

**NORTH MAHARASHTRA UNIVERSITY,  
JALGAON (M.S.)**

**FINAL YEAR ENGINEERING (B.E.)**

**CHEMICAL ENGINEERING**

**TERM – I & II**

**W.E.F. 2008-2009**

# NORTH MAHARASHTRA UNIVERSITY, JALGAON

## STRUCTURE OF TEACHING & EVALUATION

**B.E. (CHEMICAL ENGINEERING)**

**W.E.F.2008-2009**

### First Term

Sr. No.	Subject	Teaching Scheme Hours/Week		Examination Scheme				
		Lectures	Practical	Paper Duration Hours	Paper	TW	PR	OR
1	Process Dynamics & Control	04	02	03	100	25	--	25
2	Transport Phenomenon	04	--	03	100	--	--	--
3	Chemical Reaction Engineering-II	04	04	03	100	50	--	25
4	Elective –I	04	--	03	100	--	--	--
5	Energy Engineering	04	02	03	100	25	--	25
6	Project –I	--	02	--	--	25	--	25
7	Seminar	--	02	--	--	25	--	--
		20	12		500	150	--	100
	Grand Total	32			750			

### Second Term

Sr. No.	Subject	Teaching Scheme Hours/Week		Examination Scheme				
		Lectures	Practical	Paper Duration Hours	Paper	TW	PR	OR
1	Computer Aided Process Equipment Design Modeling & Simulation	04	04	03	100	50	25	--
2	Process Engineering Economics & Costing	04	02	03	100	25	--	25
3	Chemical Plant Design & Project Engineering	04	04	03	100	25	--	25
4	Elective –II	04	--	03	100	--	--	--
6	Project –II	--	04	--	--	100	--	50
7	Industrial Visit / Case Study	--	--	--	--	25	--	--
		16	14		400	225	25	100
	Grand Total	30			750			

#### Subjects:

Elective-I

1. Biochemical Engineering
2. Polymer Engineering
3. Advance Catalysis

Elective-II

1. Industrial Pollution & Control
2. Advance Separation Techniques
3. Petrochemicals

## 1. PROCESS DYNAMICS & CONTROL

Teaching Scheme:

Lectures: 4 Hrs./ Week

Practical: 2 Hrs./ Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

Oral : 25 Marks

Term Work: 25 Marks

### UNIT- I

Characteristics of Chemical Process Control, Mathematical Modeling of Chemical Processes, State Variables and State Equation for Chemical Processes.

Input –Output Model, Linearization of non linear systems, Solution of Linear differential equation using Laplace Transform.

First order system and their transfer functions.

(10 Hrs, 20 Marks)

### UNIT- II

Dynamic behavior of first order system , Pure capacity process, First order system with variable time constant and gain, Response of first order system in series :Interacting and Non-interacting.

Second order system and their transfer function.

(10 Hrs, 20 Marks)

### UNIT- III

Dynamic behavior of second order system: under damped and over damped and critically damped systems, Transportation lag.

Higher order systems.

Introduction to feedback control, Controllers and final control elements.

Control action block diagram of chemical reactant control systems.

(10 Hrs, 20 Marks)

### UNIT- IV

Dynamic behavior of feedback control processes: P, PD, PI, and PID.

Design of feedback controller: Performance criteria, selection of type of controller, Tuning of feedback controller.

Stability analysis by Routh criteria, Root Locus Diagram

(10 Hrs, 20 Marks)

### UNIT-V

Frequency response analysis of linear processes: Bode's diagram, Nyquist plots.

Design of feedback control system using frequency response technique: Bode's stability criteria, gain and phase margin.

Ziegler – Nichols tuning technique. Nyquist stability criteria,

Control Systems with Multiple Loops: Feed forward control, Cascade control, Ratio control, selective control, split range control, Adaptive and Inferential control. Multi Variable Control

(10 Hrs, 20 Marks)

### PRACTICAL and TERM WORK:

Practical and Term work shall consist of minimum eight experiments from list given below.

Dynamic behavior of first order system

1. Mercury Thermometer
2. Single tank system.
3. C.S.T.R.

Dynamic behavior of first order system in series

4. Two tank non-interacting system.

5. Two tank interacting system.  
Dynamic behavior of second order system
  6. Mercury Manometer  
Dynamic behavior of final control Element
  7. Pneumatic control valve.  
Study of Pneumatic controllers.
  8. Proportional Controller
  9. Proportional Derivative Controller
  10. Proportional Integral Controller
  11. Proportional Integral Derivative Controller
- Control Systems
12. Study of closed loop control system.

#### REFERENCES

1. George Stephanopolous, Chemical Process Control, Prentice Hall of India.
2. D.R. Coughnour, Process System Analysis and Control, McGraw-Hill.
3. R.P.Vyas, Process Control & Instrumentation {2<sup>nd</sup> edition}. Central Techno publication, Nagpur.
4. K. Krishnaswamy, Process Control, New age International.

## 2. TRANSPORT PHENOMENON

Teaching Scheme:

Lectures: 4 Hrs./ Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

#### UNIT-I

Introduction. Transport phenomenon and Unit Operation.

Equilibrium and Rate Processes. Fundamental variables and Unit The role of Intermolecular forces.

Simple Balance: Material and Energy.

Molecular transport Mechanism:

The Analogy. The Case of Heat Transfer. The Case of Mass Transfer. The Case of Momentum Transfer. The Analogues forms. Heat, Mass, Momentum Diffusivities. Thermal Conductivity. Diffusion Coefficient. Viscosity.

(10 Hrs, 20 Marks)

#### UNIT-II

Viscosity and Mechanism of Momentum Transport.

Velocity Distribution in Laminar Flow.

(10 Hrs, 20 Marks)

#### UNIT-III

Thermal Conductivity and The Mechanism of Energy Transport.

Temperature Distribution in Solids and in laminar Flow.

(10 Hrs, 20 Marks)

#### UNIT-IV

Diffusivity and Mechanism of mass Transport.

Concentration Distribution in Solids and in Laminar Flow.

(10 Hrs, 20 Marks)

#### UNIT-V

The Equation of Change for Isothermal System.

The Equation of Change for Non-Isothermal System.

