Appendix " P " Item No.34

**AICTE Scheme and Syllabi**

**B.TECH. (CHEMICAL ENGINEERING)**

**&**

**B.TECH. + M.TECH. (CHEMICAL ENGINEERING)**

 **I/IV B.TECH (FOUR YEAR COURSE)**

**&**

**I/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)

**BRANCH: CHEMICAL ENGINEERING**

**SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

ENG 1101 English 2 30 70 100 2

ENG 1102 Maths -I 3 30 70 100 3

ENG 1103 Maths-2 3 30 70 100 3

ENG 1104 Chemistry 3 1 30 70 100 4

ENG 1106 Computer Programming
 & Numerical Methods 3 30 70 100 3

ENG 1108 Chemistry Lab., 3 50 50 100 2

ENG 1110 CPNM Lab., 3 50 50 100 2

ENG 1112 History of Science &
 Technology 2 0

 Total 16 1 10 700 19

**I/IV B.TECH (FOUR YEAR COURSE)**

**&**

**I/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BRANCH: CHEMICAL ENGINEERING**

 **SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

ENG 1201 Maths-3 3 1 30 70 100 4

ENG 1202 Physics 3 1 30 70 100 4

ENG 1205 Engineering Graphics 2 4 30 70 100 4

ENG 1206 Introduction to Chemical
 Engineering and
 Biotechnology 3 1 30 70 100 3

ENG 1208 Physics Lab., 3 50 50 100 2

ENG 1210 Workshop 3 50 50 100 2

ENG 1212 English Lab., 3 50 50 100 2

ENG 1214 Professional Ethics &
 Moral Values 2 0

 Total 13 3 17 700 21

 **II/IV B.TECH (FOUR YEAR COURSE)**

**&**

**II/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)

**BRANCH: CHEMICAL ENGINEERING**

**SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

CHE1301 Solid Mechanics 3 1 0 30 70 100 2

CHE1302 Mechanical Engineering 3 1 0 30 70 100 2

CHE1303 Organic Chemistry 3 1 0 30 70 100 3

CHE1304 Material Science &
 Engineering 3 1 0 30 70 100 3

CHE1305 Biology 3 1 0 30 70 100 3

CHE1306 Basic Electrical
 Engineering 3 1 0 30 70 100 3

CHE1308 General Engineering Lab
 (Electrical Engineering. &
 Mechanical Engineering.) 0 0 3 50 50 100 2

CHE1310 Organic Chemistry Lab., 0 0 3 50 50 100 2

 Total 18 6 6 800 20

**SCHEME OF INSTRUCTION & EXAMINATION**

**II/IV B.TECH (FOUR YEAR COURSE)**

**&**

**II/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)

**CHEMICAL ENGINEERING**

**SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

CHE1401 Particle & Fluid Particle
 Processing 3 1 0 30 70 100 3

CHE1402 Fluid Mechanics 3 1 0 30 70 100 3

CHE1403 Thermodynamics-I 3 1 0 30 70 100 3

CHE1404 Material & Energy Balance 3 1 0 30 70 100 3

CHE1405 Managerial Economics 3 1 0 30 70 100 3

CHE1406 Numerical Methods in
 Chemical Engineering 2 0 3 30 70 100 2

CHE1407 Environmental Science 3 - - 100 — 100 0

CHE1410 Particle & Fluid Particle
 ProcessingLab 0 0 3 50 50 100 2

CHE1412 Fluid Mechanics
 Laboratory 0 0 3 50 50 100 2

 Total 20 05 09 900 21

**SCHEME OF INSTRUCTION & EXAMINATION**

**III/IV B.TECH (FOUR YEAR COURSE)**

**&**

**III/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BRANCH: CHEMICAL ENGINEERING**

**SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

CHE1501 General Chemical
 Technology 3 1 0 30 70 100 3

CHE1502 Mass Transfer -I 3 1 0 30 70 100 3

CHE1503 Core Elective-I 3 1 0 30 70 100 3

CHE1504 Thermodynamics-II 3 1 0 30 70 100 3

CHE1505 Open Elective-I 3 0 0 30 70 100 3

CHE1506 Heat Transfer 3 1 0 30 70 100 3

CHE1508 Heat Transfer Lab 0 0 3 50 50 100 2

CHE1510\* General Chemical
 Technology Lab/ Petroleum
 Engineering., Lab.,/Ceramic
 Technology Lab. 0 0 3 50 50 100 2

CHE1512 Slot for MC (Constitution
 of India/Essence of Indian
 Traditional Knowledge) 3 0 0 0

 Total 24 05 6 800 22

**\*** General Chemical Technology Lab for B.Tech., (Chemical Engg.) & B.Tech+ M.Tech. (Chemical Engg.)/ Petroleum Engg., Lab., for B.Tech., (Chemical Engg. with Petroleum Engg. as elective) /Ceramic Technology Lab for B.Tech., (Chemical Engg. with Ceramic Technology as elective)

***Core Elective-I:***

For Chemical Engineering ;

A.Paper technology, B. Fertilizer technology, C. Petroleum Refinery Engg. D. Ceramic raw materials. E. Fuel cell technology, F. Polymer technology. G.Intellectual Property Rights

**For Chemical Engineering with petroleum Engineering as elective**:

C. Petroleum Refinery Engg.

**For Chemical Engineering with Ceramic Technology as elective**:

D. Ceramic raw materials

**Open Elective-I:**Corrosion Engineering

**SCHEME OF INSTRUCTION & EXAMINATION**

**III/IV B.TECH (FOUR YEAR COURSE)**

**&**

**III/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BRANCH: CHEMICAL ENGINEERING**

**SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

CHE1601 Chemical Reaction
 Engineering 3 1 0 30 70 100 4

CHE1602 Process Engineering &
 Economics 3 1 0 30 70 100 3

CHE1603 Core Elective-II 3 1 0 30 70 100 3

CHE1604 Transport Phenomena 3 1 0 30 70 100 4

CHE1605 Mass Transfer –II 3 1 0 30 70 100 3

CHE1606 Open Elective-II 3 0 0 30 70 100 3

CHE1608 Chemical Reaction
 Engineering., Lab. 0 0 3 50 50 100 2

CHE1610 Mass Transfer Lab 0 0 3 50 50 100 2

 Total 18 05 06 800 24

***Core Elective-II:***

For Chemical Engineering ;

A. Process modeling and simulation,

B. Petrochemicals

C. White ware and heavy clayware,

D. Computational fluid dynamics ,

E. Multi component separation processes

F. Chemical Engineering Mathematics

**For Chemical Engineering with petroleum Engineering as elective**:

B. Petrochemicals

**For Chemical Engineering with Ceramic Technology as elective**:

C. White ware and heavy clayware

*Open Elective-II*

Nano Science & Technology

**SCHEME OF INSTRUCTION & EXAMINATION**

**IV/IV B.TECH (FOUR YEAR COURSE)**

**&**

**IV/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BRANCH: CHEMICAL ENGINEERING**

**SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

CHE1701 Process Instrumentation
 & Control 3 1 0 30 70 100 4

CHE1702 Chemical Process
 Equipment Design 3 1 0 30 70 100 4

CHE1703 Core Elective-III 3 1 0 30 70 100 3

CHE1704 Industrial Management &
 Entrepreneurship 3 1 0 30 70 100 3

CHE1705 Open Elective-III 3 0 0 30 70 100 3

CHE1708 Process Instrumentation
 & Control Lab., 0 0 3 50 50 100 2

CHE1710 Chemical Process
 Equipment Design Lab., 0 0 3 50 50 100 2

 Total 15 4 6 700 21

*Core Elective-III*

For Chemical Engineering ;

A. Computer aided design

B. Industrial pollution control Engineering

C. Process optimization

D. Reservoir Engineering

E. Fuels , Refractories and furnaces

F. Biochemical Engineering

**For Chemical Engineering with petroleum Engineering as elective**:

D. Reservoir Engineering,

**For Chemical Engineering with Ceramic Technology as elective**:

E. Fuels , Refractories and furnaces

Open Elective-III (CHE 1705)

A. Industrial Safety and Management

B. Environmental Pollution Control Engineering

**SCHEME OF INSTRUCTION & EXAMINATION**

**IV/IV B.TECH (FOUR YEAR COURSE)**

**&**

**IV/VI B.TECH & M.TECH (SIX YEAR DOUBLE DEGREE COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

 **BRANCH: CHEMICAL ENGINEERING**

**SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

CHE1801 Project Work — — — 50 50 100 12

**2/4 B.Tech(Chemical Engineering) - First Semester**

**&**

**2/6 B.Tech + M.Tech (Chemical Engineering) First Semester**

**CHE 1301 : Solid Mechanics**

**3 L- 1T- 0P-2C**

*Objectives:*

1. To impart knowledge about the behaviour of elastic bodies subjected to different types of external forces.

2. To impart skills of analysing the statically determinate beams subjected to different types of loads for shear force, bending moment and their corresponding stress distribution.

3. To develop skills to analyse shafts, springs and shells for determining the critical stress distribution..

*Outcomes:*

1. The students are expected to analyse different bodies subjected to different types of loads like axial forces, transverse loads and torsional moment.

2. The students are expected to analyse the statically determinate beams subjected to loads.

3. The students are expected to analyse shafts, springs and shells.

*Syllabus:*

**Axial loads:** Simple stress and strain, Hook’s law, load extension diagram for mild steel, stress in compound assemblies, thermal stresses,

**Transverse loads:** Shear force and bending moment diagrams for a) cantilevers, b) simply supported beams and c) over-hanging beams due to concentrated loads and U D L s only,

**Theory of simple bending:** Relation between i) f and y, ii) M and I, iii) E and R, distribution of shear stress in common shapes of cross-section,

**Principal stresses** and principal planes, maximum shear stress and its plane, Mohar’s circle of stress,

**Torsion** of solid and hollow circular shafts, transmission of horse power, design of flange coupling, closed coil helical spring i) under axial load and ii) under axial twist, riveted joints, design of lap joints,

**Stress** in thin cylindrical shells and spherical shells, stress in thick cylinders, compound cylinders, pressure due to shrink-fitting,

*Text book:*

1. ‘Strength of Materials’ by Ramamrutaham

*Reference book:*

1. ‘Elements of Strength of Materials’ by S.P.Timoshenko and D.H.Young, East West Press, New Delhi

**CHE 1302 : Mechanical Engineering**

**3 L- 1T- 0P-2C**

*Objectives:*

\* To understand the basics in Thermodynamics

\* To get knowledge on applications of steam tables.

\* To understand the principles and applications of turbines and compressors.

*Syllabus:*

**Thermodynamics:** Definitions, systems, classification of thermodynamic systems, cycle, and zeroth law of thermodynamics, first law of thermodynamics, closed system, flow processes, open systems with steady flow process, applications of steady flow energy equation to engineering systems,

**Second law of thermodynamics:** Carnot cycle, inequality of Classius-reversible Carnot cycle, entropy, relation between heat and entropy, general expression for entropy change, entropy change of a perfect gas during various thermodynamic processes, air standard cycles, Otto, diesel, dual combustion cycles,

**Properties of steam and use of steam tables:** Boilers, classification steam boilers, simple vertical, Cocheran locomotive boiler, Babcock and Wilcox boiler, steam generation, Rankine cycle,

**Impulse and reaction turbine:** Classification of steam turbines, velocity diagram and power produced in impulse turbine, performance of steam turbines, reduction of rotor speed,

**I C engines:** Classification-main composition of IC engines, carburetter, fuel pump injector, cooling systems for IC engines, working of 2-stroke and v4-stroke petrol and diesel engines, power and efficiency of IC engines,

**Reciprocating air-compressors:** Single stage, work done during cycle, effect of clearance, two stage compressors, condition for minimum work, effect of inter-cooling, efficiency,

**Drives:** Belts, expression for the ratios of tension on the slack and tight side, power transmitted – V-belts, chain drives, gears – spur, helical, bevel gear, trains simple and compound.

*Text books:*

1. ‘A Text Book of Thermal Engineering’ by R.S.Khurmi and J.K.Gupta

2. ‘Theory of Machines’ by R.S.Khurmi

*Reference books:*

1. ‘Engineering Thermodynamics’ by P.K.Nag

2. ‘Engineering Thermodynamics’ by J.B.Jones and R.E.Dugar

3. ‘Engineering Thermodynamics’ by R.K.Rajput

4. ‘Theory of Machines’ by Balani

**CHE 1303 : Organic Chemistry**

**3 L- 1T- 0P-3C**

*Objectives:*

The student will be able to:

1. appreciate the nature and scope of organic chemistry.

2. apply key concepts from general chemistry including electronegativity, bonding (ionic and covalent), hybridization of atomic orbitals, and molecular orbital theory to organic systems.

3. draw skeletal structures for organic compounds.

4. apply acid-base concepts to organic systems; predict ordering of acid or base strength.

5. name alkanes, alkenes, polyenes, alkynes, alkyl halides, aromatic compounds, carbonyl compounds, amines and their various derivatives using systematic (IUPAC) nomenclature.

6. draw reaction mechanisms for some key reactions.

7. recognize stereochemistry and be able to apply the Cahn-Ingold-Prelog system to designation of stereochemistry (E/Z or R/S).

8. learn many of the reactions of alkanes, alkenes, polyenes, alkynes, aromatic, carbonyl, and amine compounds, and close related species. Be able to predict reactions involving these functional groups.

9. be able to solve problems employing spectroscopic methods including mass spectrometry, infrared and NMR spectroscopy

10. understand the basic chemical and structural features of biomolecules, including lipids, carbohydrates, amino acids and proteins, and nucleic acids

*Outcome:*

This course enables the students to acquire knowledge, comprehension and application in numerical problems related to organic chemistry, nomenclature and reactions of alkanes, alkenes, alkynes, dienes, electrophilic aromatic substitution, alcohols, acids, aldehydes and ketones, amines, soaps and detergents.

*Syllabus:*

**Chapter 1: Quantitative and Qualitative Organic Analysis:** Determination of percentage composition of carbon, hydrogen and nitrogen, molecular weight determination by depression in freezing point and elevation of boiling point methods, molecular weight of acids by silver salt method; molecular weight of bases by chloroplatinate method, determination of molecular formula of a compound, problems relating to reactions of carboxylic acids, functional derivatives of acids, carbonyl compounds, alcohols, amines, phenols, diazonium salts, alkenes and Functional Group Identification of Organic Compounds

**Chapter 2: Isomerism:** Structural and Optical isomerism, Geometrical isomerism, E-Z configuration, sequence rules, R & S configuration, racemic mixture and their separation, asymmetric synthesis - Fischer projection formula, definitions of axial and equatorial bonds, 1-3-diaxial interaction, enatiomers, diastereomers, mesomers, isomerism in cyclic compounds, chair,boat and twisted boat structures (1-methylcyclohexane, 1, 2-cyclohexane diol)

*Chapter 3: Hydrocarbons*

Hybridisation - sp, sp2 and sp3; Nomenclature, Preparation and chemical reactions of alkanes, alkenes, alkynes, dienes, Wurtz reaction, Clemmensen and Wulf-Kishner reduction, Diels-Alder reaction, Morkovinkov rule, Industrial preparation of ethylene, acetylene; Conformational analysis of ethane, propane and butane; Cyclic aliphatic hydrocarbons - Baeyer’s Strain Theory Preparations and their reactions

**Aromaticity and Benzene:** Structure of benzene, aromaticity, nomenclature of benzene derivatives, arenes, Electrophilic and Nucleophilic Aromatic Substitution: Mechanism of nitration, halogenation, sulphonation, Friedel-Craft’s alkylation and acylation reactions, Nucleophilic aromatic substitution; Orientation of disubstituted benzenes

*Chapter 4: Halides, Alcohols and Acids*

**Halides: N**omenclature of alkyl halides, preparation and chemical reactions, mechanisms of SN1, SN2, E1, E2 reactions, Nomenclature of aryl halides, preparation and chemical reactions: low reactivity of vinyl and aryl halides, Sandmeyer reaction,

**Alcohols:** Nomenclature of alcohols; industrial preparation of ethyl alcohol, preparation and chemical reactions, Lucas test,

**Carboxylic Acids:** Nomenclature of mono, dicarboxylic acids, industrial preparation of formic, acetic, benzoic, phthalic, salicylic acids, preparation and chemical reactions, mechanism of HVZ reaction and Claisen condensation, nomenclature of functional derivatives of acids, preparation and chemical reactions, mechanism of Hoffmann bromamide reaction, acid and base catalyzed hydrolysis of ester.

*Chapter 5: Carbonyl Compounds, Ethers, Epoxides and Carbohydrates*

**Carbonyl Compounds:** Nomenclature of aldehydes and ketenes: Industrial preparation of formaldehyde, acetaldehyde, benzaldehyde, salicyaldehyde, acetone; preparation and chemical reactions; mechanisms of Cannizaro, Aldol, Reformatsky and Wittig reactions, reactions without mechanisms -Perkin, Cope, Knoevenagel and Pinacol-Pinacolone reactions, difference between aldehyde and ketone, nomenclature of phenols, industrial preparation of phenol, preparation and chemical reactions, mechanisms of Fries rearrangement, Kobe reaction, Reimer-Tiemann reaction,

**Ethers, Epoxides and Active methylene Compounds:** Nomenclature of ethers and epoxides, industrial preparation of ether and ethylene oxide, preparation and chemical reactions; Williamson’s synthesis, Preparation of malonic, acetoacetic ester and their synthetic applications

**Carbohydrates: C**lassification of carbohydrates, structure of glucose and fructose, reactions of glucose and fructose, Ruff degradation, Wohls degradation, Killiani-Fisher synthesis, Conversion of glucose into fructose, fructose into glucose, glucose to vitamin-C, Mechanism of Osazone formation,

*Chapter 6: Amines, Diazonium Salts and Sulpha Drugs*

**Amines:** Nomenclature of amines, industrial preparation of Aniline, preparation and chemical reactions - exhaustive methylation, mechanism of Hoffmann elimination, Benzidine rearrangement without mechanism, Hinsberg test, differentiation test using nitrous acid Preparation of diazonium salts and synthetic applications,

**Sulpha Drugs**: Preparation of sulphanilamide, sulphaguanidine, sulphamerazine, sulphapyridene - mode of action of sulpha drugs,

*Chapter 7: Polymers, Soaps and Detergents*

**Polymers:** Preparation of polyethylene, polystyrene, teflon, PVC, polyvinyl cyanide, rubber-vulcanisation, styrene-butadiene rubber, polychloroprene, bakelite, nylon-6 and nylon 6-6, plexiglas, terylene, Ziegler-Natta polymerization, definition of thermoplastics and thermosetting plastics

**Soaps and detergents:** Preparation, Mode of action of soaps, difference between soaps and detergents;

***Reference books:***

1. ‘Text Book of Organic Chemistry’ by Morrison & Boyd

2. ‘Text Book of Organic Chemistry’ by Bahl&Tuli

3. ‘Text Book of Organic Chemistry’ by M.K.Jain

4. ‘Text Book of Organic Chemistry’ by I. L. Finar (Vols. 1 & 2 as

*R****eference books****)*

**CHE 1304 : Material Science & Engineering**

**3L- 1T- 0P-3C**

*Objectives:*

Materials science and engineering is an important subject to every engineer to understand about the materials’ behavior in different environments. Main objectives of the study are as follows:

1. To understand the structure of atoms

2. To learn something about the crystalline nature of the materials

3. To know about the influence of atoms controlling the properties of materials

4. To know the equivalency of the materials for replacement

5. To learn to prepare alloys, composites for conventional materials

6. To find the relation between arrangement an thermodynamic properties of materials

*Outcome:*

1. To know about the appropriate utility of materials based on their nature.

2. To know the behavior of the materials w.r.t their directions.

3. To know the behaviour of materials exposed to different conditions in different phases.

4. To calculate the stability materials and knew the importance of crystalllinity.

5. Selectivity of the materials for suitable design to manufacture the machines

6. To improve the properties choosing alternative materials suchas alloys, composites instead of conventional materials (to minimize fractures, wear and tear).

7. Leads to prepare some knew semiconductors for important purposes.

Unit – I : **Atomic Structure, chemical Bond and Crystal Geometry:** An introduction to materials, classification of engineering materials, brief review of atomic structure and theories, calculation of energy of electron of Bohr’s atomic model, Bonds in materials – classification, properties of ionic, covalent and metallic solids, variation in bonding character and properties. Levels of structure of materials, Crystal Geometry and crystal structure – classification of solids- Single crystals, polycrystalline solids and amorphous solids (non-crystalline), differences between crystalline and non-crystalline materials. Ideal crystal, space Lattice, basis for crystal formation, unit cell, lattice co-ordinates, Bravis lattices for crystal systems, crystal systems and their properties with examples, symmetries in crystals. Atomic packing faction and packing efficiency (SC, BCC, FCC, Diamond cubic and HCP structures), c/a ratio for HCP structure. Miller indices for directions, planes in crystals and their presentation, ligancy and coordination number. Determination of crystal Structure by X-ray diffraction method – Debye method, numerical problems for different cubic structures (SC, BCC and FCC).

Unit –II : **Fundamentals of thermodynamics and Crystal imperfections:** Basic thermodynamics functions: – stability and meta-stability of materials, internal energy (E), enthalpy (H), Gibb’s free Energy (G), and thermal entropy and configurational entropy (S). crystal imperfections – classification, point defects- classification and estimation of point defects in the crystals; Imperfections (dislocations) – classification (edge and screw); Berger circuits and Burgers Vector, dislocation reactions, role of dislocations in determining crystal properties; surface defects - types

Unit -III : **Mechanical Properties**: Stress –types of stresses; Strain-types of strain; true stress and true strain, engineering stress and engineering strain of the materials, relation between engineering strain and true strain, relation between engineering stress and true stress; Hooke’s Law; Poisson’s Ratio, stress-strain diagram and its uses; different moduli of elasticity – Young’s modulus, shear modulus, and bulk modulus; relation between different moduli of elasticity and strain vs stress relationship diagrams for different materials (metals, non-metals, rubbers and plastics and polmers); elastic deformation and plastic deformation and their differences. Critical Resolved shear stress (CRSS). Relaxation process and viscoelastic behavior. Fracture – types ductile fracture and its mechanism, brittle fracture and its mechanism (Griffith’s criteria), fatigue, mechanism, factors affecting the fatigue, creep and creep failure mechanisms, creep resistance materials.

Unit –IV : **Composite materials** – classification, advantages of composite materials over conventional materials, Limitations of composite materials, factors affecting the performance of fibrous composites, factors affecting the performance of matrix in composites, evaluation of Young modulus of composites when axially and transversely loaded.

**Phase Transformationns**- time scale for phase changes, Nucleation and growth, Phase diagrams- phase rule, solid solutions-types, single component systems, Binary phase changes, the lever rule and numerical problems, advantages of phase diagrams, advantages of alloying of metals on the properties of steels, Iron-iron carbide (Fe-Fe3C) phase diagram, limitations of plain carbon steels, types of steels used in chemical industries,

Unit – V : **Corrosion of Materials:** Corrosion and prevention: mechanism of oxidation, oxidant resistant materials, corrosion: Erosion and corrosion, principles of corrosion, types of corrosion, polarization, passivation, Galvanic series, formation of Galvanic cells, proper selection of materials, proper design and fabrication procedure, cathodic protection, application of protective coatings, application of inhibitors.

***Text books:***

1. ‘Materials Science & Engineering’ by V.Raghavan, Prentice Hall of India Ltd, New Delhi

2. ‘Elements of Materials Science & Engineering’, 5th Edition, Lawrence H.VanVlack, Addision-Weley Publishing Company.

3. ‘Corrosion Engineering’ by Mars G. Fantana, McGraw Hill Edition

***Reference books:***

1. ‘Science of Engineering Materials’, Vols.1-3, by Manas Chanda, McMillan Company of India, Delhi

2. ‘Principles of Materials Science & Engineering’, William F.Smith, McGraw-Hill Publishing Co.

3. ‘Essentials of Materials Science’ by A.G. Guy.

4. An introduction to corrosion science and engineering By Herbert Uhilig and R. Winston Revie, Published by John Wiley and sons, New York

**CHE1305 : Biology**

**3 L- 1T- 0P-3C**

*Objectives*

Students will be introduced to the basics of biology such as cell structure and functions, inheritance & evolution, basic concepts of genetics, and an introduction to microbiology

*Contents:*

1. Basics: Diversity of life, prokaryotes and eukaryotes, basic cell constituents and macromolecules. [6L + 1T]

2. Biochemistry: Metabolism (Catabolism and Anabolism) and Bioenergetics [12L + 3T]

3. Genetics: Basic principles of Mendel, molecular genetics, structure and function of genes and chromosomes, Transcription and Translation, gene expression and regulation. [12L + 3T]

4. Cell Biology: Macromolecules, membranes, organelles, cytoskeleton, signaling, cell division, differentiation, motility. [12L + 3T]

5. Microbiology: host-microbe interactions, physiology, ecology, diversity, and virology (6L + 2T)

Total 60 (L + T)

***Course outcomes***

Students will get insight into biology as a science, outlining the diversity, organization and fundamental principles of living systems.

**CHE 1306 : Basic Electrical Engineering**

**3 L- 1T- 0P-3C**

*Objectives:*

· An understanding of basic EE abstractions depends on analysis and design of electric and magnetic circuits and its elements.

· To provide the students with knowledge of fundamental laws in electrical engineering

· To develop the ability of the students to analyze electrical and magnetic circuits using the basic laws of electrical engineering

· To expose the students to the concepts of various types of electrical machines and application of electrical machines.

· To inculcate the understanding about the AC fundamentals

· To prepare the students to have a basic knowledge of transformers

· To acknowledge about three phase induction motor and its operating principle

· To know about the fundamentals of synchronous motors and its working principle

*Outcomes:*

After the completion of the course, the student should be able

· To predict the behavior of any electrical and magnetic circuits.

· student will be able to state and explain the basic laws of electromagnetic induction.

· To impart knowledge on Constructional details, principle of operation, types of Electrical Machines performance Characteristics ,speed control methods and its applications

· Ability to conduct experiments on Ac Machines to find its characteristics.

· Abel to calculate performance characteristics of transformer like regulation and efficiency

· The ability to formulate and then analyze the working of synchronous motors

· Able to solve simple problems on synchronous motors

*Syllabus:*

**Magnetic circuits:** Definitions of magnetic circuit, reluctance, magneto motive force (mmf), magnetic flux, simple problems on magnetic circuits, hysterisis loss (chapter 8, page nos. 155-175),

**Electromagnetic induction:** Faraday’s laws of electromagnetic induction, induced E.M.F., dynamically induced E.M.F, statistically induced EMF, self inductance, mutual inductance (Chapter 9, page nos. 176-190),

**D.C. generators:** D.C generator principle, construction of D.C generator, E.M.F equation of D.C generator, types of D.C generators, armature reaction, losses in D.C generator, efficiency, characteristics of D.C generators, applications of D.C generators (chapter 10, 11, pages 208-238),

**D.C. motors:** D.C motor principle, working of D.C motors, significance of back, E.M.F, torque equation of D.C motors, types of D.C motors, characteristics of D.C motors, speed control methods of D.C motors, applications of D.C motor, testing of D.C machines, losses and efficiency, direct load test and Swinburne’s test (Chapter 12, 13, page Nos. 239-269),

**A.C. circuits:** Introduction to steady state analysis of A.C circuits, single and balanced 3 phase circuits (chapter 16, page nos. 323-348),

**Transformers:** Transformer principle, EMF-equation of transformer, transformer on load, equivalent circuit of transformer, voltage regulation of transformer, losses in a transformer, calculation of efficiency and regulation by open circuit and short circuit tests (Chapter 20, page Nos. 423-455),

**Three phase inductance motor:** Induction motor working principle, construction of 3-phase induction motor, principle of operation, types of 3-phase induction motor, torque equation of induction motor, slip-torque characteristics, starting torque, torque under running condition, maximum torque equation, power stages of induction motor, efficiency calculation of induction motor by direct loading (Chapter 21, page nos. 463-489),

**Altemator:** Altenator working principle, EMF equation of altenator, voltage regulation by Synchronised impedance method (Chapter 23, page nos. 505-515),

**Synchonous motor:** Synchronous motor principle of operation, construction, methods of starting of synchronous motor, (Chapter- 24, page nos. 516-526),

*Text book:*

1. ‘Elements of Electrical Engineering & Electronics’ by V.K. Mehta, S.Chand & Co.

*Reference book:*

‘A first course in Electrical Engineering’ by Kothari.

**CHE 1308 : General Engineering Laboratory**

**0 L- 0T- 3P-2C**

***Mechanical Engineering Laboratory:***

**1.** Find the viscosity of the given sample of oil using Redwood viscometer-1

**2.** Find the viscosity of the given sample of oil using Redwood viscometer-II

**3.** Find the flash point of the given sample of oil using Abel’s flash point tester

**4.** To calibrate pressure gauge using standard pressure and standard weights

**5.** Draw the valve timing diagram of a 4-stroke diesel engine and port timing diagram of a 2-stroke petrol engine

**6.** Perform load test at full load, half load, ¼ th load on a 4-stroke Ruston engine and draw the performance curves

**7.** Find the volumetric efficiency, isothermal efficiency of the given compressor

**8.** To determine the moment of inertia of a fly-wheel and shaft experimentally and compare the values with the calculated values

**9.** To determine experimentally the calorific value of a gaseous fuel by using Junkers gas calorimeter

**10.** To determine the modulus of rigidity of the material of the wire by torsional oscillators

***Electrical Engineering Laboratory:***

1. Study and calibration of ammeter

2. Study and calibration of voltmeter

3. Study and calibration of wattmeter

4. Study and calibration of energy meter

5. Measurement of low resistance (armature)

6. Measurement of medium resistance (field)

7. Measurement of insulation resistance

8. Measurement of filament resistance

9. Verification of KCL and KVC

10. Superposition theorem.

11. Parameters of a choke coil

12. OC and SC tests on transformer

13. Load test D.C. shunt machine

14. OC test on DC,. separately excited machine

15. Swinburne’s test

16. 3-phase induction motor (No load and rotor block tests)

17. Alternator regulation by Syn. impedance method

**CHE 1310 : Organic Chemistry Laboratory**

**0 L- 0T- 3P-2C**

*List of Experiments:*

1. Preparation of aspirin

2. Preparation of benzanilide

3. Preparation of m-dinitrobenzene

4. Preparation of benzoic acid

5. Preparation of phthalimide

6. Preparation of methyl orange

7. Preparation of parabenzoquinone

8. Preparation of nerolin

9. Detection of extra elements

10. Analysis of compound -1

11. Analysis of compound -2

12. Analysis of compound -3

13. Analysis of compound -4

14. Analysis of compound -5

15. Analysis of compound -6

**2/4 B.Tech(Chemical Engineering) - Second Semester**

**&**

**2/6 B.Tech + M.Tech (Chemical Engineering) Second Semester**

**CHE 1401 : Particle & Fluid Particle Processing**

**3L- 1T- 0P-3C**

*Objectives:*

Mechanical Operations is one of the core subjects for chemical engineers, where student can learn some of the unit operations necessary for process industry. Main objects of the inclusion of this subject are:

1. To make the students exposed to different geometrical sizes of raw materials used in the industries, area of calculation of the particles w.r.t their sizes

2. To get familiarity with the different laws of grinding

3. To do the power consumption calculations

4. To learn different separation process on their physical properties

5. To differentiate between the process such as mixing and agitation

6. To know the movement of particles in different liquids (viscous)

*Outcome:*

By the end of the course, student will be able to know the following things:

1. Separation of materials (useful and gangue) from their physical properties.

2. Selection of Machinery for size reduction of the raw materials

3. Power consumption calculation for crushing and grinding

4. Application of different techniques for separation

5. Minimization of impurities in the raw materials

6. General outlook for transportation of materials in the industry by choosing different conveyers.

*Syllabus:*

**Characteristics of solid particles** – shape, size, differential and cumulative screen analysis, specific surface area, particle population, different mean diameters for a mixture of particles,

**Principles of comminution** - Laws of crushing, description and working of size reduction equipment - jaw, gyratory and roll crushers, hammer mills, revolving mills, attrition mills, fluid energy mill, cutting machines, open and closed circuit grinding, wet and dry grinding, grindability index,

**Size separation**, screening, industrial screens - grizzly, gyratory and vibratory screens, revolving screens, trammels, capacity and effectiveness of screens, magnetic separation, electrostatic separation, froth flotation,

**Filtration** - description and working of filtration equipment, plate and frame filter press, shell and leaf filters, rotary drum filter, filter aid, centrifugal filtration, top suspended batch centrifuge, theory of filtration, washing of cakes,

**Motion of particles through fluids**- drag, free and hindered settling, settling velocities, classification, sink and float methods, differential setting methods - jigging and tabling, cyclone separators,

**Batch sedimentation,** thickeners, flocculation, centrifugal sedimentation, gravity and centrifugal decanters,

**Agitation of liquids,** power consumption in agitated vessels, scale up of agitation equipment, mixing equipment for mixing of solids and pastes, mixers for dry powders, mixing index,

**Conveying**, tpes of conveyors – mechanical, belt, chain and screw conveyors, elevators, pneumatic conveyors, size enlargement - need and applications.

*Text books:*

1. ‘Unit Operations of Chemical Engineering’ by W.L. McCabe, J.C. Smith and P.Harriot, McGraw- Hill Book Company

*Reference books:*

1. ‘Chemical Engineering -Vol.2’ by J.H.Coulson and J.F.Richardson, Pergaman press and ELBS

2. ‘Chemical Engineer’s Hand Book’ by R.H.Perry {ed}, McGraw-Hill Book Co.

3. ‘Unit Operations’ by Brown et al., Asian Publishing House

4. ‘Introduction to Chemical Engineering’ by Badger and Banchero, McGraw-Hill Book Company

**CHE 1402 : Fluid Mechanics**

**3 L- 1T- 0P-3C**

*The main objectives are to provide:*

1. Knowledge on pressure distribution in static fluids.

2. Knowledge on rheological behavior of fluids, types of fluid flow, boundary layers and basic equations of fluid flow.

3. Knowledge of incompressible & compressible fluid flow in pipes

4. Knowledge on fluid flowing past solid surfaces

5. Knowledge on pipes, fittings, transportation and metering devices.

*Outcome:*

1. Able to estimate the pressure drop.

2. Enhance the flow by reduction by reducing boundary layer separation.

3. Estimating the pumping capacity and friction losses of flowing fluids.

4. Designing fluidized and packed beds.

5. Able to select pumps based on their performance.

6. Able to select proper measuring device and estimate the quantity of flow.

*Syllabus:*

**Dimensional Analysis:** Units and Dimensions, Dimensional Homogeneity, Dimensional Analysis, Buckingham ð theorem, Geometric similarity, kinematic similarity, and dynamic similarity.

**Fluid statics and applications:** Nature of fluids, Hydrostatic Equilibrium, Applications of fluid statics – Manometers, continuous gravity decanter and centrifugal decanter.

**Fluid Flow phenomena:** Laminar flow, shear rate, shear stress. Rheological properties of fluids – Newtonian fluids, Non Newtonian fluids, time dependent flow, viscoelastic fluids. Viscosity, Reynolds number, Turbulence - nature of turbulence, deviating velocities, intensity and scale of turbulence, Reynolds stresses and eddy viscosity. Boundary layers - boundary layer formation over flat plate, flow in boundary layers, laminar and turbulent flow in boundary layers, boundary layer formation in straight tubes, boundary layer separation and wake formation.

**Basic Equations of Fluid Flow:** Continuity equation (Mass Balance in a flowing fluid), equation of motion (Differential Momentum Balance), Navier - stokes equations, Euler’s equation, Couette flow, Macroscopic Momentum Balance, layer flow with free surface, Bernoulli equation (Energy equation), corrections for effect of solid boundaries and pump work.

**Incompressible flow in pipes and channels :** Shear Stress and skin friction in pipes, Relation with skin friction and wall shear, Friction factor, relations between skin friction parameters, equivalent diameter, laminar flow in pipes and channels, velocity distribution, average velocity, Kinetic energy correction factor and momentum correction factor for laminar flow, Hagen-Poiseuille equation, laminar flow of non-Newtonian liquids, laminar flow in annulus. Turbulent flow in pipes and channels, Velocity distribution for turbulent flow, universal velocity distribution equations, its limitations, flow quantities for turbulent flow in smooth round pipes, Reynolds number- friction factor law for smooth tubes, effect of roughness, friction factor chart, drag reduction, friction from changes in velocity or direction – sudden expansion, sudden contraction, pipe fittings, friction losses in Bernoulli equation, velocity heads, separation of boundary layer in diverging channel, minimizing losses.

**Flow in compressible fluids:** Definitions and basic equations, processes of compressible flow, isentropic flow through nozzles, Adiabatic friction flow, Isothermal friction flow

**Flow past immersed objects:** Drag and drag coefficients, flow through bed of solids, Motion of particles through fluids - mechanics of particle motion, equation for one-dimensional motion of particles through fluid, terminal velocity, criterion for settling, free and hindered settling. Fluidization – conditions, minimum fluidization velocity, types of fluidizations and its applications.

**Transportation and Metering of Fluids:** Pipes, fittings, valves. Positive displacement Pumps – reciprocating, rotary and peristaltic pumps. Centrifugal pumps - theory, construction, performance, single and multistage pumps. Fans, Blowers and Compressors. Vacuum pumps – jet ejectors.

**Metering of fluids:** Full bore meters – Venturi meter, Orifice meter, Rotameters, Vortex-Shedding meters, Magnetic meters and Coriolis meters. Insertion meters – Pitot Tube, Thermal meters, notches and weirs.

*Text Books:*

1. “Unit Operations of Chemical Engineering” Seventh Edition, by W.L. McCabe, J C Smith and P Harriot, Mc Graw Hill

*Reference Books:*

1. “Chemical Engineering” Volume I by Coulson J.M. and Richardson J.F, Elsevier

2. “Fluid Mechanics” 2nd edition by Noel de Nevers, Mc Graw Hill

**CHE 1403 : Thermodynamics-I**

**3L- 1T- 0P-3C**

*Objectives:*

Chemical Engineering Thermodynamics is one of the core subjects of Chemical Engineering Curriculum. Knowledge of thermodynamics helps student compute heat and work requirements of a process. The student would also learn how to estimate data in case of absence of experimental data.

*Outcome:*

1. Identification of system so that application of thermodynamics to real problems would be done

2. Arriving at the limitations of the first law thus enabling a need for second law

3. Application of thermodynamic laws to pipe flow, nozzle flow, expansion, compression, refrigeration and liquefaction.

4. Development of generalized correlations

5. Evolving Gibbs energy as a generating function of all thermodynamic properties

*Syllabus:*

**The first law and other basic concepts:** Joule’s experiments, internal energy, the first law of thermodynamics, thermodynamic state and state functions, enthalpy, the steady-state, steady-flow process, equilibrium, the phase rule, the reversible process, constant-V and constant-P processes, heat capacity.

**Volumetric properties of pure fluids:** PVT behavior of pure substances, virial equations, the ideal gas, application of the virial equations, cubic equations of state, generalized correlations for gases, generalized correlations for liquids, molecular theory of fluids, second virial coefficients from potential functions.

**Heat effects:** Sensible heat effects, internal energy of ideal gases, microscopic view, latent heats of pure substances, standard heat of reaction, standard of heat of formation, standard heat of combustion, temperature dependence of heat effects of industrial reactions.

**The Second law of thermodynamics:** Statement of the second law, heat engines, thermodynamic temperature scales, thermodynamic temperature and ideal-gas scale, entropy, entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, entropy from the microscopic view point.

**Thermodynamic properties of fluids:** Property relations for homogeneous phases, residual properties, two-phase systems, thermodynamic diagrams, generalized property correlations for gases.

**Thermodynamics of flow processes:** Equations of balance, duct flow of compressible fluids, turbines (expanders), compression processes.

**Refrigeration and liquefaction: -** The Carnot refrigerator, the vapor compression cycle-comparison of refrigeration cycles, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction processes.

**Textbook:**

1. ‘Introduction to Chemical Engineering Thermodynamics’ by J.M.Smith, H.C.Van Ness and M.M.Abbott, 6th Edition, McGraw-Hill International Editions, 2000.

**Reference Books:**

1. ‘Chemical Engineering Thermodynamics’ by B.F.Dodge, McGraw-Hill Book Co.,

2. ‘Schaum Outline of Theory and Problems of Thermodynamics’ by Michael M. Abbott and Hendrick C.VanNess, McGraw-Hill International Book Co., Singapore, 1981.

**CHE 1404 : Material & Energy Balance**

**3L- 1T- 0P-3C**

**Objective**: To give intensive quantitative training in the practical applications of the principles of physical chemistry to the solution of complicated industrial problems and in methods of predicting missing physicochemical data from generalized principles.

**Outcome**: 1. Able to solve the problems based on stoichiometry, ideal gas and vapor pressure. 2. Able to write and solve material and energy balances for a process.

***Syllabus****:*

**Stoichiometry and composition relationships**- the gram-mole and pound-mole, limiting reactant, excess reactant, degree of completion, basis of calculation, weight percent, volume percent and mole percent, density and specific gravity- Baume and API gravity scales,

**Behavior of ideal gases**- application of the ideal-gas law, Dalton and Amagat laws to gaseous mixtures, composition of gases on dry basis and on wet basis,

**Vapor pressures**- Effect of temperature on vapor pressure, Antoine equation, reference substance vapor pressure plots, vapor pressure of immiscible liquids, ideal solutions and Raoult’s law, non-volatile solutes,

**Humidity -** Percentage saturation, relative saturation or relative humidity, dew point, vaporization, condensation, wet and dry bulb temperatures, adiabatic vaporization and adiabatic saturation temperature,

**Material balances-** Tie substance, yield, conversion, processes involving chemical reactions, material balance- calculations involving drying, dissolution, and crystallization, processes involving recycle, bypass and purge,

**Heat capacities of gases and gaseous mixtures-** effect of temperature on heat capacity of gas, mean heat capacity of gas, Kopp’s rule, latent heats, heat of fusion, heat of vaporization, Trouton’s rule, Kistyakowsky equation for non-polar liquids, estimation of latent heat of vaporization using Classius-Clayperon equation, enthalpy of humid air and humid heat capacity,

**Standard heat of reaction -** Standard heat of formation, laws of thermochemistry, standard heat of combustion, calculation of heat of formation from heats of combustion, calculation standard heat of reaction from heats of formation and from heats of combustion, standard integral heat of solution, effect of temperature on heat of reaction, Kirchoff’s equation, adiabatic and non-adiabatic reactions, theoretical and actual flame temperatures.

*Text book:*

1. ‘Chemical Process Principles, Part-I - Material and Energy balances’ by Olaf A Hougen, K.M. Watson and R.A.Ragatz, CBS Publishers and Distributors (1995)

*Reference books:*

1. ‘Basic principles and Calculations in Chemical Engineering’ by David M. Himmelblau, Prentice Hall of India Pvt Ltd, 1995

2. ‘Stoichiometry’ by B.I. Bhatt and S.M. Vora, 3rd Edition, Tata McGraw Hill Publishing Company Limited, New Delhi (1996)

3. ‘Stoichiometry for Chemical Engineers’ by Williams and Johnson, McGraw Hill Publishers.

**CHE 1405 : Managerial Economics**

 **(Common for all 1/4 B.Tech and 1/6 B.Tech + M.Tech Branches)**

**3L- 1T- 0P-3C**

Unit -I : Significance of Economics and Managerial Economics:

**Economics:** Definitions of Economics- Wealth, Welfare and Scarcity definition Classification of Economics- Micro and Micro Economics. **(Two periods)**

**Managerial Economics:** Definition, Nature and Scope of Managerial Economics, Differences between Economics and Managerial Economics, Main areas of Managerial Economics, Managerial Economics with other disciplines. **(Four periods)**

**Demand Analysis :Demand -** Definition, Meaning, Nature and types of demand, Demand function, Law of demand - Assumptions and limitations. Exceptional demand curve. **(Two periods)**

**Elasticity of demand** - Definition, Measurement of elasticity, Types of Elasticity ( Price, Income, Cross and Advertisement), Practical importance of Price elasticity of demand, Role of income elasticity in business decisions, Factors governing Price Elasticity of demand. **(Four periods)**

**Demand Forecasting -** Need for Demand forecasting, Factors governing demand forecasting, Methods of demand forecasting: Survey methods- Experts’ opinion survey method and consumers Survey methods. **(Four periods)**

**Utility Analysis:** Utility- Meaning, Types of Economic Utilities, Cardinal and Ordinal Utility, Total Utility, Marginal Utility, The law of Diminishing Marginal Utility and its Limitations**. (Two periods)**

Unit -II : Theory of Production and Cost analysis:

**Production -** Meaning, Production function and its assumptions, use of production function in decision making; Law of Variable Proportions: three stages of the law.   **(Four periods)**

**Cost analysis -** Nature of cost, Classification of costs - Fixed vs. Variable costs, Marginal cost, Controllable vs. Non - Controllable costs, Opportunity cost, Incremental vs. Sunk costs, Explicit vs. Implicit costs, Replacement costs, Historical costs, Urgent vs. Postponable costs, Escapable vs. unavoidable costs, Economies and Diseconomies of scale. **(Four periods)**

Unit -III : **Market Structures** : Definition of Market, Classification of markets; Salient features or conditions of different markets - Perfect Competition, Monopoly, Duopoly , Oligopoly, Importance of kinked demand curve ;Monopolistic Competition. **(Four periods)**

Unit -IV : **Pricing Analysis** : Pricing - Significance: Different Pricing methods- Cost plus pricing, Target pricing, Marginal cost pricing, Going -rate pricing, Average cost pricing, Peak load pricing , Pricing of joint Products, Pricing over the life cycle of a Product, Skimming pricing Penetration pricing, Mark- up and Mark- down pricing of retailers. (Four periods)

Unit -V : Business cycles, Inflation and Deflation: **Business cycles** - Definition , Characteristics , Phases, Causes and Consequences; Measures to solve problems arising from Business cycles. **(Four periods)**

**Inflation -**Meaning, Types, Demand- pull and Cost push inflation, Effects of Inflation, Anti- inflationary measures. **(Four periods)**

**Deflation-** Meaning, Effects of Deflation, Control of Deflation, Choice between Inflation and Deflation. **(Two periods)**

*Text Books:*

1. Sankaran,S., **Managerial Economics,** Marghan Publications, 2015, Chennai.

2. Aryasri, A.R., **Managerial Economics and Financial Analysis,** MC Graw Hill Education, New Delhi,2015.

*Reference Books:*

1. Dwivedi, D.N., **Managerial Economics,** Vikhas Publishing House Pvt. Ltd. 6th Edition, New Delhi,2004.

2. Dewett, K.K., **Modern Economic Theory**, S.Chand & Company Ltd., New Delhi, 2005.

**CHE 1406 : Numerical Methods in Chemical Engineering**

**2L- 0T- 3P-2C**

*Objectives:*

The objective of this course is to provide student with

· a sufficient background regarding the applications of computers in Chemical Engineering problems.

· The Knowledge of numerical integration, numerical differentiation, function approximations, solution of linear equations using matrix methods, solution of ordinary differential equations, initial value problems, boundary value problems and solution of partial differential equations by solving number of problems.

*Outcome:*

· Enables students to learn the applications of computers in solving chemical Engineering problems

· Students will be able to solve/write programs for Chemical Engineering problems

*Syllabus:*

**Roots of algebraic and transcendental equations:** Iteration methods, Regula-Falsi method, Newton Rapson method, roots of simultaneous sets of transcendental and algebraic equations.

System of linear equations and their solution by different techniques, numerical differential and integration, regression analysis, least squares and orthogonal polynomial approximation.

Numerical solution of ordinary differential equations, Numerical solution of partial differential equations (simple case studies).

Application of the above techniques to problems of interest in Chemical Engineering.

Hand on experience on *MATLAB* software to solve liner algebraic equations, matrix methods, non liner algebraic equations, ordinary differential equations etc.

Hand on experience on *simulink* software

**Text book:**

1. ‘Digital computation for chemical engineers’ by Leaon Lapidus, McGraw Hill Book Company

**Reference books:**

1. ‘Applied Numerical Methods’ by Camehanet, McGraw Hill Book Co.

2. ‘Applied Numerical Methods with Personal Computers, by Constantinides, McGraw Hill Book Co, New York

**CHE 1407 : Environmental Science**

**3L- 0T- 0P-0C**

**OBJECTIVE** : The aim of this course is to make the students better understand the changes in the environment and be given a greater voice and planning conservation through an interdisciplinary environmental science curriculum that is design to enhance scientific enquiry and to strengthen competence.

***OUTCOME*** *:*

1. Understanding various types of pollution regulations and their scientific bases.

2. Apply knowledge for the protection and improvement of the environment.

3. Finally the students can recognize all the major concepts in environmental science and demonstrating in-depth of the environment

*Syllabus:*

**Introduction:** Definition, scope and importance, measuring and defining environmental development – indicators,

**Ecosystems:** Introduction, types, characteristic features, structure and functions of ecosystems – forest, grassland, desert, aquatic (lakes, rivers and estuaries),

**Environmental and natural resources management:** Land resources- land as a resource, common property resources, land degradation, soil erosion and desertification, effects of modern agriculture, fertilizer-pesticide problems, Forest resources- use and over-exploitation, mining and dams –their effects on forest and tribal people, Water resources – use and over utilization of surface and ground water, floods, droughts, water logging and salinity, dams-benefits and costs, conflicts over water, Energy resources- Energy needs, renewable and non-renewable energy sources, use of alternate energy sources, impact of energy use on environment,

**Bio-diversity and its conservation:** Value of bio-diversity- consumptive and productive use, social, ethical, aesthetic and option values, bio-geographical classification of India - India as a mega diversity nation, threats to biodiversity, hot spots, habitat loss, poaching of wild life, loss of species, seeds etc., conservation of biodiversity - in-situ and ex-situ conservation,

**Environmental pollution- local and global issues**: Causes, effects and control measures of air pollution, indoor air pollution, water pollution, soil pollution, marine pollution, noise pollution, solid waste management, composting, vermiculture, urban and industrial wastes, recycling and re-use, nature of thermal pollution and nuclear hazards, global warming, acid rain , ozone depletion,

**Environmental problems in India**: Drinking water, sanitation and public health, effects of activities on the quality of environment, urbanization, transportation, industrialization, green revolution, water scarcity and ground water depletion, controversies on major dams – resettlement and rehabilitation of people: problems and concerns, rain water harvesting, cloud seeding and watershed management,

**Economy and environment**: The economy and environment interaction, economics of development, preservation and conservation, sustainability: theory and practice, limits to growth, equitable use of resources for sustainable lifestyles, environmental impact assessment,

**Social issues and the environment**: Population growth and environment, environmental education, environment movements, environment versus development,

**Institutions and governance**: Regulation by Government, monitoring and enforcement of environmental regulation, environmental Acts, water (prevention and control of pollution) act, air (prevention and control of pollution) act, environment .protection act, wild life protection act, forest conservation act, coastal zone regulations, institutions and policies relating to India, environmental governance,

**International conventions**: Stockholm conference-1972, Earth summit-1992, World commission for environmental development (WCED),

**Case studies**: Chipko movement, Narmada bachao andolan, Silent valley project, Madhura refinery and Taj mahal, Industrialization of Pattancheru, Nuclear reactor at Nagarjuna sagar, Tehri dam, Ralegaon siddhi (Anna Hazare), Kolleru lake-aquaculture, Fluorosis in Andhra Pradesh,

**Field work**: Visit to a local area to document and mapping environmental assets –river/forest/grass land / hill/ mountain, study of local environment-common plants, insects, birds, study of simple ecosystems – pond, river hill, slopes etc, visits to industries- water treatment plants, effluent treatment plants.

*TEXT BOOK:*

1. Environmental Studies by Anubha Kaushik & C.P. Kaushik Second Edition, New Age International (P) Limited.

**CHE 1410 : Particle & Fluid Particle Processing Lab**

**0L- 0T- 3P-2C**

*List of Experiments:*

1. To take a representative sample from a bulk by two methods, viz. Riffle and cone & quartering and to find out the average size (volume-surface mean diameter) of the samples

2. To determine the grindability index {GI} of coal by hard groove machine

3. To determine the time of grinding in a ball mill for producing a product with 80% passing a given screen

4. To verify the laws of crushing using any size reduction equipment like crushing rolls, ball mill or vibrating mill and to find out the work Index {WI} of the material

5. To compare open circuit and closed circuit grinding by means of a ball mill

6. To determine the optimum time of sieving for a given sample of material

7. To find the effectiveness of hand screening of a given sample by a given screen

8. To find the screen effectiveness of a trommel

9. To separate a mixture of coal into two fractions using sink and float method

10. To separate a mixture of coal into two fractions using froth flotation technique

11. To find the size analysis of a given fine sample using beaker decantation method

12. To separate a mixture of particles by jigging

13. To concentrate a given material by means of tabling

14. To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions

15. To determine the specific cake resistance and filter medium resistance of a slurry in plate and frame filter press.

**CHE 1412 : Fluid Mechanics Laboratory**

**0L- 0T- 3P-2C**

*List of Experiments:*

1. Identification of laminar and turbulent flows (Reynolds apparatus)

2. Measurement of point velocities (Pitot tube)

3. Verification of Bernoulli equation

4. Calibration of rotameter

5. Variation of orifice coefficient with Reynolds number

6. Determination of venturi coefficient

7. Friction losses in fluid flow in pipes

8. Pressure drop in a packed bed for different fluid velocities

9. Pressure drop and void fraction in a fluidized bed

10. To study the coefficient of contraction for a given open orifice

11. To study the coefficient of discharge in a V - notch

12. To study the characteristics of a centrifugal pump

 **3/4 B.Tech(Chemical Engineering) - First Semester**

**&**

**3/6 B.Tech + M.Tech (Chemical Engineering) First Semester**

**CHE 1501 : General Chemical Technology**

**3L- 1T- 0P-3C**

*Objectives:*

· To provide the student understanding of importance of chemical process industries over the other manufacturing industries.

· To provide the brief introduction of chemical process equipments, the application of thermodynamics, the chemical process principles, the equipment design and also the corrosion and the safety aspects to consider in the chemical manufacturing processes.

· To provide basic inorganic chemistry background required for the undergraduate students of engineering.

· To provide an overview of chemical properties of inorganic chemicals and the manufacturing processes.

· To provide an overview of applications of materials which the engineers are likely to use during their professional career.

*Outcome:*

· The student learnt the importance of chemical process industries over the other manufacturing industries.

· The student had a brief introduction of chemical process equipments, the application of thermodynamics, the chemical process principles, the equipment design and so on.

· Provided the basic inorganic chemistry background required for the undergraduate students of engineering.

· Provided an overview on chemical process industries.

· Learn the topics “The Fuel and Industrial Gases”.

· Enabled the students to get knowledge on metallurgy.

*Syllabus:*

Water: Sources of water, hardness, treatment for different end uses, municipal water conditioning, industrial waste water treatment.

Sulphur and sulphuric acid: Sources of sulphur-sulphuric acid, different processes of manufacturing-contact process, DCDA process for sulphuric acid manufacture.

Nitrogen industries: Manufacture of ammonia, nitric acid, urea and ammonium nitrate.

Phosphorous and phosphoric acid industries: Methods for production of phosphorous and phosphoric acid, manufacture of super phosphate and triple super phosphate.

Chloro-alkali industries: - Manufacture of soda ash, caustic soda and chlorine.

Cement: Types of cement, manufacture of ordinary portland cement [opc], slag cement.

Fuel and industrial gases: Production of water gas, producer gas and coke oven gas, production of acetylene, oxygen and nitrogen.

Metallurgy: Manufacture of pig iron, cast iron, methods of making steel, open hearth process, production of aluminium by electrolytic process.

*Textbooks:*

1. “Dryden’s Outlines of Chemical Technology” by M.Gopala Rao & Marshall Sitting (Editors). Affiliated East West Press Pvt. Ltd.

2. “Shreve’s Chemical Process Industries” by G.T.Austin, McGraw Hill Books

*Reference Books:*

1. “ Encyclopedia of Chemical Technology” by R.E.Kirk & D.F.Othmer (Editors) Interscience.

**CHE 1502 : Mass Transfer –I**

**3L- 1T- 0P-3C**

*Objectives:*

· To explain the students with the basic principles of mass transfer operations and other separation processes with examples.

· To impart knowledge on how certain substances undergo the physical change with diffusion/mass transfer of components from one phase to other phases.

· To describe the students with equipment used in operations involving mass transfer and other separation processes and their advantages and disadvantages.

· To focus on absorption and distillation operations and the process design aspects of the same operations.

· To provide the knowledge on humidification and dehumidification operations and their applications in real situations

*Outcome:*

· An ability to define the basic principles of mass transfer operations and other separation processes

· An ability to identify the basic techniques for measurement of diffusivity, mass transfer coefficient, evaporation rate,

· An ability to understand the importance of mass transfer phenomena in the design of process equipment in distillation operation

· An ability to understand the VLE concepts and application to different distillations

· An ability to identify the major parts of various mass transfer equipment

· An ability to understand the design of sizing of packed columns in absorption and plate columns in distillation

· An ability to understand the importance of humidification and dehumidification processes and their industrial applications

*Syllabus:*

**Introduction**: Mass transfer Operations.

**Molecular diffusion in fluids:** Binary solutions, Fick’s law, equation of continuity, Steady state equimolal counter current diffusion, Stefan’s diffusion, estimation of diffusivity of gases and liquids, application of molecular diffusion.

**Mass transfer coefficients**: Mass transfer coefficients in turbulent flow, theories of mass transfer, analogy between momentum, heat and mass transfer in laminar and turbulent flow, correlations for mass transfer coefficients in simple situations, diffusion in solids.

**Interphase mass transfer:** Concept of equilibrium, diffusion between phases, two resistance theory, material balances in steady state co-current and counter-current stage processes, Murphy stage efficiency.

**Equipment for gas-liquid operations:** Sparged vessels, mechanically agitated vessels for single phase liquids and gas-liquid mixtures, tray towers, sieve tray for absorption and distillation, venturi scrubbers, spray towers and spray chambers, packed towers for absorption and distillation, tray towers versus packed towers.

**Humidificationoperations:** Definition of fundamental terms, Psychrometric charts, theory of adiabatic saturation and wet bulb temperature, Lewis relation, gas-liquid contact operations, water cooling with air, dehumidification of air-water-vapor mixture, cooling towers, evaporative cooling.

**Absorption: S**olubility’s of gases in liquids, two component systems, multi-component systems, ideal and non-ideal solutions, choice of solvent for absorption, single component absorption material balances, counter current multistage operations, dilute gas mixtures, on-isothermal operation, tray efficiency, continuous contact equipment, HETP, HTU, NTU concepts for single operation absorption with chemical reaction.

**Distillation:** Principles of VLE for binary systems, phase diagrams, relative volatility, ideal solutions, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, continuous distillation, McCabe-Thiele method, Ponchon-Savarit method, tray efficiencies, introduction to multi-component distillation, azeotropic and extractive distillations.

***Text book:***

1. Mass transfer Operations, Robert E. Treybal, 3rd edition, McGraw-Hill Book Co.,

***Reference books:***

1.”Unit Operations in Chemical Engineering” by McCabe,W.L.,Smith,J.C.and Harriot,P., 5th Edition, McGraw-Hill Book Co.,

2. “Chemical Engineering Hand Book” by J.H. Perry.

**CHE 1503 (A) : Paper Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

***Objectives:***

To understand the growth prospects of Indian paper mills, history of paper industry, different types, composition and uses of paper, raw materials for paper making, preparation of raw materials, classification of fibers, recovery of cooking chemicals from spent cooking liquors, Pulping processes, manufacture of paper and Testing of different properties of pulp and paper and the types of pollutants from paper industry and their treatment.

*Outcome:*

\* Able to know about the history of development of paper industry in India and Importance of paper industry, historical background of paper making.

\* Able to learn growth prospects of Indian Paper mills.

\* Able to design the equipment used for the manufacture of paper.

\* Able to reduce the paper wastes, by proper choice of the equipment, modifications in the design and process parameters to improve the production rate and recovery of use full chemicals.

*Syllabus:*

**History:** Importance of paper industry, historical background of paper making, development of paper industry in India, **Different types and uses of paper**: Different types and uses of papers and paper boards, composition, method of making different types of papers and boards, **Raw materials for paper making:** Classification of fibres, characteristics and composition of some important vegetable fibers (hard woods, softwoods, bagasse, straws, rags and paper stock)**Preparation of raw materials**: Wood preparation – pulp wood measurement, barking, chipping, screening and conveying of chips)**Pulping processes:** Mechanical pulping, alkaline pulping (Soda and Kraft), sulfite pulping, semi-chemical pulping, recovery of cooking chemicals from spent cooking liquors, **Pulp bleaching:** Bleaching agents, bleaching methods – single stage and multi stage bleaching, **Stock preparation**: Beating and refining, sizing and loading (filling),**Manufacture of paper**: Paper machines (Fourdrinier and Cylinder), making of paper – forming section, press section, dryer section, calendaring section, **Testing of different properties of pulp and paper**: Testing and evaluation of pulp, various properties of pulp and paper and their testing.

*Text books:*

*1.*‘Handbook of Pulp and Paper Technology’ by Kenneth W.Britt, Vols.I&II

2.‘Modern Pulp and Paper Making’ edited by John B.Calkin

3***.*** ‘Pulp and Paper: Science and Technology - Vols.I&II’ by E.Libby, McGraw Hill Books Co.

4.‘Pulp and Paper Manufacture- Vols. I & II’ by R.C.McDonald & Others, McGraw Hill Books Company.

**CHE 1503 (B) : Fertilizer Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

*Objectives:*

\* To introduce various nutrients and their role in growth of a plant

\* To introduce different types of the nitrogenous, phosphatic, potassic and compound fertilizers

\* To introduce different fertilizer production methods

*Outcome:*

1. Able to know different raw material availability

2. Able to know the beneficiation of rock phosphate

3. Able to know the production of all types of fertilizers

4. Able to formulate different fertilizer mixtures

*Syllabus:*

**Details about indigenous fertilizer production** – raw materials, details of various nutrients with their importance, sources of nitrogen and hydrogen, steam reforming of hydrocarbons, partial oxidation of fuel cells with gas purification including high and low temperature shift conversion, carbondioxide removal processes and methanation.

**Coal gasification,** ammonia synthesis, thermodynamic principles associated with ammonia synthesis, ammonia reactors, nitric acid and sulfuric acid.

**Urea** – total recycle and stripping processes, process details of ammonium sulfate, ammonium chloride, ammonium nitrate, calcium ammonium nitrate.

**Phosphate rock** – availability and beneficiation methods for upgrading, bone meal, basic slag, single super phosphate, triple super phosphate, phosphoric acid by wet process and furnace process, AMI process with hydrochloric acid, complex fertilizers like mono and di-ammonium phosphates, urea ammonium phosphate.

*Text book :*

1. ‘Hand Book of Fertilizers’ published by fertilizer Association of India, New Delhi

*Reference Books :*

1. ‘Chemistry and Technology of Fertilizers’ by V. Sauchelli, Reinhold Publications

2. ‘Fertilizers Manual, a UNIDO Publication from International Fertilizer Development Centre, Alabama, USA.

