Department of Chemical Engineering

Final year B.Tech Course structure

Semester- VII

Sr. No.	Course Code	Subject Title	Contact Hours L	T	P	Credits
01	CH 4101	Chemical Reaction Engineering - II	3	1	-	8
02	CH 4102	Process Instrumentation and Control - II	3	-	-	6
03	CH 4103	Engineering Economics and Project Management	3	-	-	6
04	CH 4104	Elective – I	3		-	6
05	Ch 4105	$Modeling and Simulation	3	-	2	8
06	CH 4106	Chemical Reaction Engineering Lab	-	-	2	2
07	CH 4107	Process Instrumentation and Control Lab	-	-	2	2
08	CH 4108	Mass Transfer Operations – II Lab			2	2
08	CH 4109	Project Work – Stage I	-	3	-	6
09	CH 3209	Industrial Training (Assessment)	-	-	-	-
		Total	15	4	8	46

$ Intra semester assessment

Elective – I (courses): 1. Introduction to Biochemical Engineering, 2. Introduction to Food Engineering, 3. Nuclear Chemical Engineering and 4. Non-conventional Sources of Energy.

Semester- VIII

Sr. No.	Course Code	Subject Title	Contact Hours L	T	P	Credits
01	CH 4201	Elements of Transport Phenomena	3	1	-	8
02	CH 4202	Pollution Control in Process Industries	3	-	-	6
03	CH 4203	Elective – II	3	-	-	6
04	CH 4204	Elective - III	3	-	-	6
05	CH 4205	$Simulation of Chemical Operations and Processes	2	-	2	6
06	CH 4206	Pollution Control Lab	-	-	2	2
07	CH 4207	Project Work – Stage II	-	5		10
		Total	15	6	4	44

$ Intra semester assessment.

Elective – II (courses): 1. Catalysis, 2. Newer Methods of Separation, 3. Introduction to Polymer Science and Technology, and 4. Multiphase Flow

Elective –III (courses): 1. Bio-Technology, 2. Petroleum Refining and Petrochemicals, 3. Chemical Engineering Mathematics, 4. Entrepreneurship Development

Detailed syllabi of final year B.Tech. Chemical Engineering Programme

SEVENTH SEMESTER

CH 4101 Chemical Reaction Engineering II

UNIT I

Multiple Reactions - Maximizing desired product in parallel reactions, Maximizing desired product in series reactions, Stoichiometric table using fractional conversion

UNIT II

Multiple reactions in PFR and CSTR – An alternative approach to using fractional conversion

UNIT III

Nonelementary Reaction Kinetics - Fundamentals, Searching for a mechanism, polymerization, enzyme reaction fundamentals, Bioreactors

UNIT IV

External Diffusion Effects on Heterogeneous Reactions - Mass transfer fundamentals, Binary diffusion, External resistance to mass transfer, The shrinking core model

UNIT V

Distribution of Residence times for Chemical Reactors - General characteristics, Measurement of RTD, Characteristics of RTD, RTD in ideal reactors, Reactor modeling with RTD, Zero-parameter models

UNIT VI

Models for non-ideal reactors - One-parameter models; tank-in-series model, dispersion model

Texts / References:

H. S. Fogler, "Elements of Chemical Reaction Engineering", 3rd Ed, New Delhi-Prentice Hall, 2001

O. Levenspiel," Chemical Reaction Engineering" Willey Eastern, 3rd Ed., 2000

J. M. Smith, "Chemical Engineering Kinetics", 3rd Ed., McGraw- Hill, 1988

CH 4102 Process Instrumentation and Control – II

Instrumentation

UNIT I

Level Measurement : Level measurements of open and pressure vessels measurement of interface level.

UNIT II

Density Measurement: Density measurements by displacement meter, hydrometer and densitometer.

UNIT III

Flow Measurements : Orifice, Venturi, Pitot, and Rota-meters flow measurement of open channels.

Instrumentation to flow plan symbols and chemical sensors.

Control

UNIT IV

Stability: Concept of stability, Stability criterion, Routh test for stability.