(10 Hrs, 20 Marks)

## REFERENCES

1. R.B.Bird; W.E.stewart; E.N.Lightfoot, Transport Phenomenon, John Wiley & Sons1994; Singapore
2. R.S.Brodsky & H.C.Hershey, Transport Phenomenon ,McGraw-Hill{International edition}
3. C.O.Bennett & J.E.yers; Momentum, Heat & Mass Transfer; McGraw-Hill1982.
4. James R. Welly, Charles E. Wicks & Robert E.Wilson; Fundamentals of Momentum, Heat & Mass Transfer{3<sup>rd</sup> edition}. John Wiley & Sons; Singapore

## 3. CHEMICAL REACTION ENGINEERING – II

Teaching Scheme:

Lectures: 4 Hrs. / Week

Practical: 4 Hrs. / Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

Oral : 25 Marks

Term Work: 50 Marks

### UNIT-I

Introduction – Rate equations for heterogeneous systems , Contacting patterns in Two –Phase system ,Introduction to fluid particle reaction non-catalytic reactions, unreacted core model for Spherical particle of unchanging size, Rate of reaction for shrinking spherical particles , Determination of rate controlling step , Various contacting patterns in fluid solid reactors for fluid-particle non-catalytic reactions

(10 Hrs, 20 Marks)

### UNIT-II

Introduction to fluid-fluid system (without catalyst), Rate equation for Instantaneous, Fast, Intermediate and slow reaction, Slurry Reaction kinetics, Rate equation for infinitely slow reaction Film conversion parameter , Reactors for gas-liquid reactions and their comparative evaluations on the basis of holdups .

Gas liquid reaction modeling on the basis of simultaneous absorption reaction model.

Aerobic fermentation, Tower for fast and slow reaction, Mixer settler and semi-batch contacting pattern .

Reactive distillation and extractive reaction.

(10 Hrs, 20 Marks)

### UNIT-III

Introduction , Classification , Characteristics , Preparation and Deactivation of catalyst , Promoters and inhibitors , Determination of surface area and Pore volume of catalyst , Adsorption process and its classification , Types of adsorption isotherm .

(10 Hrs, 20 Marks)

### UNIT-IV

Introduction to solid catalyzed reactor , Rate equation for adsorption , desorption and surface reaction, Diffusion and reaction in spherical catalyst pellets , Internal effectiveness factor, Over all effectiveness factor, Estimation of diffusion and reaction limited regimes, Mass transfer and reaction in a packed bed, The determination of limiting situation from reaction data, chemical vapor deposition reactors.

(10 Hrs, 20 Marks)

### UNIT-V

Introduction to heterogeneous catalytic reactors,

Design, Mechanical construction and applications of: Moving bed reactors, Fluidized bed Reactors, Slurry bed reactors, Trickle bed reactors, Isothermal and Adiabatic fixed bed reactor.

(10 Hrs, 20 Marks)

## REFERENCES

1. Octave Levenspiel , Chemical Reaction Engg” 3<sup>rd</sup> edition (1999)
2. H Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall of India , 2<sup>nd</sup> edition (1997)
3. J M Smith, Chemical Engg Kinetics 3<sup>rd</sup> edition , New York , McGraw Hill (1981)
4. Lanny D Schmidt , The Engineering of Chemical Reactions ,Oxford University Press (1998)
5. Froment and Bischoff , Chemical Reactor Analysis and Design, Wiley Publications , New York (1979)
6. Hiroo Tominaga and Masakazu Tamaki, Chemical reactions & reactor design Ed Wiley and Maruzene Publications(1997)

## PRACTICAL and TERM WORK:

Practical and Term work shall consist of eight experiments from list given below.

1. To study the reaction of solid liquid system for an instantaneous reaction for benzoic acid NaOH and calculate the enhancement factor.
2. To study the isothermal decomposition of ethyl alcohol in tubular reactor packed with activated alumina catalyst.
3. To improve the % purity of commercially used ethanol using reactive distillation.
4. To improve the % purity of commercially used ethanol using extractive distillation.
5. To carry out the catalytic reaction to convert the nitrobenzene to aniline in presence of iron filling/HCl catalyst in the reactor.
6. To study the reaction of liquid liquid system for butyl acetate NaOH and to calculate the enhancement factor.
7. Absorption – to study the reaction of liquid gas system for NaOH – CO<sub>2</sub> to determine rate of absorption.
8. Adsorption- to study the adsorption of Acetic acid on charcoal
9. Preparation of Butyl Acetate by Reactive Esterification

## 4. ELECTIVE – I

### 1. BIOCHEMICAL ENGINEERING

Teaching Scheme:

Lectures: 4 Hrs./ Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

#### UNIT-I:

Characteristics of Biological material. Types of microorganisms; general physical properties of cells and chemical composition of cells; requirement for growth of cells and formulation of media; reproduction cycles in microorganisms; changes in composition of cells with age and with growth rate; effect of substrate limiting growth on the composition of cells; strain breeding; Maintenance of pure cultures.

Material Balances in bioprocesses, Application of material balances to bioprocesses; material balance with recycle, by-pass and purge streams. Stoichiometry of growth and product formation. Thermodynamics of microbial growth. Energy balances in bioprocesses, Heat of reaction for processes with biomass production. Unsteady state energy and material balances in bioprocesses.

(10 Hrs, 20 Marks)

#### UNIT-II:

Enzymes. History. Enzyme nomenclature and classification. Properties of enzymes. Applications of enzymes. Enzyme substrate complex and enzyme action. Effect of Temperature and pH on enzyme activity.

Kinetics of enzyme catalyzed reaction; simple enzyme kinetics with one and two substrates; Michaelis Menten kinetics. Evaluation of parameters of Michaelis Menten equation. Kinetics of reversible enzyme catalyzed reaction. Enzyme inhibition. Types of enzyme inhibition. Kinetics of competitive, uncompetitive and noncompetitive enzyme inhibition. Substrate activation and inhibition. Multiple substrates reacting on a single enzyme. Immobilization of enzymes and their applications. Kinetics of immobilized enzyme system.