3. ‘Chemical Technology-II’ published by IIT, Madras.

**CHE 1503 (C) : Petroleum Refinery Engineering (Core Elective – I)**

**3L- 1T- 0P-3C**

***Objective:***

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

*Outcome:*

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

**Syllabus**

Origin and formation of Petroleum. Reserves and deposits of the world, Composition of crudes, Refinery introduction and Indian petroleum refining industry scenario.

Refinery products and test methods, Evaluation of crudes, Crude pretreatment-Dehydration and desalting, Pipe still heater. Atmospheric and Vacuum distillation of crude oil.

Thermal Conversion Process- Vis Breaking, Delayed Coking.

Catalytic Conversion Process- Fluid Catalytic Cracking, Hydrocracking, Hydrotreating, Alkylation, Isomerization, Polymerization and Reforming.

Lube Oil Process – Solvent deasphalting, solvent Extraction, Solvent Dewaxing and Hydro finishing.

Treatment of kerosene, additives, blending of gasoline, Asphalt and air blown asphalt.

*Textbooks:*

1. Petroleum Refining Technology by Dr. Ram Prasad

2. Modern Petroleum Refinery Engineering by B K Bhaskar Rao

3. Gary, J.H., Handwerk, G.E. and Kaiser, M.J. (2007) Petroleum Refining: Technology and Economics. 5th Edition, CRC Press, Boca Raton, 488 p.

4. Petroleum Refining. Vol. 3 Conversion Processes, Pierre Leprince (Editor).

**CHE 1503 (D) : Ceramic Raw Materials (Core Elective – I)**

**3L- 1T- 0P-3C**

Ceramic Raw Materials is a vital subject to the Ceramic technology students. It is life and back-bone of the ceramic engineers to become a skilled technician. This will provide knowledge regarding the raw materials which are used in the ceramic industry. Important objectives beyond the incorporation of the paper ‘Ceramic Raw Materials’ are:

***Objectives:***

1. To procure knowledge about the earth

2. To gain knowledge regarding the rocks which are host useful ores.

3. To know about the physical and optical properties of the minerals and ores

4. To gain acquaintance with formation of different raw materials.

5. To collect information about the different types of clays

6. To put on the knowledge regarding other raw materials used in the ceramics

7. To get information regarding the distribution of the deposits

***Outcome:***

1. Will be gained knowledge about the availability of raw materials for ceramics

2. Able to identify the suitable raw materials for the production of good ceramics

3. Be expertise in the selection of raw materials with quality.

4. Will be gained knowledge regarding the different beneficiation techniques through materials can be purified for further process.

5. Acquaintance with chemistry of the different raw materials suchas quartz, feldspar and rheological properties of the different clays

**Syllabus: General geology and minerology**: Formation of rocks, their characteristics, classification into igneous, sedimentary and metamorphic groups, formation of mineral deposits, physical and mineral characteristics of minerals – composition, color, streak, luster, fracture, cleavage, hardness, density and tenacity, elements of optical mineralogy.

**Clays:** Clay minerals, clay structure – kaolinite and montmorillonite groups, geology of clay deposits, their classification - china clay, ball clay, fire clay, building clay etc., beneficiation of clays, mica chlorite, illite group, talc, pyrophyllite, wollastonite group, chemical properties, physical properties.

**Fluxes:** Soda and potash feldspar, other feldspars, nephline syenite, geology of formation, physical and chemical properties, beneficiation.

**Silica and silicate materials:** Silica, polymorphic modification, silica structure, physical and chemical properties of silica, silicate chemistry, minerals, sillimanite, kyanite, and alusite, availability in India and their uses in ceramic industry.

**Other raw materials:** Geology of bauxite, magnesite, dolomite, chrome, limestone, rutile, zircon, beryllia minerals, alumina, carbides, nitrides, properties and uses.

*Textbooks:*

1. ‘Fine Ceramics Technology and Applications‘ by F.H.Norton, McGraw Hill Publishers, New York,

2. ‘Ceramic Raw Materials’ by W.E.Worrall, Pergamon press, New York.

*Reference books:*

1. ‘Forming Minerals’ by W.A.Deer, R.A. Howie & J.Rock, Longman Publishers, London

2. ‘Properties of Ceramic Raw Materials’ by W.Ryan, Pergamon press, 2nd Edition

3. ‘Clay Mineralogy’ by M.J.Wilson, Chapman & Hall.

**CHE 1503 (E) : Fuel Cell Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

1. Introduction – fuel cell; brief history of fuel cells, types of fuel cells and fuel cell applications.

2. Thermodynamics and Electrochemical kinetics – Engineering thermodynamics, conversion efficiencies of heat engines and fuel cells, chemical reactions, chemical thermodynamics and electrochemical kinetics.

3. Fuel cell components and their impact on performance – General design features, fuel cell performance: the MEA and the current/voltage curve, MEA components and the fuel cell stack.

4. Stack design – Sizing of a fuel cell stack, stack configuration, uniform distribution of reactants inside each cell, heat removal from a fuel stack and stack clamping.

5. Fuel cell modeling – Theory and governing equations, modeling domains and modeling examples.

6. Fuel cell system design – Hydrogen-air system, fuel cell systems with fuel processor, electrical subsystems and system efficiency.

7. Fuel cell applications – Transportation applications, stationary power, backup power and fuel cells for small portable power.

*Text books:*

1. For chapters 1 to 3: Fuel Cell Technology Hand Book, Edited by Gregor Hoogers, CRC Press.

2. For Chapters 4 to 7: PEM Fuel Cells: Theory and practice By Frano, Elsevier Academic Press.

*Reference Books:*

1. Fuel cells principles and applications by B.Viswanathan and M. Aulice Scibioh, Universal Press. (India) Private Limited, Hyderabad.

2. Fuel Cell Systems Explained, second edition, by James Larminie and Andrew Dicks, John Wiley & Sons Ltd.

**CHE 1503 (F) : Polymer Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

**Introductory concepts and fundamentals:** Definitions and concepts of plastics and polymers, comer, co-monomer, mesomer, co-polymer, functionality, visco-elasticity, Classification of polymers, methods of determining molecular weights of polymers-

(i) Methods based on colligative properties

(ii) Sedimentation velocity method

(iii) Sedimentation equilibrium method

(iv) Gel-chromatography method

(v) Light scattering analysis method

(vi) End-group analysis method

Natural polymers- brief study of rubber, shellac, rosin, cellulose, proteins, Lignin’s,

**Chemistry of polymerization:** Elementary concepts of addition polymerization, condensation polymerization and co-polymerization, glass transition temperature of polymers, methods of determining Tg, degradation of polymers due to mechanical, hydrolytic, thermal and backbone effects, Relation of the mechanical, thermal, electrical, physical and chemical properties with the structure of the polymer,

**Methods of polymerization:** Mass, solution, emulsion and suspension, role of the initiators, catalysts, inhibitors, solvents, fillers, reinforcing agents, stabilizers, plasticizers, lubricants, blowing agents, coupling agents, flame retardants, photo-degradants and bio-degradable on polymerization, Methods of manufacture, properties and uses of the following addition products; Polyethylene (LDPE and HDPE) , polypropylene, PVC and its copolymers, Polystyrene and its copolymers, acetals and PTFE (polytetraflouroethylene),

**Methods of manufacture, properties and uses of the following condensation products:** (i)Polyesters-PMMA, PET and ALKYO, (ii) PF-, UF- and MF-resins (iii) epoxy resins, polyurethanes and silicones,

**Description of the following processing methods:** (with the principles involved and equipments used) Mixing and compounding, extrusion, calendaring, laminating, moulding-compression, transfer, injection and blow moulding.

**Text books:**

1. ‘Plastic Materials’ by J.A.Brydson, Newnes-Butterworths (London) 1989

2. ‘Textbook of Polymer Science’, Billymeyer, F.W.Jr., 3rd edition, John Wiley & Sons,

**Reference books:**

1. ‘Introduction to Plastics’ by J.H.Briston and C.C. Gosselin, Newnes, London

2. ‘Polymeric Materials’ by C.C.Winding and G.D.Hiatt, McGraw-Hill Publishers

**CHE 1503 (G) : Intellectual Property Rights (Core Elective – I)**

 **3L- 1T- 0P-3C**

UNIT-I Introduction to Intellectual Property: Historical Perspective, Different Types of IP, agencies and treaties, Importance of protecting IP, international organizations Innovations in products, processes, services and procedures - product life cycles, favorable and unfavorable aspects in innovation; Inventions as intellectual property.

UNIT-II Patents Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India, Foundation of patents and patent laws, procedures in India and developed countries; study of patents indifferent fields and their innovative content; patent searching process, ownership rights and transfer.

UNIT-III Copyrights and GI : **Copyrights:** Introduction, How to obtain a copy right and Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law, Differences of copyrights from Patents.

**Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India.

UNIT-IV Trademarks and Trade Secrets : **Trade Marks:** Introduction to trademarks, Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

**Trade Secrets:** Introduction and Historical Perspectives, Scope of Protection, Trade secrete law, Risks involved and legal aspects of Trade Secret Protection, Determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation, Unfair competition: Misappropriation right of publicity, false advertising.

UNIT-V New developments and Infringement Issues of IP : **New development of intellectual property:** new developments in trade mark law; copy right law, patent law, intellectual property audits. International overview on intellectual property, international – trade mark law, copy right law, international patent law, and international development in trade secrets law, motivating and encouraging innovative attitude in individuals and organizations; entrepreneurial qualities and skills, learning and training.

**IP Infringement issue and enforcement** – Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assets and their valuation, Human attitudes, risks, hardships, examples of failure, case studies of inventors; Intellectual Property in the Indian Context – Various laws in India Licensing and technology transfer.

*Reference Books:*

· Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001).

· Intellectual property right, Deborah. E. Bouchoux, Cengage learning.

· Acharya, N.K. Textbook on intellectual property rights, Asia Law House (2001).

· Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers (2000).

· Watal, J. Intellectual property rights in the WTO and developing countries, Oxford University Press, New Delhi.

**CHE 1504 : Thermodynamics-II**

**3L- 1T- 0P-3C**

**Objectives:** The course will help to learn about :

1. Solution thermodynamics and Applications

2. Thermodynamic properties and VLE from equations of state

3. Concept of phase equilibrium

4. Concept of reaction equilibrium

***Outcome:***

1. This course helps the students to be proficient in applying thermodynamic principles to various chemical engineering processes involving energy flow.

2. Understand the phase equilibrium.

3. Understand the Chemical reaction equilibrium

*Syllabus :*

**Solution thermodynamics: Theory:** Fundamental property relation, chemical potential as a criterion for phase equilibria, partial properties, ideal gas mixtures, fugacity and fugacity coefficient for a pure species, fugacity and fugacity coefficient for species in solution, generalized correlations for the fugacity coefficients, the ideal solution, excess properties, behaviour of excess properties of liquid mixtures.

**Solution thermodynamics: Applications:** Liquid-phase properties from VLE data, models for the excess Gibbs Energy, property changes of mixing, heat effects of mixing processes.

**VLE at low to moderate pressures:** The nature of equilibrium, the phase rule, Duhem’s theorem, VLE- qualitative behavior, the gamma/phi formulation of VLE, dew point and bubble point calculations, flash calculations, solute (1)/solvent (2) systems.

**Thermodynamic properties and VLE from equations of state:** Properties of fluids from the virial equations of state, properties of fluids from cubic equations of state, fluid properties from correlations of the Pitzer type, VLE from cubic equations of state.

**Topics in phase equilibria:** Equilibrium and stability, liquid/liquid equilibrium(LLE), vapor/liquid/liquid equilibrium(VLLE), solid/liquid equilibrium (SLE), solid/vapor equilibrium (SVE).

**Chemical reaction equillibria:** The reaction coordinate,–application of equilibrium criteria to chemical reactions, the standard Gibbs energy change and the equilibrium constant, effect of temperature on the equilibrium constant, evaluation of equilibrium constants, relation of equilibrium constants to composition, equilibrium conversions for single reactions, phase rule and Duhem’s theorem for reacting systems, multi reaction equilibria.

**Thermodynamic analysis of processes:** Calculation of ideal work, lost work, thermodynamic analysis of steady-state flow processes.

**Text book:**

1. ‘Introduction to Chemical Engineering Thermodynamics’ by J.M.Smith, H.C.Van Ness and M.M.Abbott., 6th Edition, Tata McGraw-Hill Edition 2003

*Reference books:*

1. ‘Chemical Engineering Thermodynamics’ by Y.V.C.Rao, University Press (India) Ltd., Hyderabad 1997

**CHE 1505 : Corrosion Engineering (Open Elective-I)**

**3L- 0T- 0P-3C**

**Introduction and scope**: Corrosion definition, wet and dry corrosion, mechanism, electro-chemical principles and aspects of corrosion, Faradays laws, resistance, specific resistance, conductance, specific conductance, transport numbers, ionic mobility, corrosion rate expressions, calculation of corrosion rates, thermodynamic aspects of corrosion, equilibrium potential, Nernst equation for electrode potential, EMF series, over voltage, application of Nernst equation to corrosion reactions,

**Polarisation and corrosion potentials**: References electrodes for corrosion measurements, types of polarisation, concentration, activation and resistance polarizations, Tafel constant, Evans diagrams, anodic control, cathodic control, mixed control, Pourbaix-diagram for Fe-H2O system,

**Various forms of corrosion: U**niform attack, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching (dezincification), cavitation damage, fretting corrosion, erosion corrosion, and stress corrosion and remedial measures,

**Prevention techniques:** Modification of the material by alloying, appropriate heat treatment, chemical and mechanical methods of surface treatment, metallic, non-metallic linings, inhibitors, passivity, Cathodic protection and anodic protection.

*Text books:*

1.’Corrosion Engineering’ by Mars G. Fontana, Tata McGraw Hill Publishing Company, New Delhi

2.’Corosion and Corrosion Control’ by H.H.Uhllg, John Wiley & Sons Inc., America

*Reference books:*

1.’Electrochemistry’ by Samuel Glasstone, Litton Educational Publishing Company

2.’Electrochemistry, Principles & Applications’ by Edmond C.Potter, Cleaver Hume Press Limited.

**CHE 1506 : Heat Transfer**

**3L- 1T- 0P-3C**

*Objectives:*

· This course is designed to introduce a basic study of the phenomena of heat to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes.

· Conduction: Fourier’s law, Thermal Conductivity – its variation with temperature & Pressure and its relationship with electrical conductivity. Heat transfer through composite walls and cylinders.

· To enable the students to learn heat transfer by conduction, convection and radiation and heat transfer equipments like evaporator and heat exchanger

· Radiation: Radiation laws like Stefan Boltzmann’s law, Kirchhoff’s law, Wien’s law, Plank’s law etc. Black body, Grey body.

· Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces. Radiation through semi transparent materials.

· Heat transfer with phase change: Boiling of liquids, Pool boiling curve, different types of pool boiling, condensation of vapor, film wise & drop wise condensation, weighted LMTD & Overall Heat transfer Coefficient for desuperheating & sub cooling.

· Evaporation: Performance of tubular evaporator. Individual & overall Coefficients, Capacity & economy of evaporators. Boiling point elevation, Durhing’s rule, Effect of liquid head & friction on pressure drop, Types of evaporators, Multiple effect evaporators. Vapor recompression, Thermal recompression & mechanical recompression.

***Outcome:***

· Understand the basic laws of heat transfer.

· Account for the consequence of heat transfer in thermal analyses of engineering systems.

· Analyze problems involving steady state heat conduction in simple geometries

· Develop solutions for transient heat conduction in simple geometries.

· Apply the concepts of heat transfer and associated thermal boundary conditions to transform the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.

· Understand various types of heat Transfer equipments

· Understanding of various types of heat transfer process and devices

· Evaluate heat transfer coefficients for natural convection.

· Evaluate heat transfer coefficients for forced convection inside ducts.

· Evaluate heat transfer coefficients for forced convection over exterior surfaces.

· Analyze heat exchanger performance by using the method of log mean temperature difference.

· Analyze heat exchanger performance by using the method of heat exchanger effectiveness.

· Calculate radiation heat transfer between black body surfaces.

· Calculate radiation heat exchange between gray body surfaces.

· Understanding of the basic concepts of conduction, convection and radiation heat transfer,

· Apply the concepts of heat transfer and associated thermal boundary conditions to transform the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.

*Syllabus:*

**Nature of heat flow:** Conduction, convection, natural and forced convection, radiation.

**Heat transfer by conduction :** Basic laws of conduction, thermal conductivity; Steady-state conduction – compound resistances in series, heat flow through a cylinder; Unsteady-state conduction – one dimensional heat flow with constant surface temperature, het flow with variable surface temperature, semi-infinite solid;

**Heat transfer by convection:** Principles of heat flow in fluids – Typical heat exchange equipment, countercurrent and parallel flows, energy balances, heat flux and heat transfer coefficients, overall heat transfer coefficients, integration over total surface, LMTD, individual heat transfer coefficients.

**Heat transfer to fluids without phase change :** boundary layers, laminar flow heat transfer, correction for heating and cooling, heat transfer in turbulent flow, estimation of wall temperature, cross-sections other than circular, analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids outside tubes, natural convection.

**Heat transfer to fluids with phase change:** heat transfer from condensing vapors, heat transfer to boiling liquids.

**Radiation heat transfer:** Fundamental facts concerning radiation, emission of radiation, absorption of radiation by opaque solids, radiation between surfaces, radiation to semitransparent materials, combined heat transfer by conduction-convection-radiation.

**Heat-exchange equipment:** General design of heat exchange equipment, shell and tube heat exchangers, plate-type exchangers, extended surface equipment, heat pipes, scraped-surface exchangers, condensers and vaporizers, heat transfer in agitated vessels, heat transfer in packed beds.

**Evaporation:** Evaporation, types of evaporators, performance of tubular evaporators, multiple-effect evaporators, methods of feeding, vapor compression.

**Text Book:** Unit Operations of Chemical Engineering, ***7***th Ed. by W. L. McCabe, J. C. Smith and P. Harriot, McGraw Hill International Edition, Singapore (2005).

**Reference book:** Process Heat Transfer, by D. Q. Kern, Tata McGraw Hill, New Delhi.

**CHE 1508 : Heat Transfer Laboratory**

**0L- 0T- 3P-2C**

*List of Experiments:*

1. Determination of total thermal resistance and thermal conductivity of composite wall.

2. Determination of total thermal resistance and thermal conductivity of Lagged pipe.

3. Determination of the natural convective heat transfer coefficient for a vertical tube.

4. Determination of forced convective heat transfer coefficient for air flowing through a pipe.

5. Determination of over-all heat transfer coefficient in double pipe heat exchanger.

6. Study of the temperature distribution along the length of a pin fin under natural and forced convection conditions.

7. Estimation of unsteady state film heat transfer coefficient between the medium in which the body is cooled.

8. Determination of Stefan-Boltzmann constant.

9. Determination of emissivity of a given plate at various temperatures.

10. Determination of radiation constant of a given surface.

11. Determination of the thermal conductivity of a metal rod.

12. Determination of critical heat flux point for pool boiling of water

**CHE 1510 (A) : General Chemical Technology Laboratory**

 **0L- 0T- 3P-2C**

*List of experiments:*

A. Analysis of water:

1. Total solids, dissolved solids,pH

2. Chlorides and sulphates

3. Temporary, permanent and total hardness.

B. Analysis of oils:

4. Acid value

5. Iodine value

6. Saponification value

C. Miscellaneous analysis:

7. Analysis of coal: Proximate analysis

8. Analysis of lime: Estimation of acid insolubles, available lime and

 calcium carbonate

9. Analysis of bleaching powder: Estimation of chlorine content.

10. Analysis of starch/glucose: Estimation of total reducing sugars

11. Analysis of saw dust: Estimation of total cellulose and –cellulose

E. Miscellaneous preparations:

12. Preparation of soap

13. Preparation of copper pigment

14. Preparation of chrome yellow pigment

15. Preparation of phenol formaldehyde resin

**CHE 1510 (B) : Petroleum Engineering Laboratory**

**0L- 0T- 3P-2C**

*List of experiments:*

1. Evaluation and test methods for crude petroleum

2. Evaluation and test methods for products

3. ASTM distillation

4. TBP distillation

5. Flash and fire points

6. Viscosity index

7. Smoke point

8. Cloud and pour points

9. Carbon residue

10. Aniline point and diesel index

11. Drop point

12. Penetration number

13. Softening point

14. Water content and melting point

15. Demonstration experiments:

16. Extraction in RDC column and catalytic reactors

**CHE 1510 (C) : Ceramic Technology Laboratory**

**0L- 0T- 3P-2C**

***List of experiments****:*

1. Preparation of ceramic slip in a pot mill

2. Determination of slip specific gravity

3. Determination of slip viscosity

4. Effect of water on viscosity of slip

5. Effect of deflocculant on viscosity of slip

6. Determination of residue in a slip

7. Plaster mould making

8. Making of solid slip cast article

9. Making of drain slip cast article

10. Biscuit firing

**CHE 1512 : Slot for MC (Constitution of India)**

**3L- 0T- 0P-0C**

1. Meaning of the constitution law and constitutionalism

2. Historical perspective of the Constitution of India

3. Salient features and characteristics of the Constitution of India

4. Scheme of the fundamental rights

5. The scheme of the Fundamental Duties and its legal status

6. The Directive Principles of State Policy – Its importance and implementation

7. Federal structure and distribution of legislative and financial powers between the Union and the States

8. Parliamentary Form of Government in India – The constitution powers and status of the President of India

9. Amendment of the Constitutional Powers and Procedure

10. The historical perspectives of the constitutional amendments in India

11. Emergency Provisions : National Emergency, President Rule, Financial Emergency

12. Local Self Government – Constitutional Scheme in India

13. Scheme of the Fundamental Right to Equality

14. Scheme of the Fundamental Right to certain Freedom under Article 19

15. Scope of the Right to Life and Personal Liberty under Article 21.

**3/4 B.Tech(Chemical Engineering) – Second Semester**

**&**

**3/6 B.Tech + M.Tech (Chemical Engineering) Second Semester**

CHE 1601 **:** Chemical Reaction Engineering

**3L- 1T- 0P-4C**

**Introduction** and overview of the subject, kinetics of homogeneous reactions, non elementary reactions, Arrhenius relation, Collision theory and Transition-state theory, various methods of analyses of batch reactor data obtained for various types of reactions including variable volume and variable pressure data .

**Isothermal batch reactor design**, **Homogeneous flow reactors**: Design equation for plug flow reactor (PFR) and continuous stirred tank reactor (CSTR), data analysis in flow reactors, space time, space velocity, recycle reactor, cascade of CSTRs and combination for PFR and CSTR.

**Multiple reactions:** Design for multiple reactions, parallel reactions, series reactions.

**Non-isothermal design**: Energy balance equations for batch, PFR and CSTR under non-isothermal conditions, Equilibrium conversion under adiabatic conditions, Design of the homogeneous reactors under adiabatic conditions.

**Non-ideal flow:** Residence time distribution curves, C ,E and F curves; Interpretation of the response data for the “Dispersion” and “Tanks-in-series” models, calculation of conversion using E data and tanks- in -series model.

**Heterogeneous Catalysis:** Catalyst-properties, calculation of surface area, porosity and pore volume, catalyst preparation methods, promoters, inhibitors and catalyst poisons, physical adsorption & chemisorption, adsorption isotherms, Derivation of rate equations for various mechanisms (Adsorption, surface reaction and desorption controlling etc.,) Data analysis for heterogeneous laboratory catalytic reactors. Isothermal packed bed (PFR) rector design, effectiveness factor and internal pore diffusion, Criteria for internal pore diffusion limitation.

***Text book:***

1‘Chemical Reaction Engineering’ by Octave Levenspiel, 3rd Edition, John Wiley & Sons, 1999

***Reference books****:*

1. ‘Elements of Chemical Reaction Engineering’ by H.S.Fogler, 3rd Edition, Printice Hall International, 2000

2. ‘Chemical Engineering Kinetics’ by J.M.Smith, 3rd Edition, McGraw Hill, 1981

**CHE 1602 : Process Engineering & Economics**

**3L- 1T- 0P-3C**

*Objectives:*

1. To introduce types of interests, annuity, perpetuity, bond, debenture

2. To introduce depreciation and cost accounting methods

3. To introduce cash flow tree diagram, methods of cost estimation.

4. To introduce profitability, profitability evaluation

5. To introduce optimization in industries

6. To introduce economic balance of various operations.

*Outcome:*

1. Able to determine the different types of interests

2. Able to determine time value of annuity, perpetuity, bond and debenture

3. Able to determine depreciation costs and various ratios to tell about financial status of the company

4. Able to determine total cost of the project

5. Able to select an alternate investment using different profitability methods

6. Able to determine different optimum parameters in different operations.

*Syllabus:*

**Value of money - equivalence:** Value of money, equations for economic studies, equivalence, types of interest- discrete and continuous, annuities - relation between ordinary annuity and the periodic payments, continuous cash flow and interest compounding, present worth of an annuity, perpetuities and capitalized costs, bonds and debentures, value of a bond and yield rate,

**Depreciation:** Types and various methods of calculating depreciations, depreciation accounting,

**Cost accounting**: Basic relationship in accounting, balance sheet and income statement, various ratios to study the balance sheet and income statements,

**Cost estimation**: Cash flow for industrial operations, factors affecting investments and production costs, estimation of capital investment, cost indices, cost factors in capital investment, methods of estimating capital investment, estimation of total product cost- manufacturing costs and general expenses,

**Profitability:** Alternate investments and replacements. mathematical methods for profitability evaluation, economic production charts for plants operating below 100%, above 100% and under dumping conditions, general procedure for determining optimum conditions, break even chart for production schedule and its significance for optimum analysis,

**Economic balance** in fluid flow, heat transfer and mass transfer operations; optimum economic pipe diameter in fluid dynamics, optimum flow rate of cooling water in condenser in heat transfer and optimum reflux ratio in distillation operation,

**Economic balance** in cyclic operations and semi continuous cyclic operations, economic balance in yield and recovery, economic balance in chemical reactors, batch and flow reactors.

***Text books****:*

1. ‘Plant Design and Economics for Engineers’ by Max S. Peters and K.D.Timmerhans, McGraw Hill Book Company,

2. ‘Process Engineering Economics’ by Herbest E. Schweyer, McGraw Hill Book Company.

**CHE 1603 (A) : Process Modeling & Simulation (Core Elective-II)**

**3L- 1T- 0P-3C**

*Objectives:*

· To introduce different types of models along with examples related to chemical engineering

· To instruct how to develop empirical models using different tools and the use of numerical methods for solution of Non- Linear Algebraic equations

· To disseminate the use of different numerical techniques for carrying out numerical integration and differentiation.

· To impart knowledge on modelling of various equipment and their simulation using different numerical techniques.

· To guide selection of the solution method based on the computational requirements of various solution options.

· To elucidate process simulation using modular and equation based solving approaches.

***Course outcomes:***

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

· Classify different types of mathematical models

· Develop mathematical model for the given chemical engineering problem from basic engineering principles.

· Identify the appropriate numerical method for solving a given model.

· Solve ODEs and PDEs using different numerical methods.

· Simulate binary distillation column, gravity flow tank, batch reactor, Non- isothermal CSTR, and counter-current heat exchanger.

· Compare and contrast modular approaches with equation oriented approach

**UNIT I : Mathematical models for chemical engineering systems**: classification of mathematical models- steady state vs dynamic models, lumped vs distributed parameter models, deterministic vs stochastic models. **Examples of mathematical models**- Two heated tanks, batch reactor, constant volume CSTRs, non-isothermal CSTR, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup.

UNIT II : **Empirical model building**- method of least squares, linear, polynomial and multiple regression, non-Linear regression. **Solution of Non- Linear Algebraic equations**- bisection, false position, Quasi Newton and Newton- Raphson methods.

UNIT III : **Numerical integration**- Trapezoidal rule, Simpson’s rule and Newton– Cotes formula. **Numerical solution of differential equations**- Euler’s method, Runge- Kutta methods, predictor corrector methods.

**UNIT IV : Numerical solution of partial differential equations**- elliptic, parabolic and hyperbolic equations, finite difference methods, Leibman’s method, Crank Nicholson method. Applications to steady state and Unsteady state heat conduction and temperature distribution problems.

UNIT V : **Process Simulation examples**: VLE dew point and bubble point calculations, binary distillation column, gravity flow tank, batch reactor, Non- isothermal CSTR, countercurrent heat exchanger.

**Process simulation using modular and equation based solving approaches**: Developing a simulation model, a simple flow sheet, Sequential modular approach, Simultaneous modular approach, Equation solving approach.

***Textbooks:***

1. Process modelling, Simulation and Control for Chemical Engineers, 2nd ed., W. L. Luyben, McGraw-Hill, New York, 1990.

2. Numerical Methods for Engineers, S.K. Gupta, Wiley Eastern, New Delhi, 1995.

***Reference:***

1. Numerical Methods for Engineers and Scientists, S.S. Rao

2. Introduction to Numerical Methods in Chemical Engineering, P. Ahuja, PHI learning Pvt. Ltd., New Delhi, 2010

3. Process Modelling and Simulation, Amiya K. Jana, 2012.

 **CHE 1603 (B) : Petrochemicals (Core Elective-II)**

**3L- 1T- 0P-3C**

***Objectives:***

To make a thorough understanding of the availability of petroleum resources, technical and financial constrains of all the elementary problems. To know the development of petrochemical industries and methodolically furnishes the conversion of petroleum feedstock’s to chemical and intermediates.

*Outcome:*

\* Able to know Petrochemical industry-Feedstock, various important Chemicals produced from ethylene and C3, C4 and higher carbon atoms.

\* Able to know the structure of Polymer, methods of polymerization, high pressure polyethylene (LDPE), low pressure polyethylene (HDPE),

\* Able to know Petroleum aromatics, synthetic fibers, Synthetic rubber, Plastics and Synthetic detergents.

\* Able to understand all the production processes and will get an awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

*Syllabus:*

**Petrochemical industry-Feedstocks:** Petrochemical industry in India, feed stocks for petrochemicals.

**Chemicals from ethylene:** Vinyl chloride monomer, vinylacetate monomer, ethylene oxide, ethylene glycol, acetaldehyde.

**Chemicals from C3,C4 and higher carbon atoms:** Isopropylalcohol, acrylonitrile, acrylic acid, phenol, bisphenol-A, iso and n-butanol, methyltertbutylether, methacrylic acid, malic anhydride.

**Polymers of olefins:** Polymer structure, methods of polymerization, high pressure polyethylene (LDPE), low pressure polyethylene (HDPE), polypropylene, polyvinylchloride, polystyrene.

**Petroleum aromatics:** Benzoic acid, caprolactum, terephthalic acid, phthalic anhydride,

**Synthetic fibres**: Production techniques of synthetic fibres, production of polyester, nylon-6,6, nylon-6, acrylic fibers.

**Synthetic rubber:** Styrene butadiene rubber (SBR), butyl rubber, synthesis of polyurethane.

**Plastics:** Phenol formaldehyde resins, urea formaldehyde resins, polycarbonates.

**Synthetic detergents:** Classification of detergents, general manufacture of sulphonates, keryl benzene sulphonate (Surf).

**Textbook:**

1. ‘A Text on Petrochemicals’ by B.K.Bhaskara Rao, 3rd Edition, Khanna Publishers, NewDelhi.

**Reference text books:**

1. ‘Petrochemical processes’, Vol.2, 2nd edition, by A.Chanvel and G. Lefebvre, Gulf publishing company.

2. ‘Shreve’s chemical process industries’, 5th edition, by George T. Austin, Mc Graw Hill Publishers

**CHE 1603 (C) : White ware And Heavy Clayware (Core Elective - II)**

**3L- 1T- 0P-3C**

*OBJECTIVE:*

The main objective of this subject is: Applications for advanced ceramics have received major media attention in recent years, particularly for use as parts in a future ceramic heat engine. However, corrosion resistance, chemical inertness, thermal shock resistance and other properties that materials scientists and engineers can design into ceramic materials make both traditional and advanced ceramics highly attractive in a large number of applications.

*OUTCOME:*

At the end of the course student will be able to understand

1. Lowering the social cost and risks of waste.

2. Reducing the damage to the environment from waste generation and disposal.

3. Use resources more efficiently.

4. Enhance product design.

5. Include the costs of waste management into the price of products.

*Syllabus:*

**Claassification of whiteware products:** Body formulation and properties, tableware, earthenware talc bodies, vitreous bodies, high alumina bodies, porcelain, bone china, sanitary ware, stoneware, majolica, terracotta, art ware, physical properties of mixtures, role of water.

**Whiteware:** Classification, body composition, white wares at home, construction, electrical appliances, industrial uses, manufacturing and properties.

**Heavy clayware:** Raw materials, methods of winning and handling, classification of building materials, manufacture of building bricks, hollow bricks and other bricks, roof tiles, paving tiles, sewer pipes.

**Fine ceramics:** Packing of two component system, porosity, effect of grain size, unfired porosity, experimental verifications, wet to dry contraction, unfired strength, permeability and casting rate, dry to fired contraction.

**Tests and quality control:** IS inspection, LOI, plasticity, strength, MOR, thermal shock resistance, abrasion resistance, porosity, acid and alkali resistance, chipping resistance, chemical analysis, electrical and thermal conductivity.

*Text books:*

1. ‘Pottery Science: Materials, Processes and Products’ by Allen Dinsdale, Ellis Horwood Ltd., New York,

2. ‘Ceramic White Ware’ by Sudhir Sen, Oxford & IBH Publishing Co., New Delhi

*Reference book:*

1. ‘Industrial Ceramics’ by F. Singer and S. Singer, Oxford & IBH Publishing Company,

 **CHE 1603 (D) : Computational Fluid Dynamics (Core Elective - II)**

**Numerical solution of ordinary differential equations:** Initial value problems of first order, Runge-Kuta methods, linear multi-step and predictor-corrector methods, R-K method for two simultaneous first order equations,

**Finite difference discretization of first and second derivatives: I**mplementation of finite difference equations, explicit and implicit methods, errors and stability analysis,

**Selected examples for finite difference applications in heat conduction:** Heat dissipation through a constant area fin, two-dimensional steady heat conduction in rectangular geometry, one dimensional transient heat conduction in a slab, Crank-Nicolson method, Thomas algorithm,

**Fundamentals of fluid flow modeling**: Upwind scheme, transportive property, second upwind differencing, hybrid scheme,

**Solution of unsteady Navier-Stokes equations for incompressible flows:** Staggered grid, introduction to MAC method, MAC formulation of momentum balance equation, pressure correction equation,

**Introduction to SIMPLE method**: One-dimensional convection, diffusion equation, formulation of flow problem, discretized continuity and momentum equations, pressure correction equation,

**Concept of finite volume method:** Regular finite volumes, discretization procedure for continuity equation.

***Text Book****:*

1. ‘Computational Fluid Flow and Heat Transfer’ 2nd edition by K. Muralidharan and T. Sundararajan, Narosa Publishing House, New Delhi, 2003

*Reference book:*

1.‘Computational Fluid Dynamics - The Basics and Applications’ by John D. Anderson, Jr., McGraw-Hill Inc., New Delhi, 1995.

**CHE 1603 (E) Multi Component Separation Processes**

**(Core Elective - II)**

**3L- 1T- 0P-3C**

**Multi component vapor –liquid equilibria**: Ideal mixtures at low pressures, non-ideal mixtures, activity coefficient models - Wilson, NRTL, UNIQUAC and UNIFAC equations, evaluation of model constants from binary experimental data, prediction of multicomponenet VLE from the model constants of the constituent binaries,

**High pressure equilibria:** Vaporization constants, K, Thermodynamic method for K, graphical charts, chao-Seader correlation,

**Equilibrium and Simple Distillation**: Multicomponent equilibrium, flash vaporization(EFV), multicomponent differential distillation,

**Design considerations in fractionating process:** Quantitative relationships, temary and multicomponent system fractionation, key fractionation concepts, selecton of key components, column pressure, material balance, rigorous and approximate minimum reflux calculations, recommended short-cut methods for minimum reflux minimum plates at total reflux, FUG methods, Smith Brinkley method,

**Multicomponent fractionation rigorous design procedures**: Sorel method, Lewi Metheson method, Thiele-Geddes method and its versions in distillation column design, techniques of separating azeotropic and close boiling mixtures by fractional distillation, azeotropic and extractive distillation, selection of solvents, design considerations, pseudo binary methods, solvent recovery,

**Tray design and operation**: The common tray types, tray capacity limits, tray hydraulics parameters, flow regies on trays, column sizing, tray efficiency, fundamentals, tray efficiency prediction,

**Packing design and operation**: Packing types, packing hydraulics, comparing packings and trays, packing efficiency and scale-up.

*Text books:*

1. ‘Distillation’ by M.Van Winkle, McGraw Hill Book Company

2. ‘Phase Equilibria in Chemical Engineering’ by S.M.Wales, Butterworth publishers, 1985

3. ‘Distillation Design’ by Henery Z Kister, McGraw Hill Book Company

**CHE 1603 (F) : Chemical Engineering Mathematics (Core Elective - II)**

 **3L- 1T- 0P-3C**

Objectives:

· To learn various computational techniques for analyzing and solving chemical engineering problems.

· To develop engineering models by integrating the fundamentals of mathematics and computer programming.

*Outcome:*

· Understanding of fundamental Mathematics and to solve problems of algebraic and differential equations, simultaneous equations and partial differential equations.

· Ability to convert problem solving strategies to procedural algorithms and to write program structures.

· Ability to solve engineering problems using computational techniques.

*Syllabus:*

**Mathematical formulation of the physical problems**: i). Application of the law of conservation of mass, salt accumulation in stirred tank, starting an equilibrium still, solvent extraction in N stages, diffusion with chemical reaction and ii). application of the law of conservation of energy, radial heat transfer through a cylindrical conductor, heating a closed kettle, flow of heat from fin,

**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 and ii). second order differential equations, non-linear equations, linear equations, simultaneous diffusion and chemical reaction in a tubular reactor, continuous hydrolysis of tallow in a spray column,

**Partial differential equations:** i). Formulation of partial differential equations, unsteady-state heat conduction in one dimension, mass transfer with axial symmetry, continuity equation, ii). boundary conditions- function specified, derivative specified and mixed conditions and iii). particular solutions of partial differential equation- compounding the independent variable into one variable, superposition of solutions, the method of images and particular solution suggested by the boundary conditions,

**Finite differences:** i). The difference operator, properties of the difference operator, difference tables, other difference operators, ii). linear finite difference equation, complementary solution, particular solution, simultaneous linear difference equations and iii). non-linear finite difference equations, analytical solutions,

**Solutions for 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 and c). calculation of number of stages required for a counter current extraction and leaching operation,

**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 method of averages, linear least squares and weighted linear least squares methods and iii). design of experiments - factorial and fractional factorial methods.

***Text book:***

1. ‘Mathematical Methods in Chemical Engineering’ by V.G.Jenson and G.V.Jeffreys, Academic Press, London

*Reference books:*

1. ‘Applied Mathematics in Chemical Engineering’ by Harold S. Mickley, Thomas S. Sherwood and Charles E. Reed, Tata McGraw Hill Publications

2. ‘Applied Statistics’ 2nd edition by Volk, W., McGraw Hill Chemical Engg. series

3. ‘Applied Numerical Methods with Personal Computers, by Alkis Constantinides,S., McGraw Hills, Chemical Engineering series, 1987

**CHE 1604 : Transport Phenomena**

**3L- 1T- 0P-4C**

*PART-A*

**Momentum transport:** Viscosity and the mechanism of momentum transport- i). Newton’s law of viscosity, ii). Non-Newtonian fluids and iii). pressure and temperature dependence of viscosity,

**Velocity distributions in laminar flow**: i). Shell momentum balances boundary conditions, ii). flow of a falling film, iii). flow through a circular tube and iv). flow through an annulus,

**The equations of change for isothermal systems**: i). The equations of continuity, motion and mechanical energy in rectangular and curvilinear coordinates, ii). use of the equations of change to set up steady flow problems and iii). dimensional analysis of the equations of change,

**Velocity distributions** with more than one independent variable and unsteady viscous flow,

*PART-B*

**Energy transport:** Thermal conductivity and the mechanism of energy transport- i). Fourier’s law of heat conduction and ii). temperature and pressure dependence of thermal conductivity in gases and liquids,

**Temperature distributions in solids and in laminar flow**: i) Shell energy balances-boundary conditions, ii). heat conduction with an electrical heat source, iii). heat conduction with a viscous heat source, iv). heat conduction through composite walls, v). forced convection and vi). free convection,

**The equationsof change for non-isothermal systems:** i). The equation of energy in rectangular and curvilinear coordinates, ii). the equations of motion for forced and free convection in non-isothermal flow, iii). use of the equations of change to set up steady state heat transfer problems and iv). dimensional analysis of the equations of change,

**Temperature distribution with more than one independent variable**: Unsteady state heat conduction in solids,

*PART-C*

**Mass transport:** Diffusivity and mechanism of mass transport- i). Definitions of concentrations, velocities and mass fluxes, ii). Fick’s law of diffusion and iii). temperature and pressure dependence of mass diffusivity,

**Concentration distribution** in solids and in laminar flow: i). Shell mass balances – boundary conditions, ii). diffusion through a stagnant gas film, iii). diffusion with heterogeneous chemical reaction, iv). diffusion with homogeneous chemical reaction and v). diffusion into a falling liquid film,

**The equations of changefor multicomponent systems:** i). The equations of continuity for a binary mixture, ii). the equations of continuity of A in curvilinear coordinates and iii). dimensional analysis of the equations of change for a binary isothermal fluid mixture,

***Text book****:*

1. ‘Transport Phenomena’ by R. Byron Bird, W.E. Steward and Edwin N. Lightfoot, John Wiley & Sons Inc., New York

***Reference books:***

1. Transport phenomena’ by Robert S. Brodkey & Haryr C. Hershey, McGraw Hills Company, New Yark

1. Transport Phenomena-for engineers’ byLouis Theodore, International Book Compnay, London

2. ‘Transport Phenomena’ by W.J.Book and K.M.K.Multzall, JW&Sons Ltd.

3. ‘Fundamentals of Momentum, Heat and Mass Transfer’ by Mames R Welty, Charlese Wicks and Robert E Wilson, J W & Sons Inc., New York

4. ‘Fluid Dynamics and Heat Transfer’ by James G. Knudsen and Donald L.Katz., McGraw Hills Company Inc., New York.

**CHE 1605 : Mass Transfer –II**

**3L- 1T- 0P-3C**

**Objective :** To explore about different mass transfer operations and its applications in industrial scale.

**Outcome:** At the end of the course student would have learnt about the liquid-liquid extraction processes ,leaching, adsorption phenomena, drying, crystallization and different membrane separation process/techniques and their applications.

*SYLLABUS:*

**Liquid-liquid operations: Extraction:** Introduction, liquid-liquid equilibria, analytical and graphical solutions for single and multistage operations, continuous counter current operation without and with reflux, fractional extraction, equipment for liquid-liquid contacting operations, single stage, multistage and continuous contacting equipment,

**Leaching:** Preparation of solid, steady and unsteady state operation, equipment, analytical methods both theoretical and problematic approaches for single and multistage operations,

**Adsorption:** Theory of adsorption, Industrial adsorbents, adsorption equilibria, Freundlich equation, single and multistage operations, unsteady state adsorption, equipment for single stage and continuous contact, ion-exchange,

**Drying:** Equilibria, drying rate curve, batch and continuous drying, time of drying and calculations, mechanism of batch drying, equipment’s for batch and continuous drying operations,

**Crystallization:** Equipment and analytical methods, factors governing nucleation and crystal growth rates, controlled rate of crystals, incorporation of principles into the design of the equipment,

**Less conventional operations:** Dialysis, thermal diffusion, mass diffusion,

**Membrane separation processes**: Separation of gases, separation of liquids, dialysis, membranes for liquid extraction, pervaporation, reverse osmosis.

**Text book:**

5. ‘Mass Transfer Operations’, by Robert E.Treybal, III Edition, McGraw-Hill Book Co.

**Reference books:**

1. ‘Unit Operations in Chemical Engineering’ by McCabe,W.L., Smith, J.C. and Harriot, P., 5th Edition, McGraw-Hill Book Co.

2. ‘Chemical Engineering Hand Book’ by J.H.Perry

**CHE 1606 : Nano Science & Technology**

**3L- 0T- 0P-3C**

 **General Introduction:** Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mossbauer and Spectroscopy, optical phenomena bonding in solids, anisotropy,

**Silicon Carbide:** Application of silicon carbide, nano materials preparation, sintering of SiC, X-ray diffraction data, electron microscopy sintering of nano particles, nano particles of alumina and zirconia, nano materials preparation, characterization, wear materials and nano composites,

**Mechanical properties**: Strength of nano crystalline SiC, preparation for strength measurements, mechanical properties, magnetic properties,

**Electrical properties**: Switching glasses with nanoparticles, electronic conduction with nano particles,

**Optical properties:** Optical properties, special properties and the coloured glasses

**Process of synthesis of nano powders**, electro deposition, important nano materials,

**Investigaing and manipulating** materials in the nanoscale: Electron microscope, scanning probe microscope, optical microscope for nano science and technology, X-ray diffraction,

**Nanobiology:** Interaction between bimolecules and naoparticle surface, different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, application of nano in biology, naoprobes for analytical applications - a new methodology in medical diagnostics and biotechnology, current status of nano biotechnology, future perspectives of nanobiology, nanosensors,

**NanoMedicines**: Developing of nano-medicines, nanosytems in use, protocols for nanodrug administration, nanotechnology in diagnostics applications, materials for used in diagnostics and therapeutic applications, molecular nanomechanics, molecular devices, nanotribology, studying tribology at nanoscale, nanotribology applications.

***Text books:***

1. ‘Nano Materials’ by A.K.Bandyopadhyay, New Age Publishers

2. ‘Nano Essentials’by T.Pradeep, TMH.

**CHE 1608 : Chemical Reaction Engineering Laboratory**

**0L- 0T- 3P-2C**

1. Determination of the order of a reaction using a batch reactor and analyzing the data by (a) differential method and (b) integral method

2. Determination of the activation energy of a reaction using a batch reactor

3. To determine the effect of residence time on conversion and to determine the rate constant using a CSTR

4. To determine the specific reaction rate constant of a reaction of a known order using a batch reaction.

5. To determine the order of the reaction and the rate constant using a tubular reactor

6. Determination of RTD and dispersion number in a tubular reactor using a tracer

7. Mass transfer with chemical reaction (solid-liquid system) – Determination of mass transfer coefficient

8. Axial mixing in a packed bed - Determination of RTD and the dispersion number for a packed bed using tracer

9. Langmuir adsorption isotherm - Determination of surface area of activated charcoal.

10. Performance of reactors in series: (i) A plug flow reactor followed by a CSTR and (ii) A CSTR followed by a plug flow reactor.

**CHE 1610 : Mass Transfer Laboratory**

**0L- 0T- 3P-2C**

***List of Experiments:***

1. Steam distillation

2. Differential distillation

3. Height equivalent to a theoretical plate

4. Vapor-liquid equilibria

5. Determination of liquid diffusion coefficient

6. Determination of vapor diffusion coefficient

7. Surface evaporation

8. Height of a transfer unit

9. Ternary liquid equillibria (Binodal curve)

10. Liquid-liquid equilibria.

11. Limiting flow rates in spray tower

12. Hydrodynamics of perforated plate tower

13. Volumetric mass transfer coefficients in perforated plate tower

14. Dynamics of liquid drops (Single drop extraction tower)

15. Studies of axial mixing characteristics in a packed bed

16. Gas-liquid mass transfer in packed tower

17. Drying characteristics of a given material

**4/4 B.Tech(Chemical Engineering) - First Semester**

**&**

**4/6 B.Tech + M.Tech (Chemical Engineering) First Semester**

**CHE 1701 : Process Instrumentation and Control**

**3L- 1T- 0P-4C**

*Objectives:*

To understand how physical quantities are measured and how they are converted to electrical or other forms.

To have an adequate knowledge on various types of instruments.

To study the characteristics of Instruments.

To deal with control equipment and various controllers and their functions and applications. So, in studying this course Chemical Engineering students will come to know the measurement of various process variables and learn the operation of control systems effectively.

*Outcome:*

Understand the measurement techniques for Pressure, Temperature, Flow and Level.

Understand recording, indicating and signaling instruments.

Analyze repeatability, precision and accuracy of instruments.

Able to understand the simple control system and its elements

Study various Controllers like P, P-I ,P-I-D Controllers and its mechanism

Develop transfer functions for Controllers Control systems

Understand the tuning of Controllers

UNIT-I : **Qualities of measurement:** The elements of instruments, static and dynamic characteristics, dynamic response of first order and second order instruments.

**Expansion thermometers:** Temperature scales, constant-volume gas thermometer, bimetallic thermometer, pressure spring thermometer, theory of volumetric and pressure thermometers, static accuracy of thermometer, comparison of pressure-spring thermometers.

**Thermoelectric temperature measurement:** Thermoelectricity, industrial thermocouples, thermocouple lead wires, thermal wells, response of thermocouples, the mill voltmeter.

**Resistance thermometers:** Thermal coefficient of resistance, industrial resistance thermometer bulbs, resistance thermometer circuits, null-bridge resistance thermometers, deflectional resistance thermometers.

**Radiation temperature measurement**: Introduction, blackbody devices and radiation receiving elements, radiation pyrometers, photoelectric pyrometers and optical pyrometers.

UNIT-II : **Methods of Composition analysis**: Spectroscopic analysis, absorption, Emission and Mass spectroscopy- IR, UV absorption and mass spectrometers, Gas analysis by thermal conductivity, analysis of moisture in gases (humidity), psychrometer method, hygrometer method, dew-point method for moisture analysis in gases, measurement of moisture in paper, textile and lumber.

UNIT-III : **Measurement of pressure and vacuum**: Pressure, vacuum and head, liquid column manometers, measuring elements for gauge pressure and vacuum, indicating elements for pressure gauges, measurement of absolute pressure, measurement of pressure in corrosive fluids, static accuracy of pressure gauges.

**Measurement of Head and Level:** Density and specific gravity, direct measurement of liquid level, pressure(level) measurement in open vessels, level measurement in pressure vessels, density measurement, level measurement by weighing.

UNIT-IV : Introduction to process dynamics and control, Response of First Order Systems - Physical examples of first order systems.

UNIT-V : Response of first order systems in series, higher order systems: Second order and transportation lag.

UNIT-VI : Control systems Controllers and final control elements, Block diagram of a chemical rector control system.Closed loop transfer functions, Transient response of simple control systems.

UNIT-VII : Stability Criterion, Routh Test, Root locus. Transient response from root locus, Application of root locus to control systems Introduction to frequency response, Control systems design by frequency response.

UNIT-VIII : Advanced control strategies, Cascade control, Feed forward control, ratio control, Smith predictor, dead time compensation, internal model control. Controller tuning and process identification. Control valves.

*Text Books:*

1. Donald P Eckman. Industrial Instrumentation, CBS Publishers, New Delhi, 2004. (For Units I, II, III)

2. D.R. Coughanowr. Process Systems Analysis and Control, Mc Graw Hill, 1991.(For Units IV to VIII)

*Reference books:*

1. Hand Book of Instrumentation and control, Considine.

2. Chemical Process Control, G. Stephanopolous, Prentice Hall, 1984.

**CHE 1702 : Chemical Process Equipment Design**

**3L- 1T- 0P-4C**

***Introduction of plant design and costs,***

**Process design development:** Design project procedure, design information from the literature and other sources of information, flow diagrams, preliminary design, comparison of different processes, firm process design, equipment design and specialization, scale up in design, safety factors specifications, materials of construction,

**General design considerations:** Health and safety hazards, fire and explosion hazards, personnel safety, loss prevention, thermal pollution control, noise pollution and control, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling, materials and fabrication selection.

**Material transfer, handling and treatment equipment design and costs:** Incompressible fluid flow systems design, flow through parallel, series and piping network systems, compressible fluid flow systems design, design and cost estimation of filters.

**Mechanical design of process equipment:** Design and selection of storage vessels and low pressure vessels, design of roofs, bottom plates, formed heads, flat plate and conical closures, tall vertical columns, supports to process vessels, distillation columns, heat exchanges, evaporators.

**Heat transfer equipment design and costs:** Heat exchangers for sensible heat exchange - double pipe, shell and tube, plate heat exchangers, heat exchangers with extended surface, optimum heat exchanger design, heat exchangers with phase change – single effect evaporators, multiple effect evaporators, vapor recompression evaporators, condensers – condensation of single vapors, condensation with boiling range, reboilers.

**Mass transfer equipment design:** Continuous distillation- design for binary systems and pseudo binary systems for multi component distillation, plate efficiencies, entrainment, approximate column sizing, selection of plate type, plate construction, plate hydraulic design, plate design procedure, plate areas, diameters, liquid flow arrangements, entrainment, weep point weir dimensions, perforated area, hole size, hole pitch, hydraulic gradient, liquid flow, plate pressure drop, down comer design, packed columns - choice of plate or packing, types of packing, packed bed height, prediction of height of transfer unit (HTU) liquid distribution, stimulation of pressure drop in packed towers, allowable velocities, column diameter, column internals, wetting rates, reactor design, equations for reactor design application - batch reactor, tubular flow reactor, back mix reactors expression of reaction rates mechanical features of reactor design.

*Text books:*

1. ‘Plant design & Economics for Chemical Engineers’, 4th edition, M.S.Peters & K.D.Timmerhaus, Mc Graw Hills Publishing Company

2. ‘Process Equipment Design’, 3rd Edition, M.V.Joshi, MacMillan India Ltd 1981

***Reference books:***

1. ‘Process-Plant-Design’ by J.R.Backhurst & J.H.Harker, Heieman Education London

2. ‘Chemical Engineering’ Volume-VI (An introduction to Chemical Engineering Design’ by J.M.Coulson & J.F.Richardon

**CHE 1703 (A) : Computer Aided Design (Core Elective -III)**

**3L- 1T- 0P-3C**

*Objective:*

To revise the basic concepts in Fluid Mechanics, Heat Transfer, Mass Transfer and Chemical Reaction Engineering and apply the numerical methods with the aid of computer in designing such systems.

*Outcome:*

Able to understand the concept behind the designing of various systems which includes Fluid Mechanics, Heat Transfer, Mass Transfer and Chemical Reaction Engineering. From this course, student gains the knowledge of how to apply the theoretical knowledge gained into practical design of any process; equipment. From this course, student also gains knowledge in terms of application of various numerical methods, correlations and computer applications in designing the equipment. In addition, student is able to know the importance of optimization of the process conditions with the given conditions.

Using the knowledge gained during this course, one can easily start the job as process engineer or design engineer. Student knows the importance of practical aspect of any process. This outcome is very helpful for the student in delivering the job as basic design engineer.

Syllabus:

CAD of fluid flow system:

Flow of Newtonian fluids in pipes

Pressure drop in compressible flow

Flow of Non-Newtonian fluids in pipes

Pipe network calculations

Two phase flow system,

**CAD of Heat transfer equipment:** Shell and tube exchangers without phase change,Condensers, Reboilers,Furnaces.

**CAD of Mass transfer equipment:** Distillation,Gas absorption ,Liquid extraction.

**CAD of chemical Reactors:** Chemical reaction equilibrium ,Analysis of rate data, Ideal reactor models,Non-ideality in chemical reaction,Performance analysis using residence time distribution,Temperature effects in homogeneous reactors,Heterogeneous systems, Fluidized bed reactors.

**Text Book:** Chemical Process Computations by Raghu Raman. Elsevier Scientific Publishers, London, 1987

***Ref. Books:***

1. Fundamentals and Modelling of Separation process by C D Holland, rentice Hall Inc. New Jercey, 1975

2. Catalytic Reactor Design by Orhan, Tarhan, Mc Graw Hill, 1983

3. Chemical Engineering, Vol 6 by Sinnot, Pergamon Press, 1993

**CHE 1703 (B) : Industrial Pollution And Control Engineering
(Core Elective -III)**

**3L- 1T- 0P-3C**

***Objectives:***

To understand the types of emissions from chemical industries and their effects on environment, methods of analysis of air pollutants, general methods of control like primary, secondary, tertiary treatment methods, solid waste management and Industrial safety.

*Outcome:*

\* Able to know the types of pollution and pollutants, sources of these pollutants from domestic and industrial wastes, permissive and excessive limits of the pollutants and standards of these pollutants especially in drinking water.

\* Able to know the sophisticated instruments used for the analysis of water and air pollutants. The student will be having knowledge to design the equipment used for the abatement of these pollutants.

\* Able to modernize the solid waste management and acquiring awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

*Syllabus:*

**Types of emission** from chemical industries and their effects on environment, Environmental legislation, noise pollution, occupational health hazards, meteriological factors in pollution dispersion (ALP and ELP), plume behaviour and characteristics, chimney design considerations: Plume raise, effective stack height,

**Methods of analysis of air pollutants**, particulate matter, SOx, NOx, COx analysis, removal of particulate matters: principles and design of setting chambers, solid traps, cyclone separators, fabric and design of fibre filters, scrubbers and electrostatic precipitators,

**General methods of control** and removal of sulphur dioxide, oxides of nitrogen, organic vapors from gaseous effluents with design aspects, sources of waste waters, effluent guidelines and standards, characterization of effluent streams, oxygen demanding wastes, oxygen sag curve, BOD curve, analysis of water pollutants,

**Methods of primary treatment**: Screening, sedimentation, floatation and neutralization, biological treatment, bacteria and bacterial growth curve, aerobic processes suspended growth processes, activated sludge process, extended aeration, contact stabilization, aerated lagoons and stabilization ponds, attached growth process with design aspects, trickling filters, rotary drum filters, fluidized bed contactors, anaerobic processes,

**Methods of tertiary treatment:** Carbon adsorption, ion exchange, reverse osmosis, ultra filtration, chlorination, ozonation & sonozone process, sludge treatment and disposal,

**Solid waste management**: solid waste collection, transportation, solid waste processing and recovery, hazards in waste management, risk assessment and safety measures, types of hazardous wastes, health effects, safety measures, risk assessment response measures, case studies or pollutants removal and safety measures in fertilizer, petrochemical, paper, pharmaceutical industries and petroleum refinery,

**Industrial safety:** Why safety, accidents, causes and remedial measures, safety aspects of site selection, plant layout and unit plot planning, hazards of commercial chemical operations and reactions, safety aspects of process design, instrumentation for safe operations, safety aspects in design and inspection of pressure vessels, effect of toxic agents, toxicity vs hazards, respiratory hazards, safe experimentation and testing of reactions, materials for safety,

**Flamable materials:** Fire extinguishing agents and their applications, eye safety in chemical processing, personnel protective equipment, permit systems, hazard evaluation techniques, modern safety management systems, safety effectiveness.

*Text books:*

1. ‘Environmental Pollution Control’, by C.S. Rao, Wiley Eastern Limited

2. ‘Safety and Accident Prevention in Chemical Operations’ by Fawcett and Wood

***Reference books:***

1. ‘Environmental Engineering’ by Arcdio P.Sincero and Geogoria Sincero

2. ‘Loss Prevention in Chemical Industries’ by Frank P.Lees

**CHE 1703 (C) : Process Optimization (Core Elective -III)**

**3L- 1T- 0P-3C**

*Objective:*

Optimization of Chemical Process is an important of subject for Chemical Engineers. It deals with various optimization techniques in reducing cost of production ,energy consumption, maximum throughput and minimum labour cost etc. Onstudying the course one can understand how to write a model of the process optimize the process using the model

*Outcome:*

1.Understand the definition of Optimization and how to write an Objective function

2. Understand various types of Objective functions like Concave and Convex functions and its properties

3. Study the Optimization of uni and multi dimensional search problems

4. Solve the Optimization problems by Linear and Non-Linear Programming methods

*Syllabus:*

UNIT I: Definition of optimization Applications of optimization optimal insulation thickness Requirements for an optimization technique, Writing an objective function Production schedule ,material balance requirements , six steps of solving an optimization problem

UNITI I: Basic concepts of optimization continuous and discontinuous , unimodal and multi modal functions concave and convex functions, Finding the optimal point, definition of maximum, minimum and saddle points with examples

UNITIII: Unconstrained unidimensional search , Newton method Quasi Newton method and Secant method, Speed of iterations linear ,order p and super linear, Quadratic interpolation, cubic interpolation, Region elimination method, Fabonacci and Golden section method

UNITIV: Multivariable unconstrained optimization ,direct methods Powell method,Conjugate searchdirection, Gradient and conjugate Gradient, Fletcher Reeves method , Positive definite of Hessian matrix Marquadt method

UNITV: Linear programming ,definition , solving the refinery schedule problem by linear programming method using graph, Simplex method and definition

UNITVI: Non linear programming , Lagrange multiplier method, Iterative linearization and Quadratic programming method, Necessary and sufficient condition for a minimum value ,Kuhn-tucker conditions

*Text books:*

1. Optimization of Chemical Process by Edgar and Himmelblau, 2nd edition, Mc GrawHill Publications.

2 Optimization Theory and Applications by S.S. Rao, 2nd Edition, Wiley Eastern Limited.

3 Formulation and optimization of Mathematical Models by C.L.Smith, R.W. Pike and P.W.Mur.

**CHE 1703 (D) : Reservoir Engineering (Core Elective -III)**

**3L- 1T- 0P-3C**

***Objective****:*

To know the fundamental concepts of reservoir engineering, basic properties of reservoir rocks, various types of reservoirs and driving mechanisms for the production of Oil and gas from an oil reservoir.

***Outcome****:*

1. Able to identify the type of oil reservoirs by knowing the characteristics and mechanisms.

2. Able to predict the reservoir performance by knowing the past performance history of the oil reservoir.

***Syllabus****:*

**Fundamental concepts of Reservoir Engineering**: Porosity, fluid saturation, permeability, flow through layered beds, flow through series beds, Klinkenberg effect, effective permeability data, phase behavior.

**Oil reservoirs:** Reservoir driving mechanisms, basic equation and tools, volatile oil reservoirs, identification of volatile oil reservoirs, ultimate recovery, predicting reservoirs behavior, performance, mechanics of reservoir performance, prediction procedure, limitations of predictions, relating reservoir performance to time, factors affecting ultimate recovery, analysis of gas oil ratio history.

**Depletion drive reservoirs**: Producing characteristics and methods of identification, detailed procedure for predicting reservoir performance, limitations of predictions, factors affecting ultimate recovery.

**Water drive reservoirs:** Effect of free gas saturation on recovery, predicting reservoirs performance, calculating water influx, use of the unsteady state equation in predicting reservoir performance, validity of performance prediction, limitations in predicting reservoir performance, the material balance equation as a straight line.

**Gravity drainage reservoirs:** Permeability in the direction dip, dip of the reservoir, reservoir producing rates, oil viscosity, relative permeability characteristics, fundamental recovery process, predicting reservoir performance, apparent relative permeability, oil saturation method.

**Combination of drive reservoirs:** Index of drives, equations used, material balance equations, instantaneous gas- oil ratio equation.

