KUMARAGURU COLLEGE OF TECHNOLOGY

CURRICULUM 2013

M.TECH BIOTECHNOLOGY

SEMESTER I

COURSE CODE	COURSE TITLE	L	T	P	C
	THEORY				
P13BTT101	Physiology and Biochemistry	3	0	0	3
P13BTT102	Applied Microbiology	3	0	0	3
P13BTT103	Bioanalytical Techniques	3	0	0	3
P13BTT104	Fermentation Technology	3	0	0	3
P13BTT105	Enzyme Technology & Applications	3	0	0	3
P13BTT106	Chemical Process Engineering	3	0	0	3
P13BTE----	Elective I	3	0	0	3
	PRACTICAL				
P13BTP101	Industrial Biotechnology Lab	0	0	6	2
Total					**23**

Total Hours: 27

SEMESTER II

COURSE CODE	COURSE TITLE	L	T	P	C
	THEORY				
P13MAT201	Applied Mathematics for Biotechnologists	3	1	0	4
P13BTT201	Bioseparation Technology	3	0	0	3
P13BTT202	Recombinant DNA Technology	3	0	0	3
P13BTT203	Computational Biology	3	0	0	3
P13BTE----	Elective- II	3	0	0	3
	PRACTICAL				
P13BTP201	Recombinant DNA Technology Lab	0	0	6	2
P13BTP202	Computational Biology Lab	0	0	4	2
P13BTP203	Bioseparation Technology Lab	0	0	6	2
Total					**22**

Total Hours: 32

SEMESTER III

COURSE CODE	COURSE TITLE	L	T	P	C
THEORY					
P13BTE---	Elective-III	3	0	0	3
P13BTE---	Elective-IV	3	0	0	3
PRACTICAL					
P13BTP301	Project –Phase I	0	0	12	6
Total					**12**

Total Hours: 18

SEMESTER IV

COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL					
P13BTP401	Project –Phase II	0	0	24	12
Total					**12**

Total Hours: 24

Grand Total (Credits): 69

LIST OF ELECTIVES

COURSE CODE	COURSE TITLE	L	T	P	C
SEMESTER I – ELECTIVE I					
P13BTE101	Metabolic Process and Design	3	0	0	3
P13BTE102	Molecular Therapeutics	3	0	0	3
P13BTE103	Plant and Animal Biotechnology	3	0	0	3
SEMESTER II – ELECTIVE II					
P13BTE201	Environmental Biotechnology	3	0	0	3
P13BTE202	Food Processing and Biotechnology	3	0	0	3
P13BTE203	Immunotechnology	3	0	0	3
P13BTE204	Mass transfer and Chemical Reaction Engineering	2	1	0	3
SEMESTER III – ELECTIVE III					
P13BTE301	Pharmaceutical Biotechnology	3	0	0	3
P13BTE302	Genomics and Proteomics	3	0	0	3
P13BTE303	Bioprocess Plant design and Practice	3	0	0	3
SEMESTER III – ELECTIVE IV					
P13BTE401	Protein Engineering	3	0	0	3
P13BTE402	Biomedical Engineering and Clinical Research	3	0	0	3
P13BTE403	Bioreactor Design	3	0	0	3
P13BTE404	Bioprocess Modeling & Simulation	3	0	0	3

CORE SUBJECTS

SEMESTER I

P13BTT101	PHYSIOLOGY AND BIOCHEMISTRY	3	0	0	3

OBJECTIVE(S):

- To understand basic physiological processes as related to mammalian biochemical homeostasis

UNIT I PHYSIOLOGY OF DIGESTION AND EXCRETION 9 h

Hydrolysis and resorption of food components; Digestive processes: formation of HCl, Zymogen activation, fat digestion; Bile salts- composition and functions, Biotransformation, Cytochrome P450 system. Liver function and diagnostic tests; Formation and acidification of urine, acid-base balance and maintenance, mechanism of action of diuretics, tests of renal function, composition of urine.

UNIT II PHYSIOLOGY OF BLOOD, AND NEURONAL SYSTEM 9 h

Blood composition, plasma proteins, lipoproteins, Buffer systems of plasma, Blood clotting and fibrinolysis; Gas transport, Cerebrospinal fluid; Neurons- types and functions, blood-brain barrier, resting and action potentials; transmission of nerve impulses; neurotransmitters.

UNIT III BIOCHEMISTRY AND FUNCTIONS OF HORMONES 9 h

Organization and regulation of secretions and function of: Anterior and Posterior pituitary, Thyroid, Adrenal cortex and medulla, Parathyroid, Pancreas; sex hormones; Clinical orientation.

UNIT IV BIOENERGETICS AND BIOLOGICAL OXIDATION 9 h

Role of High energy phosphates in Bioenergetics and energy capture; Role and mechanism of action of $NAD^+/NADP^+$, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B_{12} coenzymes and metal ions; Respiratory chain and its role in energy capture. Mechanism of oxidative phosphorylation.

UNIT V REGULATION OF INTERMEDIARY METABOLISM 9 h

Major and unique features of metabolism of the principal organs (liver, brain, muscle, kidney) in various metabolic states- fed and starved states; Coordinated Regulation of glycolysis and glycogenesis; Regulation of gluconeogenesis; Regulation of fatty acid synthesis, and degradation; ketogenesis; Metabolic interrelationships between adipose tissue, the liver, and extrahepatic tissues. Disorders of intermediary metabolism – glycogen storage diseases, diabetes, fatty liver.

Total: 45 h

COURSE OUTCOME(S):

CO1. Understand physiological principles related to mammalian digestive and urinary system
CO2. Learn the physiology of blood and neuronal system
CO3. Understand the role and interactions of hormones
CO4. Learn the concepts of coenzymes, and energy generation in biological systems
CO5. Understand the interrelationship of metabolic pathways in relation to overall physiological states

TEXTBOOK(S):

1. Thomas M. Devlin (2006), Text-book of Biochemistry with Clinical correlations, 2nd Ed, J. Wiley and Sons.
2. Nelson, D. L. and Cox, M. M., (2008) Lehninger's Principles of Biochemistry, 5th Ed, Worth Publishers.
3. Murray, R. K., Granner, D. K., Mayes, P. A., Rodwell (2006) ,Harper's Illustrated Biochemistry by, V. W., 26th Ed, The McGraw-Hill Companies, Inc.

REFERENCE(S):

1. Eric P. Widmaier, Hershel Raff, Kevin T. Strang (2001) Vander's Human Physiology: The Mechanisms of Body Function, Eighth edition, The McGraw−Hill Companies.
2. Guyton (2005) Textbook of Medical Physiology, 11th Ed, A. C., H. Sanders Philadelphia.

P13BTT102	APPLIED MICROBIOLOGY	3	0	0	3

OBJECTIVE(S)

- To understand and comprehend the role of microbes in the field of environment, medicine, industry and agriculture.

UNIT I FUNDAMENTALS OF MICROBIOLOGY 9 h

The microbial world, Evolution and Diversity, Taxonomic ranks and Classification, Functional anatomy of Prokaryotic and Eukaryotic cells, Microbial Growth, Metabolism, Control of microbes- physical and chemicals methods.

UNIT II ENVIRONMENTAL MICROBIOLOGY 9 h

Interaction between microorganisms; microorganisms- plants, microorganism- animals Degradation of xenobiotic compounds, Bioremediation, Microbial plastics, Microbial leaching, Biofilms. Microbes in Bio-hydrogen production.

UNIT III MEDICAL MICROBIOLOGY 9 h

Contamination and diseases, Microbial diseases of skin and eyes, Microbial diseases of digestive system, Microbial diseases of cardiovascular system, Microbial diseases of respiratory system, Microbial diseases of nervous system.

UNIT IV SOIL AND AGRICULTURAL MICROBIOLOGY 9 h

Soil Habitat; Biogeochemical cycle (Nitrogen, Sulfur and Phosphorous), Nitrogen fixation (symbiotic and nonsymbiotic), Microbial interaction- Rhizosphere, Phyllosphere, Spermosphere; Endophytes, Biofertilizers, Biopesticides, Microbial Composting.

UNIT V INDUSTRIAL MICROBIOLOGY 9 h

Microbial fermentation- production of organic acids (citric acid, lactic acid), Production of alcohol, production of bread, cheese and pickles. Lactic acid bacteria, Probiotics and Prebiotics and applications.

TOTAL: 45 h

COURSE OUTCOME(S):

CO1. Students understand the role of microorganism in various fields allied to biotechnology
CO2. Acquire the knowledge to apply various microbes in environment, and agriculture.
CO3. Acquire the knowledge to food and allied industries, fermentation processes
CO4. Students acquire knowledge on microbial applications of various systems

TEXT BOOK(S):

1. Atlas, R.M., Bartha, R. (1997) *Microbial Ecology: Fundamentals and applications*, 4th Ed., Benjamin Cummings.
2. Tortora, G. J., Funke, B. R., Case, C. L., (2003) *Microbiology an Introduction*, 8th Ed., Benjamin Cummings.
3. Pommerville, J.C., *Alcamo's Fundamentals of Microbiology*,9th ed., Jones and Bartlett Publishers.
4. Pelcza, M. A., (1993) *Microbiology*, 5th ed., Tata McGraw Hill, New Delhi.