(10 Hrs, 20 Marks)

#### UNIT-III:

Microbial Kinetics: Monod's growth kinetics. Environmental effects on growth kinetics. Balanced growth kinetics, Transient growth kinetics, Unstructured batch growth model, Growth of filamentous organisms, Structured kinetic model, Product formation kinetics. Unstructured model. Chemically structured kinetic model, Product formation kinetics by filamentous organisms.

Reactor Configurations: Enzyme reactors, Batch growth of microorganisms, Continuous culture of microorganisms, Stirred tank reactor with recycle of biomass, Continuous stirred tank fermenters in series, plug flow fermenter, fed batch fermenter, CSTR cell reactors with recycle and wall growth, multiphase reactors such as packed bed reactors, bubble column reactors, fluidized bed reactors and trickle bed reactors.

(10 Hrs, 20 Marks)

#### UNIT-IV:

Sterilization: Importance of Sterilization. Batch Sterilization of liquids, continuous sterilization of liquids, filter sterilization of liquids, sterilization of air, thermal death kinetics of cells and spores.

Aeration and Agitation: Mass transfer and Microbial respiration, bubble aeration and mechanical agitation, correlation between oxygen transfer coefficient and operating variables, effect of temperature, organic substances, surface active agents, mycelium and types of sparger on oxygen transfer coefficient. Measurement of oxygen transfer coefficient, Scale up.

(10 Hrs, 20 Marks)

#### UNIT-V:

Recovery of fermentation products, principle of mechanical separation; hindered settling in gravitation and centrifugal fields, filtration, pretreatment of cells to alleviated filtration resistance; Disruption of cells, mechanical methods, ultrasonic vibrations, grinding and mechanical shear, shearing by pressure, induction by lysis(physical methods, lytic agents, dessication, increasing the fragility of cells, Extraction preliminary fractionation procedures(removal of nucleic acids precipitation),high resolution techniques(ultra filtration, Chromatography, counter current distribution methods and other means ).

Instrumentation and Control: Introduction, methods of measuring process variables; temperature measurement and control, pressure measurement and control ,foam sensing and control, weight of fermenter and estimation of microbial biomass, dissolved oxygen measurement and control, inlet and exit gas analysis, pH measurement and control, online analysis of other chemical factors and computer applications in fermentation technology, bioprocess economics.

(10 Hrs, 20 Marks)

#### REFERENCES

1. Shuichi Aiba, Arthur E.H. & Nancy F.M.,Biochemical Engineering; University of Tokyo Press.

2. James E.Bailey & David F.Ollis, Biochemical Engineering. Fundamentals; McGraw Hill Publication.
3. P.F.Stanbury, A.Whitaker & S,J.Hall, Principles of Fermentation Technology; Aditya Books Ltd; New Delhi.
4. Doran Pauline M. Bioprocess Engineering Principles, Academic Press. An Imprint of Elsevier.
5. Shular Michael L.and Kargi Fikret. Bioprocess Engineering Basic Concepts, Prentice Hall of India.
6. Editors: J.F. Richardson, D.G. Peacock, Coulson's & Richardson's Chemical Engineering, (Vol-III) Asian Books Pvt. Ltd. New Delhi
7. J.H. Backhurst& J.H.Harker, Coulson's & Richardson's Chemical Engineering(Vol-V) Asian Books Pvt. Ltd. New Delhi

**4. ELECTIVE – I**  
**2. POLYMER ENGINEERING**

Teaching Scheme:  
Lectures: 4 Hrs./ Week

Examination Scheme:  
Paper: 100 Marks (3 Hrs)

**UNIT-I:**

Introduction to polymer and their classification. Types of polymerization. Addition Polymerization and Condensation Polymerization. Mechanism of polymerization.

Bulk, solution, suspension and emulsion polymerization techniques; merits, demerits and applications of these techniques.

(10 Hrs, 20 Marks)

**UNIT-II:**

Kinetics of polymerization: Kinetics of free-radical chain polymerization via initiation; propagation and Termination. Degree of polymerization and chain transfer reactions. Kinetics of catalyzed and uncatalyzed polycondensation reactions. Molecular Weight distribution; extent of reaction and degree of polymerization of polycondensation reactions.

(10 Hrs, 20 Marks)

**UNIT-III:**

Introduction to average molecular weight and Molecular Weight distribution in polymers, measurements of number, average by cryoscopy; Ebwiometry ; membrane osmometry ; vapor pressure osmometry and end group analysis. Measurement of viscosity, average molecular weight by viscometry.

(10 Hrs, 20 Marks)

**UNIT-IV:**

Thermal analysis of polymer by differential scattering calorimeter; TGA, TMA and HDT. Mechanical properties like tensile strength, Young's Modulus, hardness, etc.

(10 Hrs, 20 Marks)

**UNIT-V:**

Properties, applications and manufacturing techniques of polyethylene, PVC, Phenol formaldehyde, Urea formaldehyde resins, styrene-butadiene rubber (SBR), Nylon6, cellulose fiber (Rayon Yarn), PET.

(10 Hrs, 20 Marks)

## REFERENCES

1. V. R. Gowarikar, N. V. Vishwanathan, Polymer science; Wiley Eastern Publication, Delhi
2. B. K. Sharma, Polymer Science, Goel Publishing House; Meerut
3. Fried W. Billmeyer, Text book of polymer science, John Willey and Sons
4. M. Gopalrao, Dryden's Outlines of Chemical Technology; 3rd edn; East West Press.

### 4. ELECTIVE – I 3. ADVANCE CATALYSIS

Teaching Scheme:  
Lectures: 4 Hrs./ Week

Examination Scheme:  
Paper: 100 Marks (3 Hrs)

#### UNIT-I:

Catalysis: Introduction, History.

Homogeneous Catalysis: Introduction, Characterization of solution Processes, Examples of solution catalysis: Acid – base catalysis, Organometallic Catalysis.

Heterogeneous Catalysis: Introduction, Characterization of Surface Processes, Properties of Solid Catalysts, Influence of Mass Transport on Catalyst Performance.

Catalyst Components: Catalytically active species, Supports, Binders, Promoters.

Catalyst treatment: Activation, Deactivation, Regeneration, Redispersion, Reclamation, Disposal and Toxicity

Catalysis by Metals, Metal Oxides and zeolites, Metal Sulphides.

