Curriculum Undergraduate Programme

B. Tech. Chemical Engineering

(2012 Batch onwards)

Department of Chemical Engineering

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PREFACE

With rapidly changing industrial scenario and technological advances that have taken place in the field of Chemical Engineering has been revolutionalized. This needs upgradation and updating the existing academic programmes so that trained human resources are competent to meet requirements of today's industries. Accordingly the Department of Chemical Engineering has come forward to restructure the academic programmes stipulated under the credit based system.

The Department has tried its best to prepare a Model Curriculum and Syllabi for Four year under graduate programme for B. Tech. Degree in Chemical Engineering. It is really challenging to evolve a common programme for this discipline that meets the need of national and international industries and research establishments. However, with the rich experience of successful experimentation with above idea for over forty years, the task of development of a model curriculum could be possible.

The suggested curriculum possesses the following features:

- The suggested curriculum is in conformity with IIT/AICTE norms with emphasis on analysis and design of industrial processes required to work in control environment.
- The graduates turned out have to be acceptable by national and international industry and academic/research establishments.
- The programme has to be forward looking in context of the rapid changing scenario of science and technology which provides a proper balance in teaching of basic sciences, social sciences and management, engineering sciences and technical arts, technologies and their applications.
- Core subjects have been selected to cover all those, which are essential in training of Chemical graduates.
- The curriculum presents flexibility so that new programmes started with reasonable sources can be managed with a scope of further updating as the resource position improves.

I take this opportunity to express my deep appreciation to members of the Senate for their valuable suggestions and critical comments in finalizing the curriculum and Professor S. K. Das, Director, NIT Jalandhar for his initiative and direction. It is hoped that the curriculum compiled in the form of the booklet will be of immense help to the students and the faculty in smooth running the under graduate programme in Chemical Engineering. I thank all the members of Board of Studies for Chemical Engineering for their help and cooperation rendered in bringing out this curriculum in time.

(Dr. Ajay Bansal)
Associate Professor and Head
Department of Chemical Engineering

Vision and Mission of the Department:

Vision

The Department aspires to achieve excellence by providing best facilities in the entire spectrum of Chemical Engineering education, research and consultancy.

Mission

To become a pioneer Department of higher learning imparting state of the art education, training and research in the field of Chemical Engineering.

Programme Educational Objectives (PEOs)

The educational;objectives of the undergraduate programme of Chemical Engineering at NIT Jalandhar are:

PEO1: Professional Competence:
To nurture young engineers with sound technical fundamentals, training and problem solving skills suitable for the need of industry.

PEO 2: Professional Growth:
Placement of graduates in reputed industries handling production, projects and consultancy or life-long learning demonstrated by pursuance of under-graduation in relevant fields of engineering/management.

PEO 3: Design and Innovation:
Inculcating the chemical engineering principles and their applications leading to the design and innovation.

PEO 4: Social and Professional Ethics:
Ability of graduates to demonstrate team spirit, responsibility towards society and sound ethical behavior

Programme Outcomes (POs):

Graduates of Chemical Engineering will demonstrate:

1. **Engineering knowledge:** Students will be able to learn the basics of various unit operations and processes related to chemical and allied industries.
2. **Problem analysis**: Students to identify formulate and analyse simple and complex Chemical Engineering problems.
3. **Practical skills**: Students will be able to follow an experimental protocol, operate laboratory and pilot scale equipment following a standard operating procedure and analyze and interpret experimental data.
4. **Modern tool usage:** Students will be able to learn and apply latest engineering softwares and skills for modelling, simulation and design of chemical engineering processes.
5. **The engineer and society**: Students to understand ethical aspects of chemical engineering and the impact of the profession on society.
6. **Environment and sustainability:** Students will have an understanding of global economic, environmental, demographic and political issues, the impact of engineering decisions on the local and global environment, economy, and society and cultures other than that from which they originate.
7. **Ethics:** Students will be able to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
8. **Individual and team work**: Students will be required to do the various curricular and extra-curricular activities individually and in groups to have multifaceted growth.
9. **Communication:** Students will be able to produce effective written and oralcommunication and adapt their presentation style and content to match the audience.
10. **Project management and finance**: Students will be able to apply knowledge and understanding of the engineering and management principles and implement these to their own work, as a member and leader in a team, to investigate the techno-economic feasibility and to manage projects.
11. **Life-long learning**: Students will be proficient in the use of a variety of informational and educational media such as textbooks, scientific and technical journals, library system, internet and educational software, have an understanding of and exposure to the breadth and structure of the professional and technical support system that will be available to the students upon graduation.

Department of Chemical Engineering

B Tech Teaching Scheme

(III to VIII Semester)

	III Semester	L	T	P	C		IV Semester	L	T	P	C
MAX-201	Mathematics II	3	1	0	4	MAX-202	Mathematics III	3	1	0	4
CSX-207	Object Oriented Programming	3	0	0	3	PHX-204	Material Science and Engineering	3	1	0	4
CHX-201	Fluid Mechanics	3	1	0	4	CHX-202	Chemical Technology	3	1	0	4
CHX-203	Mechanical Operations	3	1	0	4	CHX-204	Chemical Engineering Thermodynamics	3	1	0	4
CHX-205	Chemical Process Calculations	3	1	0	4	CHX-206	Heat Transfer Operations	3	1	0	4
CSX-227	Object Oriented Programming Lab	0	0	2	1	PHX-214	Material Science and Engineering Lab	0	0	2	1
CHX-221	Fluid Mechanics Lab	0	0	3	2	CHX-222	Chemical Technology Lab	0	0	3	2
CHX-223	Mechanical Operations Lab	0	0	3	2	CHX-224	Heat Transfer Lab	0	0	3	2
	Total	**15**	**4**	**8**	**24**		**Total**	**15**	**5**	**8**	**25**

	V Semester	L	T	P	C		VI Semester	L	T	P	C
CYX-301	Nano Science and Nano Technology	3	1	0	4	CHX-302	Instrumentation and Process Control	3	1	0	4
CHX-301	Mass Transfer Operations I	3	1	0	4	CHX-304	Mass Transfer Operations II	3	1	0	4
CHX-303	Chemical Reaction Engineering I	3	1	0	4	CHX-306	Chemical Reaction Engineering II	3	1	0	4
CHX-305	Hydrocarbon Engineering	3	1	0	4	CHX-308	Environmental Engineering	3	1	0	4
CHX-307	Energy Technology	3	1	0	4	CHX-310	Process Engineering and Economics	3	1	0	4
CHX-321	Process Equipment Design	1	0	2	2	CHX-322	Mass Transfer Lab	0	0	3	2
CHX-323	Energy Technology Lab	0	0	3	2	CHX-324	Reaction Engineering and Control Lab	0	0	3	2
						CHX-326	Environmental Engineering Lab	0	0	3	2
	Total	**16**	**5**	**5**	**24**		**Total**	**15**	**5**	**9**	**26**

	VII Semester	L	T	P	C		VIII Semester	L	T	P	C
CHX-401	Transport Phenomena	3	1	0	4	CHX-402	Modeling and Simulation	3	0	0	3
CHX-4XX	Departmental Elective I	3	0	0	3	CHX-404	Industrial Safety & Hazards Management	3	1	0	4
CHX-4XX	Departmental Elective II	3	0	0	3	CHX-4XX	Departmental Elective III	3	0	0	3
OE-	Open Elective I	3	0	0	3	CHX-4XX	Departmental Elective IV	3	0	0	3
CHX-403	Process Plant Design	1	0	2	2	OE-	Open Elective II	3	0	0	3
CHX-421	Chemical Engineering Computing	0	0	3	2	CHX-422	Modeling and Simulation Lab	0	0	3	2
CHX-423	Project Phase I	0	0	4	2	CHX-424	Project Phase II	0	0	8	4
CHX-425	Industrial Practical Training	0	0	0	4						
	Total	**13**	**1**	**9**	**23**		**Total**	**15**	**1**	**11**	**22**

Credits (III to VIII Semester)	**144**
Total Credits (I to VIII Semester)	**190**

Departmental Electives I and II

CHX-451	Allied Chemical Technology
CHX-453	Biochemical Engineering
CHX-455	Environment Impact Assessment
CHX-457	Industrial Rheology
CHX-459	Membrane Separation Processes
CHX-461	Optimization Techniques
CHX-463	Petroleum Recovery Technology
CHX-465	Petroleum Refining Technology
CHX-467	Polymer Science and Engineering

Departmental Electives III and IV

CHX-452	Computational Fluid Dynamics
CHX-454	Energy Management and Audit
CHX-456	Industrial Environmental Management
CHX-458	Introduction to Multiphase Flow
CHX-460	Instrumental Methods of Analysis
CHX-462	Natural Gas Engineering
CHX-464	New and Renewable Energy Resources
CHX-466	Petrochemical Technology
CHX-468	Process Plant Utilities

Open Electives I and II

CHX-471	Environmental Engineering
CHX-472	Hydrocarbon Engineering
CHX-473	Industrial Safety & Hazards Management
CHX-474	New and Renewable Energy Resources
CHX-475	Polymer Science and Engineering
CHX-476	Oil and Natural Gas Economics

Course Code	Course Title	L	T	P
MAX-201	Mathematics II	3	1	0

Linear dependence of vectors and rank of matrices, linear transformations and inverse of matrices, reduction to normal form, bilinear form and quadratic form, consistency and solution of linear algebraic system of equation, Eigen values, Eigen vectors and their applications to system of ordinary differential equations, Cayley Hamilton theorem, orthogonal, unitary, hermitian and similar matrices.

Differential calculus of functions of several variables, partial differentiation, homogeneous functions and Euler's theorem, Taylor's and Maclaurin's series, Taylor's theorem for functions of two variables maxima and minima of functions of several variables, Langrange's method of multipliers.

Double and triple integrals, change of order of integration, change of variables, applications to evaluation of area, surface area and volume.

Scalar and vector fields differentiation of vectors, velocity and acceleration, vector differential operators Del, Gradient, Divergence and Curl and their physical interpretations, formulae involving these operators, line, surface and volume integrals, solenoidal and irrotational vecotors, Green's theorem, Gauss divergence theorem, Stoke's theorem and their applications.

