IV year B. Tech Ist Semester (7th semester)

Sr. No.	Course Code	Course Title	L	T	P	Credits
1	CH 701	Process Dynamics and Control	3	1	-	4
2	CH 702	Process Economics and Project Management	3	-	-	3
3	CH 703	Transport Phenomena	3	1	-	4
4	CH 704	Process Equipment Design and Drawing	3	-	2	4
5	CH 705	Elective - VII	3	-	-	3
6	CH 706	Elective - VIII	3	-	-	3
7	CH 707	Process Instrumentation and Control Lab.	-	-	2	1
8	CH 708	Process Design, Flow Sheeting & Simulation	-	1	2	2
9	CH 709	Project Work Stage - I	-	-	6	3
10	CH 610 & CH 710	Industrial Training (Evaluation)	-	-	-	1
		Total	18	3	12	28

IV year B. Tech IInd Semester (8th semester)

Sr. No.	Course Code	Course Title	L	T	P	Credits
1	CH 801	Elective – IX*	3	-	-	3
2	CH 802	Elective – X*	3	-	-	3
3	CH 803	Elective – XI*	3	-	-	3
4	CH 804	Elective – XII*	3	-	-	3
5	CH 805	Project Work – Stage II*	-	-	12	6
		Total	12	00	12	18

*** - Or Only one Industrial sponsored project with a MoU between the University and the corresponding Industry**

Elective VII (IV year B.Tech I semester):

1. Non-Newtonian Flow and Rheology
2. Scale up methods
3. Biochemical Engineering

Elective VIII (IV year B.Tech I semester):

1. Advanced Separation Techniques (M.TechCourse)
2. Pollution Control in Process Industries
3. Introduction to Material Science

Elective IX (IV year B.Tech II semester):

1. Advanced Materials
2. Disaster Management in Chemical Industries
3. Downstream Processing in Biochemical Industry

Elective X (IV year B.Tech II semester):

1. Mathematical Methods in Chemical Engineering
2. Membrane Technology
3. Process Design Principles

Elective XI (IV year B.Tech II semester):

1. Pulp and Paper Technology
2. Heat Transfer Equipment Design
3. Advanced Petroleum Refining

Elective XII (IV year B.Tech II semester):

1. Entrepreneurship Development
2. Management Information Systems
3. Corporate Communication

Semester VII: Core Courses

1. CH 701 Process Dynamics and Control

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

CO1	Understand the dynamic behaviour of different processes
CO2	Analyze different components of a control loop
CO3	Analyze stability of feedback control system
CO4	Design controllers for first and second order processes
CO5	Analyze frequency response for controllers and processes

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed Syllabus

UNIT I **Introduction** Block diagrams, closed loop and open loop control systems, Basic control actions.

UNIT II **Open loop response of simple systems:** Dynamics of first order systems using transfer functions; Various first order response such as, a thermometer bulb. General response to step, ramp, impulse, and sinusoidal inputs; Concentration and temperature responses of a stirred tank;

UNIT II **Linearization** of liquid level systems; Response of a pressure system, second order systems, the manometer; Response of interacting and non interacting systems.

UNIT III **Transient response of control systems:** Servo and regulated operation, General equations for the transient response, proportional control of a signal capacity process; Integral control, Proportional-integral control and derivative action.

UNIT IV **Stability:** Concept of stability, Stability criterion, Routh test for stability.

Root locus analysis: Concept of root locus, Locus diagram.

UNIT V **Frequency response analysis:** First order systems, Bode diagram, and Complex numbers to get frequency response.

UNIT VI **Controller selection and tuning**, Control valve characteristics and sizing, cascade control, Feed forward control. Introduction of digital control principles.

Text / References:

1. D. R. Coughanowr, Process system analysis and control, 2nd ed, McGraw Hill, 1991.
2. P. Harriott, Process Control, Reprint of text, ed. Tata McGraw Hill, 1983.
3. G. Stephanopoulos, Chemical Process Control: An introduction to theory and practice, Prentice Hall, New Jersey, 1984.

2. CH 702 Process Economics and Project management

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

CO1	Analyze alternative processes and equipment for manufacturing a product
CO2	Design plant layout and engineering flow diagrams
CO3	Perform economic analysis related to process design
CO4	Evaluate project profitability

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	-	-	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	✓	-	✓	-	✓	-	✓	-
CO3	-	-	✓	✓	✓	-	-	✓	✓	-	-	-
CO4	-	-	✓	✓	✓	-	-	✓	-	-	-	-

Detailed Syllabus

UNIT I Capital cost estimation in chemical industries, different methods of calculation of fixed costs. Capital Investment and working Capital.

UNIT II Time value of money, types of interest, investment costs, annuities, perpetuity and capitalized costs, discounted cash flow analysis

UNIT III Taxes and insurance, depreciation, amortization and obsolescence in chemical industries, types of depreciation methods, breakeven point analysis

UNIT IV Discussion on projects , causes for time and cost overruns, project evaluation and assessment of project profitability, organization of project engineering.

UNIT V Optimum process design with examples, project development and commercialization, plant location and layout, selection of plant capacity.

UNIT VI Project engineering management, project scheduling and its importance, use of CPM/PERT techniques.

Texts / References:

1. M. S. Peters and K. D. Timmerhaus, "Plant Design Economics for Chemical Engineers", 5th Ed., McGraw-Hill, New York - 2003.
2. V. W. Uhl and A. W. Hawkins, "Technical Economics for Chemical Engineers", AIChE - 1971.
3. J. Modes and Philips, "Project Engineering with CPM and PERT", Rein Hold.
4. Choudhary, “Project Management”
5. Jelen, “Cost and Optimization Engineering”

3. CH 703 Transport Phenomena

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

CO1	Understand the analogy among momentum, heat and mass transport
CO2	Formulate a mathematical representation of a flow/heat/mass transfer phenomena
CO3	Solve flow/heat/mass transfer problems either individually or coupled for simple geometries analytically
CO4	Identify the similarities among the correlations for flow, heat and mass transfer interfaces

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	✓	✓	-	-	-	-	-
CO2	✓	✓	✓	✓	-	✓	-	-	-	-	-	-
CO3	✓	-	✓	✓	-	✓	-	-	-	-	-	-
CO4	✓	-	✓	✓	-	✓	-	-	-	-	-	-

Detailed Syllabus

Unit1

1. **VISCOSITY AND MECHANISM OF MOMENTUM TRANSPORT :** Newton's Law of Viscosity; Non-Newtonian fluids ; The Bingham model; The power law model; The Elli's model and the Reiner Philippoff model; Temperature and pressure dependents of viscosity.

2. **VELOCITY DISTRIBUTIONS IN LAMINAR FLOW :** Shell momentum balances; Boundary conditions ; Flow of a falling film; flow through a circular tube; flow through annulus.

Unit 2

3. **EQUATION OF CHANGE FOR ISOTHERMAL SYSTEMS :** Equations of continuity and motion in Cartesian and curvilinear co-ordinates; Use of the equations of change to set-up steady flow problems. Tangential annular flow of Newtonian fluid; Shape of surface of a rotating liquid.

