FACULTY OF ENGINEERING

Syllabus for the

B.E (Chemical Engineering) 2008 Course

(w.e.f 2011-2012)

UNIVERSITY OF PUNE

TERM – I

Subject Code No.	Subject	Teaching Scheme			Examination Scheme				Total
		Theory	Practical	TW/ Drawing	Paper	Practical	Oral	TW	
409341	Elective – I	4		2	100		50		**150**
409342	Elective- II	4			100				**100**
409343	Process Dynamics and Control	4	2		100	50			**150**
409344	Chemical Reaction Engineering II	4			100				**100**
409345	Chemical Engineering Design II	3		2	100		50		**150**
409346	Computer Aided Chemical Engineering II		4				50		**50**
409347	Industrial Training II (Evaluation)							50	**50**
409348	Project			2					**-**
	Total	**19**	**6**	**6**	**500**	**50**	**150**	**50**	**750**

TERM – II

Subject Code No.	Subject	Teaching Scheme			Examination Scheme				Total
		Theory	Practical	TW/ Drawing	Paper	Practical	Oral	TW	
409349	Elective – III	4			100				**100**
409350	Elective – IV	4			100				**100**
409351	Process Modeling and Simulation	4	2		100		50	50	**200**
409352	Process Engineering Costing & Plant Design	4		4	100		50	50	**200**
409348	Project			6			50	100	**150**
	Total	**16**	**2**	**10**	**400**		**150**	**200**	**750**

List of elective subjects:

Subject Code No	**Elective I**	Subject Code No	**Elective II**
409341	Environmental Engineering	409342	Chemical Process Synthesis
	Membrane Technology		Advanced Materials
	Bioprocess Engineering		Polymer Technology
	Corrosion Engineering		Piping Design & Engineering
			Advance Separation Processes
			Petroleum Refining

Subject Code No	**Elective III**	Subject Code No	**Elective IV**
409349	Artificial Intelligence In Chemical Engineering	**409350**	Standardization and Quality Assurance in Chemical Process Industry
	Energy Conservation In Chemical Process Industries		Catalysis
	Chemical Process Safety		Nanotechnology
	Food Technology		Fuel Cell Technology
			Petrochemical Engineering
			Computer Aided Process Control
			Open Elective*

L: Lecture Th: Theory TW: Term Work Pr: Practical Or : Oral

*** Open Elective should be based on any Industry need with prior approval of BOS Chemical Engineering**

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-I

409341: ENVIRONMENTAL ENGINEERING

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks
Seminar: 2 hrs/week	Oral: 50 Marks

Unit – I: Introduction

An overview of environmental engineering, pollution of air, water and soil, impact of population growth on environment, environmental impact of thermal, hydro and nuclear energy, chemical pollution, solid wastes, prevention and control of environmental pollution, water and air pollution laws and standards, clean development mechanisms (CDM), Kyoto Protocol. **(6 Lectures)**

Unit – II: Air Pollution- Sources, Effects and Measurement

Definition of air pollution, sources scales of concentration and classification of air pollutants. Effects of air pollutants on human health, plants, animals, materials, Economic effects of air pollution, Sampling and measurement of air pollutants, Air pollution control standards: WHO, BIS, MPCB, CPCB. **(6 Lectures)**

Unit – III: Air Pollution Control Methods and Equipment

Particulate pollution: cleaning methods, collection efficiency, particulate collection systems, Basic design and operating principles of settling chamber, cyclone separator, fabric filter, electrostatic precipitator. Operating principles of spray tower, centrifugal scrubber, venturi scrubber. Selection of particulate collector. Gaseous pollution: Principles of control by absorption, adsorption, combustion or catalytic oxidation, removal of SOx, NOx. Numerical problems based on the theory. **(12 Lectures)**

Unit – IV: **Water Pollution**

Domestic and industrial wastewater, types, sources and effects of water pollutants.

Waste water characteristics–DO, BOD, COD, TOC, total suspended solids, colour and odour, bacteriological quality, oxygen deficit, determination of BOD constants. Water quality standards: ICMR, WHO, MPCB and CPCB **(4 Lectures)**

Unit – V: Wastewater Treatment

Principles of primary treatment and secondary treatment, process design and basic operating principles of activated sludge (suspended growth) process, sludge treatment and disposal, trickling filter. Advanced methods of waste water treatment: UASB, photo catalytic reactors, wet-air oxidation, and biosorption. **(8 Lectures)**

Unit – VI: Tertiary Water Treatment and Solid Waste Management:

Tertiary treatment: disinfection by chlorine, ozone and hydrogen peroxide, UV rays, recovery of materials from process effluents, micro-screening, biological nitrification and denitrification, granular medium filtration.

Land Pollution: Sources and classification of solid wastes, disposal methods, incineration, composting, recovery and recycling. **(6 Lectures)**

Seminars:

Seminar should be based on theory. Students may undertake studies in design and development, analysis, synthesis, construction and fabrication of equipments, treatment plants. Critical review on product or system, generation of new concept, idea and improvement in existing process related to the subject. **Visits to wastewater Treatment plant, Common Effluent Treatment Plant, Solid Waste Management Sites etc. should be arranged** Term work should be based on the technical report on these studies carried out by individual or a small group of students. Modern audio-visual techniques may be used at the time of presentation.

References:

1. Rao C.S. "Environmental Pollution Control Engineering", Wiley Eastern Publications.
2. Metcalf and Eddy "Wastewater Engineering", Tata McGraw Hill Publishers.
3. Mahajan S.P. "Pollution Control in Process Industry", Tata McGraw Hill Publishers
4. MyCock "Handbook of Air Pollution".
5. Flagan R.C. and Seinfield J.H. "Fundamentals of Air Pollution Engineering"
6. Peavy H.S. and Rowe D.R. and Tchobanoglous G. "Environmental Engineering"
7. Martin Crowford " Air Pollution Control theory"
8. Stern "Air Pollution", Vol.-I and Vol.-II.
9. G.Kiely, Environmental Engineering, McGraw Hill 1997.

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-I

409341: MEMBRANE TECHNOLOGY

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks
Seminar: 2 hrs/week	Oral: 50 Marks

Unit I:. Introduction: Separation processes, introduction to membrane processes, history, definition of a membrane, membrane processes. **Materials and Material Properties**: Introduction, polymers, stereoisomerism, chain flexibility, molecular weight, chain interactions, state of the polymer, effect of polymeric structure on Tg, glass transition temperature depression,

Unit II. Preparation of Synthetic Membranes: Introduction, preparation of synthetic membranes, phase inversion membranes, preparation technique for immersion precipitation, preparation technique for composite membranes,

Unit IV. Characterization of Membranes: Introduction, membrane characterization, characterization of porous membranes, characterization of ionic membranes, characterization of non porous membranes.

Unit V . Transport in Membranes: Introduction, driving forces, non equilibrium thermodynamics, transport through porous, non porous, and ion exchange membranes. Membrane Processes: Introduction, osmosis, Pressure driven membrane processes, concentration driven membranane electrically driven processes, membrane reactors.

Unit VI . Polarization phenomenon and fouling: introduction, concentration polarization, turbulence promoters, pressure drop, gel layer model, osmotic pressure model, boundary layer resistance model, concentration polarization in diffusive membrane separations and electro dialysis, membrane fouling, methods to reduce fouling, compaction. Module and process design**:** Introduction, plate and frame model, spiral wound module, tubular module, capillary module, hollow fiber model, comparison of module configurations.

Texts

1) M.H.V. Mulder, Membrane Separations. Kluwer Publictions

References:

2). S.P. Nunes, and K.V. Peinemann, membrane Technology in the chemical industry, Wiley-VCH.

3) R. Rautanbach and R.Albrecht, Membrane Process, John Wiley & Sons.

4). R.Y.M. Huang, Perevoparation Membrane Separation Processes, Elsevier.

5). J.G. Crespo, K.W. Boddekes, Membrane Processes in Separation and Purification, Kluwer Academic Publications.

6). Larry Ricci and the staff of chemical engineering separation techniques, Mc Graw Hill publications.

Seminars:

Seminar should be based on theory. Students may undertake studies in design of equipment, treatment plants. Plant visits may be encouraged. Term work should be based on the technical report on these studies carried out by individual or a small group of students. Modern audio-visual techniques may be used at the time of presentation.

