3. Chabra, Richardson, "Non Newtonian fluids in Process Industries", Butterworth, Melbourne, (1999).
4. Faith A. Morrison, "Understanding Rheology", OXFORD university press, New York (2001).
5. Welty J. R., Wilson R. E., Wicks C E, "Fundamentals of Momentum, Heat and Mass Transfer", 4th Edition, John Wiley & Sons, (2001).Tanners R. I., "Rheology: An Historical perspective", Elsevier, Amsterdam, (1998).

Course Code	Course Title	L	T	P
CHPE-357	Optimization Techniques	3	0	0

Pre-requisites:	None
Course objectives:	To understand the concepts of optimization methods and algorithms for solving various types of optimization problems. Research interest is developed and promoted in optimization techniques for engineering problems.
Syllabus:	**Introduction:** Introduction to optimization and its scope in chemical process design, Developing Models for Optimization, Formulation of the Objective Function. **Optimization Theory and Methods:** Basic Concept of Optimization of Unconstrained Functions: One-Dimensional Search, Unconstrained Multivariable Optimization.. **Linear & Nonlinear Programming and Applications:** Linear Programming (LP) and Applications, Nonlinear Programming with Constraints, Global Optimization for Problems with Continuous and Discrete Variables. Constrained multivariable optimization**.** **Mixed-Integer Programming & Examples**: Mixed-Integer Programming, Optimization in Large-Scale Plant Design and Operations, Integrated Planning, Scheduling, and Control in the Process Industries, Process integration examples. **Application of Optimization:** Heat Transfer and Energy Conservation, Separation Processes, Fluid Flow Systems, Chemical Reactor Design and Operation..
Course Outcomes:	1. Students will be able to learn techniques to solve Linear and non- Linear Programming Problems. 2. The major limitations and capabilities of deterministic operations research modeling will be learnt as applied to problems. 3. The knowledge in this course lead to optimization of resources available. 4. Ability to optimally design the equipments and resource allocation.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√	√	√		√		√				√
2	√	√		√	√						√
3	√	√		√	√						
4	√		√		√			√			√

Recommended books:

1. Edgar T. F., Himmelblau, D. M., “Optimization of Chemical Process”, McGraw Hill, (1989).
2. Urbanier K., McDermott C., “Optimal Design of Process Equipment” John, Wiley, (1986).
3. Reklaitis G. V., Ravindran A., Regsdell K. M., “Engineering Optimisation”, John Wiley, New York, (1980).
4. Biles W. E., Swain, J. J., “Optimization and Industrial Experimentation”, Inter Science, New York, (1980).
5. Seinfield J. H., Lapidus L., “Process Modelling, Estimation and Identification”, Prentice Hall, Englewood Cliffs, New Jersey, (1974).

Course Code	Course Title	L	T	P
CHPE-358	Petroleum Recovery Technology	3	0	0

Pre-requisites:	Basic knowledge of fluid mechanics and general sciences (physics and chemistry).
Course Information:	This course deals with the study of modern technology involved in the recovery of the petroleum via drilling and other operations. Also deals with the knowledge regarding the use and modification in technology by which the demand and supply for the petroleum can be full-fill in optimized way.
Syllabus:	**Petroleum as a Resource Material** Indian Sedimentary basins, Types of rocks-Igneous rocks, Metamorphic rock, sedimentary rock, Kerogen and classification, Origin, Migrations and Accumulation of Hydrocarbons source, Migration of oil-mechanism pattern and barriers, Reservoir rocks and cap rocks, Entrapment of oil-types and mechanism etc. **Physical Properties of Reservoir Rock** Core analysis, conventional core analysis, conventional core analysis, Porosity, effective porosity, primary porosity, secondary porosity, porosity measurement, permeability, Effective permeability, fluid saturation, electrical resistivity, Darcy's law, Single and Multiphase flow etc. **Special Core Analysis** Wettability, capillary pressure characteristics, relative permeability, oil window etc. Flow of fluids through porous media: Darcy's law, single and multiphase flow. Reservoir flow through porous media, reservoir drive mechanism etc. Petroleum Exploration: Gravitational, Magnetic, Seismic, Electrical, Radioactive, Well logging methods etc. **Drilling** Introduction to on-shore and offshore drilling operations, onshore drilling techniques, cable tool drilling, rotary drilling, vertical drilling, Directional drilling, Horizontal drilling, Offshore drilling rigs, drilling accessories components, drilling fluid circulation system, functions of drilling fluids, Mud parameters. **Production** Production problems and work over operations, Well stimulation method, Hydraulic fracturing, matrix treatment, acidizing etc. Open Hole Logging: Electrical Surveys, Radioactive Surveys, Introduction to Well Logging: Mud logs, Pressure logs, Core logs, Wireline logs etc. **Improved Oil Recovery Techniques** Need of additional energy for pressure maintains of a reservoirs, techniques for various artificial lift methods sucker rod pumping, Immiscible, miscible, chemical and thermal, Chemical Recovery processes: Polymer flooding, micellar flooding, surfactant flooding, alkaline flooding. Thermal recovery processes: Steam drive, cyclic steam injection, in situ combustion etc. **Petroleum Reserve Estimation** Reserve categories, proven and unproven reserve, type of reserve, prognostic reserves, commercial reserves, balance reserve, zabalance reserve. Reserve estimation: volumetric method, material balance method, decline curve analysis, numerical simulation techniques, Monte Carlo approach etc. **Development of Oil and Gas Fields** Reservoir Drive Mechanism and recovery factor, concept of well spacing, Development of the Field, Technological Scheme for Development etc.
Course Outcomes:	1. An ability to design and conduct experiments, as well as to analyze and interpret data. 2. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. 3. An ability to identify, formulates, and solves engineering problems related to petroleum industry.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓	✓		✓		✓		✓	✓	✓	✓
2	✓	✓		✓		✓	✓				✓
3	✓	✓		✓	✓	✓		✓	✓	✓	✓

Recommended books:

1. Berger B. D., Anderson K. E., “Modern Petroleum” Penn well books.
2. Bradley H. B., “Petroleum Engineering Handbook”, SPE.
3. Cole F. W., Reservoir Engineering manual.
4. Carl G., “Petroleum Engineering Drilling and Well Completions”, Prentice Hall.
5. Mc Cray, Cole, “Oil Well Drilling Technology”, Oklahoma Press.

Course Code	Course Title	L	T	P
CHPE-359	Petroleum Refining Technology	3	0	0

Pre-requisites:	Basic knowledge of organic chemistry, inorganic chemistry and chemical technology.
Course Information:	Petroleum Refining Technology is the subject which deals with the detailed study of various petroleum refining operations and processes. Various aspects of refinery operations such as petroleum sources, technology and techniques, reaction mechanism, catalysts used and safety were also been studied.
Syllabus:	**Introduction to Petroleum Industry** World petroleum resources, petroleum industries in India. Scope and Purpose of Refining, Global and Indianrefining scenario, Petroleum refining industry in India practice and prospects. **Refinery Distillation Processes** Desalting and Stabilization of crude, Process description of typical simple distillation, Fractional distillation, crudeoil distillation, vacuum distillation etc, ASTM, TBP and EFV Distillation **Fuel Refining, Lube Refining and Wax Refining** Cracking, coking, reforming, alkylation, isomerisation, polymerization, sweetening, visbreaking. Solvent extraction,de-waxing, propane de-asphalting. De-oiling of crude wax, crystallization, catalytic, sweating microcrystalline and petroleum wax applications **Hydro processing** Hydro cracking, hydro treating, hydro finishing **Two Phase oil and gas separation equipment** Types, their description, vessel sizing. Theory of separation and separator design. **Three phase Oil, gas and water separators** Types of separators, their description. Various control and vessel internals, theory and sizing of three phase separator. LACT units **Safety and pollution considerations in refineries** Treatment methods, sweetening, hydrodesulphurization, smoke point improvement.
Course Outcomes:	1. Introduction with the petroleum refinery worldwide. 2. Develop knowledge of different refining processes. 3. Develop knowledge of safety and pollution control in the refining industries. 4. To find the suitable refining technology for maximizing the gasoline yield.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1										✓	✓
2	✓	✓				✓		✓	✓	✓	✓
3	✓	✓			✓	✓	✓	✓	✓	✓	✓
4	✓	✓		✓	✓	✓		✓	✓	✓	✓

Recommended books:

1. Rao B.K.B, “Modern Petroleum Refining Processes”, 5th Edition, New Delhi, India, Oxford and IBH Publishing Company, (2008).
2. Prasad R., “Petroleum Refining Technology”, Khanna publisher.
3. Nelson W. L., “Petroleum Refinery Engineering”, McGraw Hill Book Co., (1985).
4. Watkins R. N., “Petroleum Refinery Distillation”, Gulf Publishing Co.
5. Gary J. H., Handework G. E., “Petroleum Refining Technology and Economics”, Marcel Dekker, Inc., (2001).

Course Code	Course Title	L	T	P
CHPE-360	Polymer Science and Engineering	3	0	0

Pre-requisites: Engineering chemistry and physics

Course Objectives: The course aims at understanding the basic concepts of polymer structure, properties and engineering, the manufacturing processes and process kinetics of different polymers, the different processing techniques for polymers for applications in fibres, plastics, rubber, surface coatings and adhesives, and to get familiar with common testing and evaluation methods for polymeric materials.

Syllabus:

Basic Concepts

Concepts and classification of polymers, functionality , glass transition temperature, addition, condensation, step-growth and chain-growth polymerization, molecular weight estimation: Number and weight average, sedimentation and viscosity average molecular weights, molecular weight and degree of polymerization, polydispersity, significance of molecular weight.

Polymerization Processes

Bulk, solution, emulsion and suspension polymerization, comparison of polymerization processes.

Polymerization Kinetics

Chemistry of step reaction polymerization, mechanism and kinetics of poly condensation reactions, relationship between average functionality, extent of reaction and degree of polymerization, mechanism and kinetics of free- radical chain polymerization, kinetic chain length, chain transfer reactions, Inhibition and retardation

Synthetic Fibers

Types of Fibers, spinning techniques, manufacturing technology and applications of different types of fibers: Cellulosic fibers, polyamides, acrylics, vinyls and vinylidines, fluorocarbons.

Plastics

Manufacturing technology and applications of different types of plastics: Polyester, polyethylene, Phenolics.

Rubbers

Structure, properties and preparation natural rubber synthetic rubbers: SBR, rubber compounding and reclaiming.

Testing and Evaluation of polymers

Physical testing, Electrical Properties, Softening Temperature tests, Melt flow Index.

Course Outcomes:

1. Developing understanding of fundamentals of polymers, their structure, properties and manufacturing techniques.
2. Ability to study the polymerization processes and process kinetics.
3. Understanding different process techniques and applications of fibers, plastics and rubbers.
4. To familiarize various testing and evaluation methods for polymeric materials.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		√		√	√	√					
2	√				√	√				√	
3	√				√	√				√	√
4		√	√	√		√					√

Recommended books:

1. Gowariker V. R., Viswanathan N. V., Sreedhar J., “Polymer Science”, New Age International Publishers, 37, (1996).
2. Billmeyer F. W., “Text Book of Polymer Science”, Wiley Tappers, (1994).
3. Ghosh P., “Polymer Science and Technology of Plastics and Rubber”, Tata McGraw Hill, (2001).
4. Gupta R. K., Kumar A., “Fundamentals of Polymer Engineering”, 2nd Edition, Marcel Dekkar, (2003).
5. Fried J. R. “Polymer Science and Technology”, PHI Learning, (2008).

Course Code	Course Title	L	T	P
CHPE-361	Process Plant Utilities	3	0	0

Pre-requisites:	Fluid Mechanics, Heat Transfer and Mass Transfer
Course objectives:	The course provides the knowledge of various process plant utilities and their efficient use. The course creates a fundamental understanding of importance of water, water sources, storage, consumption pattern, reuse and treatment methods. The course helps to develop an understanding for the air refrigeration cycles, vapour compression cycle, liquification processes, etc.
Syllabus:	**Steam** Boilers-classification, various types, construction, boiler mountings & accessories, properties of steam-tables, Mollier Diagram. **Power Generation** Internal Combustion Engines - classification, two- stroke, four stroke petrol & diesel engine, valve timing diagram, carburetor, Combustion Phenomena. **Refrigeration** Air refrigeration cycles, vapour compression cycle, P-H diagram, liquification processes. **Compressed Air and Vacuum** Use of compressed air, classification of compressors. Reciprocating compressors-mechanical details, single stage and two stage reciprocating compressor, inter cooler, minimum work input in multistage. Centrifugal compressor-velocity diagram for centrifugal compressors, dimensional parameters, slip factor, impeller blade shapes, losses in axial flow compressors. **Fuel** Natural gas, liquid petroleum fuels, coal & Coke. **Waste Disposal** Plant sewer system and waste disposal.
Course Outcomes:	1. The students can identify different utilities required for chemical plants and criteria for selecting the same. 2. The students gain the knowledge of use of compressed air. 3. The students learn about the different types of boilers, internal combustion engines and compressors. 4. To enable the students to solve numerical problems on steam economy, steam effectiveness and condenser duty of an evaporator.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√			√			√		√
2	√	√		√	√		√		√		√
3	√	√				√					√
4	√	√	√					√		√	

Recommended books:

1. Yadav R., “Thermodynamics & Heat Engines”, Vol.2, Central Publishing House.
2. Vasandani and Kumar, “Treatise on Heat Engineering”, (1979).
3. Lyle O., “The efficient use of steam”,Her Majesty’s Stationary Ofiice, London (1968).
4. Baasel, William D. and Barrow H. M., “Preliminary Chemical Engineering Plant Design”, John Wiley & Sons (1964).
5. Dodge B. F., “Chemical Engineering Thermodynamics”, McGraw Hill Company (1944)

Course Code	Course Title	L	T	P
CHPE-362	Process Intensification	3	0	0

Pre-requisites:	Advanced Mathematics, transport phenomena, chemical reaction engineering, process control, process equipment design
Course objectives:	The course aims to introduce concept of process integration in chemical and allied industries.
Syllabus:	**Introduction** Chemical Process Design and Integration, Onion Model of Process Design, Applications of Process Intensification **Pinch Technology** Pinch Technology Significance, Selection of Pinch Temperature Difference, Stream Splitting, Process Retrofit **Basic Element of Pinch Design** Pinch Design Methods, Heuristic Rules, Data Extraction, Designing, Optimization, Super Targeting, Grid Diagram, Composite Curve, Problem Table Algorithm, Grand Composite Curve **Heat Exchanger Network** Design of Heat Exchanger, Composite Curve, Heat Recovery, Thresholds Problem, Utility Selection, Energy Targeting, Area Targeting, Number of Units Targeting, Shell Targeting **Heat and Mass Integration** Heat Pump, Selection of heat pump relative to pinch, Heat integrations and proper selection of reactors for batch Processes and continuous processes, Integration of Distillation Column, Evaporator
Course Outcomes:	1. Able to understand the chemical process and process integration. 2. Ability to modify processes for minimization of heat, area, number of units and cost of chemical industries and allied industries. 3. Able to improve separations, heat transfer, mass transfer, mixing and integration of different process. 4. Ability to do pinch analysis and analyze heat exchanger network

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓										✓
2	✓		✓		✓						✓
3	✓		✓								✓
4		✓	✓								✓

Recommended books:

1. Kemp I. C., "Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth-Heinemann, (2007).
2. El-Halwagi M.M., "Process Integration", 7th Ed., Academic Press. (2006)
3. Smith R., "Chemical Process Design and Integration", 2nd Ed., Wiley (2005)
4. Shenoy U.V., "Heat Exchanger Network Synthesis", Gulf Publishing (1995)
5. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B. E. A., Guy A. R., and Marsland R. H.; "A User Guide on Process Integration for the Efficient Uses of Energy", Inst. of Chemical Engineers.