4. **VELOCITY DISTRIBUTIONS WITH MORE THAN ONE INDEPENDENT VARIABLE:**Unsteady viscous flow ; Flow near a wall suddenly set in motion.

Unit 3

5. **INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS :** Definition of fraction factors; Friction factors for flow in tubes; for around spheres.

6. **THERMAL CONDUCTIVITY AND MECHANISM OF ENERGY TRANSPORT :** Fourier's law of heat conduction; temperature and pressure dependence of thermal conductivity in gases and liquids.

7. **TEMPERATURE DISTRIBUTIONS IN SOLIDS AND IN LAMINAR FLOW :** Shell energy balances; Boundary conditions; Heat conduction with an electrical heat source; with a viscous heat source.

Unit 4

8. **EQUATIONS OF CHANGE FOR NON-ISOTHERMAL SYSTEMS :** Use of equations of energy and equations of motion (for forced and free convection) in non-isothermal flow; Tangential flow in an annulus with viscous heat generation; steady flow of a non-isothermal film; Transpiration cooling.

9. **TEMPERATURE DISTRIBUTIONS WITH MORE THAN ONE INDEPENDENT VARIABLE :** Unsteady heat conduction in solids; Heating of a semi-infinite slab.

Unit 5

10. **INTERPHASE TRANSPORT IN NON-ISOTHERMAL SYSTEMS :** Definition of heat transfer coefficient; Heat transfer coefficients for forced convection in tubes; for forced convection around submerged objects.

11. **DIFFUSIVITY AND THE MECHANISM OF MASS TRANSPORT :** definition of concentrations; Velocity and mass fluxes; Fick's law of diffusion; Temperature and pressure dependence of mass diffusivity.

Unit 6

12. **CONCENTRATION DISTRIBUTION IN SOLIDS AND IN LAMINAR FLOW:** Shell mass balances; Boundary conditions; Diffusion through a stagnant gas film; Diffusion with heterogeneous chemical reaction.

13. **EQUATION OF CHANGE FOR MULTICOMPONENT SYSTEMS:**Equations of continuity for a binary mixture.

14. **INTERPHASE TRANSPORT IN MULTICOMPONENT SYSTEMS:** Definition of binary mass transfer coefficients in one phase. Correlations of binary mass transfer coefficient in one phase at low mass transfer rates.

TEXT BOOK:

1. Bird R.B., Stewart W.E. and Light Foot E.N. Transport Phenomena – John Wiley International – 2nd Edition, New York, (2002).

REFERENCE BOOKS:

Christie J. Geankoplis – Transport Processes and Unit Operations – Prentice Hall of India Pvt. Ltd., New Delhi, 1997.

4. CH 704 Process Equipment Design and Drawing

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

CO1	Identify equipment and instruments based on symbols
CO2	Draw process flow diagrams using symbols
CO3	Apply mechanical design aspects to process equipment
CO4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors and filters.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	✓	-	-	✓	-	-	-	-	-	-	✓
CO2	-	✓	-	-	✓	-	-	-	-	-	-	-
CO3	✓	-	✓	✓	✓	✓	-	-	-	-	-	-
CO4	✓	-	✓	✓	✓	✓	-	-	-	-	-	-

Detailed Syllabus

Unit I: Mechanical Design of Process Equipment: Introduction to mechanical aspects of chemical equipment design,

Unit II: Design Preliminaries, Design of cylindrical and spherical vessels under internal pressure, Design of heads and closers, Design of tall vessels.

Unit III and IV: Drawing: Drawing of process equipment symbols for fluid handling, heat transfer, mass transfer, Drawing of process equipment symbols for vessels, conveyers and feeders etc. Drawing of process equipment symbols for, separators, mixing & comminution etc. Drawing of process equipment symbols for distillation, driers, evaporators, scrubbers etc. Drawing of process equipment symbols for crystallizer, grinding, jigging, elutriation, magnetic separation, compressor etc. Drawing of basic instrumentation symbols for flow, temperature, level, pressure and combined instruments, Drawing of miscellaneous instrumentation symbols, Detailed drawing of equipment, Drawing of flow sheet.

Unit V and VI: Process Equipment Design: Design of a heat exchanger, Design of an absorber, Design of a distillation column, Design of evaporator, Design of condenser, Design of a chemical reactor.

Text / References:

1. Brownell L.E, Process Equipment Design - Vessel Design, Wiley Eastern Ltd., 1986.
2. Bhattacharya B.C., Introduction to Chemical Equipment Design - Mechanical Aspects, CBS Publishers and Distributors, 2003.
3. Towler, G. P. and R. K. Sinnott, Chemical Engineering Design, Principles, Practice and Economics of Plant and Process Design, 2nd Edition, Butterworth Heinemann, 2012.
4. Donald Kern, Process Heat Transfer, 1st Edition, Tata McGraw-Hill Education, 1950
5. Robert E. Treybal, Mass-Transfer Operations, 3rd Edition, McGraw-Hill Book Company, 1981.

Semester VII: Elective Courses

1. CH 705 Elctive VII

A. Non-Newtonian Flow and Rheology

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

CO1	Identify the types of non-Newtonian fluids
CO2	Understand the macroscopic behavior of the complex fluids
CO3	Analyze the flow of non-Newtonian fluids through circular and non-circular cross sectional conduits
CO4	Develop heat and mass transfer characteristics of non-Newtonian fluids
CO5	Develop models of non-Newtonian fluid flow

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	✓	-	-	-	-	-	-	-

Detailed Syllabus

Unit I: Non-Newtonian fluid behaviour - Introduction, Classification of fluid behaviour, Time-independent fluid behaviour, Time-dependent fluid behaviour, Visco-elastic fluid behaviour, Dimensional considerations for visco-elastic fluids.

Unit II: Rheometry for non-Newtonian fluids - Introduction, Capillary viscometers, Rotational viscometers, The controlled stress Rheometer, Yield stress measurements, Normal stress measurements, Oscillatory shear measurements, High frequency techniques, The relaxation time spectrum, Extensional flow measurements.

Unit III: Flow in pipes and in conduits of non-circular cross-sections - Introduction, Laminar flow in circular tubes, Criteria for transition from laminar to turbulent flow, Friction factors for transitional and turbulent conditions, Laminar flow between two infinite parallel plates, Laminar flow in a concentric annulus, Laminar flow of inelastic fluids in non-circular ducts. Flow of multi-phase mixtures in pipes - Introduction, Two-phase gas-non-Newtonian liquid flow, Two-phase liquid-solid flow (hydraulic transport).

Unit IV: Particulate systems - Introduction, Drag force on a sphere, Effect of particle shape on terminal falling velocity and drag force, Motion of bubbles and drops, Flow of a liquid through beds of particles, Flow through packed beds of particles (porous media), Liquid-solid fluidization.

Unit V: Heat transfer characteristics of non-Newtonian fluids in pipes - Introduction, Thermo-physical properties, Laminar flow in circular tubes, Fully-developed heat transfer to power-law fluids in laminar flow, Isothermal tube wall, Constant heat flux at tube wall, Effect of temperature-dependent physical properties on heat transfer.