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

UNIT V

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

UNIT VI

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

Text / References:

1. D. P. Ecman, Industrial Instrumentation, Wiley Estern, 1989.
2. J. P. Bentley, Principles of Measurement Systems, 2nd ed. Longman London, 1988.
3. J. W. Dally, W. F. Riley and K. G. McConnell, Instrumentation , Engineering Measurements, John Wiley and Sons, Singapore, 1984.
4. C. S. Rangan, G. R. Sarma and V. S. V. Mani, Instrumentation Devices and systems, Tata McGraw Hill, New Delhi, 1983
5. B. C. Nakra and K. K. Chaudhary, Instrumentation Measurement and Analysis, Tat McGraw Hill, New Delhi, 1985.
6. D. R. Coughanowr, Process system analysis and control, 2nd ed, McGraw Hill, 1991.
7. P. Harriott, Process Control, Reprint of text, ed. Tata McGraw Hill, 1983.
8. G. Stephanopoulos, Chemical Process Control: An introduction to theory and practice, Prentice Hall, New Jersey, 1984.

CH 4103 Engineering Economics and Project Management

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

UNIT II
Depreciation, amortization obsolescence in Chemical Industries. Perpetuity and sinking fond, economic selection of equipment size, capitalized costs. Optimization of process parameters, a few examples. Break even point analysis and discount cash flow.

UNIT III
Discussion on projects in India. Causes for time and cost over runs-some case studies. Project evaluation and assessment of project profitability. Organization of project Engineering. Basic Engineering data.

UNIT IV
Project development and commercialization. Licensing and contract. Plant location and layout.

UNIT V
Piping Engineering. Project Engineering management. Selection of alternatives. Selection of plant capacity.

UNIT VI
Optimum process design a few examples of standardization and commissioning. Project scheduling its importance. Use of PERT/CMP techniques.

Texts / References:

1. M. S. Peters and K. D. Timmerhaus, "Plant Design Economics for Chemical Engineers", 3rd Ed., McGraw-Hill, New York - 1980.
2. V. W. Uhl and A. W. Hawkins, "Technical Economics for Chemical Engineers", AIChE - 1971.
3. J. Modes and Philips, "Project Engineering with CPM and PERT", Rein Hold.

CH 4104 Elective –I

(i) Introduction To Biochemical Engineering

UNIT I

Scope and possibilities, characteristics and classification of biological matter

UNIT II

Kinetics of microbial growth, balance equations for batch and continuous cultures, kinetics of enzyme catalysed reactions.

UNIT III

Analysis of mixed microbial populations.

UNIT IV

Design and analysis of biological reactors.

UNIT V

Production Isolation and utilization of enzymes.

UNIT VI

Transport phenomena in biological systems.

Text/References:

1. S. Aiba,, A. E. Humbrey, and N. F. Mills, Biochemical Engineering, 2nd ed. Academic Press, New York, 1973
2. J. E. Baley, D. F. Ollis , Biochemical Engineering Fundamentals, 2nd ed. McGraw Hill, 1986
3. B. Atkinson, Biochemical Reactor , Pion Ltd, London, 1974

(ii) Introduction To Food Engineering

UNIT I

Food chemistry: Lipids, proteins, carbohydrates, composition of foods nutrition. Food Microbiology: Introduction growth factors, degradation and spoilage of foods epidemiology of food borne diseases, food infections.

Food Biotechnology: Fermentation and enzymatic processes.

Asceptic Techniques: Food handling, food sterilization sterilization of food processing equipments.

UNIT II

Transport Phenomena in food processing: Non newtonian flow heat transfer simultaneous heat and momentum transfer thermal time distribution mixing unit operations in food systems, evaporation.

UNIT III

Preservation techniques: Thermal, Dehydration, microwave irradiation cold fermentation and by chemicals.

UNIT IV

Packaging and storage: Principles, shelf life, canning, modified atmosphere packaging, refrigeration.

UNIT V

Post Harvesting Techniques: Grain drying and storage fruit and vegetable processing seafood and meat processing

UNIT VI

Supercritical extraction: Flavours, spices, and essence.

Text/ References:

1. R. Paul Singh and Demis R. Heldman, Introduction to Food Engineering, 2nd ed, Academic Press, 1993.
2. Ernest L. Watson and John C Harper, Elements of Food Engineering, 2nd ed. Von Nostrand Reinhold Co., 1987.
3. R. Macral, R. K. Robinson, and M. J. Sadler, Encyclopedia of Food Science, Food Technology and Nutrition, Vol. 8, Academic Press 1993.