Formulation and classification of partial differential equations, solution of first order linear equations, standard forms of non- linear equations, Charpit's method, linear equations with constant coefficients, non- homogenous linear equations, Monge's method for non-homogenous equations of second order, separation of variables methods for solution for solution of heat, wave and Laplace equation.

Recommended Books:

1. E Kreyszig,"Advanced Engineering Mathematics", 8th Ed. John Wiley, Singapore (2001)
2. R K Jain and S R K Iyengar, Advanced Engineering Mathematics", 2nd Ed, Narosa Publishing House, New Delhi (2003).
3. I A N Sneddon,"Elements of Partial Differential Equations", Tata McGraw Hill, Delhi (1974).
4. B S Grewal,"Higher Engineering Mathematics",Thirty –fifth edition, Khanna Publishers, Delhi.

Course Code	Course Title	L	T	P
CSX-207	Object Oriented Programming	3	1	0

Object oriented thinking: Need for OOP Paradigm, Procedural programming v/s object oriented programming, object oriented concepts.

Functions: Main function, function prototyping, inline functions, reference variables, call by reference, Defaults arguments, function overloading, Math library functions.

Class and Object: Difference between C structure and class, specifying a class, Defining member functions: inside and outside class, scope resolution operator, Array within a class, array of objects, Static data members and member functions, Object as function arguments, returning objects, Friend function, memory allocation for objects, pointer to members, pointer to object, this pointer local classes.

Constructor and destructor: Constructor, types of constructors: default, parameterized and copy constructor,constructor overloading, constructor with default parameter, dynamic initialisation of objects, destructor

Operator overloading and Type Conversion: Defining operator overloading, overloading unary and binary operator, Data Conversion: Basic to User Defined , User defined to basic, Conversion from one user-defined to other.

Inheritance and polymorphism: Base class, derived class, visibility modes, derivation and friendship, Types of inheritance, Containership, virtual function binding, pure virtual functions, abstract class, pointer to derived class.

Console IO operations: C++ stream classes, Unformatted IO operations, formatted IO operations, managing output with manipulators.

Exception handing: Exceptions and derived classes, function exception declarations, Unexpected exceptions,

Exceptions when handling exceptions, resource capture and release etc.

Working with files: Classes for file stream operations, opening and closing files, detectinf cof, File opening modes, file Pointers, Error handling during file operations, command line arguments. Templates: Class template, class template with parameter, function template, function template with parameter.

Recommended Books:

1. Bjrane Stroustrup, "C++ Programming language", Pearson education Asia, 4/e, 2013.
2. R. Lafore, "Object oriented Programming in C++", Techmedia New Delhi, 4/e, 2002.
3. Yashwant Kanetkar, "Let us C", BPB Publications, 8/e, 2008.
4. B. A. Forouzan and R. F. Gilberg, "A structured approach using C++", Cengage Learning, 1999.

Course Code	Course Title	L	T	P
CHX-201	Fluid Mechanics	3	1	0

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.

Fluids Static

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

Fluids 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), Venturimeter, Orifice Meter.

Hydraulic pumps

Pump Classification & Applications, Centrifugal pumps verses 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

Drag force, lift and drag coefficients, drag on Flat Plate, Circular Cylinder and Sphere.

Recommended Books

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

2 Kumar D. S., "Fluid Mechanics & Fluid pwer engineering", S. K. Kataria & Sons, (2004).

3 Timoshenko S. P. and Young D. H., "Engineering Mechanics", McGraw Hill, (1937).

4 Perry's, "Handbook of Chemical Engineering", 7th Edition, McGraw Hill, (1997).

5. G.C.Sekhar., "Unit Operations in Chemical Engineering",7th Edition , Pearson Practice Series,(2005)

Course Code	Course Title	L	T	P
CHX-203	Mechanical Operations	3	1	0

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
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.

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"

Course Code	Course Title	L	T	P
CHX-205	Chemical Process Calculations	3	1	0

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.

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).

		L	T	P
Course Code	**Course Title**			
CSX-227	**Object Oriented Programming Lab**	**0**	**0**	**2**

Objectives:

1. Write a program to read a matrix of size m x n form the keyboard and display the same using function.
2. Program to make the use of inline function.
3. Write a function power () which raise a number m to a power n. The function takes double value of m and integer value of n and returns the result. Use a default value of n is 2 to make the function to calculate squares when this argument is omitted.
4. Program to show that the effect of default arguments can be alternatively achieved by overloading.
5. Write a class ACCOUNT that represents your bank account and then use it.The class should allow you to deposit money, withdraw money, calculate interest, send you a message if you have insufficient balance.
6. Write a class STRING that can be used to store strings, add strings, equate string, output strings.
7. Create the class TIME to store time in hours and minutes. Write a friend function to add two TIME objects.
8. Create two classes DM and DB. DM stores the distance in meter and centimeters and DB stores the distance in feet and inches. Write a program two add object of DM with the object of DB class.
9. Write a program to create an abstract class named Shape that contains an empty method named number Of Sides ( ).Provide three classes named Trapezoid, Triangle and Hexagon such that each one of the classes inherits the class Shape. Each one of the classes contains only the method number Of Sides ( ) that shows the number of sides in the given geometrical figures.
10. Program to demonstrate the concept of:
    a. Default constructor
    b. Parameterized constructor
    c. Copy constructor
    d. Constructor overloading
11. Program to demonstrate the concept of destructor.
12. Program to show multiple inheritance
13. Program to show multilevel inheritance
14. Program to show hybrid inheritance
15. Program to show the concept of containership.
16. Program to overload unary operator.
17. Program to overload binary operator
18. Program to show the concept of run time polymorphism using virtual function.
19. Program to work with formatted and unformatted IO operations.
20. Program to read the name and roll numbers of students from keyboard and write them into a file and then display it.
21. Program to copy one file onto the end of another, adding line numbers

22. Write a function template for finding the minimum value contained in an array.
23. Write a class template to represent generic vector (a series of float values). Include member function to perform following tasks.
    a. Create vector
    b. Modify the value of a given element
    c. To multiply by a scalar value
    d. To display vector in the form of (10, 20, 30,……)

This is only the suggested list of Practicals. Instructor may frame additional Practicals relevant to the course contents.

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

List of Experiments

1. To find coefficient of friction in pipes of different materials.
2. To verify Bernaulli'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.

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

List of Experiments

1. Determination of power consumption and study of agitation and mixing characteristic of a fluid.
2. Determination of drag coefficient from the plot of drag coefficient Vs modified Reynolds no.
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 flow through an orifice.
12. To study the settling characteristics in a batch settling experiment and use the data to design a thickener for the given flow rate.

Course Code	Course Title	L	T	P
MAX-202	Mathematics III	3	1	0

Limit and derivative of a complex function, analytic functions and Cauchy Riemann equations, line integral of elementary functions, Cauchy's integral theorem, Cauchy's integral formula and derivatives of analytic functions, Taylor and Laurent series, zeros and singularities, residues and residue theorem, evaluation of real improper integral, conformal mappings linear fractional transformations and mappings by elementary functions.

Series solution of differential equations, Bessel's differential equation and Bessel functions and their properties, differential equations reducible to Bessel's differential equation, Legendre's differential equation, Legendre's polynomials and their properties, Fourier-Legendre expansion of a function.

Fundamental concepts of calculus of variations, functional involving several independent functions, one end fixed and other end free problems, both end free problems, constrained extrema.

Recommended Books:

1. B.S. Grewal, "Higher Engineering Mathematics", Thirty –fifth edition, Khanna Publishers, Delhi.
2. L E Elsgole, "Calculus of Variations", Addison-Wisley Publishing Company.
3. J B Conway, "Functions of One Complex Variables", Narosa Publishing House, 1980.

Course Code	Course Title	L	T	P
PHX-204	Material Science and Engineering	3	1	0

Structure of Crystalline Solids
Crystal structures and crystal system, reciprocal lattice, miller indices, closed packed structures, determination of crystal structures.

Imperfection in Solid
Point imperfections and their equilibrium concentration, Edge and screw dislocations; burgers vector and the dislocations; burgers vector and the dislocation leap, stress fields and energies of dislocations, dislocations forces, dislocation sources; Multiplication of dislocations.

Diffusion in Solids
Fick's laws of diffusion, solution to fick's second law, applications based on second law solution, the kirkendall effect, the atomic model of diffusion.

Mechanical Properties
The elastic properties, model of elastic behaviour, plastic deformation tensile stress-strain curve, shear strength of perfect and real crystals, mechanical failure, fatigue and fracture, creeps: mechanism of creep, characterization of creep curves.

Electrical Properties
Classical and quantum theory of free electronics; relaxation time, collision time and mean free path, density of energy states and Fermi energy, electron motion under periodic potential, origin of energy bands in solids, classification of material on the basis of band gap, effective mass, intrinsic and extrinsic semi-conductors, hall effect and its applications.

Dielectric Properties
Mechanism of polarization concept of polarizability and internal fields, dielectrics in alternating field; frequency dependence of polarizability.

Magnetic Properties
Magnetic moments and its origin, dia-and para-magnetism, ferro and ferri-magnetism, soft and hard magnetic materials, ferrites, application of magnetic materials.

Super conductivity
Properties of superconductors. London equations, quantum explanation of super conductivity, flux quantization, application of super conductors.

Recommended Books

1 Calister W. D., Jr. "Materials Science and Engineering", John Wiley and Sons, Inc. New York, (1997).

2 Dekker A. J., "Solid State Physics", Macmillan, India Limited, Madras, (1991).

3 Azaroff L. V., "Introduction to Solid", Tata Mc Graw Hill, New Delhi, (1992).

4 Raghvan V., "Material Science and Engineering", Prentice Hall of India, New Delhi, (1998).

5 Kittal, "Solid State Physics", Wiley Eastern Limited, New Delhi, (1987).

Course Code	Course Title	L	T	P
CHX-202	Chemical Technology	3	1	0

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, hydrogen production, and 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.

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

Glass
Types of glass, Raw materials and manufacture of glass.

Soda Ash
Manufacturing, solvay and modified solvay process, materials of construction environmental considerations and corrosion problems.