**Pressure maintenance:** Pressure maintenance by gas injection, condensing gas drive, predicting performance by gas injected gas drive index, pressure maintenance by water injection, predicting performance by water injection, index of injected water drive, control of the gas cap, typical water injection pressure maintenance operations.

**Improving oil recovery**: Improving oil recovery by fluid immiscible gas–water, miscible fluid injection thermal oil recovery, predicting recovery from fluid injection products, Stiles’s method of water flood prediction, derivation of water cut and recovery equations, frontal advance techniques for prediction result of either water or gas injection, well arrangements, peripheral water flooding, predicting behavior of peripheral water floods, special consideration involved in water flooding, water flood case history, predicting the results of water flooding.

*Text book:*

1. ‘Reservoir Engineering Manual’ – 2nd Edition by Frank W. Cole, Gulf Publishing Company, Houstan, Texas, 1969.

**CHE 1703 (E) : Fuels, Refractories And Furnaces
(Core Elective - III)**

**3L- 1T- 0P-3C**

**Objective:** The main objective of this course is to study the different minerals used for the manufacturing of different types of refractories and its large scale applications in industries**.**

**Outcome:** At the end of the course the students would have learnt about the importance, types of refractories, properties, design and installation and different types of coatings on refractories.

*SYLLABUS:*

INTRODUCTION OF REFRACTORIES : Production, demand and growth of refractories in India – layout of modern refractory plant – fundamental properties of refractories – Indian and international standards – factors for selection and use of refractories – test and quality control procedures.

 SILICA REFRACTORIES : Raw materials and composition – manufacturing process steps – quality of raw materials and process parameter on quartz inversion – glassy phase and other micro structural features – porosity, strength, RUL dependence on micro structure – specifications of silica refractories.

ALUMINA – SILICA REFRACTORIES : Al2O3 – SiO2 phase diagram – clay, pyrophyllite, sillimanite, grog, bauxite and diaspore as raw materials – manufacturing processes – micro structure and properties

BASIC PROPERTIES : Magnesite, forsterite, dolomite and chrome based refractories – raw materials and composition – manufacturing processes – micro structure and properties.

SPECIAL REFRACTORIES : Oxide based, carbide based and nitride based refractories – cordierite – zirconia – carbon – fusion cast refractories, slide gate, purging refractories, and continuous casting refractories – ceramic fibres.

 REFRACTORIES FOR IRON AND STEEL INDUSTRY : Coke oven, blast furnace, twin hearth, LD converter – continuous casting – electric arc furnace, induction furnaces – reheating furnaces – slide plate system – nozzle, shroud/ SDN – ladle and tundish lining practices – monolithic - gunning techniques – refractor, slag and metal interactions.

REFRACTORIES FOR CEMENT AND NON FERROUS INDUSTRY : Wet/ dry process for cement making – preheater and pre calcinatory and zone lining – alkali and wear resistance – refractory requirement and use in copper, aluminum and hydro carbon industry – use of monolithic.

REFRACTORIES FOR GLASS INDUSTRY : Design of glass tank for container, sheet, lamp, float glasses, refractory practices in side wall, throat, forehearth, and roof of glass tanks – regenerator systems – alumina and AZS fused cast refractories – glass corrosion resistance, oxidation, seed potential tests – glass defects and analysis – feeder expendables

REFRACTORIES FOR CERAMIC INDUSTRY : Kiln furniture – types – properties of requirement - silicon carbide, mullite, corderite, alumina, zirconia – mullite, zirconia types – kiln design – LTM concept – fast firing technology

REFRACTORIES FOR ENERGY CONSERVATION : Insulation refractories – types- ceramic fiber product – design and installation – ceramic coatings – case studies in ceramic fiber usage.

*Textbook:*

1. B. M. Coop and E. M Piekson, Raw Materials for the refractory industries and industry materials and consumer survey, 1981.

*References*

1. J. H. Eheslers Refracrtories: production and Properties. Iron and Steel Institute, London, 1972.

2. Akira Nistrikawa, Technology of monolithic refractories, Plibrico japan co. Tokyo 1984

3. D.N. Nandi, Hand Book Refractory’s, Tata Mc Graw hill publishing Co. New Delhi 1991

4. K.Shaw, Refractories and thick uses ADP sciences publisher U K 1972

5. Keishi GOTON, Powder Technology Hand Book, Marcel Dekker Inc. 1997

6.Chester J.H., Steel Plant Refractories, 2nd Edition, 1973, United Steel Companies Limited, Sheffield UK8.Advances in Refractory Technology, Ed. Robert E Fisher, Ceramic Transaction Vol 4., American Ceramic society, 1990, Westerville, Ohio, USA.

**CHE 1703 (F) : Biochemical Engineering (Core Elective - III)**

**3L- 1T- 0P-3C**

*Syllabus:*

**Introduction to Biochemical engineering and Biotechnology**: Overall view of biotechnology since its practice–to date, enzyme kinetics, derivation of M.M. equation of single as well as multiple substrates, enzyme inhibition, determination of M.M. parameters, industrial applications of enzymes,

**Cell cultivation & kinetics**: Microbial, animal and plant cell cultivation, cell immobilization, batch growth of cells, yield coefficient, monod growth kinetics,

**Analysis and design of fermenters**: Batch fermenter, mixed flow fermenter (chemostat), plug flow fermenter, mixed flow fermenters in series, and cell recycling,

**Genetic engineering**: DNA and RNA, cloning of genes, stability of recombinant microorganisms, gene manipulation,

**Sterilization**: Sterilization of media and air, thermal death kinetics, design criterion, continuous sterilization methods,

**Aeration and agitation in fermenters**: Correlations of mass transfer coefficient, measurement of interfacial area and gas holdup, power consumption, scale up concepts,

**Bioanalytical techniques**: Gas chromatography, thin layer and paper chromatography, HPLC, affinity, gel, adsorption and ion exchange chromatography.

*Text book:*

1. ‘Biochemical Engineering Fundamentals’ 2nd edition by J.E.Bailey and D.F.Ollis, McGraw-Hill Publishers, Newyork, 1986

*Reference books:*

1. ‘Chemical Engineering’ volume-3, 3rd Edition by J.F Richardson and D.G. peacock, (Chapter-5: Biochemical Reaction Engineering), Pergomon Press, U.K, 1994

2. ‘Bioprocess Engineering: Basic Concepts’ 2nd edition by M.L.Shuler and F.Kargi, Prentice Hall India, New Delhi, 2003

3. ‘Biochemical engineering’ by D.G. Rao, Tata McGraw-Hill Publishers, New Delhi,

4. ‘Biochemical Engineering’ by J.M. Lee, Prentice Hall, Englewood Clifts, 1992.

**CHE 1704 : Industrial Management and Entrepreneurship**

 **(Common for all 1/4 B.Tech and 1/6 B.Tech + M.Tech Branches)**

**3L- 1T- 0P-3C**

Unit-I : Basic Concepts of Management:

**Management :-** Definition, Nature and Importance ; Functions of the Management; Levels of Management; F.W Taylor’s Scientific Management; Henry Fayol’s Principles of Management;

**( Eight Periods)**

Unit-II : **Forms of Business Organizations:** Introduction, **Types of Business organizations: Private Sector**- Individual Ownership , Partnership, Joint stock companies and Co-Operative organizations**; Public sector**- Departmental Organizations, Public Corporations and Government Companies; The Joint sector Management.                    **( Eight periods)**

Unit-III : **Production and operations Management:** Plant location- Factors to be considered in the selection of Plant location; Break - even analysis- Significance and managerial applications; Importance of Production Planning and Control and its Functions; Human Resource Management and Functions of Human Resource Manager (in brief); Functions of Marketing; Methods of Raising Finance. **(Ten periods)**

Unit-IV : **Entrepreneurship :** Definition, Characteristics and Skills, Types of Entrepreneurs, Entrepreneur vs. Professional Managers, Growth of Entrepreneurs, Nature and Importance of Entrepreneurs, Women Entrepreneurs, Problems of Entrepreneurship.         **(Six periods )**

Unit-V : **Entrepreneurial Development and Project Management:** Institutions in aid of Entrepreneurship Development, Idea generation: Sources and Techniques;, Stages in Project formulation ; Steps for starting a small enterprise - Incentives for Small Scale Industries by Government.   **(Eight periods )**

*Text Books:*

(1 ) Sharma,S.C, and Banga, T.R., **Industrial Organization & Engineering Economics**, Khanna Publishers, Delhi, 2000.

(2) Vasant Desai , **The Dynamics of Entrepreneurial Development and Management (Planning for future Sustainable growth),** HImalayan Publishing House, 2018.

*Reference Books:*

 (1) Aryasri , A.R., **Management Science,** McGraw HIll Education (India Private Limited , New Delhi 2014.

(2) Sheela, P. , and Jagadeswara Rao, K., **Entrepreneurship**, Shree Publishing House, Guntur, Andhra Pradesh, 2017.

**CHE 1705 (A) : Industrial Safety & Management (Open Elective-III)**

**3L- 0T- 0P-3C**

**Introduction :** Industrial Safety, Incident, accident, near miss, hazard, risk, emergency, disasters, risk criteria, Safety at work.

**Pediction and evaluation of unsafe conditions :** Identification of unsafe areas, unsafe acts, manifestation of unsafe conditions to emergency situation, lessons from accidents and disasters, safety audit and its elements, safety in plant layout, equipment design. Construction, erection, commissioning, material handling.

**Hazards** – chemical hazards, thermodynamic hazards, electrical & electromagnetic hazards, mechanical hazards.

**Risk** – Definition, causes, potential and adverse effects.

**Hazard Analysis** – incident scenarios, residual risk, Concept Hazard Analysis (CHA), Preliminary Process Hazard Analysis PPHA, HAZOP, Fault Tree Analysis (FTA), Event Tree Analysis (ETA).

**Risk Assessment** – Risk criteria, causes of death/damage, individual risk, societal risk, criteria for acceptable risk tolerable risk, application of risk assessment, computation of fatality rates, severity rates, vulnerability analysis, introduction to computerized risk assessment techniques.

**Safety Management (General)** – safety policy perceptions, safety organization, safety audit techniques, project and **Construction Safety** – welding & cutting operations, fabrication, material handling, equipment spacing, safe plant layout procedures, storage tanks, erection & commissioning works, housekeeping methods, maintenance of storage yards, erection & maintenance of electrical panels and MCC rooms, electrical & mechanical safe guarding.

**Emergency Preparedness** – onsite & offsite emergency preparedness, emergency preparedness plans, site specific action plans and contingency plans, emergency facilities, rehabilitation & rescue operations, post emergency actions.

**Safety Management (Industry Specific) :** Chemical Manufacturing Plants, Fertilisers, Steel Plants, Petrochemical Plants, Metallurgical Plants, Mineral Process Industries, Sugar plants, semiconductor industry, Polymer manufacturing plans, Paper industry, Pharmaceutical and bulk drug industries, Vessel manufacturing industry, LPG bottling plants, Power Plants, tanneries and textiles.

**Statutory framework** – key provisions of Factories Act, Environmental Protection Act, Manufacture, Storage and Import of Hazardous Chemical rules, Static and Mobile Pressure Vessels rules, NFPA specifications, OSHA regulations.

**Occupational health management** – occupational health perspectives, pre-employment & periodical medical examinations, diseases, causes, consequences, **Occupational health hazards in various industries** – aluminium industry, asbestos, battery manufacturing, sugar, cement, coke ovens, cotton ginning, dairy, electro plating, fish canning, poultries, irrigation, lead smelting, mining, pesticides, power plants, refineries, pulp & paper industry, PVC processing, steel plants, fertilizers, sulphuric acid plants, tanneries and textiles.

**International standards** – British council’s five star rating systems, International Safety Rating Systems (ISRS), ISO 14001 EMS, ISO 18001 OHSAS, BIS 14489 Code of Conduct for conducting safety audits.

*Prescribed books:*

1. “Hazards in Chemical industries, 3rd edition” – Authored by Frank P.Lees

2. “Hazard identification and risk assessment” – Authored by Geoff Wells ; Published by Institution of Chemical Engineers, Davis Building, 165-189 Railway Terrace, Rugby, Warwickshire CV21 3HQ, UK.

*References*

1. “Safety Management 5th edition” – Authored by John V. Grimaldi and Rollin H. Simonds; Published by A.I.T.B.S. Publishers & Distributors, J-5/6, Krishna Nagar, Delhi – 110051.

2. “Environmental Health and Safety Management” – Authored by Nicholas P. Cheremisinoff and Madelyn L. Graffia; Published by Jaico Publishing House, Hyderabad.

**CHE 1705 (B) : Environmental Pollution Control (Open Elective-III)**

**3L- 0T- 0P-3C**

***Objectives:***

To understand the types of emissions from chemical industries and their effects on environment, methods of analysis of air pollutants, general methods of control like primary, secondary, tertiary treatment methods, solid waste management and Industrial safety.

*Outcome:*

\* Able to know the types of pollution and pollutants, sources of these pollutants from domestic and industrial wastes, permissive and excessive limits of the pollutants and standards of these pollutants especially in drinking water.

\* Able to know the sophisticated instruments used for the analysis of water and air pollutants. The student will be having knowledge to design the equipment used for the abatement of these pollutants.

\* Able to modernize the solid waste management and acquiring awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

*Syllabus:*

**Types of emission** from chemical industries and their effects on environment, Environmental legislation, noise pollution, occupational health hazards, meteriological factors in pollution dispersion (ALP and ELP), plume behaviour and characteristics, chimney design considerations: Plume raise, effective stack height,

**Methods of analysis of air pollutants**, particulate matter, SOx, NOx, COx analysis, removal of particulate matters: principles and design of setting chambers, solid traps, cyclone separators, fabric and design of fibre filters, scrubbers and electrostatic precipitators,

**General methods of control** and removal of sulphur dioxide, oxides of nitrogen, organic vapors from gaseous effluents with design aspects, sources of waste waters, effluent guidelines and standards, characterization of effluent streams, oxygen demanding wastes, oxygen sag curve, BOD curve, analysis of water pollutants,

**Methods of primary treatment**: Screening, sedimentation, floatation and neutralization, biological treatment, bacteria and bacterial growth curve, aerobic processes suspended growth processes, activated sludge process, extended aeration, contact stabilization, aerated lagoons and stabilization ponds, attached growth process with design aspects, trickling filters, rotary drum filters, fluidized bed contactors, anaerobic processes,

**Methods of tertiary treatment:** Carbon adsorption, ion exchange, reverse osmosis, ultra filtration, chlorination, ozonation & sonozone process, sludge treatment and disposal,

**Solid waste management**: solid waste collection, transportation, solid waste processing and recovery, hazards in waste management, risk assessment and safety measures, types of hazardous wastes, health effects, safety measures, risk assessment response measures, case studies or pollutants removal and safety measures in fertilizer, petrochemical, paper, pharmaceutical industries and petroleum refinery,

*Text books:*

1. ‘Environmental Pollution Control’, by C.S. Rao, Wiley Eastern Limited

***Reference books:***

1. ‘Environmental Engineering’ by Arcdio P.Sincero and Geogoria Sincero

**CHE 1708 : Process Instrumentation & Control Laboratory**

**0L- 0T- 3P-2C**

1. Response of mercury-in glass thermometer

2. Response of mercury-in glass thermometer with thermal well.

3. Calibration & response of resistance thermometer

4. Response of manometer

5. Calibration of thermocouples

6. Response of single-tank liquid level system

7. Response of two-tank non-interacting liquid level system

8. Response of two tank interacting liquid level system

9. Study of on-off control – Control let off position.

10. Valve characteristics of equal % control valve

11. Valve characteristics of linear control valve

12. On-off control – controller on position

13. Studies on hysteresis characteristics of Bourdon pressure gauze

14. Hysteresis characteristics of equal % control valve

15. Studies on hysteresis characteristics of linear control valve

16. Response studies for different types of controller (P, PI, PID) using PID control trainer.

17. Level control trainer

18. Pressure control trainer

19. Temperature control trainer

**CHE 1710 : Chemical Process Equipment Design Laboratory**

**(**Open book practical examination**)**

**0L- 0T- 3P-2C**

The following equipment are to be designed in detail:

1. Sensible heat exchangers (1-2 or 2-4),

2. Condenser and reboiler,

3. Multiple effect evaporator,

4. Fractionating column-Plate and packed columns,

5. Packed bed absorber,

6. Continuous tubular reactor (homogeneous and heterogeneous)

**4/4 B.Tech(Chemical Engineering) Second Semester**

**&**

**4/6 B.Tech + M.Tech (Chemical Engineering) Second Semester**

**CHE 1801 : Project Work**

**0L- 0T- 0P-12C**

The project work should consist of a comprehensive design of a chemical plant in the form of a report with the following chapters.

1. Introduction

2. Physical and chemical properties and uses

3. Literature survey for different processes

4. Selection of the process

5. Material and energy balances

6. Specific equipment design (Process as well as mechanical design with drawings)

7. General equipment specifications

8. Plant location and layout

9. Materials of construction

10. Health and safety factors

11. Preliminary cost estimation

12. References

**SCHEME OF INSTRUCTION & EXAMINATION**

 **I/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BRANCH: BIOTECHNOLOGY**

**SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

ENG 1101 English 2 30 70 100 2

ENG 1102 Maths -I 3 30 70 100 3

ENG 1103 Maths-2 3 30 70 100 3

ENG 1104 Chemistry 3 1 30 70 100 4

ENG 1106 Computer Programming
 & Numerical Methods 3 30 70 100 3

ENG 1108 Chemistry Lab., 3 50 50 100 2

ENG 1110 CPNM Lab., 3 50 50 100 2

ENG 1112 History of Science &
 Technology 2 0

 Total 16 1 10 700 19

 **I/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BIOTECHNOLOGY : SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

ENG 1201 Maths-3 3 1 30 70 100 4

ENG 1202 Physics 3 1 30 70 100 4

ENG 1205 Engineering Graphics 2 4 30 70 100 4

ENG 1206 Introduction to Chemical
 Engineering and
 Biotechnology 3 1 30 70 100 3

ENG 1208 Physics Lab., 3 50 50 100 2

ENG 1210 Workshop 3 50 50 100 2

ENG 1212 English Lab., 3 50 50 100 2

ENG 1214 Professional Ethics &
 Moral Values 2 0

 Total 13 3 17 700 21

**SCHEME OF INSTRUCTION & EXAMINATION**

 **II/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BIOTECHNOLOGY : SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

BT 1301 Microbiology 3 1 0 30 70 100 3

CHE1303 Organic Chemistry 3 1 0 30 70 100 3

BT 1303 Genetics 3 1 0 30 70 100 3

BT 1304 Biology 3 1 0 30 70 100 3

BT 1305 Cell and Molecular Biology 3 1 0 30 70 100 3

BT 1306 Basic Electrical and
 electronics Engineering., 3 1 0 30 70 100 3

BT 1308 Microbiology Lab., 0 0 3 50 50 100 2

BT 1310 Cell and Molecular
 Biology Lab., 0 0 3 50 50 100 2

 Total 18 6 6 800 22

**SCHEME OF INSTRUCTION & EXAMINATION**

 **II/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BIOTECHNOLOGY : SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

BT 1401 Biochemistry 3 1 0 30 70 100 3

BT 1402 Fluid Mechanics and
 Heat transfer 3 1 0 30 70 100 3

BT 1403 Bio Analytical Techniques 3 1 0 30 70 100 3

CHE 1404 Material & Energy
 Balance 3 1 0 30 70 100 3

CHE 1405 Managerial Economics 3 1 0 30 70 100 3

CHE1407 Environmental Science 3 - - 100 — 100 0

BT 1408 Biochemistry and Bio
 Analytical Techniques Lab. 0 0 3 50 50 100 2

BT 1410 Fluid Mechanics Lab. 0 0 3 50 50 100 2

 Total 18 05 6 800 19

**SCHEME OF INSTRUCTION & EXAMINATION**

 **III/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BRANCH: BIOTECHNOLOGY**

**SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

BT 1501 Biostatistics 3 1 0 30 70 100 3

BT 1502 Mass Transfer 3 1 0 30 70 100 3

BT 1503 Enzyme Engineering 3 1 0 30 70 100 3

BT 1504 Thermodynamics 3 1 0 30 70 100 3

BT 1505 Elective-I 3 0 0 30 70 100 3

BT 1506 Downstream processing 3 1 0 30 70 100 3

BT 1508 Unit Operations Lab., 0 0 3 50 50 100 2

BT 1510 Downstream Processing
 Lab., 0 0 3 50 50 100 2

CHE1512 Slot for MC (Constitution
 of India/Essence of Indian
 Traditional Knowledge) 3 0 0 0

 Total 21 05 6 800 22

**Elective-I:(BT 1505)**

A. Food technology

B. Process optimization

C. Energy Engineering

D. Systems Biology

**SCHEME OF INSTRUCTION & EXAMINATION**

 **III/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BIOTECHNOLOGY : SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

BT 1601 Chemical Reaction
 Engineering 3 1 0 30 70 100 3

BT 1602 Engineering Economics
 and Bioprocess Design 3 1 0 30 70 100 3

BT 1603 Immunology 3 1 0 30 70 100 3

BT 1604 Bioinformatics 3 1 0 30 70 100 3

BT 1605 Bioprocess Engineering. 3 1 0 30 70 100 3

BT 1606 Elective-II 3 0 0 30 70 100 3

BT 1608 Bioprocess and Reaction
 EngineeringLab., 0 0 3 50 50 100 2

BT 1610 Bioinformatics Lab., 0 0 3 50 50 100 2

 Total 18 05 06 800 22

Elective-II: (BT 1606)

A. Pharmaceutical Biotechnology

B. Animal cell culture and Hybridoma technology

C. Cancer Biology

D. Stem cells in health care.

E. Intellectual Property Rights

**SCHEME OF INSTRUCTION & EXAMINATION**

**IV/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BIOTECHNOLOGY : SEMESTER: FIRST**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

BT 1701 Environmental
 Biotechnology 3 1 0 30 70 100 3

BT 1702 Genetic Engineering 3 1 0 30 70 100 4

BT 1703 Process Control 3 1 0 30 70 100 3

CHE 1704 Industrial Management &
 Entrepreneurship 3 1 0 30 70 100 3

BT 1705 Industrial biotech products 3 1 0 30 70 100 3

BT 1706 Plant cell and tissue culture 3 1 0 30 70 100 3

BT 1708 Process control Lab., 0 0 3 50 50 100 2

BT 1710 Plant cell and tissue
 culture Lab., 0 0 3 50 50 100 2

 Total 18 6 6 800 23

**SCHEME OF INSTRUCTION & EXAMINATION**

 **IV/IV B.TECH (FOUR YEAR COURSE)**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**BRANCH: BIOTECHNOLOGY**

**SEMESTER: SECOND**

 Code course Hours Per WEEK Allotment of marks Total Credits

 Number Lecture Tutorial Practical Internal External Marks

BT 1801 Project Work — — — 50 50 100 12

**2/4 B.Tech. (Biotechnology) - First Semester**

**BT 1301 : Microbiology**

**3L-1T-0P-3C**

*Objectives:*

· To make the student learn about origin and evolution of microbes.

· To make the student understand structure and functioning of different microbial groups.

· To make them to acquaint the cultivation of microbes in artificial medium.

*Outcome:*

· Students gain the knowledge and skills both theoretically and practically.

· Students are equipped with theoretical approach to study them and understand their importance in ecosystem

*Syllabus:*

**History and Development of Microbiology:** Contributions of van Leeuwenhock, Joseph Lister, Pasteur, Koch, Jenner, Winogradsky, Beijerinck, further developments of microbiology,

**Microbial Taxonomy:** Bacteria, archea and their broad classification. molecular approaches to microbial taxanomy, physiology of extremophiles,

Morphology and Functions of Viruses, Yeast, Molds and Bacteria:

**Viruses-** Morphology of viruses- size, shape and symmetry, replication of viruses- Lytic and Lysogenic cycle,

**Yeast and Molds:** Morphology, life cycle, economic importance of yeast and *Aspergillus,*

**Bacteria :** Ultra structure of bacteria, cell wall, cell membrane, flagella, pili, capsule, endospore, and cell inclusions, differences between prokaryotic and eukaryotic cell,

**Microbial growth:** Definition of growth- growth curve, measurement of bacterial growth (cell number and cell mass ) growth yield, continuous culture- chemostat, turbidostat, synchronous growth, effect of environmental factors on growth,

**Microbial Nutrition and Control of Microorganisms:** Nutritional requirements, nutritional types of bacteria, up-take of nutrients by cell, sterilization, and disinfection, effect of physical (moist and dry heat, radiation and filtration) and chemical agents, antibiotics- mode of action and resistance,

**Methods in Microbiology:** Culture media, synthetic and complex media, solidifying agents, types of media, isolation of pure cultures- spread plate, pour plate and streak plate, preservation of microorganisms, light (bright field only) and electron microscopy,

**Applied Microbiology:** Water, food and milk born contamination and remedy; basic microbial genetics- transformation, conjugation, transduction, strain improvement of industrially important micro-organisms.

*Text book:*

**1. ‘**Microbiology’, by Prescott L.M., Herley J.P., Klein D.A., McGraw- Hill

*Reference books:*

1. “Microbiology”, Pelzar, M.J., Chan, E.C.S., Kreig N.R., Tata McGraw-Hill

2. “Brock biology of Microorganisms”, Madigan M.T.,Martinco J.M. and Parker J., Prentice Hall

**CHE 1303 : Organic Chemistry**

**3 L- 1T- 0P-3C**

*Objectives:*

The student will be able to:

1. appreciate the nature and scope of organic chemistry.

2. apply key concepts from general chemistry including electronegativity, bonding (ionic and covalent), hybridization of atomic orbitals, and molecular orbital theory to organic systems.

3. draw skeletal structures for organic compounds.

4. apply acid-base concepts to organic systems; predict ordering of acid or base strength.

5. name alkanes, alkenes, polyenes, alkynes, alkyl halides, aromatic compounds, carbonyl compounds, amines and their various derivatives using systematic (IUPAC) nomenclature.

6. draw reaction mechanisms for some key reactions.

7. recognize stereochemistry and be able to apply the Cahn-Ingold-Prelog system to designation of stereochemistry (E/Z or R/S).

8. learn many of the reactions of alkanes, alkenes, polyenes, alkynes, aromatic, carbonyl, and amine compounds, and close related species. Be able to predict reactions involving these functional groups.

9. be able to solve problems employing spectroscopic methods including mass spectrometry, infrared and NMR spectroscopy

10. understand the basic chemical and structural features of biomolecules, including lipids, carbohydrates, amino acids and proteins, and nucleic acids

*Outcome:*

This course enables the students to acquire knowledge, comprehension and application in numerical problems related to organic chemistry, nomenclature and reactions of alkanes, alkenes, alkynes, dienes, electrophilic aromatic substitution, alcohols, acids, aldehydes and ketones, amines, soaps and detergents.

*Syllabus:*

**Chapter 1: Quantitative and Qualitative Organic Analysis:** Determination of percentage composition of carbon, hydrogen and nitrogen, molecular weight determination by depression in freezing point and elevation of boiling point methods, molecular weight of acids by silver salt method; molecular weight of bases by chloroplatinate method, determination of molecular formula of a compound, problems relating to reactions of carboxylic acids, functional derivatives of acids, carbonyl compounds, alcohols, amines, phenols, diazonium salts, alkenes and Functional Group Identification of Organic Compounds

**Chapter 2: Isomerism:** Structural and Optical isomerism, Geometrical isomerism, E-Z configuration, sequence rules, R & S configuration, racemic mixture and their separation, asymmetric synthesis - Fischer projection formula, definitions of axial and equatorial bonds, 1-3-diaxial interaction, enatiomers, diastereomers, mesomers, isomerism in cyclic compounds, chair,boat and twisted boat structures (1-methylcyclohexane, 1, 2-cyclohexane diol)

**Chapter 3: Hydrocarbons :** Hybridisation - sp, sp2 and sp3; Nomenclature, Preparation and chemical reactions of alkanes, alkenes, alkynes, dienes, Wurtz reaction, Clemmensen and Wulf-Kishner reduction, Diels-Alder reaction, Morkovinkov rule, Industrial preparation of ethylene, acetylene; Conformational analysis of ethane, propane and butane; Cyclic aliphatic hydrocarbons - Baeyer’s Strain Theory Preparations and their reactions

**Aromaticity and Benzene:** Structure of benzene, aromaticity, nomenclature of benzene derivatives, arenes, Electrophilic and Nucleophilic Aromatic Substitution: Mechanism of nitration, halogenation, sulphonation, Friedel-Craft’s alkylation and acylation reactions, Nucleophilic aromatic substitution; Orientation of disubstituted benzenes

**Chapter 4: Halides, Alcohols and Acids : Halides: N**omenclature of alkyl halides, preparation and chemical reactions, mechanisms of SN1, SN2, E1, E2 reactions, Nomenclature of aryl halides, preparation and chemical reactions: low reactivity of vinyl and aryl halides, Sandmeyer reaction,

**Alcohols:** Nomenclature of alcohols; industrial preparation of ethyl alcohol, preparation and chemical reactions, Lucas test,

**Carboxylic Acids:** Nomenclature of mono, dicarboxylic acids, industrial preparation of formic, acetic, benzoic, phthalic, salicylic acids, preparation and chemical reactions, mechanism of HVZ reaction and Claisen condensation, nomenclature of functional derivatives of acids, preparation and chemical reactions, mechanism of Hoffmann bromamide reaction, acid and base catalyzed hydrolysis of ester.

**Chapter 5: Carbonyl Compounds, Ethers, Epoxides and Carbohydrates**

**Carbonyl Compounds:** Nomenclature of aldehydes and ketenes: Industrial preparation of formaldehyde, acetaldehyde, benzaldehyde, salicyaldehyde, acetone; preparation and chemical reactions; mechanisms of Cannizaro, Aldol, Reformatsky and Wittig reactions, reactions without mechanisms -Perkin, Cope, Knoevenagel and Pinacol-Pinacolone reactions, difference between aldehyde and ketone, nomenclature of phenols, industrial preparation of phenol, preparation and chemical reactions, mechanisms of Fries rearrangement, Kobe reaction, Reimer-Tiemann reaction,

**Ethers, Epoxides and Active methylene Compounds:** Nomenclature of ethers and epoxides, industrial preparation of ether and ethylene oxide, preparation and chemical reactions; Williamson’s synthesis, Preparation of malonic, acetoacetic ester and their synthetic applications

**Carbohydrates: C**lassification of carbohydrates, structure of glucose and fructose, reactions of glucose and fructose, Ruff degradation, Wohls degradation, Killiani-Fisher synthesis, Conversion of glucose into fructose, fructose into glucose, glucose to vitamin-C, Mechanism of Osazone formation,

**Chapter 6: Amines, Diazonium Salts and Sulpha Drugs**

**Amines:** Nomenclature of amines, industrial preparation of Aniline, preparation and chemical reactions - exhaustive methylation, mechanism of Hoffmann elimination, Benzidine rearrangement without mechanism, Hinsberg test, differentiation test using nitrous acid Preparation of diazonium salts and synthetic applications,

**Sulpha Drugs**: Preparation of sulphanilamide, sulphaguanidine, sulphamerazine, sulphapyridene - mode of action of sulpha drugs,

**Chapter 7: Polymers, Soaps and Detergents**

**Polymers:** Preparation of polyethylene, polystyrene, teflon, PVC, polyvinyl cyanide, rubber-vulcanisation, styrene-butadiene rubber, polychloroprene, bakelite, nylon-6 and nylon 6-6, plexiglas, terylene, Ziegler-Natta polymerization, definition of thermoplastics and thermosetting plastics

**Soaps and detergents:** Preparation, Mode of action of soaps, difference between soaps and detergents;

***Reference books:***

1. ‘Text Book of Organic Chemistry’ by Morrison & Boyd

2. ‘Text Book of Organic Chemistry’ by Bahl&Tuli

3. ‘Text Book of Organic Chemistry’ by M.K.Jain

4. ‘Text Book of Organic Chemistry’ by I. L. Finar (Vols. 1 & 2 as

R**eference books**)

**BT 1303 : Genetics**

**3L-1T-0P-3C**

*Objectives:*

· To introduce Mendel’s law of inheritance.

· To introduce interaction of Genes and inheritance.

· To introduce Gene linkage, crossing over and mapping.

· To introduce sex determination & linkage.

· To introduce chromosomes & chromosomal variation.

*Outcome:*

· To know inheritance, different types of inheritance.

· To know gene interaction. To know about complementary, duplicate genes and interaction between different two gene pairs.

· To know linkage patterns, different cross gene types.

· To know sex determination mechanisms and inheritance of sex linked traits.

· To know different types of cytogenetic effects and numerical changes in chromosomes.

***Syllabus:***

**Mendel’s law of Inheritance:** Mendel’s experiments–Mendels materials, crossing technique, results of Mendel’s experiments, phenomenon of dominance, variation in dominance relation, incomplete dominance, co-dominance, principle of segregation-monohybrid cross, mechanism of segregation, monohybrid ratio, principle of independent assortment, Mendels dihybrid cross, mechanism of independent assortment, dihybrid ratio, back cross and test cross, deviations from dihybrid phenotypic ratio,

**Interaction of Genes**: Interaction of genes-combs in fowls, Epistasis, complementary genes, duplicate genes, additional interactions involving two gene pairs, interaction between more than two gene pairs,

**Quantitative / Multiple factor inheritance**: Multiple factors, quantitative and quantative traits, examples of quantitative inheritance, Kernel color in wheat, skin color in man, corolla length in tobacco, continuous variations,

**Multiple alleles** : (Based on classical concept of Allelomorphism): Multiple alleles and isoalleles, skin color in rodents, eye color in *Drosophila*, self sterility in *Nicotiana,* blood groups in humans, complementation test or cis-trans test,

**Linkage, crossing over and mapping**:

**Linkage** – coupling and repulsion hypothesis, Morgan’s view on linkage, chromosome theory of linkage, kinds of linkage-complete linkage, incomplete linkage, linkage groups, significance of linkage,

**Crossing over** – Types of crossing over - mitotic and meiotic crossing over, mechanism - synapsis, duplication of chromosomes, crossing over by breakage and union, terminalization,

Molecular mechanism of recombination- Holiday model, cytological basis of crossing over; significance of crossing over,

**Construction of a genetic mapping**: Two point and three point test crosses and gene mapping, interference and coincidence,

**Sex Determination** :Genetically controlled sex determining mechanisms, sex chromosomal mechanism of sex determination, types-heterogenetic males, heterogenetic females, genic balance mechanism (X/A ratio in *Drosophila*), sex determination in man (TDF and SRY genes), sex determination in plants; Single gene control of sex; haploid males in hymenoptera; hormonal control of sex, environmental control of sex, dosage compensation (in man and *Drosophila*),

**Sex Linkage**: Inheritance of sex linked (X-linked) traits-eye color in *Drosophila*, haemophilia and color blindness in human and barred plumage in poultry, inheritance of Y-linked genes, inheritance of XY-linked genes, primary and secondary non-disjunction of sex chromosomes, sex influenced and sex limited traits, sex linked disorders in human beings,

**Cytoplasamic Inheritance :** Maternal effects-shell coiling in snails, pigment in flour moth, cytoplasmic inheritance involving dispensable heredity units, kappa particles in *Paramecium,* cytoplasmic inheritance by cellular organelles, plastid inheritance in variegated four-o-clock plant, mitochondrial inheritance, male sterility in plants, uniparental inheritance in chlymadomonas,

**Chromosomal variations:** Origin, types and cytogenetic effects,

**Structural changes in chromosomes:** Duplications, translocations, inversions (paracentric and pericentric cross over suppressors),

**Numerical changes in chromosomes:** Aneuploidy (monosomy, nullisomy, trisomy, tetrasomy), euploidy (monoploidy, haploidy, polyploidy-autopolyploids and allopolyploids).

***Text books:***

1. “Genetics”, by P.K.Gupta, Rastogi Publications

2. “Cell Biology, Genetics, Molecular Biology, Evolution and Ecology”, by P.S. Verma & V.K. Agarwal, S. Chand & Company

*Reference book:*

1. “Principles of Genetics”, by E.J. Gardner, M.J.Simmons & D.Peter Snustard, John Wiley & Sons, INC.

**BT 1304 : Biology**

**3L-1T-0P-3C**

*Objective:*

· To study about the cell structure and function.

· To study about the plant structure, functions of various cells in the plants, flower structure, pollination and fertilization.

· To study about the physiological processes in the plant and various methods of plant breeding techniques.

· To study about the general characters of animals- invertebrates, vertebrates.

· To study about the general physiological processes like digestion, respiration, and excretion etc of the animals.

*Outcome:*

· Students will obtain knowledge in the biological processes occurring in the cells.

· Students will obtain knowledge in the structure of plants, and understand the phenomena of Embryology so that they can acquire knowledge to produce new varieties of plants.

· Students will obtain knowledge in various physiological processes of the plants and they also acquire knowledge in plant breeding techniques.

· Students will obtain knowledge in the general characters of animals and understand the phenomena of reproduction and life cycle of plasmodium vival.

· Students will obtain knowledge in various physiological processes of the animals. Digestion, respiration Excretory system, Nervous system functions are understood to the student so that student can do research in their future studies.

*Syllabus:*

**Cell Biology:** Structure and function of prokaryotic and eukaryotic cell, cell organelles, cell membrane, chloroplast, mitochondria, golgi complex, endoplasmic reticulum, lysosomes, ribosomes and nucleus, chromosome structure, mitosis and meiosis,

**Plant Biology:** Parts of a flowering plant; flower-structure of a typical flower, outline description of floral parts – androecium, gynoecium,

**Embryology:** Structure of anther, microsporogenesis and development of male gametophyte, structure of ovule, megasporogenesis, development of embryo sac. fertilization, process of fertilization and post fertilization changes,

**Anatomy:** Structure and function of xylem and phloem, internal structure of dicot root, stem and leaf, monocot root, stem and leaf, secondary growth of dicot stem,

**Plant Physiology:** Water relations of plants, absorption of water by plants, diffusion, water potential, osmosis, plasmolysis, imbibition, active and passive absorption,

Mineral nutrition: Criteria for essentiality, macro elements (nitrogen, phosphorus and potassium) and microelements,

Photosynthesis: photosynthetic pigments, light reaction-Emerson enhancement effect, photo system I and II, photolysis of water, photophosphorylation, CO2 fixation – C3, C4 and CAM pathway, photorespiration, factors affecting photosynthesis – Blackman’s law of limiting factors, Nitrogen metabolism: Introduction, nitrogen cycle, biological nitrogen fixation,

**Plant Growth Regulators:** Auxins, gibberellins, cytokinins, abscisic acid and ethylene,

**Plant Breeding:** Methods of plant breeding: selection, hybridization, hybrid vigor and mutational breeding,

**Animal Biology:** General characters of invertebrates, morphology, life cycle and reproduction of *Plasmodium Vivax,* general characters of vertebrates.

**Animal Physiology:** Animal nutrition- modes of nutrition, digestive system of humans and accessory digestive organs, gastrointestinal secretions, digestion, absorption and assimilation of digested products, egestion,

**Respiration**: Respiration in humans – respiratory system, mechanism of respiration, Circulatory system: Blood vascular system in humans, blood and its components, heart, pumping action of heart, heart beat and pulse, important blood vessels and course of blood circulation, lymphatic system-lymph, lymph vessels, lymph nodes and lymphatic ducts and pacemakers,

**Excretion**: Elimination of nitrogenous waste- ammonotelic, ureotelic and uricotelic, structure of human excretory system, structure of urinary system, anatomy of kidney, and structure of nephron,

**Nervous system:** Structure of neuron, nerve impulse and its conduction, synapse, central nervous system- lobes of brain and its meninges, spinal cord, Peripheral nervous system- Cranial nerves and spinal nerves, autonomous nervous system, sympathetic and parasympathetic nervous system, reflex action, reflex arch of humans.

*Text books:*

1. ‘Biology Text Book for class XI and XII’, NCERT.

2. ‘AP Academy Text Book for Botany and Zoology, for intermediate

**BT 1305 : Cell and Molecular Biology**

**3L-1T-0P-3C**

*Objectives :*

1. The main objective is to prepare the students for career in fields that require advance knowledge of cell and molecular biology.

2. With the application of study in cell and molecular biology, the student can also provide services and economic opportunities to the communities.

*Outcome:*

1. The student can develop basic knowledge and skills in cell & molecular biology and become aware of the complexity and harmony of the cells.

2. The student will be able to conduct research in the frontier and multi disciplinary areas of modern biology.

*Syllabus:*

**The nucleus, chromatin and the chromosome**: structure and function of nucleus; organization of genetic material – Packing of DNA into chromatin, Nucleosome organization; Chromosome structure; Cell cycle – Check points, Cdks and regulation.

**The biochemical basis of Inheritance:** DNA as the genetic material, DNA structure and replication in prokaryotes and eukaryotes – Enzymes involved and mechanism, including replication at telomere.

**Genetic code:** properties of genetic code, Wobble hypothesis.

**Gene Expression:Transcription** in prokaryotic and eukaryotic systems – enzymes and factors involved and mechanism; RNA processing in eukaryotes – capping, addition of poly(A) and removal of introns; **Translation** in prokaryotes and eukaryotes – machinery involved and mechanism;

**Regulation of gene expression** in prokaryotes – Lac operon concept in *E.coli* ; regulation of gene expression in eukaryotes by promoters, enhancers, silencers and transcription factors.

**Mutations** – Terminology, types of mutations, Biochemical basis of mutants, Mutagenesis, Chemical mutagens - base analogues - Intercalating substances, Physical mutagens- U.V radiation and ionization radiation, AMES test - Repair of DNA damage.

Text Books:

1. “The world of the cell” Becker, Klein smith & Hordin, Pearson education

*Reference:*

1. Molecular cell biology by Lodish et.al . Freeman Publications

2. “Cell & Molecular Biology”, De.Roberties. E.D.P., International Edition

3. “Molecular Biology”, Friefelder, D., Narosa publications

4. “Molecular Biology of the Gene”, J.D.Watson et.al, Banzamin

**BT 1306 : Basic Electrical and Electronics Engineering**

**3L-1T-0P-3C**

*Objectives:*

· To provide the students with knowledge of fundamental laws in electrical Engineering

· The ability to formulate and solve the differential equations describing time behavior of circuits containing energy storage elements.

· The capability to design and construct circuits, take measurements of circuit behavior and performance, compare with predicted circuit models and explain discrepancies.

· To understand the working of various D.C Machines.

· To inculcate the understanding about the AC fundamentals.

· To provide an insight into the principles of working of transformers, dc machines, alternators and induction motors.

· An understanding of how complex devices such as semiconductor diodes and field-effect transistors are modeled and how the models are used in the design and analysis of useful circuits.

· Understand the characteristics of transistors in CE, CB, CC configuration and it’s usage as an amplifier and oscillator.

*Outcome:*

At the end of the course, the students will be able to

· Understand concept source of electrical generation, transmission, distribution, protection, safety measures and power & energy measurement.

· Understand construction & working of electrical machines and evaluate their performance

· To impart knowledge on constructional details, principle of operation, Performance, starters and speed control of DC Machines

· To impart knowledge on Constructional details, principle of operation of Transformers.

· To impart Knowledge on Constructional details, principle of operation of AC Machines

· Student will learn how to develop and employ circuit models for elementary electronic components like semiconductor diodes and transistors;

**Section-A**

**Fundamentals Laws and Theorems:** KVL, KCL, ohm’s law, superposition theorem, Thevenin’s theorem, Norton’s theorem, reciprocity theorem,

**D.C. and A.C. Circuits:** Mesh analysis, nodal analysis, star-delta transformation, sinusoidal steady state analysis of 1-ö circuits, series and parallel circuits, 3-ö circuits, Star-Delta circuits,

**D.C. Machines :** Construction and working of D.C. generators, EMF equation, classification, characteristics, armature reaction, construction and working of D.C. motors, torque equation, characteristics, speed control methods and 3-point starter, efficiency calculation,

**Single phase Transformers:** Construction and working of single phase transformers, equivalent circuits, efficiency, regulation, O.C and S.C tests,

**A.C. Machines:** Construction and working of 3 – ö Induction motor, slip, torque equation, efficiency, calculation, construction and working of synchronous generator (alternator), EMF equation, regulation-synchronous impendence method, synchronous motor, torque equation, starting methods.

**Section-B**

**Electronics:** Chartersistics of semiconductor diodes, transistors, characteristics of CB, CE, CC transistor configurations, oscillators, cathode ray oscilloscope, construction, working, applications, mechanical transducers, electrical transducers, pressure gauges, LVDT.

*Text books:*

1. ‘Elements of Electrical Engineering and Electronics’ by V.K. Mehta, S.Chand & Co.

2. ‘Fundamentals of Electrical Engineering and Electronics’ by B.L.Thereja

3. ‘Electronic Devices and Circuits’ by Allen Mottorshad, Prentice Hall of India

4. ‘Basic Electrical Engineering’ by V.N. Mitthal, Tata Mc-Graw Hill

**BT 1308 : Microbiology Laboratory**

**0L-0T-3P-2C**

*List of Experiments:*

1. Preparation of Nutrient broth and inoculation of Bacteria.

2. Preparation of Nutrient agar and inoculation of Bacteria

3. Isolation of pure cultures

4. Staining of Microbes- Simple staining, Gram staining, Negative staining, Capsule staining and spore staining.

5. Motility of Microbes.

6. Morphology of Fungi-( *Aspergillus niger)*

7. Morphology of Yeast-( *Saccharomyces cerevisiae* )

8. Bio-chemical tests- IMViC test, Amylase test, Hydrogen Sulphide production test

9. Testing of Microbiological quality of milk.

10. Testing of Microbiological quality of water.

11. Microbial assay of antibiotics.

12. Evaluation of disinfectant.

***Text book:***

‘Microbiology- a Laboratory Manual’ by Cappuccino T.G., Sherman N, Addison Wesley.

**BT 1310 : Cell and Molecular Biology Laboratory**

**0L-0T-3P-2C**

**Cell biology:** Study of mitosis, meiosis, differential staining of euchromatin and heterochromatin, florescent *in situ* hybridisation - FISH (principle & photographs),

**Molecular biology:** Isolation of genomic DNA, quantification of DNA, Agarose gel electrophoresis, isolation of plasmid DNA, restriction digestion, ligation, transformation, southern blotting, isolation and analysis of RNA.

*Text books:*

1.”A Guide to Molecular Cloning”, Vol. 1,2 & 3, Sambrook, J. et al., Cold Spring Harbor Laboratory Publications

2. ‘Chromosome Techniques’ by Sharma & Sharma

**2/4 B.Tech (Biotechnology) – Second Semester**

**BT 1401 : Biochemistry**

**3L-1T-0P-3C**

*Objectives:*

· To study about the principles and significance of biochemistry.

· To study about the structure and function of Carbohydrates, Proteins and Aminoacids and Lipids.

· To study about the Nucleic acids like DNA and RNA and also to study about the structure and function of enzymes.

· To study about haemoglobin and chlorophyll molecules and their functions.

· To study about the fat soluble and water soluble vitamins also to study about the structure and function of harmones.

*Outcome:*

· Student will obtain knowledge in the subject of Biochemistry- study of chemical reactions and processes in living systems

· Students will obtain knowledge in Carbohydrates, Proteins and Amino acids and Lipids. Students will obtain knowledge in quantitative and qualitative analysis of these biomolecules.

· Student will obtain knowledge in nucleic acids-DNA and RNA hereditary materials and also acquire knowledge in enzyme structure and functions.

· Students will obtain knowledge in the basic structure of porphyrins and the detailed structure of haemoglobin and chlorophyll molecules.

· Students will obtain knowledge in the structure and function of vitamins which are necessary for sound health and students will also obtain knowledge in the structure and function of endocrinal glands, which secrete harmones.

*Syllabus:*

Scope and importance of Biochemistry.

**Carbohydrates:** Classification, chemistry and properties of monosaccharides (Ribose, Glucose, and Fructose), disaccharides (maltose, lactose, sucrose) and polysaccharides (homopolysaccharides and heteropolysaccharides), metabolism of carbohydrates - glycolysis, TCA cycle, electron transport and oxidative phosphorylation, HMP shunt pathway, glycogenesis and glycogenolysis,

**Proteins and amino acids:** Classification and properties of amino acids and proteins, peptide bond, chemical synthesis of peptides and solid-phase peptide synthesis, structural organization of proteins- primary, secondary, tertiary and quaternary structure of proteins, denaturation of proteins,

**Lipids:** Classification, structure and physiological functions of triglycerides, fatty acids, phospholipids, cerebrosides, gangliosides and cholesterol, digestion and absorption of fats, biosynthesis and degradation of fatty acids and triglycerides,

**Nucleic acids:** Structure and properties of purines and pyrimidine bases, nucleosides, nucleotides, cellular localization, isolation and estimation of nucleic acids, types of nucleic acids, double helical structure of DNA, types of RNA, biosynthesis and catabolism of purines and pyrimidines,

**Enzymes:** Introduction, nomenclature and classification of enzymes, kinetic properties of enzymes, factors affecting enzyme action, coenzymes, enzyme inhibition- competitive, non-competitive and uncompetitive inhibitions,

**Porphyrins:** Chemistry of hemoglobin and chlorophyll, synthesis of heme and chlorophyll and heme catabolism,

**Vitamins and hormones:** Definition, classification, chemistry, source, functions and deficiency of vitamins, outlines of hormones and their functions,

Text books:

1. “Fundamentals of Biochemistry” by J.L.Jain, S.Chand & Company Ltd, New Delhi

2. “Principles of Biochemistry” by Lehninger, Nelson and Cox, CBS Publications.

**BT 1402 : Fluid Mechanics and Heat Transfer**

**3L-1T-0P-3C**

*The main objectives are to provide:*

1. Knowledge on pressure distribution in static fluids.

2. Knowledge on rheological behavior of fluids, types of fluid flow, boundary layers and basic equations of fluid flow.

3. Knowledge of incompressible fluid flow in pipes

4. Knowledge on pipes, fittings, transportation and metering devices.

5. Knowledge on conduction, convection and radiation

6. Knowledge on heat flow by conduction and heat flow in fluids.

7. Knowledge on heat exchange equipment.

*Outcome:*

1. Able to estimate the pressure drop.

2. Enhance the flow by reducing boundary layer separation.

3. Estimating the pumping capacity and friction losses of flowing fluids.

4. Able to select pumps based on their performance.

5. Able to select proper measuring device and estimate the quantity of flow.

6. Able to solve heat transfer problems.

7. Able to design heat transfer equipment.

*Syllabus:*

**Dimensional Analysis:** Units and Dimensions, Dimensional Homogeneity, Dimensional Analysis, Buckingham ð theorem, Geometric similarity, kinematic similarity, and dynamic similarity.

**Fluid statics and applications:** Nature of fluids, Hydrostatic Equilibrium, Applications of fluid statics – Manometers, continuous gravity decanter and centrifugal decanter.

**Fluid Flow phenomena:** Laminar flow, shear rate, shear stress. Rheological properties of fluids – Newtonian fluids, Non Newtonian fluids, time dependent flow, viscoelastic fluids. Viscosity, Reynolds number, Turbulence - nature of turbulence. Boundary layers - boundary layer formation over flat plate, flow in boundary layers, laminar and turbulent flow in boundary layers, boundary layer formation in straight tubes, boundary layer separation and wake formation.

**Basic Equations of Fluid Flow:** Continuity equation (Mass Balance in a flowing fluid), equation of motion (Differential Momentum Balance), Navier - stokes equations, Euler’s equation, Couette flow, Macroscopic Momentum Balance, layer flow with free surface, Bernoulli equation (Energy equation), corrections for effect of solid boundaries and pump work.

**Incompressible flow in pipes and channels :** Shear Stress and skin friction in pipes, Relation with skin friction and wall shear, Friction factor, relations between skin friction parameters, equivalent diameter, laminar flow in pipes and channels, velocity distribution, average velocity, Kinetic energy correction factor and momentum correction factor for laminar flow, Hagen-Poiseuille equation, laminar flow of non-Newtonian liquids, laminar flow in annulus. Turbulent flow in pipes and channels, Velocity distribution for turbulent flow, effect of roughness, friction factor chart, drag reduction, friction from changes in velocity or direction – sudden expansion, sudden contraction, pipe fittings, friction losses in Bernoulli equation, velocity heads, separation of boundary layer in diverging channel, minimizing losses.

**Transportation of Fluids:** Pipes, fittings, valves, positive displacement pumps (reciprocating, rotary and peristaltic pumps), centrifugal pumps

**Metering of fluids:** Full bore meters – Venturi meter, Orifice meter, Rotameters, Pitot Tube, Open orifice and V-notch.

*HEAT TRANSFER*

**Nature of heat flow** - Conduction, convection and radiation

**Heat transfer by Conduction:** Basic law of conduction, thermal conductivity, steady state conduction, compound resistances in series, heat flow through a cylinder and a sphere, unsteady state conduction – one dimensional heat flow with constant surface temperature.

**Principles of heat flow in fluids:** countercurrent and parallel flows, energy balances, heat flux and heat transfer coefficients, overall heat transfer coefficients, LMTD, individual heat transfer coefficients, fouling factor.

**Heat exchange equipment**: condenser, heat exchanger, evaporator, boilers and calendears

**Heat transfer to fluids without phase change:** boundary layer, prandtl number, heat transfer by forced convection in laminar flow, heat transfer by forced convection in turbulent flow, Natural convection.

*Text Books:*

1. “Unit Operations of Chemical Engineering” Seventh Edition, by W.L. McCabe, J C Smith and P Harriot, Mc Graw Hill

*Reference Books:*

1. “Introduction to Chemical Engineering” by W L Badger and J T Banchero, Tata Mc Graw Hill

**BT 1403 : Bio-analytical Techniques**

**3L-1T-0P-3C**

**Objective**: Bioanalysis is a sub-discipline of analytical chemistry covering the quantitative measurement of xenobiotics (drugs and their metabolites, and biological molecules in unnatural locations or concentrations) and biotics (macromolecules, proteins, DNA, large molecule drugs, metabolites) in biological systems. Many scientific endeavors are dependent upon accurate quantification of drugs and endogenous substances in biological samples; the focus of bioanalysis in the pharmaceutical industry is to provide a quantitative measure of the active drug and/or its metabolite(s) for the purpose of pharmacokinetics, toxicokinetics, bioequivalence and exposure–response (pharmacokinetics/pharmacodynamics studies). Bioanalysis also applies to drugs used for illicit purposes, forensic investigations, anti-doping testing in sports, and environmental concerns. Modern drugs are more potent, which has required more sensitive bioanalytical assays to accurately and reliably determine these drugs at lower concentrations. This has driven improvements in technology and analytical methods.

**Outcome**: At the end of course the students would have learnt about the need of bio analysis and the techniques involve in various instruments which are useful in modern era.

***SYLLABUS:***

**Unit 1**: Chromatography- Distribution coefficient, modes of chromatography. Paper, Thin layer, Ion-Exchange and Affinity chromatography. GLC- Principle, sample preparation, apparatus, detectors types and applications. HPLC- Principle, Components and applications.

**Unit 2**: Electrophoresis- General principles, support media and applications. SDS-PAGE, Isoelectric focusing, Agarose gel electrophoresis, capillary electrophoresis. Centrifugation- Principle of sedimentation, sedimentation coefficient, Preparative and Analytical centrifuges, Ultracentrifuge. Differential centrifugation, density gradient centrifugation. Applications- in determination of molecular mass, purity and conformation of macromolecules.

**Unit 3:** Radioisotope techniques- Detection and measurement of radioactivity. Gas ionization, Excitation of solids and solutions, Autoradiography, Application in biological sciences-Metabolic pathways, turn over time determination, isotope dilution analysis, radiodating, clinical diagnosis and sterilization and tracer techniques. Biosensors- Principle and applications of Electrochemical, Thermometric, Optical and Peizoelectric Biosensors.

**Unit 4:** UV Visisble Spctroscopy- Principle, Beer-Lamberts law, Instrumentation of Single and Double beam spectrophotometers. Bathochromic and hypsochromic shifts and applications. Turbidometry and Nephlometry- Principles and Applications. Infra red and Raman Spectroscopy- Principles and Applications. Spectrofluorimetry- Principle and Applications.

**Unit 5**: ESR Spectroscopy- Principle, Hyperfine splitting, Instrumentation and applications. NMR Spectroscopy- Principle, Theory of Proton Magnetic resonance and Instrumentation. NMR parameters- Chemical shifts, spin-spin splitting, Intensity and line width and applications- Magnetic resonance imagning. Mass spectroscopy- Principle, Instrumentation, Ionization techniques, Electron impact and chemical Ionization, Ion desorption and evaporation methods, Magnetic and electric sector analyzers, detectors (Faraday cup). X-ray crystallography- Principle, Braggs equation, determination of crystal structure-Rotating crystal method and Powder method, and applications.

*Reference book:*

Practical Biochemistry- Principles and techniques- by Keith Wilson and John Walker.

*Text book:*

Biophysical techniques, by K.Upadhyay, A. Upadhyaya and N.Nath. Himalaya publishihng house.

**CHE 1404 : Material & Energy Balance**

**3L-1T-0P-3C**

**Objective**: To give intensive quantitative training in the practical applications of the principles of physical chemistry to the solution of complicated industrial problems and in methods of predicting missing physicochemical data from generalized principles.

**Outcome**: 1. Able to solve the problems based on stoichiometry, ideal gas and vapor pressure. 2. Able to write and solve material and energy balances for a process.

***Syllabus****:*

**Stoichiometry and composition relationships**- the gram-mole and pound-mole, limiting reactant, excess reactant, degree of completion, basis of calculation, weight percent, volume percent and mole percent, density and specific gravity- Baume and API gravity scales,

**Behavior of ideal gases**- application of the ideal-gas law, Dalton and Amagat laws to gaseous mixtures, composition of gases on dry basis and on wet basis,

**Vapor pressures**- Effect of temperature on vapor pressure, Antoine equation, reference substance vapor pressure plots, vapor pressure of immiscible liquids, ideal solutions and Raoult’s law, non-volatile solutes,

**Humidity -** Percentage saturation, relative saturation or relative humidity, dew point, vaporization, condensation, wet and dry bulb temperatures, adiabatic vaporization and adiabatic saturation temperature,

**Material balances-** Tie substance, yield, conversion, processes involving chemical reactions, material balance- calculations involving drying, dissolution, and crystallization, processes involving recycle, bypass and purge,

**Heat capacities of gases and gaseous mixtures-** effect of temperature on heat capacity of gas, mean heat capacity of gas, Kopp’s rule, latent heats, heat of fusion, heat of vaporization, Trouton’s rule, Kistyakowsky equation for non-polar liquids, estimation of latent heat of vaporization using Classius-Clayperon equation, enthalpy of humid air and humid heat capacity,

**Standard heat of reaction -** Standard heat of formation, laws of thermochemistry, standard heat of combustion, calculation of heat of formation from heats of combustion, calculation standard heat of reaction from heats of formation and from heats of combustion, standard integral heat of solution, effect of temperature on heat of reaction, Kirchoff’s equation, adiabatic and non-adiabatic reactions, theoretical and actual flame temperatures.

*Text book:*

1. ‘Chemical Process Principles, Part-I - Material and Energy balances’ by Olaf A Hougen, K.M. Watson and R.A.Ragatz, CBS Publishers and Distributors (1995)

*Reference books:*

1. ‘Basic principles and Calculations in Chemical Engineering’ by David M. Himmelblau, Prentice Hall of India Pvt Ltd, 1995

2. ‘Stoichiometry’ by B.I. Bhatt and S.M. Vora, 3rd Edition, Tata McGraw Hill Publishing Company Limited, New Delhi (1996)

3. ‘Stoichiometry for Chemical Engineers’ by Williams and Johnson, McGraw Hill Publishers.

**CHE 1405 : Managerial Economics**

 **(Common for all 1/4 B.Tech and 1/6 B.Tech + M.Tech Branches)**

**3L-1T-0P-3C**

Unit -I : Significance of Economics and Managerial Economics:

**Economics:** Definitions of Economics- Wealth, Welfare and Scarcity definition Classification of Economics- Micro and Micro Economics. **(Two periods)**

**Managerial Economics:** Definition, Nature and Scope of Managerial Economics, Differences between Economics and Managerial Economics, Main areas of Managerial Economics, Managerial Economics with other disciplines. **(Four periods)**

**Demand Analysis :Demand -** Definition, Meaning, Nature and types of demand, Demand function, Law of demand - Assumptions and limitations. Exceptional demand curve. **(Two periods)**

**Elasticity of demand** - Definition, Measurement of elasticity, Types of Elasticity ( Price, Income, Cross and Advertisement), Practical importance of Price elasticity of demand, Role of income elasticity in business decisions, Factors governing Price Elasticity of demand. **(Four periods)**

**Demand Forecasting -** Need for Demand forecasting, Factors governing demand forecasting, Methods of demand forecasting: Survey methods- Experts’ opinion survey method and consumers Survey methods. **(Four periods)**

**Utility Analysis:** Utility- Meaning, Types of Economic Utilities, Cardinal and Ordinal Utility, Total Utility, Marginal Utility, The law of Diminishing Marginal Utility and its Limitations**. (Two periods)**

**Unit -II : Theory of Production and Cost analysis: Production -** Meaning, Production function and its assumptions, use of production function in decision making; Law of Variable Proportions: three stages of the law.         **(Four periods)**

**Cost analysis -** Nature of cost, Classification of costs - Fixed vs. Variable costs, Marginal cost, Controllable vs. Non - Controllable costs, Opportunity cost, Incremental vs. Sunk costs, Explicit vs. Implicit costs, Replacement costs, Historical costs, Urgent vs. Postponable costs, Escapable vs. unavoidable costs, Economies and Diseconomies of scale. **(Four periods)**

**Unit -III : Market Structures** : Definition of Market, Classification of markets; Salient features or conditions of different markets - Perfect Competition, Monopoly, Duopoly , Oligopoly, Importance of kinked demand curve ;Monopolistic Competition. **(Four periods)**

**Unit -IV : Pricing Analysis** : Pricing - Significance: Different Pricing methods- Cost plus pricing, Target pricing, Marginal cost pricing, Going -rate pricing, Average cost pricing, Peak load pricing , Pricing of joint Products, Pricing over the life cycle of a Product, Skimming pricing Penetration pricing, Mark- up and Mark- down pricing of retailers. (Four periods)

**Unit -V : Business cycles, Inflation and Deflation: Business cycles** - Definition , Characteristics , Phases, Causes and Consequences; Measures to solve problems arising from Business cycles. **(Four periods)**

**Inflation -**Meaning, Types, Demand- pull and Cost push inflation, Effects of Inflation, Anti- inflationary measures. **(Four periods)**

**Deflation-** Meaning, Effects of Deflation, Control of Deflation, Choice between Inflation and Deflation. **(Two periods)**

*Text Books:*

1. Sankaran,S., Managerial Economics, Marghan Publications, 2015, Chennai.

2. Aryasri, A.R., Managerial Economics and Financial Analysis, MC Graw Hill Education, New Delhi,2015.

Reference Books:

1. Dwivedi, D.N., Managerial Economics, Vikhas Publishing House Pvt. Ltd. 6th Edition, New Delhi,2004.

2. Dewett, K.K., Modern Economic Theory, S.Chand & Company Ltd., New Delhi, 2005.

**CHE 1407 : Environmental Science**

 **3L-0T-0P-0C**

**Objective**: The main objective of this course is to understand the importance of the environment, various sources of pollution, impact of pollution on environment, social issues related to the atmosphere.