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-I

409341: BIOPROCESS ENGINEERING

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks
Seminar: 2 hrs/week	Oral: 50 Marks

Unit I: Introduction to biomass Bio-chemicals: Introduction to structure of cells, important cell of types, growth of microbial cells. Bio-chemicals: Primary, secondary, tertiary structure of biomacromolecules such as lipids, sugars and polysaccharides, nucleotides, RNA, DNA, amino acids, proteins, hybrid biochemical etc interactions of these molecules, structure and functions of biomembranes, Osmoregulations interacting toxins. **(8 Lectures)**

Unit II: Applications of Bioprocesses in Chemical Industry:
Discuss manufacturing process for major products produced by biochemical reactions such as penicillin, vitamins A, alcohol, acetic acid and vinegar, acetone, lactic acid, citric acid, wine, proteins. Aerobic and anaerobic waste-water treatment. **(8 Lectures)**

Unit III: Kinetics of Enzyme catalyzed reactions:
Enzyme substrate complex and enzyme action with example from industrial enzymes, simple enzyme, kinetics with one and two substrate.
Michaelis-Menten kinetics. Models of enzymes kinetics with brief introduction, substrate activation and inhibition. Multiple substrates reacting on a single enzyme.
Protein denaturation by chemical agent and heat. Numerical problems based on theory.
(10 Lectures)

Unit IV: Applied Enzyme Catalysis:
Kinetics of substrate utilization, production formation and biomass production in cell cultures. Cell in cell culture system. Computer application for kinetics developments. Numerical problems based on theory. **(8 Lectures)**

Unit V: Transport Phenomena in bioprocess system:
Modification in the design and analysis of chemical reactor as biological reactors. Computerized simulation of bioreactor. Fed batch reactor, CSTR plug flow reactors, Reactor dynamics, reactor with non-ideal mixing sterilization of reactors, immobilized biocatalyst, multiphase bioreactors, fermentation technology.
(10 lectures)

Unit VI: **Product recovery operations and Bioprocess economics**:
Dialysis, Reverse osmosis, ultra-filtration, and Micro-filtration, Chromatography, electrophoresis, electro dialysis, crystallization and drying. Bioprocess economics.
(10 Lectures)

Seminars:
Seminar should be based on theory. Students may undertake studies in design of equipment, treatment plants. Plant visits may be encouraged. Term work should be based on the technical report on these studies carried out by individual or a small group of students. Modern audio-visual techniques may be used at the time of presentation.

References:

1 Bailey, James E Ollis, Davis F: "Biochemical Engineering", McGraw Hill.
2 Aiba A-Humphery A.E., Mills N.F., "Biochemical Engineering", Academic Press.
3 Atkinson B.," Biochemical Reactors", Pion Ltd. London.
4 Ghosh T.K., et. Al., "Advances in Biochemical Engineering", Vol.1/3, Springer Verlag 1971-74
5 Biochemical and Biological Engineering science, Vol. 1 and 2.
6 Wingard L.B., "Enzyme Engineering", Fr. Interscience N.Y. 1972.
7 Shular and Kargi "Bioprocess Engineering" Prantice-Hall 2nd Ed. 2003.

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-I

409341: CORROSION ENGINEERING

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks
Seminar: 2 hrs/week	Oral: 50 Marks

Unit I: Introduction and Scope: Corrosion: Definition, wet and dry corrosion, mechanism, electro-chemical principles and aspects of corrosion, Faradays laws, specific conduction, specific resistance, transport no. mobility etc. Various forms of corrosion, a brief review of corrosion. Rate expressions. Thermodynamic aspects of corrosion, equlibrium potential, Narnst equation for electrode potential. EMF series, overvoltage, application of Nernst equation to corrosion reactions, calculation of corrosion rates.[10]

Unit II: Polarisation and corrosion potentials: Reference electrodes for corrosion measurements, types of polarisation, concentration, activation and resistance polarisations, Tafel equation, Tafel constant, Evans Diagrams. Anodic control, cathodic control, mixed control. Pourbaix-diagram for Fe -H2O system. [8]

Unit III: Galvanic corrosion, uniform attack, pitting corrosion, dezincification, cavitation, erosion, fretting corrosion, intergranular and stress corrosion cracking. Remedial measures for the above. [8]

Unit IV: High temperature oxidation, Pilling Bedworth ratio, mechanisms of Oxidation, corrosion, testing procedures and evaluation: Corrosion of iron and steel in Aqueous media, Effect of velocity, temperature and composition of media. [8]

Unit V: Prevention techniques, modification of the material by alloying, appropriate heat treatment. Chemical and Mechanical methods of surface treatment coatings - metallic, non-metallic linings, cathodic protection, passivity and anodic protection. [8]

Text Books:

1. Corrosion Engineering by Fortana and Greena.
2. Corrosion and Corrosion Control, H.H. Uhllg.

Reference Books:

1. Electrochemistry by Samuel Glasstone.

Seminars:

Seminar should be based on theory. Students may undertake studies in design of equipment, treatment plants. Plant visits may be encouraged. Term work should be based on the technical report on these studies carried out by individual or a small group of students. Modern audio-visual techniques may be used at the time of presentation.

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-II

409342: CHEMICAL PROCESS SYNTHESIS

Teaching Scheme
Lecture: 4 hrs/week

Examination Scheme
Paper: 100 Marks

Unit I: Introduction Of Chemical Process Design:
Introduction, Approach to Process Development, Development of New Process, Different Considerations, development of Particular Process, Overall Process design, Hierarchy of Process Design, Onion Model, Approach to Process Design.
(8 Lectures)

Unit II: Choice Of Reactor:
Reaction Path, Types of Reaction Systems, Reactor Performance, Idealized Reactor Models, Reactor Concentration, Temperature, Pressure, Phase, Catalyst
(8 Lectures)

Unit III: Choice Of Separator:
Separation of Heterogeneous Mixtures, Separations of Homogeneous Mixtures, Distillation, Azeotropic Distillation, Absorption, Evaporation, Drying etc.
(6 Lectures)

Unit IV: Distillation Sequencing:
Distillation Sequencing using simple columns, Heat Integration of Sequences of Simple Distillation Columns, Distillation Sequencing using thermal coupling, Optimization of Reducible Structure **(10 Lectures)**

.**Unit V : Heat Exchanger Network And Utilities:**
Energy Targets, Composite Curves, Heat Recovery Pinch, Threshold Problems, Problem Table Algorithm, Process Constraints, Utility Selection, Furnaces, Combined Heat and Power, Integration of Heat Pump, Integration of Refrigeration Cycles, Overall Heat Exchanger Network and Utilities **(10 Lectures)**

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Unit VI: Safety And Health Considerations:
Fire, Explosion, Toxic Release, Intensification of hazardous Materials, Attenuation of Hazardous Materials, Quantitive Measures of Inherent Safety, Overall Safety and Health Considerations. **(6 Lectures)**

References:

1. Chemical Process Design, Robin Smith.
2. Conceptual Design of Chemical Process-James Douglas
3. Unit process in organic synthesis –P.H. Grogins

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-II

409342: ADVANCED MATERIALS

Teaching Scheme
Lecture: 4 hrs/week

Examination Scheme
Paper: 100 Marks

Unit I: Advanced Metallic Systems. Steels for special applications, Austempered Ductile Iron. **(5 Lectures)**

Unit II: Advanced Polymeric Materials. New polymeric materials such as Kevlar, Nomex, UHMWPE and Fiber Technology. **(5 Lectures)**

Unit III: Advanced Ceramic Materials. Advanced powder synthesis techniques. Advanced processing methods. Microstructural design and grain boundary engineering. Case studies. **(4 Lectures)**

Unit IV: Introduction to Composite Materials, Factors influencing the properties of composite materials like fiber parameter, matrix, interface & molding methods . Phase selection criteria. Reinforcing mechanisms. Interfaces, advantages and disadvantages. Polymer Composites. Reinforcing and matrix materials. Prepregs. Fiber winding techniques. Fabrication techniques. Laminates. Mechanical behaviour, etc.
(6 Lectures)

Unit V: Metal Composites. Types of reinforcement. Chemical compatibility. Fabrication processes. Mechanical behaviour and properties. Ceramic Composites. Matrices and reinforcement. Why to reinforce ceramics. Fabrication methods. Crack propagation and mechanical behaviour. **(6 Lectures)**

Unit VI: Carbon composites, their properties, fabrication methods and their applications. Ablative polymers, their applications, air craft materials, Introduction to Nanomaterials. Synthesis & Characterization of nanomaterial, application of nanomaterials with special reference to Chemical Engineering. **(9 Lectures)**

References

1. Richorson R.W., Modern Ceramic Engineering, (Marcel Dekker)
2. Composites , Chawala K.K.
3. FRP Technology, Weatherhead.
4. Engg. Polymers, Dyson R.W.
5. Polymers of high technology, electronics and photonics, Bowden M.J & Tumber S.R.