(iii) Nuclear Chemical Engineering

UNIT I

Role of Chemical Engineering in the nuclear industry an overview of the various separations used in the nuclear industry.

UNIT II

Uranium ore processing, Uranium refining

UNIT III

Electrochemical technology in nuclear industry

UNIT IV

Production of UF and fluorine, choice and problems.

UNIT V

Isotope separation

UNIT VI

Fuel reprocessing Nuclear waste management, storages for primary and secondary solid wastes, Ultimate disposal.

Text / References:

1. Benedict and Pigford, Nuclear Chemical Engineering, 2nd ed. McGraw Hill.

(iv) Non Conventional Sources Of Energy

UNIT I

Conventional sources of commercial energy; fossil fuels, nuclear energy and hydroelectric power, their consumption rates. Energy reserves and estimates of time for which conventional sources will last. Alternative energy sources.

UNIT II

The solar option – direct and indirect applications. Availability of solar radiation energy collection and concentration for photo thermal applications. thermal storage.

Introduction to photo voltaic and thermoelectric conversion.

UNIT III

Wind energy, types of wind mills, Elementary design principles. Ocean thermal energy conversion.

UNIT IV

Biomass as a source of energy. Energy plantation production of fuel from wood, agricultural and animal waste. Bioconversion processes. Bio gas its generation and utilization.

UNIT V

The nuclear option fission and fusion technology fundamentals. Thermal and fast reactor. State of art Breeder reactors . Prospects and limitations, economics.

UNIT VI

Geothermal Energy System, extent of available resources. Heat Transport in geothermal systems. Introduction to tidal and wave energy M. H. D. power, Fuel cells.

Text / References:

1. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley, 1980..

N. Veziroglu, Alternative Energy Sources, Vol, 5 and 6, McGraw Hill, 1978.

CH 4105 Modeling and Simulation

Tests: 40 marks (2 tests), TW: 30 marks, Lab Report: 10 marks, Viva voce: 20 marks

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

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

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

4. **Computer simulation:** Similation examples; Gravity flow tank; Three CSTRs in series; Non-isothermal CSTR; Binary distillation column; Multicomponent distillation column; Variable pressure distillation; Approximate variable pressure model; Rigorous variable pressure model; Batch reactor; Ternary batch distillation with holdup.

List of Practicals

1. Simulation of a Chemical Processes (at least 2 Processes)
2. Optimal Design of Equipment**:**
    1. Design of Shell and Tube Heat exchangers
    2. Design of Evaporators
    3. Design of Distillation columns
    4. Design of Reactors

TEXT BOOK:

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

REFERENCE BOOKS:

1. Morton M. Denn – Process Modeling – Longman Scientific & Technical – 1987
2. A. W. Westerberg, H.P. Hutchison, R.L. Motard and P. Winter – Process Flowsheeting – Cambridge University Press – 1985.

CH 4106 Chemical Reaction Engineering Laboratory

LIST OF PRACTICALS:

1. Determine activation energy of acid catalyzed hydrolysis of methyl acetate.
2. To study effect of concentration of reactant and temperature on the rate of reaction.
3. Determination of specific reaction rate of acid catalyzed hydrolysis of ethyl acetate
4. Determination of specific reaction rate of acid catalyzed hydrolysis of ethyl acetate by sodium hydroxide at 298 K
5. To study the reaction between potassium persulphate and iodide
6. Kinetics of hydrolysis of methyl acetate by strong acid.
7. To study acid- catalyzed iodination of acetone.
8. To study saponification of ethyl acetate.
9. Study of Isothermal continuous stirred tank reactor
10. Study of RTD in packed bed
11 Study of RTD studies in continuous stirred tank reactor
12. Study of non-catalytic homogeneous reaction in a isothermal tubular flow reactor
13. Study of non-catalytic homogeneous reaction in a batch reactor
14. Study of non-catalytic homogeneous reaction in continuous stirred tank reactor
15. Study of non-catalytic homogeneous reaction in plug flow reactor

(Minimum 12 experiments to be performed by all students)

CH 4107 Process Instrumentation and Control Lab

LIST OF PRACTICALS:

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

9. To study the response of an inherently second order system (mercury thermometer)
10. To study the working of on-off controller.