**Outcome**: At the end of course the students would have learnt about the ecosystems, different sources of land, energy, water, forest. Different types of environmental issues with their causes are also discussed. Social issues affecting the environment along with different case studies will be explored.

*SYLLABUS:*

MODULE-1 INTRODUCTION : Definition, scope and importance; measuring and defining environmental development: indicators.

MODULE-2 ECOSYSTEMS : Introduction, types, characteristic features, structure and functions of ecosystems-Forest, grassland, desert and aquatic(lakes, rivers and estuaries)

MODULE-3 ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT : Land resources-land as a resource, common property resources, land degradation, soil erosion and desertification, effects of modern agriculture, fertilizers-pesticides problems Forest resources- Use and over exploitation, mining and dams- their effects on forest and tribal people Water resources- Use and over utilization of surface and ground water, floods, droughts, water logging and salinity, dams- benefits and costs, conflicts over water Energy resources- Energy needs, renewable and non renewable energy sources, use of alternate energy sources, impact of energy use on environment.

MODULE-4 BIODIVERSITY AND ITS CONSERVATION : Value of biodiversity- Consumptive and productive use, social, ethical, aesthetic and option values, bio-geographical classification of India- India as a mega diversity habitat, threats of biodiversity- in-situ and ex-situ conservation

MODULE-5 ENVIRONMENTAL POLLUTION- LOCAL AND GLOBAL ISSUES : Causes, effects and control measures of- air, indoor air, water, soil, marine, noise pollutions, solid waste management, composting, vermiculture, urban and industrial wastes, recycling and re-use, nature of thermal pollution and nuclear hazards, global warming, acid rain, ozone depletion.

MODULE-6 ENVIRONMENTAL PROBLEMS IN INDIA : Drinking water, sanitation and public health, effects of activities on the quality of environment- urbanization, transportation, industrialization, green revolution, water scarcity and ground water depletion, controversies on major dams- resettlement and rehabilitation of people: problems and concerns, rain water harvesting, cloud seeding and watershed management.

MODULE-7 ECONOMY AND ENVIRONMENT : The economy and environment interaction, economics of development, preservation and conservation, sustainability: theory and practice, limits to growth, equitable use of resources for sustainable life styles, environmental impact assessment

MODULE-8 SOCIAL ISSUES AND THE ENVIRONMENT : Population growth and environment, environmental education, environmental movements, environmental vs development

MODULE-9 INSTITUTIONS AND GOVERNANCE : Regulation by government; monitoring and enforcement of environmental regulation; environmental acts, water(prevention and control of pollution) act, air(prevention and control of pollution) act, environmental protection act, wild life protection act, forest conservation act, coastal zone regulations; institutions and policies relating to India; environmental governance.

MODULE-10 INTERNATIONAL CONVENTIONS : Stockholm conference 1972, earth summit 1992, world commission for environmental development(WCED).

MODULE-11 CASE STUDIES : Chipko movement, narmada bachao andolan, silent valley project, Mathura refinery and taj mahal, industrilisation of pattancheru, nuclear reactor at nagarjuna sagar, their dam, ralegaon siddhi(anna hazare), kolleru lake- aqua culture, flourosis in AP

MODULE-12 FIELD WORK : Visit to local area to document and mapping environmental assests-river/forest/grassland/hill/mountain; study of local environment- common plants, insects, birds; study of simple ecosystems- pond, river, hill, slopes, etc; visit to industries, water treatment plants, effluent treatment plants.

*Text Book:*

1. Environmental Studies by Anubha Kaushik & C.P. Kaushik Second Edition, New Age International (P) Limited.

**BT 1408 : Biochemistry and Bio-analytical Laboratory**

**0L-0T-3P-2C**

1. Estimation of total Carbohydrates

2. Estimation of Proteins

3. Estimation of Lipids and of Cholesterol

4. Assay of Enzymes- Amylase. Determination of its Km value

5. Estimation of DNA, Determination of Tm of DNA

6. Paper chromatography of sugar

7. Thin layer chromatography of lipids

8. Ion exchange chromatography for biomolecules separation

9. Electrophoresis of proteins and determination of their molecular weight by SDS-PAGE

10. Estimation of turbidity by Nephlometer

11. Separation of biomolecules by GLC

*Text books:*

1. ‘Introduction to Practical Biochemistry’, by Plummer, Tata Mc-Graw Hill

2. ‘Practical Biochemistry’, by Sawhney

3. ‘Laboratory Manual in Biochemistry’ by J.Jayaraman, New Age International

**BT 1410 : Fluid Mechanics Laboratory**

**0L-0T-3P-2C**

1. Discharge through an open orifice

2. Venturi meter

3. Orifice meter

4. V- Notch

5. Rotameter

6. Bernoullis theorem

7. Friction factor

8. Centrifugal pump

9. Reciprocating pump

10. Reynolds apparatus

**3/4 B.Tech (Biotechnology) - First Semester**

**BT 1501 : Biostatistics**

**3L-1T-0P-3C**

***Objectives*** *:*

To make them understand about the Introduction of bioinformatics, Moments like skewness and kurtosis, correlation, Probability distribution and sampling theory, Sampling Theory: sampling, random sampling, parameters and statistic, objectives of sampling and Numerical solutions of PDEs.

*Outcome:*

\* Able to know about collection and classification of data, an empirical relation between mean, median and mode, geometric mean and harmonic mean, measures of dispersion.

\* Acquiring knowledge on the empirical relation between measures of dispersion, standard deviation of combined samples.

\* Acquiring knowledge about coefficient of correlation both for ungrouped and grouped data, lines of regression, standard error of estimate, rank correlation.

*Syllabus:*

**Introduction**, collection and classification of data, graphical representation, histogram, frequency polygon and cumulative frequency curve, comparison of frequency distributions, measures of central tendency, mean, median and mode, an empirical relation between mean, median and mode, geometric mean and harmonic mean, measures of dispersion – range, quartile deviation or semi-inter quartile range, mean deviation, root mean square deviation, standard deviation, variance, coefficient of variation, empirical relation between measures of dispersion, standard deviation of combined samples

**Moments**, skewness and kurtosis, correlation, scatter diagram, coefficient of correlation both for ungrouped and grouped data, lines of regression, standard error of estimate, rank correlation

**Probability distribution and sampling theory:** Random variable both discrete and continuous, probability distribution both discrete and continuous, cumulative distribution, expectation, variance, standard deviation, moment generating function, binomial distribution, constants of binomial distribution, mean, standard deviation, skewness and kurtosis, fitness of a binomial distribution, Poisson distribution, constant of poisson distribution, mean, standard deviation, skewness and kurtosis – fitting of a poisson distribution, normal distribution, standard normal distribution, propertive normal distribution, probability error, fitting of normal distribution, **Sampling Theory:** sampling, random sampling, parameters and statistic, objectives of sampling, sampling distribution, standard error, testing of hypothesis, errors, null hypothesis, level of significance, testing significance, confidence limits, simple sampling of attributes, test of significance for large samples, comparison of large samples, test of significance for means of two large samples, sampling of variables, small samples, number of degrees of student t-distribution, significance test of difference between sample means, f-distribution, Fisher’s z-distribution, Chi-square distribution

**Numerical solutions of PDEs** – Elliptic (Liebmann iteration process), Parabolic (Schmidt explicit formula), Hyperbolic and Poisson’s equations (Gauss – siedel method)

 *Text Books:*

Higher Engineering Mathematics By B.s.grewal

*References:*

**1.** Numerical methods for Scientific and Engineering Computation by M.K.Jain, S.R.K.Iyengar, R.K.Jain, and Publishers New age international (P) Ltd. New Delhi

2. Probability, Statistics and random process by T. Veerarajan, Tata McGraw Hill.

3. Probability, Statistics with Reliability, Queing and Computer Science Application by Kishore S. Trivedi

**BT 1502 : Mass Transfer**

**3L-1T-0P-3C**

*Objectives:*

\* To explain the students with the basic principles of mass transfer operations and other separation processes with examples.

\* To impart knowledge on how certain substances undergo the physical change with diffusion/mass transfer of components from one phase to other phases.

\* To describe the students with equipment used in operations involving mass transfer and other separation processes and their advantages and disadvantages.

\* To focus on absorption and distillation operations and the process design aspects of the same operations.

\* To provide the knowledge on humidification and dehumidification operations and their applications in real situations

*Outcome:*

\* An ability to define the basic principles of mass transfer operations and other separation processes

\* An ability to identify the basic techniques for measurement of diffusivity, mass transfer coefficient, evaporation rate,

\* An ability to understand the importance of mass transfer phenomena in the design of process equipment in distillation operation

\* An ability to understand the VLE concepts and application to different distillations

\* An ability to identify the major parts of various mass transfer equipment

\* An ability to understand the design of sizing of packed columns in absorption and plate columns in distillation

\* An ability to understand the importance of humidification and dehumidification processes and their industrial applications

*Syllabus:*

**Introduction**: Mass transfer Operations.

**Molecular diffusion in fluids:** Binary solutions, Fick’s law, equation of continuity, Steady state equimolal counter current diffusion, Stefan’s diffusion, estimation of diffusivity of gases and liquids, application of molecular diffusion.

**Mass transfer coefficients**: Mass transfer coefficients in turbulent flow, theories of mass transfer, analogy between momentum, heat and mass transfer in laminar and turbulent flow, correlations for mass transfer coefficients in simple situations, diffusion in solids.

**Interphase mass transfer:** Concept of equilibrium, diffusion between phases, two resistance theory, material balances in steady state co-current and counter-current stage processes, Murphy stage efficiency.

**Equipment for gas-liquid operations:** Sparged vessels, mechanically agitated vessels for single phase liquids and gas-liquid mixtures, tray towers, sieve tray for absorption and distillation, venturi scrubbers, spray towers and spray chambers, packed towers for absorption and distillation, tray towers versus packed towers.

**Absorption: S**olubility’s of gases in liquids, two component systems, multi-component systems, ideal and non-ideal solutions, choice of solvent for absorption, single component absorption material balances, counter current multistage operations, dilute gas mixtures, on-isothermal operation, tray efficiency, continuous contact equipment, HETP, HTU, NTU concepts for single operation absorption with chemical reaction.

**Distillation:** Principles of VLE for binary systems, phase diagrams, relative volatility, ideal solutions, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, continuous distillation, McCabe-Thiele method, Ponchon-Savarit method, tray efficiencies, introduction to multi-component distillation, azeotropic and extractive distillations.

***Text book:***

1. Mass transfer Operations, Robert E. Treybal, 3rd edition, McGraw-Hill Book Co.,

***Reference books:***

1.”Unit Operations in Chemical Engineering” by McCabe, W.L., Smith,J.C.and Harriot,P., 5th Edition, McGraw-Hill Book Co.,

2. “Chemical Engineering Hand Book” by J.H. Perry.

**BT 1503 : Enzyme Engineering**

**3L-1T-0P-3C**

*Objectives:*

\* Improvement in the activity and usefulness of an existing enzyme or creation of a new enzyme activity by making suitable changes in its amino acid sequence is called enzyme engineering. When this approach is used to modify the properties of any protein, whether enzyme or non-enzyme, it is termed as protein engineering.

\* Since enzymes are proteins, enzyme engineering is a part of the larger activity of protein engineering. Enzyme engineering utilizes recombinant DNA technology to introduce the desired changes in the amino acid sequences of enzymes.

\* Recombinant DNA technology is also used to transfer genes encoding useful enzymes from dangerous, unapproved, slow growing or low producing microorganisms into safe, fast growing and high producing microorganisms. In addition, the level of production of an enzyme may be increased by introducing more copies of the gene into the concerned organism.

\* The recombinant strain produced the enzyme in considerably higher quantities than did the original/parent strain, which reduced production costs and enhanced enzyme purity. For the present, such applications of recombinant DNA technology are likely to be much more fruitful as well as numerous than that for modifying amino acid sequences of enzymes. But it should be kept in mind that these are not examples of enzyme or protein engineering, which must rest on modification of the amino acid sequence of the concerned enzyme or protein.

The chief objective of enzyme engineering is to produce an enzyme that is more useful for industrial and/or other applications.

The various properties of an enzyme that may be modified to achieve this objective are as follows:

1. Improved kinetic properties

2. Elimination of allosteric regulation

3. Enhanced substrate and reaction specificity

4. Increased thermostability

5. Alteration in optimal pH

6. Suitability for use in organic solvents

7. Increased/decreased optimal temperature

8. Modification of substrate specificity

9. Increased stability to oxidizing agents

10. Improved stability to heavy metals

11. Resistance to proteolytic degradation

12. Fusion of two or more enzymes to create bi- and poly-functional enzymes.

*Outcome:*

After passing the course, the student should be able to:

\* describe design of enzymatic reactions based on kinetic principles, also updated vision of the potentials and limitations of biocatalysis, especially with respect to recent applications in processes of organic synthesis.

\* describe the classification of enzymes, their sources, production and purification methods for an enzyme, also the application of enzymes in various sectors

\* describe basic principles of enzyme structure and function to reactor design for homogeneous systems with soluble enzymes and heterogeneous systems with immobilized enzymes.

\* explain the key structural and energetic factors which give rise to increased enzyme stability important for industrial application.

\* research a contemporary application of enzyme technology or metabolic engineering and present the results in a well-structured oral presentation.

\* describe methods for selection and optimization of industrial enzymes using genetic and biochemical techniques.

\* summarize current processes involved in industrial enzyme production, from protein production to purification and formulation.

*Syllabus:*

**Introduction**: Catalysis and biocatalysis, enzyme structure functionality and relationship, enzyme activity, classification of enzymes, enzymes as process catalysts,

**Enzyme Production**: Enzyme sources, synthesis, recovery, purification, and formulation of enzymes,

**Homogeneous Enzyme Kinetics**: Hypothesis of enzyme kinetics, rapid equilibrium and steady-state hypothesis, determination of kinetic parameters, various types of kinetic inhibition, reactions with more than one substrate, effect of environmental variables- pH, temperature, and ionic strength,

**Heterogeneous Enzyme Kinetics**: Various methods of enzyme immobilization, mass transfer effects in heterogeneous biocatalysis, partition effects, external (film) diffusion, internal (pore) diffusion,

**Enzyme Reactors**: Design of ideal reactors with enzymes (Batch, CSTR, PFR), effect of diffusion on enzyme reactor design, effectiveness factor, effect of thermal inactivation and mass transfer limitation on design and performance of enzyme reactors,

**Application of Enzymes**: Application in biosensors, Food processing applications, Medical and pharmaceutical applications.

 *Text books:*

1. “Enzyme Biocatalysis: Principles and Applications’ by A.Illanes, Springer

2. “Enzyme Technology” by M.F.Chaplin and C.Bucke, Cambridge University press, 1990. (Website for the book, www:lsbu.ac.uk/biology/enztech/)

***Reference books:***

1. “Biocatalysts and Enzyme Technology” by K. Buchholz,V. Kasche and U.T. Bornscheur, Wiley,2005

2. “Enzyme Technology”, by Shanmugam,S. and Satish Kumar,T.,IK International Pvt. Ltd, New Delhi, 2008

3. “Biochemical Engineering Fundamentals’ by Bailey,J.E., and Ollis,D.F., Mcgraw-Hill,1986.

4. “Bioprocess Engineering”, 2nd edition, by Shuler and Kargi, Prentice-Hall

**BT 1504 : Thermodynamics**

**3L-1T-0P-3C**

**Objective:** To understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and to predict phase equilibria and chemical reaction equilibrium.

**Outcome:** At the end of the course the student will be able to:

\* Understand the laws of thermodynamics

\* Understand the degrees of freedom and phase & chemical reaction equilibria

\* Calculate thermodynamic parameters involved in biochemical reactions

\* Differentiate between ideal and non-ideal solutions

*Syllabus:*

**The first law and other basic concepts** : Joule’s experiments, internal energy, the first law of thermodynamics, thermodynamics state and state functions, enthalpy, the steady state, Steady flow process, equilibrium, the phase rule, the reversible process, constant V and constant P processes, heat capacity.

**Heat effects:** Sensible heat effects, internal energy of ideal gases, microscopic view, latent heats of pure substances, standard heat of reaction, standard heat of formation, standard heat of combustion.

**The second law of Thermodynamics:** Statement of the second law, heat engines, thermodynamic temperature scales, ideal gas scale, entropy, entropy changes of an ideal gas, mathematical statement of second law, the third law of thermodynamics, entropy from the microscopic view point.

**Thermodynamic properties of fluids :** Property relations for homogeneous phases, residual properties, Solution thermodynamics : partial properties, concepts of chemical potential and fugacity, ideal and non-ideal solutions, Gibbs-Duhem equation, excess properties of mixture, activity coefficients, activity coefficients correlations.

**Criteria for phase equilibria:** Vapour-liquid equilibrium calculations for binary mixtures, Liquid-liquid equilibria and solid liquid equilibria, Chemical reaction equilibria.

**Biochemical thermodynamics :** Energetics of metabolic pathways, Energy coupling (ATP & NADH), Energetic analysis of cell growth and product formation. Thermodynamics of microbial growth, oxygen consumption and heat evolution in aerobic cultures, energy balance equation for cell culture, reaction thermodynamics.

*Text books:*

1. Introduction to Chemical Engineering Thermodynamics by J.M. Smith, H.C. Van Ness and M.M. Abbott, 6th Ed. McGraw-Hill, 2000.

2. Kinetics and Energetics in Biotechnology, J.A. Roels, Elsevier, 1983.

*Reference Book :*

1. Chemical Engineering Thermodynamics, Y.V.C. Rao, University Press.

**BT 1505 (A) : Food Technology (Elective - I)**

**3L-0T-0P-3C**

**Objective:** To identify Pathogenic and spoilage microorganisms in foods, the important pathogens and spoilage microorganisms in foods and the conditions under which they will grow, the conditions under which the important pathogens are commonly inactivated, killed or made harmless in foods, laboratory techniques to identify microorganisms in foods, beneficial microorganisms in food systems ,understand the principles involving food preservation via fermentation processes, influence of the food system on the growth and survival of microorganisms, understand the role and significance of microbial inactivation, adaptation and environmental factors (i.e., pH, temperature) on growth and response of microorganisms in various environments, Understand the principles involving food preservation via fermentation processes.

 **Outcome**: At the end of the course the students must be able to identify the conditions, including sanitation practices, under which the important pathogens and spoilage microorganisms are commonly inactivated, killed or made harmless in foods.

*SYLLABUS:*

**Food processing and preservation**: Biotechnology in relation to the food industry, nutritive value of the food, types of microorganisms associated with the food, food colors and flavors, enzymes and chemicals used in food processing, food preservation.

**Fermented food products:** Microbial culture used in food industry, fermentation technology for food industry & waste utilization. Bioprocessing and fermentation of meat, vegetables, fruits, dairy products, non-beverage plant products, beverages and related products of baking,

**Food spoilage and Food Microbiology:** Food spoilage, food borne illness, food quality and quality control, HFCS (High Fructose Corn Syrup), single cell protein production,

**Food processing operations:** Food engineering operations: characteristics, cleaning, sorting and grading of food raw materials, food conversion operations, size reduction, mixing, emulsification, filtration, membrane separation, centrifugation, extraction, and crystallization, microwave heating, thermal inactivation of microorganisms, freezing and thawing of foods,

*Text books:*

“Biotechnology: Food fermentation”, by V.K. Joshi & Ashok pandey. “Food processing and preservation”, by B. Sivasankar

*Reference books:*

I. “Food Biotechnology”, by Roger Angold, Gordon Beech & Taggart

2. “Basic Food Microbiology”, by George J Banward, CBS publishers “Modern Food Microbiology”, by James M Jay, CBS publishers.

**BT 1505 (B) : Process Optimization (Elective I)**

**3L-0T-0P-3C**

**Basic Concepts of Optimization:** Introduction to process optimization; continuity of functions, unimodal versus multimodal functions, convex and concave functions, convex region, necessary and sufficient conditions for an extremum of unconstrained function, interpretation of the objective function in terms of its quadratic approximation,

**Optimization of unconstrained Functions - One-dimensional Search:** Numerical methods for optimizing a function of one variable, scanning and bracketing procedures; Newton, quasi-Newton and secant methods of unidimensional search, Newton’s method, quasi-Newton method, secant method,

**Region Elimination Methods, p**olynomial approximation methods - quadratic interpolation, cubic interpolation, how the one-dimensional search is applied in a multidimensional problem, evaluation of unidimensional search methods,

**Unconstrained Multivariable Optimization:** Direct methods- random search, grid search, univariate search, simplex method, conjugate search directions, Powell’s method, indirect methods first order - gradient method and conjugate gradient method, indirect method second order – Newton’s method,

**Linear Programming and its Applications:** Basic concepts in linear programming, degenerate LP’s – graphical solution, natural occurrence of linear constraints; the Simplex method of solving linear programming problems,

**Nonlinear Programming with Constraints:** Lagrange multiplier method, necessary and sufficient conditions for a local minimum, generalized reduced-gradient method, random search methods, and comparative evaluation of different methods,

**Global Optimization:** Overview of genetic algorithm, simulated annealing and other global optimization methods, heuristic search methods.

***Text book:***

 1.”Optimization of Chemical Processes”, 2nd Edition, by T.F.Edgar, D.M.Himmelblau and L.S.Lasdon McGraw-Hill, 2001.

*Reference books:*

1. “Applied Optimization with MATLAB” by . P.Venkataraman, John Wiley

2. ‘Optimization for Engineering Design’ by K.Deb, Prentice Hall of India Private Limited, New Delhi, 2003

3. ‘Engineering Optimization’, 3rd Edition, by S.S. RaoWiley, 1996.

**BT 1505 (C) : Energy Engineering (Elective-I)**

**3L-0T-0P-3C**

**Conventional energy sources**: The present and scope for future development, \_ utilization of coal, formation, analysis, classification, storage and carbonization, byproduct recovery,

**Petroleum:** Origin, classification, single and multi-stage fractionation, reforming, catalytic cracking, specification of kerosene, motor gasoline and fuel oils, liquified petroleum gas and nature gas, composition, properties and uses,

**Non-conventional energy sources**: Solar radiation, principles of heating, cooling and photo-voltaic cells,

**Biogas production:** Biomass, wind energy, tidal and wave energy, geothermal energy, nuclear energy, ocean thermal energy, hydrogen energy,

**Fuel cells: S**torage of energy, types - water storage, packed bed storage, solar storage, chemical storage, phase change storage, mechanical energy storage and windmill storage.

*Text books:*

1. “Fuels and Combustion”, by S. Sirkar, Orient Longmans, 2nd Ed.

2. “Solar Energy, Thermal Storage”, by S.P. Sukhatme, TMH

3. “Non-conventional Energy Sources”, by G. D. Rai, Khanna Publications.

**BT 1505 (D) : Systems Biology (Elective- I)**

**3L-0T-0P-3C**

**Introduction:** Basic principles of systems biology, experimental techniques,

**Standard models and approaches:** Metabolism- enzyme kinetics and thermodynamics, metabolic networks, metabolic control analysis,

**Biological processes:** Signal transduction- introduction, function and structures, interactions, structural components, signaling selected biological processes,

**Evolution:** Introduction, mathematical models, prediction of biological systems, data integration,

**Applications:** Systems biology in various fields, databases and tools, modeling tools.

*Text books:*

1. “Systems Biology in Practice-Concepts, Implementation and Application” by Edda Klipp and Ralf Herwig, Wiley VCH, I Edition

2. “Systems Biology: Definitions and Perspectives” by Lilia Alberghina and Hans V. Westerhoff, Springer, 2005.

*Reference books:*

1.“Systems Biology: Principles, Methods, and Concepts” by Andrzej K. Konopka, CRC Press, 2006

2.“Stochastic Modelling for Systems Biology” *by* Darren James Wilkinson, CRC Press, 2006.

**BT 1506 : Down Stream Processing**

**3L-1T-0P-3C**

***Objectives:***

The course will help to:

1. Learn the fundaments of downstream processing

2. Understand the principle, working and application of major unit operations in Bioprocessing of industrially important products.

3. Understand strategies for development of novel Bioprocessing protocol by applying the concise principles of downstream processing.

**Outcome:** On completion of this course student will have improved ability:-

1. To better understand the applied concepts of downstream processing.

2. To execute precise and efficient bioseparation process, which in cost effective and yield high degree of pure substance.

3. To develop novel bio separation process which is gives high resolution, economical bioproducts.

*Syllabus :*

**SEPARATION OF INSOLUBLE PRODUCTS:** Filtration, centrifugation (batch, continuous, basket), Coagulation and flocculation, gravity sedimentation, settling, decanting.

**CELL DISRUPTION:** Physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear), Chemical methods (alkali, detergents), Enzymatic methods.

**SEPARATION OF SOLUBLE PRODUCTS:** Extraction, precipitation, adsorption, dialysis, reverse osmosis, ultra filtration, Cross- flow ultra filtration and micro filtration, electrophoresis, gel exclusion chromatography, ion exchange chromatography, electro dialysis.

**PRODUCTS PURIFICATION & POLISHING:** Crystallization, drying and pervaporation.

**ADSORPTION:** Theory of adsorption, industrial adsorbents, adsorption equilibria, freundlich equation, single and multi stage operations, unsteady state adsorption, equipment for single stage and continuous contact, ion- exchange.

*Text Books:*

1) “Bioprocess Engineering” by Michael L.Shuler Fikret Kargi, Prentice Hall of India

2) “Bioseperations – downstream processing for Biotechnology”, by paul A belter and E.L.cussler.

*Reference Books:*

1) “Biochemical engineering fundamentals” 2nd ed. by J E Bailey and D Ollis, McGraw-Hill (1986).

2) “Bioseperations–principles & techniques” by B.Siva sankar.

3) “Priniciples of fermentation technology” by P F Stanbury and A Whitaker, Pergamon press (1984).

**BT 1508 : Unit Operations laboratory**

**0L-0T-3P-2C**

1. Emissivity measurement apparatus

2. Natural Convection

3. Forced Convection

4. Pin Fin Apparatus (Natural Convection)

5. Pin Fin Apparatus (Forced Convection)

6. Liquid-Liquid Extraction

7. Solid –Liquid Equilibrium

8. Hydrodynamic Studies in Sieve tray tower

9. Ternary – Liquid Equilibrium

10. Single drop Liquid – Liquid equilibrium

**BT 1510 : Down Stream Processing Laboratory**

**0L-0T-3P-2C**

1. Cell Disruption by Sonication

2. Cell Disruption by Enzymatic Reaction

3. Centrifugal Separation- Ultra Centrifugation, Gel Filtration

4. Micro filtration

5. Ultra filtration

6. Aqueous Two-phase Extraction

7. Dialysis

8. Ammonium Sulphate Precipitation

9. Isoelectric Precipitation

10. Affinity Chromatography

11. Ion Exchange Chromatography

12. Gas Chromatography

13. Adsorption Chromatography.

14. Gel Exclusion Chromatography

15. Crystallization

16. Freeze Drying.

**CHE 1512 : Slot for MC (Constitution of India)**

**3L-0T-0P-0C**

1. Meaning of the constitution law and constitutionalism

2. Historical perspective of the Constitution of India

3. Salient features and characteristics of the Constitution of India

4. Scheme of the fundamental rights

5. The scheme of the Fundamental Duties and its legal status

6. The Directive Principles of State Policy – Its importance and implementation

7. Federal structure and distribution of legislative and financial powers between the Union and the States

8. Parliamentary Form of Government in India – The constitution powers and status of the President of India

9. Amendment of the Constitutional Powers and Procedure

10. The historical perspectives of the constitutional amendments in India

11. Emergency Provisions : National Emergency, President Rule, Financial Emergency

12. Local Self Government – Constitutional Scheme in India

13. Scheme of the Fundamental Right to Equality

14. Scheme of the Fundamental Right to certain Freedom under Article 19

15. Scope of the Right to Life and Personal Liberty under Article 21.

**3/4 B.Tech (Biotechnology) – Second Semester**

**BT 1601 : Chemical Reaction Engineering**

**3L-1T-0P-3C**

*Objectives:*

To learn principles of rate law and stoichometry. Isothermal reactor- Batch, plug flow reactor and mixed flow reactor.

**Outcome:** The student learns the design of homogeneous reactors

*Syllabus:*

**Introduction** and overview of the subject, kinetics of homogeneous reactions, elementary and non elementary reactions, Arrhenius relation, Collision theory and Transition-state theory

**Analysis of batch reactor data:** Various methods of analyses of batch reactor data obtained for various types of reactions including variable volume and variable pressure data.

**Isothermal batch reactor design**, **Homogeneous flow reactors**: Design equation for plug flow reactor (PFR) and continuous stirred tank reactor (CSTR), data analysis in flow reactors, space time, space velocity, recycle reactor, cascade of CSTRs and combination for PFR and CSTR.

**Multiple reactions:** Qualitative treatment of multiple reactions, parallel reactions, series reactions.

**Heterogeneous Catalysis:** Catalyst-properties, calculation of surface area, porosity and pore volume, catalyst preparation methods, promoters, inhibitors and catalyst poisons, physical adsorption & chemisorption, adsorption isotherms, Derivation of rate equations for various mechanisms (Adsorption, surface reaction and desorption controlling etc.,).

*Text book:*

1. Chemical Reaction Engineering’ by Octave Levenspiel, 3rd Edition, John Wiley & Sons, 1999

*Reference books:*

1. Elements of Chemical Reaction Engineering by H. S. Fogler, 3rd Edition, Printice Hall International, 2000

2. Chemical Engineering Kinetics by J. M. Smith, 3rd Edition, McGraw Hill, 1981

**BT 1602 : Engineering Economics & Bioprocess Design**

**3L-1T-0P-3C**

Objectives:

\* To introduce bioprocess design with its basic function of a bioreactor.

\* To study the construction of bioreactor.

\* To introduce the basic fundamentals such as aeration and agitation used in fermentation industrial.

\* Designing of fermentation vessels and problems related to scale up of microbial processes.

\* Engineering economics deals with value of money equivalence and depreciation.

*Outcome:*

\* Fundamentals concepts of bioprocessing

\* Bioprocess design and operation.

\* Ability to design of fermentation vessels.

\* To understand the value of money equivalence and depreciation.

***Syllabus:***

**Engineering Economics:Value of money equivalence**: Value of money, equations for economic studies, equivalence, types of interest, discrete, continuous, annuities: relation between ordinary annuity and the periodic payments, continuous cash flow and interest compounding, present worth of an annuity, perpetuities and capitalised costs, bonds and debentures: value of a bond and yield rate,

**Depreciation:** Types and various methods of calculating depreciations, depreciation accounting, cost accounting- basic relationship in accounting, balance sheet and income statements.

**Bioprocess Design:Basic function of a Bioreactor** for plant and microbial or animal cell culture, factors involved in bioreactor design and principal operating characteristics of bioreactors.

**Body construction**: construction material, temperature control,

**Aeration and agitation: A**gitators (impellers), stirrer glads and bearings, baffles, aeration system (spargers), valves and steam traps used in fermentation industries,

**Scale up:** Basic concepts, problems related to the scale up of the microbial processes, designing of other fermentation vessels,

*Text books:*

1. ‘Plant Design and Economics for Chemical Engineers’ fourth edition, by Max S Peters and Klans D Timmerhans, Mc Graw Hill Book Company

2. ‘Fermentation and Biochemical Engineering Handbook’ 2nd Edition by Henry C. Vogel and Celeste L. Todaro, Noyes Publications, 1997.

*Reference books:*

1. ‘Biochemical Engineering Fundamentals’, 2nd edition, E.Bailey and D.F.Ollis, McGraw Hill, 1986

2. ‘Bioprocess Engineering’ 2nd edition, M.L.Shuler and F.Kargi, Prantice Hall India, New Delhi

3. ‘Principles of Fermentation Technology’ by Stanbury, Pergamon

4. ‘Text Book of Biochemical Engineering’, by D.G. Rao, Tata McGraw Hill

**BT 1603 : Immunology**

 **3L-1T-0P-3C**

*Objective:*

To study about the process of immunity and organs and cells of lymphoid system.

\* To study about the properties of antigens and structure and function of antibodies and various reactions of antigen and antibody.

\* To study about complement system, major histocompatibility and various immune responses.

\* To study about the hypersensitive reactions and their role in graft rejection and to study transplantation and various auto immune diseases.

\* To study the hybridoma technology and to study the various vaccines and vaccination process.

*Outcome:*

\* Student will obtain knowledge in immunology, the structure and function of lymphoid organs and cells.

\* Student will obtain knowledge in the process of antigenecity, and in the production of antibodies and student will also acquire knowledge in the precipitation, agglutination, and other antigen-antibody reactions so that student will become a good immunologist.

\* Student will obtain knowledge in the complement system which is in the blood and immune response –humoral and cell mediated and student will also obtain knowledge in MHC( Majorhistocompatibility).

\* Students will obtain knowledge in the hypersensitive reactions, organ transplantations and also obtain knowledge in various auto immune diseases.

\* Students will obtain knowledge in the fusion of cells to produce hybrid cells( Hybridoma technology) so that they can obtain knowledge to produce monoclonal antibodies. Student will also obtain knowledge in the preparation of vaccines and understand clearly the method of vaccination

***Syllabus:***

**Immunity, Lymphoid organs and cells:** Introduction to Immunology and its origin in vertebrates and invertebrates, immunity-innate immunity and acquired immunity and the various lines of defence, organs of immune system, Thymus, bone marrow, bursa of fabricius, spleen, lymphnode and MALT, cells of immune system- B-cells, T-cells, antigen presenting cells, monocytes, NK cells and langerhan cells,

**Antigens, Antibodies and Ag-Ab reactions:** Antigens- properties of antigens, haptens, epitopes, T-dependent and T-independent antigens, adjuvants and their clinical importance, immunoglobulins- classification, structure and functions of immunoglobulins, antigenic determinants on antibodies, antigen – antibody reactions, and tests involving them - precipitation tests, agglutination tests, complement fixation tests, immunofluorescence, RIA, ELISA, Western blotting and ELISPOT,

**Complement, MHC and Immune response:** Complement system- its components, complement fixation pathways and consequences, MHC- In mice and human, structure of MHC molecules and their role in antigen presentation, immune response- humoral and cell, mediated immune response, IR curve, role of cytokines in immunity, interferons and interleukins, immune suppression, immune tolerance,

**Hypersentivity, Transplantation, Autoimmune disease:** Hypersensitive reactions- Type I, II, III and IV reactions and their role in graft rejection, transplantation immunology- classification of grafts and immunology of graft rejection, agents used for preventing graft rejection, autoimmune diseases- definition and few examples,

**Hybridoma and Vaccination:** Hybridoma technology- production of monoclonal antibodies and their applications, vaccines and vaccination, methods of attenuation of live forms, types of vaccines- whole organisms as vaccines, attenuated forms, purified molecules as vaccines, recombinant organisms, DNA vaccines and synthetic peptides.

*Text book:*

**1.** ‘Immunology’ by A.Goldsby, Thomas J.Kindt, Barbara A.Osborne and Janis Kuby

2.‘A Text book of Microbiology’ by R.Ananthanarayan and C.K.J.Pandey.

**BT 1604 : Bioinformatics**

**3L-1T-0P-3C**

**Objective:** Objectives of this course essentially focuses on the development of skills of students for a successful career in industry or research. The course emphasizes enough effort on theory. The course emphasizes on the delivery of the state of the art technologies in Genomics, Proteomics and Drug discovery. It is essential for the students to read research papers and deliver seminars that would help them to know the recent advances in the subject and also develop the communication skills.

**Outcome**: At the end of the course the students would have learnt about the major bioinformatics resources available so far, sequencing alignments and its data bases, taxonomy and phylogenetics neural networks leading to the role idea of the Dna in computer applications.

***SYLLABUS:***

**UNIT – I Major Bioinformatics Resources:** Knowledge of the following databases with respect to: organization of data, retrieval of data using text-based search tools, sources of data method for deposition of data to databases. Introduction, Primary & Secondary databse, Nucleic acid sequence databases: GenBank, EMBL, DDBJ Protein sequence databases: SWISS-PROT, TrEMBL, PIR\_PSDGenome Databases at NCBI, EBI, ExPASy, TIGR, SANGER Prosite, PRODOM, Pfam, PRINTS, CATH, SCOP, DSSP, FSSP, DALI

Sequence and Structure Databases: PDB, MMDB Metabolic pathways databases such as KEGG, EMP.

**UNIT – II Sequence Alignment and Database Searching:** Introduction- Collection, annotation and alignment of sequences. Basic concepts of sequence similarity, identity and homology. Scoring matrices – PAM and BLOSUM, gap penalties, Database similarity searching, FASTA, BLAST.

**Pairwise sequence alignments:** basic concepts of sequence alignment, Dynamic programming- Needleman & Wuncsh, Smith & Waterman algorithms for pairwise alignments

**Multiple sequence alignments (MSA):** the need for MSA, basic concepts of MSA (e,g. progressive, hierarchical etc.). Algorithm of CLUSTALW. Use of HMM method, concept of dendograms and its interpretation.

**UNIT – IV Taxonomy and phylogenetic analysis:** Basic concepts in taxonomy and phylogeny; molecular evolution; nature of data used, Definition and description of phylogenetic trees and various types of trees, tree building and tree evaluation methods, Phylogenetic analysis algorithms such as Maximum Parsimony, UPGMA, Neighbor-Joining; Maximum likelihood algorithm.

**UNIT – V: Secondary structure prediction methods**- ChouFASMAN/GOR, Nearest neighbor, Neural network

**UNIT – VI Genome Mapping and Applications:** Human genome project, application of genome mapping, DNA microarrays.

*Text Books:*

1.Introduction to Bioinformatics. T.K. Attwood and P.J.Parry – Smith. Pearson Bioinformatics.

2. Bioinformatics: Sequence and Genome Analysis by D.W. Mount, 2001, Cold Spring Harbor Laboratory Press.

*References:*

1. Bioinformatics: A practical guide to the analysis of genes and proteins A.D. Baxevanis and B.F.F. Ouellette (Eds). 2002 John Wiley and Sons.

2. Evens, W.J. and Grant, G.R., Statistical Methods in Bioinformatics: An Introduction.

3. Bioinformatics Basics. Applications in Biological Science and Medicine by Hooman H. Rashidi and Lukas K.Buehler CAC Press 2000.

4. Algorithms on Strings Trees and Sequences Dan Gusfiled. Cambridge University Press

**BT 1605 : Bioprocess Engineering**

**3L-1T-0P-3C**

*Objectives:*

1. To understand the importance of bioprocess engineering and the role of bioprocess engineer and the importance of regulatory constraints.

2. To understand the mechanism of enzyme action, their kinetics and about stoichiometry of microbial growth.

3. To know the configuration of various bioreactors for cell growth and their operations.

4. To understand the instrumentation and control of bioreactors their scale up aspects etc.

*Outcomes:*

1. The student is able to know the importance of bioprocess aspects and the role of bioprocess engineer.

2. The student can analyze the kinetics and mechanism of enzyme action.

3. The student will be able to design a bioreactor.

4. The student will know about the instrumentation used in bioreactors and their operation.

*Syllabus:*

**Introduction** to biotechnology and bioprocess engineering, role of bioprocess engineer, regulatory constraints in bioprocesses, FDA, GMP, GLP and SOPs.

**Enzyme kinetics**: Mechanism of enzyme action, Michaelis-Menten equation and determination of kinetic parameters, effect of pH and temperature.

**Stoichiometry of microbial growth and product formation**: Elemental balances, degree of reduction, yield co-efficients, maintenance co-efficients.

**Cell kinetics and fermentor design**: Batch growth cultivation, batch, continuous and plug flow fermentors, Monod growth kinetics in continuous culture and evaluation of kinetic parameters, Fed batch operation, chemostat with cell recycle, multistage chemostat systems. Non-conventional bioreactors, Scale up of bioreactors, bioreactor instrumentation and control, bioreactors for animal culture.

**Principles and mechanism of media and air sterilization**: Batch and continuous sterilization of media, air sterilization, air filter design.

*Text books:*

1. Bioprocess Engineering 2nd edition, M. L. Shuler and F. Kargi, Prantice Hall India, New Delhi.

2. Biochemical Engineering fundamentals, 2nd Edition, E.Bailey and D.F.Ollis, McGraw Hill, 1986.

*Reference Books:*

1.Textbook of biochemical engineering, D.G. Rao, Tata McGraw Hill, New Delhi,2004.

2. Biochemical Engineering, J. M. Lee, Prantice Hall 1992.

**BT 1606 A : Pharmaceutical Biotechnology (Elective –II)**

**3L-0T-0P-3C**

**Objective**: The main objective of this course is to contribute to improve human health by exploiting the potential biopharmaceutical research by

\* Promoting research and development in the field of pharmaceutical biotechnology.

\* Promoting interactions between academia, biotechnology and pharma companies within the field of pharmaceutical biotechnology to support creativity, innovations and facilitate the commercialization of scientific finding.

**Outcome**: At the end of course the students would have learnt about the \* Promoting appropriate education and training for students in the field of pharmaceutical biotechnology.

***SYLLABUS:***

Introduction- Development of Drug and Pharmaceutical Industry, Therapeutic agents – their uses and economics, Regulatory aspects.

Drug metabolism and Pharmacokinetics- Metabolism, Physico-chemical principles, radioactivity, Pharmaco kinetics action of drugs on human bodies.

Important Unit Processes and their applications: Bulk drug manufacturing, Types of reactions in bulk drug manufacturing and processes, Special requirements for Bulk Drug manufacture.

Manufacturing Principles: Wet granulation, Dry granulation or slugging, Direct compression, Tablet presses. Coating of tablets, capsules. Sustained action dosage. Forms- Parental solutions, oral liquids, injections, ointments. Various topical drugs and pharmaceuticals, Packaging- Packaging techniques, Quality management and GMP.

Pharmaceutical products and their control- Therapeutical categories such as laxatives, vitamins, analgesics, non-steroid contraceptives, antibodies and Biologicals- Hormones.

*Reference Book:*

Remington’s Pharmaceutical Sciences, Mark publishing and Co.

*Text Books:*

Leon and Lachman et al- Theory and Practice of Industrial pharmacy. Cooper and Gunn’s – Dispencing Pharmacy.

**BT 1606 B : Animal Cell Culture and Hybridoma Technology (Elective II)**

**3L-0T-0P-3C**

**Cell culture**: Laboratory design and equipments planning, construction and services and equipment, cryopreservation equipment and principle, water purification system, washing, packing and sterilization of different materials used in animal cell culture, asceptic concepts, maintenance of sterility in cell culture vessels,

**Media and Reagents:** Types of cell culture media, ingredients of media; physiochemical properties, CO2 and bicarbonates, buffering, oxygen, osmolarity, temperature, surface tension and foaming, balance salt solutions, antibiotics and growth supplements, foetal bovine serum, serum free media, selection of medium and serum, conditioned media, other cell culture reagents, preparation and sterilization of cell culture media, serum and other reagents.

**Different types of cell cultures: P**rimary culture and its preparation, establishment of primary culture, subculture –passage number, split ratio, seeding efficiency and criteria for subculture, continuous cell lines, suspension culture, behavior of cells in culture conditions: division, growth pattern, estimation of cell number, development of cell lines, characterization and maintenance of cell lines, common cell culture contaminants, cell transformation, normal Vs transformed cell and agents that cause transformation.

**Scale-up:** Cell culture reactors, scale-up in suspension, scale and complexity, mixing and aeration, rotating chambers, perfused suspension cultures, fluidized bed reactors for suspension culture, scale-up in monolayers, multisurface propagators, multiarray disks, spirals and tubes, roller culture, microcarriers, perfused monolayer cultures, membrane perfusion, hollow fiber perfusion, matrix perfusion, microencapsulation, growth monitoring,

**Applications:** Cell cloning and selection, transfection and transformation of cells, commercial scale production of animal cells, stem cells and their application, application of animal cell culture in pharmaceutics, production of vaccines, growth hormones and interferons, hybridoma technology, production of hybridoma, screening and applications of monoclonal antibodies in various fields.

*Text books:*

1. “Culture of Animal Cells”, (3rd Edition) by F1. Ian Freshney, Wiley-Liss,

2. “Animal Biotechnology” by M.M.Ranga, 2002 Edition.

**BT 1606 C : Cancer Biology (Elective II)**

**3L-0T-0P-3C**

**Fundamentals of Cancer Biology:** Introduction, regulation of cell cycle, mutations that cause changes in signal molecules, effects on receptor, signal switches, classification of cancer, modulation of cell cycle in cancer. Carcinogenesis, cancer initiation, promotion and progression,

**Causes for Carcinogenesis:** Chemical carcinogenesis, metabolism of carcinogenesis, natural history of carcinogenesis, targets of chemical carcinogenesis, principles of physical carcinogenesis, X - ray radiation, mechanism of radiation carcinogenesis,

**Molecular Cell Biology of Cancer:** Oncogenes, identification of oncogenes, retroviruses and oncogenes, detection of oncogenes, growth factor and growth factor receptors that are oncogenes, oncogenes / proto oncogene activity, growth factors related to transformations, tumor suppression, tumor suppressor genes,

**Principles of Cancer Metastasis:** Clinical significances of invasion, heterogeneity of metastatic phenotype, metastatic cascade, basement membrane disruption, three-step theory of invasion, proteinases and tumor cell invasion,

**Detection of Cancer;** Detection of cancers, prediction of aggressiveness of cancer, advances in cancer detection, different forms of therapy, chemotherapy, radiation therapy and immuno therapy, advantages and limitations.

*Text books:*

1. “Cancer Biology” by Raymond W. Ruddon, Oxford University Press Inc., 2007 Ed., NY.

2. “The Basic Science of Oncology” by Ian F.Tannock et al, 4th edition, 2007. Mc Graw Hill Company.

**BT 1606 D : Stem Cells in Health Care (Elective II)**

**3L-0T-0P-3C**

**Stem cell basics:** Unique properties of stem cells, embryonic stem cells, adult stem cells, umbilical cord stem cells, similarities and differences between embryonic and adult stem cells, properties of stem cells – pluripotency, totipotency, multipotency,

**Embryonic stemcells:** Invitro fertilization, human embryonic stem cells, blastocyst, inner cellmass, growing ES cells in laboratory, laboratory tests to identify ES cells, stimulating ES cells for differentiation, properties of ES cells, human ES cells, monkey and mouse ES cells,

**Adult stem cells:** Somatic stem cells, test for identification of adult stem cells, adult stem cell differentiation, trans-differentiation, plasticity, different types of adult stem cells,

**Stem cell in drug discovery and tissue engineering:** Target identification, manipulating differentiation pathways, stem cell therapy Vs cell protection, stem cell in cellular assays for screening, stem cell based drug discovery platforms, drug screening and toxicology,

**Genetic engineering and therapeutic application of stem cells:** Gene therapy, genetically engineered stem cells and animal cloning (transgenic animals), biomarkers in cancer, therapeutic applications in parkinson’s disease, neurological disorder, limb amputation, heart disease, spinal cord injuries, diabetes, matching the stem cell with transplant recipient, HLA typing, Alzheimers disease, spinal cord injuries, tissue engineering application, production of complete organs – kidney, eyes, heart, brain.

*Text books:*

1. “Stem Cells, Human Embryos and Ethics: Interdisciplinary Perspectives” by Larstnor, Springer, 2008

2. ‘Handbook of Stem Cells’, Volume-1, by Robert Paul Lanza, Gulf Professional Publishing, 2004

*Reference books:*

1. “Embryonic Stem cells”by Kursad and Turksen. 2002, Humana Press.

2. “Stem Cell and Future of Regenerative medicine by Committee on the Biological and Biomedical Applications of Stem cell Research”, 2002, National Academic Press.

**BT 1606 E : Intellectual Property Rights (Elective – II)**

**3L- 1T- 0P-3C**

**Intellectual property Rights**: Patents and intellectual property rights (IPR): definition, scope, objectives, sources of patent information, patent processing, copy rights, trade marks,

**Plant biotechnology:** Indian patents and foreign patents, plant variety protection act, the strategy of protecting plants, patent litigation, role of patent in pharmaceutical industry,

**Why there is a need to commercialize biotechnology?** Creating and marketing the image of the biotechnology company, art of negotiation and effective communication, role of venture capitalism, business plan, selection of CEO and personnel, real estate for a biotech start-up,

**Role of a biotechnology manager**, role of research and development, university-industry technology transfer arrangements, how and why a biotech company can benefit.

*Text / Reference books:*

1. ‘The Law and Strategy of Biotechnological Patents’ by Sibley, Butterworth publications.

2. ‘Good Manufacturing Practices for Pharmaceuticals’ by S.H. Willing

3. ‘Intellectual Property Rights’ by Ganguli, Tat Mc-Graw Hill

4. ‘Intellectual Property Right’ by Wattal, Oxford Publishing House

5. ‘Positioning’ by All Rise and Jack Trout (1986), Warner Books

6. ‘Protection of Industrial Property Rights’ by P. Das and Gokul Das

7. ‘Biotechnology: The Science & The Business’ by V. Moser and R.E. Cape, (1999) Harwood.

8. Latest review articles and papers on the subject.

**BT 1608 : Bioprocess and Reaction Engineering Laboratory**

**0L-0T-3P-2C**

***Bioprocess Engineering***

1. Isolation and characterization of industrial cultures for use as biocatalysts in bioprocesses and Analysis of raw materials used in common industrial bioprocesses

2. Production Ethanol & Protease

3. Parameter optimization studies in bioprocesses eg. Ethyl alcohol, amino acid production etc.

4. Product purification in bioprocess studies. Eg. Enzyme production (amylase, protease etc).

5. Measurement of Volumetric Oxygen transfer coefficient

6. Cell immobilization protocols

7. Immobilized bioprocess with cells and enzymes

8. Filter efficiency of common air filters

9. Heat inactivation of microbial cells, thermal death rate

*Reaction Engineering*

1. Batch Reactor (Order)

2. Batch Reactor (Rate Constant)

3. CSTR (Rate Constant)

4. PFR (Rate Constant)

5. CFR (CSTR to PFR)

6. CFR (PFR to CSTR)

7. RTD studies in a packed bed Reactor

8. RTD studies in a Plug flow reactor

**BT 1610 : Bioinformatics Laboratory**

**0L-0T-3P-2C**

1. Sequence retrieval from DNA & Protein databases.

2. Sequence alignment /Annotation-Dot Plot

3. BLAST

4. Multiple Sequence Alignment (CLUSTALW).

5. Phylogenetic Analysis.

6. Structure Visualization of Proteins

7. Restriction Mapping.

8. Identification of Genes in Genomes.

9. Primer Design.

10. Molecular Docking

**4/4 B.Tech (Biotechnology) - First Semester**

**BT 1701 : Environmental Biotechnology**

**3L-1T-0P-3C**

*Objectives:*

\* To make the student learn about origin and evolution of microbes.

\* To make the student understand structure and functioning of different microbial groups.

\* To make them to acquaint the cultivation of microbes in artificial medium.

*Outcome:*

\* Students gain the knowledge and skills both theoretically and practically.

\* Students are equipped with theoretical approach to study them and understand their importance in ecosystem

*Syllabus:*

**Environment :** Types and Components of Environment, Environmental Education, Ecology,Ecosystems, Ecological Pyramids, Food Chains, Food Web, Nutrient Cycling, Ecological Succession, Microbial Associations. History of Environmental Biotechnology.

**Biological Waste Water Treatment:** Biological Processes for Domestic and Industrial Waste Water Treatment. Trickling filters, Activated Sludge Process, Rotating Biological Contactors (RBC), Packed Bed Reactors (PBR), Anaerobic Digestion, Fixed Film Reactors, Up Flow Anaerobic Sludge Blanket Reactor(UASBR), Waste Water Cycling.

**Biodegradation and Bioremediation:** Introduction, Factors Effecting Bioremediation, Enzyme Systems for Bioremediation, Types of Bioremediation, Bioremediation of Contaminated Soils and Waste Lands, Phytoremediation, Degradation of Xenobiotic Compounds:Petroleum products, Alkanes, Aromatic Compounds. Biofertilisers and Biopesticides, Biopolymers and Bioplastics, Bioabsorption, Bioleaching Biofuels, Biodiversity.

*TEXTBOOKS:*

1. Environmental Biotechnology: Basic concepts and applications by Indu Sekhar Thakur I.K. International Pvt. Ltd. New Delhi.

2. Buiotechnology by U. Satyanarayana, Books and Allied (P) Ltd. Koldata.

*REFERENCE BOOKS:*

1. Biotechnology and Biodegradation. Advances in applied biotechnology, Vol-4 by Karnely, D. Chakraborthy, Omen, G.S. Guld Publications co; LONDON.

2. Bioremediation Engineering: Design and Applications by John CooksonJr; McGrawHill.INC.

**BT 1702 : Genetic Engineering**

**3L-1T-0P-4C**

***Objectives:***

\* The objective of this course is to discipline to students knowledge of main engines of implementation and transmission of a genetic material at molecular and cellular levels, and also methods of change of a genetic material and constructioning of transgene organisms with the given properties.

\* Genetic engineering: refers to the process of manipulating the characteristics and functions of the original genes of an organism. The objective of this process is to introduce new physiological and physical features or characteristics.

\* A gene is a basic constituent unit of any organism. It is a locatable region of a genome which contains the whole hereditary information of the organism. A gene corresponds to a unit of inheritance. It is a segment of the DNA which determines the special features or functions of the organism.

\* Genetic engineering meddles with the organism’s natural reproductive process, whether sexual or asexual. It gives it a new direction which is different from its natural disposition and development. The process involves the isolation and manipulation of the genes by introducing the new DNA into the cells. DNA is a blue print of the individual characteristics of an organism. The information stored in the DNA controls the management of biochemical process of each organism. The life, development and unique characteristics of the organism depend upon on its own DNA.

*OUTCOMES*

After passing the course, the student should be able to know about:

The aims of the study, development and practice of **genetic engineering** are noble and beneficial for mankind. Genetic engineering may help make crops resistant to herbicides used to kill the unwanted plants and weeds which obstruct their full growth. Though some herbicides are selective and kill only the  specifically targeted unwanted plants, there are others which are non selective and  besides killing the useless and obstructive weeds,  kill any plants they come in contact thus killing the plants which are sought to be protected.

The domain of genetic engineering can extend from plants to cover both the animal and human life. It can, for example, hybridize the production of the animals and promote the growth of healthy species of milk producing animals, stronger and healthier horses, cows and bullocks which can better withstand the wear and tear of life.

**Introduction, Purification and manipulation of DNA:** History and scope of gene manipulation, isolation and purification of total cell DNA and plasmid DNA, DNA manipulative enzymes, restriction endonucleases- types, nomenclature, recognition sequence, cleavage pattern, restriction digestion and its analysis, Ligases – mode of action, strategies of ligation, linkers, adaptors and homopolymer tailing, DNA modifying enzymes,

**Cloning Vectors and Libraries:** *E. coli* vectors – construction and features of plasmids – pBR322, pUC8, pUC18, pGEM3Z, bacteriophage vectors – Lambda phage & M-13 phage vectors, cosmids, phasmids, shuttle vectors, yeast vectors - 2µm plasmid, yeast episomal plasmid and YACs, transfer and cloning of recombinant vectors, construction of genomic DNA libraries, cDNA libraries and their screening, gene cloning strategies,

**PCR, Blotting and Fingerprinting techniques:** Preparation of labeled probes and primers, DNA sequencing methods – Maxam & Gilbert method, Sangers and Automated sequencing method, PCR and its applications, southern blotting, northern blotting, DNA finger printing technique- RFLP and RAPD and its applications,

**Gene transfer methods and mutagenesis:** Gene transfer techniques – transformation, transfection, electroporation, lipofection and gene gun methods, cause of the mutagenesis, site specific mutagenesis, transposon mutagenesis, gene knockout technologies,

**Applications, achievements and limitations:** Application of genetic engineering in agriculture, animal husbandry, medicine, environmental management and in industry, achievements, limitations and negative aspects of geneic engineering.

*Text books:*

1. “Gene cloning and DNA analysis” – An Introduction, T. A. Brown, Blackwell Publishing, 2006.

2. “Biotechnology” – B.D.Singh, kalyani Publishers, New Delhi, 2006.

*Reference books:*

1.“Principles of Gene Manipulation and Genomics”, S. B. Primrose and R. M. Twyman, Blackwell Publishing, 2006.

2. “From Genes to Clones- Introduction to Gene Technology”, Winnacker, Panima Publishing Corporation, New Delhi.

**BT 1703 : Process Control**

**3L- 1T- 0P-3C**

*Objectives:*

To understand how physical quantities are measured and how they are converted to electrical or other forms.

To have an adequate knowledge on various types of instruments.

To study the characteristics of Instruments.

To deal with control equipment and various controllers and their functions and applications. So, in studying this course Chemical Engineering students will come to know the measurement of various process variables and learn the operation of control systems effectively.

*Outcomes:*

Understand the measurement techniques for Pressure, Temperature, Flow and Level.

Understand recording, indicating and signaling instruments.

Analyze repeatability, precision and accuracy of instruments.

Able to understand the simple control system and its elements

Study various Controllers like P, P-I ,P-I-D Controllers and its mechanism

Develop transfer functions for Controllers Control systems

Understand the tuning of Controllers

UNIT-I : Introduction to process dynamics and control, Response of First Order Systems - Physical examples of first order systems.

UNIT-II : Response of first order systems in series, higher order systems: Second order and transportation lag.

UNIT-III : Control systems Controllers and final control elements, Block diagram of a chemical rector control system. Closed loop transfer functions, Transient response of simple control systems.

UNIT-IV : Stability Criterion, Routh Test, Root locus. Transient response from root locus, Application of root locus to control systems Introduction to frequency response, Control systems design by frequency response.

UNIT-V : Advanced control strategies, Cascade control, Feed forward control, ratio control, Smith predictor, dead time compensation, internal model control. Controller tuning and process identification. Control valves.

*Text Books:*

1. D.R. Coughanowr. Process Systems Analysis and Control, Mc Graw Hill, 1991.(For Units IV to VIII)

*Reference books:*

1. Chemical Process Control, G. Stephanopolous, Prentice Hall, 1984.

**CHE 1704 : Industrial Management and Entrepreneurship**

 **(Common for all 1/4 B.Tech and 1/6 B.Tech + M.Tech Branches)**

**3L-1T-0P-3C**

**Unit-I : Basic Concepts of Management : Management :** Definition, Nature and Importance ; Functions of the Management; Levels of Management; F.W Taylor’s Scientific Management; Henry Fayol’s Principles of Management; **( Eight Periods)**

**Unit-II : Forms of Business Organizations:** Introduction, **Types of Business organizations: Private Sector**- Individual Ownership , Partnership, Joint stock companies and Co-Operative organizations**; Public sector**- Departmental Organizations, Public Corporations and Government Companies; The Joint sector Management.                    **( Eight periods)**

**Unit-III : Production and operations Management :** Plant location- Factors to be considered in the selection of Plant location; Break - even analysis- Significance and managerial applications; Importance of Production Planning and Control and its Functions; Human Resource Management and Functions of Human Resource Manager (in brief); Functions of Marketing; Methods of Raising Finance.         **(Ten periods)**

**Unit-IV : Entrepreneurship :** Definition, Characteristics and Skills , Types of Entrepreneurs, Entrepreneur vs. Professional Managers, , Growth of Entrepreneurs, Nature and Importance of Entrepreneurs, Women Entrepreneurs, Problems of Entrepreneurship.         **(Six periods )**

**Unit-V : Entrepreneurial Development and Project Management:** Institutions in aid of Entrepreneurship Development, Idea generation: Sources and Techniques;, Stages in Project formulation ; Steps for starting a small enterprise - Incentives for Small Scale Industries by Government.   **(Eight periods )**

*Text Books:*

(1 ) Sharma,S.C, and Banga, T.R., Industrial Organization & Engineering Economics, Khanna Publishers, Delhi, 2000.

(2) Vasant Desai , The Dynamics of Entrepreneurial Development and Management (Planning for future Sustainable growth), HImalayan Publishing House, 2018.

*Reference Books:*

(1) Aryasri , A.R., Management Science, McGraw HIll Education (India Private Limited , New Delhi 2014.

(2) Sheela, P. , and Jagadeswara Rao, K., Entrepreneurship, Shree Publishing House, Guntur, Andhra Pradesh, 2017.

**BT 1705 : Industrial Biotech Products**

**3L-1T-0P-3C**

*Objectives:*

\* To study about fermentation process and to study the culturing of micro organisms and maintenance of cultures.

\* To study about the preparation of alcohol using yeast cells and sugars by fermentation process.

\* To study about the production of Acetic acid, Citric acid and lactic acid using fermentation technology.

\* To study about the production of fungal foods- mushroom and other foods like cheese. And also studies the production of bakers yeast, amino acids and vitamins( Microbial origin)

\* To study about the antibiotics production, industrial enzymes-amylase, protease, lipase, and the production of biopolymers- Xanthan gum.

*Outcome:*

\* Students will obtain knowledge in the preparation of microbial slants, maintenance of stock cultures and other microbial techniques and they will also acquire knowledge in fermentation technology.

\* Students will obtain knowledge in the production of alcohols using fermentation technology.

\* Students will obtain knowledge in production of acetic acid, citric acid, lactic acid using micro organisms and biological substrates by fermentation technology.

\* Students will obtain knowledge in the production of foods using microorganisms and Students will obtain knowledge in the production of mushrooms, cheese and vitamins, etc.

\* Students will acquire knowledge in the production of antibiotics and enzymes used in large scale and also in the production of vaccines and biopolymers eg- Xanthan gum, Dextran.

*Syllabus:*

**Microbial Processes:**  Introduction, types of fermentations, components of industrial microbial process, source of industrial cultures, maintenance and improvement of culture for better production,

**Alcohol fermentation**: Production of industrial alcohol, biosysthetic mechanism, recovery of latest developments, wine manufacture, glycerol fermentation, production of acetone and butanol,

**Organic acid production**- Biochemistry of acetic acid production, vinegar manufacture, production of citric acid and lactic acid,

**Microbial foods**: Mushrooms, cheese, Baker’s yeast Amino acids – L-Glutamic acid, Lysine Vitamins – Vitamin B12 Antibiotics – Penicilin and streptomycin. Industrial enzymes: production of amylase, protease and lipase Miscellaneous-Biopolymers (Xanthan gum, dextran etc), vaccines.

*Text books:*

1. “Industrial Microbiology” by Cruger & cruger

2. “Industrial Microbiology” by Cassida

3. “Industrial Microbiology” by A.H.Patel

*Reference books:*

1 ‘Industrial Microbiology’ by Prescott & Dunn

2 “Biotechnology” by U. Satyanarayana.

