

Detailed Syllabus

B. Tech. Chemical Technology (Biochemical Engineering) (Effective from the session 2022-23 for new entrants)



**HARCOURT BUTLER TECHNICAL UNIVERSITY
KANPUR-208002(UP)–INDIA**

Fundamental of Life Processes

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-201 | 4 | 3 | 1 | 0 | 15 | 20 | 15 | 50 | 50 | 100 |

| | |
|---------------------------|---|
| Course Objectives: | To introduce the students to gain knowledge, fundamental skills, and experience to explore how management practices affect the life processes of plants and/or livestock in primary production. |
|---------------------------|---|

Course outcome: - On successful completion of the course, the student will be able to-

| | | |
|------------|---|-------------------|
| CO1 | Understanding the basic of life | Understand |
| CO2 | Understanding the polymeric macromolecules and their monomeric building blocks. | Understand |
| CO3 | Able to distinguished between autotrophs & heterotrophs and understanding the flow of energy in ecosystem | Analyze |
| CO4 | Understanding the bioenergetics | Understand |
| CO5 | Understand the role of microorganism in ecological cycles | Understand |

| COs | POs | | | | | | | | | | | | PSOs | | |
|--------------|----------|----------|----------|---|---|---|----------|---|---|----|----|----|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | |
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 3 | 2 | - | - | - | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 2 | 2 | - | - | - | 2 | - | - | - | - | - | 3 | 3 | 3 |
| Total | 3 | 3 | 2 | - | - | - | 2 | - | - | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put “-”

Syllabus

Unit I

The cellular basis of life, Cell theory and cell as the basic unit of life; Morphology, Structure and characteristics of prokaryotic and eukaryotic cells; Plant cell and animal cell; cell organelles - structure and function; Microorganism: Classification, Characterization, Identification, and nomenclature

Unit II

Biomolecules: Role of water, structure and function of Carbohydrates, Proteins, Lipids, Nucleic acids, Vitamins, coenzymes and metal ions

Unit III

Nutrition and Nutrients, Classification of Nutrients. Movement and transportation: transportation in plants and animals.

Unit IV

Bioenergetics and Thermodynamics, Metabolism: Catabolism and Anabolism; Photosynthesis; Respiration: Respiration in plants and animals; Reproduction and mode of Reproduction.

Unit V

Current status of biotechnology in environmental protection and its prospects. Characteristics of wastewater, Classification of pollutants. Role of microorganisms in geochemical cycles; microbial ecology.

Textbooks:

1. Cell: the fundamental unit of life: part-i: the evolution of first cell (the cell book 1), kindle edition by Tufail Idris
2. "Principles of Biochemistry", A.L. Lehninger, D.L. Neston, N.M. Cox, CBS Publishers & Distributors.
3. Outlines of Biochemistry by Conn, E.E and Stumpf P.K.
4. Biochemistry by Stryer Lubert.

Reference Books:

1. NCERT Science books

Industrial Microbiology

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-203 | 4 | 3 | 1 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|---|
| Course Objectives: | The objective of this course is to enable the students to understand the importance of microorganisms in Biochemical Engineering and to acquaint them with the scope and basic techniques of industrial microbiology. |
|---------------------------|---|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|---|-------------------|
| CO1 | Measure microbial growth, types of microbial interactions, growth rates, etc. for microbiological processes. | Apply |
| CO2 | Analyze the mechanism of microbial growth and its control parameters | Understand |
| CO3 | Identify and analyze the role of microorganisms in fermentation | Understand |
| CO4 | Comprehend processes of growth-related and non-growth-related products | Understand |
| CO5 | Analyze the basic bioprocesses operated at an industrial scale and apply the basic principles, methods, and models to solve industrial tasks. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 2 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | - | 3 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | - | 2 | 3 | 3 | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | - | 3 | 2 | 3 | 3 | - | - | - | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | - | 3 | 3 | 3 | 3 | 2 | 2 | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

Syllabus

Unit-I: Introduction

Scope of industrial microbiology, Cultivation of Microorganisms: simple and complex media, Medium formulation: carbon sources, nitrogen sources, minerals, vitamins and other nutrients, precursors, inducers, chelators, growth factors, and antifoams. Pure culture techniques – microbial culture media, isolation, identification and maintenance of cultures, characteristics of pure culture.

Unit-II: Basic Requirements for microbial growth

Reproduction and Growth of Microorganism: Modes of cell division, the growth curve of microbes, Quantitative measurement of growth, Aerobic and Anaerobic growth, Transport of nutrients across cell membranes, Aerobic and Anaerobic respiration.

Unit-III: Basic Requirements for Microbial Production

Isolation of industrially important microorganisms, isolation methods utilizing selection of desired characteristics, methods not utilizing a selection of desired characteristics, preservation and maintenance of microorganisms, improvement of strains by modifying properties other than the yield of products.

Unit-IV: Microbial Products

Microbial Production of Organic acid, Solvent, Antibiotics, Polysaccharides, Enzymes, Vitamins, Pigments, Wine, Dextran, Aroma

Unit-V: Industrial and Medicinal Applications

Application of enzymes in industrially analytical purpose and medical therapy. Biodegradation of cellulose and lignin. Production of Biodiesel and Rapeseed methyl esters. Microbial metabolic products; Primary metabolites and Secondary metabolites.

Textbooks:

1. Pelczar M J, Chan E C S and Krieg N R “Microbiology, 5th Edition” Mc Graw Hill, New York (1995)
2. Casida L E, “Industrial Microbiology”, New Age International Publishers, New Delhi (2003)

Reference Books:

1. Industrial Microbiology by A. H. Patel.
2. Salle A J, “Fundamental Principles of Bacteriology”, 7th Edition, Tata McGraw Hill, New Delhi (1984)
3. Stanier R Y, “Text in Microbiology” McMillan Press London (1995)
4. Willey M J, Sherwood M L and Woolverton J C “Prescott's Microbiology” 9th Edition, Mc Graw Hill, New York (2014)

Microbial Techniques Lab

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-207 | 2 | 0 | 0 | 4 | 0 | 20 | 30 | 50 | 50 | 100 |

| | |
|---------------------------|---|
| Course Objectives: | To enable the students to: Understand the methods involving isolation of different microorganisms to study their morphology. Have depth knowledge and hands on experience on preparation and sterilization of different media. |
|---------------------------|---|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|---|--------------------------|
| CO1 | Explain the chemical and theoretical basis of biological staining. | Analyze |
| CO2 | Identify the components of and demonstrate the proper use and care of the brightfield microscope. Correctly use the microscope to observe and measure microorganisms. | Understand, Apply |
| CO3 | Explain different techniques for isolation of microorganisms from a mixed microbial population for subsequent pure culture isolation. | Analyze |
| CO4 | Explain the principles associated with the use of routine and special-purpose media for microbial cultivation. | Understand, Apply |
| CO5 | Describe the method used to determine the number of cells in a bacterial culture. | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 3 | - | 3 | - | - | - | 3 | 2 | - | 2 | 3 | 3 |
| CO2 | - | - | - | - | 2 | - | - | - | 3 | - | - | 3 | 3 | 3 |
| CO3 | - | 2 | 3 | - | 3 | 2 | - | 2 | 3 | 2 | - | 2 | 3 | 3 |
| CO4 | 3 | - | 3 | - | 2 | - | - | - | 3 | 2 | - | 3 | 3 | 3 |
| CO5 | - | - | - | - | 3 | - | - | - | 3 | - | - | 2 | 3 | 3 |
| Total | 3 | 2 | 3 | - | 3 | 2 | - | 2 | 3 | 2 | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

List of Experiments

1. Different staining of bacteria
 - a. Simple staining
 - b. Negative staining
 - c. Gram staining
 - d. Acid-Fast staining
2. Study the morphological characteristics of microorganisms.
3. Preparation and sterilization of different media used for the differentiation or isolation of bacteria
 - a. Selective media
 - b. Differential Media
 - c. Enriched media
4. Isolation of micro-organisms by
 - a. Streak plate method.
 - b. Pour plate method.
 - c. Spread plate technique
 - d. Serial dilution technique
5. Quantify the number of viable cells using serial dilution-agar plate procedure
6. To determine cell biomass concentration by optical density and dry weight method.

Textbooks:

1. Pelczar M J, Chan E C S and Krieg N R “Microbiology” 5th Edition, Mc Graw Hill, New York (1995)
2. Casida L E, “Industrial Microbiology”, New Age International Publishers, New Delhi (2003)

Reference Books:

1. Cappuccino G. J. and Welsh C. “Microbiology, A Laboratory Manual” 12th Edition, Pearson (2019)
2. Leboffe J M and Pierce E B “Microbiology Laboratory Theory and Application” 3rd Edition, Morton, USA (2010)

Weblinks:

1. www.mvi-au.vlabs.ac.in/#

Biochemistry

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-202 | 4 | 3 | 1 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|---|
| Course Objectives: | Biochemistry focuses on understanding the biochemical control of biological processes, and to study the chemical reactions at a molecular level to better understand the world and develop new ways to harness these. |
|---------------------------|---|

Course outcome: - On successful completion of the course, the student will be able to-

| | | |
|------------|---|-------------------|
| CO1 | Know the specificity of enzymes (biochemical catalysts), and the mechanism involved in enzyme action. | Apply |
| CO2 | Understanding the metabolism of carbohydrates, and express their role in energy generation | Understand |
| CO3 | Understanding the metabolism of carbohydrates in plants | Understand |
| CO4 | Understanding the metabolism of amino acids (i.e., protein metabolism) and the concept of Nucleic acid biosynthesis | Understand |
| CO5 | Understanding the biosynthesis and metabolism of fatty acids | Understand |

| COs | POs | | | | | | | | | | | | PSOs | |
|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 3 | - | 3 | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | - | 3 | - | 3 | 3 | - | - | - | 2 | 3 | 3 | 3 |
| CO3 | 3 | 3 | - | 3 | - | 3 | 3 | - | - | - | 2 | 3 | 3 | 3 |
| CO4 | 3 | - | - | 3 | - | 3 | 3 | - | - | - | 2 | 3 | 3 | 3 |
| CO5 | 3 | - | - | 3 | - | 3 | 3 | - | - | - | - | 3 | 3 | 3 |
| Average | 3 | 3 | - | 3 | 3 | 3 | 3 | - | - | - | 2 | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put “-”

Syllabus

Unit 1

Aims and scope of Biochemistry; Biochemistry of water, acid, and base, Importance of buffer in homeostasis, Henderson-Hasselbach equation; Enzymes: - Concepts of ligands, activation energy, action mechanism, inhibition, Michaelis Menton equation, and its modification.

Unit 2

Classification of Biomolecules: Carbohydrates, Lipids, Nucleic acids, and Protein. Bioenergetics and Metabolism. Carbohydrate Metabolism: Glycolysis, Embden Meyerhoff pathway, TCA cycle, Gluconeogenesis, Glycogenesis, Glycogenolysis, Pentose Phosphate Pathway, Electron transport chain.

Unit 3

Photosynthesis and Calvin cycle: The light reaction, chlorophyll, accessory pigments, reaction centers, two photosystems, generation of the proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C4 pathway.

Unit 4

Biosynthesis of amino acids, catabolism of carbon skeletons of amino Acids – oxidative deamination and oxidative de-carboxylation, nitrogen excretion, and urea cycle. Biosynthesis and catabolism of some vital amino acid. Nucleotide metabolism - biosynthesis of purines and pyrimidines, de novo and salvage pathways.

Unit 5

Fatty acid synthesis and degradation: TAG as an energy source, β oxidation of fatty acids, ketone bodies; Biosynthesis of fatty acids - elongation and unsaturation of fatty acids; Regulation of fatty acid oxidation and synthesis. Cholesterol metabolism, Steroid hormones and their role.

Textbooks:

1. "Principles of Biochemistry", A.L. Lehninger, D.L. Neston, N.M. Cox, CBS Publishers & Distributors.
2. Outlines of Biochemistry by Conn, E.E and Stumpf P.K.
3. Biochemistry by Stryer Lubert.