REFERENCE(S):

1. Talaro, K. P. (2011) *Foundations in Microbiology*. 8thEd. NY: McGraw Hill.
2. Frazier W.C. Westhoff D.C. (1998) *Food Microbiology*, 4th Ed NY: McGraw Hill Book Co. NY.
3. Adams, M.R., Moss. M.O. (2004) *Food Microbiology*, 2nd Ed, C.B.S. Publishers.

P13BTT103	BIOANALYTICAL TECHNIQUES	3	0	0	3

OBJECTIVE(S):

- Students will understand the working, instrumentation and application of analytical techniques as applied to biotechnology

UNIT I GENERAL TECHNIQUES 9 h

Computers for data collection, analysis; scientific statistical packages- SPSS, Electrodes for pH and O_2 measurement. Biosensors- types, working principle and applications, Microscopy – Light, Phase contrast, fluorescence, TEM, SEM, atomic force, scanning tunneling. Centrifugation- differential, density gradient and Ultracentrifugation –basic principle and applications

UNIT II CHROMATOGRAPHIC AND ELECTROPHORETIC TECHNIQUES 9 h

Theoretical concepts: Rate and Plate theory, Column resolution, Gel filtration, Ion exchange, affinity chromatography- theory, applications. Determination of molecular weight using gel filtration chromatography. GC and HPLC- Theory, instrumentation and Applications. Electrophoresis- theory, native SDS PAGE, 2D PAGE and applications

UNIT III SPECTROSCOPIC TECHNIQUES 9 h

Theory, instrumentation and biological applications of UV-Vis, IR, CD/ORD, Fluorescence, NMR, ESR, Mossabaeur, ICP emission and Mass Spectroscopes

UNIT IV CELL AND MOLECULAR BIOLOGICAL TECHNIQUES 9 h

Growth, maintenance and equipment for bacterial, animal and plant cell cultures. Maintenance of obligate anaerobic cultures using anaerobic glove box. PCR, blotting techniques- Southern, Northern and Western blotting. RFLP analysis, Shot-gun sequencing, Microarray- theory, equipment and applications

UNIT V IMMUNOTECHNIQUES AND RADIOTECHNIQUES 9 h

Immunodiagnostics- ELISA, sandwich ELISA; Immuno enzyme assays (IEA), Immunofluorescence (IFA) - theory, equipment and applications. Radioisotopes- basics and applications in biology. Autoradiography, Geiger-Muller counter, Scintillation counting, Radiotracers, Radioimmunoassay (RIA)

TOTAL: 45 h

COURSE OUTCOME(S):

CO1. Explain and distinguish microscopy, centrifugation and biosensor techniques
CO2. Compare and contrast the various types of chromatographic and electrophoretic techniques
CO3. Recall and summarize the different spectroscopic techniques
CO4. Demonstrate the cell culture, blotting and microarray techniques
CO5. Describe the techniques like ELISA, autoradiography and radiotracers

REFERENCE(S):

1. Keith Wilson and John Walker Ed., Principles and Techniques of Biochemistry and Molecular Biology, Ed., 5th Edition, Cambridge University Press, 2000
2. M.L. Srivatsava, Ed., Bioanalytical Techniques, Alpha Science International Ltd, 2007.
3. Irwin. H. Segal, Ed .,Biochemical Calculations,., 2nd Edition, Cambridge University Press, 2005
4. Douglas A. Skoog, Brooks Cole Principles of Instrumental Analysis, 6 edition 2006
5. Hobarth Willard, Lynne Merritt, John Dean, Frank Settle., Instrumental methods of Analysis; 7 Sub edition, Wadsworth Publishing Company; 1988

P13BTT104	FERMENTATION TECHNOLOGY	3	0	0	3

OBJECTIVE(S):

- To make the students to understand the products of fermentation process and principles of fermentation technology

UNIT I SCOPE OF INDUSTRIAL BIOTECHNOLOGY 9 h

Introduction: Nature and Characteristics of Industrial Biotechnology, Patents and Intellectual Property Rights in Industrial Biotechnology, Fermentation, Organizational Set-up in Biotechnology Establishment; Media: Basic Nutrient Requirements of Industrial Media, Criteria for the Choice of Raw Materials Used in Industrial Media, Raw Materials Used in Compounding Industrial Media, Potential Sources of Components of Industrial Media, Use of

Plant Waste Materials in Industrial Media, Optimization of Media Components by experimental design

UNIT II FERMENTERS AND FERMENTER OPERATION 9 h

Definition of a Fermenter, Aerated Stirred Tank Batch Fermenter, Anaerobic Batch Fermenter, Fermenter Configurations, Fed-batch Cultivation, Design of Fermenter, Microbial Experimentation in the Fermentation Industry - The Place of the Pilot Plant, Inoculum Preparation, Surface or Solid State Fermenter, Sterility**:** Basis of Loss by Contaminants, Methods of Achieving Sterility, Aspects of Sterilization in Industry

UNIT III FERMENTATION PRODUCTS 9 h

Production of fermented products like beer, wine, spirit, vinegar, bread, yoghurt, sauerkraut, citric acid, ethanol, amino acids, enzymes etc.,

UNIT IV KINETICS IN CELL CULTURES 9 h

Kinetics of Balanced Growth, Transient Growth Kinetics, Structured Kinetic Models, Product Formation Models, Segregated Kinetic Models, Thermal Death Kinetics of cells

UNIT V ANALYSIS OF BIOREACTORS 9 h

Reactors with recycle, Reactor Dynamics, Reactors with Non-ideal mixing, Multiphase Bioreactors, Bioreactors for Plant and Animal Cell Culture

TOTAL 45 h

COURSE OUTCOME(S):

CO1. Explain the various products of fermentation process and principles of fermentation technology
CO2. Demonstrate the various fermentation configurations
CO3. Develop the structural and unstructural models for cell growth and product formation

TEXT BOOK(S):

1. Nduka Okafor (2007). *Modern Industrial Microbiology and Biotechnology*, Latest Edition, Enfield.,U.S: Science Publishers.
2. James Edwin Bailey and David F. Ollis *Biochemical Engineering Fundamentals*, Second Edition, New Delhi: McGraw Hill, Inc.

REFERENCE(S):

1. Doran, P. M. (2012) *Bioprocess Engineering Principles*, Latest Edition, United Kingdom: Academic Press
2. Stanbury, Peter F., Hall, Stephen J. & Whitaker A.,(1995) *Principles of Fermentation Technology*, Second Edition, USA: Butterworth-Heinemann Publisher.
3. Lee. & James M. (1992) *Biochemical Engineering*, Latest Edition New Delhi: Prentice Hall of India.
4. Shuler, M. L., & Kargi, F. (1992) Bioprocess *Engineering: Basic Concepts*, Latest Edition, New Delhi: Prentice Hall of India.

5. Blanch H.W. and Clark, D.S. (1992) *Biochemical Engineering*, Latest Edition, United Kingdom: CRC Press.

P13BTT105	ENZYME TECHNOLOGY AND APPLICATIONS	3	0	0	3

OBJECTIVE(S):

- To make the students to understand the mechanism of enzyme kinetics and mass transfer of immobilized enzymes
- To provide a broad knowledge about the significance recombinant enzymes in various industrial sectors

UNIT I ENZYME KINETICS 9 h

Classification of enzymes; Enzyme assay – developing assay and analysis of progressive curves; Enzyme units – definition; Estimation of Michaelis-Menten parameters - Lineweaver-Burk plot, Eadie – Hofstee plot, Hanes plot and Eisenthal & Cornish-Bowden plot; Parameters affecting enzyme activity – pH, temperature, ionic strength and special components; Modeling of rate equations for single and multiple substrate reactions; Interfacial enzymes – introduction and catalysis.

UNIT II INHIBITORY AND IMMOBILIZED ENZYME KINETICS 9 h

Enzyme inhibition kinetics – competitive, non-competitive and mixed; Dose response curves on enzyme equilibrium; Mechanism based inhibition – introduction and suicide inhibition; Techniques of enzyme immobilization-matrix entrapment, ionic and cross linking; Effect of external mass transfer resistance; Analysis of intraparticle diffusion and reaction; Simultaneous film and intraparticle mass transfer resistance; Effects of electrostatic potential of the microenvironment; Bioconversion studies with immobilized enzyme packed -bed reactors.

UNIT III ENZYME APPLICATIONS 9 h

Commercial applications of enzymes in food, pharmaceutical and other industries; enzymes for diagnostic and therapeutic applications; Use of enzymes in analytical applications; Abzymes.

Case studies on applications - Lipase and pectinase.

UNIT IV BIOSENSORS 9 h

Biosensors – general design, types and characteristic features; Microbial biosensor; Avidin-Biotin mediated biosensor; Polymer membrane based potentiometric polyion sensor; Surface Plasmon resonance biosensor – design and applications.