Course Code	Course Title	L	T	P
CHPE-363	Paint Technology	3	0	0

Pre-requisites: Engineering physics and Chemistry

Course objectives:

The objectives of this course is to familiarize the students with basics of paint formulations, the ingredients used esp. pigments and binders, their properties, ratios, manufacturing process.

To make students understand the basic concepts of paint processing, paint auxiliaries, the machinery used and methods of application

Syllabus:

Paint Formulations

Introduction and development of paint industry, Basics of paint formulations, Constituents of paint, Color chemistry.

Pigments

Organic and inorganic pigments, classification, Pigment Properties, Pigment volume concentration, Pigment dispersion and wetting, White inorganic pigments, Colored inorganic pigments, Miscellaneous pigments.

Binders or Resins

Natural and synthetic resins, Acrylic resins and emulsions, Alkyd resins, Epoxy resins and polyurethanes.

Drying Oils

Types of oils from natural origins, Drying and semidrying oils, Modification of drying oils/bodied oils, Auto oxidation and reactions.

Paint Auxiliaries

Paint additives, solvents, Lacquers, varnishes, Plasticizers, softeners, extendrers, opacifiers, Exterior and interior house paints.

Paint Manufacture and Application

Paint processing, Machinery for grinding of pigments and extenders, Application of industrial and architectural paints, Analysis and testing of paint, Environmental aspects.

Course Outcomes:

1. Students will learn the history and development of paint and surface coatings.
2. Students will understand the various nanomaterials used for paint technology.
3. Students will learn the paint auxiliaries and varnishes.
4. Students will learn formulation of various paints for different applications.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓	✓			✓	✓	✓				✓
2	✓		✓	✓	✓						
3			✓	✓	✓					✓	✓
4	✓	✓	✓	✓	✓			✓	✓	✓	✓

Recommended books:

1. Payne H F, Organic Coating Technology Vol. I & II, Wiley, New York, (1954)
2. Morgans H M, Outlines of Paint Technology, 3e, CBS, New Delhi, (2001)
3. Joseph Bijos, Good Painting Practicies, Wiley, New York, (1967)
4. Bentley and Turner, Introduction to Paint Chemistry, and Principles of Paint Technology, fourth Edition, CRC Publishers, Austria, (1997)

Course Code	Course Title	L	T	P
CHPE-451	Corrosion Engineering	3	0	0

Pre-requisites:	Basics course on material science and chemistry
Course objectives:	This course provides a foundation for understanding the forms of corrosion, the mechanisms of corrosion, electrochemical methods to study and measure corrosion, and the principles and methods leading to mitigation of corrosion problems that might occur in engineering practice.
Syllabus:	**Basic Concepts** Definition and importance, impact on economy, Electrochemical reactions, Corrosion rate and its determination, Theories of corrosion, Polarization, Passivity, Metallurgical aspects. **Forms of Corrosion** Galvanic corrosion, crevice corrosion, pitting, intergranular corrosion, erosion corrosion, flow-accelerated corrosion**,** stress corrosion cracking, hydrogen induced cracking,Microbiologically induced corrosion, underground corrosion, high-temperature corrosion**,** corrosion fatigue and some case studies. **Corrosion Testing** Specimen preparation, exposure tests, open corrosion potential, linear polarization, Tafel slopes, corrosion current, slow-strain-rate tests, AC impedance and Commercial corrosion probes. **Prevention and Control of Corrosion** Cathodic protection, Sacrificial anodic protection,Modification of environment, Coatings and inhibitors, Material selection and design.
Course Outcomes:	1. Understanding the importance and mechanisms of corrosion 2. Understanding the aspects of electrochemistry relevant to corrosion rate measurement. 3. Ability to understand the concepts of various types of corrosion and its testing. 4. Ability to select viable techniques for corrosion prevention.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√		√		√	√					
2	√	√	√	√	√	√					
3	√	√	√	√	√	√					
4	√		√	√	√						

Recommended books:

1. Fontana, M.G., Corrosion Engineering, Tata McGraw-Hill (2008). 3rd ed.
2. Denny A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Pearson-Prentice Hall, 2005.
3. Roberge P R , Corrosion Engineering, McGraw Hill, New York.
4. Uhling H H and Revie R W, Corrosion Control, John Wiley & sons. INC,.
5. Trethewy& Chamberlain, Corrosion for Science and Engineering, Longman Sc& Tech; 2nd revised edition edition, 1996

Course Code	Course Title	L	T	P
CHPE-452	Cement Technology	3	0	0

Pre-requisites: Chemistry, Physics, Mechanical operations

Course objectives: The course aims to provide knowledge to the students regarding the raw materials for the cement, manufacturing of the cement, types of the cement, testing of the cement and hydration of the cement

Syllabus:

Introduction to Cement

Cement and its importance in construction, History of cement and cement manufacturing process, material composition of cement, various unit operation of cement manufacture, the present status and future of cement industry in India.

Types of Cement

Description and use of various type of Cement such as, Ordinary Portland Cement, Portland Pozzalana Cement, Portland Slag Cement, Sulphate Resistant Cement, White Portland Cement, and Low heat Cement, Masonry Cement, Oil Well Cement.

Raw material for Cement

Source of Lime, Limestone, Chalk, Marl, Industrial waste, geological distribution of limestone deposits in India, Assessment of limestone deposits for Cement manufacture. Argillaceous Raw Materials: Source of Silica, Alumina, Iron Oxide, Shale and effect of coal ash and additives use as corrective materials, Fly ash , Slag, lime sludge as cement raw materials.

Manufacturing of cement

Process flow diagram, Chemical reaction during clinkerisation, Role of miner constituents in clinkerization , Thermo chemistry of clinker formation

Packing and Dispatch of Cement

Finish grinding of clinker with gypsum and other additives, combined grinding and separate grinding packing machines, use of grinding aids, type of packing medium, tolerances, bag and bulk supply, dispatch of cement.

Testing of Cements

Insoluble residue in cement, estimation of free lime in cement, fineness of cement, standard consistency of cement, Initial and Final setting of cement, soundness of cement, slump test of concrete, Flow table test of mortar , Heat of hydration of cement .Vee Bee consistometer test.

Hydration of Cement

Hydration of clinker minerals, role of gypsum in cement hydration process, hydration of Portland cement and strength of Portland cement

Course Outcomes:

1. Ability to analyze the flow of raw material to cement formation quantitatively and qualitatively
2. Ability to apply the concepts of unit operation and unit processes that are employed in cement plants
3. Ability to identify the engineering problems associated with the manufacturing of cement
4. Ability to understand the testing and application of cement as building material

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√				√			√	√	√
2	√	√		√		√		√	√	√	√
3	√	√	√	√		√		√	√	√	√
4	√	√	√		√	√	√	√	√	√	√

Recommended books:

1. F. M. Lea, Chemistry of Cement and Concrete, Arnold, London.
2. W. H Duda, Cement Data Book, Verlag G m Bh, Berlin
3. R. H. Bouge, Chemistry of Portland Cement, Reinhold, New York

Course Code	Course Title	L	T	P
CHPE-453	Energy Management and Audit	3	0	0

Pre-requisites: None

Course Objectives: The course aims at understanding the basic concepts of energy management, energy monitoring and optimization of energy-use. The processes and parameters involved in an Energy Audit are also included. The course also aims to study the human and non-human project resource management, relevant to energy consumption. Finally, the course is meant to get familiar with techniques and tools for energy monitoring and targeting.

Syllabus:

Energy Scenario

Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features. Kyoto Protocol. Global warming.

Energy Management & Audit

Definition, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments, Energy and Cost Indices.

Energy Action Planning

Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification, Organizing - location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager, Accountability.

Motivating-Motivation of Employees

Information system designing barriers, Strategies; Marketing and communicating-training and planning. Financial Management, Investment-need, Appraisal and criteria, Financial analysis techniques- Simple pay-back period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs.

Project Management

Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification.

Energy Monitoring and Targeting

Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Monitoring methods such as Sankey-Diagrams, Pie-charts and Bar-diagrams, Techniques of energy consumption, Production, Cumulative sum of differences (CUSUM).

Course Outcomes:

1. To understand the basic concepts of energy management, energy monitoring and optimization of energy-use.
2. To study the processes and parameters involved in an Energy Audit.
3. To study the human and non-human project resource management, relevant to energy consumption.
4. To get familiar with techniques and tools for energy monitoring and targeting.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		√		√	√	√	√			√	
2		√			√	√	√			√	
3					√		√	√		√	
4		√		√		√		√		√	

Recommended books:

1. Capehart, Barney L., Turner W. C., Kennedy W. J., "Guide to Energy Management", Third Edition, Fairmont Press, Atlanta, GA, (2000).
2. Thumann A., Mehta D. P., "Handbook of Energy Engineering", 4th Edition Lilburn, GA: Fairmont Press, (1997).
3. Loftness, Robert L. "Energy Handbook." 2nd Edition, New York: Van Nostrand Reinhold Co., (1984).
4. Turner W., "Energy Management Handbook", John Wiley &. Sons, New York, (1982).
5. Lapedes, D. N., "Encyclopaedia of Energy", McGraw-Hill, New York, (1976).

Course Code	Course Title	L	T	P
CHPE-454	Heterogeneous Catalysis and Reactor Design	3	0	0

Pre-requisites: Basic knowledge of chemical reaction engineering (various types of reactors: batch, CSTR and PFR) and catalysts and catalytic reactions.

Course objectives: Objective of this course is to deliver a knowledge to the students regarding the heterogeneous catalytic reactions. Also gives knowledge about various type of preparation methods and characterization methods of solid catalysts. It will also help students to design reactors for heterogeneous catalytic reactions.

Syllabus:

Introduction to Heterogeneous Catalysis

Introduction to catalysis, types of catalysts, biocatalysts: enzymes, lipases and microbes ascatalysts, application to industrial processes:one example from variouschemical and allied industries, basic concepts in heterogeneous catalysis and green chemistry, catalyst preparation and catalyst characterization, poisoning and regeneration.

Type of Reactors for Heterogeneous Catalysis

Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes, environmental catalysis, commercial catalytic reactors (fixed bed, fluidized bed, trickle-bed, slurry, etc.).

Catalytic Reactors Design

Design of reactor for gas-solid reactions, basic design equations and guidelines, Heterogeneous data analysis for reactor design.

Reactor Modeling and Deactivation Kinetics

Reactor modeling, emphasizes the chemistry and engineering aspects of catalytic processes along withproblems arising in industry, catalyst deactivation kinetics and modeling.

Heat and Mass Transfer Effect and Consideration

Heat and mass transfer and its role in heterogeneous catalysis, calculations of effective diffusivity and thermal conductivity of porous catalysts,reactor modeling, emphasizes the chemistry and engineering aspects of catalytic processes along with problems arising in industry, catalyst deactivation kinetics and modeling.

Course Outcomes:

1. Basic knowledge about the heterogeneous catalytic reactions.
2. Will also able to prepare catalysts using different catalysts preparation methods and also able to identify various physio-chemical properties of the catalysts.
3. Students are able to design the reactors used for two phase and three phase catalytic reactions.
4. Student will able to design the catalytic reactor with heat and mass transfer limitations.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√					√	√	√	√		√
2	√							√	√	√	√
3	√	√		√	√	√		√	√	√	√
4	√	√		√	√	√		√	√	√	√

Recommended books:

1. Levenspiel O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., “Elements of Chemical Reaction Engineering”, 3rd Edition, Prentice Hall Inc., (1999).
3. Shuler M. L., Kargi F., “Bioprocess Engineering”, Prentice Hall of India Pvt. Ltd., Second Edition, (2005).
4. Smith J. M., “Chemical Engineering Kinetics”, 3rd Edition, McGraw Hill, (1981).
5. Hill C. G., “Chemical Engineering Kinetics and Reactor Design”, John Wiley, (1977).

Course Code	Course Title	L	T	P
CHPE-455	Hydrocarbon Engineering	3	0	0

Pre-requisites: Basic knowledge of organic chemistry, inorganic chemistry and chemical technology.

Course Information: Hydrocarbon engineering is the subject which deals with the study of various types of hydrocarbons, their structure present in petroleum crude. Also deals with the chemistry of various reactions involving petroleum refining operations. This subject also brings knowledge regarding various properties, standard, transportation, handling and storage methods used for the various petroleum products.