(10 Hrs, 20 Marks)

#### UNIT-II:

Supported Catalysts: Introduction, Definition of Supported Catalysts.

Advantages of Supported Catalysts: Separability, Cost, Catalyst activity, Catalyst Selectivity.

Support Materials for the Catalyst, Composition, Size and Shape, Surface Area., Porosity and Pore size. Attrition Loss, Density, Cost and quality.

Design and Development of Supported Catalysts: Preparation and Manufacture, Catalyst Preparation Methods, Catalysts from Physical Mixtures, Impregnated Catalysts, Ion exchange Catalysts. Testing and evaluation of Supported Catalysts, Application of Supported Catalysts.

(10 Hrs, 20 Marks)

#### UNIT-III:

Regeneration of Catalysts

Fluid Catalytic Cracking Unit: Process Description, Heat Balance, Coke formation, Coke burning, CO Combustion, Environmental aspects. Regenerator Operating Parameters. Influence of Regenerator design on Catalyst Fluidization, Equipment/Unit Operation in Cracking Units.

Noble and Base Metal Catalysis: Noble Metal Catalysis, Deactivation, Regeneration, Regeneration Processes such as continuous Catalyst Regeneration, Fixed Bed Semi Regenerative Process, Cyclic or swing, Reactor regeneration.

Base Metal Catalysis: Process and Catalyst Description.

(10 Hrs, 20 Marks)

#### UNIT-IV:

Catalysis in Petroleum and Petrochemical Industries:

Applications of zeolites in Petrochemical Refining. Improving quality of Petroleum fuels through Catalysis. O-xylene isomerization over Nickel containing SAPO-5 molecular sieves. Pd-sulfonated Polysiloxane catalyst for etherification of FCC light gasoline. Oxidation of Ethylbenzene catalyzed

by Soluble Cobalt (III) complexes. Comparative evaluation of various catalysts used for removal of NO<sub>x</sub> from air streams.

(10 Hrs, 20 Marks)

#### UNIT-V:

Biocatalysts: Introduction and importance of biocatalysts. Type of biocatalysts.

Enzymes: Definition, Sources of Enzymes, production of Enzymes. Formation of enzyme substrate complex. Applications.

Simple enzyme kinetics. Derivation of Michaelis Menten equation. Evaluation of parameters of Michaelis Menten equation. Effect of Temperature and pH on enzyme Kinetics.

Microbial Cell: Classification of cells. Requirement for the growth of cells and growth Media.

Microbial Kinetics. Monods Equation. Parameters affecting the growth kinetics of cells.

Immobilization of enzymes and cells. Methods and Techniques of immobilization. Application of immobilized enzymes and cells.

(10 Hrs, 20 Marks)

#### REFERENCES

1. Kirk Othmer, Encyclopedia of Chemical Technology, 4<sup>th</sup> edition, Volume-V. John wiley and sons New York.
2. Editors: Bhattacharya KG and Talukdar A K, Catalysis in Petroleum and Petrochemical Industries. Narosa Publishing House, New Delhi.
3. Editors: Richardson J.F. and Peacock D.G. Richardson and Coulson's , Chemical Engineering , Volume-III, Asian Books Pvt. Ltd., New Delhi.
4. James E. Bailey and David F.Ollis, Biochemical Engineering. Fundamentals; McGraw Hill Publication.

### 5. ENERGY ENGINEERING

Teaching Scheme:

Lectures: 4 Hrs./ Week

Practical: 2 Hrs./ Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

Oral : 25 Marks

Term Work: 25 Marks

#### UNIT-I:

Introduction to energy engineering. Energy resources and forms of energy. Energy demand. Changing energy consumption trends. National energy strategies. National energy plan. Energy power management and Energy planning in India. Energy Audit. Energy Conservation and recycling.

(10 Hrs, 20 Marks)

#### UNIT-II:

Conventional Energy Sources

Coal : Type of coal, classification of Indian coal. Important Properties of coal. Exploration, Storage and Transportation of coal. Coal gasification, coal liquefaction. Carbonization of coal, Production of coke and coal gas, By-products.

Petroleum, Natural gas and Refinery Products: Introduction to Petroleum and Natural gas and Naphtha. Energy routs of petroleum. Exploration of petroleum. Production of crude oil and Natural gas. Transportation of crude oil and Natural gas. Refining of crude oil and Natural gas. Liquefaction of Natural gas. Petroleum and Natural gas in India.

(10 Hrs, 20 Marks)

### UNIT-III:

Chemical Energy Sources:

Fuel cells: Introduction, Design and operation of a Fuel cell. Classification of fuel cells, Types of fuel cells, Advantages and disadvantages of fuel cells, Conversion efficiency of fuel cells, Work out put and EMF of fuel cell, Applications of fuel cells.

Hydrogen: Introduction, Applications of Hydrogen, Production of Hydrogen, Storage and transportation safety and management, Hydrogen technology development in India.

Methanol: Production of methanol, Applications of methanol as fuel.

Nuclear Energy: Nuclear energy and application compared with coal, Fuels for Nuclear Fission Reactor. Nuclear fuel cycle, Storage and Transportation. Energy from nuclear fission reaction.

Uranium Enrichment Process. Nuclear Waste management.

(10 Hrs, 20 Marks)

### UNIT-IV:

Solar Energy: Solar radiation and its measurement. Solar energy collectors, solar energy storage, Applications of Solar energy.

Wind energy: Basic Principles of wind energy conversion. Site Selection Considerations Classification of wind energy conversion system, Advantages and disadvantages of wind energy conversion systems, Storage and Applications of wind energy.

Geothermal Energy: Geothermal energy resources, utilization of geothermal energy, Applications of geothermal energy.

Tidal Energy: Tidal energy conversation, Tidal power, Tidal energy resources in India.

Bioenergy: Biomass energy resources, Biomass conversion processes, direct combustion of biomass, Thermo chemical conversion of biomass, Biochemical conversion, Ethanol from biomass, Applications.