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-II

409342: POLYMER TECHNOLOGY

Teaching Scheme
Lecture: 4 hrs/week

Examination Scheme
Paper: 100 Marks

Unit – I

Introduction and Classification of Polymers. Thermosets, Thermoplastics, Linear Branch, Cross Linked Polymers. Factors influencing the polymer properties. **(6 Lectures)**

Unit – II

Addition & Condensation polymers, Polymerization Techinques, Bulk Solution Suspension, Emulsion, Interfacial Polymerization with their merits & Demerits. **(6 Lectures)**

Unit – III

Molecular Weights, Mn, Mw, Mv, Polydispersity Index. Different Methods of determination of Molecular weight. Effect of Molecular weight on Engg. Properties of Polymers, Numerical based on theory. **(8 Lectures)**

Unit – IV

Kinetics of free radical polyumerization (initiation propagation & termination.) Chain transfer agents. Kinetic of Step growth polymerization. Copolymers & its Kinetics Coordination Polymerization. **(6 Lectures)**

Unit – V

Polymer additives, compounding. Fillers plastisizers lubricants colourants UV stabilizers, fire retardants, antioxidants. Different moulding methods of polymers. **(6 Lectures)**

Unit – VI

Manufacturing of typical polymers with flow-sheet diagrams, their properties & applications : PE, PP, PS, PPO, Teflon Polyesters, Nylons, Kevlar, Nomex. Thermosets like Epoxies, unsaturated polyesters, phenolics, vinyl esters, cynate esters etc.Elastomers like natural rubber, butyl, neoprene, Bunas Silicons, Thiokol etc. **(10 Lectures)**
Numerical/Problems based on Theory

References:

1. Principals of Polymerization, Odion G.G., MaGraw Hill.
2. Text Book of Polymer Science, Billmer F.W, John Wiley & Sons.
3. Polymer Science, Gowarikar et al.
4. Text Book of Polymer Science, F. Rodrigues.
5. Polymer Science & Technology, Fried J.R., PHI.
6. Rubber Technology & Manufacturing, Blow C.M., Hepbun C.
7. Synthetic Rubbers Chemistry & Technology, D.C. Blackly.
8. Plastics by Brydson.

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-II

409342: PIPING DESIGN AND ENGINEERING

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Line sizing and optimization

A brief revision covering friction factor, pressure drop for flow of non-compressible and compressible fluids, (Newtonian Fluids), pipe sizing, economic velocity. Pipe line networks and their analysis for flow in branches, restriction orifice sizing. Non-Newtonian fluids – types with examples, pressure drop calculations for Non-Newtonian fluids. **(6 Lectures)**

Unit II : Materials for Piping system

Desirable properties of piping materials, materials for low, normal and high temperature services, materials for corrosion resistance. Common ASTM and IS specifications for: Seamless / ERW pipes, pipe fittings, flanges, and fasteners, materials for valves. Gaskets: Functions and properties, types of gaskets and their selection. **(6 Lectures)**

Unit III: Types of Valves, Control Valves, Safety Valves, Constructional features, Criteria for selection. Piping components. Safety valves and other pressure relieving devices, constructional features, selection criteria. **(6 Lectures)**

Unit IV: Piping System Design

Two phase flow, types of two phase flow, two phase flow as encountered in piping for steam, distillation column, related aspects of two phase flow such as pressure drop, vibrations. Important system characteristics and design principles related to steam flow at high and low pressures. Calculations for line sizing, steam traps, P.R.V. & condensive systems. Design principles and line sizing for vacuum pipelines, slurry pipelines, surge drums and flare stacks, vacuum devices including ejector system. Classification of pumps, compressors, fans and blowers. Considerations governing pump selection, analysis of system and pump characteristics in connection with series, parallel flow, minimum flow and equalizing lines, NPSH, allowable nozzle loads in various codes.

Design principles and line sizing of pneumatic conveying of solids, components of conveying systems, dust and fume extraction systems principles. **(12 Lectures)**

Unit V : Piping Layouts

Introduction to P & I Diagrams, Process flow diagrams, standard symbols and notations. Introduction to various facilities required guidelines for Plot Plan / Plant Layout.

Introduction to equipment layout, piping layout, piping isometrics and bill of material (Material take off exercise).

Typical piping system layout considerations for following systems:

(i) Distillation systems and heat exchangers
(ii) Reactors
(iii) Pipe racks
(iv) Storage tanks
(v) Pumps **(8 Lectures)**

Unit VI: (Thermal Insulation for Piping) / Costing of Piping

Purposes of Thermal Insulation. Principles of conductive and convective heat transfer to the extent of application to heat loss / gain through bare pipe surfaces. Critical thickness of insulation, estimating thickness of insulation, optimum thickness of insulation. Insulation for hot and cold materials and their important properties, insulation material selection criteria, typical insulation specification – hot and cold materials.

(8 Lectures)

References:

1. Piping Design Handbook by John J. Mcketta, by Marcel Dekker, Inc, New York.
2. Process plant layout and piping design by Ed Bausbacher & Roger Hunt (PTK Prentice Hall Publication)
3. Piping Handbook Edited by Mohinder Nayyar
4. Pipe Drafting and Design by Roy A Parisher & Robert A. Rhea.
   ASME Codes 31

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-II

409342: ADVANCED SEPARATION PROCESSESS

Teaching Scheme
Lecture: 4 hrs/week

Examination Scheme
Paper: 100 Marks

UNIT I: General Principle, Temperature swing adsorption (TSA) Pressure swing adsorption (PSA), Liquid Chromatography processes- basic concepts, phenomena and their characterization, Chromatography options, separation systems, characteristics of solids and their selection for various applications, column design and filling, applications of chromatography in separation of enzymes and proteins, industrial examples. **(9 Lectures)**

UNITII: Membrane Separation Process:
Introduction, Principle classification, types of membranes, mechanisms of separation in MF,UF,RO, dialysis, electro dialysis, pervaporation, gas permeation,fouling,liquid emulsion membranes, industrial applications. **(9 Lectures)**

UNIT III: **Reactive Separations**
Separation based on reversible chemical complexation, reactive distillation, reactive extraction, reactive crystallization. **(7 Lectures)**

UNIT IV: Bubble and Foam Separations:
Foam formation, Collapse and drainage phenomena, and equipments, adsorption properties of foams, modes of operation of foam fractionation equipments, principle of froth flotation, properties of foam related to flotation operation, design and development of flotation equipment, applications to protein and enzyme separation and waste water treatment. **(11 Lectures)**

UNIT V :Zone electrophoresis, Zone refining, Molecular sieves, Adductive crystallization. **(7 Lectures)**

UNIT VI : Ultra centrifugation, recoil methods, Exchange reactions, ring oven technology, Selection of separation processes with case studies. **(7 Lectures)**

References :

1) Mulder M. "Basic Principles of Membrane Technology", Luksvar Academic.
2) Richardson – Coulson "Chemical Engineering Vol- 3 ", Pargmon.
3) Treybal," Mass transfer Operations", Mc GRaw Hill Publication.
4) Rousseau, "Handbook of Separation Process Technology", Wiley –Interscience.
5) M.N. Sasteri, "Separation Methods" , Himalaya Publishing House.
6) Schweitzer, "Separation Techniques for chemical engineers", Mc Graw – Hill Publications.
7) King C. J. Separation Techniques.

