Revised Scheme of Courses for B.Tech. Chemical Engineering

3rd Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	ChBC-31	Introduction to Chemical Eng.	3	1	0	4
2.	ChBC-32	Material and Energy Balance	3	1	0	4
3.	ChBC-33	Process Fluid Mechanics	3	1	0	4
4.	ChBC-34	Thermodynamics and Chemical Kinetics	3	1	0	4
5.	EEBC-31	Basic Electrical & Electronics Eng.	3	1	0	4
6.	HSBC-31	Ethics and Self Awareness	2	0	0	2
7	MTBC-31	Chemical Eng. Mathematics-I	2	1	0	3
		TOTAL = 19+6 = 25	19	6	0	25

4th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	ChBC-41	Chemical Eng. Thermodynamics	3	1	0	4
2.	ChBC-42	Heat Transfer	3	1	0	4
3.	ChBC-43	Mechanical Operations	3	1	0	4
	ChBC-44P	Fluid Mechanics & Mechanical Operations Lab	0	0	4	2
4.	ChBC-45	Mass Transfer -I	3	1	0	4
5.	ChBS-41	Seminar	0	0	4	2
6.	EEBC-41P	Basic Electrical & Electronics Eng. Lab.	0	0	4	2
7.	MTBC-41	Chemical Eng. Mathematics –II	2	1	0	3
		TOTAL = 14 + 5 + 12 = 29	**14**	**5**	**12**	**25**

5th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	ChBC-51	Process Equipment Design – I (Mechanical Aspects)	3	0	2	4
2.	ChBC-52	Chemical Reaction Eng.	3	2	0	5
3.	ChBC-53	Material Science & Technology	3	1	0	4
4.	ChBC-54	Chemical Technology – I	3	0	0	3
5.	ChBC-55P	Heat Transfer Lab.	0	0	4	2
6.	HSBC-51	Basic Management Principles	3	0	0	3
7.	MTBC-51	Numerical Methods	3	1	0	4
		TOTAL = 18 +4 + 6 = 28	**18**	**4**	**6**	**25**

6th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	ChBC-61	Process Equipment Design -II (Process Aspect)	3	0	2	4
2.	ChBC-62	Mass Transfer – II	3	1	0	4
3.	ChBC-63	Chemical Technology – II	3	0	0	3
4.	ChBC-64	Energy Eng.	3	0	0	3
5.	ChBC-65P	Energy Eng. Lab.	0	0	2	1
6.	ChBC-66	Process Instrumentation	3	0	0	3
7.	ChBC-67	Transport Phenomena	3	1	0	4
8.	ChBC-68P	Thermodynamics and Reaction Eng. Lab.	0	0	2	1
9.	ChBC-69	Industrial Training & Presentations	0	0	4	2
		TOTAL = 18 +2+10 = 30	**18**	**2**	**10**	**25**

7rd Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	ChBP-71	Pre-project work	0	0	4	2
2.	ChBC-72	Chemical Process Safety	3	0	0	3
3.	ChBC-73	Process Dynamics & Control	3	1	0	4
4.	ChBC-74P	Process Dynamics & Control Laboratory	0	0	2	1
5.	ChBC-75	Process Economics & Plant Design	3	1	0	4
6.	ChBC-76	Biochemical Eng.	3	1	0	4
7.	ChBC-77P	Mass Transfer Lab.	0	0	2	1
8.	E-I	Elective – I	3	0	0	3
9.	E-II	Elective – II	3	0	0	3
		TOTAL = 18 + 3 + 8 =29	**18**	**3**	**8**	**25**

8th Semester

S. No.	Course No.	Subjects	L	T	P	Credits
1.	ChBP-81	Project	0	0	16	8
2.	ChBC-82	Bioresource Technology	2	1	0	3
3.	ChBC-83P	Biochemical Eng. Lab.	0	0	4	2
4.	ChBC-84	Modeling and Simulation in Chemical Eng.	2	1	0	3
5.	ChBC-85	Industrial Pollution Abatement	2	1	0	3
7.	E-3	Elective – III	3	0	0	3
8.	E-4	Elective – IV	3	0	0	3
		TOTAL = 12 + 3 + 20 = 35	**12**	**3**	**20**	**25**

E-1: Any one of the following electives

S. No.	E-1	Elective courses	L	T	P	Credit
1.	ChBE-71	Polymer Sciences and Eng.	3	0	0	3
2.	ChBE-72	Petrochemical Technology	3	0	0	3
3.	ChBE-73	Advanced Separation Processes	3	0	0	3
4.	MTBE-71	Operation Research	3	0	0	3
5.	HSBE-71	Human Resource Development	3	0	0	3

E-2: Any one of the following electives

S.No.	E-2	Elective courses	L	T	P	Credit
1.	ChBE-74	Computational Fluid Dynamics	3	0	0	3
2.	ChBE-75	Multi-component Distillation	3	0	0	3
3.	ChBE-76	Optimization Techniques in Chemical Eng.	3	0	0	3
4.	HSBE-72	Managerial Economics for Engineers	3	0	0	3

E-3: Any one of the following electives

S. No.	E-3	Elective courses	L	T	P	Credit
1.	ChBE-81	Instrumental Methods of Analysis	3	0	0	3
2.	ChBE-82	Petroleum Refining	3	0	0	3
3.	ChBE-83	Food Technology	3	0	0	3
4.	ChBE-84	Nano-Science and Technology	3	0	0	3

E-4: Any one of the following electives

S. No.	E-4	Elective Courses	L	T	P	Credit
1.	ChBE-85	Process Heat Integration	3	0	0	3
2.	ChBE-86	Fuel Cell Technology	3	0	0	3
3.	ChBE-87	Clean Technology in Process Industries	3	0	0	3
4.	HSBE-81	Entrepreneurship Development	3	0	0	3

<u>Abbreviations</u>

B	B. Tech. Programme
C	Core Course
Ch	Chemical Engineering Department/Subject
E	Elective
EE	Electrical Engineering Dept/subject
Eng	Engineering
HS	Humanities and Social Sciences Department/Subject
L	Lecture
MT	Mathematics Department/Subject
P	'P' alone, Practical
P	Before digit "project", after digit "practical"
S	Seminar
T	Tutorials
Digit first	Semester

Digit Second Course number of subject of particular Department in the Semester

3rd Semester

Introduction to Chemical Engineering

Course No. ChBC-31	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Outcomes

CO1 Introduction to Chemical Engineering: Origin, Growth, Relation to other sciences.

CO2 Knowledge of Unit Operations and Unit Processes and its application to Chemical Process Industries.

CO3 Concerns of Chemical Engineering in areas of Energy, Environment, new materials, health, bioengineering and safety.

CO4 Implementation of Chemical Engineering Basics to simple systems.

CO5 Role of modeling and simulation in chemical engineering.

Details of Syllabus

Chemical engineering and chemical technology. Chemical engineering: Origin, growth and role in chemical process industries. Chemical Process Industry: Definition, origin, growth and the present scenario. Problems associated with industrial expansion. Process flow sheeting and symbols. Concepts of unit processes and unit operations. Systematic analysis of chemical processes: Need and basic considerations. Chemical engineers, the diversity of employment opportunities for them. A successful chemical engineer. Professional ethics. Intimate connections with physico-chemical sciences, biological and biomedical sciences and other engineering streams: case studies. Concerns of chemical engineering traditional areas: environment, energy, new materials, bioengineering and biotechnology, food, health and safety. Concepts of scale-up, modeling and simulation. Dimensional analysis. Computer in chemical engineering. Future challenges. Nanotechnology. Bioinformatics.

Books Suggested:

1. Anderson, L.B., Wenzel, L.A., "*Introduction to Chemical Engineering*", McGraw-Hill Book Company, Inc., New York (1961).
2. Ghosal, S.K., Sanyal, S.K., Datta, S., "*Introduction to Chemical Engineering*", Tata McGraw-Hill Publishing Company Ltd., New Delhi (1997).
3. Pushpavanam, S., "*Introduction to Chemical Engineering*", PHI Learning Pvt. Ltd. (2012).
4. Rao, M.G., Sittig, M., "*Dryden's Outlines of Chemical Technology*", East-West Press (1997).
5. Perry, R.H., Green, D.W., "*Perry's Chemical Engineers' Handbook*", McGraw-Hill Book Company (2008).

Material and Energy Balance

Course No. ChBC-32

L	T	P	Credit
3	1	0	4

Course Outcomes

CO1 To understand the fundamentals and basic principles of mass transfer in various unit operations and their applications in both chemical and non chemical systems.

CO2 Identify and understand the principles of energy transfer for chemical systems.

CO3 To design, analyze, formulate processes where both mass and energy balance is taking place for various engineering systems

CO4 Application of Mass and energy balance for non conventional engineering systems.

Details of Syllabus

Mathematical principles, significant figures and rounding off. Graphical and numerical methods of data fitting. Solutions of equations by trial and error, and interaction techniques. Units and dimensions: Basic and derived units, dimensional and empirical equation. Different ways of expressing units of quantities and physical constants. Properties of gases, liquids and solids: ideal and real gas laws, critical properties, properties of mixtures and solutions, and phase equilibria. Mass Balance: Concepts of limiting and excess reactants, tie element, recycle, purging, bypass etc., in batch, stage-wise and continuous operations in systems with and without chemical reactions, and in unit operations. Energy Balance: Concepts, calculation of enthalpy changes for systems with and without reactions. Thermo Chemistry: Heats of formation, combustion, solution, dilution etc. and the effects of pressure and temperature on them. Material and energy balance for nuclear, electrochemical, photochemical and biochemical processes. Material and energy balance for non-conventional separation processes.

Books Suggested:

1. Hougen, D.A., Watson, K.M., Ragatz, R.A., "*Chemical Process Principles, Part I" ,* 2nd Edn., John Wiley & Sons (1995).
2. Narayanan, K.V., Lakshmikutty, B., "*Stoichiometry and Process Calculations*", Prentice Hall of India (2006).
3. Williams, E.T., Johnson, R.C., "*Stoichiometry for Chemical Engineers*", McGraw-Hill Book Company Ltd. (1958).
4. Bhatt, B.I., Vora, S.M., "*Stoichiometry*", 5th Ed., Tata McGraw-Hill (2010).
5. Himmelblau, D.M., "*Basic Principles and Calculations in Chemical Engineering",* 8th Edn.,Prentice-Hall of India Ltd. (2012).

Process Fluid Mechanics

Course No. ChBC-33

L	T	P	Credit
3	1	0	4

Course Outcomes

CO1 Able to understand the fundamentals and basic principles of process fluid mechanics.
CO2 Able to formulate and solve the fluid flow problems with the application of conservation laws.
CO3 Able to examine energy losses and evaluate pressure drop in pipes.
CO4 Able to understand and analyze the functions and performances of various equipments and flow measuring devices.

Details of Syllabus

Introduction: Units and dimensions, fluid properties, concepts of consecutive relations, Newtonian and non-Newtonian fluids.

Fluid Statistics: Fluid forces and pressure measurement. Dimensional analysis and similitude. Kinematics of flow, velocity fields, streamline etc. Stream function, potential function, rotational and irrotational flows. Laminar and turbulent flows. Flow in pipes, frictional losses in pipes, equation of continuity, equation of motion. Eulers" equation. Bernoulli"s theorem and its application to blowers, pumps, compressors and turbines. Flow past immersed body, drag and fluidized bed. Flow measuring instruments, pitot tube, orifice, venturimeter, wet gas meter, notches, pumps and compressors. Characteristics, applications and specifications of pumps, blowers, compressors and turbines. Navier-Stokes equation.

Books Suggested:

1. Shames, J.H., “*Mechanics of Fluid*”, McGraw-Hill (1992).
2. Darby, R., “*Chemical Engineering Fluid Mechanics*”, Marcel Dekker (1996).
3. Wilkes, J.O., “*Fluid Mechanics for Chemical Engineers*”, Prentice-Hall International Series (1998).
4. Streeter, V.L., Wylie E.B., Bedford, K.W. “*Fluid Mechanics”* McGraw-Hill Book Company, New York (1998).
5. Mc Cabe, W.L., Smith, J.C., Harriott, P., “*Unit Operation of Chemical Engineering*”, McGraw-Hill (2004).

Thermodynamics & Chemical Kinetics

Course No. ChBC-34	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Outcomes

CO1 Understanding and application of laws of thermodynamics
CO2 Ability of application of thermodynamics to phase equilibrium and reaction equilibrium.
CO3 Basic Idea of Reactors
CO4 Basic insight into the interpretation of kinetic data and reactor design.

Details of Syllabus

Introduction: Thermodynamic system, surroundings, state, process, properties, equilibrium, heat and work.

Properties of Pure Simple Compressible Substance: P-V-T surface, P-V, T-V and T-P diagrams. Equations of state for ideal and real gases. Virial equation of state, van der Waals and Redlich-Kwong equations of state; Use of Thermodynamic tables.

First Law of Thermodynamics: Energy balance for closed systems. Various forms of energy balance. Specific heat, internal energy, enthalpy, and specific heat of ideal gases. Application of first law to non-flow isochoric, isobaric, isothermal, and adiabatic and polytropic processes.

Conservation of mass for a control volume, mass and volume flow rates, mass balance for steady flow processes, flow work, steady flow energy equation. Application to various practical systems viz. nozzles, diffusers, etc. Transient Analysis.

Second Law of Thermodynamics: Second law, reversible and irreversible processes, Clausius and Kelvin Planck statements. Carnot cycle, Clausius inequality, entropy as a property, principle of increase of entropy. Calculation of entropy change.

Thermodynamic Cycles: Otto, Diesel, Rankine cycles and their applications.

Rate Expression and Reaction Mechanism: Use of pseudo steady state approximation to get rate expression from mechanism, temperature-dependence of reaction rate-collision theory, transition state theory, thermodynamics and Arrhenius law.

Interpretation of Kinetic Data of Batch Reactors: Constant volume and variable volume batch reactions, Integral and differential methods of analysis of data of uni, bi and tri-molecular irreversible reactions. Reversible reactions, homogeneously catalysed, auto-catalysed, series and parallel reactions. Estimation of rate constants and its temperature-dependence.

Solid-Catalysed Fluid Reactions: Characterization of catalyst, Physical and chemical adsorption, various reaction steps, Langmuir-Hinshelwood kinetics.

Kinetics of Biochemical Reactions: Microbial and enzymatic reactions. Substrate and product inhibition.

Books Suggested:

1. Smith, J.M., Van Ness H.C., Abbott, M.M., "*Introduction to Chemical Engineering Thermodynamics*", McGraw-Hill (2005).
2. Çengel, Y.A. , Boles, M.A., "*Thermodynamics: An Engineering Approach*", 6th Edn., McGraw-Hill (2008).
3. Borgnakke, C. , Sonntag R.E., "*Fundamentals of Thermodynamics*", John Wiley & Sons (2009).
4. Levenspiel, O., "*Chemical Reaction Engineering*", John Wiley & Sons (1998).
5. Fogler, H.S., "*Elements of Chemical Reaction Eng.*", Prentice Hall of India (2005).