Reference Books:

1. "Biochemistry", Lubert Stryer, W.H. Freeman & Co. , New York.
2. "General Biochemistry", J.H. Weil, New Age International (PLD).

Environmental Biotechnology

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Seasonal Marks | | | | ESE | Totals Marks |
|-------------|--------------|---------|---------|---|---|----------------|----|-----|-------|-----|--------------|
| | | | L | T | P | MSE | TA | Lab | Total | | |
| PCC | NBE-204 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | <ul style="list-style-type: none"> • To teach basics of environment and its challenges in terms of pollution due to various activities • To develop understanding of biotechnology and microbiology in treating various kind of waste Leading to production of various useful products • To Impart knowledge of core engineering design in environmental waste treatment using biological processes • To develop mathematical and analytical skills required to design and operate system for source-based waste treatment • To Impart knowledge in the area of regulatory framework and environmental compliance |
|---------------------------|--|

Course Outcome:- On successful completion of the course student will be able to –

| | | |
|-----|--|------------|
| CO1 | To understand basics of the environment and its challenges in terms of pollution due to various activities | Understand |
| CO2 | Apply the biotechnology core principles in waste treatment system | Apply |
| CO3 | Design the novel biological treatment system at institutional as well as industrial scale | Create |
| CO4 | Apply knowledge of microorganisms in process of Microbial Enhanced Oil Recovery and treatment of pollutants discharge from industry. | Apply |
| CO5 | Understand the regulatory mechanism in the area of environmental compliance laid down by various agencies | Understand |

| COs | POs | | | | | | | | | | | | PSOs | |
|---------|-----|-----|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | - | - | - | 3 | - | - | - | - | | 3 | 3 | 3 |
| CO2 | 3 | 2 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | - | 3 | - | 3 | 3 | 3 | 3 |
| Average | 3 | 2.5 | - | 3 | 3 | 3 | 3 | - | 3 | - | 3 | 3 | 3 | 3 |

Syllabus

Unit-I

Introduction to environmental biotechnology: Basic components of environment: Concept of ecosystem, abiotic and biotic components. Microbial Ecology and Environmental Biotechnology: Concepts and importance of microbial ecology in Environmental Biotechnology. Environmental pollution: Air, water, and soil pollution (introduction, sources, effects and measurements).

Unit-II

Waste to wealth: bioconversion of agricultural and other highly organic waste materials into gainfully utilizable products – biogas, H₂, celluloses and food and feed stocks. Biofuels from waste: Methods and processes for utilization of waste for production of fuels, economical and social aspects of waste treatment, Community biogas plant, biogas scheme – scope of rural development

Unit-III

Biodegradation and bioremediation: Principle and mechanism of biodegradation of xenobiotic compounds (Lignin, Hydrocarbons, Detergents, Dyes and pesticides). Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), organic pollutants (PAHs, PCBs, Pesticides, etc.), technological aspects of bioremediation (in situ, ex situ)

Unit –IV

Efficacy of microorganisms: Microbial Enhanced Oil Recovery; Microbial role in Carbon Storage and Capture (sequestration, conversion to useful biopolymers, etc.) . Aerobic and Anaerobic Degradation of Aliphatic and Aromatic Compounds. Microbial interaction with plastics, antibiotics, and other emerging pollutants.

Unit-V

Environmental Impact Assessment: Relation between development and environment. Sustainable development and carrying capacity. Environmental Protection Act, 1986, Water Prevention and Control of Pollution Act, 1974, Water Prevention and Control of Pollution Cess Act, 1974, Air Prevention and Control of Pollution Act, 1981, Hazardous Wastes (Management and Handling) Rules. International environmental laws.

Books recommended

1. Karrely D., Chakrabarty K., Omen G.S., Biotechnology and Biodegradation, Advances in Applied Biotechnology Series, Vol.4, Gulf Publications Co. London, 2009
2. R.M.Maier, I.L.Pepper and C.P.Gerba, Elsevier, “Environmental Microbiology: A Laboratory Manual”, 2nd Edition, Academic Press, 2004.
3. B.C. Bhattacharyya and R. Banerjee, “Environmental Biotechnology”, Oxford University Press.
4. Foster C.F., John Ware D.A., Environmental Biotechnology, Ellis Horwood Ltd., 2007.
5. Environmental Biotechnology, Principles and Applications by Bruce E Rittman and Perry L McCarty, McGrawhill Higher education.
6. Environmental Biotechnology Edited by Hans-Joachim Jördening and J Winter, WILEY-VCH Verlag GmbH & Co.
7. Bioremediation and Natural Attenuation by Pedro J J Alvarage and Walter A Illman, Wiley Interscience.
8. Environmental Biotechnology, Vol 10 Handbook of Environmental Engineering, Edited by L K Wang et al, Humana Press.

Biochemical Analysis Lab

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-206 | 2 | 0 | 0 | 4 | 0 | 20 | 30 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | Biochemical Analysis Lab enable students to understand the elemental chemistry of the biomolecules and hands on experience on experiments related with biochemical analysis. |
|---------------------------|--|

Course outcome: - On successful completion of the course, the student will be able to-

| | | |
|------------|--|--------------------------|
| CO1 | Basics of Biochemical analysis | Understand |
| CO2 | Describe the method used to estimate reducing sugar in the sample | Analyze |
| CO3 | Describe the method used to estimate amino acids in the sample | Analyze |
| CO4 | Explain the principles of Paper Chromatography and its application in amino estimation | Understand, Apply |
| CO5 | Identification of bacterial isolate using different biochemical test | Evaluate |

| COs | POs | | | | | | | | | | | | PSOs | |
|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 2 | - | - | - | - | 1 | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | - | - | - | 3 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | - | - | - | 3 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | - | 3 | 3 | - | 3 | - | - | - | - | 3 | 3 | 3 |
| CO5 | - | - | - | 3 | - | 3 | 2 | 3 | - | - | - | 3 | 3 | 3 |
| Average | 3 | 2 | - | 3 | 3 | 3 | 2 | 3 | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put “-”

List of Experiments

1. Buffer preparations with the help of pH meter.
2. Estimation of reducing sugar by
 - a) DNS Methods.
 - b) Benedict's method.
3. Estimation of proteins by
 - a) Lowrey's method
 - b) Biuret method
4. Estimation of DNA by Diphenyl amine reagent.
5. Extraction of Lipids by egg yolk.
6. Separation of amino acids by paper chromatography.
7. Thin Layer chromatography.
8. Biochemical Test for bacterial identification.

Textbooks:

1. "An Introduction to Practical Biochemistry", David T. Plummer, Tata McGraHill Co. Ltd., New Delhi.
2. "Biochemistry Laboratory: Modern Theory & Techniques" 2nd Edition, Rodney Boyer, United State Edition

Reference Books:

1. "Laboratory Manual for Practical Biochemistry by Shivaraja Shankara YM, Ganesh MK, Shivashankara AR"

Bioinformatics

Evaluation Scheme

| Course Type | Subject Code | Credit | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|--------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-301 | 4 | 3 | 0 | 2 | 15 | 20 | 15 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | <ul style="list-style-type: none"> • To teach the basic concept of Bioinformatics, databases, and sequence analysis • To develop an understanding of sequence analysis • To provide knowledge of scoring matrix and detection of functional sites etc. • To impart knowledge related to phylogenetic analysis and protein structure prediction |
|---------------------------|--|

Course outcome: - On completion of this course, the students will be able to:

| | | |
|-----|--|-------------------|
| CO1 | Understand concepts and application of Bioinformatics, types of databases, sequence similarity, sequence patterns | Understand |
| CO2 | Use sequence alignment techniques, database searching, pairwise and multiple sequence alignment using various tools. | Apply |
| CO3 | Understand scoring matrices and their types including PAM, BLOSUM series, and matrices for nucleic acid and protein sequences. | Understand |
| CO4 | Apply phylogeny and its concepts in molecular evolution and different methods of Phylogenetic tree construction | Apply |
| CO5 | Understand and apply the protein structure prediction and application of bioinformatics in drug designing | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 3 | 2 | - | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 2 | - | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | - | - | - | 2 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 2 | - | 2 | 3 | - | - | - | 2 | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | 3 | 3 | 2 | 3 | - | - | - | 2 | 3 | 3 | 3 |

Syllabus

Unit-I

Introduction to Bioinformatics and its Relation with Molecular Biology, Molecular Biology's Central Dogma. Introduction of Biological Databases: Nucleic acid databases (NCBI, DDBJ, and EMBL), Protein databases (Primary, Composite, and Secondary), Specialized Genome databases: (SGD, TIGR, and ACeDB), Structure databases (CATH, SCOP, and PDBsum).

Unit-II

Introduction to Sequences, Basic concepts of sequence similarity: identity and homology. Sequence alignment, optimal alignment method, statistical significance of alignment. Pairwise sequence alignment, global and local Sequence alignment. Sequence alignment algorithms. Scoring Matrices, Substitution matrices, PAM, and BLOSUM series.

Unit-III

Database similarity searching, Multiple sequence alignment: progressive method and Iterative method; Applications of pairwise and multiple sequence alignment; Tools for multiple sequence alignment: CLUSTALW (Algorithmic concepts). Phylogenetics: Phylogeny and concepts in molecular evolution; definition and description of Phylogenetic trees and various types of trees; Different methods of Phylogenetic tree construction: UPGMA and Fitch-Margoliash Algorithm.

Unit-IV

Protein structure prediction: Secondary structure prediction (Statistical method: Chou Fasman and GOR method, Neural Network, and nearest neighbor method) and Tertiary structures prediction (Homology Modeling); Structure visualization methods (RASMOL, CHIME, etc.); Application of bioinformatics in drug discovery and drug designing.

Unit-V

1. Get five nucleotide and five protein sequences in FASTA format from NCBI and EMBL and find out five similar sequences using BLAST and FASTA.
2. Access and use of different online nucleotide and protein alignment tools (Pairwise and Multiple sequence alignment).
3. Construct a Phylogenetic tree of five evolutionary-related protein/nucleotide sequences.
4. Carry out the alignment of genomes of given organisms.
5. Predict the homology model of any protein sequence.
6. ORF prediction in the given nucleotide sequence.
7. Secondary structure prediction for given amino acid sequences of a given protein using Chou Fasman, GOR method, and Neural Network method.
8. Visualize the tertiary structure of any given protein sequence.

Textbooks:

1. Bioinformatics: Principles and applications by Ghosh and Mallick (oxford) university press)
2. Bioinformatics by Andreas D Boxevanis (Wiley Interscience)
3. Fundamental Concept of Bioinformatics by Dan e. Krane
4. Bioinformatics-Sequence and genome analysis by D.W.Mount Cold Spring HarbourLab press

Reference books:

1. Introduction to bioinformatics by Attwood and Parry Smith (Pierson Education Publication)
2. Instant notes in Bioinformatics by Westhead, parish, and Tweman (Bios scientific publishers)
3. Bioinformatics: Concept and application by B.N.Mishra Pearson Education

Online Resources:

1. <https://www.ncbi.nlm.nih.gov/>
2. <https://www.embl.org/>
3. <https://www.ddbj.nig.ac.jp/index-e.html>
4. <https://pubmed.ncbi.nlm.nih.gov/>
5. <https://guides.lib.berkeley.edu/bioinformatics>
6. <https://vlab.amrita.edu/index.php?sub=3&brch=273>
7. <https://vlab.amrita.edu/index.php?sub=3&brch=274>
8. <https://vlab.amrita.edu/index.php?sub=3&brch=275>
9. <https://bds-au.vlabs.ac.in/List%20of%20experiments.html>

Bioprocess Engineering

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Seasonal Marks | | | | ESE | Totals Marks |
|-------------|--------------|---------|---------|---|---|----------------|----|-----|-------|-----|--------------|
| | | | L | T | P | MSE | TA | Lab | Total | | |
| PCC | NBE-303 | 4 | 3 | 1 | 0 | 30 | 20 | -- | 50 | 50 | 100 |

Objective:- To introduce the engineering principles of bioprocesses including microbial kinetics, sterilization principles and design considerations.