B.E. CHEMICAL (SEMESTER I)

ELECTIVE-II

409342: PETROLEUM REFINING

Teaching Scheme
Lecture: 4 hrs/week

Examination Scheme
Paper: 100 Marks

Unit I. Petroleum composition, specifications of petroleum and some petroleum products such as LPG, Gasoline, Kerosene, Diesel oil and Engine oil. **(8 Lecturers)**

Unit II. Pre- refining operations such as, Settling, Moisture removal, Storage, Heating through exchangers and pipe seal heaters, Atmospheric distillation, Vacuum distillation. **(8 Lecturers)**

Unit III. Significant conversion units such as, Reforming, Cat-Cracking, Hydro-cracking and coking. **(8 Lecturers)**

Unit IV. Refining of petroleum products such as Acid refining, Chemical refining, Hydro-refining, HDS, HDM, HAD. **(8 Lecturers)**

Unit V. Blending, Additives, Storage of products, Transportation, Safety norms, House keeping, Marketing of petroleum and petroleum products. **(8 Lecturers)**

Unit VI. Recent trends in petroleum in terms of Distillation, Packing materials, Catalyst , etc. **(8 Lecturers)**

References:

1. Gary J H, Handwerk G E, 'Petroleum refining'.
2. Speight J G, 'The Chemistry and technology of petroleum'
3. Myers, 'Handbook of Petroleum Processing'.

B.E. CHEMICAL (SEMESTER I)

409343: PROCESS DYNAMICS & CONTROL

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks
Practical: 2 hrs/week	Practical: 50 Marks

Unit1: Dynamic Behavior of Complicated Processes: (08)

Brief review of dynamic behavior of low-order simple processes (such as- pure capacitive, pure gain, first-order, and second order systems, dead-time systems), Dynamic behavior of systems with zeros, lead- lag systems, inverse response systems, Process identification using impulse, and frequency- response techniques.

Unit 2: Stability analysis and design of single-loop feedback control systems: (08)

Brief review of single-loop feedback control systems and classical controllers,

Stability analysis of feedback control systems using Routh- Hurwitz, root locus, and frequency- response techniques (Bode and Nyquist plots only).

Simple and time-integral performance criteria for feedback control systems, design of feedback control systems using root locus and frequency response techniques, open and closed-loop methods of tuning of classical controllers,

Unit 3: Design of Complex Control Systems: (08)

Design of controllers with difficult dynamics such as large time-delay systems, inverse-response systems.Analysis and design of control systems with multiple loops (cascade, selective, split range control systems).Analysis and design of advanced control systems (feedforward, ratio, adaptive and inferential control systems)

Unit 4: Control of Multivariable Systems: (restricted to maximum third-order systems only) (08)

Introduction to multivariable systems, transfer function and state-space models, poles and zeros of multivariable systems, multiple single- loop controllers for multivariable systems, interaction analysis and loop pairing using the Relative Gain Array (RGA) method, decoupling, design of decouplers.

Unit 5: Digital and Computer- based Control Systems: (09)

Sampling of continuous signals to discrete- time signals, reconstruction of continuous-time signals from discrete- time signals using hold elements, Digital approximation of classical controllers.

Role of digital computer in process control as process interface for data acquisition and control, Centralized control systems, supervisory control systems (SCADA), microcomputer- based control systems (PLC, DCS)

Unit 6: Introduction to Plant wide Control: (09)

Issues in plant wide control, process design and process control, internal feedback of material and energy, design of plant wide control systems for the plants involving reactors, flash unit, etc., effect of control structure on closed- loop performance.

Recommended Books:

1. Instrument Engineers' Handbook (Process Measurement)- Bella G. Liptak, Elsevier
2. Instrument Engineers' Handbook (Process Control)- Bella G. Liptak, Elsevier
3. Instrumentation devices and systems- Rangan, Sharma, Mani, Tata McGraw Hill

Publishing Co. Ltd.
4 .Instrumental methods of analysis – Willard, Merritt, Dean, Settle, CBS Publishers and Distributors
5. Instrumental approach to Chemical Analysis- Shrivastava, Jain, S. Chand and Co.
6. Handbook of Analytical Instruments- Khandpur, Tata McGraw Hill Publishing Co. Ltd.
7. Process Control- Bequette, PHI publications
8. Chemical process control- Stephanopoulos, PHI publications
9. Process Dynamics and Control- Seborg, Edgar, Mellichamp- John Wiley and sons Inc.
10. Computer-based Industrial Control-Krishna Kant, PHI publications

LIST OF PRACTICALS

(Perform minimum 08 experiments from the following list)

1 .Characteristics of single-loop and advanced control systems such as cascade, ratio, split- range, feed forward control

2Multivariable/ multi process control systems

2. Study of plant wide control systems using dynamic simulators such as UniSim, gPROMS, Hysis, etc.

4.MATLAB and SIMULINK exercises(using Control System Toolbox and System Identification toolboxes) on

3. Study of dynamic behavior of systems using LTI viewer
4. Comparison of open-loop and closed-loop response characteristics of processes using different types of classical controllers
5. Root locus and frequency response design of control systems/ compensators using SISO design tool
6. Process identification using System Identification Toolbox
7. Simulation of control systems using SIMULINK

5. Study of computer-based control systems such as Centralized, Supervisory, SCADA, DCS, PLC

B.E. CHEMICAL (SEMESTER I)

409344: CHEMICAL REACTION ENGINEERING - II

Teaching Scheme: **Exam Scheme:**
Theory: 4 hr/week **Paper: 100 Marks**

Unit I : Heterogeneous Reactions: Types, rates, contacting patterns. Fluid – Particle reactions: Selection of model Unreacted core model, progressive conversion model, Rate of reaction for shrinking spherical particles. Application to design. Fluidized bed with entrainment. **(6 Lectures)**

Unit II Fluid – Fluid Reaction: Rate equation for reaction, kinetic regimes, slurry reaction kinetics, Aerobic fermentation. Application to Tower design, Mixer settler, Semi batch contacting pattern. **(8 Lectures)**

Unit III: Adsorption: Surface chemistry and adsorption. Isotherms, Determination of surface area by BET method. Catalysis: Determination of surface area, void volume and solid density, pore-volume distribution, catalyst selection, preparation of catalyst and its deactivation, poisoning and regeneration. Nature and mechanism of catalytic reactions **(10 lectures)**

Unit IV: Diffusion in porous catalyst: Gaseous diffusion in single cylindrical pore. Diffusion in liquids in porous catalyst, surface diffusion. Mass transfer with reaction. Effectiveness factor, Experimental and calculated effectiveness factor, selectivity's for porous catalysts, rate and mechanism of deactivation **(10 Lectures)**

Unit V: Solid- catalyzed Reaction: Rate equation (For all resistances) experimental methods for finding rates, Determining controlling resistances and rate equation, product distribution. **(8 Lectures)**

Unit VI: Design: Introduction to design of Staged adiabatic reactors, fluidized bed reactor, slurry reactor, bubble, column reactor, fermentors (As multiphase reactors) Enzyme catalyzed reactions: Introduction to Michaelis –Menten kinetics, inhibition. **(10 Lectures)**

References:

1) Chemical Reaction Engineering: Levenspile O.
2) Chemical Engineering Kinetics: Smith J.
3) Chemical and Catalytic Reaction Engineering- Carberry & Verma.
4) Elements of Chemical Reaction Engineering: H. Scott Fogler.
5) Principles of Reaction Engineering: Dawande, Denett publications.
6) Heterogeneous Reactions: Analysis Examples and reactor Design. Vol.1 & 2- Doraiswamy L.K. and Sharma M.M.
7) An Introduction to Chemical Reaction Kinetics & Reactor Design.-C.G.Hill.