Basic Electrical and Electronics Engineering

Course No. EEBC-31	L	T	P	Credit
	3	1	0	4

Course Outcomes

CO1 To analyze and evaluate the electrical circuits, apply basic laws in circuit theory and to determine electric circuit parameters.

CO2 To study and analyses of AC and DC series-parallel circuit, various network theorems, and basics of phasor and power of electrical circuit.

CO3 To analyses the characteristics of 3 phase systems, current and voltage relations in star/delta configuration's, Balanced/unbalanced systems.

CO4 To study and analyze of fundamental/basic operation, construction and working DC machines.

CO5 To study and analyze of fundamental/basic operation, construction and working AC machines.

Details of Syllabus

SECTION A

DC Circuits and Single Phase A.C. Fundamentals

Introduction, basic physical laws, circuit elements. KVL, KCL, and a few important circuit theorems, simple circuits. Generation of alternating voltages and currents, basic definition of AC circuits, calculation of R.M.S values, Average values for different waveforms, solution and phasor diagram of single phase AC circuit with sinusoidal source of excitation.

Three Phase AC Fundamentals

Advantages of three phase systems, star and delta connection in three phase circuits, relation between line and phasor quantities, power in three phase system, solution of three phase balanced circuits.

Electrical Machines

Basic principle and construction of transformers, E.M.F equation, approximate equivalent circuit, phasor diagram. Operating principle and construction of DC machines, types of DC machines, three phase induction motors, alternators.

SECTION B

Transducers

Introduction, working and application of LVDT, Strain Gauge and Thermistor. Introduction and application of Digital Multimeter.

Semiconductor Devices

Principle of operation, characteristic and application of PN Junction Diode, Rectifiers, Zener Diode, Principle of operation characteristic and application of Bipolar Junction Transistor

Digital Electronics

Binary, Octal and Hexadecimal number System & its arithmetic operations, Logic gates, Introduction of R-S and J-K Flip Flops.

Books Suggested:

1. Charles K. Alexander, Matthew N.O. Sadiku, "*Fundamentals of Electric Circuits*", 5th Edn., McGraw-Hill (2013).
2. Irwin,J.D., Nelms, R.M., " *Basic Engineering Circuit Analysis*", John Wiley & Sons (2008).
3. Franco, " *Electric Circuits Fundamentals*", Hartcourt Brace College (1994).
4. Johnson & Hilburn, " *Electric Circuit Analysis*", 3rd edn., John Wiley & Sons (1997).
5. Muthusubramanian, R., Salivahanan, S., Muraleedharan, K. A., "*Basic Electrical and Electronics and Computer Engineering*" , Tata McGraw-Hill (1999).
6. Theraja, B.L, Theraja, A. K, "*A Textbook of Electrical Technology*", S. Chand.
7. Sawhney, A.K,"*A Course in Electrical and Electronic Measurements & Instumentation*", Dhanpat Rai & Co.

Ethics and Self Awareness

Course No. HSBC-31

L	T	P	Credit
2	0	0	2

Course Outcomes

CO1 Study human experience and behavior situation in social and cultural context.

CO2 Promote the appreciation of students' own culture, ethics and values as well as the culture, ethics and values of others.

CO3 Empower students to think critically and evaluate theories, concepts and perspectives related to psychology, human mind and human behavior as well as current societal advances related to career.

CO4 Develop an understanding of the importance of self-awareness, self-reflection and self-regulation as well as gain practical knowledge and experience.

Details of Syllabus

Introduction: Definition of ethics, approaches to ethics: psychological, philosophical, social Psycho-Social theories of Moral Development: view of Kohelberg: Morality and Ideology, culture and morality, morality in everyday context.

Ethical concerns: work ethics and work values, Business ethics, human values in organizations

Self awareness: Self concept, Johari window, self and culture, self knowledge, self esteem, perceived self control, self serving bias, self presentation, self growth: transactional analysis and life scripts.

Bringing out the best of self: Character strengths and virtues, emotional intelligence, social intelligence, positive cognitive states and process: self efficacy, empathy, gratitude, compassion and forgiveness, post traumatic growth.

Books Suggested:

1. Hall, Calvin S., Lindzey, Dardner., Cambell, John, B., "*Theories of Personality",* Hamilton Printing Company, USA (1998).
2. David. J., Fritzche, "*Business Ethics*", McGraw-Hill (2004).
3. Leary, Mark, R. "*The Curse of Self-Awareness, Egotism and the Quality of Human Life",* Oxford University Press, New York (2004).
4. Corey, G., Schneider Corey, M. , Callan, P., "I*ssues and Ethics in the Helping Professions",* CA: Brooks/Cole (2011).
5. Snyder, C.R., Shane, J., Pedrotti, J.T., "P*ositive Psychology",* New Delhi (2011).

Chemical Engineering Mathematics-I

Course No. MTBC-31	**L**	**T**	**P**	**Credit**
	2	**1**	**0**	**3**

Course Outcomes

CO1 Understand the concept of complex differentiation and analyticity of complex valued functions.

CO2 Understand the concept of complex integration and its properties.

CO3 Expand a complex valued function about a point using Taylor and Laurent's theorem.

CO4 Understand the concept of Special functions like Legendre and Bessel functions and their properties.

Details of Syllabus

Complex Variables: Analytic functions, Cauchy Riemann equations, Complex integration, Cauchy"s fundamental theorem, Cauchy"s integral formula, Cauchy"s inequality and Liouville"s theorem on integral function, Taylor"s and Laurent"s expansions, Zeros and poles of analytic functions, Residues and Contour integration. Conformal Mappings, Bilinear Transformation.

Special Functions: Solution in Series, Legendres Functions, Rodriguess formula, generating functions for Legendres Polynomials and recurrence formulae. Bessel"s functions, Recurrence formulae and Bessel"s functions of integral order.

Books Suggested:

1. Brown, J.V., Churchill, R.V., "*Complex Variables and Applications*", McGraw-Hill (2013).
2. Copson, E.T., "*Theory of Functions of Complex Variables*", Oxford University Press, New Delhi (1988).
3. Hamming, R.W. "*Numerical Methods for Scientists and Engineers*", McGraw-Hill, Inc., N.Y. (1973).
4. Freeman, H., "*Finite Differences*" Cambridge University Press (1962).
5. Iyengar, S.R.K., Jain, R.K., "*Advanced Engineering Mathematics*", Narosa (2001).

4th Semester
Chemical Engineering Thermodynamics

Course No. ChBC-41 **L T P Credit**
3 1 0 4

Course Outcomes

CO1 Basic understanding of the thermodynamic properties of fluid, mixture and solutions.
CO2 Apply thermodynamic principles to understand fugacity, partial molar properties, chemical potential, and activity coefficients for non-ideal fluid systems.
CO3 Investigate binary phase equilibria; perform vapour-liquid equilibrium (VLE) calculations.
CO4 Apply thermodynamic principles to reaction equilibrium between phases and reactions.

Details of Syllabus

Thermodynamic Properties of Homogeneous Fluids: Fundamental property relations, Maxwell"s relations, Residual properties and their estimation, two phase systems, thermodynamic diagrams and tables, generalized property correlation for gases.
Thermodynamic Properties of Mixtures or Solutions: Property relationships for systems of variable composition; chemical potential, partial molar properties, fugacity and fugacity coefficients – pure species and species in a mixture, fugacity in ideal solutions, activity coefficients, excess properties.
Applications of Solution Thermodynamics: VLE-qualitative behavior, Duhem"s theorem, simple models for VLE (Raoult"s law, modified Raoult"s law, etc.). Liquid properties from VLE. Activity coefficients from experimental data – Margules, Van-Laar, and Wilson equations. Property changes of mixing, heat effects in mixing processes.
Phase Equilibria: Importance of phase equilibria in process industries, equilibrium and stability, vapour-liquid equilibria (VLE) for miscible, partially miscible and immiscible systems, their phase diagrams, azeotropes. VLE calculations at low and high pressures, analysis of multi-component systems.
Chemical Reaction Equilibria: Reaction coordinate, application of equilibrium criteria to chemical reactions, standard Gibbs energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of equilibrium constant and composition. Calculation of equilibrium compositions for single reactions; Phase rule and Duhem"s theorem for reacting systems.
Thermodynamic Analysis of Processes: Work and free energy, availability, analysis of mixing, separation processes, heat exchange, lost work calculations.

Books Suggested:

1. Smith, J.M., Van Ness, H.C., Abbott, M.M., "*Introduction to Chemical Engineering Thermodynamics",* 7th Edn., McGraw-Hill (2005).
2. Sandler, S.I., "*Chemical, Biochemical and Engineering Thermodynamics",* 4th Edn., John Wiley (2006).
3. Kyle, B.G., "*Chemical and Process Thermodynamics",* 3rd Edn., Prentice Hall (1999).
4. Narayanan, K.V., "*Chemical Engineering Thermodynamics*", Prentice Hall (2007).
5. Koretsky, M.D., "*Engineering and Chemical Thermodynamics*", John Wiley (2004).

Heat Transfer

Course No. ChBC-42	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Outcomes

CO1 Able to understand the fundamentals and basic principles of conduction and convection heat transfer mechanisms and their applications in various heat transfer equipments in process industries.

CO2 Able to formulate, analyze, design and solve the problems related to heat transfer.

CO3 Able to perform the thermal analysis and sizing of heat transfer equipments.

CO4 Able to understand radiation heat transfer.

Details of Syllabus

Introduction: Modes of heat transfer and basic equations, study of unsteady states, dimensional analysis.

Conduction: Thermal conductivity of material. Steady state conduction through flat wall, multi-layer wall, cylinders and hollow spheres. Lagging of pipes and optimum lagging thickness.

Convection: Natural and forced convection. Laminar and turbulent flow heat transfer inside and outside tubes. Individual and overall heat transfer coefficients, fouling, individual factors. Extended surfaces. Condensation film types and drop-wise. Heat transfer of boiling liquids. Analogies.

Radiation: Emissivity, absorptivity, black body and grey body radiation, view factors, radiation between various types of surfaces.

Evaporation: Energy and material balance. Single & multiple effects evaporators and their accessories. Design of evaporators.

Heat Exchangers: Design principles, examples. Codes in heat exchanger design.

Books Suggested:

1. McCabe, W.L., Smith, J.C., "*Unit Operation of Chemical Engineering*", 7th Edn., McGraw-Hill (2011).
2. Holman, J.P., " *Heat Transfer*", 10th Edn., McGraw-Hill (2009)
3. Bergman, T.L., Lavine, A.S., Incropera, F.P., DeWitt, D.P., "*Introduction to Heat Transfer*", 6th Edn., Wiley (2011).
4. Kreith, F., Manglik, R.M., Bohn, M., "*Principles of Heat Transfer*", 7th Edn., Cengage Learning (2010).
5. Hewitt, G.F., Shires, G.L., Bott, T.R., "*Process Heat Transfer*", Begell House (1995).
6. Kern, D.Q., "*Process Heat Transfer*", McGraw- Hill (2001).

Mechanical Operations

Course No. ChBC-43	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Outcomes

CO1 Understand the characterization, classification, conveying and storage of solids.

CO2 Calculate the power requirements and crushing efficiencies of size reduction equipment using laws of communition and understand the working of different size reduction equipment.

CO3 Analyze the screening results to estimate the screen effectiveness and acquire knowledge of screening mechanism and separation of solids from solids and gases.

CO4 Apply the knowledge of filtration theory to estimate the filtration time, specific cake and medium resistance of filtration processes and understand the settling characteristics.

CO5 Acquire the knowledge of agitation and different types of agitated vessels.

Details of Syllabus

Settling: Free and hindered settling, classification of classifiers (simple and mechanical), introduction to the design of continuous thickeners.

Filtration: Classification of filters, effect of pressure on filtration, filter aids, constant pressure and constant rate filtration theory, membrane filtration.

Agitation and Mixing: Theory of mixing, power consumption of mixer impellers, mixing liquids with liquids, mixing gas with liquid, mixing of viscous masses, mixing of solids with solids mixing of solid with liquid.

Size Separation: Principle of screening, screen analysis, types of screening equipments (grizzlies, trommels, shaking and vibrating screens), effectiveness of a screen, air separating method (cyclone separator, bag filters, electrostatic precipitator, scrubbers).

Crushing and Grinding: Classification of crushing and grinding machinery, coarse crusher, jaw crusher, gravity crushers, intermediate crushers (roll, disc or cone crusher, edge runners, squired cage disintegrator, hammer mill), fine grinders-burhstones, roller mills, ball and tube mills. Theory of Crushing. Laws of crushing-Rittingers" law, Kick"s law. Storage and transportation of bulk solids (types of conveyers, their selection)

Conveying of Solids: Pneumatic and hydraulic conveying of solids, general characteristics and flow relations, mechanical conveyers.

Books Suggested:

1. McCabe, W.I., Smith, J.C., "*Unit Operations in Chemical Engineering",* 7th Edn., McGraw-Hill (2011).
2. Badger, L.W., Banchero, T.J., "*Introduction to Chemical Engineering",* 3rd Edn., McGraw-Hill (1997).
3. Coulson, J.M., Richardson, J.F., "*Chem. Engineering, 2nd Vol.*", Butterworth-Heinemann.
4. Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., "*Principles of Unit Operations*", 2nd Ed., Wiley-India (2008).
5. Perry, R.H., Green, D.W., "*Perry's Chemical Engineers' Handbook",* 7th Edn.", McGraw-Hill Book Company (2008).

Fluid Mechanics and Mechanical Operations Lab.

Course No. ChBC-44P	**L**	**T**	**P**	**Credit**
	0	**0**	**4**	**2**

Course Outcomes

CO1 Make velocity measurements using flow meters and viscosity measurements by Stoke's Apparatus.

CO2 Understand the laminar and turbulent flow behaviour, verify Bernoulli's principle and pipe fittings.

CO3 Understand the classification, conveying and communication of solids.

CO4 Understand the theories of sedimentation and to study the settling characteristics of batch settling.

Details of Syllabus

Fluid Mechanics: Calibration of flow meters for gas and liquid, Reynold"s experiment. Study of pipe fitting, mechanical features of pumps, blowers and compressors, flow through network of pipes and pipe fittings, Stokes law verification, flow through helical coils, verification of Bernoulli"s theorem, study of reciprocating and centrifugal pump test rigs,

M**echanical Operations:** Study of sedimentation, cyclone separator, ball mill, leaf filter, plate and frame filter, ribbon mixer, belt conveyor, screw conveyor, trommel, vibrating screen, elutriator; sieve analysis; verification of grinding laws, determination of specific surface and particle population of a crushed material.