Syllabus:

Scope and Purpose of Refining

Global and Indian refining scenario, Petroleum refining industry in India practice and prospects, Separation and Conversion processes etc.

Refinery Distillation Processes

Desalting, Process description of typical crude distillation, Fractional distillation, Vacuum distillation, Flooding, Weeping, Entrainment, Setting of cut point, Crude assay analysis, ASTM, TBP EFV Distillation etc.

Fuel Refining and Lube Refining

Cracking, Coking, Reforming, Alkylation, Isomerisation, Polymerization, and Sweetening etc. Solvent extraction, Dew axing, Propane deasphalting etc.

Hydro processing

Hydro cracking, Hydro treating, Hydro desulphurization

Oil and Gas separators

Principal of separation, Types of separators, their description. Various control and vessel internals, Oil and gas gravitational separator, Vertical two and three phase separator, Horizontal three phase separator etc.

Quality Monitoring of Petroleum Products

API gravity, Flash point, Fire point, Smoke point, Aniline point, Carbon residue, Kinetic viscosity, Pour point, Freezing point, octane number, Cetane number, Viscosity index, Diesel index, Calorific value, Burning test 24 hours, Characterization factor, Cloud Point, Vapour lock index, Carbon hydrogen ratio, Calculated ignition index, Carbon aromaticity index, U.O.P Characterization factor, Conrad son carbon residue, Water and sediment content.

Storage of Petroleum Products

Classification of inflammable liquids, Classification of storage tank, Floating roof tank, Fixed roof tank, Semi buried tank, Import/export loss, Breathing losses, Hazards and non-hazards area, and underground storage tank etc.

Transportation

Transportation of oil and natural gas by rail, road and pipeline, Various type of pipelines, Pipe line automation, Lease Automatic Custody Transfer units, SCADA, Batch transport of petroleum products, Multiproduct pipelines, Product handling, Pumping cycle, Interface , Problems in waxy crude, Role of flow behaviour etc.

Course Outcomes:

1. Student will be able to identify different types of hydrocarbon based on their structure present in petroleum crude.
2. Gain knowledge of reaction chemistry of specific reaction that took place in petroleum refining operations.
3. Students will learn about the various operations take place in refineries to convert raw crude into various commercial products.
4. Students will able to implicate technical knowledge to analyzed and solve the engineering problems involves in the petroleum refineries.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1						✓		✓	✓		
2	✓	✓	✓		✓			✓	✓	✓	✓
3	✓	✓	✓	✓	✓			✓	✓	✓	✓
4	✓	✓	✓	✓			✓	✓		✓	✓

Recommended books:

1. Nelson W. L., “Petroleum Refinery Engineering”, Mc-Graw Hill Book Co., (1985).
2. Watkins R. N., “Petroleum Refinery Distillation”, Gulf Publishing Co.
3. Gary J. H., Handwork G. E., “Petroleum Refining Technology and Economics”, Marcel Dekker, Inc., (2001).
4. Jones D. S. J., “Elements of Petroleum processing”, John Wiley &Sons, (1995).
5. Waquier J. P., “Petroleum Refining” Vol. I & II , Technip, (1995)

Course Code	Course Title	L	T	P
CHPE-456	Industrial Environmental Management	3	0	0

Pre-requisites: Knowledge of Environment Science & Technology

Course objectives: The course introduces the principles associated with the industrial environmental management and application of these principles in avoiding common difficulties associated with industrial environmental management. It will provide detailed understanding of the methods and techniques to resolve key issues for making industrial production and processing, cleaner and safer. The course will help the students to understand the processes and waste characteristic. The course will give an overview of the safety and environmental issues in the chemical industry.

Syllabus:

Introduction

Introduction, Processes and Waste Characteristics, Pollution Control in Process and Waste Management according to the environment standards specific to the following types of Industries:

Chemical Process and Allied Industries

Pesticides Industry, Paint Industry, Pharmaceutical Industry, Fertilizer Industry, Sugar and Distillery Industry, Acids and Explosives Industry, Petroleum Refinery and Petrochemical Industry, Dyes and Dye-intermediate Industry, Pulp and Paper Industry, Leather Industry.

Food Processing and Allied Industries

Dairy Industry, Poultry Industry, Edible Oil Industry.

Textile and Allied Industries

Textile Industry, Man-made Fibre and Rayon Industry, Jute Processing Industry.

Metallurgical and Mining Industries

Iron and Steel Industry, Aluminium Industry, Copper Industry, Foundry Industry, Coal Mining Industry, Lead and Zinc Mining Industry.

Cement and Allied Industries

Cement Industry, Ceramic Industry, Lime and Brick Kiln.

Mechanical, Electrical, Electronics and Allied Industries

Metal Fabricating Industry, Electroplating Industry, Printing Industry, Electrical and Electronics Industry, Aerospace Industry.

Course Outcomes:

1. The students will get the knowledge of pollution control in process and waste management according to the environment standards specific to the various types of industries.
2. The students will acquaint with the industrial environmental management skills.
3. The students will be able to identify and assess hazards in any stage of operation, to quantify and manage them as well.
4. This course will also highlight lessons learnt from the past incidents.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√				√		√		
2	√	√	√		√	√		√			√
3	√	√	√							√	
4	√	√		√			√				

Recommended books:

1. Sell N. J., "Industrial Pollution Control-Issues and Techniques", Van Nostrand Reinhold Publication, Second Edition.
2. Hocking M. B., "Handbook of Chemical Technology and Pollution Control", Academic Press, Third Edition, (2005).
3. Bhatia S. C., "Handbook of Industrial Pollution and Control", CBS Publishers and Distributors, Volume I and II, First Edition, (2002).
4. Dryden C. E., "Outlines of Chemical Technology", East-West Press Pvt. Ltd., Second Edition, (1973).

Austin G. T., "Shreve's Chemical Process Industries", McGraw Hill Book Company, Fifth Edition, (1986).

Course Code	Course Title	L	T	P
CHPE-457	Introduction to Multiphase Flow	3	0	0

Pre-requisites: Knowledge of differential equations and fluid mechanics

Course objectives: The course attributes the knowledge of the principles of multiphase flow. The course helps the students to understand the concepts of flow past immersed bodies, two-phase flow and interaction of fluids.

Syllabus:

Introduction to multiphase flow:

Introduction to multiphase flow, types and applications, Common terminologies, flow patterns and flow pattern maps. One-dimensional steady homogenous flow. Concept of choking and critical flow phenomena. One dimensional steady separated flow model: (1) Phases are considered together but their velocities differ. (2) Phases are considered separately, flow with phase change.

Two-phase flow:

Two–phase flow through pipes: Elementary aspects, Two phase Flow pattern in vertical and Horizontal pipes. Two phase pressure drop calculation in Homogeneous and separated flow model for flow inside tube. Lockhart-Martinelli parameters and their application in analysis of two-phase flows.

Interaction of fluids:

Mixing of a single fluid; degree of segregation, early and late mixing of fluids, models for partial segregation, mixing of two miscible fluids. Gas-liquid flow phenomenon, Types of regimes formation – trickle, pulse, bubble, dispersed bubble, spray regime etc.

Introduction to three phase flow and flow measurement technique:

An introduction to three phase flow. Measurement techniques for multiphase flow. Flow regime identification, pressure drop, void fraction and flow rate measurement.

Course Outcomes:

1. Understanding of the characteristics of multiphase flow and master motion equations.
2. Capability to analyze the multiphase flow problem with multiphase flow dynamics.
3. Reinforcement of knowledge through practice with realistic problems.
4. Enhancement of team working skills.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√				√		√				√
2		√				√		√			
3				√	√				√	√	√
4								√			√

Recommended books:

1. C.T. Crowe, "Multiphase Flow Handbook", CRC Press, (2005).
2. C. E. Brennen, "Fundamentals of multiphase flow", Cambridge University Press, (2005)
3. N.I. Kolev, "Multiphase Flow Dynamics 1: Fundamentals", Springer, (2007).
4. G. Wallis, "One Dimensional Two Phase Flow", Mc-Graw Hill, (1969).
5. G. Hetsroni, "Handbook of multiphase systems, Mc-Graw Hill, (1982).

Course Code	Course Title	L	T	P
CHPE-458	Natural Gas Engineering	3	0	0

Pre-requisites: Fundamental knowledge of organic chemistry, thermodynamics, heat and mass transfer, fluid mechanics and petroleum crude and natural gas recovery.

Course objectives: This course deals with the principle involve in the recovery of natural gas from reservoir by the application of knowledge of various chemical engineering subjects such as thermodynamics, heat transfer, mass transfer, fluid dynamics and process control. It also deals with the processing, transmission and storage of natural gas.

Syllabus:

Gas from Condensate and Oilfields

Scope of natural gas industry, basic thermodynamic and system energy concepts in natural gas engineering, review of physical and chemical properties of natural gas and associate hydrocarbons, phase behavior studies of two phase hydrocarbon systems, equations of states, multiple flashes, water-hydrocarbon system, vapor liquid equilibrium.

Flow of Fluids

Compression calculations, heat transfer and mass transfer principles and applications in natural gas engineering, gas flow measurement, process control and instrumentation in natural gas processing plants.

Natural Gas Processing

Field separation and oil absorption process, refrigeration and low temperature processing, liquefaction process, dehydration, sweetening, and sulfur recovery from natural gas, processing for LPG, LNG, CNG system.

Transmission of Natural Gas

Specifications, utilization of natural gas, underground storage and conservation of natural gas.

Unconventional Gas

Coal bed methane, natural gas hydrate, conversion of gas to liquid, economic consideration for development of gas fields.

Course Outcomes:

1. The students will learn about the sources and recovery of natural gas.
2. Students will also attain the use of heat transfer and mass transfer principles in natural gas engineering.
3. Student also learns about natural gas processing, transmission of natural gas and unconventional gases.
4. The students will have a thorough understanding of scientific and engineering principles and their application to natural gas engineering problems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓	✓			✓	✓		✓	✓	✓	✓
2	✓	✓			✓			✓	✓	✓	✓
3	✓					✓		✓	✓	✓	✓
4	✓	✓		✓	✓	✓	✓	✓		✓	✓

Recommended books:

1. Katz D. L., “Hand Book of Natural Gas Engineering”, McGraw Hill.
2. Kumar S., “Gas Production Engineering”, Gulf Publishing Co., (1987).
3. Ikoku C. K., “Natural Gas Engineering”, John Wiley, (1984).
4. R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, “Transport Phenomena”, 2nd Edition., John Wiley & Sons, (2002).
5. Christie John Geankoplis, “Transport Processes and Separation Process Principles”, 4th Edition, PHI Learning Private Limited., (2013).

Course Code	Course Title	L	T	P
CHPE-459	New and Renewable Energy Resources	3	0	0

Pre-requisites: Course will be accessible to most students who have completed their first two years of study at an Undergraduate level.

Course objectives: This course covers in a comprehensive manner the operating principle of a range of non-conventional energy resources, materials used, characterization, and key performance characteristics. The technologies to be studied will include Solar energy, Wind, Fuel cells, biomass, and Geothermal conversion. The advantages and limitations of these technologies in comparison to conventional sources of energy will also be studied.

Syllabus:

Introduction

Global and Indian scenario, Sources, Energy conservation, Types of NCES with applications, Role and development of new renewable energy sources.

Solar Energy

Introduction, Solar radiation data, Instruments for measuring solar radiations, 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. Solar Calculations: Angles associated with solar rays and the collector surface, Local apparent time, Soar day length.

Geothermal Energy

Resources, Types of wells, Methods of harnessing the energy.

Wind Energy

Sources and potentials, Horizontal and vertical axis wind mills, Wind regime analysis and evaluation of wind mills.

Biomass and Biofuels

Recycling of agricultural waste, Anaerobic/aerobic digestion and types of biogas digesters, Gas yield and combustion characteristics of bio gas, Design of biogas system for heating, Lighting and running IC engines. Introduction to Biofuels such as biodiesel, ethanol, biobutanol etc. and their production and present status.

Ocean and Tidal Energy

OTEC, Settling of OTEC plants, Thermodynamic cycles, Tidal Energy: Potential and conversion techniques, mini hydel power plants and their economics.

Course Outcomes:

1. Create awareness among students about Non-Conventional sources of energy technologies
2. The students acquire sufficient knowledge about various types of renewable energy resources, the fundamental concepts and their application.
3. The students also develop an understanding of and design related concepts of equipment and instruments used.
4. Equip the students with knowledge and understanding of various possible mechanisms about renewable energy projects

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√			√				√	
2	√	√				√	√		√		√
3	√	√		√		√					
4	√	√			√			√			√

Recommended books:

1. Rai G. D., "Non-conventional Energy Sources", Standard Publishers Distributors, (2007).
2. Sukhatme K., Sukhatme S. P., Solar Energy: Principles of Thermal Collection and Storage, 2nd Edition, Tata McGraw Hill, (1996).
3. Mittal K. M., "Non-conventional Energy System", Wheeler Publishing Co. Ltd, (1997).
4. Rao S., Parulekar B. B., "Energy Technology", Khanna Publishers, (1995).
5. Desai A. V., "Non-convetional Energy", Wiley Eastern, (1990).

Course Code	Course Title	L	T	P
CHPE-460	Petrochemical Technology	3	0	0

Pre-requisites: Basic knowledge of organic chemistry and chemical technology.

Course Information: Petrochemical technology is the subject which deals with the manufacturing processes of various chemicals whose origin is from petroleum products. This subject also deals with the information about the technologies which are being used in the manufacturing of these various products.

Syllabus:

Petrochemicals- An Overview

Growth of global and Indian petrochemicals industries, definition of petrochemicals, history of petrochemicals industry, development of petrochemicals industry in India, economics of petrochemicals industry, sources of petrochemicals- natural gas and petroleum, classification of petrochemicals.