Recommended Books

1 Dryden C. E., "Outlines of Chemical Technology", 2nd Edition, East–West Press Pvt. Ltd., New Delhi, (1973).
2 Austin G. T., "Shreve's Chemical Process Industries", 5th Edition, McGraw Hill Book Company, New Delhi, (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., Pandey G. N., "A text book of Chemical Technology, Vol. I", Vikas Publishing House Pvt. Ltd., New Delhi, (1986).
5 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
CHX-204	Chemical Engineering Thermodynamics	3	1	0

Review of First , Second and Third Law of Thermodynamics

First law of Thermodynamics , Thermodynamics state and state functions, enthalpy, the steady state steady flow process, equilibrium, phase rule, reversible processes, 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, Clausius clapeyon equation.

Phase Equilibria

Fugacity, Determining of fugacity of pure substances, Fugacity in mixture, Ideal solution, Excess properties, and Liquid 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.

Recommended Books

1 Smith J. M., Van Ness H. C., Abbott M. M., "Introduction to Chemical Engineering Thermodynamics", 6th Edition, Tata McGraw Hill, (2003).

2 Rao Y. V. C., "Chemical Engineering Thermodynamics", First Edition, Universities Press (India) Ltd., Hyderabad, (1997).

3 Kyle B. G., "Chemical and Process Thermodynamics", Third Edition, Prentice Hall Inc., (1999).

4 Denbigh K. G., "Principles of Chemical Equilibrium", 4th Edition, Cambridge University Press, (1981).

5 Halder G., "Introduction to Chemical Engineering Thermodynamics", Prentice Hall Inc., (2009).

Course Code	Course Title	L	T	P
CHX-206	Heat Transfer Operations	3	1	0

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.

Recommended Books

1 Dutta B. K., "Heat Transfer: Principles and Applications", Prentice Hall of India Limited, (2004).

2 Holman J. P., "Heat Transfer", McGraw Hill Book Co., (1992).

3 Geankopolis C. J., "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition, (2004).

4 Kern D. Q., "Process Heat Transfer", McGraw Hill Book Co., (1997).

5 Coulson J. M., Richardson J. F., "Chemical Engineering" Volume 1, Pergamon Press, (1999).

Course Code	Course Title	L	T	P
PHX-214	Material Science and Engineering Lab	0	0	2

List of Experiments

1. To determine the magnetic susceptibility of a paramagnetic salt by Guoy's balance method.
2. To calibrate an electromagnet.
3. To determine the resistivity of a semiconductor by four-probe method.
4. To estimate the band gap energy of a semiconductor using four probe method.
5. To find Young's modulus, modulus of rigidity and Poisson's ratio for the material of a given wire by Searle's method.
6. To find the coefficient of thermal conductivity of bad conductor by Lee's disc method.
7. To determine the Hall coefficient of a semiconductor and hence to estimate the charge carrier concentration.
8. To investigate creep of a copper wire at room temperature.
9.

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

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 estimate the given reducing sugar
4. To estimate the given non reducing sugar

5. To study loss on Heating of Tar and Bitumen
6. To analyze the given cement sample
7. To determine the viscosity of a given sample by Redwood Apparatus
8. To standardize the given Fehling's solution
9. To study the given polymerization reaction
10. To determine the viscosity of a given sample by U-tube viscometer

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

List of Experiments

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

Course Code	Course Title	L	T	P
CYX-301	Nano Science and Nano Technology	3	1	0

1. Introduction
Nano science, Nano technology, history and scope

2. Characterization & Fabrication
Contemporary Characterization Methods, Top down & Bottom up Fabrication, Solution based Synthesis of Nanoparticles, Vapour Phase Synthesis & Synthesis with framework

3. Lithography and Chemical Patterning
Nanolithography, Dip Pen Lithography, e-beam lithography, Nanosphere liftoff lithography

4. Quantum Structures
Quantum Well, Quantum wires, Quantum Dots, Super lattices & Layered Structures, Quantum Computing

5. Self Assembly
Supramolecular & Dimension Control in Nanostructure, thermodynamic and coded self assembly

6. Carbon Nanostructures and Biomaterials
Carbon molecules, clusters, carbon nanotubes and their applications DNA & Nanomaterials, Bionanocomposites, Biometrics, molecular motors. DNA Computing

7. Nanoelectronics Molecular wires, Molecular switch, Molecular logic gates and molecular storage devices, Nanowires, Nanotubes

Recommended Books:

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

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

Mass Transfer Operations
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 equipments.

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 equipments.

Recommended Books

1 Geankopolis C. J., "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition, (2004).

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

3 McCabe W. L., Smith J. C. "Unit Operations of Chemical Engineering", McGraw Hill, (2001).

4 Coulson J. M., Richardson J. F., "Chemical Engineering, Vol. 2", McGraw Hill, (1999).

5 Walter L., Badger, Julius T. B, "Introduction to Chemical Engineering", McGraw Hill, (1997).

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

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

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 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, semi batch reactors.

Non Catalytic Fluid Solid Reactions

Selection of model, unreacted core model for spherical particles, diffusion through gas film control, diffusion through ash layer control, chemical reaction control, Design.

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).

Course Code	Course Title	L	T	P
CHX-305	Hydrocarbon Engineering	3	1	0

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.

Marketing of Petroleum and Petroleum products

Role of International oil companies and OPEC pricing mechanism, Administered and market determined pricing mechanism in India.

Natural gas

Structural analysis of gas industry, Types of natural gas, Units of natural gas, Impurities of natural gas, Natural gas quality, LNG Scenario in India etc.

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
CHX-307	Energy Technology	3	1	0

Solid Fuels

Principle Solid Fuels–Coal, origin, composition & classification of coal, Properties of coal, terms used in analysis of coal, classification of Indian coals, petrology of coal

Coal Preparation

Dry and Wet processes, storage of coal. Coal carbonisation: mechanism of carbonisation, high temperature and low temperature carbonization briquetting, gasification of coal, Lurgi process, Winkler process, Kopper–Totzek process, liquefaction of solid fuels.

Liquid Fuels

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

Gaseous Fuels

Classification, Wobbe Index natural gas, methane from coal mines, producer, water, carburetted water gas, coal, blast furnace, refinery gases, LPG.

Combustion

General Principles of combustion, stoichiometry & heat balance calculations, coal burning equipments, stokers, pulverized fuel burners gas and oil burners, fluidized bed combustion.

Alternate Energy Systems

Solar Energy–Photovoltaic cells, solar collectors. Nuclear energy: nuclear reactions, fuel materials, moderators and structural materials, reactors, wind energy, tidal energy, and geothermal energy.

Furnaces

General classification and description of different types of furnaces

Recommended Books

1 Brame J. S., King J. C., "Fuels-Solid, Liquid and Gaseous", St. Martin Press (2007).

2 Sarkar S., "Fuels and combustion", Longman publishers India Ltd., 2nd Edition (1990).

3 Haslam R. T., Russel R. P., "Fuels and their combustion", McGraw Hill (2007).

4 Gupta O. P., "Elements of Fuels, Furnaces and Refractories", Khanna Publishers,(2007).

5 Griswold J., "Fuels combustion and furnaces", McGraw Hill (2008).

Course Code	Course Title	L	T	P
CHX-321	Process Equipment Design	1	0	2

Introduction

Introduction to principles involved in the design and construction of plant.

Design preliminaries

Design codes, pressure, temperature, factor of safety, corrosion allowance, weld joint efficiency factor, design loadings, Poisson's ratio, dilation of pressure vessels, criteria of failure, material of construction.

Storage tanks
Introduction to Indian standards for storage tanks and their use to design cylindrical and spherical vessels under internal pressure, fixed roof and open roof tanks.

Mechanical design
Mechanical design of tall vessels for distillation and absorption columns.

Design of supports
Design of supports for vertical and horizontal vessels, Flanges.

Recommended Books

1 Bhattacharya B. C., "Chemical Equipment Design", CBS Publisher, (1985).

2 Sinnott R. K., Coulson & Richardson, "Chemical Engineering, Vol.6", 2nd Edition, Butterworth Heinemann, Oxford, (1998).

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 Ulrich G. D., "A Guide to Chemical Engineering Process Design and Economics", John Wiley, (1984).

Course Code	Course Title	L	T	P
CHX-323	**Energy Technology Lab**	**0**	**0**	**3**

List of Experiments

1. To determine the 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 estimate the moisture content in the given coal sample
6. To determine the Cloud Point and Pour Point of a given sample
7. To study the burning properties of the given sample
8. To determine the Melting Point of Petroleum wax

Course Code	Course Title	L	T	P
CHX-302	Instrumentation and Process Control	3	1	0

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.

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
CHX-304	Mass Transfer Operations II	3	1	0

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.

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.

Recommended Books

1 Geankopolis C. J., "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition, (2004).
2 Treybal R. E., "Mass Transfer Operations" 3rd Edition, McGraw Hill, (1980).
3 McCabe W. L., Smith J. C. "Unit Operations of Chemical Engineering", McGraw Hill, (2001).
4 Coulson J. M., Richardson J. F. "Chemical Engineering, Vol. 2", McGraw Hill, (1999).
5 Walter L, Badger, Julius T., "Introduction to Chemical Engineering", McGraw Hill, (1997).

Course Code	Course Title	L	T	P
CHX-306	Chemical Reaction Engineering II	3	1	0

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 Hishelwood 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
Fixed Bed Catalytic Reactor, Single and multibed adiabatic reactors, Multitubular fixed bed reactors

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

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).

Course Code	Course Title	L	T	P
CHX-308	Environmental Engineering	3	1	0

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, 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.

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, Special Indian Edition, (2007).

Course Code	Course Title	L	T	P
CHX-310	Process Engineering and Economics	3	1	0

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, 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 for optimum analysis. Examples of optimum design in a Chemical Process Plant.

Recommended Books

1 Peters M. S., Timmerhaus K. D., "Plant Design and Economics for Chemical Engineers", 2003, 4th Edition, McGraw Hill, New York,(2003).

2 Ulrich G. D., "A Guide to Chemical Engineering Process Design and Economics", John Wiley, (1984).

3 Guthrie K. M., "Process Plant Estimation, Evaluation and Control", Craftsman Solano Beach, California, (1974).

4 Douglas, "Conceptual Design of Chemical Processes", McGraw Hill, (1998).

5 Valle Riestra , "Project Evaluation in Chemical Process Industries", McGraw Hill, (1983)

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

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. 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. temp.