CH 4108 Mass Transfer Operations – II Lab

LIST OF PRACTICALS:

1. T-x-y diagram for water-acetone system
2. To prove Rayleigh equation by carrying out simple distillation of methanol-water system
3. To carry out crystallization of given salt
4. To determine rate of drying of given sample and to plot (kg moisture content/ kg of dry solid) V/S time and rate of drying V/S time
5. To study Swenson Walker crystallizer
6. Determination of HETP (Height equivalent to theoretical plate)
7. Study of fluidized bed dying
8. Study of steam distillation

CH 4109 Project Work (Stage-I)

1. **EACH STUDENT HAS** to work on one of the following projects and submitted a comprehensive, typed, and bound report (3 Copies) at the end of the eighth semester.

2. **TYPES OF PROJECTS :**

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

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

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

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

8. DURING THE SEVENTH SEMESTER EACH STUDENT is expected to complete at least 40% of the quantum of total work involved in the Project Work (Stage I & II). The student will make a power point presentation of his/her progress work before the panel of internal examiners appointed by Head of the Department. The examiners panel will assess

the progress of the student's work considering his/her quantum and quality of work completed and presentation skills.

7. **THE BALANCE OF THE WORK** will be continued under course No. CH 4207 Project Work (stage II).

CH 3209 Industrial Training (Evaluation)

GUIDE LINES:

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

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

8th SEMESTER

CH 4201 Elements of Transport Phenomena

Unit1

1. **VISCOSITY AND MECHANISM OF MOMENTUM TRANSPORT :** Newton's Law of Viscosity; Non-Newtonian fluids ; The Bingham model; The power law model; The Elli's model and the Reiner Philippoff model; Temperature and pressure dependents of viscosity.
2. **VELOCITY DISTRIBUTIONS IN LAMINAR FLOW :** Shell momentum balances; Boundary conditions ; Flow of a falling film; flow through a circular tube; flow through annulus.

Unit 2

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

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

Unit 3

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

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

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

Unit 4

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

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

Unit 5

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

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

Unit 6

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

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

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

TEXT BOOK :

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

REFERENCE BOOKS:

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

CH 4202 Pollution Control in Process Industries

Unit1

1. **INTRODUCTION :** The Biosphere, Energy Problem, Pollution of Air, Water and Soil.
2. **AIR POLLUTION :** Definition, Concentration, Classification, Emission Sources Behaviour and Effects of air pollution, Temperature lapse rates, Plume behaviour. Dispersion of air pollutants, the Gaussian plume model.

Unit2

3. **AIR POLLUTION SAMPLING AND MEASUREMENT :** Types of sampling and measurement, Ambient air sampling, Gaseous air pollutants, Analysis of air pollutants, like Sulphur dioxide, Nitrogen Oxides, Carbon Monoxide, Oxidants and zones, Hydrocarbons, Particulate matter.

Unit 3

4. **AIR POLLUTION CONTROL METHODS AND EQUIPMENT :** Control methods, Source correction methods, cleaning of gaseous effluents, particulate emission control, control of gaseous emissions.

Unit 4

5. **CONTROL OF SPECIFIC GASEOUS POLLUTANTS:** Control of Sulphur dioxide emission, Nitrogen oxides, Carbon monoxide and hydrocarbons.
6. **SOURCES AND CLASSIFICATION OF WATER POLLUTANTS :** Water resources, origin of waste water, types of water pollutants and their effects, water pollution laws and standards.

Unit 5

7. **WASTE WATER SAMPLING, ANALYSIS AND TREATMENT :** Sampling and methods of analysis, Organic and inorganic substance, physical character sticks, Bacteriological measurements, water quality standards, Primary, Secondary and advanced waste water treatment, recovery of materials from process effluents.

Unit 6

8. **SOLID WASTE MANAGEMENT:** Sources & classifications of solid waste, Public health aspects, Methods of collection, Methods of disposal: Open dumping, Sanitary land fill, Incineration, Composting; Potential methods of disposal

TEXT BOOK :

1. Rao C.S. - Environmental Pollution Control Engineering - Wiley Eastern Limited, India, 1991

REFERENCE BOOKS:

1. K. V. S. G. Murali Krishna – Air Pollution and Control – Kaushal and Co., 1999.
2. W. Wesley Eckenfelder Jr. – Industrial Water Pollution Control – McGraw Hill International, 1989;

CH 4103 ELECTIVE – II

(i) - Catalysis

UNIT I

Review of chemical kinetics, homogeneous catalysis, acid base catalysis

UNIT II

Enzymatic reaction kinetics and design for enzymatic reaction.