Unit VI: Momentum transfer in boundary layers - Introduction, Integral momentum equation, Laminar boundary layer flow of power-law liquids over a plate, Laminar boundary layer flow of Bingham plastic fluids over a plate, Transition criterion and turbulent boundary layer flow, Heat transfer in boundary layers, Mass transfer in laminar boundary layer flow of power-law fluids, Boundary layers for visco-elastic fluids. Liquid mixing - Introduction, Liquid mixing, Gas-liquid mixing, Heat transfer, Mixing equipment and its selection, Mixing in continuous systems.

Text / Refernces:

1. Chhabra R.P., J.F. Richardson, Non-Newtonian Flow and Applied Rheology: Engineering Applications, 2nd Edition, Butterworth-Heinemann, 2008.
2. Christopher W. Macosko, RHEOLOGY: Principles, Measurements and Applications, WILEY-VCH, 1994.
3. Alexander Ya. Malkin, Rheology Fundamentals, ChemTech Publishing, 1994.

B. Scale – up methods

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

CO1	Understand scale up in chemical engineering plants
CO2	Apply dimensional analysis technique for scale up problems
CO3	Scale up of chemical reactors
CO4	Scale up mixers and heat exchangers, distillation columns and packed towers

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed Syllabus

Unit I: Principals of Similarity, Pilot Plants & Models: Introduction to scale-up methods, pilot plants, models and principles of similarity,

Unit II: Industrial applications.

Unit III: Dimensional Analysis and Scale-Up Criterion: Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering, experimental techniques for scale-up.

Unit IV: Scale-Up of Mixing and Heat Transfer Equipment: Typical problems in scale up of mixing equipment and heat transfer equipment.

Unit V: Scale-Up of Chemical Reactors: Kinetics, reactor development & scale-up techniques for chemical reactors.

Unit VI: Scale-Up of Distillation Column & Packed Towers: Scale-up of distillation columns and packed towers for continuous and batch processes.

Text / Refernces:

1. Johnstone and Thring, Pilot Plants Models and Scale-up methods in Chemical Engg., McGraw Hill, New York, 1962.
2. W. Hoyle, Pilot Plants and Scale-Up, Royal Society of Chemistry, 1st Edition, 1999.
3. Marko Zlokarnik, Dimensional Analysis and Scale-up in Chemical Engineering, Springer Verlag, Berlin, Germany,1991.
4. E. Bruce Nauman, Chemical Reactor Design, Optimization and Scale-up, McGraw Hill, New York, 2002.

C. Biochemical Engineering

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

CO1	Understand cell and enzyme kinetics
CO2	State methods of immobilization
CO3	Calculate volume of a bioreactor
CO4	State sterilization methods
CO5	Select downstream process to separate the products

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed Syllabus

Unit I: Introduction: Biotechnology, Biochemical Engineering, Biological Process, Definition of Fermentation.

Unit II: Enzyme Kinetics: Introduction, Simple Enzyme Kinetics, Enzyme Reactor with Simple Kinetics, Inhibition of Enzyme Reactions, and Other Influences on Enzyme Activity. Immobilized Enzyme: Immobilization techniques and effect of mass transfer resistance.

Unit III: Industrial application of enzymes: Carbohydrates, starch conversion and cellulose conversion. Cell Cultivation: Microbial cell cultivation, animal cell cultivation, plant cell cultivation, cell growth measurement and cell immobilization.

Unit IV: Cell Kinetics and Fermentor Design: Introduction, growth cycle for batch cultivation, stirred tank fermenters, multiple fermenters connected series, cell recycling, alternate fermenters and structured model. Sterilization: Sterilization methods, thermal death kinetics, design criterion, batch sterilization, continuous sterilization and air sterilization.

Unit V: Agitation and Aeration: Introduction, basic mass transfer concepts, correlation for mass transfer co-efficient, measurement of interfacial area, correlations for ‘a’ and

D32, gas-holdup, power consumption, determination of oxygen absorption rate, correlation for kLa, scale-up and shear sensitivity.

Unit VI: Downstream Processing: introduction, solid-liquid separation, cell rupture, recovery and purification.

Text / Refernces:

1. Lee J.M., Biochemical Engineering, Ebook, version 2.32, 2009.
2. James E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, 2nd edition, McGraw Hill International, 1986.
3. Michael L. Shuler & Fikret Kargi, Bioprocess Engineering – Basic Concepts, 2nd edition, Prentice Hall of India, New Delhi, 2002.

2. CH 706 Elctive VIII

A. Advanced Separation Techniques

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

CO1	Characterize materials using ultraviolet and visible absorption and fluorescence techniques
CO2	Analyze materials, minerals and trace samples using atomic absorption, emission and X-ray fluororescenet techniques
CO3	Analyze environmental, industrial, production-line materials by liquid, gas and size-ecclusion chromatography
CO4	Characterize interfaces and traces of surface adsorbed materials using electro-analytical techniques
CO5	Understand principles of thermogravimetry and differential thermal analyses.
CO6	Characterize chemical, inorganic and engineering materials using analytical techniques

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	✓	-	-	-	-	-	✓	-	-	-
CO2	-	-	✓	-	-	-	-	-	✓	-	-	-
CO3	-	-	✓	-	-	-	-	-	✓	-	-	-
CO4	-	-	✓	-	-	-	-	-	✓	-	-	-
CO5	-	-	✓	-	-	-	-	-	✓	-	-	-
CO6	-	-	✓	-	-	-	-	-	✓	-	-	-

Detailed Syllabus

Unit I and II: Solute transport parameters for membrane performance prediction in RO/UF systems involving aqueous and non aqueous solution. Physic – chemical. Polar, on-polar criteria governing RO separations – membrane transport mechanism.

Unit III and IV: Membrane fouling and compaction. TFC membrane development RO/UF/Ed process design and module analysis. RO/F/ED and DD in acid and enzyme recovery from scarified hydrolytes.

Unit V and VI: Membrane techniques in reclamation of water and chemicals along with pollution control from industrial effluents. Cost benefits analysis in resources cycling and environmental quality improvement by MT. Industrial processing with membranes – membrane reactor concept in biotechnology concentration. Gas separation by RO.

Text / References:

1. S. Sourirajan and T. Matsuuura (Ed.), RO – UF: Principles and Applications, NRCC Publications, Ottawa, Canada (1986).
2. Munir Cheryan, UF Applications Handbook, Technique Publishing Co, Lancaster, USA (1986).

B. Pollution Control in Process Industries

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

CO1	Analyze the effects of pollutants on the environment
CO2	Understand meteorological aspects of air pollution
CO3	Understand air pollution control methods
CO4	Select treatment technologies for water/wastewater/solid waste
CO5	Design unit operations for pollution control

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO2	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO3	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO4	✓	✓	-	✓	✓	-	✓	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	✓	-	-	-	-	-

Detailed Syllabus

Unit I: Introduction: Biosphere, Hydrological cycle, Nutrient cycle, Consequences of population growth, Pollution of air, Water and soil. Air pollution sources & effects: Classification and properties of air pollutants, Emission sources, Behavior and fate of air pollutants, Effect of air pollution.