Chemicals from Methanol and Synthesis gas,

Oxo-products, methanol, formaldehyde, carbon-di-sulphide, Hydrogen cyanide

Ethane, Ethylene and Acetylene

Synthetic ethanol, aldehyde, acetaldehyde, acetic acid, vinyl acetate, butraldehyde and ethyl hexanol and DOP, ethylene oxide, ethylene glycol, acrylonitrile, ethanol, amines, ethyl chloride, ethylene di chloride

Chemicals from Propane and Propylene

Butadiene, butanol amines, butyl acetate, methyl-ethyl ketone

Butanes, Butane, Pentanes and Pentanes

Iso-propanol, acetone, glycerol, propylene oxide, propylene glycols, cumene,

Chemicals from Aromatics

monochloro, dichloro benzene, BHC nitro benzene, benzoic acid, nitrotoluene, pthalic anhydride, isopthalic acid, terethalic acid, dimethyl terepthalate, maelic anhydride.

Future of Petrochemicals

Integrated petro chemical complex, energy crisis in petro chemical industries, natural gas as petro chemical feed stock, import of heavy feed stocks on petro chemicals, ecology and energy crisis. Coal as an alternative to oil, energy crisis and industrial fuel, synthetic fuels, trends in petro chemical industries.

Course Outcomes:

1. Students will have knowledge of the past, present and future of petrochemical industries globally and nationally.
2. Will get a knowledge regarding the manufacturing of various petrochemicals.
3. Will have ability to understand the process technology employed in the manufacturing of various petrochemical.
4. Will provide the overview of petrochemical industry.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓				✓		✓			✓	✓
2	✓	✓				✓		✓	✓	✓	✓
3	✓	✓		✓		✓		✓	✓	✓	✓
4	✓	✓			✓	✓	✓	✓	✓		✓

Recommended books:

1. Rao M. G. and Sitting M. "Dryden'd Outlines of Chemical Technology", 3rd Edition, East-West Press, (1997).
2. Rao B.K.B., "A Text on Petrochemicals", 5th Edition, New Delhi, India, Khanna Publishers, (2015).
3. Sukumar M., "Introduction to Petrochemicals", Oxford and IBH publishing Co., (1992).
4. Chauvels A. and Lefebvre G., "Petrochemical Process", Vol. 4.

Course Code	Course Title	L	T	P
CHPE-461	Biochemical Engineering	3	0	0

Pre-requisites:	Basic course on introduction to biosciences
Course objectives:	This course provides the fundamental background of biological systems, bio-chemical engineering, advanced bioprocess engineering, biologically mediated processes and enhances the skills in the areas of biochemical processes.
Syllabus:	**Introduction** Introduction to Biotechnology and Biochemical Engineering, An overview of basics of Biology. **Enzyme Kinetics** Enzyme kinetics, Immobilized enzyme systems, Industrial and Pharmaceutical applications of enzymes. **Cell Growth** Batch and Continuous growth, Quantifying cell concentration, growth patterns and kinetics. **Engineering Principles** Operating considerations for bioreactors for suspension and immobilized cultures, Modifying batch and continuous **Genetically Engineered Cells** Introduction to mutation, Natural mechanisms for gene transfer and rearrangement, Basic elements of genetic engineering, Genomics, Bioinformatics, Application of recombinant DNA technology.
Course Outcomes:	1. Understanding of biological basics and bioprocessing. 2. Understand the integrated approach of chemical engineering with basic life sciences in developing processes and products. 3. Acquire the knowledge of enzyme catalyzed reaction and inhibition mechanisms 4. Acquire knowledge about different types of bioreactor, its industrial applications and scale up criteria.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√	√	√		√	√					
2	√	√	√	√		√					
3	√	√	√	√							
4	√	√	√	√		√					

Recommended books:

1. Bailey J. E., Ollis D. F., "Biochemical Engineering Fundamentals", McGraw Hill International Editions, Second Edition, (1986).
2. Primrose S. B., Twyman R. M., "Principles of Gene Manipulation and Genomics", Blackwell Publishing, Seventh Edition, (2006).
3. Shuler M. L., Kargi F., "Bioprocess Engineering", Prentice Hall of India Pvt. Ltd., Second Edition, (2005).
4. James M.Lee- Biochemical Engineering, Prentice Hall, 1992.
5. Dutta R., "Fundamentals of Biochemical Engineering", Springer Publications, (2010).

Course Code	Course Title	L	T	P
CHPE-462	Catalysis	3	0	0

Pre-requisites:	Basic knowledge of physics, chemistry, materials and reaction engineering
Course objectives:	Objective of this course is to deliver a knowledge to the students regarding catalysts, preparation, characterization and catalytic reactions.
Syllabus:	**Introduction** Introduction to catalysis, adsorption in catalysis, adsorption types and kinetics **Heterogeneous catalysis** Catalyst types and preparation, precipitation and co-precipitation, solgel method, supported catalysts, drying, calcinations and formulation. **Characterization** Introduction, fundamentals of solid state chemistry,structure of solids,structure-property relationship and analysis, surface area analysis, pore analysis, XRD analysis, thermal analysis, FTIR analysis, catalyst tests **Catalytic reactions** Reaction mechanism, rate equations, kinetic analysis, internal and external transport, catalyst deactivation, assessment of catalyzed reactions, analysis of reaction data **Homogeneous catalysis** Introduction and different types of reactions, mechanism and kinetics, industrial homogeneous processes **Modern catalysts** Zeolite catalysts, nanocatalysts, photocatalysts, carbon nanotubes, non-metal and metal oxide catalysts
Course Outcomes:	1. Ability to develop an understanding of the catalytic processes 2. Understanding of methods of preparation and characterization of the catalysts 3. Ability to improve the physical and chemical properties of the catalysts 4. Understanding of techniques of synthesize of novel catalysts

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	✓					✓	✓	✓	✓		✓
2	✓							✓	✓	✓	✓
3	✓	✓		✓	✓	✓		✓	✓	✓	✓
4	✓	✓		✓	✓	✓		✓	✓	✓	✓

Recommended books:

1. Levenspiel O., “Chemical Reaction Engineering”, 3rd Edition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., “Elements of Chemical Reaction Engineering”, 3rd Edition, Prentice Hall Inc., (1999).
3. Smith J. M., “Chemical Engineering Kinetics”, 3rd Edition, McGraw Hill, (1981).
4. Coulson J. M., Richardson J. F., “Chemical Engineering, Volume 3”, Pergamon Press, (1999). Sons, NY, (1990).

Course Code	Course Title	L	T	P
CHPE-463	Pressure Driven Membrane Separation Processes	3	0	0

Pre-requisites:	Basic of Mathematics, Transport phenomena
Course objectives:	The objective of the course is to impart knowledge to the students about various membrane separation processes, covering the fundamentals as well as the recent developments of different processes as well as their industrial applications. Students are exposed to the basic principles, operating parameters, types of membrane used, flux equation, transport mechanism, and applications of membrane-based technologies.
Syllabus:	**Overview of Membrane Science And Technology** Definition of Membrane and Membrane Process, Chemical Potential and Osmotic Pressure Relationship Criteria of Desalination,Classification of Membraneand Membrane Based Processes, Membrane Chemistry, Synthesis and Materials **Reverse Osmosis and Nano Filtration** Introduction and Definition, Theory and Design, Different Membrane Modules, Selected Applications and Economics. **Ultra Filtration** Introduction and Definition, Theory and Design, Membrane Module and Process Configuration, Applications and Economics. **Micro Filtration** Introduction and Definition, Theory of Cross Flow Filtration, Dead End Micro Filtration, Applications and Economics. **Dialysis, Electodialysis, Pervaporation, Gas Permeation,Emulsion Liquid Membranes** Brief Introduction and Applications.
Course Outcomes:	1. Understand the basic principles for different membrane separation processes 2. Identify and design the suitable membrane separation technique for intended problem 3. The students are capable of applying various transport models for the calculation of membrane fluxes and the other separation properties for various membrane systems 4. Student's are able to identify established membrane separation processes and learn concepts of upcoming membrane separation processes

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓										✓
2		✓									✓
3		✓								✓	✓
4		✓		✓						✓	✓

Recommended books:

1. Wilson, S “Membrane Handbook”, McGraw Hill, London, (2001).
2. Nune S.P. and Peinemann K. V., “Membrane Technology in Chemical Industries”, Wiley, New York, (2000).
3. Cheryan M., “Ultra filtration Handbook”, Technomic, New York, (1985).
4. Noble, S., “Membrane Separation and Technology, Principles and Applications”, Elsevier, (1995).
5. Baker R. W., “Membrane Technology and Applications, Wiley, New York, (2000).

Course Code	Course Title	L	T	P
CHPE-464	Process Instrumentation and Analytical Methods	3	0	0

Pre-requisites: Knowledge of Fluid Mechanics, Mathematics, Chemistry

Course objectives: The objective of the course is to introduce to students various types of instruments and their applications in chemical processes. The course will help students to understand the concepts of different types of analysis, e.g., chemical analysis, data analysis, thermal analysis, electrochemical analysis, etc

Syllabus:

General Principles of Measurements

Static and Dynamic Characteristics of Instruments, Dynamic Response to First and Second Order Systems.

Industrial Instrumentation

Temperature Measurement: Thermocouples, Resistance, Thermometers, Thermistors, and Radiation Pyrometers. Pressure Measurement: Manometers, Bourdon Gauge, Bellows Type Gauge, Measurement of Vacuum and Pressure Transducers. Flow Measurement: Variable Area Meters. Pressure Probes, Positive Displacement Type Meters. Liquid Level Measurement

Data Analysis

Error, Accuracy, Precision, Significant Figures, Correlation, Regression, Analysis of Variance, Optimization Methods, Factor Analysis.

Spectroscopic Analysis

Introduction, Theory and Mechanism of Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, Mass Spectroscopy, Nuclear Magnetic Response Spectroscopy, Infrared Spectroscopy, UV Spectroscopy, Raman Spectroscopy, XRD, SEM, TEM.

Chromatographic Analysis

Introduction, Theory, Principles and Methodology of Thin Layer Chromatography, Liquid Chromatography (HPLC, UPLC) and Gas Chromatography, GC Mass Spectroscopy.

Thermal Analysis

Introduction, Theory, Principles and Methodology of Thermo Gravimetric (TG), Differential Thermo Gravimetric (DTG), Derivative Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC).

Electrochemical Analysis

Introduction, Theory, Principles and Methodology of Electrogravimetric Analysis, Coulometry, Potentionmetry, Voltammetry, Polarography.

Course Outcomes:

1. The students will get acquaintance about various types of instruments for measurement of temperature, pressure, conductivity, pH, composition of the given mixture etc.
2. Students will attain the knowledge of principles for spectroscopic and chromatographic, etc.
3. The course helps the students to extend the skills in procedures and instrumental methods applied in analytical tasks.
4. The students will able to design and data analysis of the industrial instruments.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓										✓
2	✓										✓
3	✓		✓								✓
4		✓		✓							

Recommended Books:

1. Eckman D. P., “Industrial Instrumentation”, Wiley Eastern Ltd., (1975).
2. Kerk F. W., Rimboi W., Tarapore R., “Instrumentation”, Wiley and Sons, (1983).
3. Mendham J., Denney R. C., Barnes J. D., Thomas M. J. K., “Vogel’s Text Book of Quantitative Chemical Analysis”, Pearson Education, Sixth Edition, (2006).
4. Willard, Merritt, Dean, Settle, “Instrumental Methods of Analysis”, CBS Publisher and Distributors. (1986).
5. Haines J., Blackie, “Thermal methods of Analysis, Principles, Application and Problems”, Academic and Professional, (1994).

Course Code	Course Title	L	T	P
CHPE-465	Introduction to Colloids and Interfacial Science and Engineering	3	0	0

Pre-requisites: Fluid mechanics and thermodynamics

Course objectives: Colloids (including nanoparticles) and interfaces (surfaces) are the two most fundamental, widespread and useful nano-entities. Study of colloids and interfaces is highly multidisciplinary in nature combining both the concepts and applications from such diverse domains as chemical engineering and manufacturing

Syllabus:

Surface Tension, Adhesion and Capillarity

Effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; A polar (van der Waals) and polar (acid-base) components of interfacial tensions. Young-Laplace equation of capillarity; examples of equilibrium surfaces; multiplicity, etc. Free energies of adhesion; Kinetics of capillary and confined flows.

Nano-scale and Interfacial Forces

Van der Waals, Electrostatic double layer, Acid-base interactions including hydrophobic attraction and hydration pressure.

Mesoscale Thermodynamics and Applications

Gibbs treatment of interfaces; concept of excess concentration; variation of interfacial tensions with surfactant concentration, Adhesion, wetting, nucleation, flotation, patterning of soft material by self - organization and other techniques.

Stability of Nanoparticle Dispersions

DLVO and DLVO like theories and kinetics of coagulation plus general principles of diffusion in a potential field/Brownian movement.

Nanofluidics and Functional Interfaces

Stability of thin (<100 nm) films; self-organization in confined systems; meso-patterning, Superhydrophobicity, functional coatings, structural colors, nano-adhesives; nanocomposites.

Course Outcomes:

1. Understanding of basic nomenclature, concepts and tools of colloid and interface science and engineering.
2. Ability to understand multi-phase nano-systems; mechanics and thermodynamics on small scales.
3. Understanding of differences between the surface and bulk dominated regimes and behavior and exploitation of nano-behavior.
4. Appreciation of how these concepts and tools translate into a variety of applications from processes to materials.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√						√	√	√		
2		√									√
3					√			√			
4				√	√	√				√	√

Recommended books:

1. Paul C. Hiemenz, Marcel Dekker, "Principles of Colloid and Surface Chemistry" 3rd Edition, CRC Press, (2016).
2. P. Ghosh, "Colloid and Interface Science", PHI Learning Pvt. Ltd., (2009).
3. R. J. Hunter, "Foundations of Colloid Science", Oxford University Press, (2005).
4. J. Israelachvili,, "Intermolecular and Surface Forces", Academic Press, London, (1992).
5. R. J. Stokes, D. F. Evans, "Fundamentals of Interfacial Engineering", Wiley-VCH, (1997).

Course Code	Course Title	L	T	P
CHPE-466	Fluidization Engineering	3	0	0

Pre-requisites: Fluid mechanics, Heat transfer and engineering mathematics.