UNIT III

Heterogeneous catalysis: reaction rates and selectivity, Fixed bed and fluidized bed catalytic reactors.

UNIT IV
Catalyst deactivation with separable kinetics, Reactor Design with and without catalyst deactivation, temperature – time trajectories, effect of deactivation on selectivity, determination of order of deactivation by integral and differential methods.

UNIT V
Role of diffusion in catalysis.

UNIT VI
Selection, preparation, and evaluation of catalysts.

Texts / References:
H. S. Fogler., "Elements of Chemical Reaction Engineering", PHI, 3rd Ed. (2002).

O. Levenspiel, "Chemical Reaction Engineering", John Wiley, 3rd Ed. (1999).

J. M. Thomas and W. J. Thomas, "Introduction of the Principles of Heterogeneous Catalysis", Academic Press, (1967).

C. N. Satterfield and T.K. Sherwood, "The Role of Diffusion in Catalysis", Addison Wesley, (1963).

P. H. Emmett (Ed.), "Catalysis", Reinhold, (1954.)

(ii)- Newer Methods of Separation

UNIT I
Supercritical Fluid Extraction - Physiochemical principles, thermodynamics modeling

UNIT II
Supercritical Fluid Extraction - Process synthesis and energy analysis, case studies.

UNIT III
Membrane Processes - Brief review, module design and module characteristics, plant design and operation

UNIT IV
Membrane Processes - Reverse osmosis, ultrafiltration and microfiltration.

UNIT V
Surfactant based Separation - Fundamentals of surfactants at surfaces and in solution, liquid membrane permeation

UNIT VI
Surfactant based Separation - Foam separations, micellar separations
Texts / References:

M. A. McHugh, and V. J. Krukonis, "Supercritical Extraction", Butterworths, Boston, (1985).

R. G. Gutman, "Membrane Filtration", Adam Hilger, Bristol, (1987).

R. Rautenbach, and R. Albercht, "Membrane Processes", John Wiley & Sons,(1994).

J. F. Scamehorn, and J. H. Harwell, "Surfactant Based Separation Processes", Surfactant Science Series, Vol. 33, Marcel – Dekkar Inc., New York, (1989).

(iii) Introduction To Polymer Science And Technology

UNIT I

Introduction: Basic concepts of Polymer Science, Various molecular forces in polymer, Various Molecular weights and their distribution.

UNIT II

Polymerization: (i) Step growth: Mechanism, Kinetics, Polyfunctional Step growth polymerization. (ii) Radical polymerization: Mechanism, Kinetics, Effects of temperature, pressure. (iii) Ionic and Coordination Polymerization: Kinetics of Cationic and Anionic polymerization.

UNIT III

Polymerization Conditions: Bulk, Solution, Suspension and Emulsion polymerization.

UNIT IV

Measurement of Molecular Weight: End group analysis, Colligative property measurement, Gel Permeation Chromatography.

UNIT V

Polymer Processing: Plastic technology: Molding, Extrusion, Additives and Compounding;

UNIT VI

Fiber Technology: Textile and Fabric properties, Spinning, Elastomer technology: Vulcanization, Reinforcement.

Text/References:

1. Text book of Polymer Science: Fred W. Billmeyer, Jr., Second Edition, 1994, John Wiley and Sons, Inc., Singapore.

2. Principals of Polymerization, George Odian, Third Edition, 2002, John Wiley and Sons, Inc., Singapore.
3. Fundamentals of Polymers, Anil Kumar and Gupta, R. K., McGraw Hill, 1998.
4. Polymer Science and Technology, Premamoy Ghosh, Tata McGraw Hill, 2nd Ed. 2002.

(iii) Introduction To Polymer Science And Technology

UNIT I

Introduction: Basic concepts of Polymer Science, Various molecular forces in polymer, Various Molecular weights and their distribution.

UNIT II

Polymerization: (i) Step growth: Mechanism, Kinetics, Polyfunctional Step growth polymerization. (ii) Radical polymerization: Mechanism, Kinetics, Effects of temperature, pressure. (iii) Ionic and Coordination Polymerization: Kinetics of Cationic and Anionic polymerization.