Unit II: Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, Wind velocity and turbulence, Plume behavior, Dispersion of air pollutants, Estimation of plume rise. Air pollution sampling and measurement: Types of pollutant sampling and measurement, Ambient air sampling, Stack sampling, Analysis of air pollutants.

Unit III: Air pollution control methods & equipment: Control methods, Source correction methods, Cleaning of gaseous effluents, Particulate emission control, Selection of a particulate collector, Control of gaseous emissions, Design methods for control equipment.

Unit IV: Control of specific gaseous pollutants: Control of sulphur dioxide emissions, Control of nitrogen oxides, Carbon monoxide control, Control of hydrocarbons and mobile sources. Water pollution: Water resources, Origin of wastewater, types of water pollutants and there effects.

Unit V: Waste water sampling, analysis and treatment: Sampling, Methods of analysis, Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Basic processes of water treatment, Primary treatment, Secondary treatment, Advanced wastewater treatment, Recovery of materials from process effluents.

Unit VI: Solid waste management: Sources and classification, Public health aspects, Methods of collection, Disposal Methods, Potential methods of disposal. Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods.

Text / References:

1. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, India, 1993.
2. Noel de Nevers, Air Pollution and Control Engineering, McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke, Environmental Science and Engineering, 2nd Edition, Prentice Hall of India, 2004.
4. Rao M.N. and Rao H.V.N - Air Pollution, Tata – McGraw Hill Publishing Ltd., 1993.
5. De A.K - Environmental Chemistry, Tata – McGraw Hill Publishing Ltd., 1999.

C. Introduction to Material Science

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

CO1	Understand the characteristics and usefulness of metals and alloys.
CO2	Differentiate metals and alloys and their fabrication techniques
CO3	Correlate the microstructure, properties, processing and performance of materials
CO4	Select metal/alloy for engineering applications.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	✓	✓	-	-	-	-	✓	-	-	-
CO2	-	-	✓	✓	-	-	-	-	✓	-	-	-
CO3	-	-	✓	✓	-	-	-	-	✓	-	-	-
CO4	-	-	✓	✓	-	-	-	-	✓	-	-	-

Detailed Syllabus

Unit 1: **Crystal structure: S**ymmetry, elements of symmetry in cubic crystals-space lattices two and three dimensiona, unit cell, crystal, Bravais lattices, crystal systems with examples, lattice coordinates, Miller and Miller –Bravais indices for directions and planes, linear density of atoms, planar density of atoms-close packed directions and planes, atomic and ionic packing fractions, densities of metals and ionic structures, covalent structures, close packed structures, crystal structure determination,

Unit 2: **X-ray diffraction:** Powder method, ionic covalent and metallic structures, structure determination of cubic crystals, Ligancy and limiting radii ratio, **Basic thermodynamic functions:** Impure phases, solid solutions, alloys, single phase and multi phase alloys, crystal defects, point imperfections, classification, application of configurational entropy to estimate vacancy concentration and other defect concentrations, defect structures, line imperfections, edge and screw dislocations –their nature, Burgers circuit and Burgers vector, dislocation reaction, dislocation motion, multiplication of dislocations during deformation, role of dislocations in determining crystal properties, twining – surface defects, grains and grain boundary, dislocation energy, stress required to move a dislocation, dislocation density,

Unit 3: **Elasticity, plasticity, stress, strain**: True stress, true strain, Poissons ratio, elastic compliances, strain energy, stress-strain diagrams for ductile and brittle materials, proof stress, yield stress, plastic stress, modulus of elasticity, rigidity, bulk modulus–relationship between the three, plastic deformation, uniform elongation and necking strain hardening, work hardening as strengthening mechanism, plastic deformation by slip-slip systems and planes, critical resolved shear stress (CRSS), cold working, dynamic recovery, re-crystallization, grain growth, grain size and yield stress, Hall-petch equation, single crystal, polycrystalline material, comparison of stress – strain diagrams, anelasticity, elastic after effect, damping, internal friction, energy loss, viscoelasticity, viscoelastic models.

Unit 4: **Composite materials:** Fibrous, particulate, their properties and Young's modulus of composites when axially and transversely loaded, fraction of the load taken by fiber and matrix.

Unit 5: **Fracture, ductile and brittle:** Griffth's criterion for brittle failure, ductile brittle transition temperature, creep, mechanisms of creep, creep resistance materials, creep rate and related equations to find creep rates, fatigue-mechanism-factors to increase fatigue resistance.

Unit 6: **Transition between states of matter:** Energetics of transitioin, structure of solids, nucleation, mechanisms, nucleation rates, homogeneous and heterogeneous nucleation, phase rule, unary, binary phase diagrams, thermal equilibrium diagrams, eutectic, eutectic phase diagrams, Cd-Bi, Pb-Sn, Cu-Ni, Ag-Cu, Fe-C or Fe-Fe_3C-phase transformations, time temperature, transformation curves for eutectoid steels, plain carbon steels, effect of addition of alloying elements on the properties of steels, types of steels used in Chemical industries.

Text books:

1. `Materials Science & Engineering' by V.Raghavan, Prentice Hall of India Ltd, New Delhi.
2. `Elements of Materials Science & Engineering', 5th Edition, Lawrence H.VanVlack, Addision-Weley Publishing Co.

Reference books:

1. Science of Engineering Materials', Vols.1-3, by Manas Chanda, McMillan Company of India, Delhi
2. Principles of Materials Science & Engineering', William F.Smith, McGraw-Hill Publishing Co.
3. Essentials of Materials Science' by A.G. Guy.

Semester VII: Labs

1. CH 707 Process Instrumnetation and Control Lab

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

CO1	Calculate the characteristics of control valves
CO2	Determine the dynamics of level and temperature measurement process
CO3	Determine the dynamics of two capacity liquid level process without interaction and with interaction, U-tube manometer
CO4	Determine the performance of controllers for a flow process, pressure process, level process, temperature process
CO5	Evaluate the performance of cascade control

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	-	-	✓	-	✓	-	-	✓	-	✓	-
CO2	✓	-	-	✓	-	✓	-	-	✓	-	✓	-
CO3	✓	-	-	✓	-	✓	-	-	✓	-	✓	-
CO4	✓	-	-	✓	-	✓	-	-	✓	-	✓	-
CO5	✓	-	-	✓	-	✓	-	-	✓	-	✓	-

List of Experiments:

1. To determine the time constant of given thermometer with positive step change.
2. To determine the time constant of given thermometer with negative step change.
3. To determine the time constant and valve properties of single tank system.
4. To study the step response of two tank non-interacting liquid level system and compare the observed transient response with the theoretical transient response.
5.. To study the step response of two tank interacting liquid level system and compare the observed transient response with the theoretical transient response for the condition $T_1=T_2=T$.
6. To study the impulse response of a tank.