**BT 1706 : Plant Cell and Tissue Culture**

**3L-1T-0P-3C**

*Objectives:*

\* To know the basics of plant tissue culturing.

\* To know the production of callus from carrot.

\* To measure the efficacy of root and shoot.

\* To develop the graduate capabilities of knowledge ability, comprehension and applications of plants in cell and tissue culture systems.

\* To know how cell and tissue culture contributes to global sustainability.

\* To develop the practical skills and confidence of students to successfully culture plant cells and tissues.

*Outcome:*

By the end of the course, students could be able to:

\* Explain the various components of plant tissue culture media, e.g. minerals, growth factors, hormones, and what governs the choice of components

\* Explain the various steps taken to establish and optimize media for particular purposes in particular species, without the aid of texts.

\* Explain and perform some of the more advanced techniques, e.g. embryo rescue, and protoplasting.

\* Establish and maintain plants in tissue culture and micropropagation, including morphogenesis.

\* Explain the various cell lines used in tissue culture and their origins and uses.

*Syllabus:*

**UNIT I:** Fundamentals of plant tissue culture: laboratory organization, sterilization methods, culture medium and growth regulators. Totipotency, callus culture and organogenesis- Expression of totipotency in cell culture and importance; Principle of callus culture, characteristics of callus culture and importance; Principle of organogenesis, factors effecting organogenesis and applications.

**UNIT II: Cell culture:** single cell culture-isolation, methods of single cell culture and importance; Cell suspension culture, types of suspension culture, growth pattern, synchronization, assessment of growth and viability of cultured cells, significance of suspension cultures.

**UNIT III: Somatic embryogenesis and synthetic seeds:** principle, induction of embryogenesis, embryo development and maturation, factors effecting somatic embryogenesis, synchronization, large scale production and importance of Somatic embryogenesis, synthetic seeds- methods of making synthetic seeds and applications.

Germplasm conservation

**UNIT IV: Somoclonal variations** – its genetic basis and application in crop improvement- cell line selection for resistance to herbicides, stress and diseases. **Haploid production and its advantages-** androgenesis, principle, pollen culture, advantages of pollen culture over anther culture, homozygous diploids, importance of anther and pollen culture.

**UNIT V: Clonal propagation** –technique- multiplication by axillary and apical shoots, adventitious buds/bulbs/protocorms, by callus culture, transplantation, acclimatization

**Production of disease free plants**- meristem tip culture- virus indexing.

**UNIT VI: Protoplast technology**- isolation, culture and plant regeneration, protoplast fusion, methods, identification and characterization of somatic hybrids, cybrids and importance of somatic hybridisation.

**UNIT VII: Genetic transformation** – plant vectors – Ti plasmids, Ri plasmids - indirect and direct methods, current status and limitations. Automation and Economics of tissue culture.

*Text Books*

1. Plant tissue culture – Kalyan Kumar De – New Central Book Agency

*Reference*

1. An Introduction to Plant tissue culture. Razdan. M. K., Oxford & LBH.

2. Plant tissue culture- theory and practice. Bhojwani, SS & Razdan MK.Elsevier

3. Plant tissue and Cell culture. Street, HE.Blackwell

**BT 1708 : Process Control Laboratory**

**3L-0T-0P-3C**

1. Response of Bare Thermometer for a step input

2. Response of Bare Thermometer for a impulse input

3. Response of first order system for a step input

4. Response of Non – Interacting system for a step change

5. Response of Non – Interacting system for a impulse input

6. Response of a Interacting system for a step change

7. Response of Interacting system for a impulse change

8. study of Control Valve Coefficient

9. Study of inherent characteristics of Control Valve

10. Temperature Control trainer

**BT 1710 : Plant Cell and Tissue Culture Laboratory**

**0L-0T-3P-2C**

1. Sterilization methods

2. Preparation of stock solutions

3. Preparation of medium

4. Establishment of callus cultures from carrot cambial explants

5. Establishment of cell culture

6. Establishment of growth and preparation of growth curve

7. Embryo culture of maize or any suitable crop, root/shoot initiation (organogenesis) from different explants

8. Micro propagation and plant regeneration

9. Isolation, culture and fusion of plant protoplasts

10. Anther and pollen culture

**4/4 B.Tech(Biotechnology) Second Semester**

**BT 1801 : Project Work**

**0L-0T-0P-12C**

The project work should consist of a comprehensive design of a chemical plant in the form of a report with the following chapters.

1. Introduction

2. Physical and chemical properties and uses

3. Literature survey for different processes

4. Selection of the process

5. Material and energy balances

6. Specific equipment design (Process as well as mechanical design with drawings)

7. General equipment specifications

8. Plant location and layout

9. Materials of construction

10. Health and safety factors

11. Preliminary cost estimation

12. References

**M.TECH. CHEMICAL ENGINEERING**

**SCHEME OF INSTRUCTION & EXAMINATION**

**I/II M.TECH. (CHEMICAL ENGINEERING) FIRST SEMESTER**

(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

CHEM 1.1.1 Process Modeling
 and Simulation 4 3 1 — 4 30 70 100

CHEM1.1.2 Process Dynamics
 and Control 4 3 1 — 4 30 70 100

CHEM 1.1.3 ChemicalReaction
 Engineering 4 3 1 — 4 30 70 100

CHEM 1.1.4 Transport Phenomena 4 3 1 — 4 30 70 100

CHEM 1.1.5 Elective-I 4 4 — — 4 30 70 100

CHEM1.1.6 Elective-II 4 4 — — 4 30 70 100

CHEM 1.1.7 Elective lab 2 — — 3 3 50 50\* 100

CHEM 1.1.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

*\*Only internal evaluation.*

**Elective-I :** 1.Petroleum Refinery Engineering-I

 2. Process Dynamics and control-I

 3. Electrochemical Engineering-I

**Elective-II**: 1. Corrosion Engineering-I

 2. Energy Engineering-I

 3. Reaction Engineering-I

 **SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH (CHEMICAL ENGINEERING) SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

CHEM 1.2.1 Computer Aided
 Design 4 3 1 — 4 30 70 100

CHEM1.2.2 Advanced Engineering
 Maths and Statistics 4 3 1 — 4 30 70 100

CHEM 1.2.3 Advanced Mass
 Transfer 4 3 1 — 4 30 70 100

CHEM 1.2.4 Pollution Control 4 3 1 — 4 30 70 100

CHEM 1.2.5 Elective-III 4 4 — — 4 30 70 100

CHEM1.2.6 Elective-IV 4 4 — — 4 30 70 100

CHEM 1.2.7 Elective lab 2 — — 3 3 50 50 100

CHEM 1.2.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

**Elective-III:** 1. Petroleum Refinery Engineering-II

 2. Process Dynamics and control-II

 3. Electrochemical Engineering-II

**Elective-IV**: 1. Corrosion Engineering-II

 2. Energy Engineering-II

 3. Reaction Engineering-II

**SCHEME OF INSTRUCTION & EXAMINATION**

**2/2 M.TECH (CHEMICAL ENGG) FIRST & SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

*PROJECT WORK:*

CHEM-2.1.1 - FIRST SEMESTER: CREDITS:10, MARKS:100

CHEM-2.2.1- SECOND SEMESTER: CREDITS:14, MARKS:100

\* Project guide will be allotted at the beginning of first semester and the student has to give presentation on his/her project work at the end of first semester and grading will be awarded as A,B,C or F.

\* At the end of second semester final viva-voce examination will be conducted and grading will awarded as A,B,C or F.

**M.TECH. I SEMESTER**

**CHEM-1.1.1: Process Modeling and Simulation**

**(Common for MPE, CACE & IPCE )**

***Objective:***

Deals with writing various process models based on basic physical process. It also deals with solving the various models by means of numerical methods by computer simulation. By studying this course, one can simulate various chemical processes by computer simulation.

*Outcome:*

1. Understand the writing of a model of a process based on basic physical processes like mass, momentum and energy balances.

2. Able to develop a model equation for Tanks, Isothermal and Non-Isothermal Systems

3. Able to understand the models for binary distillation column, batch reactors, etc.

4. Able to solve the model equations by numerical methods.

*Syllabus:*

Principles of formulation - Continuity equations – Energy equation – Equation of motion – Equations of state – Transport equations – Chemical Kinetics – Algebraic and Integral / differential equations, Explicit and Implicit equations –Numerical Integration,Feed forward and feed backward control.

Basic modeling for tank system, mixing vessel – Simultaneous mass and energy balances – Models for boiling, batch distillation, and partial condenser.

Models for Reactor – Model for heterogeneous catalysis – Models for pumping system – Model for heat exchanger.

Operational blocks in simulation- Simulation Programming – Simulation examples of three CSTR’s in series, gravity flow tank, binary distillation column, non–isothermal CSTR.

Implicit function convergence ,Internal–halving convergence, Newton–Raphson method, False position convergence, Explicit convergence methods, Numerical Integration, Euler Integration, Runge - Kutta (fourth order) method.

*Textbooks:*

1. Process Modeling, Simulation and Control for Chemical Engineers by Luyben, W.L., McGraw Hill Books Co.

2. Mathematical Modeling in Chemical Engineering by Roger, G.E. Franks – John Wiley Sons Inc.

*Reference Book:*

Mathematical Methods in Chemical Engineering by V.G. Jenson and G.V. Jefferys, Academic Press – 2nd Edition.

**CHEM-1.1.2: Process Dynamics & Control**

**(Common for MPE, CACE & IPCE )**

***Objectives*** *:*

The main purpose of teaching Process Dynamics & Control for first year postgraduate students is to take the student from basic mathematics to a variety of design applications in a clear, concise manner. This course is focused on the use of the digital computer in complex problem solving and in process control instrumentation. For chemical engineering problem solving students need more advanced mathematical preparation like partial differential equations, linear algebra and Fourier series all are introduced in this course.

*Outcome:*

\* Able to know the sampled data control systems consists of sampling and advanced mathematical model Z- transforms.

\* Able to describe the process in which the flow of the signals is interrupted periodically like in chromatograph.

\* Able to calculate the open loop response of a sampled data system and can develop a pulse transfer function that is the counterpart of the transfer function for continuous systems.

\* Able to know the sophisticated instruments used for the analysis of water and air pollutants, The student should have knowledge to design the equipment used for the abatement of these pollutants.

\* In a position to modernize the solid waste management and the student must be in a position to get awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

***Syllabus:***

Review of time domain, Laplace domain and frequency domain dynamics of process and control system.

Sampled data control system – sampling and Z–Transforms , open loop and closed loop response, Stability.

State space methods – representation of physical systems – transfer function matrix – Multivariable systems – Analysis and control.

Non linear control –examples of non linear systems – Methods of phase plane analysis.

Control of heat exchangers, distillation columns and Chemical Reactors.

*Textbooks:*

1. Process system Analysis and control, 2nd edition, Donald R Coughanower and Koppel.

2. Automatic process Control by Peter Harriot.

3. Process Modeling, Simulation and control for Chemical Engineers by W.L. Luyben.

**CHEM-1.1.3: Chemical Réaction Engineering**

**(Common for MPE, CACE & IPCE )**

***Objectives:***

\* To focus on the thermal characteristics of various reactions and the design aspects of non isothermal and adiabatic reactors

\* To focus on Heterogeneous data analysis and design

\* To focus on CVD reactors

\* To study the design aspects of heterogeneous catalytic systems

\* To impart the knowledge on mass transfer with reaction in process catalysts

*Outcome:*

\* Enables the students to understand the design aspects of non isothermal and adiabatic reactors

\* Enables the students to on heterogeneous data analysis and design aspects of heterogeneous catalytic systems

\* Able to derive the rate laws for CVD

\* Able to develop the rate laws for heterogeneous fluid solid catalyzed reactions under rate limiting situations.

*Syllabus:*

Review of Fundamentals Rate laws and stiochiometry, reactions with phase change (Scope: Chapter 3 of Fogler) Least squares Analysis of rate data: differential reactors: Laboratory reactors (Scope: sections 5.4 to 5.6 of Fogler) Multiple reactions (Scope: Chapter 9 of Fogler).

Isothermal reactor design (Scope: Chapter 4 of Fogler) Batch reactor, PFR, CSTR design. Pressure drop in reactors, Reversible reactions, unsteady state operation of reactors, Simultaneous reaction and separation

Catalysis and catalytic reactors (Scope: Chapter 6 of Fogler) Steps in catalytic reaction: derivation of rate laws, design for gas-solid reactions, heterogeneous data analysis and design; Chemical vapour deposition, catalyst reactivation, moving bed reactions. Diffusion and reaction in process catalysts (Scope: Chapter 11 of Fogler).

Diffusion and reaction in spherical catalyst.

Internal effectiveness factor, falsified kinetics; estimation of diffusion and reaction limited regimes. Mass transfer and reaction in packed bed. Determination of limiting situations from reaction data, CVD reactors.

Non-isothermal reactor design (Scope: Chapter 8 of Fogler), Energy Balance, equilibrium conversion under adiabatic conditions unsteady state operation, multiple steady states.

*Textbook:*

1. Fogler. H.S: Elements for Chemical Reaction Engineering 2nd Edition, Prentice Hall, New Delhi, 1992.

*Reference:*

2. Smith J.M: ‘Chemical Engineering Kinetics’ 3rd Edition, McGraw Hill, 1981.

**CHEM-1.1.4: Transport Phenomena**

**(Common for MPE, CACE & IPCE )**

*Objectives:*

\* To be able to analyze various transport processes with understanding of solution approximation methods and their limitations.

*Outcomes:*

\* Ability to understand the chemical and physical transport processes and their mechanism.

\* Ability to do heat, mass and momentum transfer analysis.

\* Ability to analyze industrial problems along with relevant approximations and boundary conditions.

\* Ability to develop steady and time dependent solutions along with their limitations.

***Syllabus:***

**Unit 1: Momentum Transport :**

1.1 The Equations of change for isothermal systems.

1.2 Velocity distributions with more than one independent variable.

1.3 Velocity distributions in turbulent flow.

1.4 Inter phase transport in isothermal systems.

**Unit 2: Energy Transport :**

1.1 The Equations of change for non – isothermal systems.

1.2 Temperature distributions with more than one independent variable.

1.3 Temperature distributions in turbulent flow

1.4 Interphase transport in nonisothermal systems.

**Unit 3: Mass Transport :**

1.1 The Equations of Change for multicomponent systems.

1.2 Concentration distribution with more than one independent variable.

1.3 Concentration distribution in turbulent flow.

*Textbook:*

1. “Transport phenomena” R. Byron Bird, Warren E. Stewart and E.N. Light foot, Wiley & Sons, Inc., New York.

*Reference Books:*

1.”Fundamentals of Momentum, Heat and Mass Transfer” James R. Welty, Charles E. Wicks and Robert E. Wilson, John Wiley & Sons, Inc., New York.

2. “Boundary – Layer Theory”, Dr.H.Sehlichting, McGraw – Hill Book Company, New York.

**CHEM-1.1.5: Elective – I**

**CHEM- 1.1.5 A - Elective-I (Petroleum Refinery Engineering-I)**

***Objective:***

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

*Out come:*

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

*Syllabus:*

***Origin and formation of petroleum***: Reserves and deposits of the world - Indialn petroleum industry - Composition of crudes.

***Refinery products specifications and test methods***: Evaluation of crudes. Crudes Pretreatment dehydration and desalting. Physical properties of petroleum oils and products.

Introduction to processing- Refinery distillation - processes - catalytic cracking, Reforming Hydro cracking , and hydro treating, hydrosulfurization.

***Chemical treatments & Extraction Processes*** *:* Alkylation, polymerization Lube oil processing.

**De-waxing** :

Asphalt and air blown asphalt.

Treatment of products, additines, blending of gasoline, treatment of gasoline, Kerosene etc.,

***Heat transfer equipment in Refinery***- Heat exchangers and pipe still heaters.

Design of atmospheric distillation tower and Vacuum distillation tower, catalytic cracking units.

*Text Books :*

1. Petroleum Refinery Engineering - Nelson.

2. Refinery distillation - Watkins.

**CHEM- 1.1.5 B - Elective-I (Process Dynamics and Control-I)**

*Objectives:*

The student is equipped with the analytical tools that are required in the actual design and analysis of distillation control systems. Further this subject provides a unified treatment of steady-state and control aspects of distillation operations.

*Outcome:*

1. The student know different techniques to formulate and solve binary and multicomponent distillation problems along with case studies

2. Knowing of those variables that affect the composition of the products

3. Dynamic mathematical tools used in controller tuning and process-identification techniques would be known.

4. Design and application of advanced control concepts to distillation would be thoroughly understood.

*Syllabus:*

Unit 1 : Overview of steady state distillation concepts.

Unit 2 : Distillation control concept - Controlled variables in distillation - Basis for distillation control strategies - Dynamic Modelling & Simulation.

Unit 3 : Process identification - Frequency response and Controller tuning - Pairing and interaction in distillation.

Unit 4 : Feed forward control - Cascade and parallel cascade control - Dead time compensation.

 Unit 5 : Inferential control and model algorithmic control.

***Textbook :***

Distillation Dynamic and Control - Pradeep B., Deshpande, ISA, Tata McGraw Hill Co. Ltd.

***Reference****:*

Design of Distillation Column Control Systems -Luyben and Shunta ISA. Tata McGraw Hill Co.

**CHEM- 1.1.5 C - Elective-I (Electrochemical Engineering-I)**

*OBJECTIVES:*

\* To enable the basic principles of electrochemistry, electrochemical devices, electro active materials used in such devices, and case studies of batteries.

\* To enable the clean energy needs and demands especially in the electrochemical power generation sector; and to become educators, practicing engineers, and national leaders in electrochemical energy conversion and storage.

\* To enable the integrated skills in fundamentals of electrochemistry (e.g.; chemistry, physics, mathematics, thermodynamics, and chemical kinetics) and electrochemical engineering applications (batteries, solar, flow and fuel cells, electrochemical synthesis and corrosion) to ensure successful career opportunities and growth within electrochemical power generation industries and academia.

\* To enable the students in energy related programs such as clean power generation and future green technologies.

 *OUTCOMES:*

\* The student would know how to solve the problems relating to the production, storage, distribution and utilization of electrochemical energy and the associated environmental issues. And he would know integration of electrochemical principles and materials science for application in modern electrochemical devices.

\* The student would know design and conduct experiments, acquire data, analyze, interpret data, solve practical and complex problems on a variety of electrochemical devices such as batteries, solar cells, flow and fuel cells and integrate the professional, ethical, social and environmental factors in electrochemical engineering and understand the impact of these factors on global energy issues.

*Syllabus:*

Introduction:

Unit- I : Basic Concept: Mechanism of Electrolysis, Laws of Electrolysis, Curent and Voltage Efficiency - Electrolytic dissociation, Coulometers, Ionic conduction. Electrolytic conductivity, Absolute ionic velocities, ionic mobilities, Transference Nos. Modern Ionic Theory, Ionic activity Degree of dissociation. Ionic Atmosphere Time of relaxation and relaxation effect, Electrophoretic effect - Debye - Huckel Onsager equation of conductance (Derivation is not required) and its validity.

Unit II: Thermodynamics I: Chemical Potential and Free Energy changes. Cell and Electrode potentials. Thermodynamics of Electrode potentials - Nernst Equation. Equilibrium Constant, Arbitrary Zero of potential, EMF series and their limitations Activity Coefficient of and their evaluation, Liquid Junction potentials, Concentration Cells - Reference Electrodes.

Unit III : Thermodynamics II : Electrode Kinetics, Role of Interface, Electric Double Layer and its capacitance - Irreversible Electrode processes - Irreversibility, Tates of Electrode Processes. Electrode Kinetics Model, Cathodic Hydrogen evolution, Depolarisation - Overpotential, Tafel Equation, Ohmic or resistance Over potential, Concentration overpotential, Oxygen Evolution reaction and Decompostion potential, Ionic Transport by Migration, Diffusion and Convection - Mass transfer.

Unit IV : Kenetics of Corrosion Processes and Evans Diagrams : Electrokinetic phenomenon - Straming potential, zeta potential and Electro - Osmosis, Electrophoresis, Dorn Effect.

Measurements and Systems Analysis : Conductivity measurements - Conductometric analysis - Titrations, Measurements of pH, potential - potentiometric titrations, Polarography Electrogravimetry, Coulometry. Current Distribution in a cell. Rotating Disc Electrode, Rotating Cylinder electrode, Rough Surface Electrode Limiting Current Technique.

Unit-V: Potential relations in corrosion cells potentials, pH diagrams in corrosion.

Corrosion theory : Manifestation of corrosion, bases of electrochemical corrosion, amount and intensity of corrosion, Eight forms of corrosion : Uniform attack, Galavanic corrosion, crevice corrosion,Pitting, inter granular corrosion. Selective leaching, stress corrosion cracking. Conditions leading to pitting attack., environmental factors, hydrogen damage. Corrosion inhibition and prevention : Domestic water supplies, recirculating water systems, corrosion inhibitors, Inhibitors for acid pickling, vapor phase inhibitors. Coatings and paits: Phosphating, Protective metal coatings; cathodic protection and corrosion of buried structures.

*Textbooks:*

1. An Introduction to Electrochemistry by Samuel Glasstone, D. Van Nostrand Company Inc princeton, Affiliated East-West press Pvt. Ltd.

2. Electrochemistry - Principles and Applications by Edmund C. Fotter Oliver Hume Press Ltd., London.

***Reference Books:***

1. Electrochemical Engineering, Principles, by Geofferey Prentice, The Johns Hopkins University, Prentice Hall, Englewood Cliffs, New Jersy, 07632.

2. Electrochemistry - Bookris and A.K.Reddy.

3. Electrochemical Engineering by C.L.Mantell.

4. Principles of Electrochemical Engineering by L.W.Shemilt.

5. Chemical Engineering Development Centre, Indian Institute of Technology, Madras 600 036.

6. Fontanna and Grene ‘Corrosion Engineering’.

**CHEM-1.1.6: Elective –II**

**CHEM-1.1.6 A - Elective-II (Corrosion Engineering-I)**

*The main objectives are to provide:*

1. Basic aspects of electrochemistry relevant to corrosion phenomena,

2. Importance and forms of corrosion.

3. Knowledge on corrosion rate expressions and measurement techniques.

4. Knowledge on factors influencing corrosion of iron and steel exposed to atmospheric, soil and aqueous medium.

5. Basic knowledge on remedial measures for corrosion.

*Outcome:*

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion, corrosion tendency and electrode potentials.

2. Able to identify the nature of corrosion and form in which it attacks(Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage .

3. By acquiring knowledge on polarization and its influence on corrosion rates will be able to measure corrosion rates and analyze.

4. Acquires knowledge on mechanism and propose viable remedial measures.

*Syllabus:*

Basic Concepts and Outlines of Electrochemistry: Fundamentals of Electrochemical reactions, Faraday’s Laws Electrolytic and ionic conductance, ionic mobility’s, Transport Nos. Galvanic Cell and Electrolytic cells.

Definition and importance of corrosion, Dry cell, analogy, Corrosion Cells, Types of Corrosion Cells- a) Dissimilar electrode cells b) Concentration cells such as a salt concentration cells, differential aeration cells c) differential Temperature cells. Corrosion Rate Expresions - mdd, ipy, cpy, mpy, etc.

 Corrosion Tendency and Electrode Potentials: Free Energy changes, Development of Nernst Equation for calculation of Half-cell potentials, Hydrogen electrode, Spontaneity of a reaction, Reversible cells and potentials – convention of Sign and calculations of EMF from standard Equilibrium potentials., EMF Series and Galvanic series, Reference Half Cells – Calomel, Silver-Silver Chloride and Saturated Copper-Copper Sulphate Half Cells. Pourbaix Diagram for Iron, Aluminum and magnesium, limitations of pourbaix diagrams.

Polarization and Corrosion Rates: Polarization and a Polarized Cell, Causes of Polarization – Concentration Polarization, Activation Polarization and IR drop. Hydrogen Over potentials, combined polarization and Mixed potential theory. Tafel Slopes and Tafel Equation. Graphical method of expressing Corrosion Reactions (Polarization diagrams/Evans diagrams), Derivation of Stern-Geary Equation, Influence of Polarization on Corrosion rates.

Passivity: Characteristics of Passivation, Flade potential, behavior of passivators, transpasivity, Theories on Passivity.

Forms of Corrosion: Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage. Factors influencing, mechanisms and prevention techniques for all forms of corrosion. Calculation of Corrosion rates using weight lost method and Polarization data. Electrochemical Impedance Spectroscopy.

Effect of Dissolved Oxygen (Air saturated Water, High Partial Pressure of Oxygen and Anaerobic bacteria), Temperature, pH, Galvanic coupling, velocity, dissolved salts concentration. Wet and dry corrosion.

*Textbooks :*

1. Corrosion and Corrosion Control by Herbert, H. Uhlig John Wiley and Sons Inc., New York.

2. Corrosion Engineering by Mars F Fontana, McGraw Hill.

3. An Introduction to Electrochemistry by Samuel Glass stone, Affiliated East West Press Pvt. Ltd.,

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**CHEM- 1.1.6 (B) - Elective-II (Energy Engineering-I)**

*Objectives:*

To lean overview of solar radiation and it’s potential for collection to meet the energy needs of mankind and potential for solar energy option. To learn measuring techniques of solar radiation and its compilation.

To learn various design and operational aspects of solar energy collection and storage.

To learn the design and operation of solar energy appliances like liquid flat plate collectors, Solar Air Heaters, Thermal energy storage, Thermal energy storage, Solar Pond, Solar thermal power generation.

To learn theory and application of Photovoltaic cells

*Outcome:*

The student learns collection and design of various kinds of equipment operated on solar energy. The student learns principles and practice of Photo voltaic cells.

*Syllabus:*

The Solar : Energy option Thermal conversion – collection and storage Thermal applications – photovoltaic conversion – wind energy – Energy from Bio – mass – ocean thermal energy conversion.

Solar Radiation : Solar Radiation outside the earths – atmosphere Solar radiation at the Earth’s surface – Instruments for measuring Solar Radiation – Solar Radiation data – Solar Radiation Geometry Empirical equations for predicting the availability of Solar Radiation – Solar radiation on tilted surface.

Liquid flat – Plate Collectors : Components of liquid flat plate – various types of collectors – Performance Analysis – Transmissivity – Absorptivity product – Overall loss coefficients and heat Transfer correlations – Collector efficiency heat removal factors – effect of various parameters on performance. Transient Analysis – Testing procedures.

**Solar Air Heaters :** Various types of solar Heaters – Performance Analysis of a conventional Air Heater – Testing procedures – Concentrating collectors – various types of concentrating collectors cylindrical and parabolic collectors – General receiver collectors.

**Thermal energy storage :** Sensible heat storage – Latent heat storage – Thermochemical storage.

Solar Pond Description – Performance analysis – Experimental studies – Operational problems.

**Solar Air Conditioning and Refrigeration :** Heat pump cycle – Coefficient of performance of the heat pumps – solar air-conditioning with absorption – Refrigeration system (Ammonia water and lithium bromide – water systems).

Solar thermal power generation : Thermal and direct electricity generation – Major sub-stations of a solar thermal power plant, Examples of installed systems – Concentration ratio. Temperature and efficiency concepts – Solar farm and tower – Economics.

Photovoltaic Energy Conversion : Photovoltaic Energy Conversion Fundamentals – band theory of solids – Physical processes in a solar cell – Solar cell with light incidence – Solar cell module – Silicon Solar Cells – Copper Sulphate / Cadmium sulphide Solar Cells.(Banasal et at.,chapters 9;Taylor, chapters 6, pages 256-298.

*Text Books:*

1. Solar Energy: Principles of thermal collection and storage by S.P. Sukhatme, Tata McGraw Hill, New Delhi 1984 (Chapters 2 to 8)

2. Renewable energy sources and conversion technology by N. K. Bansal, M. Kleemann, Michael Mcliss, 1990 (Chapters 2 – 9).

**CHEM- 1.1.6 C - Elective-II (Reaction Engineering-I)**

**Unit I** : (Scope : J.M. Smith : Chapter 7): Heterogeneous Processes, catalysis, and absorption: Global Rates of Reaction - Types of Heterogeneous Reactions - The nature of catalytic Reactions - The Mechanism of catalytic Reactions - Surface Chemistry and Absorption - Absorption Isotherms - Rates of Absorption.

**Unit II** ( Scope : J. M. Smith: Chapter 8 : Solid Catalysts: Determination of surface area - Void Volume and solid density - Fore volume distribution - Theories of Heterogeneous Catalysis - Classification of catalysts - Catalyst Preparation - Promoters and Inhibitors Catalyst Deactivation (Poisoning).

**Unit III:** (Scope: J.M. Smith : Chapter 9): Rate equations for fluid - Solid Catalytic Reactions: Rates of adsorption, Desorption, Surface Reaction - Rate equations in terms of Fluid phase concentrations at the catalyst surface - Qualitative analysis of rate equation - Quantitative inter pretation of Kinetic data - Redox Rate equations.

**Unit IV:** ( Scope : Octave Levenspiel : Chapter 15) : Deactivating Catalysts : Mechanism of Catalyst Deactivation - The ratre of equation - The rate of equation from experiment - Batch - solids: Determining the rate for Independent Deactivation Batch - solids : Determining the rate of parellel, series or side - by - side Deactivation - Flowing solids experimental Reactors - Finding the Mechanism of Decay from experiment Design.

**Unit V**: ( Scope : J. M. Smith : Chapter 10) : External transport Processes in Heterogeneous Reactions: Fixed bed reactors - The effect of physical processes on observed rate of reaction - Mass and Heat transfer coefficients (fluid particle) in packed beds - Quantitative treatment of external transport effects - Stable operating conditions - Effect of external transport Processes on selectivity.

Fluidised bed reactors - Particle - fluid Mass and Heat transfer Slurry Reactors - Mass transfer coefficients: Gas bubble to liquid (K1) - Mass transfer coefficients: Liquid to particle

(Kc) - The effect of mass - transfer on observed rates Trickle - Bed reactors - mass transfer coefficients: Gas to liquid (K1 ag) - Liquid to particle (kc ac) - Calculation of global rate.

*Text Books:*

1. Smith. J.M., “ Chemical Engineering Kinetics”, McGraw Hill book Company, New Delhi (Third Edition) 1981.

2. Octave Levenspiel, “ Chemical Reaction Engineering” , Wiley Eastern Limited - Second Edition - 1972.

***Reference Books*** *:*

1. Thomas, J.M. And Thomas, W.J. “ Introduction to the Principles of Heterogeneous Catalysis”. Academic Press Inc., New York 1967.

2. Carbnerry, James, J., “ Chemical and Catalytjic Reaction - Engineering”, McGraw - Hill, Engineering Series.

**II SEMESTER**

**CHEM –1.2.1: COMPUTER–AIDED DESIGN**

**(Common for Chemical Engineering, CACE & IPCE )**

The objectives of this course are to provide the student with:

\* a basic understanding of the fundamentals of executive program, executive program aided simulation, unit computations, information flow diagram, encoding of information flow diagram, simulation of a simple plant, applications of simulation

\* knowledge to write algorithm and programs for various fluid flow problems, pressure drop in two phase flow, pipeline network calculations

\* knowledge to write algorithm and programs for rating and design calculations heat exchanger, condenser, reboiler, flash calculations, distillation column, gas absorption column, crosscurrent and counter current extraction, analysis of data in a reactor, extent of reaction, ideal reactors, semibatch reactor, packed bed reactor and fluidized bed reactor

*Outcome:*

\* Enables students to learn the basics of computer aided design, executive program aided simulation and its applications

\* Students will be able to write/develop unit computations (programs) for fluid flow, mass transfer, heat transfer and reaction engineering problems

*Syllabus:*

Unit I : Introduction on simulation and importance of simulation for chemical process industries Introduction to computer aided design- executive program. coding of chemical process flow chart. Information flow diagram, unit computations, developing a description of information flow diagram, information flow diagram to numerical form, planning calculations, finding recycles, planning calculations for recycle set.

Unit II : Mass transfer operations: introduction, distillation- simple binary distillation, Multicomponent flash calculations, multi component stage wise calculations, Gas absorption- absorption and stripping in plate columns, absorption in packed columns, Liquid extraction- single stage contact, cross current extraction, counter current extraction

Unit III : Flow of fluids in pipes: Introduction, flow of Newtonian fluid in a pipe- incompressible fluid flow, sizing of pipes, Pressure drop in compressible fluid flow, flow of non Newtonian fluids- Bingham plastic fluid, Power law fluid, generalized Reynolds number, Sizing of pipes for non Newtonian fluid How, Pipe network calculations, two phase flow systems- gas liquid flow, solid liquid flow, gas solid flow.

Unit IV : Heat transfer: Introduction, shell and tube exchangers without phase change- tube side heat transfer coefficients, shell side heat transfer coefficients, pressure drop in shell and tube heat exchanger, condensers, reboilers

Unit V : Chemical reaction Engineering: Introduction, extent of reaction, chemical reaction equilibrium- independence of reactions, calculation of chemical equilibrium, Analysis of rate data - Integral method, differential method, nonelementary reactions, temperature dependence of rate constant, Ideal reactors- batch reactor, continuous stirred tank reactor, plug flow reactor, semi batch reactor, Temperature effects in homogeneous reactors- ideal batch reactor, CSTR, PFR, Heterogeneous system- analysis of rate data, fixed bed reactor, catalyst deactivation.

***Prescribed book:***

1. Chemical Process calculations by Raghu Raman, Elsevier applied science publishers, London-New York

2, Simulation of sulphuric acid plant by Crowe

3. Product and process design principles- synthesis, analysis and evaluation by Warren Sieder, J.D. Sieder, Daniel R. Lewin

**CHEM-1.2.2 – ADVANCED ENGINEERING MATHEMATICS &
STATISTICS**

***Objective:***

The main objective is to make the students get familiar with the Advanced Numerical Methods and Statistical techniques by learning them. The student should be able to learn how to get the Numerical solutions of Boundary value problems as these arise in several engineering studies, such as in Hydrodynamics, Quantum mechanics, applied elasticity, Heat and Mass transfer etc. The student should be able to study about Probability and Statistics; which provides a mathematical frame work for different assertions and is essential in every decision making process.

***Outcome:***

The Students come out with the good knowledge of Advanced Numerical Methods and Statistical Techniques and they will be able to implement these techniques whenever required in their further studies.

***SYLLABUS:***

**1. Finite Difference Methods of Solving Boundary value problems Associated with partial Differential Equations:** Introduction, Finite difference scheme for Laplace’s equation, Finite difference methods for the parabolic type of partial differential equations, Forward difference method, Crank-Nicholson implicit method, Stability analysis, backward difference equation for parabolic equations, finite difference explicit scheme for the wave equation. An implicit scheme for the linear wave equation, method of characteristics for solving hyperbolic partial differential equations.

**2. Boundary value problems in ordinary differential equations:** Reduction to an intial value problems, Finite difference method, The shooting method, Multiple integration.

**3. Statistics and probability:** Concept of random variable – distribution and density functions conditional distribution and density functions, Functions of one and two random variables, Many random variables, Concept of Stochastic Processes.

*Textbooks:*

1. Computer Programming and Numerical Analysis by N.Datta Published by Universities Press(India) Private Limited, 3-5-819, Hyderabad – 500029 for Section I & II.

2. Probability by Seymour Lipschutz: Schaum’s outline series for Section III.

3. Introductory Methods of Numerical Analysis by S.S.Sastry.

**CHEM- 1.2.3 - ADVANCED MASS TRANSFER**

*Objectives:*

\* To develop skills in the process design of mass transfer operations

\* To understand problems involving mass transfer using the principles of material and energy balances.

*Outcomes:*

\* Ability to design process equipment for various mass transfer operations.

\* Ability to use equations of change for multi-component systems.

\* Ability to solve problems of mass transfer in laminar and turbulent regimes.

\* Ability to solve problems of interphase transport in non-isothermal systems.

*Syllabus:*

**Chapter 1: Flux Definition**

\* Mass and molar transport by convection

\* Summary of mass and molar fluxes

\* Fick’s law

**Chapter 2: Differential Equations of Mass transfer**

\* Differential equation for mass transfer

\* Boundary conditions

**Chapter 3: Molecular diffusivities**

\* Diffusivities in gases

\* Diffusivities in liquids

**Chapter 4: Molecular diffusion**

\* Steady state molecular diffusion

\* Steady-State Equimolal counter diffusion in gases

\* Steady state Equimolal unidirectional diffusion in gases

\* Molar diffusion in liquids

\* Diffusion through a stagnant gas film

\* Diffusion with a moving interface

\* Diffusion through a Nonisothermal Spherical film

\* Diffusion with a Heterogeneous Chemical reaction

\* Diffusion with a slow Heterogeneous Chemical reaction

\* Diffusion with a homogeneous Chemical reaction

\* Unsteady state diffusion in a sphere

\* Unsteady state diffusion in a slab

\* Unsteady state diffusion in a Cylinder

**Chapter 5: Mass Transfer coefficients**

\* Individual Mass transfer coefficients

\* Overall Mass Transfer coefficients

\* Mechanism of Mass transfer

\* The two-film theory

\* The penetration theory

\* The theory of penetration with Random surface renewal

**Chapter 6: Mass transfer in Laminar Flow**

\* Mass transfer in the laminar boundary layer on a flat plate (Integral Solution)

\* Mass transfer in laminar Natural convection on a vertical plate

\* Mass transfer in a falling liquid film in a laminar flow

\* Mass transfer between a gas phase and a falling liquid film ( gas absorption)

\* Mass transfer between an inclined plate and a falling liquid film ( Solid dissolution)

\* Gas absorption with rapid reaction

**Chapter 7: Mass Transfer in turbulent flow**

\* Mass transfer in the turbulent boundary layer on a flat plate

\* Mass transfer in turbulent Natural convectionon a vertical plate

\* Mass transfer between inclined plate and a falling liquid film in turbulent flow

\* Anologies between momentum, heat and mass transfer

\* Reynolds analogy

\* Prandtl analogy

\* Von Karman analogy

\* Analogies in terms of j factor

*Text Books:*

1. A H P Skelland, Diffusional Mass transfer, John Wiley and Sons (1974)

*Reference Books:*

1. R B Bird, W E Steward and E N Lightfoot, Transport Phenomena, 2nd Ed., John Wiley and Sons (2002)

2. J R Welty, C E Wicks, R E Wilson and G. Rorrer, Fundamentals of Momentum, Heat and Mass transfer, 4th Ed., John Wiley and Sons (2001)

**CHEM-1.2.4: POLLUTION CONTROL**

*Objectives:*

\* Focus on classification of air pollutants, water pollutants and solid waste –causes, effects and control methods, need of environmental Legislation.

*Outcome:*

\* Enables the students to adopt the preventive measures for the control of air pollutants, waste water treatment methods, and solid waste management methods in domestic, municipal waste.

\* Enables the students to understand the control measures of pollutants emitted from different industries like Paper and pulp, fertilizer, sugar and alcohol, petrochemical and petroleum refinery, pharmaceutical and metal finishing industries.

*Syllabus:*

Kinds of ecology, environment and ecofactors, types of ecosystems, sulphur cycles, phosphorous cycle, Nitrogen cycle and hydrological cycle

Sources for water, Air and solid pollution, Analysis and effects of the pollutants in air, in water, Solids(particulate matter, SOx, NOx, Cox, CHx).

Limits of pollutants, Environmental Legislation.

Control aspects of various pollutants Air (Particulate matter, SOx, NOx, COx, CHx, Noise) water (primary, secondary and territory treatment techniques) Solids (recycling, incineration,bio-conversion).

Case studies of Industries: Paper and pulp, petrochemical, Fertilizer, Pharmaceuticals, tannery, sugar and alcohol industries, metal finishing industries.

*Text books:-*

1. S.P.Mahajan., Pollution control in process Industries, Tata McGraw hill publishing company.

2. Arcadio P. Sincero and Georgia Sincero., Environmental Engineering

3. Environmental Pollution Control., by C.S.Rao, wiely eastern ltd.

**CHEM-1.2.5 - Elective-III**

**CHEM-1.2.5 (A) – ELECTIVE-III (Petroleum Refinery Engg-II)**

***Objective:***

To know about various production processes for the manufacture of C1 to Aromatic Compounds.

To know the design aspects to be taken into consideration for the designing of various equipments used in the process.

***Outcome****:*

1. Able to understand the processes and mechanisms of various production processes of C1 to Aromatic compounds.

2. Able to understand the design aspects of various equipment used in the production processes.

***Syllabus****:*

Raw materials for petrochemicals - Refinery process and petrochemical feed stocks - pyrolysis for petrochemical feed stocks - separation of individual hydrocarbons by fractionation.

Petrochemicals from C1, C2 , C3 & C4 fractions. Petrochemicals from aromatic feed stocks.

*Design of petrochemical equipment:* Pyrolysis furnace, Pyrolysis reactor (Ethane Cracking or propene cracking).

Super fractionator ( Ethyane - Ethylene, Propene - Propylene, Ethyle Benzene - styrene).

Fixed bed reactor ( Ethyle Benzene - Styrene).

Multiphase reactor ( Oxo synthesis).

*Text Books :*

1. Ethylene & its derivations - S.A. Miller

2. Propylene and its derivations - E.G. Hancock.

3. Benzene, Toluene, Xylene and their Derivations. E.G. Hancock.

**CHEM-1.2.5 (B) – ELECTIVE-III (Process dynamics and control-II)**

***Objectives*** *:*

The main purpose of teaching Process Dynamics and Control as elective-II for M. tech second year postgraduate students is to make them to understand the unity in outlook that has been lacking in the field of chemical reactor design. The stability viewpoint does in a sense in diverse areas like stirred tank reactor, plug flow reactor. The course in common emerge as qualitative description of the behavior of the respective models, for the stability viewpoint deals with certain structural aspects present in both problems.

*Outcome:*

\* The student should be able to know a brief introduction about the most common chemical reactor models. The subject of steady state multiplicity in stirred tank reactors and develops uniqueness criteria for various cases that may be of interest for design.

\* The student should be able to know the interpretation of terms such as steady and stable. The student should have knowledge to explore the implications of the stability concept in dealing with finite disturbances of practical magnitude.

\* The student should be in a position to analyze from ordinary differential equation models to partial differential equation models.

\* The student should be in a position to understand the steady state multiplicity, local stability, and regional stability are treated for distributed systems.

*Syllabus:*

**Unit I :** Mathematical modeling of reactors - Mass and energy balance equations for CSTR,PFTR, TRAM, TRRM, catalyst particle - multiphase models.

Lumped parameter model - steady state multiplicity of a CSTR- Van Herden diagram - criteria for uniqueness of steady state for isothermal and temperature dependent reactors and multiphase systems - design consideration.

**Unit II :** Geometry of dynamics for a lumped parameter model - stable and unstable steady states - phase plane for the CSTR and eigen values - linear second order system and eigen vector - Liapunov stability criterion and Liapunov functions - fundamental linearization theorem - local stability and steady state operating curves for a temperature - dependent reactor.

**Unit III :** Region of asymptotic stability and v-function in x-space - Krasovskil’s theorem and V-function in f-space.

Unit IV : **Steady states in distributed parameter systems - uncoupling the energy and mass balances for TRAM model - Steady state models of a PFTR and parametric sensitivity - Steady state multiplicity of a TRAM and catalyst particle model - uniqueness criteria for fixed bed reactors.**

**Unit V** : Local stability of distributed parameter systems - the techniques of linearization of nonlinear differential equations and uncoupling of certain transient conservation equations - applications of these techniques to the cases of catalyst particle and TRAM.

Methods of solution of transient mass and energy balance quations applied to catalyst particle model and TRAM - Galerkin method - Collocation method.

*Text Book:*

1. Stability of Chemical Reactors by Daniel D. Perlmutter, John Weily and Sons Inc. (New York, (1976).

**CHEM-1.2.5 (C)- ELECTIVE-III (Electro Chemical Engineering-II)**

The main objectives are to provide:

1. Knowledge on Electroplating, Electroforming, electro refining, electro wining.

2. Knowledge on Electrolysis and Manufacturing process.

3. Knowledge on primary & secondary batteries and fuel

*Outcome:*

1. Acquires knowledge on electrochemical ore beneficiation techniques, electroplating, electro refining and electro winning.

2. Able to work in commercial and industrial manufacturing units using electrolysis.

3. Familiarize with batteries and components like separators, binder, electrolyte, and additives used in batteries.

4. Familiarize with the characterization methods of batteries, e.g. charge/discharge cycles, overpotential, battery capacity, state of charge, state of health, impedance.

5. Familiarize with the Fuel cells.

Syllabus:

**Part –A**

Electroplating, Electroforming and Electrophoresis

Electrorefining of metals - Copper, Silver, Gold, Nickel, Lead and Cobalt.

Electrowinning of metals - Copper, Zinc, Cadmium, Chromium and Manganese.

Electrolysis of Alkali Halides and Sulfates - Chlorine and Caustic, Potassium halides, Hydrochloric acid, Fluorine and sodium sulfate.

Manufacture of Hydrogen and Oxygen. Electrolytic Reduction and Oxidation - Persalts, Cuprous oxide, Mercuric oxide, Manganese dioxide and Perchlorates.

Electrolysis of fused Salts - Aluminum, Magnesium, Sodium, Beryllium and Zirconium.

**Part –B**

Batteries: Classification of cells and batteries, theoretical cell voltage, capacity, energy, electrochemical principles and reactions

Primary batteries: Zinc carbon batteries(Leclanche and Zinc chloride cell system), Magnesium and Aluminum batteries, Alkaline manganese dioxide batteries, Lithium batteries.

Secondary batteries: Lead acid batteries, nickel cadmium batteries, nickel metal hydride batteries, lithium ion batteries, rechargeable zinc, alkaline, manganese dioxide batteries

Fuel cells: Molten carbonate fuel cell(MCFC), phosphoric acid fuel cell(PAFC), Solid oxide fuel cell (SOFC), proton exchange membrane fuel cell(PEMFC).

*Textbooks:*

1. Electrochemical Engineering by Mantell, C.L. McGraw–Hill

2. Electrochemistry Principles and Applications Edmund Potter, Cleaver–Hume Press Ltd.

3. Handbook of batteries by David linden and Thomas B Reddy, McGraw –Hill

**CHEM-1.2.6- ELECTIVE-IV**

**CHEM-1.2.6 A-ELECTIVE-IV (Corrosion Engineering-II)**

***Objectives:***

\* To enable the principles of corrosion, common corrosion forms, uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement corrosion control methods, and material selection to reduce corrosion cost.

\* To enable the ability to understand electrochemical fundamentals

\* To enable the ability to understand corrosion preventing methods

*Outcome:*

\* The student would know application of weight loss method

\* The student would know application of cathodic protection, anodic ptotection

\* At the end of this course, the student would know effective surface preparation of specimen can be done

\* After completion of this course, the student would understand the causes and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion.

\* The student would know application of Corrosion Processes and Evans Diagrams and application of electroplating, coatings and importance of inhibitors.

*Syllabus:*

Corrosion in selective environments: Marine, Acids (Sulfuric acid, Hydrochloric acid, Nitirc acid, Phosphoric acid) Biological and industrial gases (SO2H2S).

Corrosion Testing - Purposes, Materials and specimen. Surface preparation, Measuring and weighing , Exposure Techniques - duration, Planned - Interval Tests, Aeration, cleaning specimens after exposure, Temperature, Standard expression for corrosion rates - Galvanic Corrosion, Erosion Corrosion, crevice Corrosion, Intergranular corrosion, test for stainless steels, warren test pitting, stress corrosion, Paint tests, Sea Water tests, Presenting and summarizing data - Nomo graph for corrosion rates and interpretation of results.

Cathodic and anodic protection, surface preparation for coatings and chemical conversions: Degreasing, Descaling , Polishing - Anodized coating : anodizing oxidizing, chromate coating, phosphate coatings - Metallic coatings : Hot dipping, cementation, vapor deposition of metallic coating; Sprayed coatings: flame spraying plasma spraying, Galvanizing - Electroplating : Nickel & chromium coatings, chromizing.- Organic coatings : paints, enamels, lacquers, resin mixtures.

Linings, laminates, reinforced plastic, fibre glass - Corrosion inhibitors: mechanism of inhibition, recirculating of water of water systems Measurement and testing of preventive coatings ; Thickness and Resistance tests for anodized, Painted, electroplated surfaces using polarization resistance, Linear polarization, curve fit analysis and Electrochemical impedance spectroscopy.

*Reference books :*

1. Mars GFontana - Corrosion Engineering

2. Burns, R.M., Bradley, W.W., ‘protective coatings for Metals.’ Chapters 2 to 18.

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**CHEM- 1.2.6 (B) - Elective-IV (Energy Engineering-II)**

*Objectives:*

The student is provided with the fundamentals of some renewable energy processes. Basic information to comprehend the various non-conventional energy systems would be gained by the student.

*Outcome:*

1. Methods to be adopted to utilize biomass as an important energy source.

2. Application of thermodynamics to convert ocean energy.

3. Possible mechanism to drawn energy from wind and other natural sources

4. Fuel cells as sources of energy.

5. New technologies to produce energy such as thermionics, thermoelectricity etc.

*Syllabus:*

Non – Conventional & New Energy Systems and Energy Conservation Technology

Systems based on bio mass Physical and Bio mass – Definition – potential thermo – chemical methods of Bio - Conversion – Gasification – Liquefaction – Pyrolysis.

Bio-gas technology – Historical review and development in India Different designs of bio-gas jplants – Selection of a model and size – Installation – Gas collection and distribution – operation and maintenance – Properties and uses of bio-gas – Utilization of manure – National Projects for Bio – gas development – safety.(Bansal et at,chapters 10 and 11; Khandelwal and Mahdi, Chapters 3,4,5,6,7,8,9,10: Chawla,chapters 2,3,4,5,6,7 & 8).

Fuel Cells : Hydrogen – Oxygen Fuel Cells – carbonaceous Fuel Cells – Molten Alkali Carbonate Cells – Electrode Reactions and kinetics. (Fuel Cells by Young).

Energy Wind, Tidal and OTEC

Potential in India – Origin of wind and general circulation systems of Earth – Wind direction – Wind measurement – Wind energy converters – Historical development – Power coefficient – Aerodynamic construction of a rotor blade Rotors – Wind electric generators in India – Economics of wind farm – Fundamentals and concepts of Wave energy – Ocean thermal – energy conversion (OTEC). (Bansal et at., Chapters 12,13 & 14).

Hydrogen Energy, Methanol & Ethanol

Hydrogen from fossil fuels from Electrolysis – Developments of various electrolytic cells – High pressure cells – Solid electrolytic systems – Hydrogen powered IC engines – Storage system – Handling and Transmission.(Journals on Hydrogen energy).

Methanol and Ethanol as Automobile fuels – Comparison with Gasoline and Diesel oil. (Journals on Hydrocarbon on processing).

Energy Conservation Technologies:

Principles of Energy Conservation – Optimum Energy Conservation – Industrial Energy Conservation modeling – waste heat recovery and utilization.

*Prescribed Books:*

1. Renewable Energy Sources and Conversion Technology, N.K.Bansal, Manfred Klieemann,Michael Meliss, tataMcGraw Hill, 1990.

2. Bio Gas Technology, A practical hand book Vol 1, K.C.Khandelwal and S.S.Maholi, TataMcGraw Hill, 1986.

3. Advances in Bio Gas Technology: O.P.Chawla,publications and Information Division, Indian council of Agricultural Research,New Delhi, 1986.

4. Alternative Energy Sources: R.H .Taylor, Adam Hilger Ltd.,Brister.

5. Fuel cells, Vols.I & II: Reinhold publishing Crop.,New York.

6. International journal of hydrogen Energy, Vol.5, No. I, 1980 pages 1- 84: No.2, pages 119-129; pages 151-203; No.5. Pages 527 – 534 & 539 – 553; No.6, Pages 611 – 625.

7. Hydro Carbon Processing Vol. 58, May 1979 pages 127 – 138:Vol. 59, Feb. 1980, pages 72–75.

8. Handbook of Industrial Energy Conservation, David Hu, S., Van Nostrand Reinhold Company pages 73 – 133, 149-199, 297-327.

**CHEM- 1.2.6 (C) - Elective-IV (Reaction Engineering-II)**

*Syllabus:*

UNIT - I : Laboratory Reactors - Interpretation of Experimental Data - Interpretation of Laboratory Kinetics Data - Homogeneous and Heterogeneous Laboratory Reactors. Calculation of Global Rate - The structure of Reactor Design. (Scope: Chapter 12 of J.M Smith 3rd Edition)

UNIT - II : Design of Heterogeneous Catalytic Reactors Isothermal and Adiabatic Fixed Bed Reactors Non-isothermal, Non-adiabatic Fixed Bed Reactors. (Scope: Chapters 13.1 - 13.9 of J.M Smith 3rd Edition)

UNIT - III : Design of fluidized bed Reactors - Two -Phase Fluidized Bed model - Operating characteristics - Slurry Reactors - Trickle - Bed Reactors - Optimization. (Scope: Chapter 13.10 - 13.13 of J.M Smith 3rd Edition.)

UNIT - IV : Fluid - Solid Noncatalytic Reactions - Design concepts - Single Particle Behavior - Reactor Models. *(Scope: Chapter 14 of J.M Smith 3rd Edition)*

UNIT - V : Short notes from the portions of all the above four units. Four bits are to be answered out of 7 bits (Not more than 2 bits to be given from any one Unit).

***Text Book:***

1. Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book Company , 1980, 3rd Edition.

 **SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH(MINERAL PROCESS ENGG) FIRST SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

MPE-1.1.1 Process Modellling &
 Simulation 4 3 1 — 4 30 70 100

MPE-1.1.2 Process Dynamics &
 Control 4 3 1 — 4 30 70 100

MPE-1.1.3 Chemical Reaction
 Engg 4 3 1 — 4 30 70 100

MPE-1.1.4 Transport Phenomena 4 3 1 — 4 30 70 100

MPE-1.1.5 Elective-I 4 4 — — 4 30 70 100

MPE-1.1.6 Elective-II 4 4 — — 4 30 70 100

MPE-1.1.7 MPE lab 2 — — 3 3 50 50\* 100

MPE-1.1.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

*\*Only internal evaluation.*

Elective-I: 1.Geology-1

 2. Petroleum Refinery Engineering-I

 3.Electrochemical Engineering-I

Elective-II: 1. Corrosion Engineering-I

 2. Energy Engineering-I

 3. Reaction Engineering-I

 **SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH (MINERAL PROCESS ENGG) SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

MPE-1.2.1 Mineral Process
 Engg., -I 4 3 1 — 4 30 70 100

MPE-1.2.2 Mineral Process
 Engg.,-II 4 3 1 — 4 30 70 100

MPE-1.2.3 Processing of Ores 4 3 1 — 4 30 70 100

MPE-1.2.4 Coal Preparation 4 3 1 — 4 30 70 100

MPE-1.2.5 Elective - III 4 4 — — 4 30 70 100

MPE-1.2.6 Elective - IV 4 4 — — 4 30 70 100

MPE-1.2.7 MPE lab 2 — — 3 3 50 50 100

MPE-1.2.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

Elective-III :

1. Analytical techniques in Mineral Engineering

2. Petroleum Refinery Engineering-II

3. Electrochemical Engineering-II

Elective-IV:

1. Corrosion Engineering-II

2. Energy Engineering-II

3. Reaction Engineering-II

 **SCHEME OF INSTRUCTION & EXAMINATION**

**2/2 M.TECH (MINERAL PROCESS ENGG) FIRST &
SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

***PROJECT WORK:***

**MPE-2.1.1 - FIRST SEMESTER: CREDITS:10, MARKS:100**

**MPE-2.2.1- SECOND SEMESTER: CREDITS:14, MARKS:100**

\* Project guide will be allotted at the beginning of first semester and the student has to give presentation on his/her project work at the end of first semester and grading will be awarded as A,B,C or F.

\* At the end of second semester final viva-voce examination will be conducted and grading will be awarded as A,B,C or F.

**SYLLABUS : M.TECH. I SEMESTER**

**MPE-1.1.1: PROCESS MODELING AND SIMULATION**

**(Common for CHEMICAL, CACE & IPCE )**

*Objective:*

Process Modeling and Simulation is a important subject of study for Post Graduate Chemical Engineers. It deals with writing various process models based on basic physical process. It also deals with solving the various models by means of various numerical methods by computer simulation. By studying this course ,one can simulate various chemical process by computer simulation .

*Outcome:*

Understand the writing of a model of a process based on basic physical processes like mass ,momentum and energy balances

1. Develop a model equation for Tanks, Isothermal and Non-Isothermal Systems

2. Understand the models for Binary Distillation Column, Batch Reactors etc

3. Solve the model equations by Numerical methods like Euler and Runge –Kutta etc.

*Syllabus:*

Principles of formulation - Continuity equations – Energy equation – Equation of motion – Equations of state – Transport equations – Chemical Kinetics – Algebraic and Integral / differential equations, Explicit and Implicit equations –Numerical Integration,Feed forward and feed backward control.

Basic modeling for tank system, mixing vessel – Simultaneous mass and energy balances – Models for boiling, batch distillation, and partial condenser.

Models for Reactor – Model for heterogeneous catalysis – Models for pumping system – Model for heat exchanger.

Operational blocks in simulation- Simulation Programming – Simulation examples of three CSTR’s in series, gravity flow tank, binary distillation column, non–isothermal CSTR.

Implicit function convergence ,Internal–halving convergence, Newton–Raphson method, False position convergence, Explicit convergence methods, Numerical Integration, Euler Integration, Runge - Kutta (fourth order) method.

*Textbooks:*

1. Process Modeling, Simulation and Control for Chemical Engineers by Luyben, W.L., McGraw Hill Books Co.

2. Mathematical Modeling in Chemical Engineering by Roger, G.E. Franks – John Wiley Sons Inc.

*Reference Book:*

1. Mathematical Methods in Chemical Engineering by V.G. Jenson and G.V. Jefferys, Academic Press – 2nd Edition.

**MPE-1.1.2: PROCESS DYNAMICS & CONTROL**

**(Common for CHEMICAL, CACE & IPCE )**

***Objectives*** *:*

 The main purpose of teaching Process Dynamics & Control for first year postgraduate students is to take the student from basic mathematics to a variety of design applications in a clear, concise manner. This course is focused on the use of the digital computer in complex problem solving and in process control instrumentation. For chemical engineering problem solving students need more advanced mathematical preparation like partial differential equations, linear algebra and Fourier series all are introduced in this course.

*Outcome:*

\* Able to know the sampled data control systems consists of sampling and advanced mathematical model Z- transforms.

\* Able to describe the process in which the flow of the signals is interrupted periodically like in chromatograph.

\* Able to calculate the open loop response of a sampled data system and can develop a pulse transfer function that is the counterpart of the transfer function for continuous systems.

\* Able to know the sophisticated instruments used for the analysis of water and air pollutants.The student should have knowledge to design the equipment used for the abatement of these pollutants.

\* In a position to modernize the solid waste management and the student must be in a position to get awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

*Syllabus:*

Review of time domain, Laplace domain and frequency domain dynamics of process and control system.

Sampled data control system – sampling and Z–Transforms , open loop and closed loop response, Stability.

State space methods – representation of physical systems – transfer function matrix – Multivariable systems – Analysis and control.

Non linear control –examples of non linear systems – Methods of phase plane analysis.

Control of heat exchangers, distillation columns and Chemical Reactors.

*Textbooks:*

1. Process system Analysis and control, 2nd edition, Donald R Coughanower and Koppel.

2. Automatic process Control by Peter Harriot.

3. Process Modeling, Simulation and control for Chemical Engineers by W.L. Luyben.

**MPE-1.1.3: CHEMICAL REACTION ENGINEERING**

**(Common for CHEMICAL, CACE & IPCE)**

*Objectives:*

\* To focus on the thermal characteristics of various reactions and the design aspects of non isothermal and adiabatic reactors

\* To focus on Heterogeneous data analysis and design

\* To focus on CVD reactors

\* To study the design aspects of heterogeneous catalytic systems

\* To impart the knowledge on mass transfer with reaction in process catalysts

*Outcome:*

\* Enables the students to understand the design aspects of non isothermal and adiabatic reactors

\* Enables the students to on heterogeneous data analysis and design aspects of heterogeneous catalytic systems

\* Able to derive the rate laws for CVD

\* Able to develop the rate laws for heterogeneous fluid solid catalyzed reactions under rate limiting situations.

*Syllabus:*

Review of Fundamentals Rate laws and stiochiometry, reactions with phase change (Scope: Chapter 3 of Fogler) Least squares Analysis of rate data: differential reactors: Laboratory reactors (Scope: sections 5.4 to 5.6 of Fogler) Multiple reactions (Scope: Chapter 9 of Fogler).

Isothermal reactor design (Scope: Chapter 4 of Fogler) Batch reactor, PFR, CSTR design. Pressure drop in reactors, Reversible reactions, unsteady state operation of reactors, Simultaneous reaction and separation

Catalysis and catalytic reactors (Scope: Chapter 6 of Fogler) Steps in catalytic reaction: derivation of rate laws, design for gas-solid reactions, heterogeneous data analysis and design; Chemical vapour deposition, catalyst reactivation, moving bed reactions.

Diffusion and reaction in process catalysts (Scope: Chapter 11 of Fogler).

Diffusion and reaction in spherical catalyst.

Internal effectiveness factor, falsified kinetics; estimation of diffusion and reaction limited regimes. Mass transfer and reaction in packed bed. Determination of limiting situations from reaction data, CVD reactors.

Non-isothermal reactor design (Scope: Chapter 8 of Fogler), Energy Balance, equilibrium conversion under adiabatic conditions unsteady state operation, multiple steady states.

***Textbook:***

Fogler. H.S: Elements for Chemical Reaction Engineering 2nd Edition, Prentice Hall, New Delhi, 1992.

***Reference:***

Smith J.M: ‘Chemical Engineering Kinetics’ 3rd Edition, McGraw Hill, 1981.

**MPE-1.1.4 : TRANSPORT PHENOMENA**

**(Common for CHEMICAL, CACE & IPCE)**

*Objectives:*

\* To be able to analyze various transport processes with understanding of solution approximation methods and their limitations.

*Outcomes:*

\* Ability to understand the chemical and physical transport processes and their mechanism.

\* Ability to do heat, mass and momentum transfer analysis.

\* Ability to analyze industrial problems along with relevant approximations and boundary conditions.

\* Ability to develop steady and time dependent solutions along with their limitations.

*Syllabus:*

**Unit 1: Momentum Transport**

1.1 The Equations of change for isothermal systems.

1.2 Velocity distributions with more than one independent variable.

1.3 Velocity distributions in turbulent flow.

1.4 Inter phase transport in isothermal systems.

**Unit 2: Energy Transport**

1.1 The Equations of change for non – isothermal systems.

1.2 Temperature distributions with more than one independent variable.

1.3 Temperature distributions in turbulent flow.

1.4 Interphase transport in nonisothermal systems.

**Unit 3: Mass Transport**

1.1 The Equations of Change for multicomponent systems.

1.2 Concentration distribution with more than one independent variable.

1.3 Concentration distribution in turbulent flow.

*Textbook:*

“Transport phenomena” R. Byron Bird, Warren E. Stewart and E.N. Light foot, Wiley & Sons, Inc., New York.