(10 Hrs, 20 Marks)

### UNIT-V:

Energy conversion technologies and Electrical power plants: Energy conversion processes and devices, Power plants with conventional energy sources, Coal fired steam thermal power plants, Hydro electric power plants, Nuclear fission reaction power plants, Gas-turbine power plants, Combined cycle power plants, Integrated coal gasification combined cycle power plants, Diesel electric power plants, Geothermal electrical power plants. Plant factors and reserves.

(10 Hrs, 20 Marks)

### REFERENCES

1. S. Rao and Dr. B.B. Parulekar, "Energy Technology" Non Conventional, Renewable and Conventional, Khanna Publishers, Delhi.
2. G.D. Rai "Non conventional Energy Sources", Khanna Publishers Delhi
3. S.B. Pandya, "Conventional Energy Technology" Fuels and Chemical Energy Tata McGraw-Hill Publishing Company Ltd, New Delhi
4. S.P. Sukhatme, "Solar Energy", Principals of thermal collection and Storage. Tata McGraw-Hill Publishing Company Ltd, New Delhi

### TERM WORK:

Term Work shall consist of any eight assignments given below.

1. Energy power management and Energy planning in India
2. Energy Audit, Energy Conservation and recycling.

3. Conventional Energy Sources: Coal
4. Petroleum, Natural gas and Refinery Products
5. Chemical Energy Sources
6. Nuclear Energy and Power plant
7. Solar Energy
8. Wind Energy, Geothermal Energy, Tidal Energy and Bioenergy
9. Energy conversion technologies and power plants

## **6. PROJECT-I**

Teaching Scheme:  
Practical: 2 Hrs./ Week

Examination Scheme:  
Oral : 25 Marks  
Term Work: 25 Marks

The project topic shall consist of either some investigation work or design problem or experimental set up of some development work or prototype equipment or dissertation related to field of chemical engineering.

Project shall be taken in the beginning of the seventh term in consultation with concerned guide and must be completed in eighth term. The project proposal must be submitted in the beginning of the seventh term by every student or a group of students (not more than five students in a group).

The students shall submit the report to the corresponding guide, present their work in due time based on following points,

- Introduction.
- Literature survey.
- Physical / chemical properties etc.
- Experimental setup and procedure.
- Extent of project completed.

Presentation can be performed with OHP slides / LCD.

The progress of the project shall be evaluated by a committee of internal teachers which shall include concerned guide also and shall award the term work marks.

The oral examination of the project shall be conducted by concerned guide and external examiner jointly.

## **7. SEMINAR**

Teaching Scheme:  
Practical: 2 Hrs./ Week

Examination Scheme:  
Term Work: 25 Marks

During seventh term, every student individually will study a topic assigned to him and submit a report in a typed form and shall deliver a short lecture / seminar on the topic at the time of seminar oral examination. The topic assigned will be related to the field of chemical engineering.

The students shall deliver the seminar (10 to 15 minutes) and submit the seminar report to the staff member on different technical subjects during the semester. The assessment of the term-work shall be based on the: -

1. Attendance to the seminar
2. Performance of the seminar delivery
3. Seminar reports and
4. Viva voce during the seminar.

The staff member/members shall guide the students in:

1. Selecting the seminar topic.

2. Information retrieval (literature survey)
  - a) Source of Information i.e. names of the journals, reports, books etc.
  - b) Searching for the information i.e. referring to chemical abstracts etc.
3. Preparing the seminar report
4. Delivering the seminar

The oral examination shall be conducted by a committee of teachers internally which shall include the concerned guide also and shall award the oral marks (in the seventh term / at the end of seventh term).

# 1. COMPUTER AIDED PROCESS EQUIPMENT DESIGN MODELING & SIMULATION

Teaching Scheme:

Lectures: 4 Hrs. / Week

Practical: 4 Hrs. / Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

Practical: 25 Marks

Term Work: 50 Marks

UNIT-I:

Computer Aided Design:

Shell and Tube Heat Exchanger.

Reactor

(10 Hrs, 20 Marks)

UNIT-II:

Computer Aided Design:

Single Effect Evaporator.

Distillation Column.

(10 Hrs, 20 Marks)

UNIT-III:

Computer Aided Design:

Absorption Column.

Rotary Dryer.

(10 Hrs, 20 Marks)

UNIT-IV:

Introduction to Lumped Parameter Model.

Comparison of Model with Real Situation.

Modeling of An Activated Sludge Process as a continuous Operation by Recycling Biological Sludge

Modeling Difficulties in C.S.T.R.

Modeling of Constant Hold up Three CSTR's in Series.

Modeling of Batch Reactor With First Order Consecutive Reaction Takes Place as Time Proceed for Study of Optimal Batch Time.

Modeling for Maximizing the Yield of the Intermediate (Desirable) Product.

Modeling for Evaluation of the Adiabatic Equilibrium Temperature.

Modeling for Catalyst Decay in a CSTR.

Modeling for Evaluation of Conversion with Catalyst Decay in Batch Reactor.

(10 Hrs, 20 Marks)

UNIT-V:

Introduction of the Chemical Engineering Simulation.

Simulation Language.

When to Use Simulation?

Steps of Simulation Process.

Chemical Engineering Application of Simulation Techniques.

Advantage and Limitation of Simulation Technique.

Simulation of Ammonia Production System.

Simulation of Catalyst Temperature by Newton-Raphson Method.

Simulation of CSTR By Euler's Method.

Simulation of CSTR with Second Order Irreversible Exothermic Reaction Using Runge-Kutta Method.

(10 Hrs, 20 Marks)

Practical and Term Work shall consist of following experiments.

1. Computer aided design of shell & tube heat exchanger.
2. Computer aided design of single effect evaporator.
3. Computer aided design of rotary dryer.
4. Simulation of ammonia production system.
5. Simulation of catalyst temperature by Newton Raphson method.
6. Simulation of Reactor Design.
7. Computer control heat exchanger.
8. Computer Aided Design of absorber.

#### REFERENCES

1. W. L. Luyben , Process Modeling Simulation and Control for Chemical Engineers; 1988 McGraw Hill.
2. B.C. Bhattacharya & C. M. Narayan, Computer Aided Design of Chemical Process Equipment : 1st Edition, 1992, NCBA, Calcutta

Note: Students Can Utilize FORTRAN -77 And / Or C And/Or C++ Programming Language for the Above Syllabus.