2. CH 708 Process Design, Flow Sheeting, & Simulation

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

CO1	Identify equipment and instruments based on symbols
CO2	Draw process flow diagrams using symbols
CO3	Apply mechanical design aspects to process equipment
CO4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors and filters.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	✓	-	-	✓	-	-	-	-	-	✓	✓
CO2	-	✓	-	-	✓	-	-	-	-	-	-	-
CO3	✓	-	✓	✓	✓	✓	-	-	-	-	-	-
CO4	✓	-	✓	✓	✓	✓	-	-	-	-	-	-

Detailed Syllabus

Unit I: **Mathematical models of chemical engineering systems:** Introduction; Use of mathematical models; Scope of coverage; Principles of formulation; Fundamental laws; Contimuity equation; Energy equation; Equations of motion; Transport equations; Equations of state; Equilibrium; Chemical kinetics.

Unit II: **Examples of Mathematical Models of Chemical Engineering Systems:** Introduction; Series of isothermal, constant holdup CSTRs; CSTRs with variable hold-ups; Two heated tanks; Gas phase pressurized CSTR; Non-isothermal CSTR; Single component vaporizer; Multicomponent flash drum; Batch reactor; Reactor with mass transfer; Ideal binary distillation column; Batch distillation with holdup; pH systems.

Unit III: **General Concepts of Simulation for Process Design:** Introduction; Process simulation models; Methods for solving non-linera equations; Recycle partitioning and tearing; Simulation examples.

Unit IV: Design of Piping network using software tools

Unit V: Design of following equipment using ASPENPLUS software

a. Heat Exchanger
b. Absorption column
c. Distillation column
d. Reactor
e. Evaporator

f. Flow sheeting of a chemical plant
g. Simulation of a small size chemical plant.

Unit VI: Simulation of a chemical plant using AUTOPLANT software.

TEXT BOOK:

1. William L. Luyben – Process Modeling, Simulation and Control for Chemical Engineers – 2nd edition, McGraw Hill International Edition; 1990 (Ch. 1, 2 and 4)
2. Lorentz T. Biegler, E. Ignacio Grossmann and Arthur W. Westerberg – Systematic Methods of Chemical Process Design – Prentice Hall International – 1997.

CH 709 Project Work Satge – I

1. **EACH STUDENT WILL** work on one of the following projects or as directed by the respective guide(s) and submit a comprehensive, typed, and bound report (3-4 Copies) at the end of the semester.

2. **TYPES OF PROJECTS :**

3. **PROCESS BASED PROJECT :** Manufacture of a product with detailing

4. **EQUIPMENT - BASED PROJECT :** Detailed design of the equipment for a given capacity.

5. **EXPERIMENT - BASED PROJECT :** Experimental investigation of a basic or applied research problem.

6. **THE REPORT SHALL CONSIST** of collection of literature, study of the various processes available, selection of the process, computation of material and energy balances, process design of important pieces of equipment, detailed design of experimental set-up, treatment of data, conclusions, bibliography, etc. - as applicable to the individuals problems .

8. DURING THE SEVENTH SEMESTER EACH STUDENT is expected to complete 30 - 40% of the quantum of total work involved in the Project Work. The student will make a power point presentation of his/her progress work before the panel of internal examiners appointed by Head of the Department. The examiners panel will assess the progress of the student's work considering his/her quantum and quality of work completed and presentation skills.

7. **THE BALANCE OF THE WORK** will be continued under course No. CH 805 Project Work (stage II).

CH 710 /CH 610 Industrial Training (Evaluation)

GUIDE LINES:

Each student is expected to spend FOUR weeks in any one factory/project/workshop at the end of sixth semester (during summer vacation). Here he /she shall observe layout, working and use of various machinery, plants, design, instruments, process etc. under the general supervision of the foreman/artisan/engineer of the factory etc.

The student shall submit the report in a systematic technical format about the major field of the factory, particularly about the section/department where he/she has received the training giving details of equipment, machinery, materials, process etc. with their detailed specifications, use etc.,. The report shall be checked and evaluated by the concerned teacher and appropriate grade shall be awarded.

Semester VIII: Electives

CH 801 Elective IX

A. Advanced Materials

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

CO1	Unddrstand the synthesis and properties of nanomaterials
CO2	Evaluate the usefulness of nanomaterials in medicine, biology and sensing
CO3	Unddrstand modeling of composite materials by finite element analysis
CO4	Differentiate between superconducting and other materials
CO5	Understand the characteristics and uses of functional materials

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	✓	-	✓	-	-	✓	-	✓	-	-	-
CO2	-	✓	-	✓	-	-	✓	-	✓	-	-	-
CO3	-	✓	-	✓	-	-	✓	-	✓	-	-	-
CO4	-	✓	-	✓	-	-	✓	-	✓	-	-	-
CO5	-	✓	-	✓	-	-	✓	-	✓	-	-	-

Detailed Syllabus

Unit 1: Nano Materials: Origin of nano technology, Classification of nano materials, Physical, chemical, electrical, mechanical properties of nano materials. Preparation of nano materials by plasma arcing, physical vapour deposition, chemical vapour deposition (CVD), Sol-Gel, electro deposition, ball milling, carbon nano tubes (CNT). Synthesis, preparation of nanotubes, nano sensors, Quantum dots, nano wires, nano biology, nano medicines.

Unit 2: Biomaterials: Overview of biomaterials. Biomaterials, bioceramics, biopolymers, tissue grafts, soft tissue applications, cardiovascular implants, biomaterials in ophthalmology, orthopedicim plants, dental materials.

Unit 3: Composites: General characteristics of composites, composites classes, PMCs, MMCs, CMCs, CCCs, IMCs, hybrid composites, fibers and matrices, different types of fibers, whiskers, different matrices materials, polymers, metal, ceramic matrices, toughening mechanism, interfaces, blending and adhesion, composite modeling, finite element analysis and design.

Unit 4: Optical materials: Mechanisms of optical absorption in metals, semiconductors and insulators. Nonlinear optical materials, optical modulators, optical fibers. Display devices and materials photo-emissive, photovoltaic cells, charge coupled devices (CCD), laser materials.

Unit 5: Super conducting materials: Types of super conductors, an account of mechanism of superconductors, effects of magnetic field currents, thermal energy, energy gap, acoustic attenuation, penetration depth, BCS theory, DC and AC Josephson effects, high Tc superconductors, potential applications of superconductivity, electrical switching element, superconductor power transmission and transformers, magnetic mirror, bearings, superconductor motors, generators, SQUIDS etc.

Unit 6: Smart materials: An introduction, principles of smart materials, input – output decision ability, devices based on conductivity changes, devices based on changes in optical response, biological systems smart materials. Devices based on magnetization, artificial structures, surfaces, hetero structures, polycrystalline, amorphous, liquid crystalline materials. Surface Acoustic Wave (SAW) Materials and Electrets: Delay lines, frequency filters, resonators, Pressure and temperature sensors, Sonar transducers. Comparison of electrets with permanent magnets, Preparation of electrets, Application of electrets..

Text and References

1. T. Pradeep, Nano: The Essentials; TATA McGraw-Hill, 2008.
2. B.S. Murthy et al., Textbook of Nano science and Nanotechnology, University press
3. Krishan K Chawla, Composite Materials; 2nd Ed., Springer 2006.