Course objectives: Fluidization finds extensive application today in Process Industry and also in combustion. Objective of this course is to make the student aware of fundamentals of Fluidization and understand the design aspects of fluidized bed systems.

Syllabus:

Introduction and Applications

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

Gross Behaviour of Fluidised Beds

Gross behaviour of fluidised beds. Minimum and terminal velocities in fluidised beds. Types of fluidisation. Design of distributors. Voidage in fluidised beds. TDH, variation in size distribution with height, viscosity and fluidity of fluidised beds, Power consumption.

Analysis of Bubble and Emulsion Phase

Davidson's model, Frequency measurements, bubbles in ordinary bubbling bed model for bubble phase. Emulsion phase: Experimental findings. Turnover rate of solids. Bubbling bed model for emulsion phase Interchange co-efficient. Residence time distribution and size distribution of solids in fluidized bed. Circulating fluidized bed; Pneumatic transport of solids. Design of fluidized bed for physical operations, catalytic reactions and non-catalytic reactions

Flow Pattern of Gas and Heat & Mass Transfer in Fluidised Beds

Flow pattern of gas through fluidized beds. The bubbling bed model for gas inter change 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 Fluidized Beds and Surfaces - Entrainment &Elutriation

Heat transfer between fluidized beds and surfaces: Experiment finding theories of bed heat transfer comparison of theories. Entrainment of or above TDH, model for Entrainment and application of the entrainment model to elutriation.

Course Outcomes:

1. Ability to understand and solve Fluidization.
2. Able to understand the Heat and Mass transfer in fluidized bed systems
3. Able to understand the Fluidization of different phases.
4. Able to design a fluidized bed system for different applications.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√				√						√
2	√										
3	√	√						√		√	√
4	√	√		√	√	√	√	√	√		√

Recommendedbooks:

1. Diazo Kunii, Octave Levenspiel, "Fluidization Engineering", 2nd Ed, Wiley(1991).
2. M. Rhodes, "Introduction to Particle Technology", 2nd Ed., Wiley (2008).
3. L. G. Gibilaro, "Fluidization - Dynamics", Butterworth - Heinemann (2001).
4. J.F. Davidson, D. Harrison, "Fluidized Particle", Cambridge University Press (1963).

Course Code	Course Title	L	T	P
CHPE-467	Fertilizer Technology	3	0	0

Pre-requisites: Chemical Technology

Course objectives: The course will provide the knowledge on various types of fertilizers, their methods of manufacture, materials of construction, economics and corrosion problems of the fertilizer industry.

Syllabus:

Introduction

Elements required for plants growth, classification of fertilizers, compound, complex & bulk blended fertilizers. N-P-K values and calculations.

Nitrogenous Fertilizers

Manufacturing Processes for Ammonia, effects of various factors on the process. Manufacture of ammonium sulphate, ammonium chloride, ammonium phosphate, Ammonium nitrate, nitric acid, Urea etc.Economics & other strategies, Materials of construction and corrosion problems.

Phosphatic fertilizers

Calculation of percentage tricalcium phosphate of lime in phosphatic rock. Manufacture of triple super phosphate and single super phosphate, Nitrophosphate, Sodium phosphate, Phosphoric acid and other phosphatic fertilizers.

Potash Fertilizers

Manufacture of potash fertilizers like potassium sulphate, potassium chloride etc.

Other Fertilizers

Mixed fertilizers and granulated mixtures; bio fertilizers, nutrients, secondary nutrients and micro nutrients; fluid fertilizers, controlled release fertilizers.

Course Outcomes:

1. Ability to understand the importance of fertilizers.
2. Able to know different methods of production of various fertilizers.
3. Able to understand the various engineering problems occurring in fertilizer industries.
4. Ability to get knowledge on materials of construction and corrosion problems.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√		√		√	√					
2	√	√	√	√	√	√	√				
3	√	√	√	√	√	√	√				
4	√		√	√	√						

Recommended books:

1. Dryden C E, "Outlines of Chemical Technology", East –West Press Pvt. Ltd., New Delhi, 2 nd Edition (1973)
2. Austin G T, "Shreve's Chemical Process Industries", McGraw Hill Book Company, New Delhi 5th Edition (1986)
3. Chemical Engineering Education Development Centre– "Chemical Technology I, II, III , IV , Manual of Chemical Technology, Indian Institute of Technology , Madras".
4. Shukla S D and Pandey G N, "A text book of Chemical Technology Vol I", Vikas Publishing House Pvt. Ltd., New Delhi
5. Shukla S D and Pandey G N, "A text book of Chemical Technology Vol lI", Vikas Publishing House Pvt. Ltd., New Delhi

Course Code	Course Title	L	T	P
CHPE-468	Biorefineries and Bioproducts Engineering	3	0	0

Pre-requisites:	None
Course objectives:	The course will provide the fundamental basis of bioproducts bioengineering based on the biorefinery concept, aimed to form the students on green chemical strategies for the processing of biomass and waste into valuable biomaterials, biochemicals and biofuels.
Syllabus:	**Introduction:** Introduction and basic concepts: Green Chemistry, biorefineries, biofuels , Bioproducts and platform molecules **.** **Bioproducts from biomass:** Production of Biomaterials from Biomass, Chemicals from Biomass & waste, Biofuels from Biomass & Waste. **Biomass Conversion processes:** Biochemical conversion processes, Thermochemical conversion processes-Combustion, gasification, pyrolysis, hydrothermal liquefaction and Integrated hybrid conversion processes. **Biorefinery:** Design of a biorefinery by incorporating various unit operations, mass and energy balance, sustainability aspects using Aspen plus and other simulation packages. Examples of biorefinery concepts.
Course Outcomes:	1. Understanding the possibilities of biorefineries in a future scenario without fossil fuels. 2. Understanding Green Chemical approaches and alternative processes to bioproducts from biomass and waste. 3. Ability to identify key pathways for sustainable processing of feedstocks. 4. Knowing basic concepts of Biorefineries and Green Chemical methods and application to present industrial processes.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√		√		√	√					
2	√	√	√	√	√	√	√				
3	√	√	√	√	√	√	√				
4	√		√	√	√						

Recommended books:

1. Kamm, B., Gruber, P.R., and Kamm, M. (2006). Biorefineries – Industrial Processes and Products. WILEY-VCH.
2. Brown, R.C. (Ed.) Thermochemical processing of biomass into fuels, chemicals and power, Wiley, 2011.
3. Clark, J., Deswarte, F. (Ed.) Introduction to chemicals from biomass, John Wiley and Sons, U.K., 2008.
4. Basu, Prabir. Biomass gasification, pyrolysis and torrefaction: practical design and theory. Academic press, 2013.
5. Bergeron, C., Carrier, D.J., and Ramaswamy, S. (2012). Biorefinery Co-Products. Wiley & Sons, Ltd. ISBN: 978-0-470-97357-8.

OPEN ELECTIVES

Course Code	Course Title	L	T	P
CHOE-401	Hydrocarbon Engineering	3	0	0

Pre-requisites: Basic knowledge of organic chemistry, inorganic chemistry and chemical technology.

Course Information: Hydrocarbon engineering is the subject which deals with the study of various types of hydrocarbons, their structure present in petroleum crude. Also deals with the chemistry of various reactions involving petroleum refining operations. This subject also brings knowledge regarding various properties, standard, transportation, handling and storage methods used for the various petroleum products.

Syllabus:

Scope and Purpose of Refining

Global and Indian refining scenario, Petroleum refining industry in India practice and prospects, Separation and Conversion processes etc.

Refinery Distillation Processes

Desalting, Process description of typical crude distillation, Fractional distillation, Vacuum distillation, Flooding, Weeping, Entrainment, Setting of cut point, Crude assay analysis, ASTM, TBP EFV Distillation etc.

Fuel Refining and Lube Refining

Cracking, Coking, Reforming, Alkylation, Isomerisation, Polymerization, and Sweetening etc. Solvent extraction, Dew axing, Propane deasphalting etc.

Hydro processing

Hydro cracking, Hydro treating, Hydro desulphurization

Oil and Gas separators

Principal of separation, Types of separators, their description. Various control and vessel internals, Oil and gas gravitational separator, Vertical two and three phase separator, Horizontal three phase separator etc.

Quality Monitoring of Petroleum Products

API gravity, Flash point, Fire point, Smoke point, Aniline point, Carbon residue, Kinetic viscosity, Pour point, Freezing point, octane number, Cetane number, Viscosity index, Diesel index, Calorific value, Burning test 24 hours, Characterization factor, Cloud Point, Vapour lock index, Carbon hydrogen ratio, Calculated ignition index, Carbon aromaticity index, U.O.P Characterization factor, Conrad son carbon residue, Water and sediment content.

Storage of Petroleum Products

Classification of inflammable liquids, Classification of storage tank, Floating roof tank, Fixed roof tank, Semi buried tank, Import/export loss, Breathing losses, Hazards and non-hazards area, and underground storage tank etc.

Transportation

Transportation of oil and natural gas by rail, road and pipeline, Various type of pipelines, Pipe line automation, Lease Automatic Custody Transfer units, SCADA, Batch transport of petroleum products, Multiproduct pipelines, Product handling, Pumping cycle, Interface , Problems in waxy crude, Role of flow behaviour etc.

Course Outcomes:

1. Student will be able to identify different types of hydrocarbon based on their structure present in petroleum crude.
2. Gain knowledge of reaction chemistry of specific reaction that took place in petroleum refining operations.
3. Students will learn about the various operations take place in refineries to convert raw crude into various commercial products.
4. Students will able to implicate technical knowledge to analyzed and solve the engineering problems involves in the petroleum refineries.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1						✓		✓	✓		
2	✓	✓	✓		✓			✓	✓	✓	✓
3	✓	✓	✓	✓	✓			✓	✓	✓	✓
4	✓	✓	✓	✓			✓	✓		✓	✓

Recommended books:

1. Nelson W. L., “Petroleum Refinery Engineering”, Mc-Graw Hill Book Co., (1985).
2. Watkins R. N., “Petroleum Refinery Distillation”, Gulf Publishing Co.
3. Gary J. H., Handwork G. E., “Petroleum Refining Technology and Economics”, Marcel Dekker, Inc., (2001).
4. Jones D. S. J., “Elements of Petroleum processing”, John Wiley &Sons, (1995).
5. Waquier J. P., “Petroleum Refining” Vol. I & II , Technip, (1995)

Course Code	Course Title	L	T	P
CHOE-402	Energy Management and Audit	3	0	0

Pre-requisites: None

Course Objectives: The course aims at understanding the basic concepts of energy management, energy monitoring and optimization of energy-use. The processes and parameters involved in an Energy Audit are also included. The course also aims to study the human and non-human project resource management, relevant to energy consumption. Finally, the course is meant to get familiar with techniques and tools for energy monitoring and targeting.

Syllabus:

Energy Scenario

Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features. Kyoto Protocol. Global warming.

Energy Management & Audit

Definition, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments, Energy and Cost Indices.

Energy Action Planning

Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification, Organizing - location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager, Accountability.

Motivating-Motivation of Employees

Information system designing barriers, Strategies; Marketing and communicating-training and planning. Financial Management, Investment-need, Appraisal and criteria, Financial analysis techniques- Simple pay-back period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs.

Project Management

Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring. Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification.

Energy Monitoring and Targeting

Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Monitoring methods such as Sankey-Diagrams, Pie-charts and Bar-diagrams, Techniques of energy consumption, Production, Cumulative sum of differences (CUSUM).

Course Outcomes:

1. To understand the basic concepts of energy management, energy monitoring and optimization of energy-use.
2. To study the processes and parameters involved in an Energy Audit.
3. To study the human and non-human project resource management, relevant to energy consumption.
4. To get familiar with techniques and tools for energy monitoring and targeting.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		√		√	√	√	√			√	
2		√			√	√	√			√	
3					√		√	√		√	
4		√		√		√		√		√	

Recommended books:

1. Capehart, Barney L., Turner W. C., Kennedy W. J., "Guide to Energy Management", Third Edition, Fairmont Press, Atlanta, GA, (2000).
2. Thumann A., Mehta D. P., "Handbook of Energy Engineering", 4th Edition Lilburn, GA: Fairmont Press, (1997).
3. Loftness, Robert L. "Energy Handbook." 2nd Edition, New York: Van Nostrand Reinhold Co., (1984).
4. Turner W., "Energy Management Handbook", John Wiley &. Sons, New York, (1982).
5. Lapedes, D. N., "Encyclopaedia of Energy", McGraw-Hill, New York, (1976).

Course Code	Course Title	L	T	P
CHOE-403	Polymer Science and Engineering	3	0	0

Pre-requisites: Engineering chemistry and physics

Course Objectives: The course aims at understanding the basic concepts of polymer structure, properties and engineering, the manufacturing processes and process kinetics of different polymers, the different processing techniques for polymers for applications in fibres, plastics, rubber, surface coatings and adhesives, and to get familiar with common testing and evaluation methods for polymeric materials.

Syllabus:

Basic Concepts

Concepts and classification of polymers, functionality , glass transition temperature, addition, condensation, step-growth and chain-growth polymerization, molecular weight estimation: Number and weight average, sedimentation and viscosity average molecular weights, molecular weight and degree of polymerization, polydispersity, significance of molecular weight.

Polymerization Processes

Bulk, solution, emulsion and suspension polymerization, comparison of polymerization processes.

Polymerization Kinetics

Chemistry of step reaction polymerization, mechanism and kinetics of poly condensation reactions, relationship between average functionality, extent of reaction and degree of polymerization, mechanism and kinetics of free- radical chain polymerization, kinetic chain length, chain transfer reactions, Inhibition and retardation

Synthetic Fibers

Types of Fibers, spinning techniques, manufacturing technology and applications of different types of fibers: Cellulosic fibers, polyamides, acrylics, vinyls and vinylidines, fluorocarbons.

Plastics

Manufacturing technology and applications of different types of plastics: Polyester, polyethylene, Phenolics.

Rubbers

Structure, properties and preparation natural rubber synthetic rubbers: SBR, rubber compounding and reclaiming.