Course Outcome:- On successful completion of the course student will be able to –

| | | |
|-----|---|------------|
| CO1 | Understand the roles and responsibilities of a bioprocess engineer. | Understand |
| CO2 | Develop the design equations for bioreactors and calculate the oxygen demand for cell growth | Apply |
| CO3 | Understand the rheology of fermentation fluids and determine the power requirement in bioreactors | Understand |
| CO4 | Analyze the sterilization techniques and estimate the sterilization time | Analyze |
| CO5 | Apply the scale up concepts for bioprocesses | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | | | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 2 | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 2 | 2 | 3 | - | - | 3 | - | - | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | - | 3 | - | - | 3 | | |
| Total | 3 | 3 | 3 | 2 | 2 | 3 | 3 | - | 3 | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put “-”

Syllabus

Unit –I Introduction

Role of a bioprocess engineer, Kinetics of microbial growth, substrate utilization and product formation; Simple structured models, Design of fermentation media.

Unit-II Bioreactor Operation

Batch, fed-batch and continuous processes: Operation of batch, continuous and fed-batch processes and industrial applications, Comparison of batch, fed-batch and continuous processes. Chemostate with cell recycle. Substrate utilization and product formation in batch and continuous reactors. Stoichiometry of growth and product formation, Maximum possible yield.

Unit-III Rheology of fermentation fluids

Newtonian and non-Newtonian fluids, Aeration and agitation, power requirement for gassed and un-gassed systems, time calculation for mixing.

Unit-IV Sterilization

Media sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization, Sterilization of air: Methods & Mechanism, Design of depth filter and estimation of its efficiency..

Unit – V Mass transfer in bioreactors

Theories of mass transfer, metabolic oxygen demand, measurement of K_La , Maximum cell concentration. Scale up concepts, criteria for bioreactors scale up

References:

1. “Biochemical Engineering Fundamentals” by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
2. “Principle of Fermentation Technology”, P.F. Stanbury and A. Whitaker; Pergamon Press.
3. Bioprocess Engineering – P.M. Doran
4. “Biochemical Engineering”, Shuichi Aiba, Arthur E. Humphrey, Nancy F. Millis; University of Tokyo Press.
5. “Basic Biotechnology”, J. Bu’lock, B. Kristiansen, Academic Press.

Enzyme Engineering & Technology

Evaluation Scheme:

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-305 | 3 | 2 | 1 | 0 | 30 | 20 | -- | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | The objective of this course is to enable the students to understand the basics of enzyme kinetics and production and industrial application of enzymes. |
|---------------------------|--|

Course outcome:-On successful completion of the course student will be able to –

| | | |
|-----|--|-------------------|
| CO1 | Understand the importance of enzymes, their classification, and nomenclature. | Understand |
| CO2 | Analyze the mechanism of enzyme catalysis and kinetics of single as well as multiple substrates. | Analyze |
| CO3 | Analyze the inhibition kinetics and activation. | Analyze |
| CO4 | Analyze the regulation of enzymes. | Analyze |
| CO5 | Analyze immobilization kinetics and methods of whole cell immobilization and enzyme immobilization, enzyme reactors. | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|---|----------|---|---|---|----|----|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | - | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 2 | 2 | - | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | - | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 3 | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | 3 | - | 3 | - | - | - | - | - | 3 | 3 | 3 |

1:Slight(Low), 2: Moderate (Medium), 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit-I: Introduction to Enzymes

General introduction and historic background, Nomenclature and Classification of Enzymes, characteristic features of Enzymes, Specificity of Enzyme, Protein nature of enzymes, and Nonprotein enzymes. Metalloenzymes and metal-activated enzymes. Coenzymes and Cofactors- Prosthetic group, Classification of coenzymes. Isozymes, Abzymes, Synzyme

Unit-II: Enzyme Catalysis and Kinetics

Enzymes as Biocatalysts; Lock and key, Induced fit, and Transition state hypotheses. Mechanism of enzyme catalysis- Acid-base catalysis, covalent catalysis, Metal ion catalysis, Proximity and orientation effects, etc. Mechanism of Serine proteases-Chymotrypsin, Lysozyme, Carboxypeptidase A and Ribonuclease., Proenzymes (Zymogens). Enzymatic kinetics of single substrates reaction. Derivation of Michaelis Menten equation, turnover number, determination of K_m and V_m (Lineweaver Burk plot), multiple substrate reaction mechanism.

Unit-III: Enzyme Inhibition and Kinetics

Reversible Inhibition- Competitive, Non-Competitive, Uncompetitive, Mixed, Substrate, Allosteric, and Product Inhibition. Irreversible Inhibition- Suicide inhibition. Examples and Mechanisms of various Inhibitions like Penicillin, Iodoacetamide, and DIPP, Kinetics of inhibition and activation; King and Altman Method, allosteric enzymes.

Unit-IV: Enzyme Regulation

Feedback Regulation, Allosteric Regulation, Reversible Covalent Modification, and Proteolytic Activation. The organization of enzymes in the cell. Enzymes in the cell, localization, compartmentation of metabolic pathways, enzymes in membranes, concentrations. Mechanisms of enzyme degradation, lysosomal and nonlysosomal pathways, examples.

Unit-V: Enzyme Immobilization

Immobilization of enzymes and cells, methods of immobilization adsorption, entrapment, encapsulation, covalent binding, crosslinking and their examples; merits and demerits of different immobilization methods. Effect of micro and macro environmental parameters on the immobilized enzymes; External film and internal pore diffusion partitioning and electrostatic interaction. Performance of soluble and immobilized enzyme reactors, operational strategies, carrier life and cycle time.

Reference:

1. Enzyme Technology by Chaplin and Bucke Cambridge University Pres.
2. Fundamentals of Enzymology: Nicholas Price & Lewis Stevens
3. Enzymes: Biochemistry, Biotechnology, and Clinical Chemistry- Trevor Palmer
4. Immobilized Enzymes An Introduction and Applications in Biotechnology, Michael D. Trevan, Wiley-Blackwell (3 December 1980)
5. Enzyme Kinetics by Roberts, Cambridge University Press
6. Biochemical Engineering Fundamentals” by J.E. Bailey and D. F.Ollis, Mcgraw-Hill Book Co, New Yor

Bioprocess Engineering Lab

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Seasonal Marks | | | | ESE | Totals Marks |
|-------------|--------------|---------|---------|---|---|----------------|----|-----|-------|-----|--------------|
| | | | L | T | P | MSE | TA | Lab | Total | | |
| PCC | NBE-307 | 3 | 0 | 0 | 6 | 0 | 20 | 30 | 50 | 50 | 100 |

Objective:- To introduce the engineering principles of bioprocesses including microbial kinetics, sterilization principles and design considerations.

Course Outcome:- On successful completion of the course student will be able to –

| | | |
|-----|---|----------|
| CO1 | Estimate MM constants | Analyze |
| CO2 | Find the effect of pH and temperature on enzyme activity | Apply |
| CO3 | Estimate the Monod parameters in batch, fed-batch and continuous cultures | Apply |
| CO4 | Estimate residence time distributions in batch and continuous bioreactors | Evaluate |

| COs | POs | | | | | | | | | | | | PSOs | |
|---------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 2 | - | - | - | - | 1 | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | - | - | - | 3 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | - | - | - | 3 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | - | 3 | 3 | - | 3 | - | - | - | - | 3 | 3 | 3 |
| CO5 | - | - | - | 3 | - | 3 | 2 | 3 | - | - | - | 3 | 3 | 3 |
| Average | 3 | 2 | - | 3 | 3 | 3 | 2 | 3 | - | - | - | 3 | 3 | 3 |

1:Slight(Low), 2: Moderate (Medium), 3: Substantial (High) *If there is no correlation, put “-”*

Experiments

1. Estimate MM constants
2. Growth kinetics of bacteria in Batch
3. Determination of mixing time and power number in chemostat,
4. Effect of temperature, on enzyme activity
5. Effect of pH on enzyme activity
6. Effect of substrate on enzyme activity
7. Determination of K_{la} values

References:

1. Paulin M. Doran, Bioprocess Engineering Principles, Elsevier Science & Technology Books, 2008.

Downstream Techniques in Bioprocesses

Evaluation Scheme:

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|-----|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab | Total | | |
| PCC | NBE-302 | 4 | 3 | 0 | 2 | 15 | 20 | 15 | 50 | 50 | 100 |

| | |
|--------------------------|---|
| Course Objectives | To enable the students to: |
| | <ul style="list-style-type: none"> • Understand the methods to obtain pure proteins, enzymes, and in general product development R & D. • Have depth knowledge and hands-on experience with downstream processes. |

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|---|-------------------|
| CO1 | Describe the principles that underlie major unit operations used in downstream processing | Understand |
| CO2 | Define and carry out the separation and purification of fermentation products | Apply |
| CO3 | Design and formulate effective strategies of downstream processing based on characteristics of biomolecules | Apply |
| CO4 | Analyze the quality and characteristics of the purified product | Understand |
| CO5 | Integrate biological and engineering principles involved in the production and recovery of commercial products. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|---|---|----|----|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 3 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 3 | 2 | - | 3 | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 2 | - | 2 | 3 | - | - | - | - | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | 3 | 3 | 2 | 3 | - | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

Syllabus

Unit I

Introduction to downstream processing, principles, and characteristics of biomolecules and bioprocesses. Cell disruption for product release – mechanical, enzymatic, and chemical methods. Pretreatment and stabilization of bioproducts

Unit II

Separation of insoluble products: Centrifugation, Sedimentation, Filtration, and Ultracentrifuges.

Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction

Unit III

Precipitation of proteins by different methods: Salting in and salting out method, Adsorption.

Membrane-based purification: Ultrafiltration and Microfiltration, Reverse osmosis, Dialysis.

Unit IV

Chromatography: principles, instruments and practice, adsorption, reverse phase, ion exchange, size exclusion, hydrophobic interaction, bioaffinity, and pseudo affinity chromatographic techniques. Electrophoresis.

Unit V

Final product formulation: Drying, Freeze drying, lyophilization, and crystallization

Textbooks

1. P.A. Belter, E.L. Cussler and Wei-Houhu, Bioseparations – Downstream Processing for Biotechnology, Wiley Interscience Pub
2. P. M. Doran, Bioprocess Engineering principles, Academic press
3. P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, Elsevier Science & Technology

Reference Books

1. M. L. Shular and F. Kargi, Bioprocess Engineering Basic concepts, Prentice Hall
2. R.O. Jenkins, (Ed.), Product Recovery in Bioprocess Technology – Biotechnology, Open Learning Series, Butterworth-Heinemann

Biomolecules in Pharmaceutical

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|-----|-------|-----|-------------|
| | | | L | T | P | MSE | TA | MSE | Total | | |
| PCC | NBE-304 | 3 | 2 | 1 | 0 | 15 | 20 | 15 | 50 | 50 | 100 |

Objective:-

The objective of this course is to enable the students to understand the applications of biomolecules of bioprocesses in Biochemical Engineering to know their various uses .

Course outcome:- On successful completion of the course student will be able to –

| | | |
|-----|---|-------------------|
| CO1 | Understand broad aspects of applications of biomolecules in different fields. | Understand |
| CO2 | Understand nutraceuticals and functional foods and their applications. | Understand |
| CO3 | Understand Probiotic foods and their functional, role of Specific Food ingredients | Understand |
| CO4 | Understand about immune system, Innate and adaptive immune system | Understand |
| CO5 | Understand about Antibiotics and their types, history of discovery of antibiotics by different scientist and their mode of action | Understand |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|---|----------|---|---|----------|----|----|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | - | - | - | - | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO6 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | - | - | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put*

Syllabus

Unit I

Introduction to pharmaceutical : definition and broad aspects of applications of biomolecules in different perspectives considering their different properties like stereo Isomerism, Chiral Molecules, Racemic Mixture, Elements Of Symmetry, Asymmetric Synthesis, Geometrical Isomerism, Conformational Isomerism, Stereospecific Reactions, properties and selection criteria for various excipients like surfactant, viscosity promoters, diluents, coating materials, plasticizers, preservatives, flavours and colours.