*Reference Books:*

1.”Fundamentals of Momentum, Heat and Mass Transfer” James R. Welty, Charles E. Wicks and Robert E. Wilson, John Wiley & Sons, Inc., New York.

2. “Boundary – Layer Theory”, Dr.H.Sehlichting, McGraw – Hill Book Company, New York.

**MPE-1.1.5: Elective – I**

**MPE- 1.1.5 A - Elective-I (Geology-I)**

*Objectives:*

Geology is one of the core subjects not only for Engineers who are working in the mineral industry but also important for everybody to have better understanding of the surrounds. Following are the main objectives of the learning Geology:

1. To know about the history of the earth and its interior

2. To make the people learn about the materials available in and on the earth.

3. To know about the different natural process responsible for the formation of materials

4. To know about the things surrounded the earth’s surface.

5. To familiar with dynamic processes causing for damage on the human -beings

6. To locate the new useful materials used as raw materials.

7. To educate the students know much about the stable places on the surface

8. To procure knowledge about the suitability of the dam constructions

*Outcome:*

Students are able to know about the following things:

1. Able to identify the useful materials in the form of ore minerals

2. Site selection for construction purposes dams/massive multistoried building etc

3. To know how to protect the environment to reduce the pollution

4. To have knowledge about the distribution of mineral resources

5. Come to understand about the process of nature beatification

6. Knowledge in the field lead to become a responsible citizen to protect nature

*Syllabus:*

**Unit I General Geology : Introduction to geotogy**

a) Origin of the earth

b) Interior of the earth (crust, Mantley core)

c) Crustal abundance of elements

d) Crustal abundance of rocks and minerals

**Unit II. Mineralogy:**

a) Symmetry elements of crystals.

b) Normal classes of six crystalorgraphic systems.

c) Physical & Chemical Properities of minerals.

d) Origin of minerals (i)Endegenetic (ii) Exegenetic.

e) Occurrence of mirerals.

**Unit III. Elements of petrology:**

a) Igneous rocks: Modes of occurrence, Texture and structures, Bowens reaction principles, Classification.

b) Sedimentary Rocks : Mode of formation, Textures and structures, classification.

c) Metamorphic Rocks: Agents of metamorphism, Zones of progressive meatamophism, Textures and structures.

**Unit IV. Structural Geology:**  Dep and strike. Folds, faults, Joints, and Unconfirmities.

**Unit V. Stratigraphy:** Introduction Time scales Stratigfraphic units distribution in India ( Age wises)Important stratigraphic units and their economic importance. (i) The Archaen group (ii) The Cuddapah Sysstem (iii) The vindhyam system (iv) Thje Gondwana Group (v) The tertiary group.

*Text Books:*

1. An introduction to crystal Chemistry by R.C. Evans.

2. A. Textbook of Mineralogy by Dana.

3. Rutley’s elements of Mineralogy By H.H Read.

**MPE- 1.1.5 B - Elective-I (Petroleum Refinery Engineering-I)**

***Objective:***

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

*Out come:*

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

*Syllabus:*

***Origin and formation of petroleum***: Reserves and deposits of the world - Indialn petroleum industry - Composition of crudes.

***Refinery products specifications and test methods***: Evaluation of crudes. Crudes Pretreatment dehydration and desalting. Physical properties of petroleum oils and products. Introduction to processing- Refinery distillation - processes - catalytic cracking, Reforming Hydro cracking , and hydro treating, hydrosulfurization.

***Chemical treatments & Extraction Processes*** *:* Alkylation, polymerization Lube oil processing.

**De-waxing** : Asphalt and air blown asphalt. Treatment of products, additines, blending of gasoline, treatment of gasoline, Kerosene etc.,

***Heat transfer equipment in Refinery***- Heat exchangers and pipe still heaters. Design of atmospheric distillation tower and Vacuum distillation tower, catalytic cracking units.

*Text Books :*

1. Petroleum Refinery Engineering - Nelson.

2. Refinery distillation - Watkins.

**MPE- 1.1.5 (C) - Elective-I (Electrochemical Engineering-I)**

*OBJECTIVES:*

\* To enable the basic principles of electrochemistry, electrochemical devices, electro active materials used in such devices, and case studies of batteries.

\* To enable the clean energy needs and demands especially in the electrochemical power generation sector; and to become educators, practicing engineers, and national leaders in electrochemical energy conversion and storage.

\* To enable the integrated skills in fundamentals of electrochemistry (e.g.; chemistry, physics, mathematics, thermodynamics, and chemical kinetics) and electrochemical engineering applications (batteries, solar, flow and fuel cells, electrochemical synthesis and corrosion) to ensure successful career opportunities and growth within electrochemical power generation industries and academia.

\* To enable the students in energy related programs such as clean power generation and future green technologies.

*OUTCOME:*

\* The student would know how to solve the problems relating to the production, storage, distribution and utilization of electrochemical energy and the associated environmental issues. And he would know integration of electrochemical principles and materials science for application in modern electrochemical devices.

\* The student would know design and conduct experiments, acquire data, analyze, interpret data, solve practical and complex problems on a variety of electrochemical devices such as batteries, solar cells, flow and fuel cells and integrate the professional, ethical, social and environmental factors in electrochemical engineering and understand the impact of these factors on global energy issues.

***Syllabus:***

***Introduction:***

Unit I : Basic Concept: Mechanism of Electrolysis, Laws of Electrolysis, Curent and Voltage Efficiency - Electrolytic dissociation, Coulometers, Ionic conduction. Electrolytic conductivity, Absolute ionic velocities, ionic mobilities, Transference Nos. Modern Ionic Theory, Ionic activity Degree of dissociation. Ionic Atmosphere Time of relaxation and relaxation effect, Electrophoretic effect - Debye - Huckel Onsager equation of conductance (Derivation is not required) and its validity.

Unit II: Thermodynamics I: Chemical Potential and Free Energy changes. Cell and Electrode potentials. Thermodynamics of Electrode potentials - Nernst Equation. Equilibrium Constant, Arbitrary Zero of potential, EMF series and their limitations Activity Coefficient of and their evaluation, Liquid Junction potentials, Concentration Cells - Reference Electrodes.

Unit III : Thermodynamics II : Electrode Kinetics, Role of Interface, Electric Double Layer and its capacitance - Irreversible Electrode processes - Irreversibility, Tates of Electrode Processes. Electrode Kinetics Model, Cathodic Hydrogen evolution, Depolarisation - Overpotential, Tafel Equation, Ohmic or resistance Over potential, Concentration overpotential, Oxygen Evolution reaction and Decompostion potential, Ionic Transport by Migration, Diffusion and Convection - Mass transfer.

Unit IV : Kenetics of Corrosion Processes and Evans Diagrams : Electrokinetic phenomenon - Straming potential, zeta potential and Electro - Osmosis, Electrophoresis, Dorn Effect.

Measurements and Systems Analysis : Conductivity measurements - Conductometric analysis - Titrations, Measurements of pH, potential - potentiometric titrations, Polarography Electrogravimetry, Coulometry. Current Distribution in a cell. Rotating Disc Electrode, Rotating Cylinder electrode, Rough Surface Electrode Limiting Current Technique.

Unit-V: Potential relations in corrosion cells potentials, pH diagrams in corrosion. Corrosion theory : Manifestation of corrosion, bases of electrochemical corrosion, amount and intensity of corrosion, Eight forms of corrosion : Uniform attack, Galavanic corrosion, crevice corrosion,Pitting, inter granular corrosion. Selective leaching, stress corrosion cracking. Conditions leading to pitting attack., environmental factors, hydrogen damage. Corrosion inhibition and prevention : Domestic water supplies, recirculating water systems, corrosion inhibitors, Inhibitors for acid pickling, vapor phase inhibitors. Coatings and paits: Phosphating, Protective metal coatings; cathodic protection and corrosion of buried structures.

*Textbooks:*

1. An Introduction to Electrochemistry by Samuel Glasstone, D. Van Nostrand Company Inc princeton, Affiliated East-West press Pvt. Ltd.

2. Electrochemistry - Principles and Applications by Edmund C. Fotter Oliver Hume Press Ltd., London.

***Reference Books:***

1. Electrochemical Engineering, Principles, by Geofferey Prentice, The Johns Hopkins University, Prentice Hall, Englewood Cliffs, New Jersy, 07632.

2. Electrochemistry - Bookris and A.K.Reddy.

3. Electrochemical Engineering by C.L.Mantell.

4. Principles of Electrochemical Engineering by L.W.Shemilt.

5. Chemical Engineering Development Centre, Indian Institute of Technology, Madras 600 036.

6. Fontanna and Grene ‘Corrosion Engineering’.

**MPE-1.1.6: Elective –II**

**MPE-1.1.6 A - Elective-II (Corrosion Engineering-I)**

The main objectives are to provide:

1. Basic aspects of electrochemistry relevant to corrosion phenomena,

2. Importance and forms of corrosion.

3. Knowledge on corrosion rate expressions and measurement techniques.

4. Knowledge on factors influencing corrosion of iron and steel exposed to atmospheric, soil and aqueous medium.

5. Basic knowledge on remedial measures for corrosion.

*Outcome:*

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion, corrosion tendency and electrode potentials.

2. Able to identify the nature of corrosion and form in which it attacks(Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage .

3. By acquiring knowledge on polarization and its influence on corrosion rates will be able to measure corrosion rates and analyze.

4. Acquires knowledge on mechanism and propose viable remedial measures.

*Syllabus:*

Basic Concepts and Outlines of Electrochemistry: Fundamentals of Electrochemical reactions, Faraday’s Laws Electrolytic and ionic conductance, ionic mobility’s, Transport Nos. Galvanic Cell and Electrolytic cells.

Definition and importance of corrosion, Dry cell, analogy, Corrosion Cells, Types of Corrosion Cells- a) Dissimilar electrode cells b) Concentration cells such as a salt concentration cells, differential aeration cells c) differential Temperature cells. Corrosion Rate Expresions - mdd, ipy, cpy, mpy, etc.

Corrosion Tendency and Electrode Potentials: Free Energy changes, Development of Nernst Equation for calculation of Half-cell potentials, Hydrogen electrode, Spontaneity of a reaction, Reversible cells and potentials – convention of Sign and calculations of EMF from standard Equilibrium potentials., EMF Series and Galvanic series, Reference Half Cells – Calomel, Silver-Silver Chloride and Saturated Copper-Copper Sulphate Half Cells. Pourbaix Diagram for Iron, Aluminum and magnesium, limitations of pourbaix diagrams.

Polarization and Corrosion Rates: Polarization and a Polarized Cell, Causes of Polarization – Concentration Polarization, Activation Polarization and IR drop. Hydrogen Over potentials, combined polarization and Mixed potential theory. Tafel Slopes and Tafel Equation. Graphical method of expressing Corrosion Reactions (Polarization diagrams/Evans diagrams), Derivation of Stern-Geary Equation, Influence of Polarization on Corrosion rates.

Passivity: Characteristics of Passivation, Flade potential, behavior of passivators, transpasivity, Theories on Passivity.

Forms of Corrosion: Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage. Factors influencing, mechanisms and prevention techniques for all forms of corrosion. Calculation of Corrosion rates using weight lost method and Polarization data. Electrochemical Impedance Spectroscopy.

Effect of Dissolved Oxygen (Air saturated Water, High Partial Pressure of Oxygen and Anaerobic bacteria), Temperature, pH, Galvanic coupling, velocity, dissolved salts concentration. Wet and dry corrosion.

*Textbooks :*

1. Corrosion and Corrosion Control by Herbert, H. Uhlig John Wiley and Sons Inc., New York.

2. Corrosion Engineering by Mars F Fontana, McGraw Hill.

3. An Introduction to Electrochemistry by Samuel Glass stone, Affiliated East West Press Pvt. Ltd.,

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths,
London.

**MPE- 1.1.6 B - Elective-II (Energy Engineering-I)**

**Objectives:** To lean overview of solar radiation and it’s potential for collection to meet the energy needs of mankind and potential for solar energy option. To learn measuring techniques of solar radiation and its compilation.

To learn various design and operational aspects of solar energy collection and storage.

To learn the design and operation of solar energy appliances like liquid flat plate collectors, Solar Air Heaters, Thermal energy storage, Thermal energy storage, Solar Pond, Solar thermal power generation.

To learn theory and application of Photovoltaic cells

**Outcome:** The student learns collection and design of various kinds of equipment operated on solar energy. The student learns principles and practice of Photo voltaic cells.

*Syllabus:*

**The Solar Energy option :** Thermal conversion – collection and storage Thermal applications – photovoltaic conversion – wind energy – Energy from Bio – mass – ocean thermal energy conversion.

**Solar Radiation :** Solar Radiation outside the earths – atmosphere Solar radiation at the Earth’s surface – Instruments for measuring Solar Radiation – Solar Radiation data – Solar Radiation Geometry Empirical equations for predicting the availability of Solar Radiation – Solar radiation on tilted surface.

**Liquid flat – Plate Collectors :** Components of liquid flat plate – various types of collectors – Performance Analysis – Transmissivity – Absorptivity product – Overall loss coefficients and heat Transfer correlations – Collector efficiency heat removal factors – effect of various parameters on performance. Transient Analysis – Testing procedures.

**Solar Air Heaters :** Various types of solar Heaters – Performance Analysis of a conventional Air Heater – Testing procedures – Concentrating collectors – various types of concentrating collectors cylindrical and parabolic collectors – General receiver collectors.

**Thermal energy storage :** Sensible heat storage – Latent heat storage – Thermochemical storage.

Solar Pond Description – Performance analysis – Experimental studies – Operational Problems.

**Solar Air Conditioning and Refrigeration :** Heat pump cycle – Coefficient of performance of the heat pumps – solar air-conditioning with absorption – Refrigeration system (Ammonia water and lithium bromide – water systems).

**Solar thermal power generation :** Thermal and direct electricity generation – Major sub-stations of a solar thermal power plant, Examples of installed systems – Concentration ratio. Temperature and efficiency concepts – Solar farm and tower – Economics.

**Photovoltaic Energy Conversion :** Photovoltaic Energy Conversion Fundamentals – band theory of solids – Physical processes in a solar cell – Solar cell with light incidence – Solar cell module – Silicon Solar Cells – Copper Sulphate / Cadmium sulphide Solar Cells.(Banasal et at.,chapters 9;Taylor, chapters 6, pages 256-298.

*Text Books:*

1. Solar Energy: Principles of thermal collection and storage by S.P. Sukhatme, Tata McGraw Hill, New Delhi 1984 (Chapters 2 to 8)

2. Renewable energy sources and conversion technology by N. K. Bansal, M. Kleemann, Michael Mcliss, 1990 (Chapters 2 – 9).

**MPE- 1.1.6 (C) – Elective-II (Reaction Engineering-I)**

***Syllabus:***

**Unit I** : (Scope : J.M. Smith : Chapter 7): Heterogeneous Processes, catalysis, and absorption: Global Rates of Reaction – Types of Heterogeneous Reactions – The nature of catalytic Reactions – The Mechanism of catalytic Reactions – Surface Chemistry and Absorption – Absorption Isotherms – Rates of Absorption.

**Unit II** ( Scope : J. M. Smith: Chapter 8 : Solid Catalysts: Determination of surface area – Void Volume and solid density – Fore volume distribution – Theories of Heterogeneous Catalysis – Classification of catalysts – Catalyst Preparation – Promoters and Inhibitors Catalyst Deactivation (Poisoning).

**Unit III:** (Scope: J.M. Smith : Chapter 9): Rate equations for fluid – Solid Catalytic Reactions: Rates of adsorption, Desorption, Surface Reaction – Rate equations in terms of Fluid phase concentrations at the catalyst surface – Qualitative analysis of rate equation – Quantitative inter pretation of Kinetic data – Redox Rate equations.

**Unit IV:** ( Scope : Octave Levenspiel : Chapter 15) : Deactivating Catalysts : Mechanism of Catalyst Deactivation – The ratre of equation – The rate of equation from experiment – Batch – solids: Determining the rate for Independent Deactivation Batch – solids : Determining the rate of arallel, series or side – by – side Deactivation – Flowing solids experimental Reactors – Finding the Mechanism of Decay from experiment Design.

**UnitV**: ( Scope : J. M. Smith : Chapter 10) : External transport Processes in Heterogeneous Reactions: Fixed bed reactors – The effect of physical processes on observed rate of reaction – Mass and Heat transfer coefficients (fluid particle) in packed beds – Quantitative treatment of external transport effects – Stable operating conditions – Effect of external transport Processes on selectivity. Fluidised bed reactors – Particle – fluid Mass and Heat transfer Slurry Reactors – Mass transfer coefficients: Gas bubble to liquid (K1) – Mass transfer coefficients: Liquid to particle

(Kc) – The effect of mass – transfer on observed rates Trickle – Bed reactors – mass transfer coefficients: Gas to liquid (K1 ag) – Liquid to particle (kc ac) – Calculation of global rate.

*Text Books:*

1. Smith. J.M., “ Chemical Engineering Kinetics”, McGraw Hill book Company, New Delhi (Third Edition) 1981.

2. Octave Levenspiel, “ Chemical Reaction Engineering” , Wiley Eastern Limited – Second Edition – 1972.

***Reference Books*** *:*

1. Thomas, J.M. And Thomas, W.J. “ Introduction to the Principles of Heterogeneous Catalysis”. Academic Press Inc., New York 1967.

2. Carbnerry, James, J., “ Chemical and Catalytjic Reaction – Engineering”, McGraw – Hill, Engineering Series.

**II SEMESTER**

**MPE-1.2.1 - MINERAL PROCESS ENGINEERING-I**

**Objectives:**  Identification of ores and their constituents. Identification of various aspects of liberation and separation methods. To know various aspects of comminution like- principles of comminution, classification and operation of comminution equipment, industrial practice. To know the methods of laboratory sizing practice and industrial aspects of sizing equipment. To know Classification principles and application operation of mineral processing equipment.

**Outcome:** Able to know various aspects of comminution and their equipment.

***Syllabus:***

1. a) Concept of Mineral and ore: b) Constituents of ore - Chief minerals, associated minerals, rare minerals - elements in solid solution and gangue minerals; c) Mineral Processing - Scope, and objective; d) Liberation and separation Processes depending on physical including surface properties of minerals.

2. Size reduction: a) Crushing - Characteristics of Jaw and gyratory crushers, cone crushers, crushing rolls and stamp mills; b) Grinding - Rotary mills - Ball, tube and rod mills Fluid Jet pulverisers and vibration mills; c) Batch, continuous, open and closed circuit grinding.

3. a) Sizing and size determination in the laboratory by screening and its classification and sedimentation techniques, graphical presentation of date of size analysis; b) Reduction ratio, average particle size and surface area calculation ;. c) Industrial sizing and equipment.

4. Attributes of communication, laws of crushing - Rittinger, Kicks and Bond’s laws, work index and relative crushing efficiency and their applicability in industry.

5. Principles of flow of solids in fluids - Stocks and Newton’s equation, free and hindered settling and their application in classification for thickening, sorting and sizing including the relevant equipment.

*Text Book :*

Principles of Mineral Dressing by A.M. Gaudin and E.J. Pryior.

**MPE-1.2.2 - MINERAL PROCESS ENGINEERING-II**

***OBJECTIVE:***

Mineral Process Engineering course deals with various process for upgrading the original ores. Concentration of ore is an important section of mineral recovery. After successfully completing the course Mineral Process Engineers can know the various ores and their properties and various concentration methods. This is very useful course for Mineral Engineers.

*OUTCOME:*

1.Under stand the process of Heavy Media Separation and its applications

2. Understandthe process of Jigging and Tabling and its applications

3. Know the Electro static and Magnetic Separation and its applications

4. Understand the phenomenon Flotation Technique and its applications in industries

5. Understand the basic operation of Thickening and Filtration and Cyclone Separation operations

*Syllabus:*

1. Heavy media separation processes Materials for media, characteristics of media Industrial processes Equipment and flow sheets.

2. a) Principles of flowing film concentration - Tabling Wilfley Table and Prematric tabling and agglomeration tabling. b) Application of Principles of hindered settling defferntial acceleration and consolidation trickling - Typical hydraulic jigs and Prematric jigs.

3. Principles of magnetic and electro-separation process and equipment.

4. a) Flotation and agglomeration - Surface energy, absorption, contact angle and other physical aspects. b) Flotation Chemical aspects - Chemical reagents in flotation; c) Flotation technology different types of cells and Practice.

5.a) Miscellaneous Processes of benefication - Cyslone classifiers, hydrcyclone, spiral and hydraulic classifiers; b) Flow -sheet - Selection of process and machinery.

***Text Book:***

1. Principles of Mineral Dressing by A.M. Gaudin & E.J. Prior.

**MPE-1.2.3- PROCESSING OF ORES**

***Objective:***

The course titled ‘**Processing of Ores’** is designed to meet the objective that the students will understand various aspects pertaining to its origin, occurrence and enhancement of grade & yields and also the appropriate methods/techniques for eco friendly exploitation of different ore deposits.

***Outcome:***

1. After completion of this course the students will gain proper knowledge on suitable options of processing techniques

2. Development of skills in modification of process flow sheets.

3. Knowledge in prudential utilization and conservation of mineral resources,

4. Brightening the opportunities for their employability.

5. Base for taking up research work for innovation of more feasible techniques for optimization of production, energy consumption and environmental pollution control etc.

*Syllabus:*

**I. Introduction:** Principles of ore formation – magmatic segregation deposits – pegmatite deposits – igneous metamorphic deposits – hydrothermal deposits – sedimentary deposits – supergene sulphide deposits

**II. Mineral beneficiation techniques:** Size reduction – Screening – Separation of solids suspended in fluids –Froth flotation – Separation of solids from fluids – Magnetic and Electrostatic separation Methods

**III. Beneficiation of metallic ores:** Iron ores – Manganese ores – Copper ores – Lead & Zinc deposits – Bauxite deposits – Chromite deposits

**IV. Beneficiation of non- metallic ores:** White stone deposits – Refractory Materials – silica - feldspar – clays - Mica - asbestos – gypsum – pyrites – rock phosphate – coal & lignite

**V. Beneficiation of precious metals and beach sands:** Gold deposits – diamond deposits – beneficiation of uranium deposits, Beach sand - Ilmenite, Rutile, Zircon, Garnet, Monazite, Silliminate, etc.

***Textbook:***

1. “Ore deposits of India -their distribution and processing” by K.V.G.K. Gokhale and T.C.Rao

***References:***

1. The Practice of Mineral Dressing by F.B Michell, Class notes and Mining & Mineral Dressing Journals.

**MPE-1.2.4 - COAL PREPARATION**

***Objective:***

\* To get total insight on “coal” , its origin and formation, industrial uses and different techniques available to screen the coal in order to use in various industries.

*Outcome:*

\* Well versed knowledge on basic concepts including origin and formation of coal and its preparation for various industrial applications.

\* Knowledge on the important screening methods and classification methods.

\* Knowledge on coal and its industrial uses, which helps MPE specialization student to work in the coal related industry.

*Syllabus:*

1.Origin and formation of coal of Insitu and drift origin Classification of coal Goudwana coals and their distribution. Lignites and anthracites and their distribution.

2. Composition of coals Ash in coals (3) Ultimate and proximate analysis of coal coking coals, mining and stock poling and industrial utility of different types of coal.

1. Testing of coal, sink and fioat tests, washability curves.

2. Coal preparation - Principles in dry and wet methods. Washing techniques and methods, equipment and effidrence callculations.

3. a) Special types of crushers, screens and other equipment used in coal washeries for conveyance, dewatering and such other. Auxillary operation ; (b) Choice, selection, operation, maintenance instrumentation and automation in coal washeries.

*Reference Books:*

1. Chemical Engineers Practice, Vol. 3. Solid systems, Edited by H.W. Cremer and T. Davis and Journals.

**MPE-1.2.5 - ELECTIVE-III**

**MPE-1.2.5 A- ELECTIVE-III (Analytical Techniques in Mineral Engineering)**

***Objectives****:*

The main purpose of teaching Analytical Techniques in Mineral Engg. to M. Tech, final year postgraduate students is to make them to understand the different types of analysis methods used in chemical industries. The course consists of both chemical and instrumental methods and also both qualitative and quantitative methods of analysis. In this course, the chemical methods of quantitative analysis include all the aspects such as: selection and sampling of materials, preparation of solutions, and analysis of various chemical raw materials and products. In instrumental methods colorimetric, spectrophotometric, spectrographic, flame emission, photo meter have been discussed.

***Outcome:***

\* The student should be able to know the theory of sampling, selection and preparation of the sample.

\* The student should be able to know the sophisticated instruments used for the analysis of mineral ores and chemical samples. The student should have knowledge of analysis for the ores and chemical samples.

\* The student should be in a position to understand the operation of instruments like X- Ray, flame emission spectroscopy.

\* The student can determine the traces of elements in the metals and alloys required for specific application.

*Syllabus:*

**Theory of sampling,**  sampling of ores, minerals and coals, proximate and ultimate analysis of coal; coking index, calorific value of coal, its determination and calculation, analysis of ash.

**Wet assaying** of ores of iron, copper, lead, zinc and manganese, dry assaying process, fire saving methods for gold and silver,

**Instrumental methods of mineral investigation:** Theory and techniques of colorimetry and absorptiomestry, photometer, spectrophotometers, atomic absorption spectohotometer,

**Electrochemical methods of analysis**, Electrogravimetry methods, potentiometric titration, polarography, DTA,

**X-ray techniques,** emission of X-rays, X-rays instrumentation, X-ray diffraction, flame emission spectroscope – source, equipment and application of emission spectroscopy,

*Reference books:*

1. ‘An Introduction of Metallurgical Analysis: Chemical & Instrumental’ by S.K. Jain Vikas Publishing House.

2. ‘A Text Book of Metallurgical Analysis’ by B.C.Agarwal & S.P.Jain, Khanna Publications.

3. ‘a Text Book of Quantitative Inorganic Analysis’ by A.I.Vogel, ELBS Edition.

**MPE-1.2.5 B - ELECTIVE - III (Petroleum Refinery Engg-II)**

**Objective:** To know about various production processes for the manufacture of C1 to Aromatic Compounds.

To know the design aspects to be taken into consideration for the designing of various equipments used in the process.

**Outcome**: 1.Able to understand the processes and mechanisms of various production processes of C1 to Aromatic compounds. 2.Able to understand the design aspects of various equipment used in the production processes.

**Syllabus**: Raw materials for petrochemicals - Refinery process and petrochemical feed stocks - pyrolysis for petrochemical feed stocks - separation of individual hydrocarbons by fractionation.

Petrochemicals from C1, C2 , C3 & C4 fractions. Petrochemicals from aromatic feed stocks.

*Design of petrochemical equipment:* Pyrolysis furnace, Pyrolysis reactor (Ethane Cracking or propene cracking).

Super fractionator ( Ethyane - Ethylene, Propene - Propylene, Ethyle Benzene - styrene)

Fixed bed reactor ( Ethyle Benzene - Styrene)

Multiphase reactor ( Oxo synthesis).

*Text Books :*

1. Ethylene & its derivations - S.A. Miller

2. Propylene and its derivations - E.G. Hancock.

3. Benzene, Toluene, Xylene and their Derivations. E.G. Hancock.

**MPE-1.2.5 C- ELECTIVE - III (Electrochemical Engineering-II)**

*The main objectives are to provide:*

1. Knowledge on Electroplating, Electroforming, electro refining, electro wining.

2. Knowledge on Electrolysis and Manufacturing process.

3. Knowledge on primary & secondary batteries and fuel

*Outcome:*

1. Acquires knowledge on electrochemical ore beneficiation techniques, electroplating, electro refining and electro winning.

2. Able to work in commercial and industrial manufacturing units using electrolysis.

3. Familiarize with batteries and components like separators, binder, electrolyte, and additives used in batteries.

4. Familiarize with the characterization methods of batteries, e.g. charge/discharge cycles, overpotential, battery capacity, state of charge, state of health, impedance.

5. Familiarize with the Fuel cells.

**Syllabus:**

**Part –A**

Electroplating, Electroforming and Electrophoresis Electrorefining of metals - Copper, Silver, Gold, Nickel, Lead and Cobalt. Electrowinning of metals - Copper, Zinc, Cadmium, Chromium and Manganese.

Electrolysis of Alkali Halides and Sulfates - Chlorine and Caustic, Potassium halides, Hydrochloric acid, Fluorine and sodium sulfate.

Manufacture of Hydrogen and Oxygen.

Electrolytic Reduction and Oxidation - Persalts, Cuprous oxide, Mercuric oxide, Manganese dioxide and Perchlorates.

Electrolysis of fused Salts - Aluminum, Magnesium, Sodium, Beryllium and Zirconium.

**Part –B**

Batteries: Classification of cells and batteries, theoretical cell voltage, capacity, energy, electrochemical principles and reactions

Primary batteries: Zinc carbon batteries(Leclanche and Zinc chloride cell system), Magnesium and Aluminum batteries, Alkaline manganese dioxide batteries, Lithium batteries.

Secondary batteries: Lead acid batteries, nickel cadmium batteries, nickel metal hydride batteries, lithium ion batteries, rechargeable zinc, alkaline, manganese dioxide batteries

Fuel cells: Molten carbonate fuel cell(MCFC), phosphoric acid fuel cell(PAFC), Solid oxide fuel cell (SOFC), proton exchange membrane fuel cell(PEMFC).

*Textbooks:*

1. Electrochemical Engineering by Mantell, C.L. McGraw–Hill

2. Electrochemistry Principles and Applications Edmund Potter, Cleaver–Hume Press Ltd.

3. Handbook of batteries by David linden and Thomas B Reddy, McGraw –Hill

**MPE-1.2.6 - ELECTIVE-IV**

**MPE-1.2.6 A-ELECTIVE-IV (Corrosion Engineering-II)**

***Objectives:***

\* To enable the principles of corrosion, common corrosion forms, uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement corrosion control methods, and material selection to reduce corrosion cost.

\* To enable the ability to understand electrochemical fundamentals

\* To enable the ability to understand corrosion preventing methods

*Outcome:*

\* The student would know application of weight loss method

\* The student would know application of cathodic protection, anodic ptotection

\* At the end of this course, the student would know effective surface preparation of specimen can be done

\* After completion of this course, the student would understand the causes and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion.

\* The student would know application of Corrosion Processes and Evans Diagrams and application of electroplating, coatings and importance of inhibitors.

*Syllabus:*

Corrosion in selective environments: Marine, Acids (Sulfuric acid, Hydrochloric acid, Nitirc acid, Phosphoric acid) Biological and industrial gases (SO2H2S).

Corrosion Testing - Purposes, Materials and specimen. Surface preparation, Measuring and weighing , Exposure Techniques - duration, Planned - Interval Tests, Aeration, cleaning specimens after exposure, Temperature, Standard expression for corrosion rates - Galvanic Corrosion, Erosion Corrosion, crevice Corrosion, Intergranular corrosion, test for stainless steels, warren test pitting, stress corrosion, Paint tests, Sea Water tests, Presenting and summarizing data - Nomo graph for corrosion rates and interpretation of results.

Cathodic and anodic protection, surface preparation for coatings and chemical conversions: Degreasing, Descaling , Polishing - Anodized coating : anodizing oxidizing, chromate coating, phosphate coatings - Metallic coatings : Hot dipping, cementation, vapor deposition of metallic coating; Sprayed coatings: flame spraying plasma spraying, Galvanizing - Electroplating : Nickel & chromium coatings, chromizing.- Organic coatings : paints, enamels, lacquers, resin mixtures.

Linings, laminates, reinforced plastic, fibre glass - Corrosion inhibitors: mechanism of inhibition, recirculating of water of water systems

Measurement and testing of preventive coatings ; Thickness and Resistance tests for anodized, Painted, electroplated surfaces using polarization resistance, Linear polarization, curve fit analysis and Electrochemical impedance spectroscopy.

*Reference books :*

1. Mars GFontana - Corrosion Engineering

2. Burns, R.M., Bradley, W.W., ‘protective coatings for Metals.’ Chapters 2 to 18.

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**MPE-1.2.6 (B) ELECTIVE – IV (Energy Engineering-II)**

***Objectives:***

The student is provided with the fundamentals of some renewable energy processes. Basic information to comprehend the various non-conventional energy systems would be gained by the student.

***Outcome:***

1. Methods to be adopted to utilize biomass as an important energy source.

2. Application of thermodynamics to convert ocean energy.

3. Possible mechanism to drawn energy from wind and other natural sources

4. Fuel cells as sources of energy.

5. New technologies to produce energy such as thermionics, thermoelectricity etc.

*Syllabus:*

Non – Conventional & New Energy Systems and Energy Conservation Technology Systems based on bio mass.

Physical and Bio mass – Definition – potential thermo – chemical methods of Bio - Conversion – Gasification – Liquefaction – Pyrolysis.

Bio-gas technology – Historical review and development in India Different designs of bio-gas jplants – Selection of a model and size – Installation – Gas collection and distribution – operation and maintenance – Properties and uses of bio-gas – Utilization of manure – National Projects for Bio – gas development – safety.(Bansal et at,chapters 10 and 11; Khandelwal and Mahdi, Chapters 3,4,5,6,7,8,9,10: Chawla,chapters 2,3,4,5,6,7 & 8).

Fuel Cells : Hydrogen – Oxygen Fuel Cells – carbonaceous Fuel Cells – Molten Alkali Carbonate Cells – Electrode Reactions and kinetics. (Fuel Cells by Young). Energy Wind, Tidal and OTEC

Potential in India – Origin of wind and general circulation systems of Earth – Wind direction – Wind measurement – Wind energy converters – Historical development – Power coefficient – Aerodynamic construction of a rotor blade Rotors – Wind electric generators in India – Economics of wind farm – Fundamentals and concepts of Wave energy – Ocean thermal – energy conversion (OTEC). (Bansal et at., Chapters 12,13 & 14).

Hydrogen Energy, Methanol & Ethanol : Hydrogen from fossil fuels from Electrolysis – Developments of various electrolytic cells – High pressure cells – Solid electrolytic systems – Hydrogen powered IC engines – Storage system – Handling and Transmission.(Journals on Hydrogen energy). Methanol and Ethanol as Automobile fuels – Comparison with Gasoline and Diesel oil. (Journals on Hydrocarbon on processing).

Energy Conservation Technologies: Principles of Energy Conservation – Optimum Energy Conservation – Industrial Energy Conservation modeling – waste heat recovery and utilization.

*Prescribed Books:*

1. Renewable Energy Sources and Conversion Technology, N.K.Bansal, Manfred Klieemann,Michael Meliss, tataMcGraw Hill, 1990.

2. Bio Gas Technology, A practical hand book Vol 1, K.C.Khandelwal and S.S.Maholi, TataMcGraw Hill, 1986.

3. Advances in Bio Gas Technology: O.P.Chawla,publications and Information Division, Indian council of Agricultural Research,New Delhi, 1986.

4. Alternative Energy Sources: R.H .Taylor, Adam Hilger Ltd.,Brister.

5. Fuel cells, Vols.I & II: Reinhold publishing Crop.,New York.

6. International journal of hydrogen Energy, Vol.5, No. I, 1980 pages 1- 84: No.2, pages 119-129; pages 151-203; No.5. Pages 527 – 534 & 539 – 553; No.6, Pages 611 – 625.

7. Hydro Carbon Processing Vol. 58, May 1979 pages 127 – 138:Vol. 59, Feb. 1980, pages 72–75.

8. Handbook of Industrial Energy Conservation, David Hu, S., Van Nostrand Reinhold Company pages 73 – 133, 149-199, 297-327.

**MPE-1.2.6 (C) ELECTIVE - IV (Reaction Engineering-II)**

*Syllabus:*

UNIT - I : Laboratory Reactors - Interpretation of Experimental Data - Interpretation of Laboratory Kinetics Data - Homogeneous and Heterogeneous Laboratory Reactors. Calculation of Global Rate - The structure of Reactor Design.

(Scope: Chapter 12 of J.M Smith 3rd Edition)

UNIT - II : Design of Heterogeneous Catalytic Reactors Isothermal and Adiabatic Fixed Bed Reactors Non-isothermal, Non-adiabatic Fixed Bed Reactors. (Scope: Chapters 13.1 - 13.9 of J.M Smith 3rd Edition)

UNIT - III : Design of fluidized bed Reactors - Two -Phase Fluidized Bed model - Operating characteristics - Slurry Reactors - Trickle - Bed Reactors - Optimization. (Scope: Chapter 13.10 - 13.13 of J.M Smith 3rd Edition.)

UNIT - IV : Fluid - Solid Noncatalytic Reactions - Design concepts - Single Particle Behavior - Reactor Models. *(Scope: Chapter 14 of J.M Smith 3rd Edition)*

UNIT - V : Short notes from the portions of all the above four units. Four bits are to be answered out of 7 bits (Not more than 2 bits to be given from any one Unit).

***Text Book:***

1. Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book Company , 1980, 3rd Edition.

**SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH(CACE) FIRST SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

CACE 1.1.1 Modellling &
 Simulation 4 3 1 — 4 30 70 100

CACE1.1.2 Process Dynamics
 & Control 4 3 1 — 4 30 70 100

CACE 1.1.3 Chemical Reaction
 Engg 4 3 1 — 4 30 70 100

CACE 1.1.4 Transport Phenomena 4 3 1 — 4 30 70 100

CACE 1.1.5 Elective-I 4 4 — — 4 30 70 100

CACE1.1.6 Elective-II 4 4 — — 4 30 70 100

CACE 1.1.7 Computational lab 2 — — 3 3 50 50\* 100

CACE 1.1.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

\*Only internal evaluation.

Elective-I: 1.Computational Fluid Flow &Heat Transfer

 2.Distillation Design & Control

 3.Process Flow sheeting

Elective-II: 1. Corrosion Engineering-I

 2. Energy Engineering-I

 3. Reaction Engineering-I

**SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH(CACE) SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

CACE 1.2.1 Computer Aided
 Design 4 3 1 — 4 30 70 100

CACE1.2.2 Computational Methods 4 3 1 — 4 30 70 100

CACE 1.2.3 Separation Processes 4 3 1 — 4 30 70 100

CACE 1.2.4 Optimization 4 3 1 — 4 30 70 100

CACE 1.2.5 Elective-III 4 4 — — 4 30 70 100

CACE1.2.6 Elective-IV 4 4 — — 4 30 70 100

CACE 1.2.7 Computational lab 2 — — 3 3 50 50 100

CACE 1.2.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

Elective-III: 1.Nanotechnology

 2.Bioinformatics

 3.Neural Networks

Elective-IV: 1. Corrosion Engineering-II

 2. Energy Engineering-II

 3. Reaction Engineering-II

**SCHEME OF INSTRUCTION & EXAMINATION**

**2/2 M.TECH (CACE) FIRST & SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

*PROJECT WORK:*

**CACE-2.1.1 - FIRST SEMESTER: CREDITS:10, MARKS:100**

**CACE-2.2.1- SECOND SEMESTER: CREDITS:14, MARKS:100**

\* Project guide will be allotted at the beginning of first semester and the student has to give presentation on his/her project work at the end of first semester and grading will be awarded as A,B,C or F.

\* At the end of second semester final viva-voce examination will be conducted and grading will be awarded as A,B,C or F.

**SYLLABUS**

**M.TECH. I SEMESTER**

**CACE-1.1.1: PROCESS MODELING AND SIMULATION**

**(Common for MPE, CHEMICAL & IPCE )**

***Objective:***

Process Modeling and Simulation is a important subject of study for Post Graduate Chemical Engineers . It deals with writing various process models based on basic physical process. It also deals with solving the various models by means of various numerical methods by computer simulation. By studying this course ,one can simulate various chemical process by computer simulation .

***Outcome:***

1. Understand the writing of a model of a process based on basic physical processes like mass ,momentum and energy balances.

2. Develop a model equation for Tanks, Isothermal and Non-Isothermal Systems

3. Understand the models for Binary Distillation Column, Batch Reactors etc.

4. Solve the model equations by Numerical methods like Euler and Runge –Kutta etc.

*Syllabus:*

Principles of formulation - Continuity equations – Energy equation – Equation of motion – Equations of state – Transport equations – Chemical Kinetics – Algebraic and Integral / differential equations, Explicit and Implicit equations –Numerical Integration,Feed forward and feed backward control.

Basic modeling for tank system, mixing vessel – Simultaneous mass and energy balances – Models for boiling, batch distillation, and partial condenser.

Models for Reactor – Model for heterogeneous catalysis – Models for pumping system – Model for heat exchanger.

Operational blocks in simulation- Simulation Programming – Simulation examples of three CSTR’s in series, gravity flow tank, binary distillation column, non–isothermal CSTR.

Implicit function convergence, Internal–halving convergence, Newton–Raphson method, False position convergence, Explicit convergence methods, Numerical Integration, Euler Integration, Runge - Kutta (fourth order) method.

*Textbooks:*

1. Process Modeling, Simulation and Control for Chemical Engineers by Luyben, W.L., McGraw Hill Books Co.

2. Mathematical Modeling in Chemical Engineering by Roger, G.E. Franks – John Wiley Sons Inc.

*Reference Book:*

 Mathematical Methods in Chemical Engineering by V.G. Jenson and G.V. Jefferys, Academic Press – 2nd Edition.

**CACE-1.1.2: PROCESS DYNAMICS & CONTROL**

**(Common for MPE, CHEMICAL & IPCE )**

***Objectives*** *:*

The main purpose of teaching Process Dynamics & Control for first year postgraduate students is to take the student from basic mathematics to a variety of design applications in a clear, concise manner. This course is focused on the use of the digital computer in complex problem solving and in process control instrumentation. For chemical engineering problem solving students need more advanced mathematical preparation like partial differential equations, linear algebra and Fourier series all are introduced in this course.

*Outcome:*

\* Able to know the sampled data control systems consists of sampling and advanced mathematical model Z- transforms.

\* Able to describe the process in which the flow of the signals is interrupted periodically like in chromatograph.

\* Able to calculate the open loop response of a sampled data system and can develop a pulse transfer function that is the counterpart of the transfer function for continuous systems.

\* Able to know the sophisticated instruments used for the analysis of water and air pollutants, The student should have knowledge to design the equipment used for the abatement of these pollutants.

\* In a position to modernize the solid waste management and the student must be in a position to get awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

*Syllabus:*

Review of time domain, Laplace domain and frequency domain dynamics of process and control system.

Sampled data control system – sampling and Z–Transforms , open loop and closed loop response, Stability.

State space methods – representation of physical systems – transfer function matrix – Multivariable systems – Analysis and control.

Non linear control –examples of non linear systems – Methods of phase plane analysis. Control of heat exchangers, distillation columns and Chemical Reactors.

*Textbooks:*

1. Process system Analysis and control, 2nd edition, Donald R Coughanower and Koppel.

2. Automatic process Control by Peter Harriot.

3. Process Modeling, Simulation and control for Chemical Engineers by W.L. Luyben.

**CACE-1.1.3: CHEMICAL REACTION ENGINEERING**

**(Common for MPE, CHEMICAL & IPCE )**

***Objectives:***

\* To focus on the thermal characteristics of various reactions and the design aspects of non isothermal and adiabatic reactors

\* To focus on Heterogeneous data analysis and design

\* To focus on CVD reactors

\* To study the design aspects of heterogeneous catalytic systems

\* To impart the knowledge on mass transfer with reaction in process catalysts

*Outcome:*

\* Enables the students to understand the design aspects of non isothermal and adiabatic reactors

\* Enables the students to on heterogeneous data analysis and design aspects of heterogeneous catalytic systems

\* Able to derive the rate laws for CVD

\* Able to develop the rate laws for heterogeneous fluid solid catalyzed reactions under rate limiting situations.

*Syllabus:*

Review of Fundamentals Rate laws and stiochiometry, reactions with phase change (Scope: Chapter 3 of Fogler) Least squares Analysis of rate data: differential reactors: Laboratory reactors (Scope: sections 5.4 to 5.6 of Fogler) Multiple reactions (Scope: Chapter 9 of Fogler).

Isothermal reactor design (Scope: Chapter 4 of Fogler) Batch reactor, PFR, CSTR design. Pressure drop in reactors, Reversible reactions, unsteady state operation of reactors, Simultaneous reaction and separation

Catalysis and catalytic reactors (Scope: Chapter 6 of Fogler) Steps in catalytic reaction: derivation of rate laws, design for gas-solid reactions, heterogeneous data analysis and design; Chemical vapour deposition, catalyst reactivation, moving bed reactions.

Diffusion and reaction in process catalysts (Scope: Chapter 11 of Fogler). Diffusion and reaction in spherical catalyst.

Internal effectiveness factor, falsified kinetics; estimation of diffusion and reaction limited regimes. Mass transfer and reaction in packed bed. Determination of limiting situations from reaction data, CVD reactors.

Non-isothermal reactor design (Scope: Chapter 8 of Fogler), Energy Balance, equilibrium conversion under adiabatic conditions unsteady state operation, multiple steady states.

*Textbook:*

1. Fogler. H.S: Elements for Chemical Reaction Engineering 2nd Edition, Prentice Hall, New Delhi, 1992.

*Reference:*

2. Smith J.M: ‘Chemical Engineering Kinetics’ 3rd Edition, McGraw Hill, 1981.

**CACE-1.1.4: TRANSPORT PHENOMENA**

**(Common for MPE, CHEMICAL & IPCE )**

***Objectives:***

\* To be able to analyze various transport processes with understanding of solution approximation methods and their limitations.

***Outcomes:***

\* Ability to understand the chemical and physical transport processes and their mechanism.

\* Ability to do heat, mass and momentum transfer analysis.

\* Ability to analyze industrial problems along with relevant approximations and boundary conditions.

\* Ability to develop steady and time dependent solutions along with their limitations.

***Syllabus:***

Unit 1: Momentum Transport

1.1 The Equations of change for isothermal systems.

1.2 Velocity distributions with more than one independent variable.

1.3 Velocity distributions in turbulent flow.

1.4 Inter phase transport in isothermal systems.

 **Unit 2: Energy Transport**

1.1 The Equations of change for non – isothermal systems.

1.2 Temperature distributions with more than one independent variable.

1.3 Temperature distributions in turbulent flow

1.4 Interphase transport in nonisothermal systems.

**Unit 3: Mass Transport**

1.1 The Equations of Change for multicomponent systems.

1.2 Concentration distribution with more than one independent variable.

1.3 Concentration distribution in turbulent flow.

*Textbook:*

“Transport phenomena” R. Byron Bird, Warren E. Stewart and E.N. Light foot, Wiley & Sons, Inc., New York.

*Reference Books:*

1. “Fundamentals of Momentum, Heat and Mass Transfer” James R. Welty, Charles E. Wicks and Robert E. Wilson, John Wiley & Sons, Inc., New York.

2. “Boundary – Layer Theory”, Dr.H.Sehlichting, McGraw – Hill Book Company, New York.

**CACE- 1.1.5 A - Elective-I (Computational Fluid flow
and Heat transfer)**

***Objective:***

The main purpose of teaching “COMPUTATIONAL FLUID FLOW AND HEAT TRANFER” for the first year M.TECH students is to introduce the basics of FLUID FLOW, HEAT TRANSFER and TRANSPORT PHENOMENA combined subjects for CACE specialization students to gain fair knowledge of overall fluid flows, fluid dynamics and the importance of heat transfer .

***Out come:***

Student gains fair knowledge which every CACE specialization student should know to derive the derivations and problems which are related to fluid flow, transport phenomena and heat transfer as well as chemical engineering problems. Student will learn the importance solving the problems. Student is able to gain the complete knowledge on the subject. This knowledge is very helpful for the students how the heat transfer is taking place in a different materials for industrial applications and designing new Chemical Industries .

**Syllabus:**

1. Types of partial differential equations - parabolic, elliptic and hyperbolic equations - boundary layer equations for laminar and turbulent flows - Crank-Nicolson and ADI methods to solve heat transfer problems.

2. External laminar flow: Flow of an incompressible fluid over an isothermal flat plate by (a) similarity method, and (b) implicit finite difference method.

3. Internal laminar flow: equations and solution for the problem of fully developed flow through a pipe and heat transfer - fully developed flow in a duct or channel and heat transfer - plane duct with a developing temperature field - pipe flow with developing velocity and temperature fields - pipe flow with developing velocity and temperature fields.

4. Introduction to turbulent flow: Governing equations - turbulence models - mixing length model - K-? model.

5. External turbulent flow: Flow over a flat plate - solution by analogy between momentum and heat transfer - - numerical solution of the boundary layer equations by finite difference method.

6. Internal turbulent flow: Analogy solution for fully developed pipe flow.

7. Solution of laminar incompressible flow problems by vorticity-stream function formulation - flow in a rectangular cavity - application to cylindrical coordinates - flow over a sphere.

8. MAC and SIMPLE algorithms: Solution of Unsteady state Navier-Stokes equations for incompressible flows - staggered Grid - MAC (Marker and Cell) method - implementation of boundary conditions - solution of energy balance equation - SIMPLE formulation - discretization of one-dimensional convection-diffusion equation - formulation of flow problem - upwind differencing - pressure correction - TDMA and Thomas algorithm.

*Text Books:*

1. Introduction to convection heat transfer analysis, Patrick H. Oosthuizen and David Naylor, McGraw-Hill Inc., New York (1999). (For topics 1 to 6)

2. Computational fluid flow and heat transfer, Second Edition, K. Muralidharan and T.Sundararajan (Editors), Narosa Publishing House, New Delhi (2003). (For topics 1, 7 and 8)

*Reference Books:*

1. An Introduction to computational fluid dynamics: The finite volume method, H.K. Versteeg, W. Malalasekra, Prentice Hall (1995).

2. Computational fluid dynamics – the basics with applications, John D. Anderson, Jr., McGraw-Hill International Editions, New York (1995)

**CACE-1.1.5B: Elective – I**

**CACE-1.1.5 B: DISTILLATION DESGIN & CONTROL**

***Syllabus:***

(Design and control of Distillation columns will be emphasized using ASPEN in this subject.)

1. Review of vapor-liquid equilibrium. Analysis of distillation columns: degrees of freedom, McCabe-Thiele method, approximate multicomponent methods, analysis of ternary systems.

2. Setting up a steady-state simulation: configuring a new simulation, specifying chemical components and physical properties, specifying stream properties and equipment parameters, running the simulation, finding the optimum tray and minimum conditions, column sizing.

3. Distillation economic optimization: heuristic optimization, economic basis, operating optimization.

4. Steady-state calculation for control structure selection: summary of methods, binary Propane/Isobutane system, ternary BTX system, multicomponent hydrocarbon system, ternary azeotropic system.

5. Converting from steady-state to dynamic simulation: equipment sizing, exporting to ASPEN dynamics, installing basic controllers, performance evaluation, comparison with economic optimum design.

6. Reactive Distillation: types reactive distillation systems, TAME process basics, TAME Reaction Kinetics and VLE, plant control structure.

7. Control of Petroleum Fractionators: petroleum fractions, characterization of crude oil, steady-state design of pipestill, control of pipestill.

*Text book:*

W.L. Luyben, Distillation Design and Control using Aspen Simulation, John Wiley,2006.

*Reference books:*

1. M.F. Doherty and M.F.Malone, Conceptual Design of Distillation Systems, Mcgraw-Hill, 2001.

2. P.B. Deshapande, Distillation Dynamics and Control, Instrumentation Systems Publishers, 1985.

3. H.Z. Kister, Distillation Design, Mcgraw-Hill, 1992.

4. M. Van Winkle, Distillation , Mcgraw-Hill, 1967.

**CACE-1.1.5C: Elective – I**

**CACE-1.1.5 C: PROCESS FLOWSHEETING**

***Syllabus:***

1. Steady state and dynamic flow sheeting and the design process, the total design project, Flow sheeting on the computer: motivation for the development, developing a simulation model, approaches to flow sheeting systems

2. Solving linear and nonlinear algebraic equations: solving one equation in one unknown, solution methods for linear equations, general approaches to solving sets of nonlinear equations, sloving sets of sparse nonlinear equations

3. Physical property service facilities: The data cycle, computerized physical property systems, physical property calculations; Degrees of freedom in a flow sheet: degrees of freedom, independent stream variables, degrees of freedom for a unit, degrees of freedom for a flowsheet

4. The sequential modular approach to flowsheeting: The solution of an example flowsheeting problem, other features, convergence of tear variables. Partitioning and tearing of a flowsheet.

5. Flowsheeting by equation solving methods based on tearing

6. Simulation by linear methods

7. Simulation by quasi linear methods

*Text book:*

A.W. Westerberg, H.P. Hutchison, R.L. Motard, and P. Winter , Process Flowsheeting, Cambridge University press, 1979

*Reference books:*

1. Leesley, M.E., Computer aided process plant design, Gulf Publishing, Huston, 1982

2. R.Turton, R.C.Bailie, W.B.Whiting and J.A.Shaeiwitz, Analysis, Synthesis and Design of Chemcal Processes, Prentice Hall, 1998.

3. W. D. Seider, J.D. Seader, and D.RLewin, Product and Process Design Principles: Synthesis, Analysis and Evaluation, 2nd edition, 2003, John Wiley & Sons(Asia) Pte. Ltd.

**CACE-1.1.6: Elective –II**

**CACE-1.1.6 A - Elective-II (Corrosion Engineering-I)**

***The main objectives are to provide:***

1. Basic aspects of electrochemistry relevant to corrosion phenomena,

2. Importance and forms of corrosion.

3. Knowledge on corrosion rate expressions and measurement techniques.

4. Knowledge on factors influencing corrosion of iron and steel exposed to atmospheric, soil and aqueous medium.

5. Basic knowledge on remedial measures for corrosion.

***Outcome:***

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion, corrosion tendency and electrode potentials.

2. Able to identify the nature of corrosion and form in which it attacks(Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage .

3. By acquiring knowledge on polarization and its influence on corrosion rates will be able to measure corrosion rates and analyze.

4. Acquires knowledge on mechanism and propose viable remedial measures.

**Syllabus**

Basic Concepts and Outlines of Electrochemistry: Fundamentals of Electrochemical reactions, Faraday’s Laws Electrolytic and ionic conductance, ionic mobility’s, Transport Nos. Galvanic Cell and Electrolytic cells.

Definition and importance of corrosion, Dry cell, analogy, Corrosion Cells, Types of Corrosion Cells- a) Dissimilar electrode cells b) Concentration cells such as a salt concentration cells, differential aeration cells c) differential Temperature cells. Corrosion Rate Expresions - mdd, ipy, cpy, mpy, etc.

Corrosion Tendency and Electrode Potentials: Free Energy changes, Development of Nernst Equation for calculation of Half-cell potentials, Hydrogen electrode, Spontaneity of a reaction, Reversible cells and potentials – convention of Sign and calculations of EMF from standard Equilibrium potentials., EMF Series and Galvanic series, Reference Half Cells – Calomel, Silver-Silver Chloride and Saturated Copper-Copper Sulphate Half Cells. Pourbaix Diagram for Iron, Aluminum and magnesium, limitations of pourbaix diagrams.

Polarization and Corrosion Rates: Polarization and a Polarized Cell, Causes of Polarization – Concentration Polarization, Activation Polarization and IR drop. Hydrogen Over potentials, combined polarization and Mixed potential theory. Tafel Slopes and Tafel Equation. Graphical method of expressing Corrosion Reactions (Polarization diagrams/Evans diagrams), Derivation of Stern-Geary Equation, Influence of Polarization on Corrosion rates.

Passivity: Characteristics of Passivation, Flade potential, behavior of passivators, transpasivity, Theories on Passivity.

Forms of Corrosion: Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage. Factors influencing, mechanisms and prevention techniques for all forms of corrosion. Calculation of Corrosion rates using weight lost method and Polarization data. Electrochemical Impedance Spectroscopy.

Effect of Dissolved Oxygen (Air saturated Water, High Partial Pressure of Oxygen and Anaerobic bacteria), Temperature, pH, Galvanic coupling, velocity, dissolved salts concentration. Wet and dry corrosion.

*Textbooks :*

1. Corrosion and Corrosion Control by Herbert, H. Uhlig John Wiley and Sons Inc., New York.

2. Corrosion Engineering by Mars F Fontana, McGraw Hill.

3. An Introduction to Electrochemistry by Samuel Glass stone, Affiliated East West Press Pvt. Ltd.,

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**CACE- 1.1.6 B - Elective-II (Energy Engineering-I)**

**Objectives:** To lean overview of solar radiation and it’s potential for collection to meet the energy needs of mankind and potential for solar energy option. To learn measuring techniques of solar radiation and its compilation.

To learn various design and operational aspects of solar energy collection and storage.

To learn the design and operation of solar energy appliances like liquid flat plate collectors, Solar Air Heaters, Thermal energy storage, Thermal energy storage, Solar Pond, Solar thermal power generation.

To learn theory and application of Photovoltaic cells

**Outcome:** The student learns collection and design of various kinds of equipment operated on solar energy. The student learns principles and practice of Photo voltaic cells.

***Syllabus:***

**The Solar Energy option :** Thermal conversion – collection and storage Thermal applications – photovoltaic conversion – wind energy – Energy from Bio – mass – ocean thermal energy conversion.

**Solar Radiation :** Solar Radiation outside the earths – atmosphere Solar radiation at the Earth’s surface – Instruments for measuring Solar Radiation – Solar Radiation data – Solar Radiation Geometry Empirical equations for predicting the availability of Solar Radiation – Solar radiation on tilted surface.

**Liquid flat – Plate Collectors :** Components of liquid flat plate – various types of collectors – Performance Analysis – Transmissivity – Absorptivity product – Overall loss coefficients and heat Transfer correlations – Collector efficiency heat removal factors – effect of various parameters on performance. Transient Analysis – Testing procedures.

**Solar Air Heaters :** Various types of solar Heaters – Performance Analysis of a conventional Air Heater – Testing procedures – Concentrating collectors – various types of concentrating collectors cylindrical and parabolic collectors – General receiver collectors.

**Thermal energy storage :** Sensible heat storage – Latent heat storage – Thermochemical storage.

Solar Pond Description – Performance analysis – Experimental studies – Operational Problems.

**Solar Air Conditioning and Refrigeration :** Heat pump cycle – Coefficient of performance of the heat pumps – solar air-conditioning with absorption – Refrigeration system (Ammonia water and lithium bromide – water systems).

**Solar thermal power generation :** Thermal and direct electricity generation – Major sub-stations of a solar thermal power plant, Examples of installed systems – Concentration ratio. Temperature and efficiency concepts – Solar farm and tower – Economics.

**Photovoltaic Energy Conversion :** Photovoltaic Energy Conversion Fundamentals – band theory of solids – Physical processes in a solar cell – Solar cell with light incidence – Solar cell module – Silicon Solar Cells – Copper Sulphate / Cadmium sulphide Solar Cells.(Banasal et at.,chapters 9;Taylor, chapters 6, pages 256-298.

*Text Books:*

1. Solar Energy: Principles of thermal collection and storage by S.P. Sukhatme, Tata McGraw Hill, New Delhi 1984 (Chapters 2 to 8)

2. Renewable energy sources and conversion technology by N. K. Bansal, M. Kleemann, Michael Mcliss, 1990 (Chapters 2 – 9).

**CACE- 1.1.6 C – Elective-II (Reaction Engineering-I)**

***Syllabus:***

**Unit I** : (Scope : J.M. Smith : Chapter 7): Heterogeneous Processes, catalysis, and absorption: Global Rates of Reaction – Types of Heterogeneous Reactions – The nature of catalytic Reactions – The Mechanism of catalytic Reactions – Surface Chemistry and Absorption – Absorption Isotherms – Rates of Absorption.

**Unit II** ( Scope : J. M. Smith: Chapter 8 : Solid Catalysts: Determination of surface area – Void Volume and solid density – Fore volume distribution – Theories of Heterogeneous Catalysis – Classification of catalysts – Catalyst Preparation – Promoters and Inhibitors Catalyst Deactivation (Poisoning).

**Unit III:** (Scope: J.M. Smith : Chapter 9): Rate equations for fluid – Solid Catalytic Reactions: Rates of adsorption, Desorption, Surface Reaction – Rate equations in terms of Fluid phase concentrations at the catalyst surface – Qualitative analysis of rate equation – Quantitative inter pretation of Kinetic data – Redox Rate equations.

**Unit IV:** ( Scope : Octave Levenspiel : Chapter 15) : Deactivating Catalysts : Mechanism of Catalyst Deactivation – The ratre of equation – The rate of equation from experiment – Batch – solids: Determining the rate for Independent Deactivation Batch – solids : Determining the rate of arallel, series or side – by – side Deactivation – Flowing solids experimental Reactors – Finding the Mechanism of Decay from experiment Design.

**UnitV**: ( Scope : J. M. Smith : Chapter 10) : External transport Processes in Heterogeneous Reactions.

Fixed bed reactors – The effect of physical processes on observed rate of reaction – Mass and Heat transfer coefficients (fluid particle) in packed beds – Quantitative treatment of external transport effects – Stable operating conditions – Effect of external transport Processes on selectivity. Fluidised bed reactors – Particle – fluid Mass and Heat transfer Slurry Reactors – Mass transfer coefficients: Gas bubble to liquid (K1) – Mass transfer coefficients: Liquid to particle (Kc) – The effect of mass – transfer on observed rates Trickle – Bed reactors – mass transfer coefficients: Gas to liquid (K1 ag) – Liquid to particle (kc ac) – Calculation of global rate.

*Text Books:*

1. Smith. J.M., “ Chemical Engineering Kinetics”, McGraw Hill book Company, New Delhi (Third Edition) 1981.

2. Octave Levenspiel, “ Chemical Reaction Engineering” , Wiley Eastern Limited – Second Edition – 1972.

***Reference Books*** *:*

1. Thomas, J.M. And Thomas, W.J. “ Introduction to the Principles of Heterogeneous Catalysis”. Academic Press Inc., New York 1967.

2. Carbnerry, James, J., “ Chemical and Catalytjic Reaction – Engineering”, McGraw – Hill, Engineering Series.

**II SEMESTER**

**CACE-1.2.1-COMPUTER AIDED DESIGN**

**{Common for Chemical and IPCE}**

*The objectives of this course are to provide the student with:*

\* a basic understanding of the fundamentals of executive program, executive program aided simulation, unit computations, information flow diagram, encoding of information flow diagram, simulation of a simple plant, applications of simulation

\* knowledge to write algorithm and programs for various fluid flow problems, pressure drop in two phase flow, pipeline network calculations

\* knowledge to write algorithm and programs for rating and design calculations heat exchanger, condenser, reboiler, flash calculations, distillation column, gas absorption column, crosscurrent and counter current extraction, analysis of data in a reactor, extent of reaction, ideal reactors, semibatch reactor, packed bed reactor and fluidized bed reactor

***Outcome:***

\* Enables students to learn the basics of computer aided design, executive program aided simulation and its applications

\* Students will be able to write/develop unit computations (programs) for fluid flow, mass transfer, heat transfer and reaction engineering problems

***Syllabus:***

Unit I : Introduction on simulation and importance of simulation for chemical process industries Introduction to computer aided design- executive program. coding of chemical process flow chart. Information flow diagram, unit computations, developing a description of information flow diagram, information flow diagram to numerical form, planning calculations, finding recycles, planning calculations for recycle set.