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 Code	Course Title	L	T	P
CHX-324	Reaction Engineering and Control Lab	0	0	3

List of Experiments

1. Determination of rate constant for saponification reaction in a batch reactor
2. Determination of porosity and sphericity of the given catalyst.
3. RTD study in a Packed bed reactor
4. To study the adsorption of acetic acid on charcoal and prove the validity of Freundlich and Langmuir adsorption isotherm
5. To study the adsorption of oxalic acid on charcoal and prove the validity of Freundlich and Langmuir adsorption isotherm
6. Determination the time constant of a given Mercury Thermometer.
7. Determination of time constant in a liquid level tank
8. Determination of time constant in interacting and non-interacting tank
9. Determination of time constant in a heated tank
10. To study the effect of proportional controller in a liquid level tank
11. To study the effect of proportional Integral controller in a liquid level tank

Course Code	Course Title	L	T	P
CHX-326	Environmental Engineering Lab	0	0	3

List of Experiments

1. To determine the Total Solids of a given sample.
2. To find out Total Dissolved Solids of a given sample.
3. To find out Fixed and Volatile solids of the given sample.
4. To determine Acidity of the given sample.
5. To determine the Alkalinity of the given sample.
6. To determine the Total Hardness of the given sample.
7. To find out amount of Sulphates in a given sample.
8. To estimate the content of Chlorides in the given water sample
9. To find the quantity of the Dissolved Oxygen present in the given sample.
10. To determine the BOD of a given wastewater sample.
11. To determine the COD of a given wastewater sample.

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

Summary of vector and tensor Notation

Vector operations from a geometrical view point. Vector operation from an analytical view point, the vector differential operations, second order tensors, vector and tensor components in curvilinear coordinates, and differential operations in curvilinear coordinates.

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.

Recommended Books

1 Bird R. B., Stewart W. E., Lightfort R. N., "Transport Phenomena", John Wiley and Sons, (2002).

2 Welty J. R., Wilson R. E., Wicks C. E., "Fundamentals of Momentum, Heat and Mass Transfer", 4th Edition, John Wiley and Sons (2001).

3 John C. S., "Momentum, Energy and Mass transfer in continua", McGraw Hill, Co., (1972).

4 Bennet C. U., Myers J. E., "Momentum, Heat and Mass Transfer" ,Tata McGraw Hill Publishing Co., (1975).

5 Robert S. B., Harry C. H., "Transport Phenomena a Unified approach", McGraw Hill Book Co., (1988).

Course Code	Course Title	L	T	P
CHX-403	Process Plant Design	1	0	2

Heat exchangers

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 Equipments

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.

Recommended Books

1 Kern D. Q., "Process Heat Transfer", McGraw Hill, (2001).

2 Perry's, "Handbook of Chemical Engineering" McGraw Hill, 7th Edition, (1997).

3 Coulson J. M., Richardson R. E., "Chemical Engineering" Vol. 2 and 6, Pergamon Press, (1998).

4 Van Winkle M., "Distillation", 1st Edition, McGraw Hill Company, New York, (1967).

5 Ludwig E. E., "Applied Process Design for Chemical and Petrochemical Plants", Vol. 1, 2 and 3, 3rd Edition, Gulf Publishing Company, Houston, (1995).

Course Code	Course Title	L	T	P
CHX-421	Chemical Engineering Computing	0	0	3

List of Experiments

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 Code	Course Title	L	T	P
CHX-423	Project Phase I	0	0	4

Project

As a part of the B. Tech. curriculum, the students are required to do a research oriented B. Tech. project work in their final year. The aim of this project is to impart to students a flavour of design, innovation and research. Every student will be required to submit a project report in a typed form on a topic selected by the student, but specifically approved by the Department Faculty member, who will guide the student or on a topic to be assigned by one or more Department Faculty members.

The project work on the topic will consist of some investigational work or computer simulation or design problem or experimental set up of some development work or of prototype equipment. Every student will be orally examined on the topic incorporated in the project and in the related area of specialization.

Course Code	Course Title	L	T	P
CHX-425	Industrial Practical Training	0	0	0

Industrial Practical Training

As a requirement every student studying for Bachelor's Degree in Technology has to undergo Industrial Practical Training for duration of six to eight weeks during May to July after completion of VI semester in any reputed industry or CSIR Laboratory or any Institute of National Importance including National Institute of Technology, Jalandhar etc. as approved by the Department. The training is aimed at giving students exposure to the profession in the real world of work as well as provide them with opportunities to correlate their theoretical understanding and the reality of the profession. The main objective of Industrial Practical Training is to promote the development of appropriate technology that meets national, regional and international needs through skills and practical oriented training, research and consultancy.

At the beginning of the next academic year, each student is supposed to hand in a report on the activities during the training and to make an oral presentation about it. The report should contain the following elements as per the guidelines of the Centre of Training and Placement of the Institute:

- Title of the work, name of the company with the full address and e-mail
- A short description of the company
- A description of the important parts of the work during the training
- Conclusions of the work

Based on this report and presentation, the Department Faculty will evaluate the training work of each student.

B. Tech. Chemical Engineering VIII Semester

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

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 foe heat exchanger, Model for interacting & non-interacting tanks, Model for biochemical reaction.

Simulation

Meaning of simulation, Simulation examples of isothermal CSTR, non-isothermal CSTR, Batch reactor

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
CHX-404	Industrial Safety & Hazards Management	3	1	0

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

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

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

Accident Investigations and Case Histories

Bhopal gas tragedy, flixborough disaster, Pasadena accident, IOCL Jaipur fire

Recommended Books
1 Crowl D. A., Louvar J. F., "Chemical Process Safety Fundamentals with applications", (2002), 2nd Edition, Prentice Hall, NJ.
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
CHX-422	Modeling and Simulation Lab	0	0	3

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

Course Code	Course Title	L	T	P
CHX-424	Project Phase II	0	0	8

Project

As a part of the B. Tech. curriculum, the students are required to do a research oriented B. Tech. project work in their final year. The aim of this project is to impart to students a flavour of design, innovation and research. Every student will be required to submit a project report in a typed form on a topic selected by the student, but specifically approved by the Department Faculty member, who will guide the student or on a topic to be assigned by one or more Department Faculty members.

The project work on the topic will consist of some investigational work or computer simulation or design problem or experimental set up of some development work or of prototype equipment. Every student will be orally examined on the topic incorporated in the project and in the related area of specialization.

Course Code	Course Title	L	T	P
CHX-451	Allied Chemical Technology	3	0	0

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 and 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.

Recommended Books

1 Dryden C. E., "Outlines of Chemical Technology", 2nd Edition, East–West Press Pvt. Ltd., New Delhi, (1973).
2 Austin G. T., "Shreve's Chemical Process Industries", 5th Edition, McGraw Hill Book Company, New Delhi, (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., Pandey G. N., "A text book of Chemical Technology, Vol. I", Vikas Publishing House Pvt. Ltd., New Delhi. (1986).
5 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
CHX-453	Biochemical Engineering	3	0	0

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

reactors. Selection, scale-up, operation and control of bioreactors.

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.

Recommended Books

1 Bailey J. E., Ollis D. F., "Biochemical Engineering Fundamentals", McGraw Hill International Editions, Second Edition, (1986).

2 Shuler M. L., Kargi F., "Bioprocess Engineering", Prentice Hall of India Pvt. Ltd., Second Edition, (2005).

3 Primrose S. B., Twyman R. M., "Principles of Gene Manipulation and Genomics", Blackwell Publishing, Seventh Edition, (2006).

4 Dutta R., "Fundamentals of Biochemical Engineering", Springer Publications, (2010).

5 Najafpour G. D., "Biochemical Engineering and Biotechnology", Elsevier Publications, First Edition, (2007).

Course Code	Course Title	L	T	P
CHX-455	Environment Impact Assessment	3	0	0

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.

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
CHX-457	Industrial Rheology	3	0	0

Introduction

Introduction to non Newtonian and non Newtonian fluid behaviour, time independent fluid behaviour, time dependent fluid behaviour (thixotropy and rheopexy), visco elastic fluids, dimensional considerations.

Rheometry for Non Newtonian Fluids

Capillary viscometers, rotational viscometers, normal stress measurements, Introduction and working of Capillary viscometers, rotational viscometers, stress rheometers.

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, laminar flow in concentric annulus.

Heat Transfer Characteristics of non-Newtonian fluids in pipes

Laminar flow in circular tubes, full developed heat transfer to power law fluids in laminar flow.

Momentum heat and Mass transfer in boundary layers and liquid mixing

Integral momentum equation, laminar flow of power law liquids over a plate, Liquid mixing, scale up of stirred vessels, power consumptions in stirred vessels.

Recommended Books

1 Chabra, Richardson, "Non Newtonian fluids in Process Industries", Butterworth, Melbourne, (1999).

2 Bird, Stewart W. E. and Lightfort, "Transport Phenomena", John Wiley and Sons, (2002).

3 Welty J. R., Wilson R. E., Wicks C E, "Fundamentals of Momentum, Heat and Mass Transfer", 4th Edition, John Wiley and Sons, (2001).

4 Tanners R. I., "Rheology: An Historical perspective", Elsevier, Amsterdam, (1998).

5 Skelland, A. H. P., "Non Newtonian Flow and Heat Transfer", Wiley, New York, (1967).

Course Code	Course Title	L	T	P
CHX-459	Membrane Separation Processes	3	0	0

Introduction

Definition of membrane and membrane process, Commercial membrane separation processes, new membrane separation process under development

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.

Emulsion liquid membranes

Introduction and definition, theory and design, selected applications and economics

Dialysis, Electodialysis, Pervaporation, Gas permeation

Brief introduction and applications.

Recommended Books

1 Wilson, Sirkar, "Membrane Handbook", McGraw Hill, London, (2001).

2 Nune, Peinemann, "Membrane Technology in Chemical Industries", Wiley, New York, (2000).

3 Cheryan M., "Ultra filtration Handbook", Technomic, New York, (1985).

4 Noble, Stern, "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
CHX-461	Optimization Techniques	3	0	0

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.

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
CHX-463	Petroleum Recovery Technology	3	0	0

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.

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
CHX-465	**Petroleum Refining Technology**	**3**	**0**	**0**

Introduction to Petroleum Industry
World petroleum resources, petroleum industries in India. Scope and Purpose of Refining, Global and Indian refining 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, crude oil 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.