UNIT V RECOMBINANT ENZYMES 9 h

Recombinant enzymes – introduction & current market status; List of enzymes from recombinant microorganisms; Production characteristic features of different host systems;

Host systems for the production of recombinant enzymes – *E. coli*, *Bacillus sp.*, Yeast, Plants and mammals.

TOTAL: 45 h

COURSE OUTCOME(S):

CO1. Ability to understand the mechanism of enzyme kinetics, inhibition and mass transfer effects of immobilized enzymes
CO2. Capacity to decode the principles of biosensor fabrication and its applications
CO3. Achieved competence in the area of recombinant enzymes

REFERENCE(S):

1. Bailey J.E. and Ollis, D.F. (2010) *Biochemical Engineering Fundamentals*, 2nd Ed., Tata McGraw Hill, India.
2. Trevor Palmer. (2007). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*, Second Edition, Horwood Publishing Limited.
3. Donald L.Wise (Ed.), (2009). *Bioinstrumentation and Biosensors*, Marcel Deckker Inc. USA, Special Indian Edition.
4. Victor C. Yang and That T. Ngo (Eds). (2007). *Biosensors and their applications*, Springer International Edition.
5. Nicholas Price and Lewis Stevens. (2009). *Fundamentals of Enzymology*, 3rd Edition, Oxford University Press, India.
6. Robert A. Copeland (2000). *Enzymes*, 2nd Edition, Wiley-VCH.
7. Blanch, H.W., Clark, D.S. (2007). *Biochemical Engineering*, Marcel Dekker, 1st Indian reprint.
8. Shanmugam.S, Sathishkumar.T and Shanmugaprakash M. (2012). *Enzyme Technology*, Second Edition, IK International Publishers, India
9. Demain A.L and Vaishnav P. (2009). Production of recombinant proteins by microbes and higher organisms. *Biotechnology Advances*, 27: 297–306.

P13BTT106	CHEMICAL PROCESS ENGINEERING	3	0	0	3

OBJECTIVE(S)

- To make the students to understand the concepts of chemical engineering applied in bioprocess industries

UNIT I MATERIAL AND ENERGY BALANCES 12 h

Introduction to flow sheeting, Problems involving material and energy balance with and without chemical reactions, Recycle, Bypass and Purge, Unsteady state material and energy balances, Stoichiometry of growth and product formation, Oxygen consumption and heat evolution in microbial cultures

UNIT II MOMENTUM TRANSFER 12 h

Fluids in motion, Momentum transfer, Non-Newtonian fluids, Viscosity measurement, Rheology of fermentation broth, Factors affecting viscosity of fermentation broth

UNIT III HEAT TRANSFER **12 h**

Modes of heat transfer - Conduction, Convection and Radiation; Heat transfer equipments – Heat exchangers, condensers, reboilers and evaporators; Heat transfer configurations for bioreactors, Design equations for heat transfer systems and their applications

UNIT IV MASS TRANSFER **12 h**

Diffusivity and mass transfer coefficient, Theories and analogies of mass transfer, Mass transfer in bioreactors - Oxygen uptake in cell cultures, Oxygen transfer in fermenter and large vessels, Estimation of oxygen solubility, Overview of methods of measurement of k_La

UNIT V MECHANICAL OPERATIONS **12 h**

Filtration, Centrifugation, Agitation and Mixing – Mechanism, Principles and Equipments.

TOTAL: 60 h

COURSE OUTCOME(S):

CO1. Understand the Stoichiometry principles.
CO2. Enumerate momentum transfer and factors involved in fermentation.
CO3. Describe the modes of heat transfer and their equipments.
CO4. Explain the principles of mass transfer in bioreactors.
CO5. Describe the principles of mechanical operations and their equipments.

TEXT BOOK(S):

1. Doran, P. M. (2012) *Bioprocess Engineering Principles*, Latest Edition, United Kingdom: Academic Press.

REFERENCE BOOK(S):

1. Hougen O A., Watson K M and Ragatz R A, (2004) *Chemical process principles* - Part I, New Delhi: CBS publishers.
2. Noel de Nevers., (2005).*Fluid Mechanics for Chemical Engineers*, Latest Edition, New Delhi: McGraw Hill, Inc.
3. Badger W.L. and Banchero J.T., (1955) *Introduction to Chemical Engineering*, New Delhi: McGraw Hill, Inc.
4. Holman, J. P., (2005) *Heat Transfer*, Latest Edition, New Delhi: McGraw Hill, Inc.
5. Treybal, R.E., (1980) *Mass Transfer Operations*, Latest Edition, New Delhi: McGraw Hill, Inc.

P13BTP101	INDUSTRIAL BIOTECHNOLOGY LAB	0	0	6	2

OBJECTIVE(S):

- Provide hands-on training on mode of operation of fermenters
- To familiarize microbial growth kinetics and mass transfer in fermenters
- To know the production of microbial and plant metabolites

LIST OF EXPERIMENTS:

1. Enzyme kinetics – Michaelis-Menten plot & LB plot / Inhibition
2. Enzyme and whole cell immobilization – Gel entrapment / Adsorption
3. Batch / Fed-batch / Continuous cultivation – Specific growth rate and Yp/s
4. Residence Time Distribution (RTD)
5. K_La determination by sodium sulfite method / power correlation method
6. Medium optimization – Plackett-Burman design / RSM
7. Degradation of xenobiotics with immobilized enzymes - Metabolite analysis by HPLC
8. Production of any one of the following, per group: Ethanol / xylanase / biopesticide / mushroom / lactic acid
9. Production of primary / secondary plant metabolites in suspension cultures
10. Case study involving selection of suitable microbe(s), inexpensive nutrients for fermentation process, fermenters and techno-economic studies of bio-products.

COURSE OUTCOME(S):

The students will able to:

CO1. Understand the operation of batch, fed-batch and continuous fermenters
CO2. Describe mass transfer in bioreactors
CO3. Learn the production of various commercial microbial products

REFERENCE(S):

1. Ninfa. A.J, and D.P. Ballou (1998) Fundamental laboratory approaches for biochemistry and biotechnology, 2st Edition, Oxford University press, UK.
2. Sadasivam.S and Manickam, A (2008), 3rd Ed, New Age International Publishers, India

SEMESTER II

P13MAT201	APPLIED MATHEMATICS FOR BIOTECHNOLOGISTS	3	1	0	4

OBJECTIVE(S):

- to frame differential equation and to solve it.
- to gain knowledge in Laplace transforms and its properties.
- to know about fitting of curves and statistical measures.
- to be able to test hypothesis using various tests for large and small samples.
- to analyze experiments based on one-way, two – way and Latin square classifications.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9 h

Formation of differential equations – Simple problems - Linear equations of second order with constant coefficients – Euler's and Legendre's linear equations – Simultaneous first order linear equations with constant coefficients.

UNIT II LAPLACE TRANSFORM 9 h

Laplace Transform – Sufficient conditions – Transforms of elementary functions – Basic properties - Transforms of derivatives and integrals – Transform of periodic functions – Inverse transforms - Convolution theorem.

UNIT III CURVE FITTING AND BASIC STATISTICS 9 h

Principle of least squares: Fitting of straight line, parabola, exponential curve and power curve. Measures of central tendency: mean, median and mode – Measures of dispersion: Range, mean deviation and standard deviation – correlation and regression

UNIT IV TESTING OF HYPOTHESIS 9 h

Testing of hypothesis for large samples (single mean, difference of means, single proportion, difference of proportion) – Small samples – t – test (single mean, difference of means, paired t- test) – F – test (variance ratio test) – Chi-square test – Tests for independence of attributes and Goodness of fit.

UNIT V DESIGN OF EXPERIMENTS 9 h

Principles of experimental design – Completely randomized design– Randomized block design –Latin square design.

L+ T: 45+15 = 60 h

COURSE OUTCOME(S):

After pursuing the above mentioned course, the students will be able to:
CO1 – form and solve the ordinary differential equations of certain types.
CO2 – acquire the knowledge in Laplace transforms and its properties.
CO3 – discover the equations of curve fit and compute various statistical measures.
CO4 – analyze sample data and interpret the same for population.
CO5 – analyze the experimental design based on one-way, two-way and Latin squares.

REFERENCE(S):

1. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, Delhi, 38th Edition, 2004.
2. Kreyszig E., "Advanced Engineering Mathematics", John Wiley and Sons (Asia) Ltd., Singapore, 8th Edition, 2001.
3. Gupta. S. P., "Statistical Methods", Sultan Chand & Sons Publishers, 2004.
4. Johnson. R. A., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Delhi, 6th Edition, 2000.
5. Gupta S.C, and Kapur J.N., "Fundamentals of Mathematical Statistics", Sultan Chand, New Delhi, 9th Edition, 1996.

P13BTT201	BIOSEPARATION TECHNOLOGY	3	0	0	3

OBJECTIVE(S):

- To develop an understanding of concepts in efficient separation of biomolecules (proteins, peptides, oligosaccharides, DNA, etc) and particularly with relevance to pharmaceuticals

UNIT I INTRODUCTION TO BIOSEPARATION 7h

Fundamentals and concepts in bioseperation technology. Characterization and analysis of fermentation broth, Physical methods of structure determination of biomolecules, Guidelines to recombinant protein purification.