Unit II : Mass transfer operations: introduction, distillation- simple binary distillation, Multicomponent flash calculations, multi component stage wise calculations, Gas absorption- absorption and stripping in plate columns, absorption in packed columns, Liquid extraction- single stage contact, cross current extraction, counter current extraction

Unit III : Flow of fluids in pipes: Introduction, flow of Newtonian fluid in a pipe- incompressible fluid flow, sizing of pipes, Pressure drop in compressible fluid flow, flow of non Newtonian fluids- Bingham plastic fluid, Power law fluid, generalized Reynolds number, Sizing of pipes for non Newtonian fluid How, Pipe network calculations, two phase flow systems- gas liquid flow, solid liquid flow, gas solid flow.

Unit IV : Heat transfer: Introduction, shell and tube exchangers without phase change- tube side heat transfer coefficients, shell side heat transfer coefficients, pressure drop in shell and tube heat exchanger, condensers, reboilers

Unit V : Chemical reaction Engineering: Introduction, extent of reaction, chemical reaction equilibrium- independence of reactions, calculation of chemical equilibrium, Analysis of rate data - Integral method, differential method, nonelementary reactions, temperature dependence of rate constant, Ideal reactors- batch reactor, continuous stirred tank reactor, plug flow reactor, semi batch reactor, Temperature effects in homogeneous reactors- ideal batch reactor, CSTR, PFR, Heterogeneous system- analysis of rate data, fixed bed reactor, catalyst deactivation.

***Prescribed book:***

1. Chemical Process calculations by Raghu Raman, Elsevier applied science publishers, London-New York

2, Simulation of sulphuric acid plant by Crowe

3. Product and process design principles- synthesis, analysis and evaluation by Warren Sieder, J.D. Sieder, Daniel R. Lewin

**CACE-1.2.2- COMPUTATIONAL METHODS**

***Objective:***

The main purpose of teaching “COMPUTATIONAL METHODS” for the first year M.TECH students is to introduce the basics of computational techniques subject for CACE specialization students to gain fair knowledge of overall computational techniques. To learn various computational methods which are available to solve the chemical engineering problems which are related to computer aided chemical engineering applications.

***Out come:***

Student gains fair knowledge which every CACE specialization student should know to solve the problems. Student will learn the importance of solving the problems. Student is able to gain the complete knowledge on the subject. This knowledge is very helpful for the student to solve the different types of problems in Chemical Industry with different computational methods.

***Syllabus:***

**1. Linear and Non-linear Algebric Systems:** Elimination methods for solving linear systems, matrix inversions, factorization, norm and rank; Solutions of nonlinear algebric equations, iterative methods, methods of Newton, Secant, Bracketing and Bisection, Newton’s methods for multiple non-linear equations, Jacobian, Quasi-Newton methods.

**2. Matrix Eigen Value Analysis:** Orthogonal matrices, eigen values and vectors of real matrix, eigen values and properties of linear systems, estimating eigen values, eigen vector matrix decomposition and basis sets, numerical calculation eigen values and vectors, extremal eigen values, QR method, Single Values Decomposition, eigen problems in quantum mechanics, computing the roots of polynomial.

**3. Initial Value Problems:** Initial Value Problems of ordinary differential equations, polynomial interpolation, Newton Cotes integration, Gaussian quadrature, multi­ dimensional integrals, dynamic stability, accuracy and stability of single step methods, stiff stability of BDF methods, simplistic methods for classical mechanics, differential-algebraic equation systems, parametric continuation.

**4. Boundary Value Problems (BVPs) :** BVPs from conservation principles, real space versus function space methods, finite difference methods for 2-D BVP, extension of finite difference method, chemical reaction and diffusion in spherical catalysts pillet, conversion/diffusion equation, modeling a tubular reactor with dispersion, numerical issues for discretized PDEs with more than tow spatial dimensions, finite differences in complex geometries, finite volume method, finite element method (FVM).

*Text book:*

1. K.J.Beers, Numerical Methods for Chemical Engineering, Cambridge University Press, 2006.

*Reference books:*

1. B.A. Finlayson, Introduction to Chemical Engineering Computing, John Wiley, 2006

2. A.Constantinides and N.Mostoufi, Numerical Methods for Chemical Engineers with MATLAB Applications, Prentice Hall, 1999.

3. A.Varma and M.Morbidelli, Mathematical Methods in Chemical Engineering, Oxford University Press 1997

4. M.B.Cutlip and M.Shachasm, Problem Solving in Chemical Engineering with Numerical Methods, Prentice Hall, 1999

5. OT.Haanna and IO.C.Sandall, Computational Methods in Chemical Engineering, Prentice Hall, 1995

6. J.H.Mathews and K.D.Fink, Numerical Methods using MATLAB, 4th ed.,Prentice-Hall India Private Limited, 2005

**CACE – 1.2.3- SEPARATION PROCESSES**

***OBJECTIVES:***

\* To enable the physical and thermodynamic principles of mass transfer with an emphasis on how these principles affect the design of equipment and result in specific requirements for quality and capacity.

\* To enable the students to know the design of a distillation column, design of a absorber and calculations involved in liquid liquid extraction.

\* To enable the Model and solve problems related to flash distillation, liquid-liquid extraction, batch distillation, cascades, simple and complex binary distillation systems and absorption in packed towers

\* To enable the Types and characteristics of membranes. Separation of gases. Separation of liquids. Osmosis. Reverse osmosis. Dialysis, Electro-dialysis. Pervaporation. Ultra filtration. Industrial applications

***OUTCOMES:***

\* The student would know Design of design absorber and stripper, distillation column and extraction and the student would build and develop quantitative models of how these separation processes work and how to apply these in new applications

\* The student would understand equilibrium and rate governed multistage separation processes and also characterization of membranes and separation processes such as reverse osmosis, dialysis, ultra filtration and electro dialysis.

***Syllabus:***

Unit: -I : Introduction: Classification of reparation processes; Equilibrium – Based reparations General properties operation and complexities of reparations that involve mass rap rating agents and energy repeating agents. Review of vapor liquid and energy separating agents. Review of vapor liquid equilibrium and other equilibrium. Thermodynamic consistency test for VLE date phase rule and degrees of freedom estimations. Eqmilirinor ratio concept and its estimation from Defroster’s charts; Bubble and Dew-Point calculations, Flash calculation estimation of state of the mixture

Unit-II : Binary separation process: Common approach for process design estimation of feed location, product qualities and theoretical stages of equilibrium based reparations: single stage-single component and Multistage single component reparation processes involving absorption stripping liquid -liquid immiscible extraction adsorption and distillation Kermes-brown equation and its limitation process designee (estimation of feed location, product qualities and theoretical stages) of multistage multiple feeds and side stream process.

Unit III : Multi component separation process: Multi component Distillation Introduction. Key components; Estimation of minimum theoretical stages (Fizzles equation0 Distribution as non-key components in airhead and bottom products at total refuse; Determination of minimum refuse ratio (under wood’s method), Approximate calculation for multi component, multistage distillation estimation of actual refuse ratio and theoretical stages) kirks-Bridge equation) distribution of no-key components at actual refuse.

Unit-IV : Capacity and efficiency of contacting devices energy requirements of reparation process case studies in the reelection of separation process

Unit –V : Membrane separation process principled, characteristics and clarification of membrane reparation process, membrane materials, structure preparation of techniques, membrane modules, Membrane characterization pose size, pore distribution. Factors affecting retentively, Concentration polarization, gel polarization, fouling, eleaqing and refrigeration of membranes. Mechanisms of separation processes membrane, deme membranes and liquid membranes science and Technology of micro filtration reverse osmosis ultra filtration, Nan filtration dialysis and electro dialysis perspiration, liquid membrane permeation, gas permeation membrane reactor: polymeric, ceramic metal and Bio membranes

*Textbook:*

1. Separation Process Principles, 2nd Edition

2. J. D. Seader, Ernest J. Henley, John Willey & Sons,2nd Edition 2006.

*REFERENCE BOOKS:*

1. R.E. Treybal, Mass Transfer operation, 3rd edition MC Graw – Hill 1980

2. G.J. Geankoplis, Transport Process and separation process Principles, 4th equation, pretice Hall of India, 2007

3. P.H. Mankat, Equilibrum Stays Separation, Elsewies publication, 1988.

**CACE – 1.2.4: OPTIMIZATION**

***OBJECTIVE:***

Optimization of Chemical Process is an important of subject for Post Graduate Chemical Engineers. It deals with various optimization techniques in reducing cost of production ,energy consumption, maximum throughput and minimum labour cost etc. On studying the course one can understand how to write a model of the process optimize the process using the model

***OUTCOME:***

After successfully completing the course the student be able to

1.Understand the definition of Optimization and how to write an Objective function

2. Understand various types of Objective functions like Concave and Convex functions and its properties

3. Study the Optimization of uni and multi dimensional search problems

4. Solve the Optimization problems by Linear and Non-Linear Programming methods

*Syllabus:*

**1. Basic Concepts of Optimization:** Introduction to Process Optimization; Continuity of Functions; Unimodal versus Multimodal Functions; Convex and Concave Functions; Convex Region; Necessary and Sufficient Conditions for an Extremum of Unconstrained Function; Interpretation of the Objective Function in Terms its Quadratic Approximation.

**2. Optimization of unconstrained Functions - One-dimensional Search:** Numerical Methods for Optimizing a Function of One Variable; Scanning and Bracketing Procedures; Newton, Quasi-Newton and Secant Methods of Unidimensional Search – Newton’s Method, Quasi-Newton Method, Secant Method.

**3. Region Elimination Methods** - Polynomial Approximation Methods - Quadratic Interpolation, Cubic Interpolation; How the One-Dimensional Search is Applied in a Multidimensional Problem; Evaluation of Unidimensional Search Methods.

**4. Unconstrained Multivariable Optimization:** Direct Methods - Random Search, Grid Search, Univariate Search, Simplex Method, Conjugate Search Directions, Powell’s Method; Indirect Methods First Order - Gradient Method and Conjugate Gradient Method. Indirect Method Second Order – Newton’s method

**5. Linear Programming and its Applications:** Basic Concepts in Linear Programming; Degenerate LP’s – Graphical Solution; Natural Occurrence of Linear Constraints; The Simplex Method of Solving Linear Programming Problems

**6. Nonlinear Programming with Constraints:** Lagrange multiplier method, necessary and sufficient conditions for a local minimum, generalized reduced-gradient method, random search methods, and comparative evaluation of different methods.

**7. Global Optimization:** Overview of Genetic Algorithm, Simulated Annealing and other global optimization methods, Heuristic Search methods.

(*Problems dealing with the applications of optimization techniques for various chemical engineering operations using optimization software packages will be given as assignments to the students and will be evaluated by internal assessment)*

*Texts Book:*

1. T.F.Edgar, D.M.Himmelblau and L.S.Lasdon, Optimization of Chemical Processes, 2nd Edition, McGraw-Hill , 2001.

Reference Books:

1. P.Venkataraman, Applied Optimization with MATLAB, John Wiley, 2002

2. Ravindran , A., Ragsdell, K.M., and Reklaitis, G.V., Engineering Optimization - Methods and Applications, Wiley, 2nd ed., 2006.

3. WH.Ray and J.Szekely, Process Optimization with Applications in Metallurgy and Chemical Engineering, John Wiley, 1973.

4. K. Deb, Optimization for Engineering Design, Prentice Hall of India Private Limited, New Delhi, 2003

5. S.S.Rao, Engineering Optimization, 3rd Edition, Wiley, 1996.

**CACE-1.2.5 A. ELECTIVE –III( Nanotechnology)**

***Objectives:***

Nanotechnology may be treated as **Green technology**. It is one of the most advanced technologies now-a-days. It leads to have revolutionary changes in the fields of medical, Bio-medical, and fabrication of materials. Technologists are able to prepare ageless materials with the help of nano-techniques. Main objectives of the subject nanotechnology are :

1. To define green technology properly

2. To expose the students with new techniques of the nanotechnology.

3. To make them to learn the importance of quantum technology

4. To learn the procedure ageless materials to avoid wear-tear.

5. To learn the importance of nano –robots, machines

6. To know about the latest microscopes such as SEM, TEM

7. To know the importance of nanotechnology in the dawn of optical instruments

***Outcome:***

1. Application of nanotechnology in the development of energy

2. Application of nanotechnology in the development of solar panels, Fuel cells

3. Knew the importance of atoms manipulation

4. Knew that the applications of nanoparticles in the development of DVD, LEDs etc.

5. Biomedical applications in terms of preparing artificial, drug delivery, encapsulation, addition to that pharmaceuticals.

***Syllabus:***

**1.** Introduction tonanotechnology, molecular and atomic size, surface and dimensional spaces. Molecular nanotechnology: atoms by inference, electron microscopes, nanomanipulator, nanotweezers, atom manipulation, nanodots, nanolithography.

**2.** Nanopowders and nanomaterials: preparation, plasma arcing, chemical vapor deposition, sol-gels, electrodeposition, Ball milling, applications.

Carbon nanotubes: types, formation, assemblies, purification, properties and uses.

**3.** Molecular mimics: Catenanes and rotaxanes, various molecular switches, synthesis of rotaxanes and catenanes, molecular computers, chemical rotors, prodders, flippers, atom shuttles, actuators, contacts.

**4.** Nanobiometrics: Lipids as nano-bricks and mortar, self – assembled monolayers, proteins, 3-D structures arising from amines acids, nanoscale motors, Biological Computing, ion channels as sensors, Information in DNA structure, using DNA to build nano-cubes, hinges, smart glue, wire template.

**5.** Optics, photomics and solar energy: Properties of light and nanotechnology, Interaction of light and nanotechnology, Nanoholes and photons, Imaging, New low cost energy efficient windows and solar absorbers based on nanoparticles, Photonic crystals, surface wave guides and control of light paths.

**6.** Nanoelectrons: birth of electrons, semiconductors, transistor, integrated circuits, the tools of micro and nanofabrication, quantum electronic devices, quantum information and quantum computers, experimental implementations of quantum computers.

**7.** Future applications: microelectomechanical systems, nano-robots , ageless materials, invisible mending of atomic dislocations inside damaged materials, nanomechanics and nanoelasticity, nanoparticle coatings, nanoelectronic and magnetic devices and new computing systems, optoelectronic devices, environmental applications.

**8.** Molecular Dynamics, Simulation and Optimization of Nanosystems: Integration of Newton equation of motion, simulation of systems in contact with a heat bath, simulation methods based on accuracy and computational time, use of local and global optimization methods. (Scope: Chapters 5&6, Ali Mansoori\*: Principles of Nanotechnology)

(*This last section is not open for external assessment, but students are assessed* internally by means of assignments and home work problems).

*Text-book:*

1. M.Wilson, K.Kannangara, G. Smith, M. Simmons and B. Ragues, Nanotechnology, Overseas press ( India) Private Ltd; New Delhi, 2005.

Reference books:

1. G. Ali Mansoori\*, Principles of Nanotechnology, World Scientific Publishing Company, 2005.

2. G. Timp, Nanotechnology, Springer-Verlag, Network, 1999.

3. P. Poole and F.J. Owens, Introduction to Nanotechnology, John Wiley, 2003.

4. D.Ratner and M.Ratner, Nanotechnology: A Gentle Introduction, Pearson Education,2003.

5. B. Bhusan, Handbook of Nanotechnology, Springer, 2004

**CACE-1.2.5 B-ELECIVE-III ( BIOINFORMATICS)**

***Syllabus:***

1. Introduction, Molecular Biology and Bioinformatics, Biological database: Primary, Secondary and Structural data bases, tools for web search, data retrieval tools.

2. Genome analysis and gene mapping: sequence assembly problem, genetic mapping and linkage analysis, genome sequencing, sequence assembly tools, Human genome project.

3. Alignment of pairs of sequences, scoring matrices, multiple sequences, phylogenetic analysis, Tree evaluation, automated tools for phylogenetic analysis, working with FASTA and BLAST.

4. Gene identification and prediction: Basis for gene prediction, pattern recognition, gene prediction methods, working with DNA, Micro arrays, Micro array analysis.

5. Protein classification and structure visualization: structure – based protein classification, protein structure databases, visualization databases and tools, protein structure alignment, tools for plotting protein-ligand interaction.

6. Protein structure prediction: Analysis and prediction of primary structure and secondary structure, motifs, profiles, patterns and fingerprints search, Ab Initio approach, 2-D structure prediction, protein function prediction from DNA sequence.

7. Proteomics: Tools and techniques in proteomics, protein – protein interactions, gene family identification methods.

Computational Methods for pathways and systems Biology: Analysis of pathways, metabolic network properties, metabolic control analysis, simulation of cellar activities.

*Text-book:*

1. S.C..Rastogi, N.Mendiratta and P.Rastogic, Bioinformatics, Prentice- Hall of India Pvt.Ltd, New Delhi, 2004

*Reference books:*

1. T.K.Attwood and D.J. Parry-Smith, Introduction to Bioinformatics, Pearson Education Asia, Delhi, 2002

2. A.M. Lesk, Introduction to Bioinformatics, Oxford University press, New Delhi, 2004.

**CACE 1.2.5 C-ELECTIVE – III (Neural Networks)**

***Syllabus:***

*Theory*

1. Introduction to the theory of Artificial Neural networks, unsupervised learning.

2. Back propagation and its variations; General approximation for feed-forward neural networks

3. Radial basis neural networks and generalized regression neural networks.

*Applications*

4. Application of neural networks in process dynamics, process modeling of fault detection using neural networks.

5. Modeling chemical process using multi resolution representation neural networks

6. Neural networks based control strategies for a continuous polymerization reactor

7. Statistical and neural methods in classification and modeling.

*Text-book*

1. A.B.Bulsari, Neural Networks for Chemical Engineers, Elsevier, 1995.

*Reference books*

1. I.M. Mujtaba and M.A. Hussain, Application of Neural Networks and other learning technologies in Process Engineering, World Scientific Publishing Company, 2006

2. D.R. Baughman, Y.A. Liu, Neural Networks in Bioprocessing and Chemical Engineering, Academic Press, 1995.

3. S.N. Sivanandam, S.Sumathi and S.N. Deepa, Introduction to Neural Networks using MATLAB-6, Tata McGraw-Hill , New Delhi, 2006

**CACE-1.2.6-ELECTIVE-IV**

**CACE-1.2.6 A-ELECTIVE-IV(Corrosion Engineering-II)**

***Objectives:***

\* To enable the principles of corrosion, common corrosion forms, uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement corrosion control methods, and material selection to reduce corrosion cost.

\* To enable the ability to understand electrochemical fundamentals

\* To enable the ability to understand corrosion preventing methods

*Outcome:*

\* The student would know application of weight loss method

\* The student would know application of cathodic protection, anodic ptotection

\* At the end of this course, the student would know effective surface preparation of specimen can be done

\* After completion of this course, the student would understand the causes and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion.

\* The student would know application of Corrosion Processes and Evans Diagrams and application of electroplating, coatings and importance of inhibitors.

**Syllabus**

Corrosion in selective environments: Marine, Acids (Sulfuric acid, Hydrochloric acid, Nitirc acid, Phosphoric acid) Biological and industrial gases (SO2H2S).

Corrosion Testing - Purposes, Materials and specimen. Surface preparation, Measuring and weighing , Exposure Techniques - duration, Planned - Interval Tests, Aeration, cleaning specimens after exposure, Temperature, Standard expression for corrosion rates - Galvanic Corrosion, Erosion Corrosion, crevice Corrosion, Intergranular corrosion, test for stainless steels, warren test pitting, stress corrosion, Paint tests, Sea Water tests, Presenting and summarizing data - Nomo graph for corrosion rates and interpretation of results.

Cathodic and anodic protection, surface preparation for coatings and chemical conversions: Degreasing, Descaling , Polishing - Anodized coating : anodizing oxidizing, chromate coating, phosphate coatings - Metallic coatings : Hot dipping, cementation, vapor deposition of metallic coating; Sprayed coatings: flame spraying plasma spraying, Galvanizing - Electroplating : Nickel & chromium coatings, chromizing.- Organic coatings : paints, enamels, lacquers, resin mixtures.

Linings, laminates, reinforced plastic, fibre glass - Corrosion inhibitors: mechanism of inhibition, recirculating of water of water systems

Measurement and testing of preventive coatings; Thickness and Resistance tests for anodized, Painted, electroplated surfaces using polarization resistance, Linear polarization, curve fit analysis and Electrochemical impedance spectroscopy.

*Textbooks :*

1. Mars GFontana - Corrosion Engineering

2. Burns, R.M., Bradley, W.W., ‘protective coatings for Metals.’ Chapters 2 to 18.

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**CACE- 1.2.6 B - Elective-IV (Energy Engineering-II)**

***Objectives:***

The student is provided with the fundamentals of some renewable energy processes. Basic information to comprehend the various non-conventional energy systems would be gained by the student.

*Outcome:*

1. Methods to be adopted to utilize biomass as an important energy source.

2. Application of thermodynamics to convert ocean energy.

3. Possible mechanism to drawn energy from wind and other natural sources

4. Fuel cells as sources of energy.

5. New technologies to produce energy such as thermionics, thermoelectricity etc.

*Syllabus:*

Non – Conventional & New Energy Systems and Energy Conservation Technology Systems based on bio mass.

Physical and Bio mass – Definition – potential thermo – chemical methods of Bio - Conversion – Gasification – Liquefaction – Pyrolysis. Bio-gas technology – Historical review and development in India Different designs of bio-gas jplants – Selection of a model and size – Installation – Gas collection and distribution – operation and maintenance – Properties and uses of bio-gas – Utilization of manure – National Projects for Bio – gas development – safety.(Bansal et at,chapters 10 and 11; Khandelwal and Mahdi, Chapters 3,4,5,6,7,8,9,10: Chawla,chapters 2,3,4,5,6,7 & 8).

**Fuel Cells** : Hydrogen – Oxygen Fuel Cells – carbonaceous Fuel Cells – Molten Alkali Carbonate

Cells – Electrode Reactions and kinetics. (Fuel Cells by Young).

**Energy Wind, Tidal and OTEC :**

Potential in India – Origin of wind and general circulation systems of Earth – Wind direction – Wind measurement – Wind energy converters – Historical development – Power coefficient – Aerodynamic construction of a rotor blade Rotors – Wind electric generators in India – Economics of wind farm – Fundamentals and concepts of Wave energy – Ocean thermal – energy conversion (OTEC). (Bansal et at., Chapters 12,13 & 14).

**Hydrogen Energy, Methanol & Ethanol :** Hydrogen from fossil fuels from Electrolysis – Developments of various electrolytic cells – High pressure cells – Solid electrolytic systems – Hydrogen powered IC engines – Storage system – Handling and Transmission.(Journals on Hydrogen energy).

Methanol and Ethanol as Automobile fuels – Comparison with Gasoline and Diesel oil. (Journals on Hydrocarbon on processing).

**Energy Conservation Technologies:** Principles of Energy Conservation – Optimum Energy Conservation – Industrial Energy Conservation modeling – waste heat recovery and utilization.

*Prescribed Books:*

1. Renewable Energy Sources and Conversion Technology, N.K.Bansal, Manfred Klieemann,Michael Meliss, tataMcGraw Hill, 1990.

2. Bio Gas Technology, A practical hand book Vol 1, K.C.Khandelwal and S.S.Maholi, TataMcGraw Hill, 1986.

3. Advances in Bio Gas Technology: O.P.Chawla,publications and Information Division, Indian council of Agricultural Research,New Delhi, 1986.

4. Alternative Energy Sources: R.H .Taylor, Adam Hilger Ltd.,Brister.

5. Fuel cells, Vols.I & II: Reinhold publishing Crop.,New York.

6. International journal of hydrogen Energy, Vol.5, No. I, 1980 pages 1- 84: No.2, pages 119-129; pages 151-203; No.5. Pages 527 – 534 & 539 – 553; No.6, Pages 611 – 625.

7. Hydro Carbon Processing Vol. 58, May 1979 pages 127 – 138:Vol. 59, Feb. 1980, pages 72–75.

8. Handbook of Industrial Energy Conservation, David Hu, S., Van Nostrand Reinhold Company pages 73 – 133, 149-199, 297-327.

**CACE- 1.2.6 C - Elective-IV (Reaction Engineering-II)**

***Syllabus:***

UNIT - I : Laboratory Reactors - Interpretation of Experimental Data - Interpretation of Laboratory Kinetics Data - Homogeneous and Heterogeneous Laboratory Reactors. Calculation of Global Rate - The structure of Reactor Design. (Scope: Chapter 12 of J.M Smith 3rd Edition)

UNIT - II : Design of Heterogeneous Catalytic Reactors Isothermal and Adiabatic Fixed Bed Reactors Non-isothermal, Non-adiabatic Fixed Bed Reactors. (Scope: Chapters 13.1 - 13.9 of J.M Smith 3rd Edition)

UNIT - III : Design of fluidized bed Reactors - Two -Phase Fluidized Bed model - Operating characteristics - Slurry Reactors - Trickle - Bed Reactors - Optimization. (Scope: Chapter 13.10 - 13.13 of J.M Smith 3rd Edition.)

UNIT - IV : Fluid - Solid Noncatalytic Reactions - Design concepts - Single Particle Behavior - Reactor Models. *(Scope: Chapter 14 of J.M Smith 3rd Edition)*

UNIT - V : Short notes from the portions of all the above four units. Four bits are to be answered out of 7 bits (Not more than 2 bits to be given from any one Unit).

***Text Book:***

1. Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book Company, 1980, 3rd Edition.

 **SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH(IPCE) FIRST SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

IPCE-1.1.1 Process Modeling &
 Simulation 4 3 1 — 4 30 70 100

IPCE-1.1.2 Process Dynamics and
 Control 4 3 1 — 4 30 70 100

IPCE-1.1.3 Chemical Reaction
 Engineering 4 3 1 — 4 30 70 100

IPCE-1.1.4 Transport Phenomena 4 3 1 — 4 30 70 100

IPCE-1.1.5 Elective-I 4 4 — — 4 30 70 100

IPCE-1.1.6 Elective-II 4 4 — — 4 30 70 100

IPCE-1.1.7 IPCE lab 2 — — 3 3 50 50\* 100

IPCE-1.1.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

\*Only internal evaluation.

Elective-I: 1.Management and control of industrial wastewater and solids

 2. Petroleum Refinery Engineering-I

 3. Electrochemical Engineering-I

Elective-II: 1. Corrosion Engineering-I

 2. Energy Engineering-I

 3. Reaction Engineering-I

**SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH (IPCE) SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

IPCE-1.2.1 Computer Aided Design 4 3 1 — 4 30 70 100

IPCE-1.2.2 Air Pollution Control In
 Industry 4 3 1 — 4 30 70 100

IPCE-1.2.3 Analytical Techniques 4 3 1 — 4 30 70 100

IPCE-1.2.4 Environmental
 Biotechnology 4 3 1 — 4 30 70 100

IPCE-1.2.5 Elective-III 4 4 — — 4 30 70 100

IPCE-1.2.6 Elective-IV 4 4 — — 4 30 70 100

IPCE-1.2.7 IPCE lab 2 — — 3 3 50 50 100

IPCE-1.2.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

Elective-III: 1. Industrial Hazards, Safety Measures & Environmental Impact Assessment

 2. Petroleum Refinery Engineering-II

 3. Electrochemical Engineering-II

Elective-IV: 1. Corrosion Engineering-II

 2. Energy Engineering-II

 3. Reaction Engineering-II

 **SCHEME OF INSTRUCTION & EXAMINATION**

**2/2 M.TECH (IPCE) FIRST & SECOND SEMESTER**

(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)

**UNDER CHOICE BASED CREDIT SYSTEM**

*PROJECT WORK:*

**IPCE-2.1.1 - FIRST SEMESTER: CREDITS:10, MARKS:100**

**IPCE-2.2.1- SECOND SEMESTER: CREDITS:14, MARKS:100**

\* Project guide will be allotted at the beginning of first semester and the student has to give presentation on his/her project work at the end of first semester and grading will be awarded as A,B,C or F.

\* At the end of second semester final viva-voce examination will be conducted and grading will be awarded as A,B,C or F.

**SYLLABUS**

**M.TECH. I SEMESTER**

**IPCE-1.1.1: PROCESS MODELING AND SIMULATION**

**(Common for MPE, CACE & CHEMICAL )**

***Objective:***

Process modeling and Simulation is a important subject of study for Post Graduate Chemical Engineers . It deals with writing various process models based on basic physical process. It also deals with solving the various models by means of various numerical methods by computer simulation. By studying this course ,one can simulate various chemical process by computer simulation .

***Outcome:***

1. Understand the writing of a model of a process based on basic physical processes like mass ,momentum and energy balances

2. Develop a model equation for Tanks, Isothermal and Non-Isothermal Systems

3. Understand the models for Binary Distillation Column, Batch Reactors etc

4. Solve the model equations by Numerical methods like Euler and Runge –Kutta etc

*Syllabus:*

Principles of formulation - Continuity equations – Energy equation – Equation of motion – Equations of state – Transport equations – Chemical Kinetics – Algebraic and Integral / differential equations, Explicit and Implicit equations –Numerical Integration,Feed forward and feed backward control.

Basic modeling for tank system, mixing vessel – Simultaneous mass and energy balances – Models for boiling, batch distillation, and partial condenser.

Models for Reactor – Model for heterogeneous catalysis – Models for pumping system – Model for heat exchanger.

Operational blocks in simulation- Simulation Programming – Simulation examples of three CSTR’s in series, gravity flow tank, binary distillation column, non–isothermal CSTR.

Implicit function convergence ,Internal–halving convergence, Newton–Raphson method, False position convergence, Explicit convergence methods, Numerical Integration, Euler Integration, Runge - Kutta (fourth order) method.

*Textbooks:*

1. Process Modeling, Simulation and Control for Chemical Engineers by Luyben, W.L., McGraw Hill Books Co.

2. Mathematical Modeling in Chemical Engineering by Roger, G.E. Franks – John Wiley Sons Inc.

*Reference Book:*

1. Mathematical Methods in Chemical Engineering by V.G. Jenson and G.V. Jefferys, Academic Press – 2nd Edition.

**IPCE-1.1.2: PROCESS DYNAMICS & CONTROL**

**(Common for MPE, CACE & CHEMICAL )**

***Objectives*** *:*

The main purpose of teaching Process Dynamics & Control for first year postgraduate students is to take the student from basic mathematics to a variety of design applications in a clear, concise manner. This course is focused on the use of the digital computer in complex problem solving and in process control instrumentation. For chemical engineering problem solving students need more advanced mathematical preparation like partial differential equations, linear algebra and Fourier series all are introduced in this course.

***Outcome:***

\* Able to know the sampled data control systems consists of sampling and advanced mathematical model Z- transforms.

\* Able to describe the process in which the flow of the signals is interrupted periodically like in chromatograph.

\* Able to calculate the open loop response of a sampled data system and can develop a pulse transfer function that is the counterpart of the transfer function for continuous systems.

\* Able to know the sophisticated instruments used for the analysis of water and air pollutants, The student should have knowledge to design the equipment used for the abatement of these pollutants.

\* In a position to modernize the solid waste management and the student must be in a position to get awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

*Syllabus:*

Review of time domain, Laplace domain and frequency domain dynamics of process and control system.

Sampled data control system – sampling and Z–Transforms , open loop and closed loop response, Stability.

State space methods – representation of physical systems – transfer function matrix – Multivariable systems – Analysis and control.

Non linear control –examples of non linear systems – Methods of phase plane analysis.

Control of heat exchangers, distillation columns and Chemical Reactors.

*Textbooks:*

1. Process system Analysis and control, 2nd edition, Donald R Coughanower and Koppel.

2. Automatic process Control by Peter Harriot.

3. Process Modeling, Simulation and control for Chemical Engineers by W.L. Luyben.

**PCE-1.1.3 : CHEMICAL REACTION ENGINEERING**

**(Common for MPE, CACE & CHEMICAL)**

*Objectives:*

\* To focus on the thermal characteristics of various reactions and the design aspects of non isothermal and adiabatic reactors

\* To focus on Heterogeneous data analysis and design

\* To focus on CVD reactors

\* To study the design aspects of heterogeneous catalytic systems

\* To impart the knowledge on mass transfer with reaction in process catalysts

*Outcome:*

\* Enables the students to understand the design aspects of non isothermal and adiabatic reactors

\* Enables the students to on heterogeneous data analysis and design aspects of heterogeneous catalytic systems

\* Able to derive the rate laws for CVD

\* Able to develop the rate laws for heterogeneous fluid solid catalyzed reactions under rate limiting situations.

*Syllabus:*

Review of Fundamentals Rate laws and stiochiometry, reactions with phase change (Scope: Chapter 3 of Fogler) Least squares Analysis of rate data: differential reactors: Laboratory reactors (Scope: sections 5.4 to 5.6 of Fogler) Multiple reactions (Scope: Chapter 9 of Fogler).

Isothermal reactor design (Scope: Chapter 4 of Fogler) Batch reactor, PFR, CSTR design. Pressure drop in reactors, Reversible reactions, unsteady state operation of reactors, Simultaneous reaction and separation

Catalysis and catalytic reactors (Scope: Chapter 6 of Fogler) Steps in catalytic reaction: derivation of rate laws, design for gas-solid reactions, heterogeneous data analysis and design; Chemical vapour deposition, catalyst reactivation, moving bed reactions.

Diffusion and reaction in process catalysts (Scope: Chapter 11 of Fogler).

Diffusion and reaction in spherical catalyst.

Internal effectiveness factor, falsified kinetics; estimation of diffusion and reaction limited regimes. Mass transfer and reaction in packed bed. Determination of limiting situations from reaction data, CVD reactors.

Non-isothermal reactor design (Scope: Chapter 8 of Fogler), Energy Balance, equilibrium conversion under adiabatic conditions unsteady state operation, multiple steady states.

*Textbook:*

1. Fogler. H.S: Elements for Chemical Reaction Engineering 2nd Edition, Prentice Hall, New Delhi, 1992.

*Reference:*

1. Smith J.M: ‘Chemical Engineering Kinetics’ 3rd Edition, McGraw Hill, 1981.

**IPCE-1.1.4: TRANSPORT PHENOMENA**

**(Common for MPE, CACE & CHEMICAL )**

*Objectives:*

\* To be able to analyze various transport processes with understanding of solution approximation methods and their limitations.

*Outcomes:*

\* Ability to understand the chemical and physical transport processes and their mechanism.

\* Ability to do heat, mass and momentum transfer analysis.

\* Ability to analyze industrial problems along with relevant approximations and boundary conditions.

\* Ability to develop steady and time dependent solutions along with their limitations.

*Syllabus:*

**Unit 1: Momentum Transport**

1.1 The Equations of change for isothermal systems.

1.2 Velocity distributions with more than one independent variable.

1.3 Velocity distributions in turbulent flow.

1.4 Inter phase transport in isothermal systems.

**Unit 2: Energy Transport**

1.1 The Equations of change for non – isothermal systems.

1.2 Temperature distributions with more than one independent variable.

1.3 Temperature distributions in turbulent flow.

1.4 Interphase transport in nonisothermal systems.

 **Unit 3: Mass Transport**

1.1 The Equations of Change for multicomponent systems.

1.2 Concentration distribution with more than one independent variable.

1.3 Concentration distribution in turbulent flow.

*Textbook:*

1. “Transport phenomena” R. Byron Bird, Warren E. Stewart and E.N. Light foot, Wiley & Sons, Inc., New York.

*Reference Books:*

1. “Fundamentals of Momentum, Heat and Mass Transfer” James R. Welty, Charles E. Wicks and Robert E. Wilson, John Wiley & Sons, Inc., New York.

2. “Boundary – Layer Theory”, Dr.H.Sehlichting, McGraw – Hill Book Company, New York.

**IPCE-1.1.5: Elective – I**

**IPCE- 1.1.5 A - Elective-I (Management and control of industrial wastewater and solids)**

***Objective:***

The course is designed as tailor-made approach to know the fundamental concepts and various technologies of industrial wastes and solid waste management helpful the students in brightening chances for getting wide range of employability both in industrial and community organizations

***Outcome:***

1. On completion of the subject course, the students will have the scope to learn various theoretical and technical aspects of industries waste water treatment and solid waste management methods which are very significant in industrial sector

2. The course will add the design approach of Effluent Treatment Plants and solid waste recovery and recycling techniques and the students can brighten their chances of job opportunity in corporate companies engaged in design of pollution control equipments

3. Sludge treatment aspects of the course will be helpful to students for further enhancing their skills when they take up practical assignments

4. The course will lay down a basic platform to persue further research in the specific fields the interest of students

5. Enhance the knowledge of latest practices being adopted in the field of wastewater treatment and solid waste management and helpful the students who take up their career in academic line

*Syllabus:*

**I. Source of Industrial wastewater:** Types, permissible limits, **sources and pollutants** - BOD, COD, TOC, sampling and analysis of industrial wastewater, **impacts on** - soil, irrigation, animal husbandry, plants, ecosystems and public health aspects

**II. Primary and secondary treatment methods:** screening, sedimentation, flotation and neutralization, bacterial and bacterial growth curve, aerobic processes, suspended processes, activated sludge processes, extended growth processes, contact stabilization, aerated lagoons and stabilization ponds, attached growth processes, trickling filters, rotary disk contractors, fluidized bed contractors, anaerobic processes

**III. Tertiary treatment techniques:** carbon adsorption, ion-exchange, reverse osmosis, ultra filtration, ozonation, sonozone processes, chlorination

**IV. Sludge treatment and disposal:** overview, mass volume relationships, secondary clarification and gravity thickness, aerobic & anaerobic digestion, cake filtration, composting, sludge disposal

**V. Solid waste Management:Terminology** – liquid waste, solid waste, refuse, garbage & food waste, rubbish, white goods, rubble. **Solid waste characteristics** – generation rates, components, moisture content, density, proximate and ultimate analysis and energy content, **solid waste collection & transportation** – haul – container system, stationary container system, layout of collection routes, transfer stations, **solid waste processing and recovery** – recovery of materials for recycling, manufacturing of solid waste products, energy recovery, **disposal of solid wastes** – land filling methods, aspects of landfill implementation, sanitary landfill equipment

*Textbooks:*

1. “Industrial Pollution Control” by C.S.Rao

2. “Environmental Engineering – A design approach” by Arcadio P. Sincero and Gregoria A. Sincero

**IPCE- 1.1.5 B - Elective-I (Petroleum Refinery Engineering-I)**

***Objective:***

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

***Outcome:***

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

***Syllabus:***

***Origin and formation of petroleum***: Reserves and deposits of the world - Indialn petroleum industry - Composition of crudes.

***Refinery products specifications and test methods***: Evaluation of crudes. Crudes Pretreatment dehydration and desalting. Physical properties of petroleum oils and products.

Introduction to processing- Refinery distillation - processes - catalytic cracking, Reforming Hydro cracking , and hydro treating, hydrosulfurization.

***Chemical treatments & Extraction Processes*** *:* Alkylation, polymerization Lube oil processing.

**De-waxing** : Asphalt and air blown asphalt. Treatment of products, additines, blending of gasoline, treatment of gasoline, Kerosene etc.,

***Heat transfer equipment in Refinery***- Heat exchangers and pipe still heaters. Design of atmospheric distillation tower and Vacuum distillation tower, catalytic cracking units.

*Text Books :*

1. Petroleum Refinery Engineering - Nelson.

2. Refinery distillation - Watkins.

**IPCE- 1.1.5 C - Elective-I (Electrochemical Engineering-I)**

*OBJECTIVES:*

\* To enable the basic principles of electrochemistry, electrochemical devices, electro active materials used in such devices, and case studies of batteries.

\* To enable the clean energy needs and demands especially in the electrochemical power generation sector; and to become educators, practicing engineers, and national leaders in electrochemical energy conversion and storage.

\* To enable the integrated skills in fundamentals of electrochemistry (e.g.; chemistry, physics, mathematics, thermodynamics, and chemical kinetics) and electrochemical engineering applications (batteries, solar, flow and fuel cells, electrochemical synthesis and corrosion) to ensure successful career opportunities and growth within electrochemical power generation industries and academia.

\* To enable the students in energy related programs such as clean power generation and future green technologies.

 ***OUTCOMES:***

\* The student would know how to solve the problems relating to the production, storage, distribution and utilization of electrochemical energy and the associated environmental issues. And he would know integration of electrochemical principles and materials science for application in modern electrochemical devices.

\* The student would know design and conduct experiments, acquire data, analyze, interpret data, solve practical and complex problems on a variety of electrochemical devices such as batteries, solar cells, flow and fuel cells and integrate the professional, ethical, social and environmental factors in electrochemical engineering and understand the impact of these factors on global energy issues.

***Syllabus:***

Introduction:

Unit I : Basic Concept: Mechanism of Electrolysis, Laws of Electrolysis, Curent and Voltage Efficiency - Electrolytic dissociation, Coulometers, Ionic conduction. Electrolytic conductivity, Absolute ionic velocities, ionic mobilities, Transference Nos. Modern Ionic Theory, Ionic activity Degree of dissociation. Ionic Atmosphere Time of relaxation and relaxation effect, Electrophoretic effect - Debye - Huckel Onsager equation of conductance (Derivation is not required) and its validity.

Unit II: Thermodynamics I: Chemical Potential and Free Energy changes. Cell and Electrode potentials. Thermodynamics of Electrode potentials - Nernst Equation. Equilibrium Constant, Arbitrary Zero of potential, EMF series and their limitations Activity Coefficient of and their evaluation, Liquid Junction potentials, Concentration Cells - Reference Electrodes.

Unit III : Thermodynamics II : Electrode Kinetics, Role of Interface, Electric Double Layer and its capacitance - Irreversible Electrode processes - Irreversibility, Tates of Electrode Processes. Electrode Kinetics Model, Cathodic Hydrogen evolution, Depolarisation - Overpotential, Tafel Equation, Ohmic or resistance Over potential, Concentration overpotential, Oxygen Evolution reaction and Decompostion potential, Ionic Transport by Migration, Diffusion and Convection - Mass transfer.

Unit IV : Kenetics of Corrosion Processes and Evans Diagrams : Electrokinetic phenomenon - Straming potential, zeta potential and Electro - Osmosis, Electrophoresis, Dorn Effect.

Measurements and Systems Analysis : Conductivity measurements - Conductometric analysis - Titrations, Measurements of pH, potential - potentiometric titrations, Polarography Electrogravimetry, Coulometry. Current Distribution in a cell. Rotating Disc Electrode, Rotating Cylinder electrode, Rough Surface Electrode Limiting Current Technique.

Unit-V: Potential relations in corrosion cells potentials, pH diagrams in corrosion. Corrosion theory : Manifestation of corrosion, bases of electrochemical corrosion, amount and intensity of corrosion, Eight forms of corrosion : Uniform attack, Galavanic corrosion, crevice corrosion,Pitting, inter granular corrosion. Selective leaching, stress corrosion cracking. Conditions leading to pitting attack., environmental factors, hydrogen damage. Corrosion inhibition and prevention : Domestic water supplies, recirculating water systems, corrosion inhibitors, Inhibitors for acid pickling, vapor phase inhibitors. Coatings and paits: Phosphating, Protective metal coatings; cathodic protection and corrosion of buried structures.

*Textbooks:*

1. An Introduction to Electrochemistry by Samuel Glasstone, D. Van Nostrand Company Inc princeton, Affiliated East-West press Pvt. Ltd.

2. Electrochemistry - Principles and Applications by Edmund C. Fotter Oliver Hume Press Ltd., London.

***Reference Books:***

1. Electrochemical Engineering, Principles, by Geofferey Prentice, The Johns Hopkins University, Prentice Hall, Englewood Cliffs, New Jersy, 07632.

2. Electrochemistry - Bookris and A.K.Reddy.

3. Electrochemical Engineering by C.L.Mantell.

4. Principles of Electrochemical Engineering by L.W.Shemilt.

5. Chemical Engineering Development Centre, Indian Institute of Technology, Madras 600 036.

6. Fontanna and Grene ‘Corrosion Engineering’.

**IPCE-1.1.6: Elective –II**

**IPCE-1.1.6 A - Elective-II (Corrosion Engineering-I)**

The main objectives are to provide:

1. Basic aspects of electrochemistry relevant to corrosion phenomena,

2. Importance and forms of corrosion.

3. Knowledge on corrosion rate expressions and measurement techniques.

4. Knowledge on factors influencing corrosion of iron and steel exposed to atmospheric, soil and aqueous medium.

5. Basic knowledge on remedial measures for corrosion.

***Outcome:***

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion, corrosion tendency and electrode potentials.

2. Able to identify the nature of corrosion and form in which it attacks(Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage .

3. By acquiring knowledge on polarization and its influence on corrosion rates will be able to measure corrosion rates and analyze.

4. Acquires knowledge on mechanism and propose viable remedial measures.

***Syllabus:***

Basic Concepts and Outlines of Electrochemistry : Fundamentals of Electrochemical reactions, Faraday’s Laws Electrolytic and ionic conductance, ionic mobility’s, Transport Nos. Galvanic Cell and Electrolytic cells.

Definition and importance of corrosion, Dry cell, analogy, Corrosion Cells, Types of Corrosion Cells- a) Dissimilar electrode cells b) Concentration cells such as a salt concentration cells, differential aeration cells c) differential Temperature cells. Corrosion Rate Expresions - mdd, ipy, cpy, mpy, etc.

Corrosion Tendency and Electrode Potentials: Free Energy changes, Development of Nernst Equation for calculation of Half-cell potentials, Hydrogen electrode, Spontaneity of a reaction, Reversible cells and potentials – convention of Sign and calculations of EMF from standard Equilibrium potentials., EMF Series and Galvanic series, Reference Half Cells – Calomel, Silver-Silver Chloride and Saturated Copper-Copper Sulphate Half Cells. Pourbaix Diagram for Iron, Aluminum and magnesium, limitations of pourbaix diagrams.

Polarization and Corrosion Rates: Polarization and a Polarized Cell, Causes of Polarization – Concentration Polarization, Activation Polarization and IR drop. Hydrogen Over potentials, combined polarization and Mixed potential theory. Tafel Slopes and Tafel Equation. Graphical method of expressing Corrosion Reactions (Polarization diagrams/Evans diagrams), Derivation of Stern-Geary Equation, Influence of Polarization on Corrosion rates.

Passivity: Characteristics of Passivation, Flade potential, behavior of passivators, transpasivity, Theories on Passivity.

Forms of Corrosion: Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage. Factors influencing, mechanisms and prevention techniques for all forms of corrosion. Calculation of Corrosion rates using weight lost method and Polarization data. Electrochemical Impedance Spectroscopy.

Effect of Dissolved Oxygen (Air saturated Water, High Partial Pressure of Oxygen and Anaerobic bacteria), Temperature, pH, Galvanic coupling, velocity, dissolved salts concentration. Wet and dry corrosion.

*Textbooks :*

1. Corrosion and Corrosion Control by Herbert, H. Uhlig John Wiley and Sons Inc., New York.

2. Corrosion Engineering by Mars F Fontana, McGraw Hill.

3. An Introduction to Electrochemistry by Samuel Glass stone, Affiliated East West Press Pvt. Ltd.,

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**IPCE- 1.1.6 B - Elective-II ( Energy Engineering-I)**

**Objectives:** To lean overview of solar radiation and it’s potential for collection to meet the energy needs of mankind and potential for solar energy option. To learn measuring techniques of solar radiation and its compilation.

To learn various design and operational aspects of solar energy collection and storage.

To learn the design and operation of solar energy appliances like liquid flat plate collectors, Solar Air Heaters, Thermal energy storage, Thermal energy storage, Solar Pond, Solar thermal power generation.

To learn theory and application of Photovoltaic cells

**Outcome:** The student learns collection and design of various kinds of equipment operated on solar energy. The student learns principles and practice of Photo voltaic cells.

*Syllabus:*

**The Solar Energy option :** Thermal conversion – collection and storage Thermal applications – photovoltaic conversion – wind energy – Energy from Bio – mass – ocean thermal energy conversion.

**Solar Radiation :** Solar Radiation outside the earths – atmosphere Solar radiation at the Earth’s surface – Instruments for measuring Solar Radiation – Solar Radiation data – Solar Radiation Geometry Empirical equations for predicting the availability of Solar Radiation – Solar radiation on tilted surface.

**Liquid flat – Plate Collectors :** Components of liquid flat plate – various types of collectors – Performance Analysis – Transmissivity – Absorptivity product – Overall loss coefficients and heat Transfer correlations – Collector efficiency heat removal factors – effect of various parameters on performance. Transient Analysis – Testing procedures.

**Solar Air Heaters :** Various types of solar Heaters – Performance Analysis of a conventional Air Heater – Testing procedures – Concentrating collectors – various types of concentrating collectors cylindrical and parabolic collectors – General receiver collectors.

**Thermal energy storage :** Sensible heat storage – Latent heat storage – Thermochemical storage.

Solar Pond Description – Performance analysis – Experimental studies – Operational Problems.

**Solar Air Conditioning and Refrigeration :** Heat pump cycle – Coefficient of performance of the heat pumps – solar air-conditioning with absorption – Refrigeration system (Ammonia water and lithium bromide – water systems).

**Solar thermal power generation :** Thermal and direct electricity generation – Major sub-stations of a solar thermal power plant, Examples of installed systems – Concentration ratio. Temperature and efficiency concepts – Solar farm and tower – Economics.

**Photovoltaic Energy Conversion :** Photovoltaic Energy Conversion Fundamentals – band theory of solids – Physical processes in a solar cell – Solar cell with light incidence – Solar cell module – Silicon Solar Cells – Copper Sulphate / Cadmium sulphide Solar Cells.(Banasal et at.,chapters 9;Taylor, chapters 6, pages 256-298.

*Text Books:*

1. Solar Energy: Principles of thermal collection and storage by S.P. Sukhatme, Tata McGraw Hill, New Delhi 1984 (Chapters 2 to 8)

2. Renewable energy sources and conversion technology by N. K. Bansal, M. Kleemann, Michael Mcliss, 1990 (Chapters 2 – 9).

**IPCE- 1.1.6 C - Elective-II (Reaction Engineering-I)**

*Syllabus:*

**Unit I** : (Scope : J.M. Smith : Chapter 7): Heterogeneous Processes, catalysis, and absorption: Global Rates of Reaction - Types of Heterogeneous Reactions - The nature of catalytic Reactions - The Mechanism of catalytic Reactions - Surface Chemistry and Absorption - Absorption Isotherms - Rates of Absorption.

**Unit II** ( Scope : J. M. Smith: Chapter 8 : Solid Catalysts: Determination of surface area - Void Volume and solid density - Fore volume distribution - Theories of Heterogeneous Catalysis - Classification of catalysts - Catalyst Preparation - Promoters and Inhibitors Catalyst Deactivation (Poisoning).

**Unit III:** (Scope: J.M. Smith : Chapter 9): Rate equations for fluid - Solid Catalytic Reactions: Rates of adsorption, Desorption, Surface Reaction - Rate equations in terms of Fluid phase concentrations at the catalyst surface - Qualitative analysis of rate equation - Quantitative inter pretation of Kinetic data - Redox Rate equations.

**Unit IV:** ( Scope : Octave Levenspiel : Chapter 15) : Deactivating Catalysts : Mechanism of Catalyst Deactivation - The ratre of equation - The rate of equation from experiment - Batch - solids: Determining the rate for Independent Deactivation Batch - solids : Determining the rate of parellel, series or side - by - side Deactivation - Flowing solids experimental Reactors - Finding the Mechanism of Decay from experiment Design.

**Unit V**: ( Scope : J. M. Smith : Chapter 10) : External transport Processes in Heterogeneous Reactions: Fixed bed reactors - The effect of physical processes on observed rate of reaction - Mass and Heat transfer coefficients (fluid particle) in packed beds - Quantitative treatment of external transport effects - Stable operating conditions - Effect of external transport Processes on selectivity.

Fluidised bed reactors - Particle - fluid Mass and Heat transfer Slurry Reactors - Mass transfer coefficients: Gas bubble to liquid (K1) - Mass transfer coefficients: Liquid to particle (Kc) - The effect of mass - transfer on observed rates Trickle - Bed reactors - mass transfer coefficients: Gas to liquid (K1 ag) - Liquid to particle (kc ac) - Calculation of global rate.

*Text Books:*

1. Smith. J.M., “ Chemical Engineering Kinetics”, McGraw Hill book Company, New Delhi (Third Edition) 1981.

2. Octave Levenspiel, “ Chemical Reaction Engineering” , Wiley Eastern Limited - Second Edition - 1972.

***Reference Books*** *:*

1. Thomas, J.M. And Thomas, W.J. “ Introduction to the Principles of Heterogeneous Catalysis”. Academic Press Inc., New York 1967.

2. Carbnerry, James, J., “ Chemical and Catalytjic Reaction - Engineering”, McGraw - Hill, Engineering Series.

**II SEMESTER**

**IPCE–1.2.1 - COMPUTER AIDED DESIGN**

**(Common for Chemical and CACE)**

*The objectives of this course are to provide the student with:*

\* a basic understanding of the fundamentals of executive program, executive program aided simulation, unit computations, information flow diagram, encoding of information flow diagram, simulation of a simple plant, applications of simulation

\* knowledge to write algorithm and programs for various fluid flow problems, pressure drop in two phase flow, pipeline network calculations

\* knowledge to write algorithm and programs for rating and design calculations heat exchanger, condenser, reboiler, flash calculations, distillation column, gas absorption column, crosscurrent and counter current extraction, analysis of data in a reactor, extent of reaction, ideal reactors, semibatch reactor, packed bed reactor and fluidized bed reactor

***Outcome:***

\* Enables students to learn the basics of computer aided design, executive program aided simulation and its applications

\* Students will be able to write/develop unit computations (programs) for fluid flow, mass transfer, heat transfer and reaction engineering problems

***Syllabus:***

**Introduction**, preliminary data base creation, preliminary process synthesis, development of base case design, principles of steady state simulation, developing information flow diagram, information flow diagram to numerical form, planning calculations, finding recycles, planning calculations of a recycle set.

**Mass transfer operations**: Introduction, distillation- simple binary distillation, multicomponent flash calculations, multicomponent stage wise calculations, Gas absorption-absorption and stripping in plate columns, absorption in packed columns, Liquid extraction- single stage contact, cross current extraction, counter current extraction

**Flow of fluids in pipes**: Introduction, flow of Newtonian fluid in a pipe – incompressible fluid flow, sizing of pipes, pressure drop in compressible fluid flow, flow of non-Newtonian fluids- Bingham plastic fluid, Power law fluid, generalized Reynold’s number, sizing of pipes for non-Newtonian fluid flow, pipe network calculations, two phase flow systems – gas liquid flow, solid liquid flow, gas solid flow

**Heat transfer**: Introduction, shell and tube heat exchangers without phase change, tube side heat transfer coefficients, shell side heat transfer coefficients, pressure drop in shell and tube heat exchanger, condensers, reboilers

**Chemical reaction engineering**: Introduction, extent of reaction, chemical reaction equilibrium – independence of reactions, calculation of chemical equilibrium, analysis of rate data- integral method, differential method, nonelementary reactions, temperature dependence of rate constant, Ideal reactors – batch reactor, continuous stirred tank reactor, plug flow reactor, semi batch reactor, Temperature effects in homogeneous reactors – ideal batch reactor, plug flow reactor, CSTR. Heterogeneous systems – analysis of rate data, fixed bed reactor, catalyst deactivation

*Text book:*

1. ‘Chemical Process Calculations’ by Raghu Raman, Elsevier Applied Science Publishers, London, New York

*Reference books:*

1. ‘Simulation of Sulphuric Acid Plant’ by C.M.Crowe

2. ‘Product and Process Design Principles- Synthesis, Analysis and Evaluation’ by Warren Sieder, J.D. Seider and Daniel R.Lewin , John Wiely and sons, New York

**IPCE-1.2.2 - AIR POLLUTION CONTROL IN INDUSTRY**

The objectives of this course are to provide the student with:

\* a basic understanding of the fundamentals of air pollution with a background on historical perspective on air pollution

\* knowledge of major air pollutants; their sources and effects (environmental, economic and health), Sampling of air pollutants and their analysis

\* Insight into the dispersion of air pollution in the atmosphere

\* knowledge of air pollution control equipment and their design aspects

\* knowledge of various techniques to reduce the concentration of pollutants like sulphur dioxide, nitrogen oxide, organic vapors etc

\* Knowledge of air pollution legislation and role of citizens in air pollution control

***Outcome:***

(a) Enables student to gain knowledge about the nature, origin of air pollution and impact of the air pollution on human beings, plants and materials

(b) Enables the student to learn the sampling and analysis of pollutants (Monitoring of air pollutants)

(c) Enables the student to understand the updated engineering technologies to control air pollution and air pollution legislation.

(d) Enables student to gain knowledge about various technologies available to control of specific air pollutants like So2, Nox , organic vapors etc.

*Syllabus:*

**Sources,** nature and type of pollutants, emission factors, meteorological factors in pollution, plume behavior and characteristics, chill index, equivalent ambient temperature, chimney design considerations, plume rise, effective stack height, element of air pollution modeling, acid rain problem,

**Health effects of pollution**, effect of plants, animals and materials, problems of air pollution in India, global problems, air pollution measurements, Ringleman’s chart.,

**Air pollution technology-I**: Sampling and analysis of particulate matter and gaseous pollutants, removal of particulate matters, principles and design of settling chambers, solid traps, cyclone separators, fabric filters and fiber filters, scrubbers and electro-static precipitators,

**Air pollution technology-II**: General methods of control and removal of sulfur-dioxide, oxides of nitrogen and organic vapors from gaseous effluents, air pollution legislation, role of citizens in air pollution control,

**Case Studies:** Madhura refinery and it’s impact on Taj Mahal, Bhopal gas tragedy, Chernobyl disaster and HPCL Visakha refinery, changes in raw materials, alternative technology for minimization of pollutants.

*Reference books:*

1. ‘Design of Pollution Control Equipment’ by Gregory Sincero and Adam Sincero

2. ‘Air Pollution’ by H.V.N. Rao, Mc Graw Hill Publications, 1998.

**IPCE-1.2.3 - ANALYTICAL TECHNIQUES**

**(Common with Mineral Process Engineering)**

***Objective****:*

To understand the different types of analysis methods used in chemical industries. The course consists of both chemical and instrumental methods and also both qualitative and quantitative methods of analysis. In this course, the chemical methods of quantitative analysis include all the aspects such as: selection and sampling of materials, preparation of solutions, and analysis of various chemical raw materials and products. In instrumental methods colorimetric, spectrophotometric, spectrographic, flame emission, photo meter have been discussed.

*Outcome:*

\* The student should be able to know the theory of sampling, selection and preparation of the sample.

\* The student should be able to know the sophisticated instruments used for the analysis of mineral ores and chemical samples. The student should have knowledge of analysis for the ores and chemical samples.

\* The student should be in a position to understand the operation of instruments like X- Ray, flame emission spectroscopy.

\* The student can determine the traces of elements in the metals and alloys required for specific application.

*Syllabus:*

**Theory of sampling**, sampling of ores, minerals and coals, proximate and ultimate analysis of coal; coking index, calorific value of coal, its determination and calculation, analysis of ash,

**Wet assaying** of ores of iron, copper, lead, zinc and manganese, dry assaying process, fire saving methods for gold and silver,

**Instrumental methods of mineral investigation:** Theory and techniques of colorimetry and absorptiometry, photometer, spectrophotometers, atomic absorption spectrophotometer,

**Electrochemical methods of analysis**, Electrogravimetry methods, potentiometric titration, polarography, DTA,

**X-ray techniques**, emission of X-rays, X-rays instrumentation, X-ray diffraction, flame emission spectroscope - source, equipment and application of emission spectroscopy.

*Reference books:*

1. ‘An Introduction to Metallurgical Analysis: Chemical & Instrumental’ by S.K. Jain, Vikas Publishing House

2. A Text Book of Metallurgical Analysis’ by B.C.Agarwal & S.P.Jain, Khanna Publications.

3. ‘A Text Book of Quantitative Inorganic Analysis’ by A.I.Vogel, ELBS Edition.

**IPCE-1.2.4 - ENVIRONMENTAL BIOTECHNOLOGY**

**(Common with Biotechnology)**

*Objectives:*

\* Student to learn and understand environmental problems locally as well as global issue and consequencies.

\* To learn about xenobiotics and their effect on ecosystem. To learn about biodiversity available.

\* To learn about alternative and noval methods like biosorption of metals and bioleaching.

***Outcome****:*

\* Students have enough skills to identify the environmental problems and control measures.

\* Students are in a position to plan to treat various industrial effluent using biotechnological methods

*Syllabus:*

**Environment,** types of environment, environment and development, environmental management, environmental education, principles of ecology, ecosystems, types of ecosystems, ecosystem structure and functioning, food chains, food webs, Ecological pyramids, nutrient cycling, microbial associations,

**Source, effects and control aspects of various pollutants:** Air (particulate matter, SOx, NOx, Cox, CHx, noise), water (primary, secondary and advanced treatment techniques), solids (recycling, incineration and bioconversion), global environmental problems - global warming, ozone depletion and acid rain, industrial effluent treatment- case studies of paper and pulp, tannery, pharmaceutical, fertilizer and petroleum industries,

**Biodegradation of xenobiotics**: Xenobiotic compounds in the environment, persistent compounds, degradation mechanisms,

**Bioremediation:** Bioremediation by microorganisms, bioremediation process and technologies, bioremediation measurement in the field, monitoring and efficacy of bioremediation

**Biosorption of metals**: Microorganisms and metal adsorption, factors affecting biosorption, bioreactors and biosorption, phytoremediation,

**Bioleaching:** Types of bioleaching, advantages and disadvantages of bioleaching, methods for bioleaching,

**Biodiversity:** Levels of biodiversity, value of biodiversity, global biodiversity, hotspots of biodiversity, threats to biodiversity, conservation of biodiversity,

**Environment and energy:** Biomass sources, biomass production and utilization for energy, biomass conversation routes, energy crops, biofuels, biodiesel, hydrogen production, conservation of energy, biofertilizers, biopesticides, biofilters, biosensors, biopolymers and bioplastics.

*Reference books:*

1. ’Environmental Pollution Control Engineering’ by C.S.Rao, Wiley Eastern Limited

2. ‘Waste Water Treatment: Rational Methods of Design and Industrial Practices’ by M. Narayana Rao and Amal K. Datta, Oxford & IBH Publishing Company Pvt. Ltd.

3. ‘Environmental Biotechnology: Basic Concepts and Applications’ by Indu Shekhar Thakur, I.K. International Pvt. Ltd.

4. ‘Microbial Ecology: A Conceptional Approach’ by I.M.Lunch, Oxford Black

5. ‘Environmental Biotechnology’ by Geetha Bali, APH Publishing Corporation, 2002

**IPCE-1.2.5 A-ELECTIVE-III (Industrial Hazards,
Safety Measures & Environmental Impact Assessment)**

***Objective of the course****:*

This course is designed to promote the knowledge on various important aspects of hazard analysis and EIA techniques which are mandatory for implementation by the industries. The objective include an intention that the student will get fair opportunities for obtaining employment as this particular course is having lot of demand in India and abroad.