UNIT III

Polymerization Conditions: Bulk, Solution, Suspension and Emulsion polymerization.

UNIT IV

Measurement of Molecular Weight: End group analysis, Colligative property measurement, Gel Permeation Chromatography.

UNIT V

Polymer Processing: Plastic technology: Molding, Extrusion, Additives and Compounding;

UNIT VI

Fiber Technology: Textile and Fabric properties, Spinning, Elastomer technology: Vulcanization, Reinforcement.

Text/References:

5. Text book of Polymer Science: Fred W. Billmeyer, Jr., Second Edition, 1994, John Wiley and Sons, Inc., Singapore.
6. Principals of Polymerization, George Odian, Third Edition, 2002, John Wiley and Sons, Inc., Singapore.
7. Fundamentals of Polymers, Anil Kumar and Gupta, R. K., McGraw Hill, 1998.

8. Polymer Science and Technology, Premamoy Ghosh, Tata McGraw Hill, 2nd Ed. 2002.

(iv) Multiphase Flow

UNIT I
Basic concept of single phase flow: Newtonian fluid and non-Newtonian fluid

UNIT II
Hydrodynamic behaviour of Newtonian and non-Newtonian fluid.

UNIT III
Two phase flow: slip, hold up, vertical and horizontal flow of two phase system (gas-liquid, liquid-liquid)-flow pattern, hydrodynamic characteristics, recommended design steps.

UNIT IV
Flow of complex mixtures (solid-liquid system) - vertical and horizontal flow, flow pattern

UNIT V
Flow of complex mixtures (solid-liquid system) - hydrodynamic characteristics, hold up, recommended design steps.

UNIT VI
Pneumatic transport (gas-solid system): vertical and horizontal flow, flow pattern, hydrodynamic characteristics, hold up, recommended design steps.

Texts / References:

G.W.Govier and K.Aziz, "The Flow of Complex Mixtures", Van Nostrand Reinhold Company, New York (1972)

E.J.Wasp,. J.P.Kenny and R.L.Gandhi, "Solid-Liquid Flow -Slurry Pipeline Transportation", Trans Tech Publication, 1977.

G. B. Wallis, "One Dimensional two phase flow", Mc Graw Hill Pub. , New York, 1969

CH 4204 Elective –III

(i) Bio-Technology

Unit 1

1. **INTRODUCTION :** Scope, Potential and achievement, enzyme technology, Biomass technology.

Unit 2

2. **PLANE CELL AND TISSUE CULTURE :** Culture Techniques, Plant Cell Fermentation's and Production of secondary Metabolites, Production of secondary Metabolites by Immobilised plant cells, Anther and Pollen culture and Androgens, Genetic Engineering of Plants, Direct Gene Transfer.

Unit 3

3. **CELL CULTURE AND BIOTECHNOLOGY OF ANIMALS :** Serum, Cell culture as sources of valuable products, Genetic Recombination in Mammalian cells and Embryos, Biotechnology and Domestic Animals.

Unit 4

4. **FERMENTATION TECHNOLOGY AND INDUSTRIAL MICROBIOLOGY :** Uses, Fermenter, Downstream processing , Role of Yeast, Solid State Fermentation, Fermented Foods, Lactose Utilisation, Signal Cell protein, Enzymes and Immobilisation of Enzymes, Fermentation monitoring and recovery of products.

Unit 5

5. **FOOD AND AGRICULTURE:** Processing under exploited plants, Petrocrops, Aquaculture Grain quality, Disease Resistance, Monoclonal Antibodies and Agriculture, Food and Feed form Wastes, Fugal Protein.

Unit 6

6. **ENVIRONMENT AND ENERGY:** Biomass Production, Bioenergy, Biogas, Use of Micro-organisms in pollution control, Hydrogen, Waste Treatment, Biological Phosphorous Removal from waste water, Waste management.

TEXT BOOKS :

1. H.D.Kumar - A Text Book on Biotechnology - Affiliated East West Press Private Ltd., 1993

REFERENCE BOOKS:

James E. Bailey & David F. Ollis – Biochemical Engineering Fundamentals – 2nd Edition – McGraw Hill International – 1986.