UNIT II PRIMARY SEPARATIONS AND CELL DISRUPTION 6h

Cell disruption – Homogeniser, dynomill – principle, factors affecting disruption, batch and continuous operation. Cell disruption by chemical methods. Separation techniques: filtration, microfiltration and centrifugation.

UNIT III ISOLATION OF PRODUCTS 10h

Extraction – theory and practice: Aqueous two phase extraction, supercritical fluid extraction. Precipitation techniques: salts, solvents, polymers (PEG). Membrane based separation – Microfiltration, Ultrafiltration, reverse osmosis, dialysis.

UNIT IV CHROMATOGRAPHY 12h

Theory, practice and selection of media for – gel-filtration chromatography, Ion exchange chromatography, Hydrophobic interaction chromatography, reverse phase chromatography, Affinity chromatography – Metal affinity chromatography, dye affinity chromatography, immunosorbent affinity chromatography & Expanded bed chromatography. Scale-up criteria for chromatography, calculation of no. of theoretical plates and design. Electrophoresis separation

UNIT V FINAL POLISHING AND CASE STUDIES 10h

Freeze drying, lyophilization, spray drying and crystallization. Case studies on purification of: cephalosporin, aspartic acid, Recombinant Streptokinase, Monoclonal antibodies, Tissue plasminogen activator, Taq polymerase, Insulin. Case studies of product recovery economics.

TOTAL: 45 h

COURSE OUTCOME(S):

CO1. Students get skills to understand the various principles involved in protein purification
CO2. Understand the characterization of various biomolecues
CO3. Understand the principles involved in various chromatography techniques

REFERENCE(S):

1. Belter, P. A, Cussler, E. L, and Hu, W. (1987). *Bioseparations: downstream processing for biotechnology*.
2. Janson, Jan-Christer, ed. (2011) *Protein purification: principles, high resolution methods, and applications*. Wiley.
3. Scopes R.K.(1994) *Protein Purification – Principles and Practice*, Narosa publishers.
4. Jenkins, R. O (Ed.) (1992) *Product Recovery in Bioprocess Technology - Biotechnology by Open Learning Series*, Butterworth-Heinemann.
5. Bailey, J. E. and Ollis, D. F. (1986)"*Biochemical engineering fundamentals*" second edition, McGraw-Hill, New Delhi.
6. Harrison R.G.; Todd P.; Rudge S.R. and Petrides D.P. (2003). Bioseparations Science and Engineering, Oxford Press.
7. Ladhish, M.R. (2001). Bioseparation engineering, Principles, practice and economics, Wiley Interscience.

P13BTT202	RECOMBINANT DNA TECHNOLOGY	3	0	0	3

OBJECTIVE(S):

- To impart knowledge on advanced cloning vectors and hosts for heterologous gene expression
- To develop theoretical skills related to rDNA techniques
- To create awareness on latest developments related to GMO in India

UNIT I CLONING VECTORS AND HETEROLOGOUS HOSTS 9 h

Expression vectors for bacterial expression; pET system- plant transformation vectors; Binary vector, animal transformation vectors-SV40 based- Heterologous expression hosts; Bacteria- *E.coli -Bacillus subtitles, -Saccahromyces cereviceae- Pitchia pastoris*-tobacco- Arabidopsis- animal cell lines- mouse.

UNIT II GENE ISOLATION METHODS 9 h

Construction of gene library; gene and cDNA library, screening of library; dig-dUTP probe, PCR based isolation of gene; designing primers from database sequences -TA cloning, transposable elements based gene isolation-positional cloning.

UNIT III EXPRESSION OF RECOMBINANT PROTEINS 9 h

Essentials of foreign gene expression; Transient and permanent foreign gene expression; problems related to heterologous gene expression; regulated expression of foreign gene - $_{p}$lac by IPTG- $_{p}$trp by tryptophan, purification of recombinant protein using affinity chromatography; His tag-Ni^{+} column based.

UNIT IV ADVANCED TECHNIQUES IN rDNA TECHNOLOGY 9 h

Advanced nucleic acid sequencing methods; 454 pyrosequenicng- DNA chip based sequencing-nanopore DNA sequencing, screening of libraries using phage display; promoter deletion analysis and elucidation of cis acting elements, gene manipulation by multi- site directed mutagenesis and selection, real time PCR and quantization of gene expression using reporter gene assay- GUS assay, allele specific PCR to detect SNP.

UNIT V APPLICATIONS OF rDNA TECHNOLOGY 9 h

Recombinant DNA products and their safety: recombinant vaccines, therapeutic hormones, recombinant therapeutic proteins, molecular diagnosis, metabolic engineering of pathways; ABC model for flower development- fatty acid pathway manipulation for oil quality,

Case study: BT cotton and BT brinjal release in India.

TOTAL: 45 h

COURSE OUTCOME(S):

The students will be able to

CO1. Demonstrate the steps in cloning and expression of a foreign gene
CO2. Explain and device various gene isolation methods from the selected organisms.
CO3. Describe expression and purification steps involved in recombinant protein products.
CO4. Understand issues related to release of GMO for commercial cultivation.

TEXT BOOK(S):

1. B. R. Glick and J.J. Pasternak (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA, Washington, ASM Press.
2. S.B Primrose and R.Twyman (2006) Principles of Gene manipulation and Genomics, 7^{th} edition, John Wiley and Sons.

P13BTT203	COMPUTATIONAL BIOLOGY	3	0	0	3

OBJECTIVE(S):

- To have a thorough understanding of theoretical principles and to acquire skill set in the area of biodatabases, hieuristics algorithms, molecular phylogenetics and Perl language

UNIT I INTRODUCTION TO COMPUTATIONAL BIOLOGY 9 h

Introduction to computational biology and bioinformatics; Applications of bioinformatics; Computer and its components; Hardware basics- Processor, motherboard slots/cards, bus parallel and serial ports and various storage devices; Network – Protocols (OSI, TCP/IP and ftp models), media and topology (Tree, star, bus, ring and hybrid).

UNIT II DATABASES & SEARCHING ALGORITHMS 9 h

Biological databases – Introduction, classification and functions; Dotmatrix analysis; Dynamic programming - Needleman - Wunsch algorithm and Smith–Waterman algorithm; Parametric alignment; Gaps – introduction, types and significance; Scoring matrices – PAM and BLOSUM; Heuristic methods of database searching- FASTA and BLAST family of programs.

Case study – EMBOSS suite, FASTA and BLAST for the analysis of proteins and DNA sequences

UNIT III MOLECULAR PHYLOGENY 9 h

Multiple sequence alignment –CLUSTAL W and Iterative methods; SAGA; Phylogenetic analysis – Molecular clock theory, Jukes – Cantor and Kimura's model; Distance methods – UPGMA, Fitch-Margoliasch and Neighbourhood joining; Character based methods – Maximum parsimony and Maximum Likelihood; Bootstrapping technique.

Case study – Multiple sequence and phylogeny analysis of protein and DNA sequences

UNIT IV MACHINE LEARNING TECHNIQUES 9 h

Comparative genomics; Homology modeling; Hidden Markov models; Artificial neural nets and their application in computational biology; Eukaryotic and prokaryotic gene finding; shotgun DNA assembly; Protein secondary structure prediction.

UNIT V INTRODUCTION TO PERL AND APPLICATIONS IN BIOINFORMATICS 9 h

Basic UNIX commands; Unix directory structure; Introduction to Perl Variables; Data types, arrays and hashes; File handling; flow control, regular expression usage; simple programs for DNA and protein sequence manipulation, microrrays-data analysis; Introduction to systems biology.

TOTAL : 45 h

COURSE OUTCOME(S):

CO1. Acquired an ability to interpret the mechanism of various heuristics algorithm based tools

CO2. Attained knowledge in the area of molecular phylogeny and its apt applications in biotechnology

REFERENCE(S):

1. Gusfield, Dan. (2005). *Algorithms on strings Trees and Sequences,* 1st ed., Cambridge University Press.

2. Baldi, P., Brunak, S. (2001). *Bioinformatics: The Machine Learning Approach,* 2nd ed., MIT Press.

3. Mount D.W. (2001). *Bioinformatics: Sequence and Genome Analysis,* Cold Spring Harbor Laboratory Press.

4. Baxevanis A.D. and Oullette, B.F.F. (2002). *A Practical Guide to the Analysis of Genes and Proteins,* 2nd ed., John Wiley.

5. Tisdall, James, (1998). *Beginning PERL for Bioinformatics,* Cambridge University Press.

6. Bryan Bergeron, (2006). *Bioinformatics Computing*, Prentice Hall of India Pvt.Ltd. New Delhi.

P13BTP201	**RECOMBINANT DNA TECHNOLOGY LAB**	**0**	**0**	**6**	**2**

OBJECTIVE(S):

- To develop practical skills related to gene cloning.
- To impart practical knowledge on use of advanced rDNA techniques.