Mass Transfer – I

Course No. ChBC-45	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Outcomes

CO1 Fundamental understanding of mass transfer operation.
CO2 Understanding of inter phase mass transfer and coefficients of mass transfer operation.
CO3 Analyze gas absorption and tower characteristics.
CO4 Understanding of absorption, humidification, drying and crystallization operation.

Details of Syllabus

Principles of mass transfer, unsteady state and steady state.
Diffusion: Molecular diffusion in fluids, diffusivities of fluids, applications of molecular diffusion-analogies and mass transfer coefficients in laminar flow, concepts, of effective diffusivity.
Eddy diffusion, mass transfer in turbulent flow, models of mass transfer analogies.
Interphase mass transfer-diffusion between phases, two phases mass transfer coefficients, individual and overall coefficients, stage wise process. Concurrent and counter current processes.
Gas Absorption: Equilibrium relationships. Material balances for cocurrent and counter current multistage equipment. Dilute system. HETP, HTU and NTU individual and overall coefficients.
Equipment: General characteristics of tray towers, efficiencies, wetted wall towers, packed towers, characteristics of packed towers, mass transfer coefficients in packed towers.
Humidification: General theory, psychometric chart, fundamental concepts in humidification and dehumidification. Cooling towers and related equipment.
Crystallization: Principles, calculation of yield, heat effect and equipment.
Drying: Equilibria, drying rate curve definitions. Batch and continues drying. Mechanism of drying. Calculation of batch and continuous drying.

Books Suggested:

1. Treybal, R.E., “*Mass Transfer Operations*” 3rd Edn., McGraw-Hill Book Company (1980).
2. Badger, W.L., Banchero, J.T., “*Introduction to Chemical Engineering*”, 3rd Edn., McGraw-Hill Book Company (1997).
3. McCabe, W.L., Smith, J.C., Harriott, P., “*Unit Operations of Chemical Engineering*”, 7th Edn., McGraw-Hill Book Company (2011).
4. Basmadjian, D., “Mass Transfer and Separation Processes: Principles and Applications”, CRC Press (2007).
5. Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., “*Principles of Unit Operations*”, 2nd Ed., Wiley-India (2008).

Seminar

Course No. ChBS-41	**L**	**T**	**P**	**Credit**
	0	**0**	**4**	**2**

Course Outcomes

CO1 To study research papers for understanding of new fields of interest, and to summarize and review.

CO2 Imparting skills for effective report writing describing the project and the results.

CO3 Identifying novel areas of research and latest trends in technologies.

CO4 Development of Comprehensive communication skills.

Details of Syllabus

Literature study on a selected topic. Report writing and submission under the guidance of a faculty member of the Department. Seminar presentation.

Basic Electrical and Electronics Eng. Laboratory

Course No. EEBC-41P	**L**	**T**	**P**	**Credit**
	0	**0**	**4**	**2**

Course Outcomes

CO1 Connection of Ammeters, Voltmeters, Wattmeter's and multi-meters in DC and AC circuits and selection of their ranges, Use of LCRQ meter.

CO2 To verify the KVL, KCL, star/delta transformation, superposition and maximum power transfer theorem on DC circuits

CO3 To measure electric power in single-phase AC circuits with resistive load, RL load and RLC load.

CO4 To measure the power and power factor in three phase AC circuits.

Details of Syllabus

1. To verify Kirchoff's voltage and current laws.
2. Verification of superposition theorem.
3. Verification of Thevenin's Theorem.
4. To measure the voltage, frequency and phase of AC waveform.
5. Measuring the resistance and inductance of a coil by ammeter-voltmeter method.
6. To find voltage-current relationship in a R-L series circuit and to determine the power factor of the circuit.
7. To measure power and power factor in a single- phase AC circuit.
8. To start and reverse the direction of rotation of a (i) DC motor (ii) Induction motor
9. To obtain the waveforms of half wave rectifier circuit on CRO
10. To obtain the waveforms of full wave rectifier circuit on CRO.
11. Using a bridge rectifier for full- wave rectification of AC supply and to determine the relationship between RMS and average values of the rectified voltage
12. To verify the working of (a)Thermocouple (b)Strain Gauge (c) LVDT,
13. To obtain the characteristics of a P-N junction diode,
14. To verify the truth table of logic gates,
15. To use BJT as a switch and as an amplifier.
16. To obtain the characteristics of a transistor under common base (CB) and common emitter (CE) configuration,

*Depending on the availability of resources in the lab, minimum of 10 experiments to be carried out.

Chemical Eng. Mathematics - II

Course No. MTBC-41

L	T	P	Credit
3	**0**	**0**	**3**

Course Outcomes

CO1 To examine the use of probability theory in decision making.
CO2 To develop rules for calculating different kinds of probabilities.
CO3 To use different probability distributions and how to find their values.
CO4 To learn how correlation analysis describes the degree to which two variables are linearly related to each other.

Details of Syllabus

Statistics and Probability: Measures of central tendency and measures of variations (dispersions), moments, measures of skewness and kurtosis. Random experiment, sample space, events, classical statistical and axiomatic definitions of probability. Statements and proof of theorems on addition and multiplication of probabilities. Simple problems. Baye‟s theorem on conditional probability. Random variables, derivation of formulae for mean, variance and moments of random variables for discrete and continuous cases. Laws of expectation, binomial, Poisson and normal distributions, beta and gamma distribution. t-distribution, F-distribution, Chi-square distribution and their applications. Method of least squares, fitting a straight line and parabola of degree „p‟. Regression and correlation. Multiple and partial correlation.

Books Suggested:

1. Gupta, S.C. and Kapoor, V.K. "*Fundamentals of Mathematical Statistics*" , Sultan Chand & Sons, New Delhi (2013).
2. Brownlee, "*Statistical Theory and Methodology in Science and Engineering*", John Wiley and Sons (1965).
3. Walpole, R.E. "*Introduction to Mathematical Statistics*", Macmillan Publication, New York (1987).
4. Meyer, "*Data Analysis for Scientists and Engineers*", John Wiley and Sons (1975).

Process Equipment Design - I

(Mechanical Aspect)*

Course No. ChBC-51	**L**	**T**	**P**	**Credit**
	3	**0**	**2**	**4**

Course Outcomes

CO1 To apply the basic principles of fluid mechanics, heat transfer, mass transfer and mechanical operation in the design of chemical process equipment

CO2 Design the appropriate process equipment for the required unit or process operation

CO3 Selection of equipments for various applications

CO4 Optimize the process condition

CO5 To analyze and evaluate the performance of existing equipments.

Details of Syllabus

Mechanics of Materials: Stress, strain, biaxial stress, stress-strain relationship for elastic bodies, theories of failure, thermal stresses, membrane stresses in shells of revolution, thin and thick cylinder.

Pressure Vessel: Selection of type of vessels, material of construction selection and design considerations. Introduction of codes for pressure vessel design, classification of pressure vessels as per codes. Design of cylindrical and spherical shells under internal and external pressure; Pipe thickness calculation under internal and external pressure; Selection and design of closures and heads, design of jacketed portion of vessels. Compensation of openings. Design of high pressure monoblock and multilayer vessels. Inspection and testing of pressure vessels.

Flanges: Selection of gaskets, selection of standard flanges, optimum selection of bolts for flanges, design of flanges.

Tall Tower Design: Design of shell, skirt, bearing-plate and anchor bolts for tall tower used at high wind and seismic conditions.

Supports: Design of lug and leg supports. Design of saddle supports including bearing plates and anchor bolts.

Storage Tanks: Introduction to Indian standards codes**,** filling and breathing losses; classification of storage tanks; optimum length to diameter ratio, design of liquid and gas storage tanks with and without floating roof.

* Note: *This is an OPEN BOOK EXAMINATION. The students are allowed to consult IS Codes, Text books, Reference books and bound lecture notes certified by the examiner concerned.*

Books Suggested:

1. Brownell, L. E., Young, H. E., “*Process Equipment Design*”, John Wiley (2004).
2. Bhattacharya, B. C., “*Introduction of Chemical Equipment Design*”, CBS Publisher (2003).
3. I.S.:2825-1969, “*Code for Unfired Pressure Vessels*”, (1969).
4. I.S.:803-1974, “*Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks*”, (1984).
5. Moss, D. R., *"Pressure Vessel Design Manual”*, 3rd Edn., Gulf (2004).
6. Megyesy, E. F., "*Pressure Vessel Handbook*", 12th Edn., Pressure Vessel Publishing (2001).

Chemical Reaction Engineering

Course No. ChBC-52

L	T	P	Credit
3	2	0	5

Course Outcomes

CO1 Understand the different types of reactions, their kinetics and their influence on chemical equilibrium.

CO2 Design of single, isothermal plug-flow, CSTR, and batch reactors for a single homogeneous reaction.

CO3 Analyze and size reactors while accounting for non-isothermal conditions and non-ideal flow patterns.

CO4 Design reactors for the homogenous and heterogeneous, and understand their effect on performance equations for reactors

Details of Syllabus

Ideal Reactors: Design equations for ideal reactors, namely batch, CSTR, plug Flow

Design for Single Reaction: Design equation for single reaction systems using batch- and semi batch- reactors, CSTR, PFR and recycle reactor, auto catalytic reacti
ons, reactor choice for single reaction.

Design for Multiple Reactions: Parallel and series reactions, quantitative treatment of product distribution and of reactor size for different types of ideal reactors, selectivity and yield factors, reactor choice for multiple reactions.

Non-isothermal Operation and Stability of Reactors: Non-isothermal design of ideal reactors, hot spot in tubular reactor, auto-thermal process, steady state multiplicity optimal temperature progression for first order reversible reaction.

Non-ideal Flow: Residence time distribution **(**RTD) theory, role of RTD in determining reactor behavior, age distribution (E) of fluid, experimental methods for finding E, relationship between E and F curve, models for non ideal flow – single parameter and multi parameter models (axial dispersion, tanks in series), performance estimation of reactor using reactor models.

Solid and Catalytic Reactions: Solid reactions-shrinking core model, catalytic reactions-homogeneous and heterogeneous**,** steps in solid catalysed reaction, rate limiting steps, effect of external resistance, effect of diffusion on reaction, Thiele modulus and effectiveness factor, performance equations for catalytic reactors (packed bed, fluidized bed), product distribution in multiple reactions, basic equations for trickle bed and moving bed reactors.

Books Suggested:

1. Levenspiel, O., "*Chemical Reaction Engineering*", 3rd Edn., John Wiley & Sons, New York (1998).
2. Fogler, H.S., "*Elements of Chemical Reaction Engineering*", 4th Edn., Prentice-Hall of India Pvt. Ltd. (1995).
3. Smith, J.M., "*Chemical Engineering Kinetics*", 2nd Edn., McGraw-Hill Book Company, New York (1981).
4. Doraiswamy, L.K., Uner, D., "*Chemical Reaction Engineering: Beyond the Fundamentals*", CRC Press (2013).
5. Froment, G.F., Bischoff, K.B., De Wilde, J.D., " *Chemical Reactor Analysis and Design*", 3rd Edn., John Wiley & Sons, Inc. (2011).

Material Science and Technology

Course No. ChBC-53	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Outcomes

CO1 Analyze the micro structure of crystalline materials like lattice systems, unit cells and theoretical density.

CO2 Clear the concept of mechanical behaviour of materials through calculations and appropriate equations along with their failure mechanics including corrosion.

CO3 Understand the concept of phase diagrams and their construction, usage and applications.

CO4 Understand and analyze the heat treatment processes and their types involving solid state diffusion processes.

Details of Syllabus

Introduction to the subject. Properties of materials of importance to chemical equipment. Materials of construction for chemical industries (metallic and non-metallic). Principles of usage of materials.

PCC, BCC, HCC crystal planes. Microscopic and macroscopic structure of metallic crystals. Imperfection in crystals: Point imperfection, line imperfection and surface imperfection. Single phase metals, properties of single phase metals. Plastic deformation, re-crystallization. Plastic deformation of metal crystals, properties of plastically deformed metals, mechanism of slip.

Failure of Metals: Creep, mechanized creep, ductile fracture, cleavage fracture, fracture in glass and theory of fracture, fatigue and mechanism of fatigue.

Iron-Carbon Alloys: Definition of alloys, substitutional and interstitial solid solutions, eutectic and eutectoid reactions, peritectic transformation, peritectic and pertectoid reaction, constituent diagram for iron-carbon system, time-temperature-transformation curves.

Inorganic Materials: Ceramic, example of ceramic phases. Structure of silicates. Dielectric ceramic semiconductors. Mechanical behaviour of ceramic materials.

Corrosion: Corrosion by solution, electrochemical oxidation. Electrode potential, galvanic couples. Types of galvanic cells. Corrosion prevention. Protective surfaces, avoidance of galvanic couples, use of galvanic protection. Use of organic, inorganic and metallic linings.

Polymers: Structure, deformation, plastic deformation.

Electrical conductivity: definition, insulators and semi-conductors, intrinsic and extrinsic semiconductors. Magnetic behaviour of metals. Introduction to ferromagnetism.

Books Suggested:

1. Van Vlack, L.H., "*Elements of Material Science and Engineering*", 6th Edn., Pearson Education (1989).
2. Callister,W.D., Rethwisch, D.G., "*Material Science and Engineering: An Introduction",* 9th Edn., John Wiley & Sons, Inc. (2014).
3. Yip-Wah Chung, " *Introduction to Materials Science and Engineering*", CRC Press (2006).
4. Callister,W.D., "*Material Science and Engineering: An Introduction",* John Wiley & Sons, Inc. (2007).

Chemical Technology – I

Course No. ChBC-54	L	T	P	Credit
	3	0	0	3

Course Outcomes

CO1 Understanding manufacturing technologies of organic and inorganic chemicals.

CO2 Draw the process flow diagrams to represent the process and look for the solution of challenges faced by the process industry at large.

CO3 Analyze the effect of chemical technology on safety and environment, through chemical reactions and mechanism involved.

CO4 Understand Engineering problems related with a particular process industry and suggest solutions thereof.

Details of Syllabus

Technology of Water: Classification of water, industrial and municipal purposes, methods for obtaining fresh water from sea water.

Basic Chemical Industries: Common salt, its uses, economics and manufacture. Soda ash, its uses, raw materials, manufacture by Solvay process and its modification. Caustic soda-chlorine types of cells, raw materials, reactions, uses and manufacture.

Bleaching Powder and Hypochlorites: The methods of production.

Sulphuric acid: Raw materials, method of manufacture by contact process.

Synthetic ammonia: Uses, reactions, manufacturing process, concentration of nitric acid.

Nitrogenous Fertilizers: Ammonium sulphate, ammonium nitrate and urea, their methods of production.

Phosphate Industries: Phosphorous, uses and manufacture; phosphoric acid, uses and types of manufacturing procedures; phosphate fertilizers, raw materials and uses. Manufacture of super-phosphates, granular super phosphate and triple super-phosphate.

Cement: History, various types of cements, raw materials, manufacture of Portland cement.