(ii) Petroleum Refining and Petrochemicals

PETROLEUM REFINING :

Unit 1

1. **ORIGIN, FORMATION AND COMPOSITION OF PETROLEUM**: Origin and formation of petroleum, Reserves and deposits of world, Indian Petroleum Industry, composition of petroleum.

2. **PETROLEUM PROCESSING DATA**: Evaluation of petroleum, thermal properties of petroleum fractions, important products, properties and test methods.

Unit 2

3. **FRACTIONATION OF PETROLEUM**: Dehydration and desalting of crudes, heating of crude-pipe still heaters, distillation of petroleum, blending of gasoline.

4. **TREATMENT TECHNIQUES**: Fraction-impurities, treatment of gasoline, treatment of kerosene, treatment of lubes.

Unit 3

5. **THERMAL AND CATALYTIC PROCESSES**: Cracking, catalytic cracking, catalytic reforming, Naphtha cracking, coking, Hydrogenation processes, Alkylation processes, Isomerization processes.

PETROCHEMICALS:

1. Petrochemical Industry – Feed stocks

2. **CHEMICALS FROM METHANE**: Introduction, production of Methanol, Formaldehyde, Ethylene glycol, PTFE, Methylamines.

Unit 4

3. **CHEMICALS FROM ETHANE-ETHYLENE-ACETYLENE**: Oxidation of ethane, production of Ethylene, Manufacture of Vinyl Chloride monomer, Vinyl Acetate manufacture, Ethanol from Ethylene, Acetylene manufacture, Acetaldehyde from Acetylene.

Unit 5

4. **CHEMICALS FROM C3, C4 AND HIGHER CARBON ATOMS**: Chemical from Propylene, manufacture of Isopropanol, manufacture of Acrylonitrile, production of Acrylic acid, polymers and copolymers of propylene, production of Phenol from cumene, production of Bisphenol-A, manufacture of maleic Anhydride, production of Acetic acid and production of Butadiene from Butane.

Unit 6

5. **SYNTHESIS GAS AND CHEMICALS**: Steam reforming of hydrocarbons, production of synthesis gas, SNG from Naphtha, Synthesis gas via partial Oxidation.

TEXT BOOKS:

1. B.K. Bhaskara Rao - Modern Petroleum Refining Processes - 3rd edition, Oxford & IBH Publishing Co. Pvt. Ltd., Jan. 1997.
2. B.K. Bhaskara Rao - A Text of Petrochemicals - 2nd edition, Khanna Publications, 1998.

REFERENCE BOOK:

1. W.L. Nelson - Petroleum Refinery Engineering; McGraw Hill Book Company.

(iii) Chemical Engineering Mathematics

Unit 1

1. **Mathematical Formulation of the Physical Problems** :
   (i) Application of the law of conservation of mass - Salt accumulation in a stirred tank - starting an equilibrium still - solvent extraction in two stages - Diffusion with chemical reaction.
   (ii) Application of the law of conservation of energy - Radial heat transfer through a cylindrical conductor - Heating a closed Kettle - Flow of heat from a fin.

Unit 2

2. Analytical (explicit) Solution of Ordinary Differential Equations Encountered in Chemical Engineering Problems :

(i) First order differential equations - Method of separation of variables - Equations solved by Integration factors - certain examples involving Mass and Energy balances and Reaction Kinetics.

(ii) Second order differential equations - Non-linear equations - linear equations - Simultaneous Diffusions and Chemical reaction in a Tubular reactor - continuous hydrolysis of Tallow is a spray column.

Unit 3

3. (i) Formulation of partial differential equations - Unsteady state heat conduction in one dimension - Mass transfer with axial symmetry - Continuity equations.

(ii) Boundary conditions - function specified - Derivative specified and Mixed conditions.

(iii) Iterative solution of algebraic equations :

(a) Jacobi's method (b) Gauss-Siedal Method
(b) Successive order - relaxation (S.O.R.) method.

Unit 4

4. (i) The difference operator - Properties of the difference operator - Difference tables and other difference operators.

(ii) Linear finite difference equations - the complimentary solution of the particular solution - Simultaneous linear differential equations.

Unit 5

(iii) Non-linear finite difference equations - analyticaal solution .
Solution of the following type of problems by finite difference method :

(a) Calculation of the number of plates required for an absorption column.