LIST OF EXPERIMENTS:

1. Cutting and cleaning up of DNA for ligation
2. Transformation and selection of recombinants using GFP selectable marker
3. Evaluation of transformants containing recombinant plasmid DNA
4. Optimization of concentration of IPTG for gene expression under $_{p}$lac
5. Yeast transformation by electroporation
6. Isolation of phage DNA and phage stock preparation
7. Bacterial strain identification by 16S rDNA sequencing
8. DNA fingerprinting by RAPD analysis
9. Recombinant protein purification using His-tag –Ni^{+}column
10. Detection of gene using Southern blotting and hybridization

COURSE OUTCOME(S):

The students will be able to

CO1. Carryout and interpret the steps involved in gene cloning and expression.

CO2. Isolate and Characterize bacterial strain using 16S rDNA analysis.

CO3. Overexpress recombinant protein in E.coli and purify recombinant protein using Ni^{+} chromatography

REFERENCE(S):

1. Sambrook et al., (2001) Molecular Cloning: A laboratory Manual 3rd ed. Cold Spring Harbour Laboratory Press, Cold Spring Harbour, NY

P13BTP202	COMPUTATIONAL BIOLOGY LAB	0	0	4	2

OBJECTIVE(S):

- To offer hands on training in the area of sequence retrieval, database searching, gene prediction, bio-programming and molecular modeling

LIST OF EXPERIMENTS:

1. Knowledge of different biological database and retrieval of sequences
2. Heuristic methods (BLAST,BLAT, FASTA) of searching for homologous sequences
3. Pair-wise and Multiple sequence alignment
4. Phylogenetic tree building using Phylip
5. Gene prediction methods
6. Unix/Linux – basic operations and working with terminal
7. Perl programming - Simple programs using Operators, Control Structures, Subroutines, Hash, Creating a static HTML file by a Perl Program
8. Python programs – syntax and control structures
9. Epitope prediction
10. Homology Modeling using SPDBV
11. Analysis of 3D structures of proteins
12. Molecule Visualization Using Rasmol –Commands, Domain identification
13. Small molecule building, using ISIS Draw and CHEM SKETCH

TOTAL : 45 h

COURSE OUTCOME(S):

The students will be able to

CO1. Demonstrate sequence analysis, database searching and alignments

CO2. Carry out gene prediction; analyze protein structures and homology modeling of proteins

CO3. Write programs in Perl and python

REFERENCE(S):

1 Applied bioinformatics- Selzer, Marhofer, Rohwer, Springer Edition.

P13BTP203	BIOSEPARATION TECHNOLOGY LAB	0	0	6	2

OBJECTIVE(S):

To develop skills in students to perform various purification techniques for the separation of biomolecules.

LIST OF EXPERIMENTS:

1. Harvesting of yeast cells after cultivation by microfiltration
2. Cell disruption technique by homogenization
3. Cell disruption technique by ultrasonication
4. Partial purification of enzyme(s) by ammonium sulphate fractionation
5. Concentration of enzyme(s)/protein(s) by ultrafiltration
6. Aqueous two phase extraction of biological samples
7. Gel filtration chromatography of protein
8. Ion exchange chromatography of protein
9. Affinity chromatography of protein
10. Assessing purity of enzyme(s)/protein(s) by SDS-PAGE
11. Assessing purity by 2-D Gel electrophoresis
12. Determination of caffeine in soft drinks by High Performance Liquid Chromatography.
13. Preservation of bacteria/yeasts cells by lyophilization

COURSE OUTCOME(S):

CO1. Students get skills to harvest the biomolecules/cells using various solid-liquid separations
CO2. Learn to purify the biomolecules using various chromatography principles
CO3. Learn to purify and quantify the biomolecules using HPLC

REFERENCE(S):

1. Roger G. Harrison, Paul W. Todd, Scott R. Rudge and Demetri Petrides (2002) *Bioseparations Science and Engineering*, Oxford University Press.

2. Robert K.Scopes, (2010) *Protein Purification: Principles and Practice*, third edition, Springer-verlag New York, inc

3. Rosenberg (Ian M) (2003) *Protein Analysis and Purification, Bench top techniques*, second edition, Springer International.

4. Kawamura, S., Murakami, Y., Miyamoto, Y., and Kimura, K. (1995). *Freeze-drying of yeasts*. Methods Mol. Biol, 38, 31-37.
5. Hatti-Kaul, Rajni. *Aqueous two-phase systems: methods and protocols*. Vol. 11. Springer, 2000.

SEMESTER III

Elective III
Elective IV
P13BTP301 Project – Phase I

SEMESTER IV

P13BTP401 Project – Phase II

ELECTIVES

P13BTE101	METABOLIC PROCESS AND DESIGN	3	0	0	3

OBJECTIVE(S):

- To understand the analysis of metabolic networks and metabolic fluxes in cells

UNIT I REVIEW OF CELLULAR METABOLISM 9 h

An Overview of Cellular Metabolism, Transport processes, Fuelling reactions: glycolysis, Fermentative pathways, Biosynthetic reactions, polymerization, cellular energetics

UNIT II MATERIAL BALANCES AND DATA CONSISTENCY 9 h

Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, yield coefficients and linear rate equations, analysis of over determined systems- identification of gross measurement errors

UNIT III METABOLIC FLUX ANALYSIS 9 h

Theory, overdetermined systems, underdetermined systems- linear programming, sensitivity analysis, methods for the experimental determination of metabolic fluxes by isotope labeling, applications of metabolic flux analysis.

UNIT IV METABOLIC CONTROL ANALYSIS 9 h

Fundamentals of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients, MCA of linear pathways, branched pathways, theory of large deviations

UNIT V ANALYSIS OF METABOLIC NETWORKS 9 h

Control of flux distribution at a single branch point, Grouping of reactions, case studies, extension of control analysis to intermetabolite, optimization of flux amplifications, consistency tests and experimental validation.

Total 45 h

COURSE OUTCOME(S):

CO1. Student will understand the metabolic kinetics, flux and its control

REFERENCE(S):

1. Stephanopoulas, G, *et al*., Introduction to Metabolic engineering – Principles and Methodologies. Elsevier Science, 1996.

P13BTE101	MOLECULAR THERAPEUTICS	3	0	0	3

OBJECTIVE(S)

- To impart knowledge on various gene and cellular therapy protocols for diseases
- To learn the production of recombinant proteins and immunotherapeutics.
- To relate the technique of gene silencing in therapeutics.

UNIT I GENE THERAPY 9 h

Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Viral mediated gene transfer - retro and adeno virus mediated gene transfer; Non-viral mediated gene transfer - liposome and nanoparticles mediated gene delivery. Gene therapy approaches – single genes disorders (cystic fibrosis, SCID), cancer, AIDS

UNIT II CELLULAR THERAPY 9 h

Stem cells: definition, properties and potency of stem cells; Sources: embryonic and adult stem cells; Role of adult and embryonic stem cells; clinical trials of stem cell therapy Concept of tissue engineering; Role of scaffolds; Role of growth factors; Clinical applications; Ethical issues

UNIT III RECOMBINANT THERAPY 9 h

Clinical applications of recombinant technology; Production of Recombinant proteins: organisms, production systems – insect cells, mammalian cells, plants, transgenic animals Source, production and applications of recombinant proteins - Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors (Factor VIII).

UNIT IV IMMUNOTHERAPY 9 h

Monoclonal antibodies and their role in cancer; Therapeutic monoclonal antibodies; Role of recombinant interferon's; Immunostimulants; Immunosupressors in organ transplants; Role of cytokine therapy in cancers; Vaccines: types, recombinant vaccines and clinical applications

UNIT V GENE SILENCING AND CLONING 9 h

Gene silencing technology - Antisense therapy; triple helix technology
si RNA - mechanism; Tissue and organ transplantation; Transgenics production and their uses;
Reproductive cloning – Dolly as an example; Ethical issues

Total : 45 h

COURSE OUTCOME(S)

CO1. Gene and cellular therapy trials for therapeutics
CO2. Recombinant proteins and monoclonals production for malignant disorders

REFERENCE(S):

1 Bernhard Palsson and Sangeeta N Bhatia, Tissue Engineering, 2nd Edition, Prentice

Hall, 2004.
2 Pamela Greenwell, Michelle McCulley, Molecular Therapeutics: 21st century medicine, 1st Edition, Sringer, 2008.

P13BTE103	PLANT AND ANIMAL BIOTECHNOLOGY	3	0	0	3

OBJECTIVE(S):

- To understand the various techniques of manipulation of plant and animal cells to produce valuable bioproducts

UNIT I PLANT TISSUE CULTURE: 9 h

Plant growth regulators; Physico-chemical conditions for propagation of plant cells and tissues; Various types of plant tissue culture methods- callus culture, meristem culture, root tip culture, continuous culture and cell suspension culture; Protoplast isolation and fusion; Techniques for immobilization of plant cells; Molecular Pharming.

UNIT II PLANT GENETIC ENGINEERING 9 h

Gene transfer techniques- Particle gun bombardment, Electroporation, and *Agrobacterium* mediated gene transfer*;* plant transformation vectors: cointegrate vector and binary vector, Viral vectors- CaMV, Gemini virus, Golden bean Virus and TMV; Conferring resistance to herbicide and plant pathogens.