B.E. CHEMICAL (SEMESTER I)

409345: CHEMICAL ENGINEERING DESIGN – II

Teaching Scheme: **Exam Scheme:**
Theory: 3 Hrs/week **Paper: 100 Marks**
TW: 2 Hrs/week **Oral: 50 Marks**

Unit I:
Agitators and Reaction vessels- Study of various types of agitators , their selection , applications , baffling , power systems which includes twisting moment , equivalent bending moment, design of blades . Reaction vessels- Introduction ,classification , heating systems , design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil. Study and design of internal coil reaction vessels, Heat transfer coefficients in coils **(7 Lectures)**

Unit II:
Design of distillation column-Design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing , plate contactors, plate hydraulic design. **(7 Lectures)**

Unit III:
Packed columns-Choices of plates or packing, packed column design procedure, packed bed height (Distillation and absorption), HTU, Cornell's method, onda's method, column diameter, column internals, wetting rates, column auxiliaries. **(7 Lectures)**

Unit IV:
Auxiliary process vessels: Study of auxiliary process vessels such as reflux drum, knockout drum, liquid-liquid and gas-liquid separators, entrainment separators, oil water separator, Decanter, gravity separator. Safety devices used in process industries, Introduction to design and engineering software. **(7 Lectures)**

Unit V: Piping Design
A brief revision covering friction factor, pressure drop for flow of non-compressible and compressible fluids, (Newtonian Fluids), pipe sizing, economic velocity. Pipe line networks and their analysis for flow in branches, restriction orifice sizing. Non-Newtonian fluids – types with examples, pressure drop calculations for Non-Newtonian fluids. Pipe line design on fluid dynamic parameter **(8 Lectures)**

Unit VI: Materials for Piping system
Desirable properties of piping materials, materials for low, normal and high temperature services, materials for corrosion resistance. Common ASTM and IS specifications for: Seamless / ERW pipes, pipe fittings, flanges, and fasteners, materials for valves. Gaskets: Functions and properties, types of gaskets and their selection. **(7 Lectures)**

Term work: Process and Mechanical design and drawing of any **Six** equipments from unit 1 to 4 which should include at least two sheets based on AUTOCAD/**Autodesk** or design software.

References:

1. “Process equipment design” by L.E. Brownell and E. Young, John Wiley, New York, 1963.
2. “Introduction to Chemical Equipment Design” by B.C. Bhattacharya C.B.S. Publications.
3. “Process Equipment Design” by M.V. Joshi, McMillan India.
4. “Chemical Engineering Vol. 6” by J.M. Coulson, J.F. Richardson, and R.K. Sinott, Pergamon Press.
5. “Chemical Engineering volume 2” by J.M. Coulson, J.F. Richardson, and R.K. Sinott Pergamon Press.
6. “Mixing theories and practices” by Uhl V.W. and Grey J.B. Academic Press, New York, 1967.
7. “Mass Transfer Operations” by Treyball R.E., McGraw Hill, New York.
8. “Chemical Process Equipment-Selection and design” Walas S.M. , Butter worth Heinamer, McGraw Hill book company, New York.
9. “Indian standards Institution” code for shell and tube heat exchangers, IS – 4503
10 “Applied Process Design for Chemical and Petrochemical Plants” vol 1 and 2, Ludwig E.E., Gulf publishing co. publishing company, Texas.
11. Pipe Drafting and Design by Roy A Parisher & Robert A. Rhea.
ASME Codes 31
12. Hydraulics and Fluid Mechanics by Modi and Seth.
13. Fluid mechanics and Hydraulic Machines by Dr. R. K. Bansal

B.E. CHEMICAL (SEMESTER I)

409346: COMPUTER AIDED CHEMICAL ENGINEERING II

Teaching Scheme: **Exam Scheme:**
Practical: 4 Hrs/ Week **Oral:50 Marks**

Minimum 10 Practical and a compulsory home paper.

1) **Steady state flow sheet synthesis.**
a) Flash Operation
b) Reaction Synthesis
c) Heat Exchangers
d) Two Stage Compression

2. **Dynamic flow sheet synthesis.**
a) Application of Controllers
b) Controller Tuning

3. **Advanced method of optimization** (e.g.: sequential quadratic programming)
4. AI methods (e.g.: XLISP program),
5. Expert system simulation (e.g.: PROLOG based program)
6. Advanced numerical method – finite difference methods
7. Finite Element Methods and Analysis
8. Basics of Computational Fluid Dynamics
9. Data modeling using support Vector Machines.
10. HAZOP and HAZAN analysis-Case Study
11. Heuristic and Separation Synthesis
12. Plant Scale up calculations for a process.
13. Computer program for Design of reactor/ Heat Exchangers. Distillation Column/ or any Chemical equipment by any language.

Home paper for each student or group of students is compulsory.

A paper written by a student may be ten to fifteen pages in double spacing; a few figures may get added.

409347: Industrial Training II

Teaching Scheme: -- **Exam Scheme:**
Term Work: 50 Marks

Evaluation of Industrial training carried out by students after Semester VI is to be evaluated.

B.E. CHEMICAL (SEMESTER I)

409348: PROJECT

Teaching Scheme	Examination Scheme
Semester I: 2 Hrs/Week	TW: 100 Marks
Semester II: 6 Hrs/ week	Oral: 50 Marks

Students will be allotted project either individually or in groups. Each project will have one guide from the faculty. Students may be encouraged to choose co-guide from the industry, wherever possible. The aim of the project work is to evaluate the quality and competence developed by the students implementing theoretical concepts learned, in terms of technical report / presentation. The students may encourage to do Plant Design Project.

In case of **Plant Design** Project, the report must consist of the following chapters:

1. *Introduction (including market report)*
2. *Process Selection*
3. *Material and Energy Balance*
4. *Sizing and detailed design of major equipment/s*
5. *Thermodynamics and Kinetics*
6. *Instrumentation & Process Control*
7. *Plant Layout*
8. *Waste Treatment & Safety aspects*
9. *Cost Analysis*
10. *References*

In case of strictly **research or more practical project,** the report must consist of the following chapters:

1. *Abstract*
2. *Aim and Objectives*
3. *Introduction/background*
4. *Literature Review*
5. *Methodology*
6. *Results*
7. *Discussion*
8. *Conclusion and recommendations*

References

Appendices

In case of **Modeling and Simulation Project**, for example "Modeling and Simulation of Trickle Bed Reactor", the report may consist of the following chapters:

1. *Introduction*
2. *Literature Review*
3. *Trickle Bed Reactor*
4. *Hydrodesulphurization*
5. *Modeling of Trickle Bed Reactor*

6. *Simulation of Trickle Bed Reactor*
7. *Sensitivity Analysis*
8. *Conclusion & recommendations*

Nomenclature
References
Appendices

The actual contents of the project report may be decided by the faculty guide. Students should guide to refer chemical abstracts/engineering abstracts, national/international journals to know about the latest field.

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-III

409349: ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Introduction, Scope, historical perspective; Implication of AI applied to problems in engineering analysis and design; Formal concepts in design, knowledge representation and data bases; Coupled symbolic and numerical computation; Qualitative reasoning, uncertainly, truth maintenance; Integrated compute aided engineering.
Knowledge based process control; Adaptive and learning systems; Applications of Neural Networks; Fuzzy logic and genetic algorithms; AI oriented languages and architechtures. Expert systems design and development; ES tools and techniques Applications in various chemical and bio – Chemical processes.

TEXT BOOK
1 Artificial intelligence in chemical engineering by Quantrille

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-III

409349: ENERGY CONSERVATION IN CHEMICAL PROCESS INDUSTRIES

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

1. Energy Outlook: Introduction, Scope of the Problem, Thermodynamic Efficiencies, The Fundamental Strategy. The Second Law of Thermodynamics Revisited: Difference between Laws, Definitions : Available Energy, Availability, and Energy, Available Energy and Fuel. Characterizing Energy Use: Understanding Energy use, Missing Data, An Illustrative Onsite Audit, An illustrative Steam Power Balance

2. Optimum performance of Existing Facilities: Principle 1 – Minimise Waste, Combustion Principles, Illustrative Problems – Combustion Efficiency, Steam Trap Principles, Principle 2 – Manage Energy Use Effectively, Facilities Improvement - An Overall Site Approach, Utilising the Energy Audit, Overall Site Interactions, Cogeneration, Total Site Cogeneration Potential, Illustrative Problem: Maximum Potential Fuel Utilisation, The Linear Programming Approach .Methodology of Thermodynamic Analysis: General Considerations, Introduction, Sign Conventions, Detailed Procedures, Illustrative Examples.

3. Detailed Thermodynamic Analysis of Common Unit Operations: Introduction, Heat Exchange, Expansion - Pressure Letdown ΔP, Mixing, Distillation – A Combination of Simple Processes, Combustion Air Preheating. Use of Thermodynamic Analysis to Improve Energy Efficiency: Introduction, Overall Strategy, Reducing available Energy (Work) Losses, Accepting "Inevitable" Inefficiencies, Optimisation through Lost Work Analysis, Research Guidance. Thermodynamics and Economics: Capital–Cost Relationships, Background Information, The Entire Plant Energy System Is Pertinent, Investment Optimisation, Defining the Limits of Current Technology, Fundamental Process Improvements.