Recommended Books

1 Nelson W. L., "Petroleum Refinery Engineering", McGraw Hill Book Co., (1985)

2 Watkins R. N., "Petroleum Refinery Distillation", Gulf Publishing Co.

3 Gary J. H., Handework 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
CHX-467	Polymer Science and Engineering	3	0	0

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 polymerisation. Mechanism and kinetics of free-radical chain polymerization, kinetic chain length, chain transfer reactions, Inhibition and retardation

Synthetic Fibres
Types of Fibres, Spinning Techniques, Manufacturing Technology and Applications of different types of fibres: cellulosic fibres, 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 plastics and rubbers
Physical testing, Electrical Properties, Softening Temperature tests, Melt flow Index.

Recommended Books

1 Gowariker V. R., Viswanathan N. V., Sreedhar J., "Polymer Science", New Age International Publishers,

(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
CHX-452	Computational Fluid Dynamics	3	0	0

Conservation laws
Governing equations of fluid flow and heat transfer–mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form.

Turbulence
Characteristics of turbulent flows, Time averaged Navier Stokes equations, Turbulence models–one and two equation, Reynolds stress, LES and DNS.

Finite volume method
Diffusion problems – explicit and implicit time integration; Convection-diffusion problems–properties of discretisation schemes, central, upwind, hybrid, QUICK schemes; Solution of discretised equations.

Flow field computation
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.

Recommended Books
1 Anderson J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill, (1995).

2 Fletcher C. A. J., "Computational Techniques for Fluid Dynamics", Springer Verlag, (1997).

3 Versteeg H.K., Malalasekera W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education Ltd., (2007).

Course Code	Course Title	L	T	P
CHX-454	Energy Management and Audit	3	0	0

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 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, Techniques - energy consumption, Production, Cumulative sum of differences (CUSUM).

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
CHX-456	**Industrial Environmental Management**	**3**	**0**	**0**

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.

Recommended Books

1 Dryden C. E., "Outlines of Chemical Technology", East-West Press Pvt. Ltd., Second Edition, (1973).

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

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

Course Code	Course Title	L	T	P
CHX-458	Introduction to Multiphase Flow	3	0	0

Flow past immersed bodies
Drag and drag coefficients, flow through beds of solids, motion of particles through fluids, fluidization, types of fluidization and applications.

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.

Types of Multiphase-Reactors
Various types of multiphase reactors. e.g. Packed bed, packed-bubble column, trickle bed reactor, three phase fluidized bed reactor, Bubbling Fluidized Bed (BFB), Circulating Fluidized Bed (CFB), slurry bubble column, and stirred tank reactor. Characteristics of above mentioned reactors such as; fluid flow phenomena and flow regimes, flow charts/correlations, pressure drop, liquid hold up etc. Reactors involving Newtonian and non-Newtonian fluids.

RTD in Multiphase Flow systems
Non Ideal Flow: Residence time distribution of fluid in vessel, E, F & C Curve, Mean and variance, the Dirac delta function, residence time, linear and non-linear processes, models for non ideal flow, dispersion model, N tanks in series model, model for small deviations from plug flow and long tails, conversion in a reactor using RTD data, diagnosing ills of operating multiphase reactors, models for multiphase reactors. Two parameter model; PD model; three parameter models; PE Model.

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 Shah Y.T., "Gas-Liquid-Solid Reactor Design", McGraw Hill Int. New York, (1979).

4 Westerterp K. R., van Swaaij W. P. M., Beenackers A. A. C. M., "Chemical Reactor Design and Operation", John Wiley & Sons, (1993).
5 Doraiswamy L. K., Sharma M. M., "Heterogeneous Reactions: Volume 2 Fluid-Fluid-Solid Reaction", John Wiley & Sons, Singapore, (1984).

Course Code	Course Title	L	T	P
CHX-460	Instrumental Methods of Analysis	3	0	0

Introduction to Chemical Analysis
Qualitative and Quantitative analysis, fundamental theory of solution reactions i.e. chemical equilibrium, buffer solutions, hydrolysis, ionic product, solubility product, electrolytic dissociation, electrode potential, common ion effect, complex ion

Data Analysis
Error, accuracy, precision, significant figures, correlation, regression, analysis of variance, optimization methods, factor analysis

Titrimetric Analysis
Classification of reactions, standard solutions, Principles of Potentiometric titrations, Spectrophotometric titrations, Neutralization titrations, Complexation titrations, Redox titrations, Precipitation titrations

Spectroscopic Analysis
Introduction, theory and principles of Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, Mass Spectroscopy, Nuclear Magnetic Response Spectroscopy, Infrared Spectroscopy, Raman Spectroscopy

Chromatographic Analysis
Introduction, theory, principles and methodology of Thin Layer Chromatography, Liquid Chromatography and Gas Chromatography

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

Recommended Books

1 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).
2 Willard, Merritt, Dean, Settle, "Instrumental Methods of Analysis", CBS Publisher and Distributors. (1986).
3 Haines J., Blackie, "Thermal methods of Analysis, Principles, Application and Problems", Academic and Professional, (1994).
4 Braithwaite A., Smith F. J., "Chromatographic Methods", Fifth Edition, Blackie Academic and Professional, London, (1996).
5 Skoog, Holder, Nieman, "Principles of Instrumental Analysis", Fifth Edition, Thomson Books, (1998).

Course Code	Course Title	L	T	P
CHX-462	Natural Gas Engineering	3	0	0

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 behaviour studies of two phase hydrocarbon systems, equations of states, multiple flashes. Water-hydrocarbon system. Vapour liquid equilibria.

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. Liquification process. Dehydration of Natural Gas sweetening of Natural gas and sulphur recovery, 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.

Recommended Books

1 Kumar S., "Gas Production Engineering", Gulf Publishing Co., (1987).

2 Beggs H. D., "Gas Production Operations", OGCI Publication, (1984).

3 Ikoku C. K., "Natural Gas Engineering", John Wiley, (1984).

4 Alexandre R., "Natural Gas: Production, Processing and Transport", Hyperion Books, (1995).

5 Katz D. L., "Hand Book of Natural Gas Engineering", McGraw Hill.

Course Code	Course Title	L	T	P
CHX-464	New and Renewable Energy Resources	3	0	0

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.

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 Desai A. V., "Non-convetional Energy", Wiley Eastern, (1990).

4 Mittal K. M., "Non-conventional Energy System", Wheeler Publishing Co. Ltd, (1997).

5 Rao S., Parulekar B. B., "Energy Technology", Khanna Publishers, (1995).

Course Code	Course Title	L	T	P
CHX-466	Petrochemical Technology	3	0	0

Petrochemical - 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, general cost considerations, indigenous technology V/S foreign know-how. 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.

Chemicals from 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

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

Chemicals from butanes, butane pentanes and pentanes

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

Chemicals from aromatics

monochloro, dichloro benzene, BHC nitro benzene, dodecyl benzene, benzoic acid, nitrotoluene, pthalic anhydride, isopthalic acid, terethalic acid, dimethyl terepthalate, maelic anhydride, adipic acid, hexamethylene diamine

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.

Recommended Books

1 Rao B. K. B., "A textbook on Petrochemicals" 2nd Edition, Khanna publisher, (1996).

2 Ram Prasad , "Petroleum Refining Technology", Khanna publisher

3 Sukumar M., "Introduction to Petrochemicals", Oxford and IBH publishing Co., (1992),

4 Chauvels A., Lefebvre G., "Petrochemical Process", Vol. 4.

Course Code	Course Title	L	T	P
CHX-468	Process Plant Utilities	3	0	0

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.

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
CHX-471	Environmental Engineering	3	0	0

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, 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.

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
CHX-472	Hydrocarbon Engineering	3	0	0

Role of oil and gas in world economy: Importance of oil and gas in the world economy, oil and gas reserves, supply and demand, Specific features of oil and gas industries.

Introduction origin of oil and its recovery: Origin and occurrence of crude oil, physical and chemical properties of oil, entrapment of oil: types and mechanism, Exploration methods, oil recovery methods, world petroleum reserves, Drilling, Production equipments.
Natural gas from condensate and oil fields, thermodynamic and energy change, Review of physical and chemical properties of NG and associate hydrocarbons.

Flow of fluids: Gas handling facilities, flow of fluids. Compression of gasses, application of heat and mass transfer principles and application in natural gas energy system, Transmission of Ng in pipelines, LPG technique, its production and distribution.

Natural Gas processing: Purifications, refrigeration and low temperature processing, liquefaction process, LNG, NGL recovery, Sweetening of NG, sulfur recovery.

Storage and handling: Storage, tanks, underground storage and conservation of NG and oil.
Economic consideration for development of gas fields.

Recommended Books

1. Carroll John, "Gas hydrates: A guide for engineers", Elsevier USA (2003)
2. Kandiyoti.R, Herod and Bartle K, "Solid Fuels and Heavy Hydrocarbon Liquids: Thermal Characterization and analysis",Elsevier (2006)
3. S.Kumar, "Gas production engineering",Gulf Publishing Co. (1987)
4. Ikoku C K, "Natural gas engineering",John Wiley (1984)
5. Beggs D H, "Gas production operations",OGCI Publication (1984)

Course Code	Course Title	L	T	P
CHX-473	Industrial Safety & Hazards Management	3	0	0

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, definitions, flammability characteristics of liquid and vapors, LOC and inerting, types of explosions, Designs for fire prevention:

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

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

Accident Investigations and Case Histories

Bhopal gas tragedy, flixborough disaster, Pasadena accident, IOCL Jaipur fire

Recommended Books

1 Crowl D. A., Louvar J. F., "Chemical Process Safety Fundamentals with applications", (2002), 2nd Edition, Prentice Hall, NJ.

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
CHX-474	New and Renewable Energy Resources	3	0	0

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.

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 Desai A. V., "Non-convetional Energy", Wiley Eastern, (1990).