***Outcome from the course****:*

1. Now a day’s industrial & occupational safety gained paramount importance for loss prevention in order to achieve considerable profit in process industries. This course significantly help the students to learn the concepts of safety, hazards, risk, occupational safety management

2. This course include an approach of conducting environmental impact assessment study and preparing reports which is mandatory for all the process industries being setup

3. The course also describes various methodologies for identification and assessment of hazards involved in handling and processing of various harmful chemicals in industries

4. Emergency preparedness plans are included in this course which enlighten the learners various aspects of planning, emergency resources, action teams and rescue operations in case of real emergencies in industries

5. The students will be knowing various statutory regulations pertaining to factories act, environmental protection act, static and mobile pressure vessel rules and other regulatory amendments to comply which can help them when they are employed in industrial sectors

6. This course may help the students for getting opportunities abroad because of huge demand of HSE engineers especially in gulf oil companies and basic chemicals manufacturing companies

7. Further learning in this field may provide self employability by way of freelanced consultancy to the industries

8. This course will provide the basis for taking up further research work in inventing new technologies for effective management of industrial hazards and occupational health

***Syllabus:***

**I. Introduction: Hazards** – chemical hazards, thermodynamic hazards, electrical & electromagnetic hazards, mechanical hazards & health hazards, **Risk** – definition, causes, potential & adverse effects, **statutory framework** – key provisions of factories act, environmental protection act, manufacture, storage & import of hazardous chemical rules, static & mobile pressure vessels rules, NFPA specifications, OSHA regulations

**II. Hazard Analysis:** Incident scenarios, residual risk, concept hazard analysis, preliminary process hazard analysis, HAZOP, Fault Tree Analysis (FTA), Event Tree Analysis (ETA), sneak analysis, Failure Mode and Effect Analysis (FMEA), Human Reliability Analysis (HRA), Cause Consequence Analysis (CCA)

**III. Safety Management Systems:** Safety policy perceptions, safety organization, safety audit techniques, **project and construction safety** – welding and cutting operations, fabrication, material handling, equipment spacing, safe plant layout procedures, storage tanks, erection and commissioning works, housekeeping methods, maintenance of storage yards, erection and maintenance of electrical panels and MCC rooms, electrical & mechanical safe guarding, **process safety management** – elements, methods of management, equipment reliability, preventive maintenance schedules, work permits, **emergency preparedness** – onsite & offsite emergency preparedness, emergency preparedness plans, site specific action plans & contingency plans, emergency facilities, rehabilitation & rescue operations, post emergency actions

**IV. Occupational Safety Management:** Occupational health perspectives, pre-employment & periodical medical examinations, diseases, causes, consequences, occupational health hazards in **various industries** – aluminium industry, asbestos, battery manufacturing, sugar, cement, coke ovens, cotton ginning, dairy, electro plating, fish canning, poultries, irrigation, lead smelting, mining, pesticides, power plants, refineries, pulp & paper industry, PVC processing, steel plants, fertilizers, sulphuric acid plants, tanneries & textiles

**V. Environmental Impact Assessment:** Introduction, comprehensive of EIA, methodology, framework of EIA, considerations, application, purpose of EIA, rapid EIA, **baseline data collection** – air pollution parameters, water pollution parameters, soil pollution, noise pollution, meteorological parameters, socio-economic studies, prediction and assessment of impacts on air environment, water environment, ecological factors, meteorological factors, flora & fauna and socio-economic conditions, environmental matrices, quantitative assessment of adverse effects, **preparation of environmental management plan** – considerations, study observations, process modifications, emission control, development of greenbelt, ecological restoration, soil conservation, rainwater harvesting, recharge of groundwater table, restoration of flora & fauna, reclamation, rehabilitation, conservation of historical monuments, review of EIA plans, modifications, **environmental impact assessment for major industries** – steel plants, refineries, power plants, bulk drugs, tanneries, mining, fertilizers and chemical industries.

*Text Books:*

1. “Hazard identification and risk assessment” by Geoff Wells, Institution of Chemical Engineers, Davis Building, UK

2. “Occupational health and safety guidelines” by Environmental Department, The World Bank, Washington DC

3. “Environmental Impact Assessment” by Larry W.Canter

**IPCE-1.2.5 B- ELECTIVE – III (Petroleum Refinery Engg - II)**

**Objective:** To know about various production processes for the manufacture of C1 to Aromatic Compounds.

To know the design aspects to be taken into consideration for the designing of various equipments used in the process.

**Outcome**: 1.Able to understand the processes and mechanisms of various production processes of C1 to Aromatic compounds. 2.Able to understand the design aspects of various equipment used in the production processes.

*Syllabus:*

Raw materials for petrochemicals - Refinery process and petrochemical feed stocks - pyrolysis for petrochemical feed stocks - separation of individual hydrocarbons by fractionation.

Petrochemicals from C1, C2 , C3 & C4 fractions. Petrochemicals from aromatic feed stocks.

*Design of petrochemical equipment:* Pyrolysis furnace, Pyrolysis reactor (Ethane Cracking or propene cracking).

Super fractionator ( Ethyane - Ethylene, Propene - Propylene, Ethyle Benzene - styrene)

Fixed bed reactor ( Ethyle Benzene - Styrene)

Multiphase reactor ( Oxo synthesis).

*Text Books :*

1. Ethylene & its derivations - S.A. Miller

2. Propylene and its derivations - E.G. Hancock.

3. Benzene, Toluene, Xylene and their Derivations. E.G. Hancock.

**IPCE-1.2.5 C- ELECTIVE – III (Electrochemical Engineering-II)**

***The main objectives are to provide:***

1. Knowledge on Electroplating, Electroforming, electro refining, electro wining.

2. Knowledge on Electrolysis and Manufacturing process.

3. Knowledge on primary & secondary batteries and fuel

*Outcome:*

1. Acquires knowledge on electrochemical ore beneficiation techniques, electroplating, electro refining and electro winning.

2. Able to work in commercial and industrial manufacturing units using electrolysis.

3. Familiarize with batteries and components like separators, binder, electrolyte, and additives used in batteries.

4. Familiarize with the characterization methods of batteries, e.g. charge/discharge cycles, overpotential, battery capacity, state of charge, state of health, impedance.

5. Familiarize with the Fuel cells.

**Syllabus:**

**Part –A**

Electroplating, Electroforming and Electrophoresis Electrorefining of metals - Copper, Silver, Gold, Nickel, Lead and Cobalt. Electrowinning of metals - Copper, Zinc, Cadmium, Chromium and Manganese.

Electrolysis of Alkali Halides and Sulfates - Chlorine and Caustic, Potassium halides, Hydrochloric acid, Fluorine and sodium sulfate.

Manufacture of Hydrogen and Oxygen. Electrolytic Reduction and Oxidation - Persalts, Cuprous oxide, Mercuric oxide, Manganese dioxide and Perchlorates.

Electrolysis of fused Salts - Aluminum, Magnesium, Sodium, Beryllium and Zirconium.

**Part –B**

Batteries: Classification of cells and batteries, theoretical cell voltage, capacity, energy, electrochemical principles and reactions

Primary batteries: Zinc carbon batteries(Leclanche and Zinc chloride cell system), Magnesium and Aluminum batteries, Alkaline manganese dioxide batteries, Lithium batteries.

Secondary batteries: Lead acid batteries, nickel cadmium batteries, nickel metal hydride batteries, lithium ion batteries, rechargeable zinc, alkaline, manganese dioxide batteries

Fuel cells: Molten carbonate fuel cell(MCFC), phosphoric acid fuel cell(PAFC), Solid oxide fuel cell (SOFC), proton exchange membrane fuel cell(PEMFC).

*Textbooks:*

1. Electrochemical Engineering by Mantell, C.L. McGraw–Hill

2. Electrochemistry Principles and Applications Edmund Potter, Cleaver–Hume Press Ltd.

3. Handbook of batteries by David linden and Thomas B Reddy, McGraw –Hill

**IPCE-1.2.6-ELECTIVE-IV**

**IPCE-1.2.6 A-ELECTIVE-IV(Corrosion Engineering-II)**

***Objectives:***

\* To enable the principles of corrosion, common corrosion forms, uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement corrosion control methods, and material selection to reduce corrosion cost.

\* To enable the ability to understand electrochemical fundamentals

\* To enable the ability to understand corrosion preventing methods

*Outcome:*

\* The student would know application of weight loss method

\* The student would know application of cathodic protection, anodic ptotection

\* At the end of this course, the student would know effective surface preparation of specimen can be done

\* After completion of this course, the student would understand the causes and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion.

\* The student would know application of Corrosion Processes and Evans Diagrams and application of electroplating, coatings and importance of inhibitors.

*Syllabus:*

Corrosion in selective environments: Marine, Acids (Sulfuric acid, Hydrochloric acid, Nitirc acid, Phosphoric acid) Biological and industrial gases (SO2H2S).

Corrosion Testing - Purposes, Materials and specimen. Surface preparation, Measuring and weighing , Exposure Techniques - duration, Planned - Interval Tests, Aeration, cleaning specimens after exposure, Temperature, Standard expression for corrosion rates - Galvanic Corrosion, Erosion Corrosion, crevice Corrosion, Intergranular corrosion, test for stainless steels, warren test pitting, stress corrosion, Paint tests, Sea Water tests, Presenting and summarizing data - Nomo graph for corrosion rates and interpretation of results.

Cathodic and anodic protection, surface preparation for coatings and chemical conversions: Degreasing, Descaling , Polishing - Anodized coating : anodizing oxidizing, chromate coating, phosphate coatings - Metallic coatings : Hot dipping, cementation, vapor deposition of metallic coating; Sprayed coatings: flame spraying plasma spraying, Galvanizing - Electroplating : Nickel & chromium coatings, chromizing.- Organic coatings : paints, enamels, lacquers, resin mixtures.

Linings, laminates, reinforced plastic, fibre glass - Corrosion inhibitors: mechanism of inhibition, recirculating of water of water systems

Measurement and testing of preventive coatings ; Thickness and Resistance tests for anodized, Painted, electroplated surfaces using polarization resistance, Linear polarization, curve fit analysis and Electrochemical impedance spectroscopy.

*textbooks :*

1. Mars GFontana - Corrosion Engineering

2. Burns, R.M., Bradley, W.W., ‘protective coatings for Metals.’ Chapters 2 to 18.

*Reference Books :*

1. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**IPCE-1.2.6 B-ELECTIVE-IV(Energy Engineering-II)**

*Objectives:*

The student is provided with the fundamentals of some renewable energy processes. Basic information to comprehend the various non-conventional energy systems would be gained by the student.

*Outcome:*

1. Methods to be adopted to utilize biomass as an important energy source.

2. Application of thermodynamics to convert ocean energy.

3. Possible mechanism to drawn energy from wind and other natural sources

4. Fuel cells as sources of energy.

5. New technologies to produce energy such as thermionics, thermoelectricity etc.

*Syllabus:*

Non – Conventional & New Energy Systems and Energy Conservation Technology

Systems based on bio mass.

Physical and Bio mass – Definition – potential thermo – chemical methods of Bio - Conversion – Gasification – Liquefaction – Pyrolysis.

Bio-gas technology – Historical review and development in India Different designs of bio-gas jplants – Selection of a model and size – Installation – Gas collection and distribution – operation and maintenance – Properties and uses of bio-gas – Utilization of manure – National Projects for Bio – gas development – safety.(Bansal et at,chapters 10 and 11; Khandelwal and Mahdi, Chapters 3,4,5,6,7,8,9,10: Chawla,chapters 2,3,4,5,6,7 & 8).

Fuel Cells : Hydrogen – Oxygen Fuel Cells – carbonaceous Fuel Cells – Molten Alkali Carbonate Cells – Electrode Reactions and kinetics. (Fuel Cells by Young).

Energy Wind, Tidal and OTEC :

Potential in India – Origin of wind and general circulation systems of Earth – Wind direction – Wind measurement – Wind energy converters – Historical development – Power coefficient – Aerodynamic construction of a rotor blade Rotors – Wind electric generators in India – Economics of wind farm – Fundamentals and concepts of Wave energy – Ocean thermal – energy conversion (OTEC). (Bansal et at., Chapters 12,13 & 14).

Hydrogen Energy, Methanol & Ethanol : Hydrogen from fossil fuels from Electrolysis – Developments of various electrolytic cells – High pressure cells – Solid electrolytic systems – Hydrogen powered IC engines – Storage system – Handling and Transmission.(Journals on Hydrogen energy).

Methanol and Ethanol as Automobile fuels – Comparison with Gasoline and Diesel oil. (Journals on Hydrocarbon on processing).

Energy Conservation Technologies: Principles of Energy Conservation – Optimum Energy Conservation – Industrial Energy Conservation modeling – waste heat recovery and utilization.

*Prescribed Books:*

1. Renewable Energy Sources and Conversion Technology, N.K.Bansal, Manfred Klieemann,Michael Meliss, tataMcGraw Hill, 1990.

2. Bio Gas Technology, A practical hand book Vol 1, K.C.Khandelwal and S.S.Maholi, TataMcGraw Hill, 1986.

3. Advances in Bio Gas Technology: O.P.Chawla,publications and Information Division, Indian council of Agricultural Research,New Delhi, 1986.

4. Alternative Energy Sources: R.H .Taylor, Adam Hilger Ltd.,Brister.

5. Fuel cells, Vols.I & II: Reinhold publishing Crop.,New York.

6. International journal of hydrogen Energy, Vol.5, No. I, 1980 pages 1- 84: No.2, pages 119-129; pages 151-203; No.5. Pages 527 – 534 & 539 – 553; No.6, Pages 611 – 625.

7. Hydro Carbon Processing Vol. 58, May 1979 pages 127 – 138:Vol. 59, Feb. 1980, pages 72–75.

8. Handbook of Industrial Energy Conservation, David Hu, S., Van Nostrand Reinhold Company pages 73 – 133, 149-199, 297-327.

**IPCE-1.2.6 C-ELECTIVE-IV (Reaction Engineering-II)**

***Syllabus:***

UNIT - I : Laboratory Reactors - Interpretation of Experimental Data - Interpretation of Laboratory Kinetics Data - Homogeneous and Heterogeneous Laboratory Reactors. Calculation of Global Rate - The structure of Reactor Design. (Scope: Chapter 12 of J.M Smith 3rd Edition)

UNIT - II : Design of Heterogeneous Catalytic Reactors Isothermal and Adiabatic Fixed Bed Reactors Non-isothermal, Non-adiabatic Fixed Bed Reactors. (Scope: Chapters 13.1 - 13.9 of J.M Smith 3rd Edition)

UNIT - III : Design of fluidized bed Reactors - Two -Phase Fluidized Bed model - Operating characteristics - Slurry Reactors - Trickle - Bed Reactors - Optimization. (Scope: Chapter 13.10 - 13.13 of J.M Smith 3rd Edition.)

UNIT - IV : Fluid - Solid Noncatalytic Reactions - Design concepts - Single Particle Behavior - Reactor Models. *(Scope: Chapter 14 of J.M Smith 3rd Edition)*

UNIT - V : Short notes from the portions of all the above four units. Four bits are to be answered out of 7 bits (Not more than 2 bits to be given from any one Unit).

***Text Book:***

1. Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book Company, 1980, 3rd Edition.

**SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH (BIOTECHNOLOGY) FIRST SEMESTER**

(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

MBIO-1.1.1 Advanced
 Microbiology 4 3 1 — 4 30 70 100

MBIO-1.1.2 Advanced
 Biochemistry 4 3 1 — 4 30 70 100

MBIO-1.1.3 Advanced Biochemical
 Engineering 4 3 1 — 4 30 70 100

MBIO-1.1.4 Advanced
 Downstream
 Processing 4 3 1 — 4 30 70 100

MBIO-1.1.5 Elective-I 4 4 — — 4 30 70 100

MBIO-1.1.6 Elective-II 4 4 — — 4 30 70 100

MBIO-1.1.7 Biotechnology lab-I 2 — — 3 3 50\* 50 100

MBIO-1.1.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

\*Only internal evaluation.

Elective-I: 1. Bioanalytical techniques

 2. Bioinformatics

 3. Biosafety & bioethics

Elective-II: 1. Corrosion Engineering-I

 2. Energy Engineering-I

 3. Reaction Engineering-I

 **SCHEME OF INSTRUCTION & EXAMINATION**

**1/2 M.TECH (BIOTECHNOLOGY) SECOND SEMESTER**

(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)

**UNDER CHOICE BASED CREDIT SYSTEM**

Code No. Course Credits Theory Tutorial Lab Total Sessional Exam Total
 marks marks marks

MBIO-1.2.1 Genetic Engineering 4 3 1 — 4 30 70 100

MBIO-1.2.2 Enzyme Engineering 4 3 1 — 4 30 70 100

MBIO-1.2.3 Environmental
 Biotechnology 4 3 1 — 4 30 70 100

MBIO-1.2.4 Nanotechnology 4 3 1 — 4 30 70 100

MBIO-1.2.5 Elective-III 4 4 — — 4 30 70 100

MBIO-1.2.6 Elective-IV 4 4 — — 4 30 70 100

MBIO-1.2.7 Biotechnology lab-II 2 — — 3 3 50 50 100

MBIO-1.2.8 Seminar 2 — — 3 3 100 — 100

 TOTAL 28 20 4 6 30 330 470 800

Elective-III: 1.Industrial Biotech Products

 2. Pharmaceutical Biotechnology

 3. Agricultural Biotechnology

Elective-IV: 1. Corrosion Engineering-II

 2. Energy Engineering-II

 3. Reaction Engineering-II

**SCHEME OF INSTRUCTION & EXAMINATION**

**2/2 M.TECH (BIOTECHNOLOGY) FIRST & SECOND SEMESTER**

**(WITH EFFECT FROM 2019-20 ADMITTED BATCH ONWARDS)**

**UNDER CHOICE BASED CREDIT SYSTEM**

*PROJECT WORK:*

**MBIO-2.1.1 - FIRST SEMESTER: CREDITS:10, MARKS:100**

**MBIO-2.2.1- SECOND SEMESTER: CREDITS:14, MARKS:100**

\* Project guide will be allotted at the beginning of first semester and the student has to give presentation on his/her project work at the end of first semester and grading will be awarded as A,B,C or F.

\* At the end of second semester final viva-voce examination will be conducted and grading will be awarded as A,B,C or F.

**I SEMESTER**

**MBIO-1.1.1: ADVANCED MICROBIOLOGY**

***Objectives:***

To understand basic as well as advanced aspects of microbiology like Epidemiology and infectious diseases and immunology.

*Outcome :*

Students are enriched with both theoretical and practical approaches to understand the problem and possible solutions.

*Syllabus:*

**Introduction to Microbiology:** Origin and evolution of microorganisms, history of Microbiology, nature and scope of microbiology, major characteristics of prokaryotes and Eukaryotes, structure and functioning of bacterial cell, staining reactions.

**Classification of microorganisms:** Major characteristics of microorganisms, concepts of Classification, classification methods, principles of nomenclature and identification, Modem trends in classification. General features and classification of some groups of microorganisms - Algae, Fungi, Chlamydiae, Rickettsiae, Mycoplasmas, Viruses and Protozoa, economic importance of Micro-organisms

**Methods in microbiology:** Nutritional requirements, nutritional types of bacteria, Characteristics of culture medium, type of culture media and preparation of culture media, isolation of microorganisms - general and selective methods, isolation of bacteria in pure culture, enrichment - enrichment methods, staining techniques, culture characteristics, maintenance and preservation of cultures, culture collections.

**Reproduction and growth:** Reproduction in bacteria, genetic transfer in bacteria, Bacterial growth, bacterial growth curve, growth measurement techniques, factors affecting growth, control of microorganisms by physical and chemical methods.

**Metabolism and energy production:** Respiratory chain, energy production by aerobic and anaerobic process, energy production by photosynthesis. Microbiology of air, water, soil, milk and food.

**Epidemiology and infectious diseases:** Epidemiological markers, role of host in infectious diseases - Air borne, water borne and food borne diseases.

**Immunology:** Natural resistance, internal defense mechanisms, non-specific defense mechanisms, immunity, types of immunity, immune systems, antibody and its diversity, Hypersensitivity, transplantation, autoimmunity, AIDS and other immune deficiencies, vaccines, types of vaccines, production of vaccines and synthetic vaccines, monoclonal anti bodies and their use, antibiotics, history of antibiotics, classification and production of antibiotics, microbial toxins, types of microbial toxins, effects of microbial toxins and their control.

*TEXT BOOKS:*

1. Microbiology by M. J. Pelczer, E. C. S. Chan, N. R. Kries. Tata McGrew Hill publications

2. Microbiology fundamentals and applications by S. S. Purohit. Agro botanical. Publications.

***REFERNCE BOOKS:***

1. Microbiology by Prescott, Harley, Klein. Mc Graw-Hill publications

2. General Microbiology by Roger Y. Stainer, Edward A. Adebery, John L. Ingraham. Published by Macmillan Press LTD.

**MBIO -1.1.2: ADVANCED BIOCHEMISTRY**

***Objectives:***

\* Tostudy about the biomolecules and importance of biochemistry in the advanced level.

\* To study the detailed structure and function of biomolecules like carbohydrates, amino acids, proteins, lipids and nucleic acids.

\* To study the detailed structure and function of biocatalysts, enzymes. To study various types of enzyme inhibitions.

\* To study in detailed vitamins, membrane assembling, bioenergetic principles and ATP cycle.

\* To study the metabolism in advanced level and biosynthesis of fatty acids, DNA, RNA, and proteins.

\* The student obtains advanced level knowledge n biomolecules and metabolic process a base for the higher research activity.

***Outcome:***

\* Students will obtain knowledge in the advanced structure of biomolecules.

\* Student will obtain knowledge in the biosynthesis and degradation of biomolecules.

\* Student will obtain advanced knowledge in the metabolism and bioenergetic principles.

\* The students can carry out independent research work to improve and to invent new biomolecules and can understand new metabolic processes.

***Syllabus:***

Scope and importance of biochemistry, molecular logic of living matter,origin of biomolecules.

Molecular structure of Water,macromolecular structure of water, hydrogen bonds, dissociation of water.

**Carbohydrates:** classification of carbohydrates, structure and properties of monosaccharides (ribose, glucose, fructose), disaccharides (maltose, lactose, sucrose) and polysaccharides (Starch, glycogen and cellulose).

**Amino acids and proteins:** Classification and properties of amino acids and proteins, peptide bond, structural organization of proteins: primary, secondary, tertiary and quaternary structure of proteins. Biochemical function of proteins, denaturation of proteins.

**Lipids:** classification, structure and physiological functions of triglycerides, fattyacids, phospholipids, cerebrosides, gangliosides and cholesterol.

**Nucleic Acids:** Structure and properties of purines and pyrimidine bases, nucleosides, nucleotides.Structure of nucleic acids-DNA and RNA.

**Enzymes:** Classification of Enzymes, Mechanism of Enzyme action, factors affecting enzyme action, co-enzymes and regulatory enzymes. Enzyme inhibition-competitive,non-competitive and uncompetitive inhibitions.

Structure and functions of vitamins.Membrane assembly and transport across the membranes.Bioenergetic principles and ATP cycle.

Mechanism of photosynthesis,Embden-Meyerhof pathway of glucose metabolism(glycolysis),citric acid cycle(Krebs cycle),electron transport and oxidative phosphorylation.

Biosynthesis of fattyacids- palmitic acid biosynthesis, -oxidation of fatty acids.

Biosynthesis of DNA (replication).

Biosynthesis of RNA (transcription).

Biosynthesis of proteins (translation).

***Text Books:***

1. Textbook of Biochemistry by Albert-Lehninger, Kalyani Publishers, Ludhiana,New Delhi.

2. Principles of Biochemistry- Lehninger,Nelson and Cox-CBS Publishers and distributors,Delhi.

3. A text book of Biochemistry by A.V.S.S.Rama Rao,UBS Publishers and Distributors Ltd,New Delhi,Chennai.

4. Fundamentals of Biochemistry-J.L.Jain,S.Chand and company Ltd. New Delhi.

**MBIO-1.1.3- ADVANCED BIOCHEMICAL ENGINEERING**

*Objectives:*

1. To introduce enzymes, enzymatic and microbial growth kinetics

2. To introduce transport of materials in biological systems with respect to mass transfer and heat transfer

3. To introduce different types of bio-reactors and special reactors like animal and plant cell reactors

4. To introduce immobilization and sterilization techniques

*Outcome:*

1. To determine the enzyme activity, parameters affecting activity and enzyme immobilization

2. To know gas liquid mass transfer. To determine the KLa and to know inter particle and intra particle diffusion

3. To know about working and analysis of all types of rectors

4. To know thermal death kinetics and sterilization of air and medium

*Syllabus:*

1. **Enzyme Kinetics**: effects on enzyme activity, deactivation, immobilized enzymes.

**2. Microbial growth kinetics**: Batch growth, unstructured models, growth in continuous culture, structured models, product formation kinetics, cell immobilization.

**3. Transport Phenomena**: Gas-liquid Mass transfer; Theoretical models for KLa, interfacial area and bubble oxygen transfer, gas-liquid mass transfer of components other than oxygen. Mass transfer into solid particles: External transfer, intraparticle diffusion. Heat transfer correlations.

**4. Bioreactors**: Review of various types of bioreactors used in the fermentation industry. Multiphase bioreactors: packed bed, bubble-column, fluidized bed and trickle-bed

reactors. Alternate fermenters: new bioreactor configurations used in the fermentation technology. Animal and plant cell reactor technology.

**5. Sterilization**: Sterilization methods, thermal death kinetics, design criterion, batch and continuous sterilization, air sterilization.

*TEXT BOOK:*

1. Shuler, M. L and F. Kargi, Bioprocess Engineering: Basic concepts, 2nd ed., Prentice Hall India, New Delhi, 2003.

*REFERNCES:*

1. Lee, J. M., Biochemical Engineering (e Book), Prentice Hall, Englewood Cliffs, 2001.

2. Bailey, J. E., and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd edition, Mcgraw-Hill, New York, 1986.

3. Blanch, H. W., and D. S. Clark, Biochemical Engineering, Marcel Dekker, New York, 1996.

4. Swamy,A.V.N.,’ Fundamentals of Biochemical Engineering’ , BS publications, 2007

**MBIO-1.1.4-ADVANCED DOWN STREAM PROCESSING**

***Objectives:***

1.To learn and understand the applied concepts of downstream processing.

2. To enable the students to Understand the methods to obtain pure proteins, enzymes and in general about Product development R & D Have depth knowledge and hands on experience with on Downstream processes

***Outcome:***

At the end of the course,

1. The student would have learnt about, methods to obtain purify various types of compounds

2. Purification and characterization of various types of bioproducts in large scale level.

3. To execute precise and efficient bioseperations, which in cost effective and yield high degree of pure substance

*Syllabus:*

**UNIT- l: Introduction** - An Overview of Bioseparations: Bioprocesses, Range and characteristics of bioproducts, Need for down stream processing, Characteristics of Fermentation broths, An overview of bioseparations; A few case studies.

**Cell Disruption**: Intracellular products, Cell wall, Cell disruption, Proteins of inclusion bodies. **Reverse Phase and Hydrophobic Interaction Chromatography:** hydrophobic interaction chromatography; Reverse phase chromatography. Basic theory of retention in RPC and HIC; Hydrophobic Interaction Chromatography. Electrokinetic Methods of Separation: the various Method; Electrophoresis; Capillary Electrophoresis; Isoelcctric Focusing; Isotachophoresis.

**UNlT.2: Liquid- Liquid Extraction with Ternary Systems-**Instructional objectives: industrial example; Equipment: mixer- settlers, spray columns, packed columns, plate columns, columns with mechanically agitated agitation; General design considerations; Hunter- Nash graphical equilibrium- stage method: number of equilibrium stages, minimum and maximum solvent- to- feed flow rate- ratios, use of right- triangle diagrams, use of an auxiliary distribution curve with McCabe- Thiele diagram, extract and raffinate reflux; Maloney- Schubert graphical equilibrium- stage method; Theory and scale-up of extractor performance: mixer- settler units, multi-compartment columns, axial dispersion.

**UNlT.3: Membrane Separations:** Instructional objectives: industrial example; Membrane materials; Membrane modules; Transport in membranes: porous membranes, bulk flow, liquid diffusion in pores, gas diffusion, nonporous membranes, solution- diffusion for liquid mixtures, solution- diffusion for gas mixtures, module flow patterns, cascades, external mass ­transfer resistances, concentration polarization and fouling; Dialysis and electro dialysis; Reverse osmosis; Gas permeation; Pervaporation; Ultra filtration: process configurations; Micro filtration: constant- flux operation, constant- pressure operation, combined operation. Introduction to liquid membranes, principle, its advantages and its applications.

**UNIT.4: Crystallization**: Instructional objectives: industrial example; Crystal geometry: crystal- size distributions, differential screen analysis, cumulative screen analysis, surface­ mean diameter, mass- mean diameter, arithmetic- mean diameter, volume- mean diameter; Thermodynamic considerations: solubility and material balances, enthalpy balances; Kinetic and transport considerations: super saturation, nucleation, crystal growth; Equipment for solution crystallization: circulating, batch crystallizers, continuous, cooling crystallizers, continuous, vacuum, evaporating crystallizers; The MSMPR crystallization model: crystal population balance; Precipitation.

**UNIT.5: Drying of Solids:** Instructional objectives: industrial example; Drying equipment: batch operation, continuous operation; Psychrometry: wet- bulb temperature, adiabatic­-saturation temperature, moisture- evaporation temperature; Equilibrium- moisture content of solids; Drying periods: constant- rate drying period, falling- rate period; Dryer models: materials and energy balances for direct- heat dryers, belt dryer with through- circulation, direct- heat rotary dryer, fluidized- bed dryer.

*Text Books:*

1. (Units 2 to 5) ‘Separation Process Principles’, Seader, J.D. and Henley, EJ, 2Ed.Wiley India.

2. (Unit 1) ‘Bioseparations: Principles and Techniques’ by B.Sivasankar, Prentice-Hall India.

**MBIO-1.1.5-ELECTIVE – I**

**MBIO-1.1.5 A- ELECTIVE-I (BIO-ANALYTICAL TECHNIQUES)**

***Objectives*** *:*

The course is designed to impart the knowledge in the field of Pharmaceutical Analysis. The various modern analytical techniques like UV-Visible, IR, NMR, Mass, GC, HPLC, different chromatographic methods and other important topics will be taught to enable the students to understand and apply the principles involved in the determination of different bulk drugs and their formulation. In addition to theoretical aspects, the basic practical knowledge relevant to the analysis will also be imparted.

**Outcome:** The appreciable knowledge will be gained in the Modern Analytical Techniques and can apply the theories in the analysis of various bulk drugs and their formulations. Able in developing the new methods for the determination and validate the procedures.

***Syllubus:***

Unit I : Chromatographic Techniques - Affinity - Adsorption - paper - Thin layer - Column - Ion Exchange - Gel Chromatography - Applications.

Unit II : Gas liquid chromatography - High Pressure liquid chromatography - Equipment - Applications.

Unit III : Spectrophotometric Techniques - IR - UV - Visible - NMR - ESR - Optical density - Circular dischroism.

Unit IV : pH - pH titrations - Determination of pKa values - Buffers - Preparation - Buffer Action - Physiological buffers - potentiometric titration - centrifugal dialysis - lyophilization - Electrophoresis - Ultra filtration - Assay techniques for proteins, lipids, sugars, amino acids and nucleic acids.

Unit V : Short notes from units I to IV

*Text Books:*

1. “ Instrumental methods of Chemical Analysis - Chatwal, G & Anand, S. Himalaya Publishing House, Bombay.

2. “Instrumental methods of Chemical Analysis - Sharma, B.K. Goel Publishing House, Meerut.

3. “Instrumental Methods Analusis - Willard, Merritt, Dean & Settle, CBS Publishers & Distributors, Delhi.

**MBIO-1.1.5 B-ELECTIVE-I (Bioinformatics)**

***Syllabus:***

1. Introduction, Molecular Biology and Bioinformatics, Biological database: Primary, Secondary and Structural data bases, tools for web search, data retrieval tools

2. Genome analysis and gene mapping: sequence assembly problem, genetic mapping and linkage analysis, genome sequencing, sequence assembly tools, Human genome project.

3. Alignment of pairs of sequences, scoring matrices, multiple sequences, phylogenetic analysis, Tree evaluation, automated tools for phylogenetic analysis, working with FASTA and BLAST.

4. Gene identification and prediction: Basis for gene prediction, pattern recognition, gene prediction methods, working with DNA, Micro arrays, Micro array analysis.

5. Protein classification and structure visualization: structure – based protein classification, protein structure databases, visualization databases and tools, protein structure alignment, tools for plotting protein-ligand interaction.

6. Protein structure prediction: Analysis and prediction of primary structure and secondary structure, motifs, profiles, patterns and fingerprints search, Ab Initio approach, 2-D structure prediction, protein function prediction from DNA sequence.

7. Proteomics: Tools and techniques in proteomics, protein – protein interactions, gene family identification methods. Computational Methods for pathways and systems Biology: Analysis of pathways, metabolic network properties, metabolic control analysis, simulation of cellar activities.

***Text-book****:*

1. S.C..Rastogi, N.Mendiratta and P.Rastogic, **Bioinformatics**, Prentice- Hall of India Pvt.Ltd, New Delhi, 2004

*Reference books:*

1. T.K.Attwood and D.J. Parry-Smith, Introduction to Bioinformatics, Pearson Education Asia, Delhi, 2002

2. A.M. Lesk, Introduction to Bioinformatics, Oxford University press, New Delhi, 2004.

**MBIO-1.1.6: Elective –II**

**MBIO-1.1.6 A - Elective-II (Corrosion Engineering-I)**

*The main objectives are to provide:*

1. Basic aspects of electrochemistry relevant to corrosion phenomena,

2. Importance and forms of corrosion.

3. Knowledge on corrosion rate expressions and measurement techniques.

4. Knowledge on factors influencing corrosion of iron and steel exposed to atmospheric, soil and aqueous medium.

5. Basic knowledge on remedial measures for corrosion.

*Outcome:*

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion, corrosion tendency and electrode potentials.

2. Able to identify the nature of corrosion and form in which it attacks(Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage .

3. By acquiring knowledge on polarization and its influence on corrosion rates will be able to measure corrosion rates and analyze.

4. Acquires knowledge on mechanism and propose viable remedial measures.

*Syllabus:*

Basic Concepts and Outlines of Electrochemistry: Fundamentals of Electrochemical reactions, Faraday’s Laws Electrolytic and ionic conductance, ionic mobility’s, Transport Nos. Galvanic Cell and Electrolytic cells.

Definition and importance of corrosion, Dry cell, analogy, Corrosion Cells, Types of Corrosion Cells- a) Dissimilar electrode cells b) Concentration cells such as a salt concentration cells, differential aeration cells c) differential Temperature cells. Corrosion Rate Expresions - mdd, ipy, cpy, mpy, etc.

Corrosion Tendency and Electrode Potentials: Free Energy changes, Development of Nernst Equation for calculation of Half-cell potentials, Hydrogen electrode, Spontaneity of a reaction, Reversible cells and potentials – convention of Sign and calculations of EMF from standard Equilibrium potentials., EMF Series and Galvanic series, Reference Half Cells – Calomel, Silver-Silver Chloride and Saturated Copper-Copper Sulphate Half Cells. Pourbaix Diagram for Iron, Aluminum and magnesium, limitations of pourbaix diagrams.

Polarization and Corrosion Rates: Polarization and a Polarized Cell, Causes of Polarization – Concentration Polarization, Activation Polarization and IR drop. Hydrogen Over potentials, combined polarization and Mixed potential theory. Tafel Slopes and Tafel Equation. Graphical method of expressing Corrosion Reactions (Polarization diagrams/Evans diagrams), Derivation of Stern-Geary Equation, Influence of Polarization on Corrosion rates.

Passivity: Characteristics of Passivation, Flade potential, behavior of passivators, transpasivity, Theories on Passivity.

Forms of Corrosion: Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage. Factors influencing, mechanisms and prevention techniques for all forms of corrosion. Calculation of Corrosion rates using weight lost method and Polarization data. Electrochemical Impedance Spectroscopy.

Effect of Dissolved Oxygen (Air saturated Water, High Partial Pressure of Oxygen and Anaerobic bacteria), Temperature, pH, Galvanic coupling, velocity, dissolved salts concentration. Wet and dry corrosion.

*Textbooks :*

1. Corrosion and Corrosion Control by Herbert, H. Uhlig John Wiley and Sons Inc., New York.

2. Corrosion Engineering by Mars F Fontana, McGraw Hill.

3. An Introduction to Electrochemistry by Samuel Glass stone, Affiliated East West Press Pvt. Ltd.,

*Reference Books :*

1. Corrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**MBIO- 1.1.6 B - Elective-II (Energy Engineering-I)**

**Objectives:** To lean overview of solar radiation and it’s potential for collection to meet the energy needs of mankind and potential for solar energy option. To learn measuring techniques of solar radiation and its compilation.

To learn various design and operational aspects of solar energy collection and storage.

To learn the design and operation of solar energy appliances like liquid flat plate collectors, Solar Air Heaters, Thermal energy storage, Thermal energy storage, Solar Pond, Solar thermal power generation.

To learn theory and application of Photovoltaic cells

**Outcome:** The student learns collection and design of various kinds of equipment operated on solar energy. The student learns principles and practice of Photo voltaic cells.

***Syllabus:***

**The Solar Energy option :** Thermal conversion – collection and storage Thermal applications – photovoltaic conversion – wind energy – Energy from Bio – mass – ocean thermal energy conversion.

**Solar Radiation :** Solar Radiation outside the earths – atmosphere Solar radiation at the Earth’s surface – Instruments for measuring Solar Radiation – Solar Radiation data – Solar Radiation Geometry Empirical equations for predicting the availability of Solar Radiation – Solar radiation on tilted surface.

**Liquid flat – Plate Collectors :** Components of liquid flat plate – various types of collectors – Performance Analysis – Transmissivity – Absorptivity product – Overall loss coefficients and heat Transfer correlations – Collector efficiency heat removal factors – effect of various parameters on performance. Transient Analysis – Testing procedures.

**Solar Air Heaters :** Various types of solar Heaters – Performance Analysis of a conventional Air Heater – Testing procedures – Concentrating collectors – various types of concentrating collectors cylindrical and parabolic collectors – General receiver collectors.

**Thermal energy storage :** Sensible heat storage – Latent heat storage – Thermochemical storage Solar Pond Description – Performance analysis – Experimental studies – Operational Problems.

**Solar Air Conditioning and Refrigeration :** Heat pump cycle – Coefficient of performance of the heat pumps – solar air-conditioning with absorption – Refrigeration system (Ammonia water and lithium bromide – water systems).

**Solar thermal power generation :** Thermal and direct electricity generation – Major sub-stations of a solar thermal power plant, Examples of installed systems – Concentration ratio. Temperature and efficiency concepts – Solar farm and tower – Economics.

**Photovoltaic Energy Conversion :** Photovoltaic Energy Conversion Fundamentals – band theory of solids – Physical processes in a solar cell – Solar cell with light incidence – Solar cell module – Silicon Solar Cells – Copper Sulphate / Cadmium sulphide Solar Cells.(Banasal et at.,chapters 9;Taylor, chapters 6, pages 256-298.

*Text Books:*

1. Solar Energy: Principles of thermal collection and storage by S.P. Sukhatme, Tata McGraw Hill, New Delhi 1984 (Chapters 2 to 8)

2. Renewable energy sources and conversion technology by N. K. Bansal, M. Kleemann, Michael Mcliss, 1990 (Chapters 2 – 9).

**MBIO- 1.1.6 C - Elective-II (Reaction Engineering-I)**

***Syllabus:***

**Unit I** : (Scope : J.M. Smith : Chapter 7): Heterogeneous Processes, catalysis, and absorption: Global Rates of Reaction - Types of Heterogeneous Reactions - The nature of catalytic Reactions - The Mechanism of catalytic Reactions - Surface Chemistry and Absorption - Absorption Isotherms - Rates of Absorption.

**Unit II** ( Scope : J. M. Smith: Chapter 8 : Solid Catalysts: Determination of surface area - Void Volume and solid density - Fore volume distribution - Theories of Heterogeneous Catalysis - Classification of catalysts - Catalyst Preparation - Promoters and Inhibitors Catalyst Deactivation (Poisoning).

**Unit III:** (Scope: J.M. Smith : Chapter 9): Rate equations for fluid - Solid Catalytic Reactions: Rates of adsorption, Desorption, Surface Reaction - Rate equations in terms of Fluid phase concentrations at the catalyst surface - Qualitative analysis of rate equation - Quantitative inter pretation of Kinetic data - Redox Rate equations.

**Unit IV:** ( Scope : Octave Levenspiel : Chapter 15) : Deactivating Catalysts : Mechanism of Catalyst Deactivation - The ratre of equation - The rate of equation from experiment - Batch - solids: Determining the rate for Independent Deactivation Batch - solids : Determining the rate of parellel, series or side - by - side Deactivation - Flowing solids experimental Reactors - Finding the Mechanism of Decay from experiment Design.

**UnitV**: ( Scope : J. M. Smith : Chapter 10) : External transport Processes in Heterogeneous Reactions: Fixed bed reactors - The effect of physical processes on observed rate of reaction - Mass and Heat transfer coefficients (fluid particle) in packed beds - Quantitative treatment of external transport effects - Stable operating conditions - Effect of external transport Processes on selectivity.

Fluidised bed reactors - Particle - fluid Mass and Heat transfer Slurry Reactors - Mass transfer coefficients: Gas bubble to liquid (K1) - Mass transfer coefficients: Liquid to particle (Kc) - The effect of mass - transfer on observed rates Trickle - Bed reactors - mass transfer coefficients: Gas to liquid (K1 ag) - Liquid to particle (kc ac) - Calculation of global rate.

*Text Books:*

1. Smith. J.M., “ Chemical Engineering Kinetics”, McGraw Hill book Company, New Delhi (Third Edition) 1981.

2. Octave Levenspiel, “ Chemical Reaction Engineering” , Wiley Eastern Limited - Second Edition - 1972.

***Reference Books*** *:*

1. Thomas, J.M. And Thomas, W.J. “ Introduction to the Principles of Heterogeneous Catalysis”. Academic Press Inc., New York 1967.

2. Carbnerry, James, J., “ Chemical and Catalytjic Reaction - Engineering”, McGraw - Hill, Engineering Series.

**II SEMESTER**

**MBIO- 1.2.1- GENETIC ENGINEERING**

**Objective:** A gene is a basic constituent unit of any organism. It is a locatable region of a genome which contains the whole hereditary information of the organism. A gene corresponds to a unit of inheritance. It is a segment of the DNA which determines the special features or functions of the organism. Genetic engineering or genetic modification refers to the process of manipulating the characteristics and functions of the original genes of an organism. The objective of this process is to introduce new physiological and physical features or characteristics.

**Outcome:** At the end of the course the students would have learnt about the importance of developing and practicing of genetic engineering as noble and beneficial for mankind. Understand the basic processes involved in manipulating genetic information used by recombinant and cloning methods, different ways that genetic engineering has used in manufacturing, agriculture, medicine and identify several current issues surrounding genetic engineering. The domain of genetic engineering can extend from plants to cover both the animal and human life.

***Syllabus:***

I.(a) Introduction to Gene manipulation. (b) Enzymology of gene cloning, modification methylases, restriction endonucleases .

II .(a) Reverse transcriptase and D N A cloning in E. Coli. (b) Plasmids, cosmide and bacteriophages as cloning vectors.

III.( a) Cloning strategies and gene libraries. (b) Recombinant selection and screening.

IV .(a) Expression of cloned genes cloning in bacteria other than E. Coil, in yeasts, in plant cells and in mammalion cells in culture. b) Micro injection genes into ocytes, eggs and embryo.

V.( a) The genetic code and regulation of gene expression. b) Application of genetic Engineering in the fields of biology, medicine and industries.

*Text Books:*

1. Introductory Bio - Technology by R. P. Singh.

2. Principles of genetic Engineering by old and primarose.

**MBIO -1.2.2- ENZYME ENGINEERING**

***OBJECTIVES:***

1. To understand the importance of enzymes, their classification, sources, extraction and purification of enzymes.

2. To understand the mechanism of enzyme action, their kinetics and types of enzyme inhibitions.

3. To know about the advantages of immobilization of enzymes, methods of immobilization.

4. To acquaint with the applications of enzymes in solution as well as immobilized enzymes.

***OUTCOME****:*

1. The student is able to appreciate the importance of enzymes and know about their sources and extraction.

2. The student can analyze the kinetics of enzyme reactions, and can identify the type of enzyme inhibition.

3. The student will know to use different immobilization techniques and enzyme purification.

4. The student will be aware of different enzymes and their applications used in various industries.

*Syllabus:*

**INTRODUCTION TO ENZYMES**: Importance of enzymes in Biotechnology, Nomenclature and classification of enzymes, enzyme specificity, coenzymes, enzyme units and turnover number, factors affecting enzyme activity (pH, temperature, chemical agents and irradiation), mechanism of enzyme catalysis.

**ENZYME KINETICS**: Simple enzyme kinetics, Michaelis-Menten equation, Quasi-steady-state kinetics and Briggs –Haldane approach, Evaluation of parameters in Michaelis-Menten equation.

**ENZYME INHIBITION**: Inhibition of enzyme reactions-Competitive, non-competitive, uncompetitive, substrate and product inhibition, deactivation kinetics, derivations of M-M form of equations for various inhibitions.

**SOURCES OF ENZYMES**: Plant, animal and microbial sources and their advantages and disadvantages.

**ENZYME EXTRACTION AND PURIFICATION**: Methods of production of enzymes, cell disruption, extraction of enzymes, purification of enzymes.

**ENZYME IMMOBILIZATION**: Methods of immobilization- physical and chemical (covalent binding, cross-linking, adsorption, matrix entrapment and microencapsulation), advantages and disadvantages of different immobilization techniques, kinetics of immobilized enzymes, mass transfer effects in immobilized enzyme systems.

**ENZYME APPLICATIONS**: Application of enzymes in various industries (brewing, detergent, starch, baking, dairy, food, leather, wool, animal feed, textile, paper and pulp, pharmaceutical).

**APPLICATION OF IMMOBILISED ENZYMES**: Immobilized enzyme processes, HFCS, production of amino acids, antibiotics.

***Text books****:*

1. Enzyme Technology by Chaplin, M.F and Bucke, C Cambridge University Press,1990.

2. Enzyme Technology 2nd Ed S.Shanmugan, T.Sathish Kumar, M.Shanuga Prakash I.K.International Publishing House Pvt. Ltd.

3. Biochemical Engineering Fundamentals. J.E.Bailey and David F Ollis 2nd Edition 1986, McGraw Hill.

***References books****:*

1. Enzyme Engineering. L.B.Wingard, J.Inter Science, New York 1972.

2. Enzymes Trevor Palmer East West Press Pvt. Ltd. New Delhi

**MBIO-1.2.3- ENVIRONMENTAL BIOTECHNOLOGY.**

**(Common with IPCE)**

***Objectives:***

\* Student to learn and understand environmental problems locally as well as global issue and consequencies.

\* To learn about xenobiotics and their effect on ecosystem. To learn about biodiversity available.

\* To learn about alternative and noval methods like biosorption of metals and bioleaching.

***Outcome****:*

\* Students have enough skills to identify the environmental problems and control measures.

\* Students are in a position to plan to treat various industrial effluent using biotechnological methods

***Syllabus:***

Environment, types of Environment, Environment and Development, Environmental management, environmental education, principles of ecology, ecosystems, types of ecosystems, ecosystem structure and functioning, food chains, food webs, Ecological pyramids, nutrient cycling, microbial associations.

Source, effects and control aspects of various pollutants: Air (Particulate matter, SOx, NOx, COx, CHx, noise), water (primary, secondary and advanced treatment techniques), solids (recycling, incineration and bioconversion) Global environmental problems: global warming, ozone depletion and acid rain. Industrial effluent treatment: case studies of paper and pulp, tannery, pharmaceutical, fertilizer and petroleum industries.

Biodegradation of xenobiotics:Xenobiotic compounds in the environment, persistent compounds, degradation mechanisms.

Bioremediation: Bioremediation by microorganisms, bioremediation process and technologies, measuring bioremediation in the field, monitoring and efficacy of bioremediation.

Biosorption of metals: Microorganisms and metal absorption, factors affecting bioabsorption, bioreactors and bioabsorption, phytoremediation.

Bioleaching: Types of bioleaching, advantages and disadvantages of bioleaching, methods for bioleaching.

Biodiversity: Levels of biodiversity, value of biodiversity, global biodiversity, hotspots of biodiversity, threats to biodiversity, conservation of biodiversity.

Environment and energy: Biomass sources, biomass production and utilization for energy, biomass conversation routes, energy crops, biofuels, biodiesel, hydrogen Production, conservation of energy.Biofertilizers, biopesticides, biofilters, biosensors, biopolymers and bioplastics.

*Reference Books:*

1. Environmental Pollution Control Engineering by C. S. Rao. Wiley Eastern Limited

2. Waste Water Treatment: Rational Methods of design and industrial practices by M. Narayana Rao and Amal K. Datta. Oxford & IBH publishing Co. Pvt. Ltd.

3. Environmental Biotechnology: Basic concepts and applications by Indu Shekhar Thakur. 1. K. International Pvt. Ltd.

4. Microbial Ecology: A conceptional approach by Lunch, 1. M. Oxford Black N.S.D.

5. Environmental Biotechnology by Geetha Bali. APH publishing corporation.

**MBIO -1.2.4- NANOTECHNOLOGY**

**(Common with CACE)**

***Objectives:***

Nanotechnology may be treated as Green technology. It is one of the most advanced technologies now-a-days. It leads to have revolutionary changes in the fields of medical, Bio-medical, and fabrication of materials. Technologists are able to prepare ageless materials with the help of nano-techniques. Main objectives of the subject nanotechnology are :

1. To define green technology properly

2. To expose the students with new techniques of the nanotechnology.

3. To make them to learn the importance of quantum technology

4. To learn the procedure ageless materials to avoid wear-tear.

5. To learn the importance of nano –robots, machines

6. To know about the latest microscopes such as SEM, TEM

7. To know the importance of nanotechnology in the dawn of optical instruments

*Outcome:*

1. Application of nanotechnology in the development of energy

2. Application of nanotechnology in the development of solar panels, Fuel cells

3. Knew the importance of atoms manipulation

4. Knew that the applications of nanoparticles in the development of DVD, LEDs etc.

5. Biomedical applications in terms of preparing artificial, drug delivery, encapsulation, addition to that pharmaceuticals.

*Syllabus:*

1. Introduction tonanotechnology, molecular and atomic size, surface and dimensional spaces.

Molecular nanotechnology: atoms by inference, electron microscopes, nanomanipulator, nanotweezers, atom manipulation, nanodots, nanolithography.

2. Nanopowders and nanomaterials: preparation, plasma arcing, chemical vapor deposition, sol-gels, electrodeposition, Ball milling, applications. Carbon nanotubes: types, formation, assemblies, purification, properties and uses.

3. Molecular mimics: Catenanes and rotaxanes, various molecular switches, synthesis of rotaxanes and catenanes, molecular computers, chemical rotors, prodders, flippers, atom shuttles, actuators, contacts.

4. Nanobiometrics: Lipids as nano-bricks and mortar, self – assembled monolayers, proteins, 3-D structures arising from amines acids, nanoscale motors, Biological Computing, ion channels as sensors, Information in DNA structure, using DNA to build nano-cubes, hinges, smart glue, wire template.

5. Optics, photomics and solar energy: Properties of light and nanotechnology, Interaction of light and nanotechnology, Nanoholes and photons, Imaging, New low cost energy efficient windows and solar absorbers based on nanoparticles, Photonic crystals, surface wave guides and control of light paths.

6. Nanoelectrons: birth of electrons, semiconductors, transistor, integrated circuits, the tools of micro and nanofabrication, quantum electronic devices, quantum information and quantum computers, experimental implementations of quantum computers.

7. Future applications: microelectomechanical systems, nano-robots , ageless materials, invisible mending of atomic dislocations inside damaged materials, nanomechanics and nanoelasticity, nanoparticle coatings, nanoelectronic and magnetic devices and new computing systems, optoelectronic devices, environmental applications.

8. Molecular Dynamics, Simulation and Optimization of Nanosystems: Integration of Newton equation of motion, simulation of systems in contact with a heat bath, simulation methods based on accuracy and computational time, use of local and global optimization methods. (Scope: Chapters 5&6, Ali Mansoori\*: Principles of Nanotechnology)

(*This last section is not open for external assessment, but students are assessed* internally by means of assignments and home work problems).

*Text-book:*

1. M.Wilson, K.Kannangara, G. Smith, M. Simmons and B. Ragues, **Nanotechnology**, Overseas press ( India) Private Ltd; New Delhi, 2005.

*Reference books:*

1. G. Ali Mansoori\*, **Principles of Nanotechnology**, World Scientific Publishing Company, 2005.

2. G. Timp, Nanotechnology, Springer-Verlag, Network, 1999.

3. P. Poole and F.J. Owens, Introduction to Nanotechnology, John Wiley, 2003.

4. D.Ratner and M.Ratner, Nanotechnology: A Gentle Introduction, Pearson Education,2003.

5. B. Bhusan, Handbook of Nanotechnology, Springer, 2004

**MBIO-1.2.5-ELECTIVE-III**

**MB10-1.2.5 A -Elective-III (Industrial Biotech Products)**

***Objectives:***

\* To study the structure and functions of various fermentors and study indetail the production media preparation, inoculums preparation and sterilization methods.

\* To study the production ethyl alcohol, vinegar, lactic acid , citric acid and amino acids using microbial fermentation processes.

\* To study the production of alcoholic and non alcoholic beverages in detail and to study the production of antibiotics, vitamins and baker’s yeast, microbial enzymes and co-enzymes in detail using modern fermentation techniques.

*Outcome:*

\* Students will obtain vast knowledge in the fermentation technology to produce various industrially important bio products.

\* Students will acquire knowledge in handling bioreactors and sterilization methods.

\* Students can start small scale industries to produce bio products using fermentation techniques.

\* As this subject gives advanced level knowledge in the production of industrial biotech products, the further improvement and advances can be achieved by research.

*Syllabus:*

I: Fundamentals involved in the’ production of industrial Microbial prod­ucts such as details of the Fermentors, Synthetic and natural medium, proces­sors, Sterilization methods, and innocuium preparation. A detailed study of ‘Ethanol’ production by fermentation, using black blinap molasses, aarchy sub­stance and glus\cosic like waste sulphate liquid purification methods of the fermented broth and production, of absolute ethyl alcohol.

II: Materials for fermentative production of Vinegar, Lactic Acid, Citric Acid, and Amino acids. The method Involves selection of the particular strain of the micro-organism for Industrial Fermentation, process details and purification.

III: Production of Alcoholic beverages with Beer, Brandy, Whisky and Wine. Baked goods, cheese and other dairy products.

IV: Production *of* Antibiotics, Tetracyclines, Alkaloids Bakers yeast and Microbial Enzymes and Co-enzymes.

V: Fermentative materials for producing vitamins, Products from plant cell Cultures, Non - alcoholic beverages (Coco, Coffee, Tea fermentation).

Textbook:

1. “Industrial Microbiology” by Samuel C. Presscott and Cecil, G. Dunn; A McGraw - Hill Publication.

*References:*

1. “Industrial Mic~obiology” by L.E. Casida. Jr. Wiley Eastern Limited.

2. “Microbial Technology Vol. 1 and Vol. 2 by H.J. Peppler and D. Pulman (Academic Press).

**MBIO-1.2.6 A-ELECTIVE-IV (Corrosion Engineering-II)**

***Objectives:***

\* To enable the principles of corrosion, common corrosion forms, uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement corrosion control methods, and material selection to reduce corrosion cost.

\* To enable the ability to understand electrochemical fundamentals

\* To enable the ability to understand corrosion preventing methods

*Outcome:*

\* The student would know application of weight loss method

\* The student would know application of cathodic protection, anodic ptotection

\* At the end of this course, the student would know effective surface preparation of specimen can be done

\* After completion of this course, the student would understand the causes and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion.

\* The student would know application of Corrosion Processes and Evans Diagrams and application of electroplating, coatings and importance of inhibitors.

*Syllabus:*

Corrosion in selective environments: Marine, Acids (Sulfuric acid, Hydrochloric acid, Nitirc acid, Phosphoric acid) Biological and industrial gases (SO2H2S).

Corrosion Testing - Purposes, Materials and specimen. Surface preparation, Measuring and weighing , Exposure Techniques - duration, Planned - Interval Tests, Aeration, cleaning specimens after exposure, Temperature, Standard expression for corrosion rates - Galvanic Corrosion, Erosion Corrosion, crevice Corrosion, Intergranular corrosion, test for stainless steels, warren test pitting, stress corrosion, Paint tests, Sea Water tests, Presenting and summarizing data - Nomo graph for corrosion rates and interpretation of results.

Cathodic and anodic protection, surface preparation for coatings and chemical conversions: Degreasing, Descaling , Polishing - Anodized coating : anodizing oxidizing, chromate coating, phosphate coatings - Metallic coatings : Hot dipping, cementation, vapor deposition of metallic coating; Sprayed coatings: flame spraying plasma spraying, Galvanizing - Electroplating : Nickel & chromium coatings, chromizing.- Organic coatings : paints, enamels, lacquers, resin mixtures.

Linings, laminates, reinforced plastic, fibre glass - Corrosion inhibitors: mechanism of inhibition, recirculating of water of water systems

Measurement and testing of preventive coatings ; Thickness and Resistance tests for anodized, Painted, electroplated surfaces using polarization resistance, Linear polarization, curve fit analysis and Electrochemical impedance spectroscopy.

*Reference books :*

1. Mars GFontana - Corrosion Engineering

2. Burns, R.M., Bradley, W.W., ‘protective coatings for Metals.’ Chapters 2 to 18.

*Reference Books :*

1. Corrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

**MBIO- 1.2.6 B - Elective-IV (Energy Engineering-II)**

***Objectives:***

The student is provided with the fundamentals of some renewable energy processes. Basic information to comprehend the various non-conventional energy systems would be gained by the student.

***Outcome:***

1. Methods to be adopted to utilize biomass as an important energy source.

2. Application of thermodynamics to convert ocean energy.

3. Possible mechanism to drawn energy from wind and other natural sources

4. Fuel cells as sources of energy.

5. New technologies to produce energy such as thermionics, thermoelectricity etc.

*Syllabus:*

Non – Conventional & New Energy Systems and Energy Conservation Technology Systems based on bio mass Physical and Bio mass – Definition – potential thermo – chemical methods of Bio - Conversion – Gasification – Liquefaction – Pyrolysis.

Bio-gas technology – Historical review and development in India Different designs of bio-gas jplants – Selection of a model and size – Installation – Gas collection and distribution – operation and maintenance – Properties and uses of bio-gas – Utilization of manure – National Projects for Bio – gas development – safety.(Bansal et at,chapters 10 and 11; Khandelwal and Mahdi, Chapters 3,4,5,6,7,8,9,10: Chawla,chapters 2,3,4,5,6,7 & 8).

Fuel Cells : Hydrogen – Oxygen Fuel Cells – carbonaceous Fuel Cells – Molten Alkali Carbonate Cells – Electrode Reactions and kinetics. (Fuel Cells by Young).

Energy Wind, Tidal and OTEC

Potential in India – Origin of wind and general circulation systems of Earth – Wind direction – Wind measurement – Wind energy converters – Historical development – Power coefficient – Aerodynamic construction of a rotor blade Rotors – Wind electric generators in India – Economics of wind farm – Fundamentals and concepts of Wave energy – Ocean thermal – energy conversion (OTEC). (Bansal et at., Chapters 12,13 & 14).

**Hydrogen Energy, Methanol & Ethanol :** Hydrogen from fossil fuels from Electrolysis – Developments of various electrolytic cells – High pressure cells – Solid electrolytic systems – Hydrogen powered IC engines – Storage system – Handling and Transmission.(Journals on Hydrogen energy).

Methanol and Ethanol as Automobile fuels – Comparison with Gasoline and Diesel oil. (Journals on Hydrocarbon on processing).

**Energy Conservation Technologies:** Principles of Energy Conservation – Optimum Energy Conservation – Industrial Energy Conservation modeling – waste heat recovery and utilization.

*Prescribed Books:*

1. Renewable Energy Sources and Conversion Technology, N.K.Bansal, Manfred Klieemann,Michael Meliss, tataMcGraw Hill, 1990.

2. Bio Gas Technology, A practical hand book Vol 1, K.C.Khandelwal and S.S.Maholi, TataMcGraw Hill, 1986.

3. Advances in Bio Gas Technology: O.P.Chawla,publications and Information Division, Indian council of Agricultural Research,New Delhi, 1986.

4. Alternative Energy Sources: R.H .Taylor, Adam Hilger Ltd.,Brister.

5. Fuel cells, Vols.I & II: Reinhold publishing Crop.,New York.

6. International journal of hydrogen Energy, Vol.5, No. I, 1980 pages 1- 84: No.2, pages 119-129; pages 151-203; No.5. Pages 527 – 534 & 539 – 553; No.6, Pages 611 – 625.

7. Hydro Carbon Processing Vol. 58, May 1979 pages 127 – 138:Vol. 59, Feb. 1980, pages 72–75.

8. Handbook of Industrial Energy Conservation, David Hu, S., Van Nostrand Reinhold Company pages 73 – 133, 149-199, 297-327.

**MBIO- 1.2.6 C - Elective-IV (Reaction Engineering-II)**

***Syllabus:***

UNIT - I : Laboratory Reactors - Interpretation of Experimental Data - Interpretation of Laboratory Kinetics Data - Homogeneous and Heterogeneous Laboratory Reactors. Calculation of Global Rate - The structure of Reactor Design. (Scope: Chapter 12 of J.M Smith 3rd Edition)

UNIT - II : Design of Heterogeneous Catalytic Reactors Isothermal and Adiabatic Fixed Bed Reactors Non-isothermal, Non-adiabatic Fixed Bed Reactors. (Scope: Chapters 13.1 - 13.9 of J.M Smith 3rd Edition)

UNIT - III : Design of fluidized bed Reactors - Two -Phase Fluidized Bed model - Operating characteristics - Slurry Reactors - Trickle - Bed Reactors - Optimization. (Scope: Chapter 13.10 - 13.13 of J.M Smith 3rd Edition.)

UNIT - IV : Fluid - Solid Noncatalytic Reactions - Design concepts - Single Particle Behavior - Reactor Models. *(Scope: Chapter 14 of J.M Smith 3rd Edition)*

UNIT - V : Short notes from the portions of all the above four units. Four bits are to be answered out of 7 bits (Not more than 2 bits to be given from any one Unit).

***Text Book:***

1. Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book Company , 1980, 3rd Edition