## 2. PROCESS ENGINEERING ECONOMICS & COSTING

Teaching Scheme:

Lectures: 4 Hrs./ Week

Practical: 2 Hrs./ Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

Oral : 25 Marks

Term Work : 25 Marks

#### UNIT-I:

Scales of Production, Selection of Plant Capacity, Plant Location. Availability of Raw Materials, Energy Gestation Period. Expansion, Diversification and Obsolescence. Scope for Standardization in Design and Production .Economics of Research and Development .Indian Chemical Industry , Current Status and Trends .

(10 Hrs, 20 Marks)

#### UNIT-II:

Cost Estimation: Factors Affecting Investment and Production Cost .Capital Investment , Fixed Investment and Working Capital .Estimating Equipment Cost By 6 /10 Factor Rule .Method of Estimating Capital Investment .Different Costs Involved in Total Product Cost .Computer Automization in Costing.

(10 Hrs, 20 Marks)

#### UNIT-III:

Interest and Investment Cost , Simple and Compound Interest , Nominal and Effective Rates of Interest , Continuous Interest , Ordinary Annuity ,Perpetuities and Capital Costs . Taxes and Insurances: Types of Taxes and Tax Returns. Types of Insurance and Legal Responsibility.

(10 Hrs, 20 Marks)

#### UNIT-IV:

Depreciation: Types of Depreciation, Service Life, Salvage Value, Present Value. Methods of Determining Depreciation, Single Unit and Group Depreciation .Causes of Obsolescence and Inadequacy.

(10 Hrs, 20 Marks)

#### UNIT-V:

Profitability, Alternative Investment and Replacement, Mathematical Methods of Profitability Evaluation, Cash Flow Diagram. Break Even Analyses, Balance Sheet, Pricing Issue Method and Income Statement.

(10 Hrs, 20 Marks)

#### TERM WORK:

Term Work shall be based on the following.

1. Location of a chemical plant
2. Indian Chemical industry
3. Cost Estimation
4. Interest and Investment costs
5. Taxes and Insurance
6. Depreciation
7. Profitability and Replacement
8. Break Even Analysis

#### REFERENCES

1. Peter M.S. Timmerhaus K.D. Plant Design and Economics for Chemical Engineers. McGraw Hill.
2. Vilbrandt F.C. and C.E. Dryden , Chemical Plant Design. McGraw Hill
3. T.R. Banga and S.C.Sharma, Industrial Organization & Engineering Economics, Khanna Publications, New Delhi.
4. O.P.Khanna Industrial Engineering & Management, Dhanpat Rai Publications Pvt. Ltd. New Delhi.
5. Dewett & Varma, Elementary Economic Theory : S Chand & Company Ltd New Delhi

### **3. CHEMICAL PLANT DESIGN & PROJECT ENGINEERING**

Teaching Scheme:

Lectures: 4 Hrs./ Week

Practical: 4 Hrs./ Week

Examination Scheme:

Paper: 100 Marks (3 Hrs)

Oral : 25 Marks

Term Work: 25 Marks

#### UNIT-I:

Introduction to Chemical Engineering Plant Design and Project Engineering.

The role of Chemical Engineer in Chemical Plant Design. Chemical Engineering Design, need for Plant Design, Process Design.

Development of the project: Evaluation of a process, process research, research evaluation, process development, preliminary engineering studies, pilot plant, semi-commercial plant, commercial plant and commercial plant design factors.

Technical factors, economic factor, safety considerations, legal phases, sources of information.

(10 Hrs, 20 Marks)

#### UNIT-II:

Process Design: Choice of process continuous Vs. Batch processing.

Process Equipments and Materials: Selection of Materials, Plan for Selection of Materials. Selection of Process Equipments, Equipment selection procedures, standard Vs. special equipment. Scale up method, types of flow sheet, development of process flow sheet from process information.

(10 Hrs, 20 Marks)

#### UNIT-III:

Plant Layout : Introduction planning-layout, factors in planning-layout methods of layout planning area concept, two dimensional layouts, scale models, principles of plant layout, safety, utilities & material handling equipments , railroads and roads, etc.Plant layout for Benzene Hexachloride process.

Locating the Chemical Plant: Introduction, summary of factors in plant location.

Economics location, plant location factors, raw material supply, market and transportation, power and fuel, water supply , temperature, plant measures for conservation of water, legal restriction, federal pollution act, climate, labour, community and site characteristics and waste disposal.

(10 Hrs, 20 Marks)

#### UNIT-IV:

Site preparations and Structures : Introduction, Site Preparation, Surface Evaluation, Foundation and Shape of Foundation, Machinery and Equipment Foundations, Supports, Outdoor Plants, Selection Building types, Building design principles, Flooring , walls, Roof, safety and higher protection conditioning , heating and ventilation. Cost Consideration for Plant Sites and Structures New Development in Management techniques. (PERT & CPM).

(10 Hrs, 20 Marks)

#### UNIT-V:

Process Auxiliaries : Introduction, Piping, Explanation of CODES, Selection of Piping, Pipe strength, Wall thickness, Nominal Pipe Size (NPS), Criteria for Selection of Materials, Pipe sizing by ID, Choosing the final pipe size, Process steam piping, piping layout, piping insulation, methods of providing flexibility for piping.

(10 Hrs, 20 Marks)

#### TERM WORK:

Term Work shall consist of minimum 5 (five) half imperial size sheets based on above syllabus.

1. Process flow diagram of Manufacturing of Benzene Hexa Chloride (BHC)
2. Process flow diagram of Manufacturing of Nitric Acid
3. Plant Layout for Manufacturing of Benzene Hexa Chloride (BHC)
4. Plant Layout for Manufacturing of Nitric Acid
5. Piping diagram for Manufacturing of Nitric Acid
6. Piping diagram for Manufacturing of Benzene Hexa Chloride (BHC)
7. Network Analysis Numerical : PERT & CPM

#### REFERENCES

1. F.C. Vilbrandt and C.E. Dryden, Chemical Engineering Plant Design McGraw Hill, New Delhi.
2. Peter M. S. and K.D. Timmerhaus, Plant Design and Economics for Chemical Engineers. McGraw Hill.
3. Modes J. and Philips, Rheinhold, Project Engineering with CPM and PERT :
4. Perry's Chemical Engineer's handbook.