Unit II

Nutraceuticals: Defining nutraceuticals and functional foods, nature, type and scope of Nutraceuticals and functional foods applications and their health benefits, classification based on chemical and biochemical nature. Antioxidants, phytochemicals, isoflavones, lycopenes, their role in Nutraceuticals and functional foods, dietary fibers as functional food ingredients. Health benefits/ mode of action of PUFA/ gamma linolenic acids, Proteins as a functional food ingredients.

Unit III

Probiotic foods and their functional, role of Specific Food Products as a Functional Food Herbs as functional foods, health promoting activity of common herbs. Cereal products as functional foods- Oats, Wheat bran, rice bran etc. Functional vegetable products, oil seeds and sea foods. Coffee, tea and other beverages as functional foods/ drinks and their protective effects

Unit IV

Immunology: Definition of immune system. Innate and adaptive immune system and their components, Interferon, Monoclonal antibody, fourth generation antibodies, Vaccines and their types including synthetic and semisynthetic vaccines, Erythroprotein ,therapeutic protein.

Unit V

Antibiotics: definition of antibiotics and their types, history of discovery of antibiotics by different scientist and their mode of action. Classification of antibiotics , Natural and Semisynthetic antibiotics, different types of microorganisms secreting different antibiotics. Steroid formulation.

Books:

1. Handbook of Nutraceutical and Functional Foods -Wildman REC
2. Handbook of Nutraceuticals -Pathak YV
3. Immunology by Kuby
4. Prescotts Microbiology: John Wiley

Fermentation Technology

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-306 | 3 | 2 | 1 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|---|
| Course Objectives: | To introduce the students to the various concepts of fermentation and impart knowledge about biological and biochemical technology, with a focus on industrial products such as alcohol, organic acids, enzymes, and amino acids. |
|---------------------------|---|

Course outcome: - On successful completion of the course, the student will be able to-

| | | |
|------------|---|--------------|
| CO1 | Understand the various concepts of fermentation, analyze the industrial aspect of the field of microbiology. | Apply |
| CO2 | Understand the industrial aspect of the field of microbiology and know the differences between aerobic and anaerobic fermentation. | Apply |
| CO3 | Understand to produce some industrially important liquid fermentation products e.g. ethanol, vinegar etc, produce some industrially important biomass based fermentation products e.g. baker's yeast etc. | Apply |
| CO4 | Understand solid and submerged fermentations. | Apply |
| CO5 | Understand different fermentation products related with recombinant technology | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|---|---|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 3 | - | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | - | - | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 3 | - | 3 | 3 | - | - | - | 2 | 3 | 3 | 3 |
| CO4 | 3 | - | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | - | 3 | 3 | 2 | - | - | 2 | 2 | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | 3 | 3 | 3 | 3 | - | - | 2 | 3 | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit I

Introduction to Fermentation Technology, History, and development of the fermentation industry. Microbial culture selection for fermentation processes, Strain development; Various types of fermentation systems (submerged, surface, and solid-state fermentation).

Unit II

Alcoholic fermentation and related products. Glycerol fermentation. Malting and brewing: beer production, wine manufacturing and other distilled liquors.

Unit III

Microbial production of organic acids (Lactic Acid and Citric acid), Aminoacid fermentation (Lysine and Glutamic acid), Biomass as a fermentation product: Baker's yeast, Bioinsecticides, Biofertilizers.

Unit IV

Commercial enzymes: solid and submerged fermentation, recovery etc. Secondary metabolites such as antibiotics (Penicillin, Streptomycin) and vitamins.

Unit – V

Microbial transformations, vaccines, recombinant therapeutic proteins (Human recombinant insulin).

Text Books:

1. Stanbury, P.F. and Whitaker, A., and Hall S. J. Principles of Fermentation Technology, Pergamon Press (2007).
2. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc. New York.
3. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.
4. "Microbial Technology", Vol.II, H.J. Peppler and D. Perlman, Academic Press, New York.

Reference Books:

1. Aiba, S., Humphrey, A.E and Millis, N.F., Biochemical Engineering, Academic Press (1973).
2. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw-Hill (1986).

Fermentation & Environmental Lab

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-308 | 3 | 0 | 0 | 6 | 0 | 20 | 30 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | To enable the students to <ul style="list-style-type: none"> • Understand in-depth knowledge and hands on experience on fermentation process • Hands on experience |
|---------------------------|--|

Course outcome: - On successful completion of the course, student will be able to –

| | | |
|-----|--|---------------------------|
| CO1 | Understand the different fermentation products obtained via solid state and submerged fermentation | Understand, Create |
| CO2 | Able to find fermentation efficiency | Analyze |
| CO3 | Able to distinguished primary and secondary microbial products | Analyze |
| CO5 | Able to determine the characteristics of wastewater | Analyze |
| CO4 | Explain the physiochemical characteristics of wastewater | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 2 | 3 | - | 3 | - | 3 | 2 | - | - | - | 3 | 3 | 3 | 3 |
| CO2 | 2 | - | - | 3 | - | 1 | 2 | - | - | - | 3 | 3 | 3 | 3 |
| CO3 | 3 | - | - | 3 | - | 1 | 1 | - | - | - | 3 | - | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | - | 3 | - | - | - | - | 3 | - | 3 | 3 |
| CO5 | 3 | - | 3 | 3 | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | 3 | - | 3 | 2 | - | - | - | 3 | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

List of Experiments

1. Analysis of molasses.
2. Determination of fermentation efficiency of yeast for batch production of ethanol.
3. Effect of substrate concentration on biomass yield for baker's yeast production and its characterization.
4. Fermentation efficiency for vinegar production.
5. Citric acid production by (a) solid state and (b) submerged fermentation.
6. Microbial production of enzymes by (a) solid state and (b) submerged fermentation.
7. Analysis of finished products (rectified spirit, beer etc.).
8. Biological characteristics of wastewater (BOD & MLSS)
9. Chemical characteristics of wastewater (TCOD, TSS, TDS & Hardness of water)
10. Physical characteristics of wastewater (pH, colour & odour)

Text Books:

5. Stanbury, P.F. and Whitaker, A., and Hall S. J. Principles of Fermentation Technology, Pergamon Press (2007).
6. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc. New York.
7. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.
8. "Microbial Technology", Vol.II, H.J. Peppler and D. Perlman, Academic Press, New York.

Reference Books:

3. Aiba, S., Humphrey, A.E and Millis, N.F., Biochemical Engineering, Academic Press (1973).
4. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw-Hill (1986).

Microbial Technology

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| OEC-I | OBE-302 | 2 | 2 | 0 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|---|
| Course Objectives: | The objectives of this course are to introduce students majoring in other branches besides Biochemical Engineering to the fundamentals of Microbial techniques and their industrial applications. |
|---------------------------|---|

Course outcome:-On successful completion of the course student will be able to –

| | | |
|-----|---|-----------------|
| CO1 | Explain the basis of the fermentation process | Apply |
| CO2 | Explain the basic requirements for microbial growth in industrial processes | Analyze |
| CO3 | Illustrate the production of different products from the microbes | Analyze |
| CO4 | Comprehend processes of growth-related and non-growth-related products | Analyze |
| CO5 | Analyze the basic bioprocesses operated at an industrial scale | Evaluate |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | - | - | - | - | - | 2 | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | - | 2 | - | 2 | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 2 | 2 | - | 2 | - | 2 | - | - | - | - | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | - | 2 | - | 2 | - | - | - | - | 3 | 3 | 3 |

1:Slight(Low), 2: Moderate (Medium), 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit-I: Introduction to microbial technology

Introduction to Microbial Technology; Basic idea on fermentation process; Submerged, Stationary, Solid and Semisolid with their merits and demerits. Media for industrial fermentation.

Unit-II: Microbial culture selection

Equipment and accessories for industrial processes. Microbial growth kinetics. Sterilization; Batch sterilization and Continuous sterilization. Media Sterilization. Filter Sterilization.

Unit-III: Microbial Products

Production of Organic acid, Solvent, Antibiotics, Polysaccharides, Enzymes, Vitamins, Pigments, Wine, Dextran, Aroma.

Unit-IV: Modification in Microbial Processes

Isolation of Industrially Important Microorganisms. Preservation of industrially important microorganisms. Improvement of microorganisms. The Improvement of industrial strains by modifying properties other than the yield of the product.

Unit-V: Industrial and Medicinal Applications

Application of enzymes in industrially analytical purpose and medical therapy. Biodegradation of cellulose and lignin. Production of Biodiesel and Rapeseed methyl esters. Microbial metabolic products; Primary metabolites and Secondary metabolites.

Text Books:

1. Principles of Fermentation Technology, second edition, by P.F.Stanbery, A. Wtaker and S.J.Hall.
2. Manual of Industrial Microbiology and Biotechnology, second edition by L. Demain and Julian E. Devies.

Reference Books:

1. Biotechnology by Dr. U. Satyanarayana
2. Industrial Microbiology by A. H. Patel.

Bioreactor Design

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-II | NBE-401 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

Objective:- To provide the basic principles of reactor design for bioprocesses.

Course Outcome:- On successful completion of the course student will be able to –

| | | |
|-----|--|--------------|
| CO1 | Understand comprehend the state of the arts in bioreactor technology and its broad range of applications, develop mathematical descriptions of reaction kinetics in cellular systems and their relationships with bioreactor design. | Apply |
| CO2 | Understand basic principles of mass and energy conservation to analyze bioreactor systems. Identify the major engineering parameters that characterizes the performance of bioreactors and techniques to measure and control these parameters. | Apply |
| CO3 | Understand complete bioreactor based on targets, constraints and physical properties. | Apply |
| CO4 | Understand suitable process instrumentation for monitoring and control of bioreactors. | Apply |
| CO5 | Understand the problem of selection of suitable bioreactor configuration. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|---|---|---|----|----|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 1 | - | - | - | - | - | - | - | - | 2 | 3 | 3 |
| CO2 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 2 | 3 | 3 |
| CO3 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 2 | 3 | 3 |
| CO4 | 3 | 2 | 1 | 1 | 2 | 1 | - | - | - | - | - | 2 | 3 | 3 |
| CO5 | 3 | 2 | - | - | - | - | - | - | - | - | - | 2 | 3 | 3 |
| Total | 3 | 2 | 1 | 1 | 2 | 1 | - | - | - | - | - | 2 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit-I

Design equations for batch, continuous and fed batch reactors. Non-ideal flow behaviour of Batch and continuous flow reactors.

Unit-II

Novel bioreactor configuration such as fluidized bed reactor, air-lift reactor, bubble column, membrane bioreactor etc.

Unit-III

Bioreactor operation measurement and control: Aseptic operations, measurement and control of process variables (pH, dissolved oxygen, viscosity, temperature, NADH), agitative power and foam control.

Unit-IV

Vessel design, material of construction, design of accessories of bioreactor like impeller etc.

Unit-V

On-line analysis, bioprocess control and computer coupled bioreactors. Bioprocess economics.

References:

1. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London,

Metabolic Engineering

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|-----|-------|-----|-------------|
| | | | L | T | P | MSE | TA | MSE | Total | | |
| PEC-II | NBE-403 | 4 | 3 | 1 | 0 | 15 | 20 | 15 | 50 | 50 | 100 |

Objective:-

The objective of this course is to enable the students to understand the importance and regulation of metabolism in Biochemical Engineering to acquaint them with scope and basic techniques of Metabolic Engineering.