4 Mittal K. M., "Non-conventional Energy System", Wheeler Publishing Co. Ltd, (1997).

5 Rao S., Parulekar B. B., "Energy Technology", Khanna Publishers, (1995).

Course Code	Course Title	L	T	P
CHX-475	Polymer Science and Engineering	3	0	0

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 polymerisation. Mechanism and kinetics of free-radical chain polymerization, kinetic chain length, chain transfer reactions, Inhibition and retardation

Synthetic Fibres

Types of Fibres, Spinning Techniques, Manufacturing Technology and Applications of different types of fibres: cellulosic fibres, 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 plastics and rubbers

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

Recommended Books

1 Gowariker V. R., Viswanathan N. V., Sreedhar J., "Polymer Science", New Age International Publishers, (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
CHX-476	Oil and Natural Gas Economics	3	0	0

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

Recommended Books

1 Conaway C.F., "The Petroleum Industry: A Non- Technical Guide", Penn Well, (1999).

2 Berger B. D., "Modern Petroleum: A Basic Primer of the Industry", (1992).

3 Tussing A., Tippee B., "The Natural Gas Industry: Evolution, Structure and Economics", Penn Well, (1995).

4 Julius D., Mashaekhi, A., "The Economics of Natural Gas: Pricing, Planning and Policy", OIES, (1990).

5 Van Groenendaal W., "The Economics Appraisal of Natural Gas Projects", OIES, (1998).

Course Outcomes (COs)

3rd Semester

Mathematics –II

Course Objectives

- The course intends to provide an overview of Matrices which occur in physical and engineering problems.
- Also provides an overview of differential equations which occur in physical and engineering problems.
- This course creates the ability to model, solve and interpret any physical or engineering problem.

Course Outcomes

- Application of the laws of mathematical statements, relevant to engineering problems.
- Ability to solve potential functions, stream functions and velocity potential.
- An ability to identify, formulates, and solves the problems.

Object Oriented Programming

Course Objectives

- This course is designed to provide a comprehensive study of the C programming language.
- It stresses the strengths of programming, which provide students with the means of writing efficient, maintainable, and portable code.

Course Outcomes

- Understand the concept and underlying principles of Object-Oriented Programming.
- Develop problem-solving and programming skills using OOP concept

Fluid Mechanics

Course Objectives

- To understand basic concept of fluid flow and its application to chemical process industries.
- To understand basic principles of various mechanical operations, construction and working of the equipments.
- To understand basic fluid flow phenomena, problem associated with metering and transportation of industrial fluids.

Course Outcome:

- After studying this subject, students would be able to measure pressure drop, flow rates etc. for incompressible and compressible fluids.
- Ability to analyze fluid flow problems with the application of the momentum and energy equations.
- Ability to select pumps and valves and would be able to calculate power requirement for pumping as well as agitation operations.

Mechanical Operations

Course Objectives

- To provide an overview of the approaches, methods and techniques of Mechanical Operations.
- Understanding basic principles of particle size measurement and distribution.

- To understand phenomena related to specific surface of particles, concepts of sedimentation, flow through packed bed, filtration.

Course Outcomes

- The student would understand the concept of particle size measurement and distribution.
- The student would understand the concept of hindered settling, sedimentation and particle mechanics.
- The student would understand the concept of solid mixing, solid storage and solid conveying.

CHX-205 Chemical Process Calculations

Course Objectives

- The objective of the course is to 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.

Course Outcomes

- The students will learn to calculate the mass and energy flow rates into and out of various process equipments.
- Students are able to identify and understand the unit operations involved in a process, and develop relationships between process variables.

Object Oriented Programming Lab

Course Objectives

- Understand the fundamentals of object oriented programming defining classes, invoking methods, using class libraries etc.
- To learn operational skills and applications for specific purpose.
- To learn software program for basic application.

Course Outcomes

- Understand concepts of objects and their significance in real world.
- Learn to co-relate relationship among different entities involved in a system.
- Have the ability to write a computer program to solve specified problems.

CHX-221 Fluid Mechanics Lab

Course Objectives

- The course aims on the properties of fluidsand 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.

Course Outcomes

- The engineering level student must be able to approach and solve typical problems in and fluid dynamic at the appropriate level.
- Student must be able to understand the fluid dynamics. Also they should know the principles of turbulent flow, calculation of turbulent boundary layers with pressuregradient,transition from laminar to turbulent flow, volumetric and mass flow rates through the Venturi meter and Orifice meter and efficiency of pump.

Mechanical Operations Lab

Course Objectives

- The course covers basic knowledge in particle technology (particle size, shape, specific surface).
- Understanding concepts of sedimentation, flow through packed bed, filtration.
- To understand solid mixing and solid conveying

Course Outcomes

- Ability to visualize and understand chemical engineering unit operations related to fluid and particle mechanics.
- Ability to understand the experimental techniques related to mechanical operations.

4th Semester

Mathematics III

Course Objectives

- Understand the fundamentals of object oriented programming defining classes, invoking methods, using class libraries etc.
- To learn operational skills and applications for specific purpose.
- To learn software program for basic application.

Course Outcomes

- Understand concepts of objects and their significance in real world.
- Learn to co-relate relationship among different entities involved in a system.
- Have the ability to write a computer program to solve specified problems.

Material Science and Engineering

Course Objectives

- This course covers structure and properties of several types of materials (e.g. metals, semiconductors, superconductors and magnetic materials).
- Students also learn the uses of materials for particular applications.

Course Outcomes

- Students will be able to select a material for a given use based on considerations of cost and performance.
- Students will be able to create a new material that will have some desirable properties.

Chemical Technology

Course Objectives

- To expose the students on how raw materials are converted into useful products that are organic in nature
- To teach unit operations and unit processes those are employed in the manufacture of organic products.
- To teach various schematic, block, symbols and legends representations used in processes flow diagrams of manufacturing processes

Course Outcomes

- Able to analyze the flow of raw material to product formation quantitatively and qualitatively in each step of processes
- Ability to apply the concepts of unit operation and unit processes that are employed in design of process plants

- Ability to identify the engineering problems associated with the various processes.

Chemical Engineering Thermodynamics

Course Objectives

- This course covers the application of thermodynamic principles to chemical engineering problems with emphasis on vapor/liquid systems
- Students also learn the application of thermodynamic principles to chemical reactions

Course outcomes

- The students will be able to understand and apply thermodynamic principles to different types of chemical engineering systems like vapor/liquid systems, solutions etc. including calculation of fugacity and activity coefficients.
- Students will be able to analyze chemical reactions in relation to thermodynamic principles.

Heat Transfer

Course Objective

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

Course Outcomes

- Ability to understand and solve conduction, convection and radiation problems.
- 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.
- Develop correlations using elementary dimensional analysis and comprehend the laws governing radiation mode.
- Ability to design and analyze the performance of heat exchangers and evaporators, reactor heating and cooling systems

Material Science and Engineering Lab

Course Objectives

- To understand the basic fundamentals of Science behind Materials on atomic scale and in bulk materials.
- To find various types of Materials and analyze how properties change due to various effects.
- To apply the above knowledge for the selection of materials for process equipments.

Course Outcomes

- Students would have knowledge about the existence of new materials and their properties.
- The students will be able to choose appropriate material for process equipments.

Chemical Technology Lab

Course objectives

- To expose the students on how raw materials are converted into useful products that are organic in nature
- To learn analytical experimental methods using sophisticated instruments and interpretation of experimental data

- To learn chemical engineering principles and their practical applications in the areas of mass transfer, reaction engineering and particle mechanics

Course Outcomes

- Analyze the flow of raw material to product formation quantitatively and qualitatively in each step of processes
- Ability to understand, explain and select instrumental techniques for analysis
- Ability to analyze chemical reactors and reaction systems

Heat Transfer Lab

Course Objectives

- This course is designed to develop among the students the skills to perform experiments related to the application of heat transfer concepts ie 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.

Course outcomes:

- 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.
- The students will develop the skill of presenting the results in form of written reports

5th Semester

CYX-301 Nano Science and Nano Technology

Course Objective/s:

- To enable the students to understand the basic concepts of Nano science and Nano technology.
- This course includes the concept of characterization and fabrication, lithography and chemical patterning, quantum structures, self assembly, carbon nanostructures and biomaterials and nanoelectronics.

Course outcomes:

- The students would develop a global understanding of the impacts and issues regarding nanotechnology and applications.
- The students are able to analyze and critically evaluate ideas/information/data and apply relevant principles to solve problems by, for example, creating hypothesis, testing theories and predictions, designing and carrying out experiments and analyzing reported data.

CHX-301 Mass Transfer Operations I

Course Objective/s:

- To introduce the students with the different types of mass transfer operations and the most important separation techniques in the process industry.
- This course includes the concept of different mass transfer operations such as diffusion, inter phase mass transfer, gas absorption and drying.

Course Outcomes:

- Students will learn about the steady state diffusion as well as the eddy diffusivity. Also, they will study the concept of local and overall mass transfer coefficient, film theories and two phase mass transfer coefficients.

- 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 equipments, 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 equipments .

CHX-303 Chemical Reaction Engineering I

Course Objective/s:

- The objective of the course is to aware the students with various types of homogeneous reactions and their analysis such as rate, order of reaction etc.
- The students learn the application of stoichiometry and rate law to design a chemical reactor for homogeneous reactions.

Course Outcomes:

- The students will be able to apply the concepts of reaction engineering and reactor design for analysis of homogeneous reactions.
- Students are able to design the various reactors used for batch and flow conditions for homogeneous reactions.

CHX-305 Hydrocarbon Engineering

Course Objective/s:

- The objective of the course is to provide the students understanding of downstream processes in petroleum industry.
- The objective of the course is to impart knowledge to the students about various selected processes, catalytic reforming and isomerization, hydro treating and hydro cracking, catalytic cracking, treatment of heavy oils, environmental concerns, new fuels.

Course Outcomes:

- After completion the course students will be able to familiar with scope and purpose of refining, distillation process, fuel lube and wax refining hydro processing, gas processing refining, feed stock and evaluation of crude oil, and functioning of oil and gas separator in petroleum industry.
- The students are able to understand the basic chemistry, thermodynamics, kinetics, catalysis, reactor technology and process design and layout for key processes in oil refining, gas conversion and petro chemistry.

CHX-307 Energy Technology

Course Objective/s:

- The course describes the fundamentals and main characteristics of solid fuels such as coal, liquid fuels, gaseous fuels, solar energy, nuclear energy, etc.
- The course compares different types of energy systems and helps in gaining the knowledge to choose the most appropriate based on local conditions.