4. Systematic Design Methods: Introduction, Process Synthesis, Applications to Cogeneration Systems, Thermo economics, Systematic Optimisation. Guidelines and Recommendations for improving process conditions: Introduction, Chemical Reactions, Separations, Heat Transfer, Process Machinery, System Interactions and Economics, A Checklist of Energy Conservation Items, Shortcomings of Guidelines.

5. Energy Conservation Measures: Introduction, Management Systems for Energy Conservation, Energy Audits and Energy Monitoring, Combined heat and power generation: Introduction, Technology of CHP Systems, Balancing Heat and Power Loads, Economic Incentives for Further CHP systems, Technical Potential for Further CHP systems, Good Housekeeping (Minor) Conservation Measures

Heat Recovery: Introduction, Heat Transfer Equipment, Heat Exchanger Networks, Heat Recovery from Waste Fuels, Heat Exchanger Fouling, Heat Pumps.Power recovery: Power recovery from pressure reduction of process fluids, Power recovery from low grade waste heat.

Energy Conservation Measures: Thermodynamics of Separation Processes, Methods for reducing energy consumption in distillation, Established Approaches to Energy Conservation in drying, Energy Conservation in Evaporation, Energy Conservation in Mixing, Energy Conservation in Comminution, Role of Equipment Manufacturers

6. Process Design: Introduction, Product Substitution, Process Routes, Thermodynamic (Second law) analysis of processes, Miscellaneous design methods, Effect of energy conservation measures on reliability and control of processes, Batch processes, Mature Processes. Economic Assessment of Energy Conservation Measures, Potential for Future Energy Savings: Potential savings through good house keeping (minor) measures, Potential savings through major measures and in the long term.

Texts/ references:

1 Energy Conservation in the Process Industries by W.F. Kenny, Academic Press, INC.
2 Energy Conservation in the Chemical and Process Industries by Colin D.Grant, Published by The Institution of Chemical Engineers, London
3 Energy Management Handbook by Wayne C.Turner, The Fairmount Press, INC.
4 Principles of Waste Heat Recovery by Robert Goldstick, Albert Thumann, The Fairmount Press, INC.
5 The Efficient Use of Energy, General Editor I.G.C.Dryden, IPC Science and Technology Press, Guildford, Surrey, England.
6.Sukhatme S. P., "Solar Energy", Tata McGraw Hill, New Delhi.
7.Diwakar Rao P. L., "Energy Conservation Handbook," Utility Publication Ltd., Jan 1988.
8. Douglas C, "Energy Technology Handbook", McGraw Hill.
9. Kern D. C. , 'Process Heat Transfer', McGraw Hill Publications

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-III

409349: CHEMICAL PROCESS SAFETY

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Concepts and definition, safety culture, storage of dangerous materials, Plant layout Safety systems, OSHA incidence rate, FAR, FR, The accident Process: Initiation, Propagation, and Termination, Toxicology: Ingestion, Inhalation, Injection, Dermal Absorption, Dose versus response curves, Relative toxicity, Threshold Limit Values. **(6 Lectures)**

Unit II: Industrial Hygiene: Government regulations, Identification, Evaluation: Evaluating Exposures to volatile toxicants by monitoring, evaluating worker Exposures to dusts, evaluating worker exposures to noise, Estimating worker exposures to toxic vapors. **(6 Lectures)**

Unit III: Technology and process selection, scale of disaster, Fire triangle, Distinction between fires and explosion, Definitions of Ignition, Autoignition temperature, fire point, flammability limits, Mechanical explosion Deflagration and detonation, Confined explosion, Unconfined explosion, Vapors cloud explosions, Boiling liquid expanding vapor explosion (BLEVE), Dust explosion, shock wave, Flammability characteristics of liquids and vapors, Minimum oxygen concentration (MOC) and Inerting. **(8 Lectures)**

Unit IV:Control of toxic chemicals, Storage and handling of flammable and toxic chemical, Runway reactions, Relief system risk and hazards management,
Design to prevent Fires and Explosions: Inerting, static Electricity, Explosion proof equipment and Instrument, Ventilation, sprinkler systems and Miscellaneous Design for preventing Fires and Explosion. **(10 Lectures)**

UnitV: Hazards Identification: Process hazards checklists, Hazard Surveys, Hazard and Operability Studies (HAZOP), Safety reviews.Risk Assessment: Review of probability Theory, Interaction between process units, Revealed and unrevealed failure, probability of coincidence, Event trees and Fault trees. **(6 Lectures)**

Unit VI: Safety versus production, Hazard models and risk data. Tackling disasters, plan for emergency. Risk management routines, Emergency shutdown systems, Role of computers in safety, Prevention of hazard human element, Technology and process selection. **(6 Lectures)**

References

1. Daniel A. Crowl and Joseph F. Louvar, Chemical Process Safety: Fundamentals with applications, Prentice Hall, Inc, 1990.
2. P. P. Leos, Loss prevention in process Industries, Vol 1 and 2 Butterworth, 1983
3. R. W. King and J. Magid, Industrial Hazards and Safety Handbook, Butterworth, 1982
4. Khulman, Introduction of Safety Science, TUV Rheinland, 1986
5. W. E. Baker, Explosion, hazards and Evaluation, Elsevier, Amsterdam, 1983
6. O. P. Kharbanda and E. A. Stallworthy, Management of Disasters and How to Prevent Them. Grower 1986

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-III

409349: FOOD TECHNOLOGY

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Introduction and Basic Principles: Importance of food Industry in India, Current status of various food products from cereals, dairy, edible oil, fruits, vegetables and beverages. Physical, chemical, biological, nutritional, sensory characteristics of food. **(6 Lectures)**

Unit II: Post Harvesting operations and storage: Storage of solid foods, Cleaning (wet and dry), sorting by shape, size, colour, weight, grading and peeling, Equipment for storage of solids, bins, silos, controlled atmosphere storage for food grains and vegetables and fruits. Principles involved in degradation and prevention **(8 Lectures)**

Unit III: Treatment of milk before storage, effect of pasteurization, heat sterilization, In-container sterilization, storage of oils, filtration, free fatty acids removal, foots and other impurities. **(6 Lectures)**

Unit IV: Processing of fruits for manufacture of Jams, Jellies, operations and equipments involved. Manufacture of Pickles, Squashes, and beverages, preservatives used in food processing. **(6 Lectures)**

Unit V: Processing of food grains, Theory of size reduction equipments and effect of size reduction on foods, evaporation extrusion, hot air dehydration, baking, roasting and hot oil frying Theory, equipments, applications and effect on food materials for Freezing / Freeze drying and Freeze concentration **(8 Lectures)**

Unit VI: Post Processing operations: Coating or enrobing operations, equipment and applications, theory of food packaging, types of packaging materials and packaging operations, filing and sealing of rigid and semi-rigid containers. Materials for handling the food items. Temper evident containers. **(8 Lectures)**

References:

1) Matz S. A. : Bakery Technology & Engineering, AVI Publishing, 1960.
2) Shapton & Shapton, Safe Processing of Foods
3) Weiser, Mountney, Gould, Practical Food Microbiology and Technology.
4) Charm S. E. Fundamentals of food Engineering, AVI, 1963.
5) Hall, Farral, Rippen, Encyclopedia of food Engineering, AVI 1970.
6) Mirajkar M, Menon- Food Science and Processing Technology Vol I & II New Delhi, Kanishka Publishers.
7) Fellows P. , Ellis H., 1990 – Food Processing Technology Principles and Practice –New York
8) Considine D. M., Food and Food Production Encyclopedia, VNR New York 1982.