Glass: history, uses and composition of glass; different types of glasses, unit operation and processes in the glass manufacture.

Ceramics: Uses, basic raw materials, unit processes in ceramic industry.

Porcelain: Manufacturing procedure.

Enamels: Raw metals, preparation of metal paint, application of enamel and firing.

Books Suggested:

1. Rao, M.G., Sittig, M., "*Dryden's Outlines of Chemical Technology for the 21st Century*", East-West Press, New Delhi (2002).
2. Austin, G.T., "*Shreve's Chemical Process Industries*", 5th Edn., McGraw-Hill Book Company (1984).
3. Kent, J.A., *"Riegel's Handbook of Industrial Chemistry,"* *CBS* Publishers (1997).
4. Mall I. D., "*Petrochemical Process Technology*", Macmillan India Ltd., New Delhi (2007).
5. Moulijn, J. K., Makkee, M., Van Diepen, A., "*Chemical Process Technology*", Wiley (2001).

Heat Transfer Lab.

Course No. ChBC-55P	L	T	P	Credit
	0	0	4	2

Course Outcomes

CO1 Estimate the thermal conductivity of a composite slab and verify the Fourier's law of heat conduction.
CO2 Measure the Heat transfer coefficient for Forced convection.
CO3 Understand and demonstrate the heat transfer in Shell and Tube Heat Exchanger.
CO4 Measure the emissivity of gray body and verify Stefan Boltzmann's Law.
CO5 Evaluate heat transfer in Drop and Film wise condensation.

Details of Syllabus

Heat Transfer

Heat transfer through composite walls, in natural convection, in forced convection, heat transfer coefficient in filmwise and dropwise condensations, heat transfer coefficient in double pipe heat exchanger (Liquid-liquid flow), heat transfer coefficient in double pipe heat exchanger (Gas-liquid flow), heat transfer coefficient in shell and tube type heat exchanger, heat of heat transfer in finned-tube heat exchanger, performance of the single effect short tube vertical evaporator with sucrose solution.

Books Suggested:

1. McCabe, W.L., Smith, J.C., "*Unit Operation of Chemical Engineering*", 7th Edn., McGraw-Hill (2011).
2. Holman, J.P., " *Heat Transfer*", 10th Edn., McGraw-Hill (2009)
3. Bergman, T.L., Lavine, A.S., Incropera, F.P., DeWitt, D.P., "*Introduction to Heat Transfer*", 6th Edn., Wiley (2011).
4. Kreith, F., Manglik, R.M., Bohn, M., "*Principles of Heat Transfer*", 7th Edn., Cengage Learning (2010).
5. Hewitt, G.F., Shires, G.L., Bott, T.R., "*Process Heat Transfer*", Begell House (1995).
6. Kern, D.Q., "*Process Heat Transfer*", McGraw- Hill (2001).

Basic Management Principles

Course No. HSBC-51	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Relate, discuss, understand, and present management principles, processes and procedures in consideration of their effort on individual actions.

CO2 Have developed a working knowledge of fundamental terminology and frameworks in the four functions of management: Planning, Organizing, Leading and Controlling.

CO3 Be able to identify and apply appropriate management techniques for managing contemporary organizations.

CO4 Participate, summarize and lead class discussions, case problems and situations from both the text and student experience that relate to the text material.

Details of Syllabus

Management: It"s nature, purpose and definition, management as a pre-requisite for any organization, aims of management, management-art of science.

Functions of Managers: Planning, organizing, actuating and controlling.

Planning: Nature and purpose of planning, types of plans, steps in planning/planning process. Objectives: The nature and importance of objectives, types of objectives, primary, secondary, individual and personal objectives. Guidelines for setting objectives.

Decision Making: Importance and limitations of rational decision making, types of decisions, programmed and non-programmed decisions, process of decision making under certainty.

Organizing: Nature and process of organizing, steps in organizing/process of organizing, formal and informal organization, span of control, and factors determining effective span.

Decentralization of Authority: The nature of decentralization, degrees of decentralization, decentralization, philosophy and policy.

Delegation of Authority: Meaning of authority/delegation, steps in the process of delegation, factors determining the degree of delegation, art of delegation.

Line/Staff Organization: Line organization, staff organization, line and staff organization, functional and committee organization, the nature of line and staff relationship.

Actuating: Nature and purpose of actuating, steps in actuating/actuating process.

Human Resource Management: Importance of human resource planning, recruitment, selection, training and development, performance appraisal, compensation, packages, promotions, transfers, demotion and separation etc.

Leadership: Meaning and importance leadership qualities, effective and ineffective leaders, leadership styles.

Motivation: Need, want and satisfaction chain. Need hierarchy. Improving employee motivation.

Communication: Meaning and importance of effective communication, communication process, formal and informal communication.

Controlling: Nature and purpose of controlling, steps in controlling/process of controlling, types of controls, requirement of effective controls.

Management Infirmation System (MIS): Definition, elements and importance of MIS, manager, management and information, changing MIS environment, managing and controlling the MIS function.

New Trends in Management.

Books Suggested:

1. George, R., Terry, Irwin, "*Principles of Management",* (1974).
2. Tara Chand, "*Industrial Organization and Management",* Nem Chand & Brothers, (1973).
3. Shukla , M.C., "*Business Organization Management 3rd Edition"*, S. Chand (1967).
4. Dean, J. "*Management Economics"* Prentice-Hall of India Pvt. Ltd., New Delhi (1976).
5. "*Principles of Management (Ascent Series)"* Tata McGraw-Hill (2004).

Numerical Methods

Course No. MTBC-51

L	T	P	Credit
3	1	0	4

Course Outcomes

CO1 Study Errors in Numerical Methods and Solution of Algebraic and Transcendental equations.
CO2 Study Solution of Simultaneous Algebraic equations, finite differences and interpolation.
CO3 Evaluate Differentials and integrals by numerical methods
CO4 Find solution of Differential equation by Numerical Methods.

Details of Syllabus

UNIT I: Errors in Numerical Calculations:(3 lectures)
Floating- point form of numbers, Round-off, Algorithm, Stability, Programming errors, Errors of Numerical Results, Error propagation, Basic error principle, Loss of significant digits.

UNIT II: Numerical Solution of Algebraic and Transcendental Equations: (3 lectures)
Bolzano‟s bisection method, iteration method, Regula-Falsi method, Newton-Raphson method.

UNIT III: Solution of Simultaneous Linear Algebraic Equations: (8 lectures)
Gauss elimination method, Gauss-Jordan method, Computation of Inverse by Gauss's Method, LU decomposition, LU decomposition from Gauss Elimination, Gauss-Siedel iteration method, Jacobi method, The Eigen value problem.

UNIT IV: Finite Differences and Interpolation: (6 lectures)
Forward, Backward and Shift operators, Central differences, their relations, Factorial polynomial, Newton‟s forward and backward interpolation formulae, Location and detection of errors, Divided differences and their basic properties, Lagrange‟s interpolation formula.

UNIT V: Numerical Differentiation and Integration: (6 lectures)
Numerical differentiation using difference techniques, Newton-Cote‟s quadrature formula, Trapezoidal, Simpson‟s 1/3 and Simpson‟s 3/8 rule, Truncation error, weddle‟s rule, Romberg‟s method.

UNIT VI: Numerical Solution of Ordinary Differential Equations: (6 lectures)
Picard‟s method, Taylor series method, Euler and modified Euler method, Runge-Kutta method of 4th order, Predictor-Corrector methods (Adam's-Moulton method & Milne's method).

Books Suggested:

1. Jain , M.K. "*Numerical Solution of Differential Equations*", Oscar Publications, New Delhi (2000).
2. Jansen, Jaffreys, "*Mathematical Methods in Chemical Engineering*", Academic Press (2006).
3. Reed, H.S., Herwood T.K.S. "*Applied Mathematics in Chemical Engineering*", McGraw- Hill (1990).
4. Lapidus, L., Seinfeld, J. "*Numerical Solution of Ordinary Differential Equation*", Academic Press (2009).
5. Jain, M. K., lyengar , Jain, R.K., "*Numerical Methods for Scientific and Engineering Computation*" Wiley Eastern Ltd.(2001).
6. Veerrarjan T., Ramachandaran ,T., "*Theory and Problems in Numerical Methods*" Tata McGraw-Hill Publishing Company, New Delhi (2004).

Process Equipment Design-II

(Process Aspect)

Course No. ChBC-61	**L**	**T**	**P**	**Credit**
	3	**0**	**2**	**4**

Course Outcomes

CO1 Basic understanding about the process equipments based on heat and mass transfer.
CO2 Design of heat and mass transfer systems.
CO3 Selection of equipments for various applications.
CO4 Optimize the process conditions.
CO5 To analyze and evaluate the performance of existing equipments.

Details of Syllabus

Shell-Tube Heat Exchangers: Basic design procedure of heat transfer equipment, overall heat transfer coefficient and fouling factors, shell & tube heat exchangers – construction details, selection algorithm, design codes, mean temperature difference, general design considerations, tube-side heat transfer coefficient and pressure drop, shell-side heat transfer coefficient and pressure drop, various design methods, CAD of shell & tube heat exchangers, mechanical and fabricational aspects. Drawing of heat exchangers.

Condensers: Design of condensers for single vapors, heat transfer coefficient correlations for condensation inside and outside of tubes of the vertical and horizontal condensers, design of desuperheater-cum-condenser and condenser-cum-sub-cooler, condensation of mixtures, pressure drop in condensers.

Reboilers, Vaporizers and Evaporators: Pool boiling, convective boiling, selection of reboilers, & vaporizers, design of reboilers, vaporizers and evaporators, drawing of evaporators.

Distillation Column: Basic design consideration of distillation column, degree of freedom analysis, various design methods of distillation column, general design consideration of multicomponent distillation, plate efficiency, tray hydraulics of sieve and valve – trays. Drawing of distillation column.

Packed Columns: Type of packing, packed bed height, column diameter, column internals, design methods, Design of liquid-liquid extraction equipment.

Miscellaneous Equipment: Design of Crystalizers, Agitated vessels and selection of agitators, design of gas-liquid separators and mixing equipment.

*Note: ***This is an OPEN BOOK EXAMINATION. The students are allowed to consult IS Codes, Text books, Reference books and bound lecture notes certified by the examiner concerned***

Books Suggested:

1. Towler, G., Sinnott, R. K., "*Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design*", Butterworth-Heinemann (2012).
2. Brownell, L. E.,Young, H. E., "*Process Equipment Design*", John Wiley (2004).
3. Bhattacharya, B. C., "*Introduction of Chemical Equipment Design*", CBS Publisher (2003).
4. I.S.:2825-1969, "Code for Unfired Pressure Vessels", (1969).
5. I.S.: 4503-1967, "*Indian Standard Specification for Shell & Tube Type Heat Exchangers",* (1983).
6. Hewitt, G.F., Shires, G. L., Bott T. R., "*Process Heat Transfer*", Begell House (1994).
7. Megyesy, E.F., "*Pressure Vessel Handbook*", 12th Edn., Pressure Vessel Publishing (2001).

Mass Transfer-II

Course No. ChBC-62

L	T	P	Credit
3	1	0	4

Course Outcomes

CO1 Understand the concept of distillation and determine the number of stages in distillation column.

CO2 Select solvent for extraction operations and determine the number of stages in extraction operations

CO3 Understand the concept of adsorption and determine the number of stages in adsorption operations.

CO4 Select solvent for leaching operations and determine the number of stages in leaching operations.

Details of Syllabus

Distillation: vapour liquid equilibria for ideal and non-ideal systems. Relative volatility. Azeotropes, Enthalpy-concentration diagrams. Single stage flash vaporisation. Partial condensation. Differential distillation for binary systems. Fractionation, McCabe-Thiele and Ponchen-Savarit methods for multistage operations. Reflux, reflux ratio and optimum reflux ratio. Reboilers. Total and partial condensers. Tray efficiencies. Azeotropic, extractive and steam distillations.
Extraction: Ternary liquid equilibria, calculation of single stage, multistage cocurrent and multistage counter current operations.
Adsorption: Adsorption equilibria, calculations for vapour, gas and liquid adsorptions. Adsorption operations such as single stage, multi stage, cocurrent and multistage counter-current operations. Equipments.
Leaching: Principles. Equilibria, Calculations of single stage and multistage leaching processes equipment.

Books Suggested:

1. Treybal, R.E., "*Mass Transfer Operations*" 3rd Edn., McGraw-Hill Book Company (1980).
2. Badger, W.L., Banchero, J.T., "*Introduction to Chemical Engineering*", 3rd Edn., McGraw-Hill Book Company (1997).
3. McCabe, W.L., Smith, J.C., Harriott, P., "*Unit Operations of Chemical Engineering*", 7th Edn., McGraw-Hill Book Company (2011).
4. Basmadjian, D., "Mass Transfer and Separation Processes: Principles and Applications", CRC Press (2007).
5. Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., "*Principles of Unit Operations*", 2nd Edn., Wiley-India (2008).

Chemical Technology - II

Course No. ChBC-63	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Understanding manufacturing technologies of organic and inorganic chemicals.

CO2 Draw the process flow diagrams to represent the process and look for the solution of challenges faced by the process industry at large.

CO3 Analyze the effect of chemical technology on safety and environment, through chemical reactions and mechanism involved.

CO4 Understand Engineering problems related with a particular process industry and suggest solutions thereof.

Details of Syllabus

Coal and Coal Tars: Cola chemicals, law temperature and high temperature carbonization, chemicals from coal tar.

Sugar and Starch: Manufacture of raw sugar crystals from sugar cane, refining operations, manufacture of starch from various materials, starch derivatives, manufacture of glucose. Leather and Gelatin: Preparation of hides, vegetable and chrome tanning, finishing operations, manufacture of gelatin from its raw materials, uses. Glues and adhesives-types and their manufacture.

Pulp & Paper: Sulphite and Kraft processes for manufacture of paper.

Oils, fats, soaps and detergents: Classification of vegetable oils and fats, production of edible oil and fats, purification, hydrogenation of oils, classification of cleaning compounds and their uses, methods for the production of soaps and detergents.

Man Made Fibres: Classification, cellulosic products. Viscose Rayons, their uses and manufacture. Polyamides-66-nylon, chemical process and method of production. Polyester (Dacron miller), its manufacturing process.

Synthetic Plastics: Methods of polymerization, phenol formaldehyde, urea formaldehyde, polyethylene and polyvinylchloride their uses and methods of production. Natural and Synthetic Rubbers: Natural rubber and its processing. Butadiene-styrene polymer, its methods of production. Polychloroprene and its manufacture.

Dyestuffs: A general study of dye stuffs with reference to their classification based on chemical structure & on its application, azo and vat dyes. Petroleum and Petrochemicals: Occurrence, refinery, practice, chemical refining, ethylene, acetylene, synthesis gas, butadiene, their uses and methods of production.