Course outcome: - On successful completion of the course student will be able to –

| | | |
|-----|---|-------------------|
| CO1 | Understand the basic of metabolism, growth and regulation. | Understand |
| CO2 | Understand about metabolic flux control and metabolome. | Understand |
| CO3 | Analyze different metabolic pathway intermediate metabolite and their flux. | Analyze |
| CO4 | Experimental Determination of metabolite concentration and flux. | Apply |
| CO5 | Application of techniques for improved pathways and their flux. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | - | - | - | - | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 2 | 2 | 2 | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO6 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | - | - | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put*

Syllabus

Unit I

Basic concepts of Metabolic Engineering, scope & Overview of cellular metabolism, Biosynthetic reactions, Polymerization, Growth Energetic; Regulation of Metabolic Pathways.

Unit II

Methods for metabolic characterization: genome, transcriptome, proteome, metabolome, fluxome
Comprehensive models for cellular reactions
Coordination of metabolic reactions: Feedback inhibition.

Unit III

Energy charge, Multigene networks, metabolic regulation network at enzyme level and whole cell level, Examples of metabolic pathway manipulations, Metabolic pathway synthesis algorithms, Metabolic flux analysis and its applications.

Unit IV

Methods for experimental determination of metabolic fluxes, Metabolite Balancing, Tracer, Determination of Flux control coefficients, MCA of Linear and Branched pathways, Thermodynamics of cellular processes,

Unit V

Metabolic design: Gene amplification, Gene-disruption, Randomized and targeted strain development, new concepts for quantitative bioprocess research and development.

Books:

1. Stephanopoulos, G, et al., Introduction to Metabolic engineering – Principles and Methodologies, Elsevier Science
2. S. Y. Lee, E.T. Papoutsakis, Metabolic Engineering, Marcel Dekker
3. Advances in Biochemical Engineering/Biotechnology; Metabolic Engineering, Volume Editor: Jens Nielsen
4. Metabolic Pathway design, A Practical Guide; P Carbonell

Green Energy and Sustainability

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Seasonal Marks | | | | ESE | Totals Marks |
|-------------|--------------|---------|---------|---|---|----------------|----|-----|-------|-----|--------------|
| | | | L | T | P | MSE | TA | Lab | Total | | |
| PEC-II | NBE- 405 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

Objective:- To provide knowledge about various types of bio-energy, processing, production and utilization of various form of biomass; Also aware about the importance of bio-energy for clean environment and about the sustainability

Course Outcome:- On successful completion of the course student will be able to –

| | | |
|-----|--|-------------------|
| CO1 | To understand the demand of energy and production of commonly used different types biofuels | Understand |
| CO2 | The student will be capable to apply the acquired knowledge to design biomass energy plants and to evaluate their performances. | Understand |
| CO3 | The student will be capable to Describe an understanding of the existing and emerging Microbial fuel technologies and its applications | Apply |
| CO4 | Able to understand the process of pyrolysis and gasification of biomass: Thermo-chemical conversion | Apply |
| CO5 | The student will be capable to explain different Biorefinery concepts using microbes and algae | Evaluate |

| COs | POs | | | | | | | | | | | | PSOs | |
|---------|-----|-----|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | - | - | - | 3 | - | - | - | - | | 3 | 3 | 3 |
| CO2 | 3 | 2 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | - | 3 | - | 3 | 3 | 3 | 3 |
| Average | 3 | 2.5 | - | 3 | 3 | 3 | 3 | - | 3 | - | 3 | 3 | 3 | 3 |

Syllabus

UNIT-I Introduction

Energy world demand, sustainability, climate changes, greenhouse gas effect, Alternate source of energy: Various Biofuels production processes from renewable energy sources, merits and demerits of different biofuels production processes

Unit-II Biomass aspects for energy production

Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection, waste biomass (municipal, industrial, agricultural and forestry) availability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, sorghum sugar beet, hemp) . Biomass Pretreatment: Barriers in lignocellulosic biomass conversion, pretreatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pretreatment in the biorefinery concept

Unit –III Microbial based bioenergy

Microbial Biofuels Production process: Various microbes involved, Different biochemical routes for the Biofuels production, Molecular biological approaches for the improvement of Biofuels production, Effect of physico-chemical parameters on the Biofuels production Microbial Electrochemical Cells: Principles, their applications, Microbial fuel cells (MFC); Microbial electrolysis cells (MEC)

Unit-IV Pyrolysis and Gasification of Biomass

Thermo-chemical conversion of ligno-cellulose biomass – Biomass processing for liquid fuel production - Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained.

Unit-V Bio-refinery concept

Basic concept, types of biorefineries, Bio-refinery concept: definition; different types of bio-refinery; biorefinery feedstocks and properties, economics; Fuel and chemical production from saccharides, lignocellulosic biomass, protein; vegetable oil; algal biorefinery.

Suggested texts and reference materials

1. Mutha, V. K. (2010). Handbook of bioenergy and biofuel SBS Publishers, Delhi
2. Clark, J. H., & Deswarte, F. (Eds.). (2014). Introduction to chemicals from biomass. John Wiley & Sons.
3. Klass, D. L. (1998). Biomass for renewable energy, fuels, and chemicals. Elsevier.
4. Mukunda, H. S. (2011). Understanding clean energy and fuels from biomass. Wiley India.
5. Higan C. and Burgt M v d (2003); Gasification, Elsevier Science
6. Speight, J. (2008). Synthetic fuels handbook: properties, process and performance. McGraw-Hill
7. Dahiya, A. (Ed.). (2014). Bioenergy: Biomass to biofuels. Academic Press.
8. Hall, D. O., & Overend, R. P. (1987). Biomass: regenerable energy.
9. San Pietro, A. (Ed.). (2012). Biochemical and photosynthetic aspects of energy production. Elsevier. New York
10. S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers, Wiley, 2013.
11. Shang-Tian Yang (Ed.), Bioprocessing for Value Added Products from Renewable Resources, Elsevier, 2007.

Plant Cell Biotechnology

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-III | NBE-407 | 3 | 3 | 0 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | To introduce the students to various aspects of plant biotechnology and familiarize them to various gene transfer methods and about transgenic plants. |
|---------------------------|--|

Course outcome: - On successful completion of the course, the student will be able to-

| | | |
|------------|---|-------------------|
| CO1 | Understand about plant cell, concept of Totipotency & different plant tissue culture techniques. | Understand |
| CO2 | Exposure to various plant products of industrial importance & development of various cultures. | Understand |
| CO3 | To optimize production of secondary metabolites from suspension culture and characterization of product. | Apply |
| CO4 | Understand to apply gene transfer techniques for improvement of plants. | Apply |
| CO5 | To understand biological & technological barriers in plant cell bioreactors & idea to construct different plant cell bioreactors. | Create |

| COs | POs | | | | | | | | | | | | PSOs | |
|----------------|----------|----------|----------|----------|----------|----------|----------|---|---|----|----|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | - | - | 3 | - | 3 | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | - | - | 3 | 1 | 3 | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | - | 3 | 2 | 3 | 3 | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | - | - | - | - | 3 | 3 | 3 |
| CO5 | - | 3 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | 3 | 3 | 3 |
| Average | 3 | 3 | 3 | 2 | 3 | 3 | 3 | - | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put “-”

Syllabus

UNIT I

Special features and organization of plant cells; totipotency and regeneration of plants; Introduction to plant tissue culture: Laboratory Organization; Tissue culture media- composition & preparation; Plant growth regulators; Various types of plant tissue cultures- Callus culture, Meristem culture, Organ culture & protoplast culture.

UNIT II

Biochemistry of major metabolic pathways and products; Plant product of industrial importance; Establishment & maintenance of different culture- Initiation and maintenance of callus cultures suspension culture.

UNIT III

Cell suspension culture development; Large scale production of secondary metabolites from suspension cultures; Characterization, kinetics of growth and product formation.

UNIT IV

Gene constructs and vector for the production of transgenic plant; Techniques for plant transformation: Agrobacterium mediated transformation; Hairy root culture & their cultivation; physical methods of gene transfer.

UNIT V

Biological & techno-economical barriers- hydrodynamic shear and its quantification and impeller design aspects; Different plant cell reactors & their performances for secondary metabolites production.

Textbooks:

1. "Introduction to Plant Biotechnology", H. S. Chawla, Science Publishers (2002).
2. "Introduction to Plant Tissue Culture", M. K. Razdan, Science Publishers (2003).
3. "Plant Cell Biotechnology", H. Smith and Mantell (Eds); Cambridge University Press, Cambridge.

Reference books:

1. "Plant Tissue Culture and its Biotechnological Application", W. Barz, E. Reinhard and M.H. Zenk (Eds.); Springer-Verlag, Berlin.
2. "Plant Biotechnology: The genetic manipulation of plants", Adrian Slater, Mark R. Fowler & Nigel W. Scott, Oxford University Press (2008).

FOOD BIOTECHNOLOGY

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ES E | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|------|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-III | NBE-409 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

Objective:-

The objective of this course is to enable the students causes of food spoilage and its effects , various methods to prevent food spoilage and testing and quality control of food materials.

Course outcome:- On successful completion of the course student will be able to –

| | | |
|-----|---|-------------------|
| CO1 | Understand about food spoiling microorganisms and microbial examination of food, | Apply |
| CO2 | Understand about food borne infections and food poisoning | Understand |
| CO3 | Understand principles and practice of food preservation by various methods | Apply |
| CO4 | Understand about good manufacturing practices, testing and quality control of food. | Apply |
| CO5 | Understand about Production of fermented foods and treatment and disposal of food waste | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|---|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 3 | 3 | 2 | | 3 | 1 | | | | 1 | | 3 | 1 |
| CO2 | | | | | | 3 | | 3 | 3 | | | 2 | 1 | 3 |
| CO3 | | 3 | 3 | 2 | | | 1 | | | | 1 | | | |
| CO4 | | 3 | | 2 | | | | | 3 | | 1 | 2 | | |
| CO5 | 3 | | | | | | | | | 3 | | | | |
| Total | 3 | 3 | 3 | 2 | | 3 | 1 | 3 | 3 | 3 | 1 | 2 | 2 | 2 |

1: Slight (Low)

2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit I Introduction

Important genera of food borne microorganisms, factors affecting the growth and survival of microorganisms in food Direct examination, culture techniques, MPN count, dye reduction assay,

Unit II Microbiological examination of food

Microbial spoilage of food, common food borne diseases, bacterial agents of food borne illness, non-bacterial agents of food borne illness.

Unit III Food preservation

Principles of food preservation, asepsis, anaerobic conditions, removal of microorganisms, low temperature, high temperature, radiation, drying, chemical preservatives and miscellaneous methods, canning.

Unit IV Cleaning

Cleaning and disinfection code for good manufacturing practices, microbial and chemical safety of food products, indicator organisms, ISO, hazard analysis and critical control points, sterility testing.

Unit V Fermented foods

Fermented milk, cheese, sauerkraut, fermented meat, beer, vinegar, fish products, products of baking, oriental foods.

Text /Reference Books:

- Modern Food Microbiology by James M. J., CBS Publishers and Publishers.
- Food Microbiology by Freiser.
- Willis Biotechnology, Challenges for the flavour and food industries by Lidsay, Elsevier Applied Science.
- Food Biotechnology by Roger A., Gordan B., and John T.
- Basic Food Microbiology by George J. B., CBS Publishers and Distributors.

Membrane Applications in Bioprocessing

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-III | NBE-411 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

Objective:-

- Acquire in-depth knowledge in the areas of membrane separation mechanisms, transport models, membrane permeability computations, membrane types and modules, membrane contactors / reactors and applications.
- Develop skills in applying transport models for the calculation of membrane permeability, flux, and the extent of separation for various membrane separation systems.
- To be able to calculate membrane process performance and analyze membrane separation characteristics
- Be able to select membrane processes for solving separation problems in the various applications like water and waste water, biotechnology and biomedical engineering etc.