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-IV

409350: Standardization and Quality Assurance in Chemical Process Industry

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Utility of standard; Standards for material consumption; Standards for equipment; Standards for manual work; Standards for financial returns, Qualitative standards. [8]

Unit II: Approach to standardization, Objective of the system, Idealized model for national standard system, Case studies of national standards systems. [8]

Unit III : Inspection and Quality Control:- Objective, Function of inspection, Elements of quality, Objective of statistical quality control; Function of S. Q. C; Control charts, Concept of sampling; Concept of zero defects. [8]

Unit IV : Study of different standards followed by the chemical industry. [8]

Unit V: Role of technology transfer in standardization; Modern trends in standardization. [8]

References:

1) **AIChE Journals/**
2) **Quality Control Journals**
3) **Indian Standards Book**
4) **Quality Assurance for the Chemical Process Industries: A Manual of Good Practices, Second Edition, ASQ Chemical and Process Industries Division,**

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-IV

409350: CATALYSIS

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Introduction to Catalysis. Application to industrial processes – one example each from Inorganic, Fine organic chemical, petroleum refining, petrochemical and biochemical industries.Types of catalysis: Homogeneous Catalysis **(8 Lectures)**

Unit II: Heterogeneous Catalysis: Introduction, Phase transfer and tri-phase catalysis, liquid – liquid and solid – liquid catalysis, mechanism, engineering problems, mass transfer considerations and reactor types. **(8 Lectures)**

Unit III: Gas – solid catalytic reactions. Adsorption theories and concept of active site. Adsorption isotherm and Langmuir – Hinshelwood approach. Diffusion effect. **(8 Lectures)**

Unit IV: Preparation of catalysts – Supported metal and metal oxide catalyst. Major steps involved in catalysts preparation and formation. Physical methods of catalyst characterization for determination of surface area, pore volume and average pore size. BET equation. **(8 Lectures)**

Unit V: Zeolites – Structural considerations. Templeted molecular sieves, size and shape selectivity, 4 – 5 industrial applications of zeolites. Modification of zeolites.**(8 Lectures)**

Unit VI: Biocatalysts – enzymes, lipases and microbes as catalysts. Mechanism of participation of enzymes in a few typical reactions. Michaelis – Menten Kinetics, inhibition. Reactions and denaturation of two biopolymers, proteins and nucleic acids: one or two industrial reactions. **(8 Lectures)**

References:

1. Smith J.M.: "Chemical Engineering Kinetics", 3rd Edition, McGraw Hill
2. Satterfield Charles N.: Heterogeneous Catalysis in Industrial Practices, McGraw-Hill International Editions, 2nd Edition 1993.
3. Bailey James, Davis Ollis: "Biochemical Engineering", McGraw Hill
4. Wingard L.B.: Enzyme Engineering, Fr. InterScience, N.Y. 1972.
5. Carberry J. J.: Chemical and Catalytic Reaction Engineering, McGraw Hill, New York, 1976.

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-IV

409350: NANOTECHNOLOGY

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Introduction : Introduction to nanotechnology and materials,Nanomaterials, How It All Began: Synthesis of carbon buckyballs ,List of stable carbon allotropes extended,fullerenes, metallofullerenes, solid C_{60}, bucky onions, nanotubes, nanocones Properties of Individual nanoparticles. Methods of synthesis. Carbon nanostructures

Unit II: Synthesis procedures of nanomaterials : Bottom-up vs. top-down , Epitaxial growth ,Self-assembly ,Modelling and Applications Production Techniques of Nanotubes Carbon arc bulk synthesis in presence and absence of catalysts High-purity material (bucky paper) production using Pulsed Laser Vaporization (PLV) of pure and doped graphite High-pressure CO conversion (HIPCO) nanotube synthesis based on Boudoir reaction Chemical Vapor Deposition (CVD)

Unit III: Characterizations of nanomaterials : Top down approach Bottom up approach Optical Microscopy, Electron Microscopy,Secondary electron scattering, back scattering, Scanning Probe Microscopes, Focussed Ion Beam Technique,X-ray imaging, SPM-AFM, STM, Optical Microscopy, Electron Microscopy,Secondary electron scattering, back scattering, Scanning Probe Microscopes, Focussed Ion Beam Technique,X-ray imaging, SPM-AFM, STM

Unit IV: Semiconductors and Quantom dots : Intrinsic semiconductors, Band gaps, Law of mass action, Mobility of charge carriers Extrinsic semiconductors The p-n junction, Ferromagnetism Energy gaps The nearly free electron model The number of orbitals in a band Electrons and holes, effective masses Review of classical mechanics, de Broglie's hypothesis ,Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function,Application: quantum well, wire, dot ,Quantum cryptography

Unit V: Nano colloids and Chemistry : Surface Tension and Interfacial Tension Surfaces at Equilibrium Surface Tension Measurement, Contact Angles, Colloidal Stability, Electrical Phenomena at Interfaces Van der Waals Forces between Colloidal Particles, photocatalysis Nanostructured materials. Self-assembly and Catalysis.

UnitVI: Unit Applications and Safety, Environment: Waste Water Treatment , Nanobiotechnology : Drug Delivery , Nanoclay, Nanocomposites, Surface coatings. Self cleaning Materials, Hydrophobic Nanoparticles. Biological nanomaterials. Nanoelectronics. Nanomachines & nanodevices Societal, Health and Environmental Impacts

Commercial Processes for Nanotechnology and Chemical Engineering Applications
Nanohydrogel, Photocatalytic reactors, Nanoclay Synthesis , Polymer nanocomposite, Introduction to industries which produces commercial nanomaterials

Text Book:

Introduction to NanoScience, (CRC Press of Taylor and Francis Group LLC), G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals and Anil K. Rao, May 2008, 856pp, ISBN-13: 978142004805

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-IV

409350: FUEL CELL TECHNOLOGY

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Fuel cell definitions. Fuel cell types: Proton-exchange membrane, phosphoric acid, molten carbonate, solid oxide ceramic type. Mechanism of power generation and applications. **(6 Lectures)**

Unit II: Solid –oxide fuel cells (SOFC) basics. Homogeneous solid oxide electrolytes: ionic conductivity, defect structure in ionic solids, defect equilibria, determination of defect concentrations, ionic transference number, temperature dependence of conductivity. **(8 Lectures)**

Unit III: Heterogeneous solid oxide electrolytes. Ionic conductivity of heterogeneous electrolytes. Classification of two phase composite materials. Models to explain conductivity enhancement in heterogeneous electrolytes. Advantages and drawbacks of solid-oxide fuel cells. Requirements of electrolytes, cathode and anode, interconnection materials. **(8 Lectures)**

Unit IV: SOFC configurations and performance: Tubular configuration, monolithic SOFC, planer (bipolar plate) design. Manufacturing processes. **(6 Lectures)**

Unit V: Thermodynamic processes in fuel cells. Operation and performance of SOFC. Multistage oxidation concept. **(6 Lectures)**

Unit VI: Fuel cell power systems. SOFC integrated power plants: Benefits of pressurization, integrated SOFC/turbine systems, internally reformed SOFC. **(8 Lectures)**

References

1. Bokris John O'm, Srinivasan S., "Fuel cells-their electrochemistry", McGraw Hill 1969.
2. Appleby A.J. Fralkes F. R., "Fuel cell handbook", Van Nostrand Reinhold 1989.
3. Kordesch Karl, Simader G., "Fuel cells and their applications", VCH publications 1996.
4. "Fuel cell: a handbook", U S Department of energy.
5. Leo J.M.J., Blomen, Mugerwa M. N., "Fuel cell systems", plenum press.

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-IV

409350: PETROCHEMICAL ENGINEERING

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Introduction to petrochemical, Petrochemical industry in India, basic raw material for petrochemical synthesis and their sources, preparation of feedstocks for petrochemical production, main building blocks of petrochemical industry **(8 Lectures)**

Unit II: First generation raw material like olefins, aromatics, naphthenes. Production of aromatics, naphthenes and other hydrocarbon feedstocks **(8 Lectures)**

Unit III: Production of low molecular weight olefins by hydrocarbon cracking, furnaces, separation techniques and purification **(8 Lectures)**

Unit IV: Combining olefins and aromatics to produce second generation intermediates such as glycols, amines, acids, ketones that can be used also as solvents and formulating agents **(8 Lectures)**

Unit V: Polymers: Bulk, engineering and speciality, types of polymerization such as bulk, emulsion and suspension etc, at least two polymeric products and manufacture from each class **(8 Lectures)**

Unit VI: Integration of refinery and petrochemical plants with power generation, pollution control – norms and methods of elimination, brief description on safety considerations **(8 Lectures)**

References:

1. Petrochemical by Hobson and Pohl
2. Introduction to petrochemical industry and refinery by Speight
3. Outline of chemical industry by Dryden and Gopal Rao

B.E. CHEMICAL (SEMESTER II)