B. Disaster Management in Chemical Industries

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

CO1	Analyze the effects of release of toxic substances
CO2	Select the methods of prevention of fires and explosions
CO3	Understand the methods of hazard identification and preventive measures
CO4	Assess the risks using fault tree diagram

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	-	✓	-	-	-	-	-
CO2	✓	✓	✓	✓	✓	-	✓	-	-	-	-	-
CO3	✓	✓	✓	✓	✓	-	✓	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	✓	-	-	-	-	-

Unit 1: General aspects of industrial disaster: Due to fire, explosion, toxicity and radiation; Chemical hazards.

Unit 2: Classification of chemical hazards, Chemical as cause of occupational diseases – dust, fumes, gases and vapours.

Unit 3: Hazard analysis and health management; Engineering control of chemical plant hazards – Plant layout, ventilation and lighting.

Unit 4: Pressure vessels, Storage, Handling, Transportation, Electrical systems, Instrumentation.

Unit 5: Emergency planning, Personal protective devices, Maintenance procedure; Emergency safety and laboratory safety; Legal aspects of safety.

Unit 6: Management information system and its application in monitoring disaster, safety and health; Hazop Analysis.

Text Book:

1. H. H. Tawcatt & W S Wood, Safety and Accident Prevention in Chemical Operations.

Reference Books:

2. R. V. Betrabet and T. P. S. Rajan in CHEMTECH-I, Safety in Chemical Industry, Chemical Engineering Development Centre, Madras, 1975.
3. Wells, Safety in Process Plant Design.
4. Less, P. Frank, Loss Prevention in Process Industries.
5. J. Lolb & S. Roy Sterm, Product Safety and Liability.

C. Downstream Processing in Biochemical Industry

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

CO1	Understand the basic principles, approaches and functions of management and identify concepts to specific situations
CO2	Understand marketing management process to discuss marketing mix in formulation of marketing strategies during the life cycle of product
CO3	Outline various techniques for improving productivity using work study
CO4	Understand concepts of quality management and use process control charts concepts and tools of quality engineering in the design of products and controls
CO5	Use and distinguish basic methods/tools of inventory classification and control
CO6	Identify activities with their interdependency and use scheduling techniques of project management PERT/CPM

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	✓	✓	✓	-	-
CO2	-	-	-	-	-	-	-	✓	✓	✓	-	-
CO3	-	-	-	-	-	-	-	✓	✓	✓	-	-
CO4	-	-	-	-	-	-	-	✓	✓	✓	-	-
CO5	-	-	-	-	-	-	-	✓	✓	✓	-	-
CO6	-	-	-	-	-	-	-	✓	✓	✓	-	-

Detailed Syllabus

Unit I: Role Of Downstream Processing In Biotechnology, Role and importance of downstream processing in biotechnological processes. Problems and requirements of bioproduct purification. Economics of downstream processing in Biotechnology, cost-cutting strategies, characteristics of biological mixtures, process design criteria for various classes of bioproducts (high volume, low value products and low volume, high Value products)

Unit II: Physico-chemical basis of bio-separation processes. Recent development in product isolation (for ex. one step purification, reverse Micro cellular extraction on line membrane separation). Primary Separation And Recover Process, Cell disruption methods for intracellular products, removal of insoluble, biomass (and particulate debris) separation techniques, flocculation and sedimentation, centrifugation and filtration methods.

Unit III Membrane separations, Membrane-based separations (micro and ultrafiltration), theory, design and configuration of membrane separation equipment applications,

<u>Unit IV</u>: Enrichment Operations precipitation methods (with salts, organic solvents, and polymers, extractive separations, aqueous two-phase extraction, supercritical extraction), in situ product removal, integrated bioprocessing.

<u>Unit V</u> Electrophoresis, Elecrtrophoresis of proteins and nucleic acids, 1D-2D Gels, Types of Electrophoretic techniques (Capillary and Pulse field), Product Resolution / Fractionation Chromatographic techniques- Paper, TLC, Adsorption, Ion exchange, Gel filtration, affinity chromatographic separation processes, GC, HPLC, FPLC, Chromato focusing electrophoretic separations.

<u>Unit VI</u> New and Emerging Technologies, Dialysis, Crystallization Pervaporation, super liquid extraction foam based separation case study with examples for processing of Two Industrial Products (Citric acid / Penicillin and Low volume high value product like recombinant proteins).

Text Books:

1. Wankat PC. Rate controlled separations, Elsevier, 1990.
2. Belter PA and Cussler E. Bioseparations, Wiley 1985.

References:

1. Product Recovery in Bioprocess Technology, BIOTOL.' Series, VCH, 1990.
2. Asenjo J.M. Separation processes in Biotechnology, 1993, Marcel Dekkere Inc.
3. Bioseparations by Siva Shankar PHI publications

CH 802 Elective X

A. Mathematical Methods in Chemical Engineering

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

CO1	Formulate lumped and distributed parameter mathematical models for chemical processes
CO2	Calculate degrees of freedom for the developed mathematical models
CO3	Solve the model equations describing chemical processes and equipment
CO4	Analyze the results of the solution methods

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	✓	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed Syllabus

Unit I: Mathematical Formulation of the Physical Problems- Introduction, Representation of the problem, blending process, continuous stirred tank reactor,

Unit II: Unsteady state operation, heat exchangers, distillation columns, biochemical reactors.

Unit III: Analytical (explicit) Solution of Ordinary Differential Equations encountered in Chemical Engineering Problems-Introduction, Order and degree, first order differential equations, second order differential equations, Linear differential equations, Simultaneous differential equations, .

Unit IV: Formulation of partial differential equations- Introduction, Interpretation of partial derivatives,Formulation partial differential equations, particular solutions of partial differential equations,Orthogonal functions, Method of separation of variables, The Laplace Transform method, Other transforms.

Unit V: Unsteady state heat conduction in one dimension - Mass transfer with axial symmetry - Continuity equations; Boundary conditions - Iterative solution of algebraic equations- The difference operator - Properties of the difference operator- Linear finite difference equations-

Unit VI: Non-linear finite difference equations- Simultaneous linear differential equations - analytical solutions - Application of Statistical Methods.

Text / References:

1. Rice R. G. and D. Do Duong, ‘Applied mathematics and modeling for chemical engineers’
   John Wiley & Sons, 1995.
2. Jenson J F and G. V. Jeffereys, 'Mathematical Methods in Chemical Engineering', Academic Press, 1977.
3. B. A. Finlayson, 'Introduction to Chemical Engineering Computing', Wiley India Edition, 2010

4. Singaresu S. Rao, 'Applied Numerical Methods for Engineers and Scientists', Prentice Hall, 2002.
5. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall India, 2nd Edition, 2011.

B. Membrane Technology

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

CO1	Understand the technologies of membrane synthesis
CO2	Classify the membranes
CO3	Select membrane according to the application
CO4	Understand the mathematical models of membrane processes

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-
CO2	-	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	-	✓	✓	✓	✓	-	✓	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-

Detailed Syllabus

Unit I: Introduction: Membrane separation process, Definition of Membrane, Membrane types, Advantages and limitations of membrane technology compared to other separation processes, Membrane materials.