Course outcome: - On successful completion of the course student will be able to –

| | | |
|-----|---|-------------------|
| CO1 | Able to explain and discuss the membrane, basic terms in membrane processes, types of membrane processes and membrane characterization | Understand |
| CO2 | Able to explain and discuss membrane transport theory, membrane modules and their design. | Analyze |
| CO3 | Able to explain and apply membrane techniques in identifying, formulating and solving problems in the membrane process like RO, NF, UF, MF etc. | Apply |
| CO4 | Able to explain and apply membrane techniques in identifying, formulating and solving problems in the membrane process like FCM, MC, MD, MB and membrane chromatography etc. | Apply |
| CO5 | Able to analyze and present the most suitable membrane process for solving separations problems in various applications like water and waste water, biotechnology and biomedical engineering etc. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|---|---|----------|----------|----------|---|----|----|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 2 | - | - | | 3 | 3 | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 2 | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | - | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

Syllabus

Unit-I

Historical Development of Membranes, Classification & characterization of membranes and membrane based processes, Advantages of membrane processes, Membrane materials.

Unit-II

Membrane Transport Theory, Membrane Modules and their design, Concentration Polarization, Fouling and Cleaning, General methods of membrane manufacturing.

Unit-III

Reverse Osmosis (RO), Pressure-Retarded Osmosis and Nanofiltration (NF), Ultrafiltration (UF), Microfiltration (MF), Gas Separation (GS), Liquid membrane Pervaporation (PV), Electrodialysis (ED) and Dialysis.

Unit -IV

Fuel Cell Membranes, Membranes in Chlor-Alkali Processes, Membrane Contactors, Membrane Distillation, Membrane Reactors and Membrane Bioreactors, Carrier Facilitated Transport, Submerged Membranes and Membrane chromatography.

Unit-V

Membrane applications in food processing industry (fruit industry, milk and its derivatives), bio-separation industry, biomedical related industry, Water & Waste Water Treatment related industries, Purification of waste and by-products.

Text Books:

1. Richard W. Baker, "Membrane Technology and Applications", 3rd edition, John Wiley & Sons, Ltd, United Kingdom, 2012.
2. Hoffman, E. J., "Membrane Separation Technology", Single Stage, Multistage and Differential Permeation", 2009.
3. Richard W. Baker "Membrane Technology and Applications", 2nd edition, John Wiley & Sons, Ltd, United Kingdom, 2004.
4. Kaushik Nath, "Membrane Separation Processes", 2nd Edition, PHI Learning Pvt Ltd. Delhi, 2017.

Reference Book:

1. W. S. Winston Ho and Kamallesh K. Sirkar (Editors), "Membrane Handbook", Chapman & Hall, New York, 1992.
2. Norman N. Li, Anthony G. Fane, W.S. Winston Ho and Takeshi Matsuura, (Editors), "Advanced Membrane Technology", John Wiley & Sons, Inc., New Jersey, 2008.
3. Marcel Mulder, "Basic Principles of Membrane Technology", Kluwer Academic Publishers, 1996.
4. R.D. Noble and S.A. Stern, "Membrane Separations Technology-Principles and Applications", Elsevier Science, 1995.

IPR and Biosafety Regulation

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-IV | NBE-413 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

Objective: -

- To introduce history and evolution of IPR- like patent, design and copy right, Indian patent act 1970 (amendment 2000), international convention in IPR, major changes in Indian patent system as post TRIPS effects (i) obtaining patent (ii) geographical indication.
- Student will understand various forms of IPR, Requirement of a patentable novelty, invention step and prior art and state of art, procedure.
- To understand the Rights/protection, infringement or violation, remedies against infringement – civil and criminal.
- Detailed information on patenting biological products, Biodiversity, Budapest treaty, Appropriate case studies

Course outcome:- On successful completion of the course student will be able to –

| | | |
|------|--|-------------------|
| CO 1 | Acquire in-depth knowledge in the areas of Intellectual Property Rights. | Understand |
| CO2 | Able to know about patent and filing of patent application for biological products and review it | Analyze |
| CO3 | Able to know implement about Bioethics, Biosafety Laws & its Regulation. | Apply |
| CO4 | Able to analyze the social, environmental and ethical issues related to plant, animal and modern biotechnology | Analyze |
| CO5 | To able evaluate issues and bioethics related to molecular technologies and GMOs. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 2 | - | - | | 3 | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | - | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | - | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 2 | 2 | - | - | 3 | 3 | - | - | - | - | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | - | - | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

UNIT-I

Jurisprudential definition and concept of property, right, duties and their correlation. History and evolution of IPR- like patent, design and copy right etc. International Treaties and Convention on IPRs, Main features of WIPO, GATT, and TRIPS agreement, Budapest Treaty.

UNIT-II

Indian Patent Act, PCT Agreement, Procedure to obtain patent of invention; Meaning and practical aspects of registration of Copy Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India and Abroad.

UNIT-III

IPR issues in relation to Biotech products/ processes; Future Aspects of Intellectual Property Rights. Limitations, Infringement & Enforcement of IPRs. Biosafety: Principles - Environmental and Health risk assessment; Biosafety regulatory guidelines and controlling agencies. Use of genetically modified organisms and their release in to the environment. Special procedures for r-DNA based products, Transgenic plants and Animals.

UNIT-IV

Environmental law for hazardous microorganisms and GMOs; Biotechnology Related Issues of Public Concern; Social and ethical issues in molecular technologies, genetic manipulations, Germ-line therapy and Transgenics.

UNIT-V

Bioethics: Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc.

Regulatory issues concerning the global biotechnology & pharmaceutical industries, including Good Laboratory & Clinical Practice (GLP & GCP).

Reference Books:

1. "An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology", Padma Nambisan, Academic Press (2017).
2. "IPR, Biosafety and Bioethics", Shomini Parashar, Deepa Goel, Pearson India (2013).
3. "Fundamentals of Intellectual Property for Engineers", Kompal Bansal, Parikshit Bansal, BS Publications (2015).
4. "Intellectual Property Rights in India", V. K. Ahuja, Lexis Nexis India (2009).

Text Books

1. "Managing Intellectual Property: The Strategic Imperative", V. Scople Vinod, Prentice Hall of India Pvt. Ltd. (2012).
2. "Intellectual Property Rights and Copy Rights", S.P. Satarkar, Ess Ess Publications, New Delhi (2002).

Biosensors

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-IV | NBE-415 | 3 | 3 | 0 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | The objective of this course is to enable the student to understand the basic concepts of biosensors, the components of biosensors, and their application in industry, medical science, and environmental studies. |
|---------------------------|--|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|--|-------------------|
| CO1 | Classify types of biosensors based on principle. | Understand |
| CO2 | Understand various types of transducers, their functioning, and criteria for selection | Understand |
| CO3 | Understand chemical, electrochemical and optical sensing mechanism and tools. | Understand |
| CO4 | Use biomaterial and nanomaterials in biosensors for signal amplification, Detection and Transducer Fabrication | Analyze |
| CO5 | Apply bio sensing techniques in health and environment. | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 2 | - | - | - | 2 | 3 | 2 | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | - | - | - | 3 | 2 | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | - | - | - | 3 | - | 2 | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 2 | 2 | - | 3 | 2 | 3 | 2 | - | - | - | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | - | 3 | 2 | 2 | 2 | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit-I

Introduction to Biosensors: General concept and terminology, General components of biosensor, Classification of biosensors based on principle: amperometric, potentiometric, piezoelectric, and calorimetric biosensors, scope of biosensors and its limitations.

Unit-II

Transduction principles: Classification of transducers, selection of transducers, Temperature transducers: thermosensitive transducers, thermoelectric, chemical thermometry. Pressure transducers, photoelectric transducers, and flow transducers.

Unit-III

Analytical techniques: Chemical sensing, optical sensing mechanisms and tools, electrochemical sensing mechanisms and tools, mass spectroscopy.

Unit-IV

Applications of Nanomaterials in Biosensors: Nano Materials in biosensors; Carbon based Nanomaterial, Metal oxide and nano particle, Quantum dots, Role of nano material in Signal Amplifications, Detection and Transducer Fabrication.

Unit-V

Applications of Biosensors in Health and Environment: Biosensors and diabetes management, Microfabricated biosensors and point-of-care diagnostics systems, Noninvasive biosensors in clinical analysis.

Textbooks:

1. Biosensors an Introduction, First edition by Brian R Eggins, John Wiley & Sons Publishers, 1996.
2. Biosensors Principles and Applications, First edition by Loic J Blum, Pierre R Coulet, Marcel Dekker, Inc, 1991.
3. Biosensors Theory and Applications, First Edition by Donald G. Buerk. Technomic Publishing Co, Inc, 1993.
4. Biosensors and modern bio-specific analytical techniques, L. Gorton (ed) Volume XLIV Elsevier 2005.
5. Advances in biosensors, B. D. Malhotra & A. P. F. Turner (eds), Volume 5, Elsevier science 2003
6. Transducers for Biomedical Instruments by S.C. Cobbold, Prentice Hall.

Reference Books:

1. Elizabeth A Hall - Biosensors, First Edition, Open University, Milton Keynes, 1990.
2. Commercial Biosensors, First edition by Graham Ramsay, John Wiley & Sons, Inc. 1998.
3. Sensor Physics & Technology - Biosensors, First Edition by Tran Minh Canh, Champan & Hall, 1993.

Nanobiotechnology

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-IV | NBE-417 | 3 | 3 | 0 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | To understand the basics of Nanobiotechnology and its applications |
|---------------------------|--|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|---|-----------------|
| CO1 | Explain the applications of various types of Nanomaterials in biotechnology. | Apply |
| CO2 | Understand the production and the applications of various types of nanostructured materials | Analyze |
| CO3 | Understand the production and the applications of various types of nanostructured materials | Evaluate |
| CO4 | Know methods of producing microbial nanoparticles and their applications. | Apply |
| CO5 | Describe ethical and socioeconomic challenges. | Create |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | | | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | - | 2 | 3 | 2 | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | - | 2 | 2 | 2 | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | - | 2 | 2 | 2 | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | - | - | - | - | 3 | - | 3 | - | - | - | 3 | 3 | 3 |
| Total | 3 | 3 | 2 | - | 2 | 3 | 2 | 3 | - | - | - | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

Syllabus

Unit-I

Nano biotechnology-introduction, development of Nanobiotechnology - timelines and progress, prospects, and challenges, applications - medical and diagnostics, environment, food, bioseparation, drug discovery, and delivery, nanotechnology for tissue engineering: applications in regenerative therapy, analytical applications.

Unit-II

Nanoscale structures and materials, basic principles underlying the fabrication of these Nanomaterials, the interaction between biomolecules and nanoparticle surfaces, brief introduction to the structure and chemical characterization of Nanomaterials, toxicity of Nanomaterials – biological toxicity and environmental toxicity, modification of nanomaterials to make them eco- friendly

Unit-III

Protein-based nanostructures, Nano motors -bacterial (E.coli) and mammalian(Myosin family), nanoparticles in biological labeling and cellular imaging, the science of nanoparticles functionalization, Nano printing of DNA, RNA, and proteins, Biochips applications in Nanoscale detection, Lab-on-a-chip devices.

Unit-IV

Microbial nanoparticles, biosynthesis of nanoparticles by microorganisms, methods of microbial nanoparticle production, applications of microbial nanoparticles, bacteriorhodopsin and its potential in technical applications overview, structure, photoelectric applications, photochromic applications and applications in energy.

Unit-V

Ethical and societal issues in Nanobiotechnology, socioeconomic challenges, ethical issues with special reference to Nanomedicine, legal issues, life-cycle assessment, and risk assessment of Nanomaterials.

Textbooks

1. Christof M Niemeyer, Chad A Mirkin (Eds.), Nanobiotechnology: Concepts, Applications, and Perspectives, Wiley VCH, 2004.
2. David S Goodsell, Bionanotechnology, John Wiley & Sons, 2004.

Reference Books

3. Tuan Vo-Dinh (Ed.), Nanotechnology in Biology and Medicine: Methods, Devices, and Applications, CRC Press, 2007.
4. Mark Wiesner, Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of nanomaterials, McGraw Hill, 2007.