Books Suggested:

1. Rao, M.G., Sittig, M., "*Dryden's Outlines of Chemical Technology for the 21st Century"*, East-West Press, New Delhi (2002).
2. Austin, G.T., "*Shreve's Chemical Process Industries*", 5th Edn., McGraw-Hill Book Company (1984).
3. Kent, J.A., *"Riegel's Handbook of Industrial Chemistry*," *CBS* Publishers (1997).
4. Mall I. D., "*Petrochemical Process Technology*", Macmillan India Ltd., New Delhi (2007).
5. Moulijn, J. K., Makkee, M., Van Diepen, A., "*Chemical Process Technology*", Wiley (2001).

Energy Engineering

Course No. ChBC-64	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Basic understanding about various energy sources and their significance with respect to energy and environmental sustainability.

CO2 Knowledge about the processing/generation of fuels and their significant characteristics for various applications.

CO3 Design of the systems for efficient fuel utilization and maximum recovery of heat.

CO4 Understanding energy audits and management of the non conventional energy utilizing systems.

Details of Syllabus

Survey of different sources of energy and their utilization. Natural fuels-coal, petroleum, processed fuels, coke, water gas, producer gas, refinery gas-LPG, synthetic petroleum, bio-gas, nuclear fuels, biodegradable material (Gobar Gas). Non-conventional sources of energy: energy from biomass, geothermal energy, energy from high velocity winds and high pressure gases, solar energy. Combustion calculation of coal and petroleum fractions. Design of burner, stackers and furnaces. Recovery of waste heat from chemical and metallurgical processes, selection of suitable energy sources. Definition and objectives of energy management. Energy management strategy. Energy audit , types and methodology. Introduction of pinch technology. Nanotech.

Books Suggested:

1. Duffia , Beckman "Solar Energy-Thermal Processes"
2. Speigler, "*Principles of Desalination*"
3. Griswold, J. , "*Fuels, Combustion and Furnaces*"
4. Himus, G.W., "*The Elements of Fuel Technology*"
5. Beredict, M., Pigford, T.M., " *Nuclear Chemical Engineering*"
6. Khadi Grammodyog Commission Report on "*Gobar Gas Plant*".
7. Sarkar, S. "*Fuel and Combustion*"
8. Handerson World Bank "*India, The Energy Sector*"
9. C. Kashkare, "*Energy-Resources, Demand and Conservation with Special reference to India*", Tata-McGraw Hill.

Energy Engineering Laboratory

Course No. ChBC-65P	**L**	**T**	**P**	**Credit**
	0	**0**	**2**	**1**

Course Outcomes

CO1 Basic understanding about the Proximate Analysis of fuels and its significance with respect to energy.

CO2 Demonstrate and understand the working principle, construction and operation of combustion equipment.

CO3 Estimate the calorific value of solid fuels like coal to ascertain their suitability in a combustion equipment.

CO4 Predict various fuel property parameters like flash point, fire point etc.

Details of Syllabus

Ultimate and proximate analysis of coal and other solid fuels, determination of calorific value of solid and liquid fuels, test for cloud and pour point of petroleum products, determination of flash point, fire point and specific gravity of petroleum products, determination of sulfur content in coal, determination of flue gas composition by Orsat"s apparatus.

Books Suggested:

1. Sarkar, S., "Fuels and Combustion", 3rd Edn., Universities Press (2012).
2. Sunavala, P.D., "Laboratory Tests on Fuels", Bombay Popular Prakashan (1975).

Process Instrumentation

Course No. ChBC-66

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Understand basic concept of instrumentation, principles and applications.
CO2 Understand the measurement techniques for Temperature.
CO3 Understand the measurement techniques for Pressure.
CO4 Understand the measurement techniques for Flow and Level.

Details of Syllabus

Introduction: Measuring instruments and their function, elements of measurement, important characteristics of industrial measurement.
Classification of Instruments: Recording and measuring types.
Temperature measurement: Classification of thermometers, and pyrometers, response of thermometers, protecting wells.
Fluid filled expansion thermometers. Thermocouples: Resistance thermometers.
Radiation and optical pyrometers.
Pressure and vacuum measurement: Classification.
Manometers- Inverted well pressure gauges.
Bourdon tube pressure gauges, diagram of pressure gauges.
Special measuring devices: Pressure and vacuum, McLeod gauge.
Thermal conductivity and ionization gauges.
Head and area flow meters-flow measuring devices
Liquid level measuring devices. Visual indicators float motivation, liquid level instruments.
Pressure differential type level gauge. Electrical contact type liquid level indicators.

Books Suggested:

1. Dunn, W.C., "*Fundamentals of Industrial Instrumentation and Process Control*", Tata McGraw-Hill (2009).
2. Nakra B. C., Chaudhry K. K., "*Instrumentation, Measurement and Analysis*" Tata McGraw-Hill (2004).
3. Andrew, W. G., "*Applied Instrumentation in the Process Industries*, Vol. I.", Gulf Publishing Company (1993).
4. Johnson, C., "*Process Control Instrumentation Technology*", Prentice Hall(2005).
5. Liptek, B.G., "*Instrument Engineers' Handbook: Process Control and Optimization*, Volume II", Taylor and Francis, CRC press (2006).

Transport Phenomena

Course No. ChBC-67

L	T	P	Credit
3	1	0	4

Course Outcomes

CO1 To Identify transport properties and analyze the mechanism of momentum, energy and mass transport.

CO2 To Apply conservation laws to formulate differential form of equations of change for mass, momentum and heat transfer problems.

CO3 To solve linear partial differential equations along with appropriate boundary conditions to get the velocity, temperature and concentration profiles of different engineering problems.

CO4 Recognize non Newtonian fluids and apply appropriate models to solve them

Details of Syllabus

Molecular Transport Phenomena: Molecular transport of momentum, heat and mass, law of molecular transport, Newton‟s law of viscosity, Fourier‟s law of conduction and Fick‟s law of diffusion. Transport coefficients- viscosity, thermal conductivity and mass diffusivity. Estimation of transport coefficients and temperature/pressure dependence.

Non-Newtonian Fluids: Time independent, time-dependent and viscoelastic fluids, constitutive equations and rheological characteristics.

Equations of Change Under Laminar Flow Conditions: Equation of continuity, motion, mechanical energy, energy and mass transport. Simple shell balance method for momentum, heat, and mass transport, velocity distribution in circular conduits and parallel plates. Generalized form of equations and simplifications.

Turbulence Phenomena: Basic theory of turbulence, time averaging, intensity and correlation coefficients, isotropic turbulence. Equations of continuity, motion and energy for turbulent condition. Reynolds stresses. Phenomenological theories of turbulence, velocity profile in circular conduits. Temperature distribution in turbulent flow.

Methods of Analysis of Transport Problems: General integral balance using macroscopic concepts, integral balance for mass, momentum, energy and mechanical energy.

Convective Transport: Free and forced convective heat transfer and mass transfer.

Transport Past Immersed Bodies: Laminar and turbulent boundary layers, Momentum, heat and mass transfer during boundary layer flow past a flat plate and flow over a sphere. Drag coefficient correlations.

Books Suggested:

1. Bird, R.B., Stewart, W.D., Lightfoot, E.W., "*Transport Phenomena*", 2nd Edn., John Wiley & Sons (2002).
2. Geankoplis, C.J., "*Transport Processes and Separation Process Principles includes Unit Operations*", 4th Edn., Prentice-Hall of India (2003).
3. Cussler, E.L., "*Diffusion: Mass Transfer in Fluid Systems*", 2nd Edn., Cambridge University Press (1997).
4. Deen, W. M., "*Analysis of Transport Phenomena*", Oxford University Press (1998).
5. Brodkey R. S. and Hershey H. C., "*Basic Concepts of Transport Phenomena*", Vol. 1 and 2, Brodkey Publishing (2001).

Thermodynamics and Reaction Engineering Lab.

Course No. ChBC-68P

L	T	P	Credit
0	0	2	1

Course Outcomes

CO1 Standardization of chemical solution.
CO2 Estimation of reaction rate constant of continuous and batch reactors.
CO3 Determination of dispersion number of CSTR and packed reactors.
CO4 To plot the RTD curve for CSTR and Packed bed reactor using a pulse and a step input.

Details of Syllabus

Thermodynamics

Vapour pressure estimation, Vapour - liquid equilibrium; Liquid - liquid equilibrium; Heat of reaction; Joule - Thomson coefficient experiment and equilibrium flash distillation

Reaction Engineering

Determination of order of reaction (Homogenous and heterogeneous systems), rate of reactions first and second orders, equilibrium conversion, RTD study in CSTR and PFR.

Books Suggested:

1. Levenspiel, O., "*Chemical Reaction Engineering*", 3rd Edn., John Wiley & Sons, New York (1998).
2. Fogler, H.S., "*Elements of Chemical Reaction Engineering*", 4th Edn., Prentice-Hall of India Pvt. Ltd. (1995).
3. Smith, J.M., "*Chemical Engineering Kinetics*", 2nd Edn., McGraw-Hill Book Company, New York (1981).
4. Doraiswamy, L.K., Uner, D., "*Chemical Reaction Engineering: Beyond the Fundamentals*", CRC Press (2013).
5. Kyle, B.G., "*Chemical and Process Thermodynamics",* 3rd Edn., Prentice Hall (1999).
6. Narayanan, K.V., "*Chemical Engineering Thermodynamics*", Prentice Hall (2007).

Industrial Training and Presentation

Course No. ChBC-69

	L	T	P	Credit
	0	**0**	**4**	**2**

Course Outcomes

CO1 Correlate class mode learning to real industrial applications
CO2 Development of written and oral communication skills.
CO3 Ability to be a multi-skilled engineer with good technical knowledge.
CO4 Development of management, leadership and entrepreneurship skill.

Details of Syllabus

Submission of training report in a proper format along with the certificate of training, power point presentation of the training, attendance on each term of presentation compulsory for all students.

Pre -project Work

Course No. ChBP-71

L	T	P	Credit
0	**0**	**4**	**2**

Course Outcomes

CO1 Able to collect the information from literature reviews
CO2 Classify a chemical engineering research problems
CO3 Ability to analyze energy and environmental problem.
CO4 Able to find objectives of research problems

Details of Syllabus

This is prerequisite for completion of the seventh semester along with other subjects. There is no course content fixed. Collection of information, survey of literature and procurement of materials including chemicals are in the pre-project work. Objective of the project work is decided. How the project work would be carried out in the eighth semester is finalised at this stage. The same project may be continued for the eighth semester. This includes report writing for pre-project work, presentation of the work done followed by viva-voce examination by the examiner (preferably external).

Chemical Process Safety

Course No. ChBC-72	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Anticipate, recognize, investigate and evaluate hazardous conditions and practices affecting people, property and the environment.

CO2 Develop and evaluate appropriate strategies designed to mitigate risk by understanding the importance of plant safety and safety regulations, different types of plant hazards and their measurement, control, principles and procedures of safety audit.

CO3 Appreciate the importance of physical, chemical and physico-chemical transformations of the material in process industries with respect to safety.

CO4 Analyze the hazards and assess the risk and Recognize that the practice of safety requires ongoing learning, and undertake appropriate preventive activities to address the need of safety.

Details of Syllabus

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

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

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"s index, Dow"s Chemical release model

Accident Investigations: Case histories of Bhopal gas tragedy, Flixborough disaster, Pasadena accident, IOCL disaster, nuclear disaster in Japan in 2011.

Books Suggested:

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

Process Dynamics & Control

Course No. ChBC-73

L	T	P	Credit
3	1	0	4

Course Outcomes

CO1 To understand and model the dynamic behavior of chemical processes based on their time domain, Laplace domain.
CO2 Analyze the properties e.g. speed of response, frequency response of first order and second order systems.
CO3 Analyze the different components of a control loop.
CO4 Understand the operation of P, I, D and PID controllers and to tune them.

Details of Syllabus

Introduction: Feed forward, feedback systems, block diagrams.
Application of Laplace transformations.
Linear open loop system transfer function, example mercury thermometer with negligible resistance of the wall.
Response of I-order system with step, sinusoidal and ramp inputs.
Further examples of I-order system (a) Mixing process (b) First order chemical reactions (c) Liquid level control.
Response of I order system in series (a) Interacting and (b) non-interacting systems.
Second order system- example period of oscillation.
Transportation lag.
Linear closed loop systems components (a) Process (b) Measuring elements (c) Conductor (d) Final control element
Controllers of final control elements: P, P+I, P+D, P+I+D Diagram of a Chemical reactor control system. Closed loop transfer function. Transient response of a simple closed loop system for changes.

Books Suggested:

1. Coughanowr, D.R., LeBlanc, S., "*Process System Analysis and Control*", 3rd Edn., McGraw-Hill (2008).
2. Stephanopoulos G. "*Chemical Process Control – An Introduction to Theory and Practice*", Prentice-Hall of India (1990).
3. Seborg, D. E., Edgar, T. F., Mellichamp, D. A., "*Process Dynamics Control*", 2nd Edn., John Wiley (2004).
4. Bequette B. W., "*Process Control – Modeling, Design and Simulation*", Prentice-Hall of India (2003).
5. Ogunnaike B. A., Ray, W. H., "*Process Dynamics Modeling & Control*", Oxford University Press (1994).

Process Dynamics & Control Lab.

Course No. ChBC-74P	**L**	**T**	**P**	**Credit**
	0	**0**	**2**	**1**

Course Outcomes

CO1 Calculate the response of first order systems to step input
CO2 Analyze dynamic behavior of liquid level as a first order system for different inputs.
CO3 Find dynamic behavior of multi capacity systems.
CO4 Analyze the behavior of 2^{nd} order systems to step input.

Details of Syllabus

1. Study of first Order Transfer function using mercury in glass thermometer.
2. Study of a non-interacting flow system.
3. Study of an interacting system.
4. Study of computerized process control system for
   a. Pressure Control
   b. Temperature control
   c. Flow control
5. Study of Multi-process control system for
   a. Off- ON Control
   b. Open loop control
   c. Basic feed back control
   d. PID Control

Process Economics & Plant Design

Course No. ChBC-75	L	T	P	Credit
	3	1	0	4

Course Outcomes

CO1 Understanding the role of economics in process plant design.
CO2 Design optimization and profitability analysis.
CO3 Application of various project management techniques.
CO4 Understands the replacement and maintenance analysis.

Details of Syllabus

Time Value of Money: Interest; Compounding and Discounting Factors; Loan Payments; Cash Flow Pattern: Discrete Cash Flow, Continuous Cash Flow.

Methods for Calculating Profitability: Methods that do not consider the time value of money; Methods that consider the time value of money; Alternative Investments by Different Profitability Methods; Effect of Inflation on Profitability Analysis; Methods of Profitability Evaluation for Replacements.

Depreciation: Straight Line, Declining Balance, Double Declining Balance, sum-of-the-years-digit, Sinking Fund.