ELECTIVE-IV

409350: COMPUTER AIDED PROCESS CONTROL

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks

Unit I: Basic Concepts: Role of digital computer in process control, elements of computer control system(block diagram), classification (DDC, supervisory), process control architecture(centralized, distributed, hierarchical), man-machine interface, advantages. **(5 Lectures)**

Unit II: Multivariable process control(MIMO Control system)

Introduction, nature, input-output pairing, interactions, controllability and observability transfer function model, open loop dynamic analysis in state space, transient response and stability, Interaction analysis and loop pairing , RGA and loop pairing, design of non-interacting control loops. **(10 Lectures)**

Unit III: Digital control:

Discretization (sampling) of continuous signals, Reconstruction of continuous signals from their discrete values, Z- transforms, dynamic analysis of discrete time systems(first order dead time, lead/lag systems), digital approximation of classical controllers, digital control algorithms for P, PI, PD & PID controllers, stability & design of digital controllers, self tuning digital control systems, Direct Digital Control (DDC)

(10 Lectures)

Unit IV: Process control Computer Hardware and Software:

Organization of general purpose computer, interfaces, communication & networking, data transfer techniques, computer aided process control softwares, real time application softwares, PC based data acquisition systems, real time programming languages, software for modeling & simulation of control systems (MATLAB, SIMULINK, System build, Easy-5, Simmon, Desire) **(8 Lectures)**

UnitV: Distributed control system and programmable Logic Controllers

Introduction to DCS, software configuration, communication, supervisory control. Introduction to microcomputers, Evolution, architecture, basic structure of PLC, programming, ladder diagram, communication and networking, advantages of PLC. Integration of DCS with PLC and computers. **(10 Lectures)**

Unit VI: Industrial application of digital/ computer control and plant wide control

Control system for MIMO system such as- two product distillation column, packed bed reactor, jacketed packed bed reactor, fired heaters, heat exchangers, pumps, compressors. Managing the process control design problem-Definition, sequence of design steps, temporal hierarchy of control structure, process decomposition, integrating of control design methods. **(10 Lectures)**

References:

1. B.G.Liptak, Instrumentation Engineers Handbook Process Control,3rd Edtion.
2. D.M.Considine, Process Instrument & Control Handbook, McGraw Hill.
3. P. Harriot, Process Control, Tata McGraw Hill publications.
4. Ogata, Modern Control Engineering, PHI publications.

5. Stephanopoulos, Chemical Process Control, PHI publications.
6. S.K.Singh, Computer aided process Control, PHI publications.
7. Nise, Control System Engineering.
8. Marlin T. Process Control: Designing process and control systems for dynamic performance, McGraw-Hill.
9. Ogunaik B.A. and W.H. Ray, Process dynamics, Modeling and control, Oxford University press, NY, 1994.
10. K.Kaul, Computer Based Industrial Control, PHI Publications.

B.E. CHEMICAL (SEMESTER II)

409351: PROCESS MODELING & SIMULATION

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks
Practical: 2 hrs/week	Oral: 50 Marks
	TW: 50 Marks

Unit: I. Introduction to Modeling: Introduction, definition of Modeling and simulation, different types of models, application of mathematical modeling, scope of coverage. **(3 Lectures)**

Unit: II Fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics. **(3 Lectures)**

Unit: III Heat Transfer and Other Equipments: Heat exchangers, evaporators, agitated vessels, pressure change equipments, mixing process, fluid – solid operations **(6 Lectures)**

Unit: IV Mass Transfer Equipments: flash distillation, differential distillation, continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, drying equipments, adsorption, absorbers and strippers. (**10 Lectures)**

Unit: V Reaction Equipments: Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor. **(10 Lectures)**

Unit: VI Applications of modeling and simulation in distillation**,** Transient analysis of staged absorbers, unsteady state analysis in reactor system, Modeling and simulation of effluent treatment plant, Use of numerical methods to solve different models. **(8 Lectures)**

Practical:

Ten practical will be conducted with the use of mathematical and chemical engineering CAD software's such as ***Hysys, ChemCAD, EnviroPro, Mathcad, Matlab*** etc. Development of programs for numerical methods and process simulation.

References:

1. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill, 1988.
2. Davis M. E., "Numerical Methods and Modeling for Chemical Engineers", Wiley, New York, 1984.
3. Finlayson B. A., "Nonlinear analysis in Chemical Engineering", McGraw Hill, New York, 1980.
4. Chapra S.C., R.P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill Publications

5. Franks R.E.G., “Modeling and Simulation in Chemical Engineering”, Wiely Intrscience, NY
6. John Ingam, Irving J. Dunn., “Chemical Engineering Dynamic Modeling with PC simulation”, VCH Publishers.
7. Kayode Coker A., “Chemical Process Design, Analysis and Simulation”, Gulf Publishing Company.
8. Himmelblau D., K.B. Bischoff, “Process Analysis and Simulation”, John wiely & Sons.
9. Wayne Blackwell, “Chemical Process Design on a Programmable Calculator”, McGraw Hill.

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B.E. CHEMICAL (SEMESTER II)

409352: PROCESS ENGINEERING COSTING & PLANT DESIGN

Teaching Scheme	Examination Scheme
Lecture: 4 hrs/week	Paper: 100 Marks
Drawing: 4 hrs/week	Oral: 50 Marks
	TW: 50 Marks

Unit I: Process Development: Process selection, study of alternative processes, pilot plant, Scale up methods, Flow sheet preparation, sketching techniques, Equipment numbering, Stream designation, Material and energy balances.

Plant Design: Design basis ,Process selection -Selection of equipment, specification and design of equipment's, material of construction, Plant location, Plant layout and installation, Safety, Start up, Shutdown and Operating guidelines. [8]

Unit II:Cost Engineering: Time value of money and equivalence, Interest, cost comparisons by present worth, Annual equivalent cost and capitalised cost methods, Uniform gradient and series.Depreciation, Taxes and Insurances,Nature of depreciation, Methods of determining depreciation, depreciation rates in current Indian situation, Types of taxes and insurance's, Procedure for cost comparison after taxes. [8]

Unit III:Cost Estimation: Types of cost estimation, capital investment cost, fixed capital cost, working capital cost, start-up costs, process equipment cost estimation, cost index, Equipment costs due to inflation, Battery limit investments, estimation of plant cost, Estimation of total product cost, Manufacturing cost, General expenses.

Profitability: Criteria of profitability, Payout period, Return on investment, Present value, Cash flow analysis, Alternative investment analysis, Sensitive analysis in project profitability. [8]

Unit IV:Economic Optimization and Optimum Design: Nature of optimisation, Uni-variable and multivariable systems, Analytical, graphical and incremental methods of solution, LaGrange multiplier method, Linear programming and dynamic programming establishing optimum conditions, Break even chart for production schedule, Optimum production rates in plant operation, Optimum conditions in batch, cyclic and semicyclic operation, Sensitivity and response analysis. [8]

Unit V:Optimisation of Different Process Equipment: Viz., transportation systems, heat exchangers, evaporators, mass transfer equipments and reactors. Determination of height and diameter of different process equipments at conditions of optimum cost .Pinch Technology analysis. Preparation of techno-economic feasibility report. [8]

Unit VI: Role of project engineering in project organisation ;Plant location and plant layout; Start up and shut downs of project; Preliminary data for construction projects; Process engineering; Flow diagram, Plot plans, Scheduling the project; Engineering design and drafting.

Critical path method (cpm): Events and activities; Network diagramming; Earliest start time and earliest finish time ;latest start time and latest finish time; Float, Advantage of CPM ;Cost to finish he projects earlier than normal cost; Precedence diagramming.

Programme evaluation and review technique (pert): PERT network and time estimates; Single versus multiple time estimates; Frequency distribution. [10]

Practicals:

1.Minimum six drawing of following preferably on Auto CAD/Autodesk.

Process flow diagram.
Piping and instrumentation diagram.
Plant layouts and elevations.
Piping GA drawing.
Piping isometrics.

2. Minimum two assignments based on theory to be solved on computer.

Reference books

1. Peter S. Max & Timmerhaus, Plant Design and economics for chemical engineers. Mc Graw Hill (2002).
2. Srinath L. S., "PERT AND CPM." affiliated east press pvt. Ltd., new york (1973)
3. Perry J. H.,"Chemical engineering handbook" 7TH ed. Mc Graw Hill (1997).
4. JELLEN F. C., "Cost and optimization in engineering". Mc Graw Hill (1983).