Course Outcomes:

- The students gain the knowledge of mechanism of coal carbonization and different types of unit process such as cracking, thermal cracking, catalytic cracking, hydrocracking, reforming thermal and catalytic reforming, alkylation, polymerization isomerization.
- The students will acquire the knowledge of general principles of combustion, stoichiometry & heat balance calculations for combustion and general classification and description of different types of furnaces.

CHX-321 Process Equipment Design

Course Objective/s:

- The objective of the course is to introduce the students to principles involved in the design and construction of plant.
- The course provides the knowledge about mechanical design of various equipments like storage tanks, pressure vessels, tall vessels for distillation and absorption columns and supports for vertical and horizontal vessels, Flanges.

Course Outcomes:

- This course enables the students to use the design codes and introduce them to standards for the mechanical design of equipments used in the process industry
- The students would demonstrate general understanding of fabrication techniques and equipment testing as a designer.

CHX-323 Energy Technology Lab

Course Objective/s:

- The students will get the experimental exposure of calculating smoke point, flash point, cloud point, pour point, melting point, etc of the sample.
- The students learn to record and present their observations in reports.

Course Outcomes:

- The students will develop the skills to handle the equipments at laboratory scale and can co-relate the theoretical aspects by performing experiments related to energy technology.
- The students will develop the skill of presenting the results in form of written reports.

6th Semester

CHX-302 Instrumentation and Process Control

Course Objective/s:

- The objective of the course is to introduce to students various types of instruments and their applications in chemical processes.
- The course aims to analyze of the dynamical behavior of systems in terms of block diagram and the stability of the process.

Course outcomes

- The students will get acquaintance about various types of instruments for measurement of temperature, pressure, conductivity, pH, composition of the given mixture etc.
- The students will be able to analyze the dynamic behavior of chemical process systems and also the control strategies to control the chemical processes.

CHX-304 Mass Transfer Operations II

Course Objective/s:

- To introduce the concepts of mass transfer operations-II and to apply those concepts to real engineering problems.
- To study the concepts of mass transfer equilibria for vapour-liquid, liquid-liquid, solid-liquid and solid-gas systems, liquid - liquid extraction, leaching, the principles of adsorption and crystallization.

Course outcomes

- The students will get acquaintance about Lewis Sorel and McCabe–Thiele methods &

numerical, Ponchon Savarit method, Underwood and Fenske equations.

- The students will be able to understand the working of different equipments used for various mass transfer operations such as leaching, crystallization, etc.

CHX-306 Chemical Reaction Engineering II

Course Objective/s:

- The objective of the course is to aware the students with catalytic and non catalytic heterogeneous reactions and their analysis such as rate expressions etc.
- The students will learn to design the reactors for heterogeneous reactions such as Fluid-Fluid reactions, fluid –solid reactions etc.

Course Outcomes:

- The students are able to analyze the yield of chemical processes with or without chemical reaction.
- Students are able to design the reactors used for fluid –solid reactions catalytic and non-catalytic reactions.

CHX-308: Environmental Engineering

Course Objective/s:

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

Course Outcomes:

- The students gain the knowledge of different standards for the measure and control of air, water and solid waste pollution in the environment.
- The students are able to design various engineering systems of control of air, water and solid waste pollution by equipment and by process changes.

CHX-310: Process Engineering and Economics

Course Objective/s:

- To make students understand various economical terms and economics related activities which can be helpful during economical evaluation of any chemical engineering process.
- The students would learn about various basic economic aspects like need, demand, supply, price, cost & market and also, to give them the knowledge about evaluation of depreciation cost as well as salvage value, scrap value, book value of property.

Course Outcomes:

- Students will be able to calculate the profitability, rate of return on investments and cost estimation.
- After acquiring the knowledge in this subject, students become familiar with various aspects related to economics and can apply them for economic evaluation of chemical process and decide its economical feasibility and will make the students well aware about economic evaluation of dissertation work that they will undertake in final year of their curriculum.

CHX-322: Mass Transfer Lab

Course Objective/s:

- The students will get the experimental exposure of different mass transfer operations

such as diffusion, extraction, drying, etc.

- The students learn to record and present their observations in reports.

Course Outcomes:

- The students will develop the skills to handle the equipments at laboratory scale and can co-relate the theoretical aspects by performing experiments related to mass transfer operations.
- The students will able to co-relate the theoretical aspects by performing experiments 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.

CHX-324: Reaction Engineering and Control Lab.

Course Objective/s:

- The students will get the experimental exposure of chemical reactions, chemical reactors and their analysis.
- The students will get the experimental exposure of chemical processes like mercury thermometer, interacting non-interacting tanks, controllers etc and their analysis.
- The students learn to record and present their observations in reports.

Course Outcomes:

- The students will develop the skills to handle the equipments at laboratory scale and can co-relate the theoretical aspects by performing experiments related to chemical reaction engineering.
- The students will able to co-relate the theoretical aspects by performing experiments related to chemical process control.

CHX-326: Environmental Engineering Lab

Course Objective/s:

- The students will get the experimental exposure of various methods used for analysis of water.
- The students learn to record and present their observations in reports.

Course Outcomes:

- The students will develop the skills to co-relate the theoretical aspects by performing experiments, such as, determining the acidity, alkalinity, hardness, Dissolved Oxygen, BOD, COD present in the given sample.
- The students will develop the skill of presenting the results in form of written reports.

7th Semester

CHX-401 Transport Phenomena

Course Objective/s:

- The fundamental connections between the conservation laws in heat, mass, and momentum in terms of vector and tensor fluxes. Classic transport solutions including rotating disks, flow around spheres and in channels with heat and/or mass transfer occurring.
- How to formulate conservation statements in heat, mass, and momentum at multi scales from microscopic to macroscopic in both steady and unsteady modes. And to formulate multi component diffusion and simultaneous heat and mass transfer.

Course Outcomes:

- Simplify the general equations of change for specific applications.
- Analyze the transport problems in heat, mass, and momentum, both macroscopic and microscopic level. Formulate simultaneous energy and mass balances in chemical processes and solve simple linear partial differential equations arising in transport problems through recognizing initial-value and boundary-value and solve them either analytically or numerically.

CHX-403: Process Plant Design

Course Objective/s:

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

Course outcomes:

- The students are able to handle the design of various typical chemical based equipments like heat exchangers, distillation columns etc.
- The students would also able to make plant layout of the newly developed plants and prepare written reports of design problems.

CHX-421: Chemical Engineering Computing

Course Objective/s:

- 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.

Course outcomes:

- The students would be well versed with the principles of computing methods with the theory involved in the solving the chemical engineering problems.
- The students would be able to independently solve the problems in the chemical engineering and would be aware about its applications.

CHX-423: Project Phase –I

Course Objective/s:

- This course has been designed to impart to students a flavour of design, innovation and research.
- The project of the topic will consist of experimental work or development of an experimental set up or design problem or computer simulation work.

Course outcomes:

- The student is able to incorporate his entire knowledge of chemical engineering principles to an industrial or academic problem.
- 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.

CHX-425: Industrial Practical Training

Course Objectives

- The industrial practical training at the end of 6th semester is aimed at making the students get acquainted with various industrial operations and practices. The students will learn about equipment used in industry along with technicalities involved.
- The students learn to record and present their observations in reports.

Course outcomes:

The Industrial practical training develops among the students:

- An understanding of industrial operations, equipment used and industrial work atmosphere.
- An ability to understand and handle industrial scale problems.

8th Semester

CHX-402: Modeling and Simulation

Course Objective/s:

- This course aims at developing the ability of the students in the mathematical treatment of chemical engineering processes.
- This course includes the concept of model formulation, an analysis of variables, parameters, and degree of freedom analysis for the solution of mathematical model through simulation.

Course outcomes:

- The students would develop an understanding of the mathematical treatment of typical chemical engineering processes.
- The students are able to comprehend the concept of model formulation, analysis of variables, parameters, and degree of freedom for the solution of mathematical models through simulation.

CHX -404: Industrial Safety and Hazard Management

Course Objective/s:

- This course aims at developing amongst the under graduate students the concept of safety in CPI conducting proper RA tools.
- The course briefs the basics of fire, explosion and toxic dispersion modeling. It also discuss the major industrial disasters happened in the CPI

Course outcomes:

- The students are able to understand the concept of loss prevention in CPI, hazard models such as pool fire, fire ball, toxic dispersion etc.
- The students learn to exhibit the skill of performing risk assessment such as conducting Dow's fire and explosion index for the real pant unit. They also perform case studies to learn from previous accidents.

CHX-422: Process Modeling & Simulation Lab

Course Objective/s:

- 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.

Course outcomes:

- The students are able to understand the simulation techniques for solving mathematical models of chemical engineering processes by means of computer programming and use of simulation software.
- The students exhibit the skill of usage of software in simulating Chemical Engineering Problems.

CHX-424: Project Phase –I

Course Objective/s:

- This course has been designed to impart to students a flavour of design, innovation and research.
- The project of the topic will consist of experimental work or development of an experimental set up or design problem or computer simulation work.

Course outcomes:

- The student is able to incorporate his entire knowledge of chemical engineering principles to an industrial or academic problem.
- 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

Departmental Electives I and II

CHX-451 Allied Chemical Technology

Course Objectives

- The objectives of the subject are to teach various methods of manufacturing various chemicals in the chemical process industry.
- The students are introduced to the unit operations and unit processes involved in the manufacture of chemicals.
- Engineering problems involved in the manufacture of various chemicals.

Course Outcomes

- After completion of this course the student would be able to draw the qualitative flow sheets for the manufacturing process of the various chemicals involved.
- Apply the concepts of unit operation and unit processes that are employed in design of process plants
- Identify the engineering problems associated with the various processes.

CHX-453 Biochemical Engineering

Course Objectives

- To enhance skills in the areas of biochemical processes
- To provide the fundamental background of biological systems, bio-chemical engineering, advanced bioprocess engineering, biologically mediated processes.

Course Outcomes:

- Understanding of biological basics and bioprocessing
- Understanding the difference between bioprocesses and chemical processes
- Understanding of bioprocess design and operation

- Ability to understand heat & mass transfer considerations and scale up of bioprocesses

CHX-455 Environment Impact Assessment

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

Course Outcomes

- Ability to understand the current EIA methods and the techniques and tools used
- Ability to understand the current assessment methods and legislation
- Ability to understand the current environmental monitoring systems
- 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

CHX-457 Industrial Rheology

Course Objectives

- To understand the classification of various Newtonian and non-Newtonian fluids.
- To learn the heat and mass transfer characteristics in nonlinear flows through pipes and piping networks.
- To introduce viscosity effects on flow and characteristics of Newtonian and non-Newtonian fluids.