Unit II: Preparation of synthetic membranes: Phase inversion membranes, Preparation techniques for immersion precipitation, Synthesis of asymmetric and composite membranes, and Synthesis of inorganic membranes.

Unit III: Transport in membranes: Introduction, Driving forces, Transport through porous membranes, transport through non-porous membranes, Transport through ion-exchange membranes.

Unit IV: Membrane processes: Pressure driven membrane processes, Concentration as driving force, Electrically driven membrane processes

Unit V: Polarisation phenomena and fouling: Concentration polarization, Membrane fouling

Unit VI: Modules: Introduction, membrane modules, Comparison of the module configuration

Text / References:

1. Mulder M, Basic Principles of Membrane Technology, Kluwer Academic Publishers, London, 1996.
2. Richard W. Baker, Membrane Technology and Research, Inc. (MTR), Newark, California, USA, 2004.
3. Kaushik Nath, Membrane Separation Processes, Prentice-Hall Publications, New Delhi, 2008.

C. Process Design Principles

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

CO1	Identify steps in product and process design
CO2	Understand principles of steady-state flow sheet simulation
CO3	Understand heuristics for process synthesis
CO4	Design reactors for complex configurations

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	-	✓	✓	✓	✓	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	✓	-	-	-	-	-	-
CO3	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-
CO4	✓	-	✓	✓	✓	✓	-	-	-	-	-	-

Detailed Syllabus

Unit I: Design Process: Design opportunities, steps in product and Process design, Environmental protection, Safety considerations, Engineering ethics, Role of computers.

Unit II: Molecular Structure Design: Introduction, Property estimation methods, Optimization to Locate molecular structure. Process Creation: Introduction, preliminary Database Creation, Experiments, preliminary Process Synthesis, Development of Base-Case Design.

Unit III: Process Synthesis: Introduction, Principles of Steady-state Flowsheet simulation, Synthesis of the Toluene Hydrodealkylation process, Steady state

Simulation of the Monochlorobenzene Separation Process, Principles of Batch flowsheet Simulation.

Unit IV: Heuristics for Process Synthesis: Introduction, Raw materials and Chemical Reactions, Distribution of Chemicals, Separations, Heat removal from and Addition to Reactors, Heat Exchangers and Furnaces, Pumping, Compression, Pressure Reduction, Vacuum, and Conveying of Solids,

Unit V: Changing the Particle Size of Solids and Size Separation of particles, Removal of Particles from Gases and Liquids.

Unit VI: Reactor Design and Reactor Network Synthesis: Reactor models, Reactor Design for Complex Configurations, Reactor Network Design Using the Attainable region.

Text / References:

1. Sieder, W.D.,Seader J.D. and Lewin D.R., Process Design Principles: Synthesis Analysis and Evaluation, John Wiley & Sons, 3rd Edition, 2008.
2. J.M., Douglas, Conceptual Design of Chemical Processes, McGraw Hill International Editions, 1988.
3. Loren T Biegler, Grossman E.I., Westerberg, Systematic Methods of Chemical Process Design, A.W. Prentice Hall Intl ed,1997

CH 803 Elective XI

A. Pulp and Paper Technology

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

CO1	Explain process for manufacturing paper
CO2	Understand harmful impacts of paper and pulp industries on environment.
CO3	Understand mechanical pulping, Chemi-thermo-mechanical processes, chemical pulping
CO4	Understand methods for pulp treatment

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	-	-	✓	-	✓	-	-	-	-	-
CO2	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO3	✓	✓	-	-	✓	-	✓	-	-	-	-	-
CO4	✓	✓	-	-	✓	-	✓	-	-	-	-	-

Detailed Syllabus

Unit I: Introduction: History of Paper Making, Technological Advancements, Global and Indian Market Situation. Paper making raw materials: Wood anatomy and chemistry, Wood chip preparation and handling at the pulp mill, Solid wood measurement, Properties of selected wood species.

Unit II: Pulping processes: Introduction to pulping, Mechanical pulping, Chemical pulping, Semi-chemical pulping, Soda pulping, Kraft pulping, Sulfite pulping, Other pulping methods.

Unit III: Pulp treatment: Bleaching mechanical pulps, Measurement of lignin content, Bleaching chemical pulps, Chemical recovery, Refining, Pulp characterization.

Unit IV: Paper making equipment and process: Fiber preparation and approach, Raw materials, Functional additives, Control additives, Wet end chemistry, Paper manufacture, Paper machine, headbox, fourdrinier wet end, Twin wire formers, cylinder machine, press section, dryer section, Post drying operations, Coating.

Unit V: Environmental protection: Water pollution, Water quality tests, Aqueous effluent treatments, Air pollution, Air quality tests and control, Solid waste disposal.

Unit VI: Properties of paper: General grades of paper, Structure, Mechanical and chemical properties, Basic optical tests of paper.

Text / References:

1. J.P. Casey, Pulp and Paper: Chemistry and Chemical Technology, 3rd Edition, Volumes 1 & 2., Wiley Interscience, 1980
2. G.A. Smook, Handbook for Pulp and Paper Technologists, 3rd Edition, Angus Wilde Publ, Inc, 2002.
3. Christopher J. Biermann, Handbook of Pulping and Paper Making, Academic Press, 1996.

B. Heat Transfer Equipment Design

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

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	-	-	✓	-	✓	-	-	-	-	-
CO2	✓	✓	-	-	-	-	✓	-	-	-	-	-
CO3	✓	✓	-	-	✓	-	✓	-	-	-	-	-
CO4	✓	✓	-	-	✓	-	✓	-	-	-	-	-

Detailed Syllabus

Unit 1: Detailed Process Design of Double Pipe Heat Exchangers

Unit II: Detailed Process Design of Shell and Tube heat exchanger

Unit III: Detailed Process design of condenser

Unit IV: Detailed Process Design of Evaporator

Unit V: Detailed process design of Agitator

Unit VI: Detailed process design of Reboiler

Text/Reference books:

1. J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergamon press, 1970
2. D. Q. Kern, "Process Heat Transfer", McGraw Hill, 1950.

Practicals

All above designs will be manually calculated and then verified using Aspen Plus software.

C. Advanced Petroleum Refining

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

CO1	Understand different refinery processes
CO2	Understand secondary gasoline manufacturing processes
CO3	Evaluate and compare different processes
CO4	Understand synthesis and working of zeolite

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Detailed Syllabus :

UNIT I

Coking and thermal processes- Types, properties and uses of petroleum coke, process description for delayed coking and fluid bed coking, case study problem.

UNIT II

Catalytic Cracking– Fludized bed catalytic cracking, New design of FCC units, cracking reactions, Coking of cracking catalyst, process variables, heat recovery, yield estimation, capital and operating cost, case study problem on catalytic cracker.

UNIT III

Catalytic Hydrocracking- Hydrocracking reactions, feed preparation, process description, hydrocracking catalyst, process variables, hydrocrcking yield, investment and operating cost, case study problem on hydrocracker.