Testing and Evaluation of polymers

Physical testing, Electrical Properties, Softening Temperature tests, Melt flow Index.

Course Outcomes:

1. Developing understanding of fundamentals of polymers, their structure, properties and manufacturing techniques.
2. Ability to study the polymerization processes and process kinetics.
3. Understanding different process techniques and applications of fibers, plastics and rubbers.
4. To familiarize various testing and evaluation methods for polymeric materials.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		√		√	√	√					
2	√				√	√				√	
3	√				√	√				√	√
4		√	√	√		√					√

Recommended books:

1. Gowariker V. R., Viswanathan N. V., Sreedhar J., “Polymer Science”, New Age International Publishers, 37, (1996).
2. Billmeyer F. W., “Text Book of Polymer Science”, Wiley Tappers, (1994).
3. Ghosh P., “Polymer Science and Technology of Plastics and Rubber”, Tata McGraw Hill, (2001).
4. Gupta R. K., Kumar A., “Fundamentals of Polymer Engineering”, 2nd Edition, Marcel Dekkar, (2003).
5. Fried J. R. “Polymer Science and Technology”, PHI Learning, (2008).

Course Code	Course Title	L	T	P
CHOE-404	Industrial Safety and Hazards Management	3	0	0

Pre-requisites: Transport Phenomena, Mechanical Unit Operation, Process Control

Course objectives: The objective of the course is to impart knowledge to the students about source of hazards and control techniques. The course briefs the basics of fire, explosion and toxic dispersion modeling, and methods of risk assessment.

Syllabus:

Introduction

Concept of Loss Prevention, Acceptable Risks, Accident and Loss Statistics, Nature Of Accident Process, Inherent Safety.

Toxicology

Dose vs. Response, Effects of Toxicant on Human, 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

Fire Triangle, Definitions, Flammability Characteristics of Liquid and Vapors, LOC and Inerting, Types of Explosions, Designs for Fire Prevention and Control

Hazard Identification

Hazard Survey, Checklist, HAZOP, Safety Reviews, what if analysis

Construction, Operation and Process Hazards

Safety aspect in construction, Operations and Processes, Runaway Reactions, unstable products, Safety in Erection and Commissioning

Risk Assessment

Probability Theory, Event Tree, Fault Tree, QRA and LOPA

Accident Investigations and Case Histories

Bhopal Gas Tragedy, Fixborough Disaster, Fukushima Daiichi Explosion, IOCL Jaipur Fire

Course Outcomes:

1. The students are able to understand the concept of loss prevention and hazard models such as pool fire, fireball, toxic dispersion etc.
2. The students learn to exhibit the skill of performing risk assessment such as conducting Dow's fire and Explosion Index for the real plant unit
3. Able to design the fire prevention and control systems
4. Able to calculate the accident and loss statics for the real plant unit

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓					✓					✓
2	✓	✓				✓					✓
3		✓		✓		✓					✓
4		✓				✓					✓

Recommended books:

1. Crowl D. A., Louvar J. F., "Chemical Process Safety Fundamentals with applications", 2nd Edition, Prentice Hall, NJ (2002),
2. Coulson J. M., Richardson J. F., "Chemical Engineering", 2nd Edition, Vol. 6, Pergamon Press (1999).
3. Dow's Chemical Exposure Index Guide, Dow Chemical Company, New York, (1993).
4. Lees F. P., Loss Prevention in Process Industries, 2nd Edition, Butterworth, London, (1996).
5. Wells G. L, Safety in Process Plant Design, George Godwin Ltd., New York, (1980).

Course Code	Course Title	L	T	P
CHOE-405	Environmental Engineering	3	0	0

Pre-requisites:	Knowledge on Environmental Science
Course objectives:	This course aims at developing the students the environmental impacts of air, water and solid pollution. This course also aims to develop the basic knowledge about the biomedical and hazardous and waste management.
Syllabus:	**Air Pollution Control Engineering** Introduction, Definition, Sources, Characteristics and Perspective of Air Pollutants, Effects of Air Pollution on Biodiversity, Economic Effects of Air Pollution, Air Quality and Emission Standards, Engineering Systems of Control of Air Pollution by Equipment and by Process Changes. **Water Pollution Control Engineering** Introduction, Definition, Sources, Characteristics and Perspective of Water and Wastewater Pollutants, Effects of Water Pollution on Biodiversity, Economic Effects of Water Pollution, Water Quality and Emission Standards, Physical, Chemical and Biological Parameters, Engineering Systems of Control of Water and Wastewater Pollution by Primary, Secondary and Advance Treatment. **Solid Waste Management** Introduction, Definition, Sources, Characteristics and Perspective of Solid Waste, Generation, Separation, Handling, Storage and Transportation of Solid Waste, Physical, Chemical and Biological Treatment of Solid Waste. **Biomedical and Hazardous Waste Management** Introduction, Definition, Sources, Characteristics and Perspective of Biomedical and Hazardous Waste, Handling, Storage, Transportation of Biomedical and Hazardous Waste, Physical, Chemical and Biological Treatment of Biomedical and Hazardous Wastes.
Course Outcomes:	1. The students are able to understand the impact of air, water and solid pollution effects on the environment. 2. The students are able to design various engineering systems of control of air, water and solid waste pollution by equipment and by process changes. 3. The students gain the knowledge of different standards for the measure and control of air, water and solid waste pollution in the environment. 4. The students exhibit the skill to solve the problems related to the environmental engineering.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√				√			√	
2	√	√			√			√			√
3	√	√				√			√		
4	√	√		√					√		

Recommended books:

1. Rao M. N., Rao H. V. N., "Air Pollution", Tata McGraw Hill Publishing Company Ltd., (2005).
2. Peavy H. S., Rowe D. R., Tchobanoglous G., "Environmental Engineering", McGraw Hill Book Company, International Edition, (1985).
3. Metcalf and Eddy, Inc., "Wastewater Engineering-Treatment and Reuse", Tata McGraw Hill Publishing Company Ltd., Fourth Edition, (2004).
4. Rittmann B. E., McCarty P. L., "Environmental Biotechnology: Principles and Application", McGraw Hill International Editions, First Edition, (2001).
5. Kiely G., "Environmental Engineering", Tata McGraw Hill Publishing Company Ltd, Special Indian Edition, (2007).

Course Code	Course Title	L	T	P
CHOE-406	Environment Impact Assessment	3	0	0

Pre-requisites: Knowledge on Environmental Science

Course objectives:

The objective of the course is to introduce students to the process of Environmental Impact Assessment (EIA) and the procedures that are followed in environmental management in industry.

Students are introduced with some of the basic environmental assessment techniques

Through case studies, students will learn to present and explain the components and decision making processes involved in environmental assessment.

Students will create a visual representation of data that comprises an environmental impact statement

Syllabus:

Environment Impact Assessment (EIA)

Concept of EIA, Origin of EIA, Procedure of EIA, Evaluation Methodology for EIA, Scope Studies, Preparation and Review of Environment Impact Statement (EIS).

Life Cycle Assessment (LCA)

Introduction of LCA, Importance of LCA, Environmental Parameters in LCA, Documentation in LCA.

Waste Minimization

Introduction, Types of Waste, Benefits of Waste Minimization, Elements of Waste Minimization Programme, Integrated System for Waste Management.

Environmental Audit (EA)

Concept of EA, Necessity and Importance of EA, Audit Items, Audit Procedures.

Environmental Management System (EMS)

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

Case Studies

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

Course Outcomes:

1. Ability to understand the current EIA methods and the techniques and tools used
2. Ability to understand the current assessment methods and legislation
3. Ability to understand the current environmental monitoring systems
4. Ability to apply knowledge acquired to the process of environmental impact modeling and prediction as a design tool with application to a number of case studies

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√			√			√		√	
2	√	√	√	√			√	√			
3	√	√	√			√					√
4	√	√	√		√				√		

Recommended books:

1. Anjaneyulu Y., “Environment Impact Assessment Methodologies”, B S Publications, (2002).
2. Canter L. W., “Environment Impact Assessment”, McGraw Hill, Second Edition, (2005).
3. Garg S. K., Garg R., Garg R., “Ecological and Environmental Studies”, Khanna Publishers, First Edition, (2006).
4. Santra S. C., “Environmental Science”, New Central Book Agency (P) Ltd., Second Edition, (2006).
5. Uberoi N. K., “Environmental Management”, Excel Books, Second Edition, (2006).

Course Code	Course Title	L	T	P
CHOE- 407	Oil and Natural Gas Economics	3	0	0

Pre-requisites: Basic knowledge of crude and natural gas, petrochemicals and petroleum refinery.

Course objectives: Oil and natural gas economics is the subject which deals with the knowledge regarding the oil and gas sources, demand, supply and economic status nationally and globally.

Syllabus:

Role of Oil and Gas in the World Economy

Importance of oil and gas, oil and gas reserves, supply and demand, specific features of oil and gas Industries.

Oil and Gas Production and Development

Exploration for oil and gas, economic cost of finding oil and gas, contractual arrangements for exploration of oil and gas, development of oil and gas Fields, economics of oil and gas field development, technological innovations in exploration and drilling etc.

Transportation and Processing of Oil and Natural Gas

Economics and technologies for transportation, refinery economics and refining technologies, gas processing technologies and economics, optimization techniques for transportation and processing etc.

Organization of Oil and Gas Industries

Evolution of the oil Industry, domination by multinationals OPEC era, recent developments, evolution of the gas Industry, gas contracts, deregulation and restructuring in oil and gas Industries

Pricing of Oil and Gas

Economic theory of exhaustible resources, analysis of oil pricing by multinational companies, OPEC pricing policy, net-back pricing and parity pricing, pricing in a competitive market, rent and rent sharing, analysis of international pricing of oil and gas

Domestic Pricing Issues in Oil and Natural gas

Objectives for oil and gas pricing at the national level, pricing mechanisms and policies, tax and subsidies etc.

Trade and Markets for Oil and Natural Gas

International oil and gas markets, new trading mechanisms, trading in a deregulated industry etc.

Issues Facing Oil and Gas Industries

Externalities, financing needs, geo-political concerns

Course Outcomes:

1. The students develop the knowledge base about the development of oil and gas fields and technological innovations in exploration and drilling etc.
2. Students will learn the role of oil and natural gas in economic growth of the nation.
3. Students will have knowledge of production, demand and supply of oil and natural gas.
4. The students are able to understand the refinery economics and refining technologies, gas processing technologies and economics, optimization techniques for transportation and processing etc.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓	✓			✓	✓		✓	✓	✓	✓
2					✓		✓				✓
3		✓						✓	✓	✓	✓
4	✓	✓		✓	✓	✓		✓	✓	✓	✓

Recommended books:

1. J. H. Gary, G. E. Handwork and M. J. Kaiser, Petroleum Refining: Technology and Economics, Fifth Edition, CPR Press, Taylor and Francis Group, (2007).
2. Conaway C.F., "The Petroleum Industry: A Non- Technical Guide", Penn Well, (1999).
3. Berger B. D., "Modern Petroleum: A Basic Primer of the Industry", (1992).
4. Tussing A., Tippee B., "The Natural Gas Industry: Evolution, Structure and Economics", Penn Well, (1995).
5. Julius D., Mashaekhi, A., "The Economics of Natural Gas: Pricing, Planning and Policy", OIES, (1990).

Course Code	Course Title	L	T	P
CHOE-408	New and Renewable Energy Resources	3	0	0

Pre-requisites: Course will be accessible to most students who have completed their first two years of study at an Undergraduate level.

Course objectives: This course covers in a comprehensive manner the operating principle of a range of non-conventional energy resources, materials used, characterization, and key performance characteristics. The technologies to be studied will include Solar energy, Wind, Fuel cells, biomass, and Geothermal conversion. The advantages and limitations of these technologies in comparison to conventional sources of energy will also be studied.

Syllabus:

Introduction

Global and Indian scenario, Sources, Energy conservation, Types of NCES with applications, Role and development of new renewable energy sources.

Solar Energy

Introduction, Solar radiation data, Instruments for measuring solar radiations, 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. Solar Calculations: Angles associated with solar rays and the collector surface, Local apparent time, Soar day length.

Geothermal Energy

Resources, Types of wells, Methods of harnessing the energy.

Wind Energy

Sources and potentials, Horizontal and vertical axis wind mills, Wind regime analysis and evaluation of wind mills.

Biomass and Biofuels

Recycling of agricultural waste, Anaerobic/aerobic digestion and types of biogas digesters, Gas yield and combustion characteristics of bio gas, Design of biogas system for heating, Lighting and running IC engines. Introduction to Biofuels such as biodiesel, ethanol, biobutanol etc. and their production and present status.

Ocean and Tidal Energy

OTEC, Settling of OTEC plants, Thermodynamic cycles, Tidal Energy: Potential and conversion techniques, mini hydel power plants and their economics.

Course Outcomes:

1. Create awareness among students about Non-Conventional sources of energy technologies
2. The students acquire sufficient knowledge about various types of renewable energy resources, the fundamental concepts and their application.
3. The students also develop an understanding of and design related concepts of equipment and instruments used.
4. Equip the students with knowledge and understanding of various possible mechanisms about renewable energy projects

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√			√				√	
2	√	√				√	√		√		√
3	√	√		√		√					
4	√	√			√			√			√

Recommendedbooks:

1. Rai G. D., “Non-conventional Energy Sources”, Standard Publishers Distributors, (2007).
2. Sukhatme K., Sukhatme S. P., Solar Energy: Principles of Thermal Collection and Storage, 2nd Edition, Tata McGraw Hill, (1996).
3. Mittal K. M., “Non-conventional Energy System”, Wheeler Publishing Co. Ltd, (1997).
4. Rao S., Parulekar B. B., “Energy Technology”, Khanna Publishers, (1995).
5. Desai A. V., “Non-convetional Energy”, Wiley Eastern, (1990).