## 4. ELECTIVE – II

### 1. INDUSTRIAL POLLUTION & CONTROL

Teaching Scheme:  
Lectures: 4 Hrs./ Week

Examination Scheme:  
Paper: 100 Marks (3 Hrs)

#### UNIT-I:

Introduction: Types of Pollution. Introduction: Pollution control aspects. Environmental Legislation: Water (Prevention and Control of Pollution) Act, 1974, Air (Prevention and Control of Pollution) Act, 1986. Industrial Waste Water Analysis. Industrial Gaseous Effluent Analysis. General Instrument for Gaseous Pollutants.

(10 Hrs, 20 Marks)

#### UNIT-II:

Removal of BOD. Introduction to removal of BOD Biological oxidation units: Activated Sludge Process; Trickling /Biological Filters; Waste Stabilisation Ponds. Anaerobic Treatment. Numerical Examples based on removal of BOD.

Removal of Chromium. Introduction to removal of Chromium. Control Methods, Reduction precipitation, Ion Exchange, Reverse Osmosis, Lime coagulation and adsorption.

(10 Hrs, 20 Marks)

#### UNIT-III:

Removal of Mercury: Introduction of removal of mercury, Measurement of Mercury, Ventron mercury removal process.

Removal of ammonia/urea: Introduction to removal of ammonia/urea, Methods for removal of nitrogen, Physico-chemical processes, Biological methods.

(10 Hrs, 20 Marks)

#### UNIT-IV:

Treatment of Phenolic Effluents: Introduction to Treatments of Phenolic Effluents, Sources of phenols.

Treatments/Removal Methods: Steam Gas Stripping. Adsorption/Ion Exchange; Extraction of phenols using Phenosolvents Biological Methods of Treatment.

Removal of particulate matter: Introduction to removal of particulate matter, Gravity settling chamber, solid traps, cyclone separators, fibre filters, fabric filters, liquid scrubbers and ESP.

Numerical Examples based on settling chamber, cyclone separators, fiber filter, liquids scrubber and ESP.

(10 Hrs, 20 Marks)

#### UNIT-V:

Pollution control in process industries:

Introduction to pollution control,

Pollution control aspects of fertilizer industry: Introduction to pollution control in fertilizer industry.

Removal of carbon in ammonia plant effluents by scrubbing with liquids using vacuum filtration,

Removal of oil in ammonia plant effluents, Removal of hydrogen sulphide in ammonia plant effluents

Pollution control in petroleum and petrochemical units: Introduction

Refinery Liquid based treatment methods: Oxidation pond treatment, disposal of sludges.

Treatment of liquid effluents from petrochemical industries, Removal of hydrogen sulphide gas from sour gas by stripping, Removal of ammonia from gases.

Alcohol industry: Treatment method by recovery of potash from distillery spent-wash.

(10 Hrs, 20 Marks)

## REFERENCES

1. S. P. Mahajan, Pollution control in process industries, Tata McGraw-Hill Publication
2. M. N. Rao & A K. Datta, Waste Water Treatment: IBH Pub., Delhi

## 4. ELECTIVE – II 2. ADVANCE SEPARATION TECHNIQUES

Teaching Scheme:  
Lectures: 4 Hrs./ Week

Examination Scheme:  
Paper: 100 Marks (3 Hrs)

### UNIT-I:

Separation Processes: Industrial Chemical Processes, Mechanism of Separation  
Separation by phase addition or creation. Separation by barrier. Separation by solid agent.  
Separation by external field or gradient. Component Recoveries and product purities. Separation power. Selection of feasible separation processes.

Crystallization from the melt: Introduction.

Progressive freezing: component Separation by progressive freezing, Pertinent variables in progressive freezing. Applications.

Zone melting: component separation by zone melting, pertinent variables in zone melting, Application.

Melt crystallization from the bulk: Investigations, commercial equipment and application.

Falling-film crystallization: Principles of operation, commercial equipment and applications.

(10 Hrs, 20 Marks)

### UNIT-II:

Enhanced distillation: Introduction. Azeotropism.

Azeotropic distillation: Introduction, exploitation of homogeneous azeotropes, exploitation of pressure sensitivity, exploitation of boundary curvature, Exploitation of azeotropy and liquid

Extractive distillation: Introduction, solvent effect in extractive distillation, extractive distillation design and optimization, solvent screening and selection extractive distillation by salt effects.

Reactive distillation: Introduction, simulation, modeling and design feasibility, Mechanical design and implementation issues, process applications.

(10 Hrs, 20 Marks)

### UNIT-III:

Supercritical fluid separation processes: Introduction. Physical properties of pure supercritical fluids; thermodynamic properties and transport properties. Process concept in super critical fluid extraction. Phase equilibria: Liquid- Fluid equilibria, Solid- Fluid equilibria, Polymer- Fluid equilibria and the Glass Transition, Cosolvents and surfactants, phase equilibria models. Mass Transfer.

Applications: Food and Pharmaceutical applications, Temperature controlled residuum Oil super critical extraction [ROSE], Extraction from aqueous solution, Adsorption and desorption, Polymer de volatilization and fractionation, Drying and Aerogel formation, Clearing, Crystallization, Reactive separations.

(10 Hrs, 20 Marks)

#### UNIT-IV:

Membrane separation processes: Introduction. Advantages of membrane separations, Basic equations, Basic concept, Membrane types, Economics.

Electro dialysis: Process description, examples, membranes, membrane efficiency, process description and configuration, Energy requirements, Equipment and economics.

Reverse osmosis and Nano filterization: Processes description, examples Basic principles of operations, RO and NF membranes, process limitations and configuration. Economics.

Ultra filtration: Process description, UF membranes, membrane characterization, process limitations, process configurations, Energy requirements, Design and economics.

Microfiltrations: process description, Examples, MF membranes, membrane characterization , process limitations, Equipments configurations, process Applications and Economics.