UNIT IV

Hydroprocessing and residprocessing- Composition of vacuum tower bottoms, process options, hydroprocessing, expanded bed hydrocracking processes, moving bed hydroprocessors, solvent extraction, summary of resid processing operations.

Hydrotreating- Hydrotreating catalyst, aromatic reduction, reactions, process variables, construction and operating cost, case study problem on hydrotreator.

UNIT V

Catalytic reforming and isomerization- Feed preparation, catalytic reforming processes, reforming catalysts, reactor design, yields and costs.

Isomerization – Capital and operating costs, isomerization yield, case study problem on Reformer and isomerization unit.

UNIT VI

Alkylation and polymerization– Alkylation reactions, process variables, alkylation feed stocks, alkylation products, HF and sulfuric acid alkylation process, comparison between the processes, alkylation yields and costs, co-polymerization , case study problem on alkylation and polymerization.

Text Book:

Reference Book:

1. J. H. Gary, “Petroleum Refining - Technology and Economics” 3rd Ed., Marcel DekkarInc, 1994

2. G. D. Hobson, “Modern Petroleum Technology” Vol. I & II, 5th Ed., Applied Science, London

CH 804 Elective XII

A. Entrepreneurship Development

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

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work
CO4	Develop a framework for technical, economic and financial feasibility
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	✓	✓	✓	-

CO2	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO3	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO4	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO5	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO6	-	-	-	-	-	-	-	-	✓	✓	✓	-

Detailed Syllabus

Unit I: Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Unit II: Establishing Small Scale Enterprise: Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

Unit III: Planning a Small Scale Enterprises**:** Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

Unit IV: Operational Issues in SSE**:** Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Unit V and VI: Performance appraisal and growth strategies**:** Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Text and References:

1. G.G. Meredith, R.E.Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
2. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
3. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
4. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd ed., Pearson Edu., 2013.

B. Management Information Systems

CO1	Determine key terminologies and concepts including IT, marketing, management economics accounting, finance in the major areas of business
CO2	Design, develop and implement Information Technology solutions for business problems
CO3	Analysis of computing systems and telecommunication networks for business information systems
CO4	Plan projects, work in team settings and deliver project outcomes in time.
CO5	Understand ethical issues that occur in business, evaluate alternative courses of actions and evaluate the implications of those actions

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	✓	✓	-	-
CO2	-	-	-	-	-	-	-	-	✓	✓	-	-
CO3	-	-	-	-	-	-	-	-	✓	✓	-	-
CO4	-	-	-	-	-	-	-	-	✓	✓	-	-
CO5	-	-	-	-	-	-	-	-	✓	✓	-	-

Detailed Syllabus:

Unit I: Organization and Information Systems, Foundation Concepts, Information Systems in Business, The Components of Information Systems, Competing with Information Technology, Fundamentals of Strategic Advantage, Using Information Technology for Strategic Advantage. Changing Environment and its impact on Business, Kinds of Information Systems.

Unit II: Computer Fundamentals, Computer Hardware, Computer Systems: End User and Enterprise Computing, Computer Peripherals: Input, Output, and Storage Technologies, Computer Software, Application Software, System Software, Computer System Management, Data Resource Management, Technical Foundations of Database Management, Managing Data Resources

Unit III: Telecommunication and Networks, Telecommunications and Networks, The Networked Enterprise, Telecommunications Network Alternatives

Unit IV: System Analysis and Development and Models, Developing Business/IT Strategies, Planning Fundamentals, Implementation Challenges, Developing Business/IT Solutions, Developing Business Systems, Implementing Business Systems

Unit V: Manufacturing and Service Systems Information systems for Accounting, Finance, Production and Manufacturing, Marketing and HRM functions, Enterprise Resources Planning (ERP), Choice of IT, Nature of IT decision, Managing Information Technology, Managing Global IT,

Unit VI: Security and Ethical Challenges, Security and Ethical Challenges, Security and Ethical, and Societal Challenges of IT, Security Management of Information Technology, Enterprise and Global Management of Information Technology

Text / References:

1. Kenneth J Laudon, Jane P. Laudon, *Management Information Systems*, 10th Edition, Pearson/PHI, 2007.
2. W. S. Jawadekar, *Management Information Systems*, 3rd Edition, TMH, 2004.

C. Corporate Communication

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

CO1	Understand corporate communication culture
CO2	Prepare business letters, memos and reports
CO3	Communicate effectively in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Practice corporate email, mobile and telephone etiquette
CO6	Develop good listening skills and leadership qualities

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO2	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO3	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO4	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO5	-	-	-	-	-	-	-	-	✓	✓	✓	-
CO6	-	-	-	-	-	-	-	-	✓	✓	✓	-

Detailed Syllabus:

Unit I: Importance of Corporate communication: Introduction to and definition of corporates – Communication, process, patterns and channels of communication- Barriers to communication and strategies to overcome them- Evolution of corporate culture- Role and contribution of individual group and organization - Role of psychology in communication.

Unit II: Oral Communication: Techniques for improving oral fluency-Speech mechanics-Group Dynamics and Group Discussion – Debate and oral presentations. Written Communication: Types and purposes- Writing business reports, and business proposals- Memos, minutes of meetings- Circulars, persuasive letters- Letters of complaint- ; language and formats used for drafting different forms of communication. Internal and external communication.

Unit III: Corporate responsibility: Circulating to employees' vision and mission statements- ethical practices- Human rights -Labour rights-Environment- governance- Moral and ethical debates surrounding -Public Relations - Building trust with stakeholders.

Unit IV: Corporate Ethics and Business Etiquette: Integrity in communication-Harmful practices and communication breakdown- Teaching how to deal with tough clients through soft skills. Body language- Grooming- Introducing oneself- Use of polite language- Avoiding grapevine and card pushing – Etiquette in e-mail, mobile and telephone.

Unit V: Listening Skills: Listening- for information and content- Kinds of listening- Factors affecting listening and techniques to overcome them- retention of facts, data and figures- Role of speaker in listening.

Unit VI: Leadership Communication Styles: Business leadership -Aspects of leadership- qualities of leader- training for leadership-delegation of powers and ways to do it-humour- commitment.

Text / References:

1. Raymond V. Lesikar, John D. Pettit, Marie E. Flatley Lesikar's Basic Business Communication - 7th Edition: Irwin, 1993
2. Krishna Mohan and Meera Banerji, Developing Communication Skills: Macmillan Publishers India, 2000
3. R.C. Sharma & Krishna Mohan Business Correspondence and Report Writing: – 3rd Edition Tata McGraw-Hill, 2008
4. Antony Jay & Ross Jay, Effective Presentation, University Press, 1999.
5. Shirley Taylor, Communication for Business, Longman, 1999

CH 805 Project Work Satge – II

This is the continuation of work started under course No. CHE 708 Project Work (Stage I). Every student will have to submit a detailed report (4 copies) of the Project Work as per the standard format prescribed by the department within the deadline announced by the Department. The students will make a power point presentation of their Project Work before a panel of Examiners comprising of guide and external examiner. The examiners panel will assess the performance of the students considering their quality of work and presentation skills.

1