Industrial Training

The students offer summer internship of 6 to 8 weeks would be giving presentation on the work they performed or learned during training

Evaluation Scheme:

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-419 | 2 | 0 | 0 | 4 | - | - | - | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | <p>The objectives of this course is to enable the students</p> <ul style="list-style-type: none"> • To expose to industrial environment • To acquaint with the various machines for the manufacturing of food products • For testing of raw materials and finished products |
|---------------------------|--|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|---|------------|
| CO1 | Understand the plant layout, work culture and human relationship | Understand |
| CO2 | Apply the theoretical knowledge in understanding the working of various machines and manufacturing processes | Apply |
| CO3 | Understand the process sequence and optimization of process parameters | Apply |
| CO4 | To get exposure to various conventional and modern tools and equipment for testing of raw materials and finished products | Apply |
| CO5 | To analyze the research problem and devise methodology/ steps to solve it and development of products | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | 3 | 2 | - | - | 2 | 1 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 2 | 2 | 1 | 2 | 2 | - | 1 | 2 | - | 2 | 3 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | - | - | - | - | - | 1 | 3 | 2 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 3 | 3 | 2 | 2 |
| Total | 3 | 3 | 2 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 2 | 2 |

1: Slight (Low)

2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

Fundamental of Enzyme Engineering

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| OEC | OBE-401 | 2 | 2 | 0 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | This course has been designed to teach the student majoring in other branches besides Biochemical Engineering about major aspects of the study of Enzymes. The course focuses on the theories of enzyme kinetics, the mechanisms of enzyme catalysis, and the applications of enzymes. |
|---------------------------|--|

Course outcome:-On successful completion of the course student will be able to –

| | | |
|-----|---|-----------------|
| CO1 | Summarize the classification of enzymes | Apply |
| CO2 | Illustrate the production of enzymes from various sources | Analyze |
| CO3 | Explain the kinetics of enzyme-catalyzed reactions | Analyze |
| CO4 | Illustrate the application of enzymes in the Chemical, Polymer, and Food industry | Evaluate |
| CO5 | Demonstrate the use of enzymes in the Energy and Environment | Evaluate |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|---|---|---|----------|---|----------|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 2 | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | - | - | - | - | - | 3 | - | 3 | - | - | 3 | 3 | 3 |
| CO5 | 3 | - | - | - | - | - | 3 | - | 3 | - | - | 3 | 3 | 3 |
| Total | 3 | 3 | 2 | - | - | - | 3 | - | 3 | - | - | 3 | 3 | 3 |

1:Slight(Low), 2: Moderate (Medium), 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit-I: Introduction to Enzyme Engineering

General introduction and historic background, Nomenclature and Classification of Enzymes, characteristic features of Enzymes, Protein nature of enzymes, and Nonprotein enzymes.

Unit-II: Production of Enzymes

Basic Enzyme Chemistry, Biosynthesis of Enzymes, Sources and Screening of Enzymes, Production of Enzymes

Unit-III: Enzyme Reaction Engineering

Enzyme Reaction Kinetics, M-M kinetics, Physical Meaning, Parameter Estimation, Regeneration of Cofactors: Regeneration of Reduced Nicotinamide Cofactors, Regeneration of Oxidized Nicotinamide Cofactors

Unit-IV: Applications of Enzymes-I

Production of Semisynthetic Penicillins and Cephalosporins, Synthesis of Phenolic Polymers and Polyester, Enzymes for the Food Industry

Unit-V: Applications of Enzymes-II

Enzymes for Bioenergy: Bioethnaol from Starch and Lignocellulose, Application to Pulp and Paper Industry. Enzymatic Removal of Pollutants: Aromatic Pollutants, Nitrogen Removal and Carbon Dioxide Conversion

Reference:

1. Fundamentals of Enzyme Engineering by Young Je Yoo, Yan Feng Yong, Hwan Kim · Camila Flor J. Yagonia, Springer; 1st ed. 2017 edition
2. Enzyme Technology by Chaplin and Bucke Cambridge University Pres.
3. Fundamentals of Enzymology: Nicholas Price & Lewis Stevens
4. Enzymes: Biochemistry, Biotechnology, and Clinical Chemistry- Trevor Palmer
5. Enzyme Kinetics by Roberts, Cambridge University Press

Minor Project

Evaluation Scheme:

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|----|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-421 | 6 | 0 | 0 | 12 | - | - | - | 50 | 50 | 100 |

| | |
|---------------------------|---|
| Course Objectives: | <p>The objectives of this course is to enable the students</p> <ul style="list-style-type: none"> • To identify a product relevant to Industry that can be manufactured in India or a research problem and conduct experiment. • To prepare a report for a project based on manufacturing of product/development of technology • To present a lecture on the topic on power point format. • To improve the communication skill of the students. |
|---------------------------|---|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|---|-----------------|
| CO1 | Review, collect and study literature on a topic of interest | Understand |
| CO2 | Apply the knowledge to prepare a report on this topic. | Apply |
| CO3 | Evaluate the collected literature and formulate a project | Apply, Evaluate |
| CO4 | Define a process/method for completion of the same | Apply |
| CO5 | Analyze sustainability of the technology | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | - | 2 | 3 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |
| CO3 | 3 | - | - | - | 2 | 2 | 2 | - | 2 | 3 | 2 | 2 | 2 | 2 |
| CO4 | 3 | - | - | - | - | 1 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 2 |
| CO5 | 2 | - | 1 | 2 | 1 | 2 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 2 |
| Total | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |

1: Slight (Low)

2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Seminar

Evaluation Scheme:

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-423 | 2 | 0 | 0 | 4 | - | - | - | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | <p>The objectives of this course is to enable the students</p> <ul style="list-style-type: none"> • Study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic. • Present a lecture on the topic on power point format. • Improve the communication skill of the students |
|---------------------------|--|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|--|-------------------|
| CO1 | Review, collect and study literature on a topic of interest | Understand |
| CO2 | Apply the knowledge to prepare a report on this topic. | Apply |
| CO3 | Deliver a lecture on the topic on power point format and answer questions from audience, if any | Apply |
| CO4 | While being in the audience listen to the lectures delivered by other participants evaluate the same and comment on the same | Evaluate |
| CO5 | Analyze own shortcomings as well as that of other participants and improve upon the same | Analyze, Evaluate |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | - | 2 | 3 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |
| CO3 | 3 | - | - | - | 2 | 2 | 2 | - | 2 | 3 | 2 | 2 | 2 | 2 |
| CO4 | 3 | - | - | - | - | 1 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 2 |
| CO5 | 2 | - | 1 | 2 | 1 | 2 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 2 |
| Total | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Bioprocess Instrumentation

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-V | NBE-402 | 4 | 3 | 1 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | <ul style="list-style-type: none"> • To become familiar with various methods of bioprocess control and instrumentation. • To understand the basic principles of sensors, transducers and actuators • To learn the techniques of spectroscopy in bioprocess engineering • To design P/PI/PID controllers for controlling the process. |
|---------------------------|--|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|--|-------------------|
| CO1 | Explain the use of control and instrumentation in bioprocess engineering. | Understand |
| CO2 | Identify instruments for the measurement of a process parameter. | Understand |
| CO3 | Understand various types of transducers, their functioning, and criteria for selection | Understand |
| CO4 | Explain the basic principles of chromatography and spectroscopy | Analyze |
| CO5 | Develop the closed-loop control system using P/PI/PID controller. | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | - | - | - | 2 | - | - | 3 | 3 | 3 |
| CO2 | 2 | - | - | - | 2 | - | - | - | 2 | - | - | 3 | 3 | 3 |
| CO3 | 3 | - | - | - | 1 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 2 | 2 | - | 2 | - | - | - | 3 | 2 | - | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | - | 2 | - | - | - | 2 | - | - | 3 | 3 | 3 |

1: Slight (Low)

2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit I

Bioprocess – historical background, stages of bioprocessing, bioreactor – types and design considerations, process modeling – 1st/2nd order and higher order, instrumentation and control, principles of measurements and classification of process control instruments, process flow diagram.

Unit II

Sensors: gas, level, foam, flow rate, temperature and heat, humidity, density, viscosity and consistency, turbidity, pressure, pH, redox potential and dissolved oxygen. Biosensors using amperometric, potentiometric, thermistor FET, fluorimetric, fiber optics and bioluminescence. Microbial biosensors.

Unit III

Transduction principles: Classification of transducers, selection of transducers, Temperature transducers, Pressure transducers, photoelectric transducers, and flow transducers.

Unit IV

Chromatography, spectroscopy (electromagnetic, mass and nuclear magnetic resonance). Spectrophotometry (UV/ VIS/ NIR, fluorescence, circular dichroism), light scattering spectroscopy and atomic absorption spectroscopy. Gas analyzers, ion-specific analyzers, continuous flow analyzers (CFA), flow injection analyzers (FIA), and high-performance liquid chromatography (HPLC). Actuators: compressors, pumps, valves (pneumatic, solenoid), positioners - servo motor.

Unit V

Process flow diagram – types, modeling and analysis. Concept of process control – online and offline monitoring, control system modeling – 1st and 2nd order process, P/PI/PID controller, implementation of control loops, digital controllers, examples.

Textbooks:

1. John Twork, Alexander M. Yacynych, Sensors in Bioprocess Control, CRC Press, Biotechnology and Bioprocessing Series
2. Donald R. Coughanowr, Steven E. LeBlanc, Process Systems Analysis and Control, McGraw Hill
3. Biosensors Theory and Applications, First Edition by Donald G. Buerk. Technomic Publishing. Co, Inc, 1993.
4. Transducers for Biomedical Instruments by S.C. Cobbold, Prentice Hall.

Reference books:

1. RS Khandpur, Handbook of analytical instruments, McGraw Hill
2. William. Bolton, Instrumentation and Control Systems, Newnes
3. Sensor Physics & Technology - Biosensors, First Edition by Tran Minh Canh, Champan & Hall, 1993.

Biochemical Calculations and Plant Design

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-V | NBE-404 | 4 | 3 | 1 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | The objective of this course is to introduce the students to the mathematical aspects of bioprocesses to analyze and evaluate modern plant designs |
|---------------------------|--|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|--|--------------------------|
| CO1 | Prepare different solutions and buffers | Apply |
| CO2 | Establish mathematical methodologies for the computation of material balances and energy balances with and without chemical reaction | Analyze, Evaluate |
| CO3 | Develop a process flow sheet and understand P&I diagrams | Evaluate, Create |
| CO4 | Explain the necessity for safety and safety guidelines. | Apply, Analyze |
| CO5 | Design of process plant equipment and Bioreactor | Evaluate, Create |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | - | 3 | - | - | - | 3 | - | - | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | - | 3 | - | - | - | - | - | - | 3 | 3 | 3 |
| CO4 | 3 | - | - | - | 2 | 2 | 2 | 2 | - | - | - | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | - | 2 | - | - | - | - | - | 2 | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | - | 3 | 2 | 2 | 2 | 3 | - | 2 | 3 | 3 | 3 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

Syllabus

Unit-I

Acid-Base Chemistry: Aqueous solutions, Equilibrium constants, Acids and Bases, Laboratory Buffers, Amino acids and Peptides, Blood Buffers

Unit-II

Material and Energy balance in bioprocesses: Material Balances with and without chemical reaction, Enthalpy calculation for systems with and without Chemical Reaction, Thermochemistry, Calculations of heat of reaction, heat of combustions, heat of formation and heat of neutralization.

Unit-III

General design considerations for a process plant, optimum design, development of process flow sheets, input-output structure (Hierarchy of decisions for Input-Output structure, overall material and energy balances, stream costs, process alternatives), Piping and Instrumentation (P&I) diagrams. Planning and scheduling. Utility supply aspects, Plant layout, Common materials of construction and their mechanical properties.

Unit-IV

Safety aspects of process plant-Good manufacturing practices; Necessity for safety, safety guidelines, common industrial accidents-causes and preventive measures, safety measures, Risk Assessment & HAZOP Study, HAZAN, chemical hazards, fire hazard, fire prevention, flame arrester, explosions. Types of plant maintenance, preventive, predictive, online, scheduled, corrective/breakdown.