Analysis of Cost Estimates: Factors Affecting Investment and Production Costs; Capital Investment; Types of Capital Cost Estimates; Methods for Estimating Capital Investment; Estimation of Revenue; Estimation of Total Product Cost; Gross Profit; Net Profit and Cash Flow; Contingencies.

Optimum Design and Design Strategy: Procedure with one, two and more variables; Optimum Production Rates in Plant Operation; Case Studies; Linear Programming: Simplex Algorithm, Dynamic Programming for Optimization; Application of Lagrange Multipliers; Method of Steepest Ascent or Descent.

Plant Location and Layout: Factors for Selection of Plant Location; Site Selection and Preparation; Plant Layout and Installation.

Scale-Up: Pilot Plants and Models; Principle of Similarity; Dimensional Analysis; Empirical and Semi-empirical Model Building; Regime Concept: Static Regime, Dynamic Regime; Similarity Criteria and Scale Equations for Important Equipments.

Books Suggested:

1. Peters, M. S., Timmerhaus, K. D. and West, R. E., "*Plant Design and Economics for Chemical Engineers*", McGraw Hill, (2002).
2. Towler, G., Sinnott, R. K., "*Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design"*, Butterworth-Heinemann, (2012).
3. Couper, J. R., "*Process Engineering Economics (Chemical Industries)*", CRC Press, (2003).
4. Zlokarnik, M., "*Scale-up in Chemical Engineering*", Wiley-VCH, (2006).
5. Silla H., "*Chemical Process Engineering: Design and Economics*", Marcel Dekker (2003).

Biochemical Engineering

Course No. ChBC-76	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Outcomes

CO1 Fundamental understanding of the subject based on various conversion routes.
CO2 Acquire basic knowledge of microbiology, biochemistry and genetics.
CO3 Exhibit knowledge for analysis of the bioprocess and the unit operations used.
CO4 Able to analyze the data and its application in bioprocess development.

Details of Syllabus

Evolution of modern biochemical processes. Role of biochemical engineer in the development of modern fermentation processes. Status of biochem. engg. in the fermentation industry.
Types of Microorganism: Bacteria, fungi, viruses, algae, protozoa. Cell types and their structure (Eucaryotic and Procaryotic).
Chemicals of Life: Carbohydrates, fats, proteins, RNA and DNA (structure, uses and functions).
Understanding Enzymes: Naming and classification, specificity of enzyme action, active cites, factors affecting enzyme-catalyzed reactions. Kinetics of enzyme-catalysed reactions (Michaclis-Menten Equation and Lineweaver Burk Plots).
Fermentation: Aerobic and anaerobic fermentation. Requirement for growth and media formation. Growth cycle phases for batch cultivation. Parameters of growth and analysis of growth data. Growth kinetics. Aeration and agitation. Sterilization. Scale-up. Bio-reactors.
Bio-separation processes.

Books Suggested:

1. Bailey, J. E., Ollis, D. F., "*Biochemical Eng. Fundamentals"*. McGraw-Hill Book Company, New York (1985).
2. Shuler, M., Kargi, F., "*Bioprocess Engineering, Basic Concep".* Prentice Hall of India Pvt. Ltd. (2004).
3. Pelczar, M.J., Chan, E.C.S., Krieg, N.R., "*Microbiology*". McGraw-Hill Book Company (1986).
4. Fairley, J .L., Kilgour, G. L., "*Essentials of Biological Chemistry*". Reinhold Publishing Corporation (1966).
5. Palmer, T., "*Understanding Enzymes*". Ellis Horwood Limited, Halsted Press, (1985).

Mass Transfer Laboratory

Course No. ChBC-77P	**L**	**T**	**P**	**Credit**
	0	**0**	**2**	**1**

Course Outcomes

CO1 Determination of gas and liquid diffusivity.
CO2 Experimental determination of heat and mass transfer characteristics using wetted wall column and cooling tower.
CO3 Plotting drying rate curve using wet solid.
CO4 Determine Gas absorption characteristics using packed tower.

Details of Syllabus

Diffusion coefficients measurements, Concentration profile, Wetted wall column, Laminar Jet, Packed and plate column for absorption and humidification, Drying rate measurements, Equilibrium still, Ternary liquid-liquid equilibrium, Simple distillation, Steam distillation, Adsorption isotherm, Packed and plate column for extraction.

Polymer Sciences and Eng.
(Elective-I)

Course No. ChBE-71	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

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

Course Outcomes

CO1 Acquire knowledge about polymerization reaction and its kinetics.

CO2 Exhibit understanding with respect to estimation of molecular weight.

CO3 Get knowledge of processes about polymerization.

CO4 Conceive understanding of mathematical expressions reflecting rheological behavior of polymers.

Details of Syllabus

Chemistry of Polymerisation Reaction: Functionality, polymerization reactions, polycondensation, addition free radical and chain polymerization, copolymerization, block and graft polymerizations, stereo specific polymerization.

Polymerisation Kinetics: Kinetics of radial, chain and ionic polymerization and co-polymerisation systems.

Molecular Weight Estimation: Average molecular weight, number average and weight average, theoretical distributions, methods for the estimation of molecular weight.

Polymerisation Processes: Bulk, solution, emulsion and suspension polymerization. Thermoplastic composites, fibre reinforcement fillers, surface treatment, reinforced thermoset composites-resins, fibers additives, fabrication methods.

Rheology: Simple rheological equations, simple linear viscoelastic models-Maxwell, Voigt, materials response time, temperature dependence of viscosity.

Books Suggested:

1. Kumar, A., Gupta, R., "*Fundamentals of Polymer Engineering*", CRC. (2003)
2. Fried, J., "*Fundamentals of Polymer Science*", Prentice Hall (2004).
3. Williams, D.J., "*Polymer Science & Engg.*" Prentice Hall (1971).
4. Billmayer, Jr., W., "*Textbook of Polymer Science*" Wiley Tappers (1984).
5. Rodriguez, F., "*Principles of Polymer Systems*", 5th Edn., CRC Press (2003).

Petrochemical Technology.
(Elective-I)

Course No. ChBE-72

L	T	P	Credit
3	0	0	3

Course Outcomes

After the completion of course, students will be able to,

CO1 Have detailed information about petroleum & petrochemicals and their formation.
CO2 Have knowledge about methods for exploration, development and production of oil and gas fields
CO3 Demonstrate comprehensive understanding of design and operation of petro refineries and petrochemical complexes.
CO4 Identify challenges, energy security issues and environmental issues.

Details of Syllabus

Petroleum: Composition and classification of petroleum crude. Distillation practice. Refining by physical and chemical methods. Thermal and catalytic cracking, reforming, polymerization isomerization, alkylation and hydrogen treating. Petroleum products including lubricating oils, waxes and coke. Petrochemicals: Natural gas, production of petrochemical recurs-ors - synthesis gas,hydrogen, acetylene, ethylene, propylene, butylene, aromatics and naphthenes. Petrochemical derivatives and products.

Books Suggested:

1. Hsu, Chang, S., Robinson, Paul R. (Eds.), "*Practical Advances in Petroleum Processing*", Springer, (2005).
2. Rao, M.G., Sitting, M.,"*Drydens Outlines of Chemicals Technology*.", East-West Press, (1997).
3. Nelson, WL, "*Petroleum Refinery Engineering*", McGraw-Hill, New York, (1961).
4. Kenneth, A., Mcketta, K., "*Advances in Petroleum Chemistry and Refining Vol. I(1958)–Vol. X(1965)*", Interscience Publishers, New York.

Advanced Separation Processes
(Elective-I)

Course No. ChBE-73

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Introduce various traditional separation processes emphasizing the drying and crystallization processes.
CO2 To study the adsorption separation process.
CO3 To study the membrane separation processes.
CO4 To study the Ionic separations and some novel separation processes.

Details of Syllabus

Introduction: Separation processes in chemical and biochemical industries, categorization of separation processes, equilibrium and rate governed processes.

Bubble and Foam Fractionation: Nature of bubbles and foams, stability of foams, foam fractionation techniques, batch, continuous, single stage and multistage columns.

Membrane Separation: Physical factors in membrane separation, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis and electro-dialysis, gas separation using membrane structure and production.

Special Processes: Liquid membrane separation, critical extraction, pressure swing adsorption and freeze drying of pervaporation and permeation; Nanoseparation.

Books Suggested:

1. Seader, J. D., Henley, E. J., "*Separation Process Principles*",Wiley-India (2006).
2. King C. J., "*Separation Processes*", Tata McGraw-Hill (1982).
3. Basmadjian, D., "*Mass Transfer and Separation Processes: Principles and Applications*", CRC (2007).
4. Khoury, F. M., "*Multistage Separation Processes*", CRC (2004).
5. Wankat, P. C., "*Separation Process Engineering*", Prentice-Hall India Pvt. Ltd. (2006).

Operation Research
(Elective-I)

Course No. MTBE-71

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Able to formulating the real-world problem into the form of mathematical equations.
CO2 Able to maximize or to minimize some numerical value.
CO3 Able to determine the schedule for transporting goods from source to destination in a way that minimizes the shipping cost.
CO4 Able to formulate the alternative strategy to compete with one another.

Details of Syllabus

The nature and development of operation research, problem formulation, linear programming problem, graphical, simplex method, two phase -simplex method, Big M method, transportation and assignment models.
Replacement models- simple problems. Game theory, two person zero sum game, Sequencing Models-processing n-jobs through two machine, processing n-jobs through three machines.
Queuing Theory: Single-Channel poisson Arrivals with exponential service (M/M/I) model.

Books Suggested:

1. Shamblin, Stenamm, C.G., "*Operations Research: A Fundamental Approach*" McGraw-Hill,Nagakusha, (1974).
2. Churchman, C.V., Apkoff, F.I, Arnoff, E.L., "*Introduction to Operations Research*", John Viley, (1976).
3. Sasieni, M., Yaspan, A., Friedman, "*Operations Research: Methods and Problems*", John Viley, (1950).
4. Hamidi, A., Taha, "*Operation Research: An Introduction*", Macmillan.
5. Maggu, P.L., "*Linear Programming and Operations Research*".

Human Resource Development
(Elective-I)

Course No. HSBE-71	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Identify each of the major HRM functions and processes of strategic HRM planning, job analysis and design, recruitment, selection, training and development, compensation and benefits, and performance appraisal.

CO2 Define strategic HR planning and the HRM process to the organization's strategic management and decision making process.

CO3 Recall the wide range of sources for attracting and recruiting talent and appropriate practices for job Placement.

CO4 Recognize emerging trends, opportunities and challenges in performance appraisal and list training and development processes as well as future trends for HRM globalization.

Details of Syllabus

Introduction to Human Resource: Human Resource Management - Definition - Objectives - Functions - Scope - Importance - HRM in India - Evolution of HRM - Computer Application in Human Resource Management - Quality of a good Human Resource Managers

Human Resource Planning: Human Resource Planning- Process. Forecasting, Job Analysis, Description and Job Evaluation. Recruitment, Selection and Recruitment, Career Planning, Training and Performance Appraisal. Transfer, Promotions and Job Rotation. Emerging Trends and Issues in HRP.

Human Resource Training: Training – Concept, role and importance, Types of Training, Role of Stakeholders in Training. Training Needs Assessment (TNA), Levels of Training Needs, Designing Training Programs. Methods of Conducting Training, developing Audio-visual Materials, Measuring Impact of Training.

Human Resource Development: HRD- Conceptual Framework, Issues in HRD, Objectives of HRD, HRD and HRM, Agents of HRD, Strategy for HRD, HRD Culture, HRD Barriers, Frame-work of HRD, HRD in Different Sectors.

Industrial Relations: Industrial Relations - Meaning & Characteristics Industrial Relations - Parties to Industrial relations - Nature of Trade Unions - Problems of Trade Union - Measures to Strengthen Trade Union Movement in India - Causes for Industrial Disputes - Settlement of Industrial Disputes.

Books Suggested:

1. Decenzo , Robbins *"Human Resource Management"* , Wiley, (2001)
2. Biswajeet Pattanayak *, "Human Resource Management"* PHI Learning, (2005)
3. Aswathappa K. *"Human Resource and Personnel Management"* Tata McGraw Hill, (2010)
4. Kapoor ,N.D., "*Personnel Management & Industrial Laws"* S. Chand & Sons, (2001)
5. Wayne , Mondy, *"Human Resource Management*" Pearson Education (2011)

Computational Fluid Dynamics
(Elective-II)

Course No. ChBE-74

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Fundamental understanding and interpretation of governing equations involved in heat and fluid flow problems.
CO2 Understanding of basic numerical techniques involved.
CO3 Understanding of Grid formation.
CO4 Understanding discretization technique's using FDM FVM.

Details of Syllabus

Basic Concepts of Fluid Flow: Philosophy of computational fluid dynamics (CFD), review of equations governing fluid flow and heat transfer, simplified flow models such as incompressible, inviscid, potential and creeping flow, flow classification.

Grid Generation: Structured and unstructured grids, choice of suitable grid, grid transformation of equations, some modern developments in grid generation in solving the engineering problems.

Finite Difference Method (FDM): Discretization of ODE and PDE, approximation for first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to the engineering problems.

Finite Volume Method: Discretization methods, approximations of surface integrals and volume integrals, interpolation and differential practices, implementation of boundary conditions, application to the engineering problems.

Case studies: Case studies using FDM and FVM: Flow and heat transfer in pipes and channels, square cavity flows, reacting flow, reactive flow, multiphase flow, Heat Transfer in Rotary Kiln Reactors, Fluid mixing, etc. Essence of Finite element method (FEM) .

Books Suggested:

1. Fletcher, C.A.J., "*Computational Techniques for Fluid Dynamics, Vol. 1: Fundamental and General Techniques*", Springer-Verlag (1998).
2. Fletcher, C.A.J., "*Computational Techniques for Fluid Dynamics, Vol. 2: Specific Techniques for Different Flow Categories*", Springer-Verlag (1998).
3. Anderson, J.D., "*Computational Fluid Dynamics*", McGraw Hill (1995).
4. Ghosh, P.S., "*Computer Simulation of Flow and Heat Transfer*", Tata McGraw-Hill (1998).
5. Patankar, S.V., "*Numerical Heat Transfer and Fluid Flow*", Taylor and Francis (2004).

Multi-component Distillation

(Elective-II)

Course No. ChBE75	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 VLE calculations like determination bubble point and dew point for multi-component systems using K-values and relative volatility.

CO2 They learn about various types of MCD column.

CO3 Students able to design multi-component distillation unit.

Details of Syllabus

Basic concepts of phase equilibria. Distribution co-efficient. Ideal and non-ideal systems. Design variables. Equilibrium flash separation. Binary distillation, x-y diagrams. Enthalpy-concentration diagrams. Design calculations. Multi-component distillation. Design calculations. Theoretical analysis. Azeotropic and extractive distillation. Distillation equipment. Plate and packed towers. Design procedures.