UNIT III SCOPE AND PROSPECT OF ANIMAL CELL CULTURE 9 h

Culture media and growth conditions for animal cell; Development of primary culture, Development of cell line; Maintenance and characterization of different cell lines; growth characteristics and kinetics. Cell culture techniques; Hybridoma technology; Organ culture technology; Basics of Gene Therapy; Tissue engineering.

UNIT IV BIOTECHNOLOGY FOR ANIMAL IMPROVEMENT 9 h

Conventional methods of animal improvement: selective breeding and cross-breeding; *Invitro* fertilization; Super ovulation; *Invitro* maturation of oocytes; - Embryo collection, evaluation and transfer, embryo culture; Micro manipulation; Transgenic animals-mice, pigs; Ethics of animal cloning; Stem cells and its applications.

UNIT V ISOLATION OF BIOACTIVE INGREDIENTS FROM PLANTS AND ANIMALS 9 h

Classification of natural plant products; Isolation techniques- terpenes, steroids, sugars, carboaromatic and related compounds, alkaloids; Isolation and production of pharmaceutically important animal metabolites like hormones, cytokines, interferon's.

Total : 45 h

COURSE OUTCOME(S)

CO1. Students learn variety of techniques that form the core of biotechnology

REFERENCE(S):

1. Slater, Scott and Fowler. Plant Biotechnology, 2nd Edition, Oxford University Press
2 H.E Street (ed): Tissue culture and Plant science, Academic press, London, 1974
3. Harborne, J.B., Phytochemical Methods, Chapman and Hall, London, 1993
4. M.M.Ranga. Animal Biotechnology. 3rd Edition, Eastern Book Corporation, 2007

5. Butterworth and Heinemann., Biotechnological Innovations in Animal Productivity; Biotechnology by Open Learning. 1992.
6. B.D. Singh, Biotechnology, Kalyani Publishers, 2003
7. Ian Freshney, Culture of Animal cells: A Manual of Basic Techniques; Wiley-Liss, 2005

P13BTE201	ENVIRONMENTAL BIOTECHNOLOGY	3	0	0	3

OBJECTIVE(S):

- To acquire a holistic understanding of key concepts in Environmental Biotechnology.
- Be able to apply these concepts in designing waste treatment systems and in developing environmentally safe bioproducts.

UNIT I OVERVIEW 9 h

Microbial flora of terrestrial, aquatic and aerial ecosystems; Ecological adaptations; Interactions among microorganisms - mutualism, cooperation, commensalism, antagonism, parasitism, predation and competition; Environmental monitoring; Ecological indicators.

UNIT II BIODEGRADATION AND BIOREMEDIATION 9 h

Introduction; Factors affecting biodegradation of xenobiotics; Biodegradation pathways - ortho and meta cleavage; Petroleum based wastes; Inorganic pollutants; Gaseous pollutants; Surfactants, Desulphurization of coal and oil, Bioremediation; Phytoremediation.

UNIT III BIOLOGICAL WASTEWATER TREATMENT 9 h

Wastewater characteristics; Overview of primary, secondary and tertiary treatment processes; Biological treatment processes (suspended and attached growth), Design and modeling of activated sludge process, Trickling biological filter, Aerobic and anaerobic digestion; Nutrient removal - nitrates and phosphates; Biofilters.

UNIT IV MANAGEMENT OF INDUSTRIAL WASTES 9 h

Overview of each industry with the process flow, typical wastewater characteristics, waste minimization and treatment processes - Dairy, Pulp, Dye, Leather and Pharmaceutical industries; Solid waste management - composting, vermi-composting, incineration and sanitary landfills; Biomedical waste management.

UNIT V BIORESOURCE TECHNOLOGY AND DEVELOPMENT 9 h

Biotechnology for energy production - biological energy sources (biomass) and bio fuels; Biotechnology for enhanced oil recovery; Biomining of metals - concepts of bioleaching; Microbial polymer production and bio-plastic technology; Biosensors and their environmental applications.

TOTAL: 45 h

COURSE OUTCOME(S):

Upon completion of the course, the student:

CO1. Develops a comprehensive understanding of wastewater treatment methodologies and waste management strategies in specific industries.
CO2. Understands the biodegradation pathways for xenobiotic compounds.
CO3. Acquires an ability to apply the concepts in real-world scenarios, for environmental clean-up.

TEXT BOOK(S):

1. Bruce Rittman, Perry L Mac Carty (2007). *Environmental Biotechnology: Principles and Applications*, New York: McGraw Hill.
2. Stanier R.Y., Ingraham J.L., Wheelis M.L., Painter R.R. (1989). *General Microbiology,* London: Macmillan Publications.
3. Howard S Peavy, Donald R Rowe, George Tchbanoglous (1985). Environmental Engineering, Singapore: McGraw-Hill, Inc.

REFERENCE(S):

1. Atlas R M and Bartha R (2008). *Microbial Ecology: Fundamentals and Applications*, 6th edition, Benjamin / Cummings Publishing Company.
2. Metcalf and Eddy (2007). *Wastewater Engineering: Treatment and Reuse*, 5th edition, New Delhi: Tata McGraw Hill Publishing Company.

P13BTE202	FOOD PROCESSING AND BIOTECHNOLOGY	3	0	0	3

OBJECTIVE(S):

- To obtain knowledge about various engineering properties of foods.
- To upgrade the students about food microbiology and food preservation.
- To learn about various food processing techniques and role of biotechnology in food.

UNIT I FOOD AND ITS PROPERTIES 9 h

Constituents of food; Definitions of properties of food: physical properties (roundness, specific gravity),case study : Physical Properties of Green Gram ; dielectric properties: dielectric constant & dielectric loss factor, aerodynamic and hydrodynamic properties: drag force & terminal velocity),textural properties :consistency, hardness, firmness, brittleness; rheological properties : Hookean body, St.Venant body, Newtonian body ; thermal properties: specific heat, enthalpy, thermal conductivity, thermal diffusivity.

UNIT II FOOD MICRBIOLOGY 9 h

Microrganisms associated with foods (bacteria, yeast and fungi); primary sources of microorganisms ; factors influencing microbial activity: intrinsic and extrinsic factors; food borne diseases; food spoilage.

UNIT III FOOD PRESERVATION **9 h**

High temperature preservation : sterilization, pasteurization, blanching, canning; Low temperature preservation: freezing characteristics of foods, factors affecting the quality of frozen foods; Irradiation of foods; drying and dehydration; Case study : Microwave drying of selected greens and their sensory Characteristics, controlled and modified atmospheric packaging and storage of foods; intentional and non-intentional food additives; enzymes in food processing.

UNIT IV FOOD PROCESSING **9 h**

Cleaning (wet and dry), grading, sorting of foods; size reduction, mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization of foods.

UNIT V FOOD BIOTECHNOLOGY **9 h**

Definition of food biotechnology ; role of biotechnology in functional foods; agricultural biotechnology and food safety; genetically modified foods; nutraceuticals in foods and its applications; microbial enzymes; fermented foods : cheese, sausages, sauerkraut, soya sauce, bread, wine, beer ,food chemicals.

Total : 45 h

COURSE OUTCOME(S):

CO1. The students will be able to describe about food and its properties.
CO2. The students will be able to apply food microbiology to preserve and prevent food spoilage.
CO3 The students will be able to produce various food products through various processes.
CO4 The students will be able to experiment food products through biotechnological aspects.

TEXT BOOK(S):

1.Shankuntala Manay N and Shadaksharaswamy M ,2009. Foods : facts and principles – 3rd edition , New Age International Publishers , India.
2.Sri Lakshmi B ,2007. Food Science, New Age International Publishers, India.

REFERENCE BOOK(S):

1. Potter N.N. 1996. Food science. CBS publishers & distributors, Delhi.
2. Food microbiology - Adams, M.R. and Moss M.O.

P13BTE203	IMMUNOTECHNOLOGY	3	0	0	3

OBJECTIVE(S):

- To develop the knowledge of the students in the area of Immuno-biology, Immuno-technology and its applications.
- To gain extensive knowledge in Immnotechniques and various assay related to immunology.

UNIT I INTRODUCTION 9 h

Innate and adaptive immunity, Cells of the immune system, hematopoiesis - process, growth factors, regulation; Antigens –factors affecting immunogenicity, adjuvants, humoral immune response; cell mediated immune responses; complement- pathways, biological consequence of activation, regulation. Antibodies- structure and classification.

UNIT II IMMUNOTECHNIQUES 9 h

Antigen-antibody interactions – precipitation, aggulutination, radioimmunoassay, ELISA, immunofluorescence – principle and applications. Immuno-electrophoresis, Rocket Immuno-electrophoresis. Immunoglobulin quantification – radial immunodiffusion, Laurell Rocket technique, light scattering assays. Monoclonal antibodies – production and their use in diagnostics; Plaque Forming Cell Assay.