(b) Calculation of the number of theoretical plates required for distillation column.

(c) Number of steps required for a counter-current extraction and leaching operations.

Unit 6

5. Application of Statistical Methods :

(i) Propagation of errors of experimental data.

(ii) Parameter estimation of algebraic equations encountered in Heat and Mass Transfer, Kinetics and Thermodynamics by
(a) the method of averages
(b) Linear least squares and
(c) Weighted linear least squares methods

(iii) Design of experiments.
Factorial, Fractional factorial methods.

Text Book : "Mathematical methods in Chemical Engineering" by Jenson, V.J. and G.V.Jeffereys, Academic Press, London and New York, 1977

Reference Book : "Applied Mathematics in Chemical Engineering" by H.S.Mickley, Thomas, K., Sherwood and C.E.Reed, Tata McGraw-Hill Publications, 1957

(iv) Entrepreneurship Development

Unit 1

1. INTRODUCTION: Objective of the course; What is entrepreneurship; Need and scope for entrepreneurship; Risks and rewards in entrepreneurship; Characteristics of an entrepreneur; Relevance and benefits of small scale industry.

Unit 2

2. HUMAN ENGINEERING (THEORY and LAB): Entrepreneur and society; Attitude towards work; Self assessment and goal setting; Achievement motivation and behaviour (TAT, Who am I, Business exercise, Ring toss game etc.); Understanding human behaviour (Maslow's hierarchy of needs).

Unit 3

3. SETTING-UP AN INDUSTRY: Forms of business organizations/ownership - their merits and demerits; Formation of a company; Procedures and formalities for setting up of a new industry; Sources of information (Whom to contact for what and where); Incentives; Subsidies and concessions for industry; Industrial development agencies and their functions; State and National level institutions for small scale industry (General set-up).

Unit 4

4. PROJECT PLANNING: Identification of opportunities; Market survey; Techno-economic feasibility studies and economic analysis (Pay back period, Return on Investment, Cost-benefit analysis and Break-even analysis); Financial viability; Sources

of finance for industry; Assessment of fixed and working capital requirements; Financial ratios, Project scheduling.

Unit 5

5. **MARKETING:** Components of marketing management; Market survey and analysis; Marketing arrangements; Strategies and assistance to small industry; Consumer behaviour; Market feed back; projections; Predictions and forecasts.

Unit 6

6. **PROJECT REPORT:** Preparation of a detailed project report.

7. **INDUSTRIAL LAWS:** The factories act 1948; minimum wages act; payment of wages act 1936; Workmen compensation act 1923.

TEXT BOOKS:

1. Handbook for New Entrepreneurs - EDII, Ahmedabad
2. P Saravanavel - Entrepreneurial Development
3. T. R. Banga - Project planning and entrepreneurship development

CH 4205 Simulation of Chemical Operations and Processes

Tests: 40 marks (2 tests), TW: 30 marks, Lab Report: 10 marks, Viva voce: 20 marks

A. Design of Piping network using software tools

B. Design of following equipment using ASPENPLUS software

   1. Heat Exchanger
   2. Absorption column
   3. Distillation column
   4. Reactor
   5. Evaporator
   6. Flow sheeting of a chemical plant
   7. Simulation of a small size chemical plant.

C. Simulation of a chemical plant using AUTOPLANT software.

Practicals:

Students are required to do simulation experiments using above software tools on the problems assigned to them.

CH 4206 Pollution Control Lab

LIST OF PRACTICALS:

1. Study of sampling techniques for collection of water sample
2. Determination of chlorine content
3. Determination of hardness of water
4. Determination of pH and conductivity of water sample
5. Determination of acidity
6. Determination of alkalinity
7. Determination of oil and grease.
8. Determination of dissolved oxygen
9. Determination of chemical oxygen demand.
10. Determination of biochemical oxygen demand.

CH 4207 Project Work (Stage II)

This is the continuation of work started under course No. CH 4107 Project Work (Stage I). Every student will have to submit a detailed report (3 copies) of the Project Work as per the standard format prescribed by the department within the deadline announced by the Department. The students will make a power point presentation of their Project Work before a panel of Examiners comprising of guide, internal examiner and external examiner. The examiners panel will assess the performance of the students considering their quality of work and presentation skills.