**M.TECH.**

**(BIOTECHNOLOGY)**

**(Effective from the admitted batch of 2019-20)**

**Scheme and Syllabi**

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**DEPARTMENT OF CHEMICAL ENGINEERING**

**AU COLLEGE OF ENGINEERING (A)**

**ANDHRA UNIVERSITY**

**VISAKHAPATNAM**

**DEPT OF CHEMICAL ENGG :: A.U.COLLEGE OF ENGINEERING(A)**

**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 marks** | **Exam marks** | **Total 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

**DEPT OF CHEMICAL ENGG :: A.U.COLLEGE OF ENGINEERING(A)**

**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 marks** | **Exam marks** | **Total 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

**DEPT OF CHEMICAL ENGG :: A.U.COLLEGE OF ENGINEERING(A)**

**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:**

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 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, β-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.

1. **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.

1. **Sterilization**: Sterilization methods, thermal death kinetics, design criterion, batch and continuous sterilization, air sterilization.

**TEXT BOOK:**

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:**

**Units 2 to 5:** 'Separation Process Principles', Seader, J.D. and Henley, EJ, 2Ed.Wiley India.

**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 titration s - 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-115 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

1. Genome analysis and gene mapping: sequence assembly problem, genetic mapping and linkage analysis, genome sequencing, sequence assembly tools, Human genome project.
2. Alignment of pairs of sequences, scoring matrices, multiple sequences, phylogenetic analysis, Tree evaluation, automated tools for phylogenetic analysis, working with FASTA and BLAST.
3. Gene identification and prediction: Basis for gene prediction, pattern recognition, gene prediction methods, working with DNA, Micro arrays, Micro array analysis.
4. 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.
5. 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.
6. 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**:

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](http://www.genetic.com.au/genetic-dna.htm) 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.

**TEXT 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.

**REFERNCE BOOKS:**

1. Microbial Ecology: A conceptional approach by Lunch, 1. M. Oxford Black N.S.D.
2. Environmental Biotedlliology 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.

1. Nanopowders and nanomaterials: preparation, plasma arcing, chemical vapor deposition, sol-gels, electrodeposition, Ball milling, applications.

Carbon nanotubes: types, formation, assemblies, purification, properties and uses.

1. Molecular mimics: Catenanes and rotaxanes, various molecular switches, synthesis of rotaxanes and catenanes, molecular computers, chemical rotors, prodders, flippers, atom shuttles, actuators, contacts.
2. 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.

1. 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.

1. 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.
2. 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.
3. 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:***

“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:** Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book Company , 1980, 3rd Edition.