UNIT III CELLULAR IMMUNOLOGY 9 h

PBMC separation from the blood; Cryopreservation of PBMC, FACS; Lympho-proliferation assay; Mixed lymphocyte reaction. Measurement of NK cell activity; Cr51 release assay, cytokine bioassays- IL2, gamma IFN, TNF alpha. HLA typing.

UNIT IV VACCINE TECHNOLOGY 9 h

Basic concept of vaccine design and development – active and passive immunization, designing vaccines for active immunization; whole organism vaccines, protein based vaccines; DNA vaccines, multisubunit vaccines; Plant based vaccines; recombinant antigens as vaccines; reverse vaccinology.

UNIT V DEVELOPMENT OF IMMUNOTHERAPEUTICS 9 h

Engineered antibodies; catalytic antibodies; idiotypic antibodies; combinatorial libraries for antibody isolation. Immunocytochemistry and Immunohistochemistry – principle and applications.

TOTAL : 45 h

COURSE OUTCOME(S):

CO1. Students will acquire the basics of Immunology and immunobiology and
CO2. Develop an understanding of various concepts of immunotechniques
CO3. Enable them to apply these concepts and techniques in immunobiology.
CO4. Acquire knowledge in cellular immunology and immunoassays

TEXT BOOK(S):

1. Roitt, I (1997) *Essential Immunology*, 9th ed., Blackwell Scientific.
2. Rose, N.R., Hamilton, R.G. and Detrick, B. (2002) *Manual of Clinical laboratory Immunology*, 6th ed., ASM Press, Washington DC.

REFERENCE(S):

1. Roitt,I., Brostoff, J. and Male D. (2001) Immunology, 6th ed. Mosby.
2. Goldsby , R.A., Kindt, T.J., Osbome, B.A. and Kuby J. (2003) *Immunology*, 5th ed., W.H. Freeman, 2003
3. Weir, D.M. and Stewart, J. (1997) *Immunology*, 8th ed., Cheerchill, Linvstone, 1997.

P13BTE204	MASS TRANSFER AND CHEMICAL REACTION ENGINEERING	3	0	0	3

OBJECTIVE(S)

To make the students to understand the concepts of catalysis, diffusion effects and RTD in heterogeneous reaction systems

UNIT I CATALYSIS AND CATALYTIC REACTORS 9 h

Catalysts, Steps in Catalytic Reaction, Synthesizing a Rate Law, Mechanism, and Rate-Limiting Step, Design of Reactors for Gas-Solid Reactions, Heterogeneous Data Analysis for Reactor Design, Chemical Vapour Deposition, Catalyst Deactivation

UNIT II EXTERNAL DIFFUSION EFFECTS ON HETEROGENEOUS REACTIONS 9 h

Mass Transfer Fundamentals, Binary Diffusion, External Resistance to Mass Transfer, Shrinking Core Model

UNIT III DIFFUSION AND REACTION IN POROUS CATALYSTS 9 h

Diffusion and Reaction in Spherical Catalyst Pellets, Internal Effectiveness Factor, Falsified Kinetics, Overall Effectiveness Factor, Estimation of Diffusion- and Reaction-Limited Regimes, Mass Transfer and Reaction in a Packed Bed, Determination of Limiting Situations from Reaction Data, Multiphase Reactors

UNIT IV RTD FOR CHEMICAL REACTORS 9 h

General Characteristics, Measurement of the RTD, Characteristics of the RTD, RTD in Ideal Reactors, Reactor Modelling with the RTD, Zero-Parameter Models, RTD and Multiple Reactions

UNIT V MODELS FOR NON-IDEAL REACTORS 9 h

One- Parameter Models, Two-Parameter Models, Tanks-in-Series Model, Dispersion Model, Flow, Reaction, and Dispersion, Tanks-in-Series Model Versus Dispersion Model, Two-Parameter Models-Modelling Real Reactors with Combinations of Ideal Reactors, Other Models of Non-ideal Reactors Using CSTRs and PFRs, Applications to Pharmacokinetic Modelling

TOTAL 45 h

COURSE OUTCOME(S):

CO1. Students would have understand the concepts of catalysis, diffusion effects and RTD in heterogeneous reaction systems

TEXT BOOK(S):

1. Fogler, Scott H., (2006).*Elements of Chemical Reaction Engineering*, Latest Edition, New Delhi: Prentice Hall of India.

REFERENCE BOOK(S):

1. Carberry, J. J., (2001). *Chemical and Catalytic Reaction Engineering*, USA: Dover Publications.
2. Froment, G. F.,& Bischoff, K. B.,(1990) *Chemical Reactor Design and Analysis*, 2nd Edition, Hoboken/New Jersey:John Wiley & Sons.

P13BTE301	PHARMACEUTICAL BIOTECHNOLOGY	3	0	0	3

OBJECTIVE:

- To understand the principles of drug metabolism.
- Acquire knowledge in drug design and manufacturing.

UNIT I INTRODUCTION 4 h

History of pharmacy, the pharmaceutical industry & development of drugs, approval process; economics and regulatory aspects

UNIT II PHARMACOKINETICS AND PHARMACODYNAMICS 11 **h**

Understanding principles of pharmacology, pharmacodynamics, Pharmacokinetics: Mechanism of drug absorption, distribution, metabolism and excretion – factors affecting the ADME process, bioequivalence

UNIT III PRINCIPLES OF DRUG MANUFACTURE 15 h

Liquid dosage forms – solutions, suspensions and emulsions, Topical applications – ointments, creams, suppositories, Solid dosage forms – powders, granules, capsules, tablets, coating of tablets, Aerosols. Preservation, package and storage methods, quality management; GMP

UNIT IV ADVANCES IN DRUG DELIVERY 5 h

Advanced drug delivery systems – controlled release, transdermals, liposomes and drug targeting

UNIT V BIOPHARMACEUTICALS 10 h

Study of a few classes of therapeutics like laxatives, antacids and drugs used in peptic ulcers, drugs used in coughs and colds, analgesics, contraceptives, antibiotics, hormones.

TOTAL: 45 h

COURSE OUTCOME(S)

CO1. Student will gain knowledge in drug interaction, drug metabolism

CO2. Acquire knowledge in drug designing and manufacture.

CO3. Understand the principles and drug manufacture

CO4. Acquire knowledge about advances in drug delivery systems

CO5. Understand the therapeutics function and use to treat humans

REFERENCE(S):

1. Leo Lachman et al., 1986. Theory and Practice of Industrial Pharmacy, 3 edition, Pub: Lea and Febiger.
2. Remington's Pharmaceutical science, Mark Publishing and co
3. Remington, The Science and practice of Pharmacy", Lippincott Williams and Wilkins, 20th edition
4. Gareth Thomas. Medicinal Chemistry. An introduction. John Wiley. 2000.
5. Katzung B.G. Basic and Clinical Pharmacology, Prentice Hall of Intl. 1995.

P13BTE302	GENOMICS AND PROTEOMICS	3	0	0	3

OBJECTIVE(S):

- To acquire solid foundation in fundamental concepts in genomics and proteomics techniques
- To learn genomics and proteomics related data generation, databases and analysis

UNIT I ORGANIZATION AND MAPPING OF GENOMES 9 h

Genome size; C-value and C-value paradox; Complexity of genomes, genome mapping methods; cytogenetic map- restriction map-Optical mapping-STS mapping- importance of high resolution genome maps.

UNIT II GENOME SEQUENCING AND SEQUENCE ANALYSIS 9 h

Advanced genome sequencing methods; automated sequencing- nextgen sequencing- whole genome sequencing, data acquisition using genome browsers, genome assembly, genome annotation, comparative genomics; gene tree construction, gene prediction rules; Genscan for gene finding- UTR scan for functional element prediction, SNP analysis.

UNIT III GENE EXPRESSION AND DATA ANALYSIS 9 h

EST database, assembly of database using CAP3, Principle of Serial Analysis of Gene Expression, SAGE data acquisition and analysis, quantization of gene expression, Microarray principle, fabrication of different types, experimental design in microarray, comparative microarray data analysis and interpretation gene expression, metagenomics; methods-applications.

UNIT IV PROTEOMICS 12 h

High throughput protein separation ; 2D gel image acquisition and analysis, protein digestion techniques; in- gel and on-blot, protein identification by peptide mass fingerprinting, protein sequencing using MS, protein expression profiling using MS, phosphoptotomics; phosphoprotein purification and identification by IMAC- MS data, Glycoprotein isolation and identification using MS, interactive proteomics; proteomics for biomarker identification

UNIT V SYSTEM BIOLOGY 6 h

Introduction to systems biology, biological networks, protein interaction networks-computational prediction of protein interactions, network topology analysis; bus-star-ring networks.

TOTAL: 45

COURSE OUTCOME(S):

The students will be able to

CO1. Understand and explain the importance of genome mapping and HGP.

CO2. Describe various genome sequencing methods.

CO3. Analyze and interpret the microarray data for gene expression profiling.

CO4. Explain the steps in 2D electrophoresis and peptide mass fingerprinting.