Books Suggested:

1. C. D. Holland: "*Multi-component distillation"*.
2. Vincle, M. V., "*Distillation*".
3. Smith B.D., "*Design of Equilibrium Stage Processes*".
4. Sawistowski, H., Smith, W. "*Mass Transfer Process Calculations*".
5. Trebal, R.E. "*Mass Transfer*".
6. Sherwood, Pigford , Wilke: "*Mass Transfer*".

Optimization Techniques in Chemical Eng.
(Elective-II)

Course No. ChBE-76

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 understand the objective functions and conditions for optimization

CO2 Application of optimization to different chemical engineering problems, problem formulation procedures for optimization

CO3 Use of various methods for both constrained and unconstrained optimization problems.

Details of Syllabus

Basic concepts of systems analysis and optimization, Classical optimization techniques, Linear programming, Two phase simple method and duality in linear programming, Transportation models, Assignment Models,Non-linear programming, Method of Lagrange Multipliers, Wolf"s method for solving N.L.P.P, Introduction to Dynamic programming, Application to Chemical Engineering.

Books Recommended

1. Beveridge & Schecter, "*Optimization Principles & Practice*"
2. Hussain, A., "*Optimization for Chem. Engineers*"

Reference Books

1. Vilde, "*Optimum Seeking Methods*"
2. Aris, R., "*Dynamic Programming*"
3. Gauss, "*Linear Programming*"
4. Hadley, "*Linear Programming*
5. Hadley, "*Non-Linear Programming*"

Managerial Economics for Engineers

(Elective-II)

Course No. HSBE-72	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Understand the roles of managers in firms and understand the internal and external decisions to be made by managers.

CO2 Analyze the demand and supply and elasticity conditions and assess the position of a company.

CO3 Analyze the production function in one as well as in two variables and explain the relevance of economies of scale in production.

CO4 Design competition strategies, including costing, pricing, product differentiation, and market environment according to the natures of products and the structures of the markets.

Details of Syllabus

Introduction to Managerial Economics: Definition, Nature and Scope. Relationship with other areas in Economics, Production Management, Marketing, Finance, Personnel and Operations Research. Total Economic Cost. Economic Profit and Accounting Profit, Objectives of the Firm.

Theory of Demand: Demand Analysis-Demand Function, the Law of Demand, and Exceptions to Law of Demand, Methods of Demand Estimation and Demand Forecasting, Elasticity of Demand, Types and significance of Elasticity of Demand. Supply Analysis – Supply function, the Law of Supply, Shifts in Demand & Supply, Market Equilibrium. Market Structure and Pricing practices: Features and Types of different competitive situations - Price-Output determination in Perfect competition, Monopoly, Monopolistic Competition and Oligopoly, Strategic Decision Making in Oligopoly.

Trade cycles: Operation of trade cycles – various theories of trade cycles and Measures to check the occurrence of trade cycle.

National income: concepts and measurement, International trade – basis of international trade – balance of payments and measures to correct imbalance in the balance of payments

Books Suggested:

1. Gupta, G.S., "*Managerial Economics"* Tata McGraw-Hill (1990).
2. Dewett, K. K., " *Modern Economic Theory*", Sultan Chand & Co. Ltd. (2006).
3. Varshney and Maheshwari "*Managerial Economics"* Sultan Chand and Sons, New Delhi (2014).
4. Pearson and Lewis "*Managerial Economics"* , Prentice-Hall, New Delhi (1999).

Project

Course No. ChBP-81

L	T	P	Credit
0	0	16	08

Course Outcomes

CO1 Apply the knowledge of chemical engineering to design or fabricate a system.
CO2 Identify chemical engineering research problems.
CO3 Apply knowledge of chemical engineering to solve energy and environmental problem.
CO4 Ability to write a research proposal.

Details of Syllabus

The major project is a prerequisite for completion of the eighth semester along with other subjects. This is in continuation of the project carried out in the seventh semester. Experimental/theoretical works are carried out by the students on problems in chemical engineering and its allied areas as assigned by the project advisor. Project report writing and submission, presentation of the work done followed by viva-voce examination by an examiner (preferably external).

Bio-resource Technology

Course No. ChBC-82	L	T	P	Credit
	3	0	0	3

Course Outcomes

CO1 Fundamental understanding of the bioresourcesand its applications for attainment of social objectives (energy, environment, product, sustainability).

CO2 Acquire knowledge with respect to the properties of the bioresources and the conversion technologies.

CO3 Exhibiting knowledge of the systems used for bioresource technology.

CO4 Understanding about analysis of data and their applications in design of the systems and development of the bioprocess.

Details of Syllabus

Bioresources- natural and anthropogenic; importance of bio-resources and their utilization. Natural bio-resources: agricultural, forestry and aquatic biomass. Biomass availability, production and food security, non- edible biomass characteristics.

Anthropogenic bio-resources : Organic wastes-domestic and industrial ; characteristics of municipal sewage / sludge and industrial sludges.

Bio-resource Conversion : biofuels , biomaterials and speciality chemicals.

Conversion processes : physico-chemical, biochemical and thermo-chemical conversion processes.

Biochemical processes : Microbial anaerobic and aerobic processes, enzymatic processes ; fermentation for alcohols and acids ; penicillin and other therapeutic products. Production of single cell protein (SCP) ; bio-pulping, biogasification.

Physico-chemical processes: Pretreatment, steam/acid/alkali hydrolysis, effect of temperature on hydrolysis.

Thermo-chemical processes; pyrolysis and oxidation-combustion, coke, pyro-oils and gasification. Various methods of manufacture of activated carbons, coke and pyro-oils. Downdraft, updraft and fixed bed gasification, fluidized bed and entrained bed Gasification.

Special topics : Biofuels - anhydrous alcohols -ethanol and butanol ;biodiesel, bio-aviation turbine fuel (BATF). Specialty chemicals - gylcol, acetic acid and downstream chemicals.

References:

1. Tripathi, G., "*Bioresource Technology*", CBS Publications (2002).
2. Pandey, A., "*Concise Encyclopaedia of Bioresource Technology*", CRC Press (2004).
3. Shuler, M., Kargi, F., "*Bioprocess Engineering, Basic Concept",* Prentice Hall of India Pvt. Ltd. (2004).
4. Chakraverty, A., "*Biotechnology and other Alternative Technologies*", Oxford and IBH Publishing Co. Pvt. Ltd. (1995).
5. Rao, M.G., Sittig, M., "*Dryden's Outlines of Chemical Technology- for the 21st Century*". East- West Press (1997).
6. Austin, G.T., "*Shreve's Chemical Process Industries*", McGraw-Hill Book Company (1984).

Biochemical Engineering Lab.

Course No. ChBC-83P

	L	T	P	Credit
	0	**0**	**4**	**2**

Course Outcomes

CO1 Acquire basic knowledge of various equipments used in biochemical engineering lab.

CO2 Fundamental understanding of techniques with respect to sterilization, preparation of solid and liquid media, culture growth and preservation.

CO3 Basic understanding of estimation techniques for biomass, substrate and product.

CO4 Generation and analysis of data for design and development of bioprocess.

Details of Syllabus

Study of a fermenter, study of sterilization, preparation of culture media for microbes, preparation of agar slants and agar plates for growth and preservation of microbial cultures, enumeration of microbes by microscopic and plate counting methods, Study of kinetics of growth, product formation and substrate utilization, study of microbial death kinetics, study of bioseparations.

Books Suggested:

1. Bhattacharya, R.N., "Experiments with Microorganisms", Emkay Publications, Delhi Delhi (1986).
2. Aneja, K.R., "Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation", Vishwa Prakashan (New Age International (P) Limited), New Delhi (1996).
3. Shuler, M., Kargi, F., "*Bioprocess Engineering, Basic Concept"*. Prentice Hall of India Pvt. Ltd. (2004).

Modelling & Simulation in Chemical Eng.

Course No. ChBC-84

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Identify the terms involved in inventory rate equation of mass, energy and momentum.
CO2 Recall the basic concepts involved in modelling and simulation.
CO3 Apply conservation of mass, momentum and energy equations to engineering problems.
CO4 Develop model equations for chemical engineering systems.
CO5 Solve the model equations and chemical engineering problems using numerical techniques.

Details of Syllabus

Introduction : Introduction to process modeling and simulation, tools of simulation, approaches for simulation, planning of calculation in a plant simulation.

Parameter Estimation: Parameter estimation techniques in theoretical as well as numerical models.

Models: Models, need of models and their classification, models based on transport phenomena principles, alternate classification of models, population balance, stochastic, and empirical models, unit models.

Models of Heat Transfer Equipment: Development of detailed mathematical models of evaporators, use of Newton-Raphson method for solving evaporator problems.

Models of Separation Processes: Separation of multicomponent mixtures by use of a single equilibrium stage, flash calculation under isothermal and adiabatic conditions, tridigonal formulation of component-material balances and equilibrium relationships for distillation, absorption and extraction of multicomponents, Thiele and Geddes method plus θ –method and K_b method, models of absorbers , strippers and extractors.

Models of Reactors: Classification of fixed bed reactor models, one dimensional and two dimensional fixed bed reactor models, fluidized bed reactor models, bioreactor models.

Process Simulation: Simulation of chemical process equipment, program development and numerical solution.

Books Suggested:

1. Denn, M. M., "*Process Modeling*", Longman (1986).
2. Holland, C. D., "*Fundamentals and Modeling of Separation Processes*", Prentice Hall (1975).
3. Luyben , W. L., "*Process Modeling, Simulation and Control for Chemical Engineers*". McGraw Hill (1990).
4. Najim, K., "*Process Modeling and Control in Chemical Engineering*", CRC (1990).
5. Aris, R., "*Mathematical Modeling, Vol. 1: A Chemical Engineering Perspective :Process System Engineering*", Academic Press (1999).

Industrial Pollution Abatement

Course No. ChBC-85

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Understand the sources, effects and prevention of pollution and recycling of water and waste.
CO2 Illustrate the methods to measure the industrial pollution.
CO3 Understand the principles of industrial pollution control and design air pollution control systems.
CO4 Apply the basic chemical engineering concepts in design of industrial wastewater treatment systems.

Details of Syllabus

Introduction: Environment and environmental pollution from chemical process industries, characterization of emission and effluents, environmental Laws and rules, standards for ambient air, noise emission and effluents.

Pollution Prevention: Process modification, alternative raw material, recovery of by/co-products from industrial emissions/effluents, recycle and reuse of waste, energy recovery and waste utilization. Material and energy balance for pollution minimization. Water use minimization, Fugitive emission/effluents and leakages and their control-housekeeping and maintenance.

Air Pollution Control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by absorption and adsorption; Design of cyclones, ESP, fabric filters and absorbers.

Water Pollution Control: Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation.

Biological Treatment: Anaerobic and aerobic treatment biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying.

Solids Disposal: Solids waste disposal – composting, landfill, briquetting / gasification and incineration.

Books Suggested:

1. Tchobanoglous , G., Burton, F. L., Stensel, H.D., "*Waste Water Engineering: Treatment and Reuse*", Tata McGraw Hill, (2003)
2. Vallero, D., "*Fundamentals of Air Pollution*", Academic Press, (2007)
3. Eckenfelder W. W., "*Industrial Water Pollution Control*", McGraw Hill, (1999)
4. Kreith F. and Tchobanoglous G., "*Handbook of Solid Waste Management*", Mc Graw Hill, (2002)
5. Pichtel, J., "*Waste Management Practices: Municipal, Hazardous and Industrial*", CRC (2005)

Instrumental Methods of Analysis.

(Elective-III)

Course No. ChBE-81	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1	Understand the general theory, applications, advantages, limitations and sources of errors of various spectrometric and spectrophotometric techniques
CO2	Understand the electrometric instrumentation methods with applications, advantages, limitations and sources of errors
CO3	Analysis of radioactive methods and isotopic dilution with applications, advantages, limitations and sources of errors
CO4	Attain the knowledge of gas chromatography including its applications, advantages, limitations and sources of errors

Details of Syllabus

General discussion, theory, instrumentation, typical application, advantages, limitations and sources of errors of the following:

Instrumental Techniques:

Spectrometric methods, Spectrophotometry, flourometry, emission spectroscopy, flame photometry and atomic absorption spectrometry.

Electrometric methods, Conductometry, potentiometry, polarography, amperometry and coulometry. Radiometric methods-Activation analysis and isotopic dilution. Gas chromatography

Books Recommended

1. Lyalikov, Y., "*Problems in Physico Chemical Methods of Analysis*", Mir Publishers, (1974).
2. Howard, A., Strobel, William, R., Heineman, "*Chemical Instrumentation: A Systematic Approach.*", John Wiley & Sons, New York, (1989).
3. Robinson, J.W., "*Undergraduate Instrumental Analysis*,", Marcel Decker, New York, (1982).
4. Ewing, G.W., "*Instrumental Methods of Chemical Analysis*", McGraw-Hill. New York, (1985).
5. Willard, H.H., Merritt, L.L., Dean, J.A., "*Instrumental Methods of Analysis*,Van Nostrand, (1981).

Petroleum Refining.
(Elective-III)

Course No. ChBE-82	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Knowledge about production of crude oil, along with its properties and characterization methods.
CO2 Understand the process of fractionation and identify the specifications for good quality petroleum.
CO3 Identify different products obtained from refining process and their best utilization.
CO4 Integrate and evaluate problems pertaining to crude oil refinery engineering.

Details of Syllabus

Introduction: Indian and Global Petroleum Industries: An overview, emerging crude oil quality and fuel norms, natural gas, shale gas and gas hydrates, changing scenario in crude oil and natural gas availability.
Origin, Occurrence and Composition of Petroleum: Origin and occurrence of petroleum crude, drilling of crude oil and natural gas, composition of crude oil and natural gas, classification and physical properties of petroleum, evaluation of crude oil and petroleum products.
Evaluation of crude oil and petroleum products:. Short term and Long term evaluation Composition of crude oil, TBP Assay, ASTM distillation, Evaluation crude oil base and other properties, Product quality analysis and fuel norms.
Crude Oil Distillation Processes: Pretreatment of crude, atmospheric and vacuum distillation process, effects of crude characteristics and operating variables in Crude oil distillation. Processing of high TAN crude oil.

Thermal Conversion Process: Thermal Cracking Reactions, Thermal Cracking, Visbreaking, Coking Processing, Delayed, Fluid And Flexi Coking, Petroleum Coke.
Catalytic Conversion Process: Fluid Catalytic Cracking (FCC), Hydrocracking, Catalytic Reforming, Alkylation, Isomerization and Polymerization.