Course Code	Course Title	L	T	P
CHOE-409	Corrosion Engineering	3	0	0

Pre-requisites:	Basics course on material science and chemistry
Course objectives:	This course provides a foundation for understanding the forms of corrosion, the mechanisms of corrosion, electrochemical methods to study and measure corrosion, and the principles and methods leading to mitigation of corrosion problems that might occur in engineering practice.
Syllabus:	**Basic Concepts** Definition and importance, impact on economy, Electrochemical reactions, Corrosion rate and its determination, Theories of corrosion, Polarization, Passivity, Metallurgical aspects. **Forms of Corrosion** Galvanic corrosion, crevice corrosion, pitting, intergranular corrosion, erosion corrosion, flow-accelerated corrosion**,** stress corrosion cracking, hydrogen induced cracking,Microbiologically induced corrosion, underground corrosion, high-temperature corrosion**,** corrosion fatigue and some case studies. **Corrosion Testing** Specimen preparation, exposure tests, open corrosion potential, linear polarization, Tafel slopes, corrosion current, slow-strain-rate tests, AC impedance and Commercial corrosion probes. **Prevention and Control of Corrosion** Cathodic protection, Sacrificial anodic protection,Modification of environment, Coatings and inhibitors, Material selection and design.
Course Outcomes:	1. Understanding the importance and mechanisms of corrosion 2. Understanding the aspects of electrochemistry relevant to corrosion rate measurement. 3. Ability to understand the concepts of various types of corrosion and its testing. 4. Ability to select viable techniques for corrosion prevention.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√		√		√	√					
2	√	√	√	√	√	√					
3	√	√	√	√	√	√					
4	√		√	√	√						

Recommended books:

1. Fontana, M.G., Corrosion Engineering, Tata McGraw-Hill (2008). 3rd ed.
2. Denny A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Pearson-Prentice Hall, 2005.
3. Roberge P R , Corrosion Engineering, McGraw Hill, New York.
4. Uhling H H and Revie R W, Corrosion Control, John Wiley & sons. INC,.
5. Trethewy& Chamberlain, Corrosion for Science and Engineering, Longman Sc& Tech; 2nd revised edition edition, 1996

Course Code	Course Title	L	T	P
CHOE-410	Biorefinery and Bioproducts Engineering	3	0	0

Pre-requisites:	None
Course objectives:	The course will provide the fundamental basis of bioproducts bioengineering based on the biorefinery concept, aimed to form the students on green chemical strategies for the processing of biomass and waste into valuable biomaterials, biochemicals and biofuels.
Syllabus:	**Introduction:** Introduction and basic concepts: Green Chemistry, biorefineries, biofuels , Bioproducts and platform molecules **.** **Bioproducts from biomass:** Production of Biomaterials from Biomass, Chemicals from Biomass & waste, Biofuels from Biomass & Waste. **Biomass Conversion processes:** Biochemical conversion processes, Thermochemical conversion processes-Combustion, gasification, pyrolysis, hydrothermal liquefaction and Integrated hybrid conversion processes. **Biorefinery:** Design of a biorefinery by incorporating various unit operations, mass and energy balance, sustainability aspects using Aspen plus and other simulation packages. Examples of biorefinery concepts.
Course Outcomes:	1. Understanding the possibilities of biorefineries in a future scenario without fossil fuels. 2. Understanding Green Chemical approaches and alternative processes to bioproducts from biomass and waste. 3. Ability to identify key pathways for sustainable processing of feedstocks. 4. Knowing basic concepts of Biorefineries and Green Chemical methods and application to present industrial processes.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√		√		√	√					
2	√	√	√	√	√	√	√				
3	√	√	√	√	√	√	√				
4	√		√	√	√						

Recommended books:

1. Kamm, B., Gruber, P.R., and Kamm, M. (2006). Biorefineries – Industrial Processes and Products. WILEY-VCH.
2. Brown, R.C. (Ed.) Thermochemical processing of biomass into fuels, chemicals and power, Wiley, 2011.
3. Clark, J., Deswarte, F. (Ed.) Introduction to chemicals from biomass, John Wiley and Sons, U.K., 2008.
4. Basu, Prabir. Biomass gasification, pyrolysis and torrefaction: practical design and theory. Academic press, 2013.
5. Bergeron, C., Carrier, D.J., and Ramaswamy, S. (2012). Biorefinery Co-Products. Wiley & Sons, Ltd. ISBN: 978-0-470-97357-8.

Syllabus for courses to be offered by Department of Chemical Engineering for Department of Biotechnology:

Course Code	Course Title	L	T	P
CHPC-281	Fluid and Particle Mechanics	3	0	0

Pre-requisites: None

Course objectives: The course aims at providing an overview of the approaches, methods and techniques of mechanical operations. To understand the fundamentals of fluid flow phenomena.

Syllabus:

Unit-I

Introduction to Fluid flow: Ideal and real fluids, Extensive and Intensive properties, viscosity, surface tension, capillarity, evaporability, vapour pressure, Newtonian and Non Newtonian fluids.

Fluid Statistics: Hydro statistics law, Pascal's law, Different types of Manometer, centrifugal decanter.

Fluids Kinematics and Dynamics: Classification of fluid flow, streamline, streakline, pathlines, flow rate and continuity equation, Bernaulli's theorem and its application, kinetic energy and momentum correction factor in Bernaulli's equation, concept of friction law in fluid flow, various pumps.

Laminar Viscous flow and flow measurement devices: Reynolds numbers, Hagen Poiseuille Law, Venturi meter, Orifice meter.

Unit-II

Size Reduction: Particle size and shape, particle mass, size and shape distributions, measurement and analysis, concept of average diameter, size reduction, crushing, grinding and law of grindings.

Screening: Equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen.

Settling: Flow around a single particle, drag force and drag coefficient, settling velocity of particles in a fluid, hindered and free settling of particles, thickening gravity separation

Separation of solid from liquid: Classification of filters, various types of cake filters, principle of cake filtration, clarification filters, liquid clarification, centrifugal settling process.

Unit-III

Agitation & Mixing: Agitation of liquids, axial flow impellers, radial flow impellers, velocity and power consumption of agitated vessels, blending & mixing.

Fluidization: Packed beds, bed porosity, flow though a bed of particles, fluidization & fluidized bed, conditions for fluidization minimum velocity, types of fluidization.

Course Outcomes:

1. After studying this subject, students would be able to measure pressure drop, flow rates etc. for incompressible and compressible fluids.
2. Ability to analyze the fluid flow problems with the application to the momentum balance.
3. The student would understand the physical properties, property measurement and handling of solid-solid and solid-fluid mixtures.
4. The student would understand separation processes for solid-solid and solid-fluid mixtures.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√			√		√				
2	√	√	√		√			√			√
3	√		√					√			
4	√				√			√			√

Recommended books:

1. Smith J C, Mccabe W L and Harriot P H, *"Unit Operations of Chemical Engineering",* McGraw Hill, 7th edition, (2005).
2. Richardson and Coulson *"Chemical Engineering Vol II", 5th ed.,* Butterworth – Heinemann (2003).
3. Perry's, "*Handbook of Chemical Engineering*", 7th Ed, McGraw Hill (1997).

Course Code	Course Title	L	T	P
CHPC-282	Heat and Mass Transfer	3	1	0

Pre-requisites: Knowledge of differential equations.

Course objectives: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries. To learn about the design of heat exchangers and evaporators, reactor heating and cooling systems

Syllabus:

Unit-I

Conduction: Fourier's law, steady state heat conduction through a composite solid, cylinders, spheres, different insulating materials for process equipment

Convection: Convection, individual and overall heat transfer coefficient, heat transfer between fluids separated by plane wall and by cylindrical wall (pipes), critical/ optimum insulation thickness, concepts of heat exchanger.

Heat Transfer with phase change: Boiling phenomena, correlation for nucleate boiling, critical heat flux, condensation phenomena, film condensation on a vertical surface.

Radiation: Blackbody radiation, Planck's law, Wein's displacement law, the Stefan Boltzmann law, Kirchoff's law.

Evaporation: Single and multiple effect evaporators, capacity and economy, boiling point elevation.

Unit-II

Mass Transfer Coefficient: Local and overall mass transfer coefficient, local two phase mass transfer coefficients, Local overall Mass Transfer coefficients.

Gas Absorption: Choice of solvent, number of ideal stages, height of column, equipment for gas absorption

Drying: Equilibrium in drying, rate of batch drying, time of drying, drying equipments.

Distillation : Raoult's Law and Dalton's law, partial vaporisation condensation, relative volatility, differential & flash distillation, steam distillation, total reflux , minimum and optimum reflux ratios, Lewis Sorel and MaCabe –Thiele methods, Ponchon Savarit method

Liquid – Liquid Extraction: Ternary phase diagrams & choice of solvent, single stage and multistage cross current, co-current and counter current extraction operation

Unit-III

Adsorption: Introduction and the nature of adsorbent, adsorption equilibria, the Langmuir isotherm, BET isotherm and Gibbs isotherm, adsorption equipments.

Crystallization: Formation and properties of crystals, crystallisers

Course Outcomes:

1. Ability to understand and solve conduction, convection and radiation problems.
2. Develop correlations using elementary dimensional analysis and comprehend the laws governing radiation mode.
3. Ability to understand theprinciples of mass transport.
4. The students are able to comprehend the concepts of co current & counter current processes, cascades and concept of Ideal stage and stage efficiencies, continuous contact equipment's.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√							√			√
2		√									
3		√			√			√			√
4					√	√		√	√	√	

Recommended books:

1. Smith J C, Mccabe W L and Harriot P H, *"Unit Operations of Chemical Engineering",* McGraw Hill, 7th edition, (2005).
2. Richardson and Coulson *"Chemical Engineering Vol II", 5th ed.,* Butterworth – Heinemann (2003).
3. Perry's, "*Handbook of Chemical Engineering*", 7th Ed, McGraw Hill (1997).
4. Geankopolis C J, "*Transport Processes and Separation Process Principles*", Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
5. Treybal R E , "Mass Transfer Operations" 3rd ed. , McGraw Hill (1980)

Course Code	Course Title	L	T	P
CHPC-481	Instrumentation and Process Control	3	0	0

Pre-requisites: Basic knowledge of mathematics, mass and energy Balance

Course objectives: The course aims to analyse of the response of chemical process systems in terms of block diagram and the stability of the process.

Syllabus:

General principles of measurement

Static and dynamic characteristics of instruments, Temperature Measurement: Thermocouples, resistance thermometers, thermistors, optical and radiation pyrometers. Pressure Measurement: Use of manometers, Bourdon gauge, bellows type gauge, measurement of vacuum and pressure transducers. Flow Measurement: Variable area meters. Pressure probes, positive displacement type meters. Liquid level Measurement: Direct and differential method, measurement in open and pressure vessels, measurement of liquid.

Process control

Laplace Transform: Transforms of simple function, Transforms of Derivative, Initial value theorem and Final value theorem, Transform of Integral

Response of First order systems and higher order systems

Mercury thermometer & its transfer function, Forcing functions, Liquid Level System, Liquid Level Process with constant flow out let, Linearization, Mixing tank & R.C. Circuit**,** Response of First order system in series: Non interacting System and Interacting Systems. Transfer function of second order system, under damped System, Impulse function, Sinusoidal function, Transportation lag

Controllers and final control element

Control Valve, Proportional controller, Integral & Derivative controller, Comparison of P, PI and PID controllers.

Transient response of control system

Components of control system, block diagram, Negative and Positive feedback, Servo problem and Regulation Problem, Development of Block diagram. Proportional control for set point change, Proportional control for load change, Proportional Integral control for load change, Proportional Integral Control for set point change

Stability of the system

Concept of stability, Stability Criteria, Routh test for stability. Introduction to frequency response: Bode diagram for first order, Bode diagram for proportional, Integral and derivative control, Second order system. Control System Design by frequency response: Bode stability criteria, Gain and phase Margin, Ziegler Nichols Controller settings.

Course Outcomes:

1. To understand the chemical process in terms of block diagram
2. The students will able to understand the effect of various forcing function on first and higher order systems.
3. The students will able to understand the transient response of various controllers.
4. The students can identified the stability of control systems and be able to design the control system for chemical and allied industries.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	✓						✓	✓			
2		✓		✓			✓	✓			
3		✓		✓				✓			
4	✓			✓				✓			

Recommended books:

1. Coughanower D. R., "Process System Analysis and Control", 2nd Edition, McGraw Hill. (1991).
2. Seborg, E., Mellichamp, "Process Dynamics & Control", 2nd Edition, John Wiley, (2004).
3. Stephanopoulos, "Chemical Process Control-An Introduction To Theory & Practice",1st Edition, Prentice Hall Inc.
4. Eckman D. P., "Industrial Instrumentation", Wiley Eastern Ltd., (1975).
5. Kerk F. W., Rimboi W., Tarapore R., "Instrumentation", Wiley and Sons, (1983).

Scheme for Minor Degree in B.Tech Chemical Engineering Programme

Code	Course Title	L	T	P	Credit	Semester
CHMI-201	Introduction to Chemical Engineering and Process Calculations	3	0	0	3	III
CHMI-202	Fluid and Particle Mechanics	3	0	0	3	IV
CHMI-301	Chemical Technology	3	0	0	3	V
CHMI-302	Heat and Mass Transfer	3	0	0	3	VI
CHMI-401	Chemical Reaction Engineering and Thermodynamics	3	0	0	3	VII
CHMI-402	Process Plant and Equipment Design	3	0	0	3	VIII
Total Credits		**18**				

Syllabi for Minor Degree in B.Tech Chemical Engineering Programme

Course Code	Course Title	L	T	P
CHMI-201	Introduction to Chemical Engineering and Process Calculations	3	0	0

Pre-requisites: Basic Knowledge of mathematics

Course objectives: This course will prepare students to make analysis of chemical processes through calculations which need to be performed in the chemical processing operations. The students are introduced to the application of laws and also to formulate and solve material and energy balances in processes with and without chemical reactions.

Syllabus:

Introduction to Chemical Engineering

Introduction to Chemical Engineering, profession, plant operation, Basic concepts of units and equations of state, Overview of unit operations and processes, basic concepts of P&I diagram. Introduction to process instrumentation and control and its importance, Introduction to safety in chemical process industries, introduction to Environmental Engineering, Challenges of Chemical Engineer.