Gas- Separations membranes: Process descriptions, examples, Basic principles of operations, selectivity and permeability, Gas- Separation membranes, membrane system design features, energy requirements and economics.

Pervaporization: Process description, definition, operational factors, vapor feed, examples, pervaporation membranes, modules.

(10 Hrs, 20 Marks)

#### UNIT-V:

Biochemical separation processes: Introduction.

Initial product harvest and concentration: centrifugation, Filtration, Selection of cell separation Unit operation, Cell disruption, protein refolding.

Initial purification: Precipitation, Extraction, Adsorption, Membrane processes.

Final Purification and product formulation.: Chromatography, Lyophilization and drying. Integration of fermentation and downstream processing operations.

(10 Hrs, 20 Marks)

#### REFERENCES

1. Perry Robert H. and Green Don W. Perry's chemical Engineers Handbook 7<sup>th</sup> edition. McGraw Hill Publication, New York.
2. Seader J. D. and Henley Ernest J, Separation Process Principles. John Wiley and Sons, Inc, New York
3. Ladisch Michael R., Bioseparations Engineering, Principles, Practice and Economics, Wiley Interscience, John Wiley and Sons, Inc. Publications New York
4. Long Robert B. Separation Process in Waste Minimization .Marcel Dekker, Inc, New York

### **4. ELECTIVE – II** **3. PETROCHEMICALS**

Teaching Scheme:  
Lectures: 4 Hrs./ Week

Examination Scheme:  
Paper: 100 Marks (3 Hrs)

#### UNIT-I

Petrochemical Industry in India. Feed stocks for petrochemicals, separation of aromatics Chemicals from methane: Manufacture of methanol, formaldehyde, acetic acid, ethylene glycol, CS<sub>2</sub>, liquid fuels from methanol, manufacture of ethanol.

(10 Hrs, 20 Marks)

#### UNIT-II

Chemicals from ethane- ethylene-Acetylene.

Ethane: Occurrence, halides of ethane, Nitroethane and oxidation of ethane.

Ethylene production, production of ethylene derivatives like vinyl acetate monomer, ethylene oxide, ethylene diamine, ethanol and acetaldehyde.

Chemicals from acetylene: acrylic acid, vinyl chloride, vinyl acetate and Acetonitrile.

(10 Hrs, 20 Marks)

#### UNIT-III

Chemicals from C<sub>3</sub>, C<sub>4</sub> and higher carbon atoms:

Products from propane. Dehydrogenation of propane and higher paraffins.

Chemicals from propylene: Isopropyl alcohol, acetone, propylene glycol, acrylic acid and ester, Phenol.

Dehydrogenation of butanes. Production of Iso and n- butanol. Production of methyl –tert-butyl ether [MTBE], Adipic acid. Derivatives from hydrocarbons higher than butane.

(10 Hrs, 20 Marks)

#### UNIT-IV

Synthesis gas and chemicals:

Synthesis gas. Steam reforming of hydrocarbons. Production of synthesis gas. Chemicals from synthesis gas. Oxo synthesis, vinyl acetate, acetic acid.

Fischer-Tropsch synthesis: catalysts and the products.

LPG: sources, properties grades of LPG. Supply of LPG to consumers, the storage and use of LPG, LPG piping system, safety consideration and emergency action. Emergency controls and action.

(10 Hrs, 20 Marks)

#### UNIT-V

Petroleum aromatics: Production of BTX.

Benzene derivatives like Aniline, phenol, alkylation of benzene.

Products from toluene: Chloro toluenes, O- Cresols, Dinitro toluenes, Benzaldehyde, caprolactum, Terephthalic acid.

Chemicals from xylene: o-xylene, m-xylene, p-xylene, Naphthalene

(10 Hrs, 20 Marks)

#### REFERENCES

1. Bhaskararao B.K. "A Text on petrochemicals", Khanna Publishers, New Delhi
2. Sarkar G.N. "Advanced Petrochemicals" Khanna Publishers, New Delhi
3. Maiti Sukumar [editor], "Introduction to Petrochemicals", Oxford and IBH Publishing co. Pvt. Ltd. New Delhi

### 6. PROJECT-II

Teaching Scheme:  
Practical: 4 Hrs./ Week

Examination Scheme:  
Oral : 50 Marks  
Term Work: 100 Marks

The students are required to carry out one of the following projects.

1. Process based Project: Manufacture of product.
2. Equipment based Project: Detailed design and fabrication of the equipment for a given capacity.
3. Experimental based Project: Experimental investigation of basic or applied research problem.
4. Industrial Problems: Any problem or project directly related to existing plants for modification of process or equipment or regarding pollution control and energy conservation under the guidance of a staff member and /or staff members and submit a typed report in duplicate.

The Project Work consists of collection of literature, study of the various processes selection of the process, computation of material and energy balances, process design of important equipments, detailed design of one of the main equipment, plant location and layout, cost Estimation, economic analysis, details of experimental set up, analysis of data, pollution control, safety, marketing, conclusions and recommendations, bibliography, etc., as applicable to the individual problem.

The object of the project is to make use of the knowledge gained by the student at various stages of the degree course. This helps to judge the level of proficiency, originality and capacity for application of the knowledge attained by the student at the end of the course.

Each group should consist of maximum 5 students. For term-work (Internal) of 100 marks, the assessment should be by conducting frequent written tests, seminars during the year and an oral examination at the end of the year conducted by all the staff members of the department. The Head of the Department should see that the assessment procedure should be the same for all the students of the class. For external 50 marks, the project work shall be assessed by an oral examination by at least two examiners, one internal and one must be external at the end of the year.

The object of the VIVA VOCE examination (Internal and External Orals) is to determine whether the objectives of the project work have been met by the student as well as to assess the originality and initiative of the student as demonstrated in the project work.

## **7. INDUSTRIAL VISIT / CASE STUDY**

Examination Scheme:

Term Work: 25 Marks

During seventh term, every student shall visit minimum three industries or organization pertaining to the Chemical Engineering arranged by College and accompanied by departmental teachers as per AICTE and University norms. The report of technical visit shall be submitted by every student at the end of eight term which shall be evaluated by the concerned teachers through internal Viva Voce.