Course Outcomes

- Knowledge of fundamental concepts in fluids, such as density, viscosity, pressure, stress/strain rate, etc.
- Ability to apply mass, energy, and momentum balances to hydrostatic and fluid flow problems.
- Ability to analyze laminar and turbulent frictional flow in pipes and piping networks.

CHX-459 Membrane Separation Processes

Course Objective/s:

- 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.

Course Outcome

- The students are capable of apply various transport models for the calculation of membrane fluxes and the extent of separation for various membrane systems.
- Students are able to select a membrane process and design components to carry out a specific separation.

CHX-461 Optimization Techniques

Course Objectives

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems
- To develop and promote research interest in applying optimization techniques in problems of Engineering and Technology.
- To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

Course Outcomes:

- The students will also be able to learn different techniques to solve Non- Linear Programming Problems
- They will be able to understand the major limitations and capabilities of deterministic operations research modeling as applied to problems.

CHX-463 Petroleum Recovery Technology

Course Objectives

- The objective of this course is to learn about the well planning and various drilling operations & Practices
- Meet the world's ever-increasing demand for hydrocarbon fuel, thermal energy, and waste and pollution management.

Course Outcomes

- An ability to design and conduct experiments, as well as to analyze and interpret data.
- 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.
- An ability to identify, formulates, and solves engineering problems related to petroleum industry.

CHX-465 Petroleum Refining Technology

Course Objectives

- The objectives of this course are to learn about the extraction and production of oil and gas to meet energy needs.
- Refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Course Outcomes:

- Introduction with the petroleum refinery worldwide.
- Develop knowledge of different refining processes.
- Develop knowledge of safety and pollution control in the refining industries.
- To find the suitable refining technology for maximizing the gasoline yield.

CHX-467 Polymer Science and Engineering

Course Objectives

- The objective of this course is to familiarize the students with the basic conceptsunderlying the polymers chemistry, their kinetics, various types, their properties and characterization.
- The students learn about the various polymerization processes, application of polymers and their testing.

Course Outcomes

- The students develop the knowledge base about the various types of polymers, their basiccharacteristics, categorization and polymerization processes.
- The students are able to understand the use of polymers and their relation to their properties..

Departmental Electives III and IV

CHX-452 Computational Fluid Dynamics

Objective/s

- 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.

Course outcomes:

- The students learn the basics for deriving mathematical equations required to describe a chemical engineering process/phenomena.
- The students learn the application of general equations of conservation of mass, momentum and energy for simulation and optimization of chemical engineering processes.

CHX-454 Energy Management and Audit

Course Objective/s:

- The course discusses about the energy scenario, energy conservation and its importance, energy strategy for the future, energy conservation act-2001 and its features, kyoto protocol and global warming.
- The students would learn about the concepts of energy management & audit.

Course Outcomes:

- Students will be able to calculate the maximizing system efficiencies and will be able to optimize the input energy requirements.
- Students will acquire the knowledge of energy action planning, motivating-motivation of employees, financial management, project management and energy monitoring and targeting.

CHX-456 Industrial Environmental Management

Course Objective/s:

- The course gives an introduction to the principles associated with the industrial environmental management and application of these principles in avoiding common difficulties associated with industrial environmental management.
- The course will help the students to understand the processes and waste characteristic.

Course Outcomes:

- The students will get the knowledge of pollution control in process and waste management according to the environment standards specific to the following types of industries: chemical process and allied industries, food processing and allied industries, textile and allied industries, metallurgical and mining industries, cement and allied industries and mechanical, electrical, electronics and allied industries.
- The students will acquaint with the industrial environmental management skills.

CHX-458 Introduction to Multiphase Flow

Course Objective/s:

- 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.

Course Outcomes:

- Students will attain the knowledge of types of fluidization, Gas-liquid flow phenomenon, and various types of multiphase reactors.
- Students will acquire the knowledge of RTD in multiphase flow systems.

CHX-460 Instrumental Methods of Analysis

Course Objective/s:

- The course gives an introduction to instrumental methods of analysis.
- The course will help students to understand the concepts of different types of analysis, e.g., chemical analysis, data analysis, titrimetric analysis, thermal analysis, electrochemical analysis, etc

Course Outcomes:

- Students will attain the knowledge of principles for spectroscopic and chromatographic, analysis.
- The course helps the students to extend the skills in procedures and instrumental methods applied in analytical tasks.

CHX-462 Natural Gas Engineering

Course Objective/s:

- The course provides an understanding of basic thermodynamic and system energy concepts in natural gas engineering and a review of physical and chemical properties of natural gas and associate hydrocarbons.
- The course provides information about the scope of natural gas industry.

Course Outcomes:

- The students will attain the knowledge regarding heat transfer and mass transfer principles and applications in natural gas engineering, natural gas processing, transmission of natural gas and unconventional gases.
- The students will have a thorough understanding of scientific and engineering principles and their application to natural gas engineering problems.

CHX-464 New and Renewable Energy Resources

Course Objective/s:

- This course is designed to make students learn about Global and Indian Energy Scenario, different types of renewable energy resources, their role and development, the equipment and devices used, their theoretical and design concepts.
- The course will also discuss implications in designing and application of these resources.

Course Outcomes:

- The students acquire sufficient knowledge about various types of renewable energy resources, the fundamental concepts and their application.
- The students also develop an understanding of and design related concepts of equipment and instruments used.

CHX-466 Petrochemical Technology

Course Objective/s:

- The objective of the course is to provide the students understanding of different processes in petrochemical industry.
- The objective of the course is to impart knowledge to the students about chemicals from methanol & synthesis gas, ethane, ethylene & acetylene, propane & propylene, butanes, butane pentanes & pentanes and aromatics.

Course Outcome

- After completion of the course students will be familiar with scope and purpose of different petrochemicals, sources of petrochemicals-natural gas and petroleum, and classification of petrochemicals.
- The students are able to understand the future of petrochemicals and trend in petro chemical industries.

CHX-468 Process Plant Utilities

Course Objective/s:

- The course provides the knowledge on the various process plant utilities and their efficient use.
- The course helps to develop an understanding for the air refrigeration cycles, vapour compression cycle, liquification processes, etc.

Course Outcomes:

- The students gain the knowledge of use of compressed air.
- The students learn about the different types of boilers, internal combustion engines and compressors

<u>Open Electives I and II</u>

CHX-471: Environmental Engineering

Course Objective/s:

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

Course outcomes:

- The students are able to understand the impact of air, water and solid pollution effects on the environment.
- The students exhibit the skill to solve the problems related to the environmental engineering.

CHX-472: Hydrocarbon Engineering

Course Objective/s:

- The objective of the course is to provide the students understanding of downstream processes in petroleum industry.
- The objective of the course is to impart knowledge to the students about various selected processes, catalytic reforming and isomerization, hydro treating and hydro cracking, catalytic cracking, treatment of heavy oils, environmental concerns, new fuels.

Course Outcome

- After completion the course students will be able to familiar with scope and purpose of refining, distillation process, fuel lube and wax refining hydro processing, gas processing refining, feed stock and evaluation of crude oil, and functioning of oil and gas separator in petroleum industry.
- The students are able to understand the basic chemistry, thermodynamics, kinetics, catalysis, reactor technology and process design and layout for key processes in oil refining, gas conversion and petro chemistry.

CHX-473: industrial Safety & Hazard Management

Course Objective/s:

- This course aims at developing amongst the under graduate students the concept of safety in CPI conducting proper RA tools.
- The course briefs the basics of fire, explosion and toxic dispersion modeling. It also discuss the major industrial disasters happened in the CPI

Course outcomes:

- The students are able to understand the concept of loss prevention in CPI, hazard models such as pool fire, fire ball, toxic dispersion etc.
- The students learn to exhibit the skill of performing risk assessment such as conducting Dow's fire and explosion index for the real pant unit. They also perform case studies to learn from previous accidents.

CHX-474: New and Renewable Energy Sources

Course Objectives

- This course is designed to make students learn about Global and Indian Energy Scenario, different types of renewable energy resources, their role and development, the equipment and devices used, their theoretical and design concepts.
- The course will also discuss implications in designing and application of these resources.

Course Outcomes

- The students acquire sufficient knowledge about various types of renewable energy resources, the fundamental concepts and their application.
- The students also develop an understanding of and design related concepts of equipment and instruments used.

CHX-475: Polymer Science and Engineering

Course Objectives

- The objective of this course is to familiarize the students with the basic concepts underlying the polymers chemistry, their kinetics, various types, their properties and characterization.
- The students learn about the various polymerization processes, application of polymers and their testing.

Course outcomes:

- The students develop the knowledge base about the various types of polymers, their basic characteristics, categorisation and polymerization processes.
- The students are able to understand the use of polymers and their relation to their properties.

CHX-476: Oil and Natural Gas Economic

Course Objectives

- The objective of this course is to familiarize the students with the basic concepts underlying the role of oil and gas in the world economy.
- The students learn about the oil and gas production, transportation of the oil and natural gas, organization industries and the pricing of the oil and the natural gas.

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. The students are able to understand the rrefinery economics and refining technologies, gas processing technologies and economics, optimization techniques for transportation and processing etc.

Programme structure indicating overall distribution of credits of both semester and category wise to be offered in B.Tech

	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**	**%**
HSS	5	3	-	-	-	4	-	-	12	6.3%
BS	5	9	9	4	-	-	-	-	27	14.2%
ESA	12	12	-	4	4	-	-	-	32	16.8%
D.C	-	-	16	16	20	22	14	13	101	53.1%
D.E	-	-	-	-	-	-	6	6	12	6.3%
O.E	-	-	-	-	-	-	3	3	6	3.2%
NCC/NSS	_____ _____ Mandatory _____									
Total	**22**	**24**	**25**	**24**	**24**	**26**	**23**	**22**	**190**	**100%**

HSS: Humanities and Social Science, BS: Basic Science, ESA: Engineering Science and Applications

DC: Departmental Core, DE: Departmental Elective, OE: Open Elective