Lubricating Oil, Wax and Bitumen: Lube refining concept, Dewaxing, deasphalting, lube hydro-finishing, bitumen and asphalt processing.
Finishing and Sweetening processes: Desulfurization and hydro-desulfurisation of petoleum products., Sweetening Processes, Desulphurisation of sour water, sulphur recovery.
Future refining trend s: Biofuel, gas to liquid technology, carbon foot prints in petroleum refining, concept of Petrochemical refinery, gas refinery and Biorefinery**.**

Books Recommended:

1. Nelson W. L., "*Petroleum Refinery Engineering*" McGraw Hill. (1987)
2. Wauquier J. P., "*Petroleum Refining 2 Separation Processes*", Vol:1-5, (1998)
3. Meyers R. A., "*Hand book of Petroleum Refining Processes*", 3rd Ed., The McGraw-Hill Publication. (2004)
4. Dawe R. A., "*Modern Petroleum Technology- Part I*", by Institute of Petroleum (IP), John Wiley. (2002)
5. Prakash Surinder " *Refining Processes Hand book*" Elsevier, (2003)
6. Hobson,G.D." *Modern Petroleum technology Volume I & II*" Wiley, (1984)
7. Bhaskar Rao, B.K. "*Modern Oetroleum refining processes*" Oxford &IBH Publishing Co Pvt.Ltd., (2005)

Food Technology.
(Elective-III)

Course No. ChBE-83

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Understand and comprehend the principle of unit operations related to food processing.

CO2 Understand basics of designing of food plant and storage system.

CO3 Stay familiarized with basic principles of refrigeration, freezing, fluid flow, heat and mass transfer, steam, psychrometrics etc. from food industrial point of view.

CO4 Apply principles from general chemistry, biology, physics, statistics, and mathematics to food science problems.

Details of Syllabus

Constituents of foods. Nutritive aspects of food. Equipments and processes used in food industries. Deteriorative aspects of food and its control. Preservation of foods by heat and by cold. Fluid food concentration. Food dehydration. Food irradiation and microwave heating. Food sterilization and pasteurization. Pickling and fermentation.

Rice. Wheat. Pulses. Fruits and vegetables. Spices. Bread and biscuits. Confectionery. Proteins. Soft and alcoholic beverages. Dairy products. Meat. Fish products.

Books Recommended:

1. Potter, N.N., “*Food Science*”, AVI Publishing Company, Westport Connecticut, (1973).
2. Singh, R.P., Heldman, D.R., “*Introduction to Food Engineering*” Academic Press, New York, (1993).
3. Toledo, R.T., “*Fundamentals of Food Process Engineering*”, AVI Publishing Co., Westport, Connecticut, (1980).
4. Karel, M., Fennema, O., “*Principles of Food Science, Part II: Physical Principles of Food Preservation*”, Marcel Dekker, Inc., (1975).
5. Lapedes, D.N., “*McGraw-Hill Encyclopedia of Food, Agriculture and Nutrition*”, McGraw-Hill, New York, (1975).
6. “*Food Industries*”, Chemical Engineering Education Centre ,IIT Madras.

Nano-Science and Technology.
(Elective-III)

Course No. ChBE-84

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Understand the properties of nanomaterials and their applications.
CO2 Apply chemical engineering principles to nanoparticles production and scale-up.
CO3 Solve the quantum confinement equations and analyze the nanomaterials characterization.
CO4 State the applications of nanotechnology in electronics and chemical industries.

Details of Syllabus

Introduction: Nanotechnology and its historic perspective; Foundation of Nanotechnology in Chemistry, Physics and Biology; Nanostructures in Nature.

Nano-scale Characterization Techniques: X-Ray Diffraction; Brunauer-Emmett-Teller (BET), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Auger Electron Spectroscopy (AES), X-Ray Photo-electron Spectroscopy (XPS), Electron Energy Loss Spectroscopy (EELS).

Nano-scale Manufacturing Techniques: Bottom-up Approach: Sol-Gel Synthesis, Hydrothermal Growth, Thin-Film Growth, Physical Vapour Deposition, Chemical Vapour Deposition; Top-Down-Approach: Ball Milling, Micro-fabrication, Lithography, Ion-Beam Lithography.

Properties of Nano-structures: Crystal defects, surfaces and interfaces in nanostructures, ceramic interfaces, Super-hydrophobic surfaces; Thermodynamics of Nanostructures; Diffusion Kinetics; Properties: Optical, Emission, Electronic transport, Photonic, Refractive Index, Dielectric, Mechanical, Magnetic, Non-linear optical, Catalytic and Photo-catalytic.

Chemical Engineering Aspects: Flow of Nano-fluids in Micro-channel; Heat Transfer from Nano-fluids: Convective and Radiative; Surface energy, Colloidal and Catalytic Behaviour of Nano-particles: Gold Nano-particles; Nano-particulate Suspensions; Membrane Nanotechnology; Nano-engineered Catalysts and Polymers; Nano-material Filters.

Books Recommended:

1. Rao, M. S. R., Singh, S., "*Nanoscience and Nanotechnology: Fundamentals to Frontiers*", Wiley India Pvt. Ltd. (2013)
2. Ashby, D. M., Ferreira, P., Schodek, D. L., "*Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects*", Butterworth-Heinemann. (2009)
3. Bhushan, B., "*Handbook of Nanotechnology*", Springer,(2010)
4. Minkowwycz, W. J., Sparrow, E. M., Abraham, J. P., "*Advances in Numerical Heat Transfer: Nanoparticle Heat Transfer and Fluid Flow*", Vol.4, Eds: CRC Press. (2013)
5. Ferry, D. K., Goodnick, S. M. and Bird, J., "*Transport in Nanostructure*", Cambridge University Press, 2nd Edition. (2009)

Process Heat Integration.
(Elective-IV)

Course No. ChBE-85

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Ability to understand the fundamentals of process integration.
CO2 Ability to determine the minimum heating and cooling requirements.
CO3 Ability to design minimum energy heat exchanger networks.
CO4 Ability to understand the composite and grand composite curves.

Details of Syllabus

Process Integration and its Building Blocks: Definition of Process Integration (PI), School of thoughts, Areas of application and Techniques available for PI, Onion diagram.
Pinch Technology – An Overview: Introduction, Basic concept, How it is different than energy auditing, Role of thermodynamic laws, Problem addressed by Pinch technology.
Key Steps of Pinch Technology: Data extraction, Targeting, Designing, Optimization-Supertargteing.
Basic Elements of Pinch Technology: Grid diagram, Composite curve, Problem table algorithm, Grand composite curve.
Targeting of Heat Exchanger Network (HEN): Energy targeting, Area targeting, Number of units targeting, Shell targeting, cost targeting.
Designing of HEN: Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches, Design for threshold problem, Loops and Paths.

Heat Integration of Equipments: Heat engine, Heat pump, Distillation column, Reactor, Evaporator, Drier, Refrigeration systems.

Heat and Power Integration: Co-generation, Steam turbine, Gas turbine.

Books Recommended:

1. Kemp I. C., "*Pinch Analysis and Process Integration: A user Guide on Process Integration for the Efficient Use of Energy*", Butterworth-Heinemann. (2007)
2. Smith R.., "*Chemical Process Design and Integration*", 2nd Ed., Wiley. (2005)
3. Shenoy U. V., "*Heat Exchanger Network Synthesis*", Gulf Publishing Company. (1995)
4. Halwagi, M. M., "*Process Integration*", 7th Ed., Academic Press. (2006)

Fuel Cell Technology

(Elective-IV)

Course No. ChBE-86

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Understanding the basics of fuel cell technology in modern energy applications
CO2 Analyzing the working and applications of various fuel cells.
CO3 Understanding of the thermodynamic and kinetic aspects of fuel cell systems
CO4 Assessment of various fuel cells by several characterization techniques.

Details of Syllabus

Introduction: Fuel cell definition, Fuel cells versus batteries, type of fuel cell, basic fuel cell operation, fuel cell performance, advantages and disadvantages of fuel cell, overview of fuel cell system, fuel cell stack, thermal management subsystem, fuel delivery and processing subsystem, hydrogen storage, generation and delivery.

Working principle and application: Phosphoric acid fuel cell (PAFC), polymer electrolyte membrane fuel cell (PEMFC), alkaline fuel cell (AFC), molten carbon fuel cell (MCFC), solid-oxide fuel cell (SOFC), performance characterization of fuel cell system.

Fuel cell thermodynamics: Thermodynamic potential, heat potential of a fuel, enthalpy of reaction, temperature dependency of enthalpy, working potential of fuel, relationship between Gibbs free energy and electrical work, relationship between Gibbs free energy and voltage, standard electrode potential, reversible voltage variation of reversible voltage with temperature, pressure and concentration, real and ideal fuel cell efficiency.

Reaction kinetics in fuel cell: Electrode kinetics, electrochemical reaction, heterogeneous electrochemical process, current rate, current amount and current density, activation energy in current transfer reaction, net rate of reaction calculation, potential and rate: Butler-Volmer equation, how to improve kinetic performance, catalyst electrode design.

Transport in fuel cell system: Ion transport in an electrolyte, electron transport, gas-phase mass transport, diffusive transport in electrode, convective transport in flow structures.

Fuel cell characterization: Overview of characterization techniques, basic fuel cell test station, current voltage measurement, Ex Situ characterization techniques, porosity, BET, gas permeability, fuel processing subsystem, steam reforming, partial oxidation, auto-thermal reforming, gasification, water-gas shift reactors, carbon Monoxide clean up, thermal management.

Environmental impact: Life cycle assessment, emission, climate change, greenhouse effect.

References:

1. Ohayre, R.P., Cha Suk-Won, Colella, W. G., Prinz, F. B., "*Fuel Cell Fundamentals*", John Wiley & Sons Inc. (2009).
2. Larminie J., Dicks A., *Fuel Cell System Explained*", John Wiley & Sons (2003).
3. Mench M. M., " *Fuel Cell Engines*", John Wiley & Sons Inc. (2008).
4. Zhao, T.S.; Kreuer, K.D., "*Advances in Fuel cells*", Elsevier (2007).
5. Linden, D., "*Handbook of Batteries and Fuel Cells*", McGraw-Hill (1984).

Clean Technology in Process Industries
(Elective-IV)

Course No. ChBE-87

L	T	P	Credit
3	0	0	3

Course Outcomes

CO1 Understanding the importance of clean technology and evaluation of conventional technologies for the same

CO2 Evaluating alternate technologies for facilitating clean technology

CO3 Process modification and waste minimization

CO4 Advanced technologies

Details of Syllabus

Introduction: Environmental impact of chemicals and chemical production, life cycle assessment, waste minimization techniques, sustainable development.

Evaluation of Conventional Technologies: Evaluation of present process technologies for ammonia, sulphuric acid, caustic soda, pulp and paper, plastics and polymers synthesis. Analysis of raw materials, intermediates, final products, by-products and wastes.

Alternate Technologies: Alternative raw materials, low temperature and low pressure and low energy consuming routes for the manufacture of caustic soda, leather, plastics, pulp and paper and rayon.

Minimization of water and heat consumption: Process Integration and water pinch technology for minimizing water and heat consumption; data extraction, minimum fresh water target with and without reuse: limiting water profile, concentration-composite curve, concentration-interval diagram, block diagram, grid diagram, mass-content diagram, network design, network evolution: lop identification and loop breaking.

Process Modification and energy production from waste: Process modification waste utilization and energy production from solid waste, recycling and reuse of water, solid waste management.

Advanced Technologies: Development of biodegradable and end-products of polymers and plastics, CO_2 capture, sequestration and utilization.

References:

1. Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen, "Chemical Process Technology"", John Wiley and Sons Ltd. (2013)
2. George T. Austin, "Shreve"s Chemical Process Industries", Tata McGraw Hill, (2012)
3. Gerard Kiely, " Environmental Engineering"", Tata McGraw-Hill Education , 2007
4. J. Mann , Y.A. Liu, "Industrial Water Reuse and Wastewater Minimization", McGraw-Hill Professional", (1999)
5. Mahmoud, M., Halwagi , *" Sustainable Design Through Process Integration: Fundamentals and Application to Industrial Pollution Prevention, Resource Conservation, and Profitability Enhancement"* , Elsevier Science & Technology, (2011)
6. Roberto Solaro, Emo Chiellini, " *Biodegradable Polymers and Plastics"*, Springer, (2003)

Entrepreneurship Development.
(Elective-IV)

Course No. HSBE-81	**L**	**T**	**P**	**Credit**
	3	**0**	**0**	**3**

Course Outcomes

CO1 Define basic terms and analyse the business environment in order to identify business opportunities.

CO2 Identify the elements of success of entrepreneurial ventures and the legal and financial conditions for starting a business venture.

CO3 Evaluate the effectiveness of different entrepreneurial strategies and specify the basic performance indicators of entrepreneurial activity.

CO4 Explain the importance of marketing and management in small businesses venture and interpret their own business plan.

Details of Syllabus

Entrepreneurship

a. Nature and importance of Entrepreneurs
b. Historical Perspective – Earliest period, Middle ages, 17th century to 20th century
c. Definition of Entrepreneurs, Entrepreneurial Decision Process – Desirability and possibility of new venture formation – Role of Entrepreneurship in Economic Development, Govt., as an innovator, Intrapreneurship Entrepreneurship Careers and Educators, Ethics and Social responsibility of entrepreneurs. The future of entrepreneurship, Incubation Centers, Role of various institution / Govt. agencies in the development of new entrepreneurs.

The Entrepreneurial and Intra-preneurial Mind

a. The Entrepreneurial Process,
   i) Identify and evaluate the opportunity
   ii) Develop a Business Plan,
   iii) Determine the Resources required,
   iv) Manage the Enterprise
   v) Entrepreneurship Skills and Strategies,
b. Managerial verses and Entrepreneurial Decision Making,
c. The individual entrepreneur
   i) Entrepreneurial feeling, Locus of Control, Independence and need for achievement, Risk Taking,
   ii) Entrepreneur Background and Characteristics, Childhood and Family Environment, Education, Personal Values, Age, Work History, Motivation,
   iii) Role Models and Support System, Moral Support Networks, Professional Support Networks, Male versus Female Entrepreneurs, Minority Entrepreneurship

Creating and starting the venture

Creativity and the Business Idea – Sources of new ideas, Methods of generating ideas, Creative Problem Solving Product Planning and Development Process

The Business Plan

a) Creating and starting the venture, Business Plan – meaning scope and value, evaluating business plan by potential lenders and investors, Presentation of Business Plan.
b) <u>The Marketing Plan</u> – Purpose, Timing and Characteristics and understanding and implementation of Marketing Plans , Marketing Mix, why some plans fail.
c) <u>Financial Plan</u>-Operating and Capital Budgets , Sources and uses of funds, Break even analysis
d) <u>The organizational plan</u>- Legal forms of Business and Developing the Management Teams, Role of BOD, Advisors and Consultants

Financing of the new venture

Sources of Capital , Debt and Equity, Personal funds and Funds from friends and relatives, Commercial loans from Banks and Financial Institutions, Venture Capital

Managing, growing and ending the new venture

Recruitment and hiring of new employees, Motivating and leading the team

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