Unit-V

Design of bioreactors (Design Approach Only)- stirred tank fermenter, Fermenter parts and design, Design considerations for maintaining sterility of process streams and process equipment. The mechanical design aspect of the pressure vessel (subjected to internal pressure only) using BIS IS 2825:1969 (R2002) Code For Unfired Pressure Vessels.

Textbooks:

1. Biochemical Calculations by Irwin Segel, Wiley India Publications
2. Fundamentals of Biochemical Calculations, 2nd Edition by Krish Moorthy, CRC Press, 2008.
3. Unit Operations–Chemical Process Principles – Part-I - Haugen, Wartson&Ragatz (CBS)
4. Basic Principles and Calculations in Chemical Engineering – Himmelblau (Prentice Hall of India)
5. Green, D.W., Perry, R.H., Perry's Chemical Engineers' Handbook, 8th Ed., McGraw-Hill, 2008.
6. J. M. Coulson, J. F. Richardson, R. K. Sinott, Coulson and Richardson's Chemical Engineering Design, Volume 6, Butterworth-Heinemann, 1999.

Reference Books:

1. Stoichiometry, Bhatt and Vora, Tata McGraw Hill Companies.
2. Chemical Engineering Thermodynamics – J. M. Smith & H. C. Van Ness and M. M. Abbott (Tata McGraw Hill)
3. Chemical & Engineering Thermodynamics – S. I. Sandler (Wiley)
4. Peters, M. S., Timmerhaus, K. D., West, R. E., Plant Design and Economics for Chemical Engineers, 5/e, McGraw-Hill, 2003
5. V.V. Mahajani, S.B.Umarji, Joshi's Process Equipment Design, 4/e, Macmillan Publishers India Ltd., 2009.
6. Rajiv Dutta, Fundamentals of Biochemical Engineering, Springer Berlin Heidelberg, 2008.

Protein Science & Engineering

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|---|-----------------|----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC-V | NBE-406 | 4 | 3 | 1 | 0 | 30 | 20 | 0 | 50 | 50 | 100 |

| | |
|---------------------------|--|
| Course Objectives: | <ul style="list-style-type: none"> To ensure strong knowledge of protein architecture to understand the protein structure and function relationship. To use the knowledge for structure prediction and design of novel proteins. To learn different techniques for protein engineering and their application in the biotechnology Industry. |
|---------------------------|--|

Course outcome: -On successful completion of the course student will be able to –

| | | |
|-----|---|-------------------|
| CO1 | Understand the basic protein structure and various interactions affecting it. | Understand |
| CO2 | Review of factors significant for protein folding processes and stability | Understand |
| CO3 | Utilize the computational methods to understand and predict unknown protein structures and their characteristics | Apply, |
| CO4 | Apply the knowledge and techniques of protein engineering to design and production of new proteins with enhanced stability and enzymatic activity | Create |
| CO5 | Analyse and characterize the new protein with modern analytical techniques like NMR etc. | Evaluate |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | 2 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | - | 3 | 3 | - | - | 2 | - | - | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | - | 3 | 3 | 2 | - | 2 | - | - | 3 | 3 | 3 |
| CO5 | 3 | - | - | - | 2 | - | - | - | 2 | - | - | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | - | 3 | 3 | 2 | - | 2 | - | - | 3 | 3 | 3 |

1:Slight(Low), 2: Moderate (Medium), 3: Substantial (High) If there is no correlation, put “-”

Syllabus

Unit I: Introduction to Protein Structure

Primary structure (peptide bonds, polypeptide chains), secondary structure (helices (α , 3₁₀, Π), β sheets, β turns & loops/coil; Ramachandran plots), tertiary structure (fold, domain & motif; classification – globular (myoglobin) membrane (collagen) & fibrous (bacteriorhodopsin)), quaternary structure (protein assembly; globular arrangement; symmetry considerations- cyclic, dihedral & cubic symmetry; helical quaternary structures). Amino acids and its properties (size, solubility, charge, pKa), Different interactions in protein (ionic, hydrophobic, hydrogen bonding, covalent, van der Waals, coordinate bonds), Protein folding, molten globule structure, characterization of folding pathways. Post-translation modification (involving amino, carboxyl, hydroxyl, thiol, and imidazole groups).

Unit II: Protein Structure Prediction and Design

Strategies for the design of novel proteins-strategies for the design of structure and function: computer methods in protein modeling. Protein sequence comparison, multiple sequence alignment, data bank scanning, pattern matching; sequence-structure comparison. secondary structure prediction, surfaces & volumes, molecular dynamics simulations, and free energy perturbation. Incorporation of Binding Sites into de Novo Proteins, Design of Catalytically Active Proteins.

Unit III: Approaches of Protein Engineering

Introduction and scope of Protein Engineering. Different approaches of protein engineering: Random mutagenesis, Mutagenesis by rational design. Effect of mutation on protein structure, stability, and folding, phi value analysis. In vitro mutagenesis- principles & variations, in vitro chemical mutagenesis, Oligonucleotide based mutagenesis, Cassette Mutagenesis, PCR-based mutagenesis, Types of template, Saturation mutagenesis, Applications of mutagenesis

Unit IV: Strategies for the Production of Novel Proteins

Site and strategies for heterologous expressions: methods for expressing recombinant proteins in yeast, in vitro mutagenesis. Proteolytic processing, Alteration in the chain termini, Genetic considerations in expression, post-translational modifications, Sites of expression. Advantages of using yeast for protein production, Methods for expressing recombinant protein in yeast. Analysis of Yeast Transformants Expressing Heterologous Proteins, Optimization of Protein Production, Recovery, and Processing

Unit V: Analysis and Characterization of Proteins

Protein identification Protein structural and biochemical characterization using NMR (Principles, Types of NMR), FTIR, mass spectrometry, Protein Crystallography- X-Ray Diffraction Pattern, Crystallization of proteins, Phase determination, Electron Density Map Interpretation, Spectroscopic – Circular dichroism, CD spectrum of proteins, Near-UV Circular Dichroism of Proteins, FT-IR spectroscopy, Raman spectroscopy Calorimetric methods- differential scanning calorimetry- reversible & irreversible transitions

Textbooks

1. Cleland and Craik, Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands 1998.
2. Paul R Carey, Protein Engineering and Design, 1996, Elsevier publisher.
3. Permington S R , Dunn M J, "Proteomics from Protein sequence to function", Viva Books Pvt. Ltd., New Delhi, 2002
4. Walsh G, "Proteins Biochemistry and Biotechnology" John Wiley and sons (2003).

Reference books

1. Park S. J. and Cochran J. R., Protein Engineering and Design, 1st Edn., CRC, 2009. Oxford, UK
2. Gregory A. Petsko and Dagmar Ringe—Protein Structure and Function, Second Edition, Oxford University Press USA, 2004
3. Koehrer, Caroline, Raj Bhandary, Uttam L., Protein Engineering, Springer, 2009

Bioresource Technology

Evaluation Scheme

| Course Type | Subject Code | Credits | Periods | | | Seasonal Marks | | | | ESE | Totals Marks |
|-------------|--------------|---------|---------|---|---|----------------|----|-----|-------|-----|--------------|
| | | | L | T | P | MSE | TA | Lab | Total | | |
| OEC-III | OBE-402 | 2 | 2 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

Objective:- To impart the fundamental knowledge on the importance of Bio resources, Bio energy

Course Outcome:- On successful completion of the course student will be able to –

| | | |
|-----|--|---------------------|
| CO1 | Fundamental understanding of the bioresources and its applications for attainment of social objectives (energy, environment, product, sustainability). | Understand |
| CO2 | Acquire knowledge with respect to the properties of the bioresources and the Biochemical conversion technologies | Understand |
| CO3 | Acquire knowledge with respect to the properties of the bioresources and the Thermo-chemical conversion technologies | Understand , |
| CO4 | Acquire knowledge with respect to the properties of the bioresources and the Physico-chemical conversion technologies | Understand |
| CO5 | The student will be capable to understand the potential solutions for valorisation of waste by incorporating the bioresources technologies | Understand |

| COs | POs | | | | | | | | | | | | PSOs | |
|----------------|----------|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | - | - | - | 3 | - | - | - | - | | 3 | 3 | 3 |
| CO2 | 3 | 2 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | - | - | - | 3 | - | - | - | - | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | - | 3 | - | 3 | 3 | 3 | 3 |
| Average | 3 | 2.5 | - | 3 | 3 | 3 | 3 | - | 3 | - | 3 | 3 | 3 | 3 |

Syllabus

UNIT- I Bioresources- natural and anthropogenic;

Importance of bio-resources and their utilization. Natural bio-resources: agricultural, forestry and aquatic biomass. Biomass availability, production and food security, non- edible biomass characteristics. Anthropogenic bio-resources : Organic wastes-domestic and industrial ; characteristics of municipal sewage / sludge and industrial sludges.

UNIT- II Biochemical conversion processes,

Biochemical processes : Microbial anaerobic and aerobic processes, enzymatic processes ; fermentation for alcohols and acids ; penicillin and other therapeutic products. Production of single cell protein (SCP) ; bio-pulping, biogasification.

Unit - III Thermo-chemical conversion processes

Pyrolysis (coke and pyro-oils), oxidation-combustion, gasification (downdraft, updraft and fixed bed gasification, fluidized bed and entrained bed gasification). Various methods of manufacture of activated carbons

Unit – IV Physico-chemical conversion processes:

Chemical and Physicochemical Pretreatment of Lignocellulosic Biomass: Pretreatment, steam/acid/alkali hydrolysis, Green Solvents.

Unit – V Waste valorisation

Production of value added products : Biofuel, biopolymer, organic acid, Bio fertilizer and Biochar. Sustainable development , Recycle and reuse

Text and Reference Books

1. Tripathi, G., "Bioresource Technology", CBS Publications (2002).
2. Pandey, A., "Concise Encyclopaedia of Bioresource Technology", CRC Press (2004).
3. Shuler, M., Kargi, F., "Bioprocess Engineering, Basic Concept", Prentice Hall of India Pvt Ltd. (2004).
4. Chakraverty, A., "Biotechnology and other Alternative Technologies", Oxford and IBH Publishing Co. Pvt. Ltd. (1995).
5. Rao, M.G., Sittig, M., "Dryden's Outlines of Chemical Technology- for the 21st Century. East-West Press (1997).
6. Austin, G.T., "Shreve's Chemical Process Industries", McGraw-Hill Book Company 1984).

Project

Evaluation Scheme:

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|-------------|--------------|---------|---------|---|----|-----------------|-----|------|-------|-----|-------------|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | NBE-408 | 16 | 0 | 0 | 32 | 100 | 100 | - | 200 | 200 | 400 |

| | |
|---------------------------|---|
| Course Objectives: | <p>The objectives of this course is to enable the students</p> <ul style="list-style-type: none"> • To identify a product relevant to Industry that can be manufactured in India or a research problem and conduct experiment. • To prepare a report for a project based on manufacturing of product/development of technology • To present a lecture on the topic on power point format. • To improve the communication skill of the students. |
|---------------------------|---|

Course outcome: - On successful completion of the course, a student will be able to –

| | | |
|-----|---|------------|
| CO1 | Review, collect and study literature on a topic of interest | Understand |
| CO2 | Apply the knowledge to prepare a report on this topic. | Apply |
| CO3 | Evaluate the collected literature and formulate a project | Apply |
| CO4 | Define a process/method for completion of the same | Apply |
| CO5 | Analyze sustainability of the technology | Analyze |

| COs | POs | | | | | | | | | | | | PSOs | |
|--------------|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | - | 2 | 3 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |
| CO3 | 3 | - | - | - | 2 | 2 | 2 | - | 2 | 3 | 2 | 2 | 2 | 2 |
| CO4 | 3 | - | - | - | - | 1 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 2 |
| CO5 | 2 | - | 1 | 2 | 1 | 2 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 2 |
| Total | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*