Introduction to Chemical process calculations

Units and dimensions, mole concept, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equations and stoichiometry, limiting and excess reactant, conversion and yield.

Material Balance

Material balance, program of analysis of material balance problems, solving material balance problems that do not involve chemical reactions, solving material balances problems involving chemical reactions, multiple subsystems, recycle, bypass, and purge calculations.

Energy Balance

Concepts and units, calculation of enthalpy changes, application of the general energy balance without reactions occurring energy balances that account for chemical reaction, reversible processes and the mechanical energy balances, heats of solution and mixing, psychometric charts and their use.

Course Outcomes:

1. The student will demonstrate the ability to understand the basic concepts of Chemical Engineering**.**
2. Understand the material and energy balances of chemical processes.
3. Able to perform material and energy balances on chemical processes/equipment without and with reactions.
4. Able to draw the flow diagram and solve the problems involving recycle, purge and bypass in a process or unit.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√					√				
2	√	√	√	√			√				
3	√	√	√	√	√			√		√	
4	√	√			√	√					

Recommended books:

1. Pushpavanam, S., Introduction to Chemical Engineering, PHI Learning Pvt. Ltd.
2. S. K. Ghoshal, S. K. Sanyal And S. Datta, ., Introduction to Chemical Engineering, Tata McGraw Hill Education Pvt. Ltd., New Delhi.
3. Himmelblau D. M., "Basic Principles and Calculations in Chemical Engineering", Prentice Hall, (1998)
4. Haugen O. A., Watson K. M. Ragatz R. A., "Chemical Process Principles (Part-I): Material and Energy Balances", Asia Publishing House, (1995).
5. Bhatt B. I., Vora S. M., "Industrial Stoichiometry", Tata McGraw Hill Publishing, New Delhi, (1987).

Course code	Course Title	L	T	P
CHMI-202	Fluid and Particle Mechanics	3	0	0

Pre-requisites: none

Course objectives: To understand the fundamentals of fluid flow phenomena. To learn about the transportation of fluids and flow measuring devices, knowledge in particle technology, sedimentation, flow through packed bed, filtration

Syllabus:

Introduction

Ideal and real fluids, Extensive and Intensive Properties, Specific Weight, Mass density and Specific gravity, Viscosity, Surface Tension and Capillarity, Newtonian & Non Newtonian fluids. Pressure, Hydrostatics law, Pascal's Law, Different types of manometer, Decanter

Fluid kinematics and Dynamics

Classification of fluid flows, streamline, streak line, and Path lines, Flow rate & continuity equation, Bernoulli's Theorem, Kinetic energy correction factor and momentum correction factor in Bernoulli's equation.

Laminar viscous flow and Flow measurement devices

Flow regimes and Reynolds numbers, Laminar flow in circular pipes (Hagen Poiseuille Law), Orifice meter, Venturimeter, Rotameter, Pitot tube.

Pump

Pump Classification & Applications, Pump losses and Efficiencies, Multistage pumps, Work and power Input, Cavitation and Maximum Suction lift

Size Reduction

Particle size and shape, particle mass, size and shape distributions, measurement and analysis, concept of average diameter, size reduction, crushing, grinding and laws of grinding.

Screening and Filtration

Screening equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen. Classification of filters, various types of cake filters, principle of cake filtration, clarification filters, liquid clarification, centrifugal settling process.

Fluidization

Packed beds, bed porosity, flow though a bed of particles, fluidization & fluidized bed, conditions for fluidization, minimum velocity, types of fluidization.

Course Outcomes:

1. Students would be able to measure pressure drop, flow rates etc. for incompressible and compressible fluids.
2. Ability to analyze the fluid flow problems with the application to the momentum balance.
3. Applying the principles of fluid mechanics to chemical engineering problems.
4. Ability to visualize and understand chemical engineering unit operations related to fluid and particle mechanics.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√			√		√				
2	√	√	√		√			√			√
3	√		√					√			
4	√				√			√			√

Recommended books:

1. Smith J. C., McCabe W. L., Harriot P. H., "Unit Operations of Chemical Engineering", McGraw Hill (2001).
2. Frank M. White, "Fluid mechanics", 7th Edition, McGraw Hill (2010).
3. Perry's, "Handbook of Chemical Engineering", 7th Edition, McGraw Hill, (1997).
4. Brown G. G. "Unit Operations", 1st Edition, CBS Publisher, (2004).
5. Richardson and Coulson "Chemical Engineering Vol II", 5th Edition, Butterworth–Heinemann, (2002).

Course Code	Course Title	L	T	P
CHMI-301	Chemical Technology	3	0	0

Pre-requisites: Basic course on chemistry and mechanical operations

Course objectives: Students will be able to understand sources and processes of manufacture of various chemicals such as Fertilizers, Soaps and Detergents,Cement, Glass, Soda ash, caustic soda, chlorine, and hydrochloric acid.

Syllabus:

Natural Products Processing

Oils and Fats**:** Major oil seeds production in India; solvent extraction, Hydrogenation of oils. Cane sugar: Sugar production and varieties, manufacturing equipment and technology, cane sugar refining.

Soaps and Detergents

Raw materials and Reaction Chemistry, Continuous process for manufacture of fatty acids, soaps and glycerine, Manufacture of detergents like alkyl benzene sulphonate, Sodium alkane sulphonate.

Polymers, Petroleum and petrochemicals

Nomenclature of polymers and their classification, Modes of polymerization, Manufacturing of plastics, synthetic fibers, synthetic and natural rubbers.Characteristics, Fuels/chemicals from petroleum and petrochemicals, Primary and Secondary processing, Treatment techniques and applications.

Alkalies, acids and salts: Manufacturing of caustic soda and chlorine, hydrochloric acid,Sulphuric acid and soda ash, corrosion problems and materials of construction

Fertilizers

Status of industry, grading and classification of fertilizers, raw materials, hydrogen production, and synthesis of ammonia based fertilizers, manufacture of phosphatic fertilizers and phosphoric acid, potash fertilizers, N-P-K values.

Cement and glass

Raw materials, Types of cement, Properties of cement, Manufacture of cement.
Types of glass, Raw materials and manufacture of glass.

Course Outcomes:

1. Able to analyze the flow of raw material to product formation quantitatively and qualitatively in each step of processes.
2. Able to understand the unit operation and unit processes involved.
3. Able to identifyprocess flow diagrams of an industry.
4. Able to understand engineering problems in chemical processes and equipments.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√	√	√	√	√	√					
2	√		√	√	√						
3	√		√	√	√						
4	√	√	√	√	√	√					

Recommended books:

1. Austin G.T., Shreve's Chemical Process Industries - International Student Edition, 5th Edition, McGraw Hill Inc., 1998.
2. Sittig M. and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010.
3. W.V.Mark, S.C. Bhatia “Chemical Process Industries volume I and II”, 2nd Edition 2007.
4. Shukla S. D., Pandey G. N., “A text book of Chemical Technology, Vol. I”, Vikas Publishing House Pvt. Ltd., New Delhi.
5. Jacob A. M., Michiel M and Annelies V D , Chemical Process Technology, 1stEdn, 2001.

Course Code	Course Title	L	T	P
CHMI-302	Heat and Mass Transfer	3	0	0

Pre-requisites: Knowledge of fluid mechanics

Course objectives: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Syllabus:

Conduction

Fourier's law, thermal conductivity, its dependence on temperature, steady state heat conduction through a composite solid, cylinders, spheres and variable area of solids, different insulating materials and their applications for process equipment and pipelines.

Convection

Convection heat transfer and the concept of heat transfer coefficient, individual and overall heat transfer coefficient, heat transfer between fluids separated by plane wall, heat transfer between fluids separated by cylindrical wall (pipes), critical/ optimum insulation thickness, heat transfer through extended surfaces.

Radiation

Basic principle of radiation from a surface, blackbody radiation, Planck's law, Wien's displacement law, the Stefan Boltzmann law, Kirchhoff's law, gray body, radiation exchange between black bodies & gray bodies.

Molecular Diffusion

Molar flux, Steady state diffusion, Mass transfer coefficient, Interface mass transfer coefficient

Distillation : Raoult's Law and Dalton's law, partial vaporisation condensation, relativevolatility, differential & flash distillation, steam distillation, total reflux , minimum andoptimum reflux ratios, Lewis Sorel and MaCabe –Thiele methods

Course Outcomes:

1. Ability to understand and solve conduction, convection, radiation and mass transfer problems.
2. Students should be able to perform heat flux calculations through constant and variable area elements and estimate optimum insulation thickness.
3. Ability to understand theprinciples of mass transport.
4. Applying the concepts to heat and mass transport to industrial flows.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1	√							√			√
2		√									
3		√			√			√			√
4					√	√		√	√	√	

Recommended books:

1. J. P. Holman., "Heat Transfer", 9th Edition, Tata McGraw-Hill, New Delhi, (2004).
2. B. K. Dutta., "Heat Transfer: Principles and Applications", Prentice Hall of India Limited, (2004).
3. Treybal R. E., "Mass Transfer Operations" 3rd Edition, McGraw Hill, (1980).
4. Geankopolis C. J., "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition, (2004).
5. McCabe W. L., Smith J. C. "Unit Operations of Chemical Engineering", McGraw Hill, (2001).

Course Code	Course Title	L	T	P
CHMI-401	Chemical Reaction Engineering and Thermodynamics	3	0	0

Pre-requisites: None

Course Objectives: The course aims at understanding the basic concepts of: chemical kinetics for different types of reactions, designing the basic reactors. To introduce the principles of Chemical Engineering Thermodynamics and illustrate their application to design of chemical process plants.

Syllabus:

Introduction

Kinetics of homogeneous chemical and biochemical reactions, single and multiple reactions, order & molecularity, rate constant, elementary and non-elementary reactions, temperature dependent term of rate equation.

Batch Reactor

Constant volume batch reactor, integral method of analysis of data, series and parallel reactions, reversible reactions, variable volume batch reactor, temperature and reactions rate.

Introduction to Homogeneous Reactor Design

Ideal batch reactor, mixed flow reactor, plug flow reactor, holding and space time, design for single reactions, size comparison (analytical and graphical method, plug flow reactors in series & parallel, mixed reactor in series, recycle reactors.

Heterogeneous Processes : Introduction of Heterogeneous Processes

Thermodynamics: Introduction to I, II, III law of Thermodynamics

Equilibrium and Stability

Criteria of equilibrium, Chemical Potential, Application of equilibrium criteria, Clausius clapeyon equation, Introduction to Phase Equilibria.

Chemical Reaction Equilibria

Reaction ordinate for single & multiple reactions, condition of equilibrium for a chemical reactions, Temperature dependence of the equilibrium constant, Estimation of equilibrium rate constant, Homogeneous gas phase reactions, Heterogeneous chemical equilibrium.

Course Outcomes:

1. To understand the mechanism of chemical kinetics for different types of reactions
2. To design batch and flow reactors for single homogeneous reactions
3. To understand solid-fluid non-catalytic reaction kinetics and design of reactors
4. Ability to apply the laws of thermodynamics for solving problems related to flow processes and equilibrium systems.

Mapping of course outcomes(CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	2	3	4	5	6	7	8	9	10	11
1		√	√	√							
2	√	√	√	√		√		√		√	
3		√		√						√	
4	√	√	√	√				√		√	

Recommended books:

1. Levenspiel O., "Chemical Reaction Engineering", 3rd Edition, John Wiley & Sons, Singapore, (1999).
2. Fogler H. S., "Elements of Chemical Reaction Engineering", 3rd Edition, Prentice Hall Inc., (1999)
3. J.M. Prausnitz, R.N. Lichtenthaler and E.G. Azevedo, Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed.,Prentice Hall, 1998.
4. J.W. Tester and M. Modell, Thermodynamics and its Applications, 3rd ed., Prentice Hall, 1999.
5. S.I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4th Edition, Wiley India, 2006.

Course Code	Course Title	L	T	P
CHMI-402	Process Plant and Equipment Design	3	0	0

Pre-requisites:	Material science and strength of material, basic knowledge of engineering drawing.
Course objectives:	This course is deals with the principals involved in the design and construction of equipment. It also provides knowledge of mechanical designs of various equipments.
Syllabus:	**Introduction to plant design** Basic considerations in chemical engineering plant design, optimization and feasibility of plant design. Selection of process-factors affecting process selection. Types of project design, Importance of Laboratory development pilot plant, safety factors, types of flow diagrams **Heat and Mass Transfer Equipments Design** Classification and description of different heat exchangers. Types of mass transfer equipment, packed and tray type towers. Process Design**:** Process design of tray and packed towers. **Introduction to principles of design** Nature of process equipment, general design procedure, basic considerations in design, standards, codes, and their significance, equipment classification and their selection, design pressure, design temperature, design stress. Materials of construction and selection for process equipment, linings and coatings for equipment. **Equipment design** Storage tanks**:** Various types of storage tanks and applications. Mechanical design**:** Mechanical design of tall vessels for distillation and absorption columns. Reaction vessels**:** Introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil. Study and design of internal coil reaction vessels, Heat transfer coefficients in coils.
Course Outcomes:	1. The students are able to handle the design of various typical chemical based equipments like heat exchangers, distillation columns etc. 2. The students would also able to make plant layout of the newly developed plants and prepare written reports of design problems. 3. Introduce to standards for the mechanical design of equipment used in the process industry. 4. Students will able to design, fabricate and identify design problems in industrial equipment based on the knowledge obtained from this course.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	√					√					√
2		√	√	√					√		√
3			√	√	√	√	√	√			
4									√	√	

Recommended books:

1. Bhattacharya B. C., "Chemical Equipment Design", CBS Publisher, (1985).
2. Ulrich G. D., "A Guide to Chemical Engineering Process Design and Economics", John Wiley, (1984).
3. D. Q. Kern, "Process Heat Transfer", McGraw Hill, (2001).
4. E. E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Vol. 1, 2 and 3, 3rd Edition, Gulf Publishing Company, (1995).
5. M. Van Winkle, "Distillation", 1st Edition, McGraw Hill Company, New York, (1967).