TEXT BOOK(S):

1. T.A .Brown (2002) Genomes, 2nd Edition, Oxford: Wiley-Liss
2. J. Pevsner (2009) Bioinformatics and Functional genomics, 2nd Edition, John Wiley.
3. I, Rigoutsos and G. Stephanopoulos (2007) Systems Biology: Genomics", Oxford University Press.
4. N. Saraswathy and P.Ramalingam (2011) Concepts and Techniques in genomics and proteomics; Woodhead Publications, Cambridge, UK.

P13BTE303	BIOPROCESS PLANT DESIGN AND PRACTICE	3	0	0	3

OBJECTIVE(S)

- To make the students to understand the concepts of equipment design with relevance to bioprocess industries

UNITI INTRODUCTION TO DESIGN AND FLOWSHEET 9 h

Nature of design, design factors, degrees of freedom, design variables, optimization, nature of process equipments, general design procedure, basic considerations in design, standards, codes, and their significance, equipment classification and their selection, design pressure, design temperature, design stress, design loads, review of fabrication techniques, economics and environmental considerations in design procedure. Sketching techniques, Equipment symbols, Process flowsheeting

UNIT II PRESSURE VESSEL DESIGN 9 h

Design of unfired pressure vessels: Types of pressure vessels, codes and standards for pressure vessels (IS: 2825; 1969), material of construction, selection of corrosion allowance and weld joint efficiency. Proportioning of pressure vessels, selection of L/D ratio, optimum proportions of vessels. Complete design as per IS: 2825; 1969 involving shells: cylindrical, spherical.

UNIT III VESSEL DESIGN 9 h

Design of vessel closures - flat, hemispherical, torispherical, elliptical and conical, design of nozzles, gasket, flange and bolt

UNIT IV MECHANICAL ASPECTS OF BIOREACTOR DESIGN 9 h

Introduction, Bioreactor design – Requirements, Guidelines, Vessels, Agitator assembly

UNIT V VESSEL SUPPORT DESIGN 9 h

Vessel support - Introduction and classification of supports, design of skirt supports considering stresses due to dead weight, wind load, seismic load, design of base plate, skirt, bearing plate, anchor bolts, bolting chairs and skirt shell plates. Design of saddle supports

TOTAL 45 h

COURSE OUTCOME(S):

CO1. Student’s would have understand the concepts of equipment design with relevance to bioprocess industries

TEXT BOOK(S):

1. R. K. Sinnott, (2005)"*Chemical Engineering Design*", Coulson and Richardson‟s Chemical Engineering Series, Volume-6, Fourth Edition, United Kingdom: Butterwoth-Heinemann, Elsevier.
2. R. H. Perry., (1998). *Chemical Engineers' Handbook*, 7th Edition., New Delhi: McGraw Hill, Inc.

REFERENCE BOOK(S):

1. L. E. Brownell and E.H. Young., (1968). *Process Equipment Design - Vessel Design*, New York: Wiley Eastern Edition.
2. B.C. Bhattacharyya, (2000).*Introduction to Chemical Equipment Design Mechanical Aspects*, New Delhi: CBS Publishers & Distributors.

3. V. V.Mahajani and S. B. Umarjii.,(2009) *Joshi "s Process Equipment Design*, 4th Edition, New Delhi:Mac Millan Publishers India Limited.
4. Robin Smith., (2006) *Chemical Process Design and Integration*, Eighth Edition, New Delhi: Wiley India Pvt Ltd.

P13BTE401	PROTEIN ENGINEERING	3	0	0	3

OBJECTIVE(S):

To make the students to understand the concepts of structure, function and engineering of proteins

UNIT I AMINO ACIDS AND THEIR CHARACTERISTICS 5 h

Different covalent and non-covalent bonds in protein structure. Detection of amino acids, peptides and proteins. Amino acids (the students should be thorough with three and single letter codes) and their molecular properties (size, solubility, charge, pKa), Chemical reactivity in relation to post-translational modification (involving amino, carboxyl, hydroxyl, thiol, imidazole groups). and peptide synthesis.

UNIT II GLOBULAR AND FIBROUS PROTEINS 5 h

Properties of globular and fibrous proteins. Salient features of silk fibroin, coiled coils, collagen and keratin. Ramachandran plot and its uses.

UNIT III PROTEIN ARCHITECTURE 12 h

Primary structure: peptide mapping, peptide sequencing - automated Edman method & mass-spec. High-throughput protein sequencing setup Secondary structure: Alpha, beta and loop structures and methods to determine.
Super-secondary structure: Alpha-turn-alpha, beta-turn-beta (hairpin), beta-sheets, alpha-beta-alpha, topology diagrams, up and down & TIM barrel structures nucleotide binding folds, prediction of substrate binding sites
Tertiary structure: Domains, folding, denaturation and renaturation, overview of methods to determine 3D structures, Quaternary structure: Modular nature, formation of complexes.

UNIT IV STRUCTURE-FUNCTION RELATIONSHIP 15 h

DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, Trp repressor, Eucaryotic transcription factors, Zn fingers, helix-turn helix motifs in homeodomain, Leucine zippers, Membrane proteins: General characteristics, Trans-membrane segments, prediction, bacteriorhodopsin and Photosynthetic reaction center, Immunoglobulins: IgG Light chain and heavy chain architecture, abzymes and Enzymes: Serine proteases, understanding catalytic design by engineering trypsin, chymotrypsin and elastase,

UNIT V PROTEIN ENGINEERING 8 h

Advantages and purpose, overview of methods, underlying principles with specific examples: thermal stability T4-lysozyme, recombinant insulin to reduce aggregation and inactivation, de novo protein design. substrate-assisted catalysis other commercial applications. Brief account on bioinformatics tools used to analyze protein structure

Total : 45 h

COURSE OUTCOME(S):

CO1. Students would have understood the concepts of structure, interaction, function
CO2. Modification of proteins for its applications

REFERENCE(S):

1. Creighton T.E. Proteins, 2nd Edition Freeman WH, 1993.
2. Moody P.C.E. and Wilkinson A.J. Protein Engineering, IRL Press, Oxford, UK, 1990.
3. Voet D. and Voet G.,Biochemistry, Third Edn. John Wiley and Sons, 2001.
4. Branden C. and Tooze J., Introduction to Protein Structure, Second Edition, Garland Publishing, NY, USA, 1999.

P13BTE402	BIOMEDICAL ENGINEERING AND CLINICAL RESEARCH	3	0	0	3

OBJECTIVE(S)

- To learn basics of Biomedical engineering and instrumentation
- To equip the students with applications of biomedical engineering in medicine.
- To study basics of clinical research, management and data analysis

UNIT I BASICS OF SIGNAL TRANSDUCTION 9 h

Different types of noises in measurements and its Suppression methods; Transducers – Classification - circuit based on transduction, temperature transducers, Pressure transducer , catheter tip transducers, Photoelectric transducer, Flow transducers, Piezoelectric transducers and their applications; Biosensors - Chemoreceptors, hot and cold receptors, baro receptors, sensors for smell, sound, vision, osmolality and taste.

UNIT II BIOMECHANICS AND BIOMATERIALS 9 h

Biomechanical properties of bone and spine; mechanical properties of blood vessels; Biofluid mechanics – Newton's laws, stress-strain, Newtonian visions fluid; Blood physical characteristics, Blood Rheology; Classification of biomaterials – polymers, metals, ceramics, composites; Biocompatibility – invitro and assessment; Implantable cardiac assist devices; skin substitutes; Burn dressing; soft tissue replacements.

UNIT III BIOMEDICAL INSTRUMENTATION 9 h

Bioelectric potential and its measurement; Measurement of blood pressure; blood flow and cardiac output; Gas exchange instrumentation; ECG, EEG instruments; Pacemakers; Defibrillators; Heart lung machine.

UNIT IV DIAGNOSTIC EQUIPMENT & MEDICAL IMAGING 9 h

Ultrasonic techniques – Echocardiograms, Echo encephalagrams; Magnetic Resonance Imaging; Emission imaging systems; Radiographic imaging systems.

UNIT V CLINICAL RESEARCH 9 h

Discovery and development of new drugs, therapies and diagnostics; Ethical Guidelines and Regulation in clinical Research; Clinical trial designs; Analysis and interpretation for studies in humans; Clinical Trial documentation; Quality control in Clinical Trials; Clinical data management.

Total : 45 h

COURSE OUTCOME(S)

CO1. Understanding Biomedical instrumentation and applications
CO2 Learn biomechanics and biomaterials
CO3. To develop an understanding of experimental design and data management in Clinical Research.

TEXT BOOK(S)

1. L.A.Geddes and L.E.Baker, Principles of Biomedical Instrumentation and Measurement.; 1st Edition ,John Wiley and Sons; 1989.
2. Adern Hilger ,The Physics of Medical Imaging, Bristol and Philadelphia, 1988
3. J.B. Park ,Biomaterial Science and Engineering, 1st Edition ,Plenum Press, 2000.
4. Duane Knudson ,Fundamentals of Biomechanics, 2003.
5. David Machlin, Simon Day, Sylvan Green, The textbook of Clinical Trials, 2nd Edition, 2007
6. Enderle,U, Blanchard,S Bronzino, S Introduction to Biomedical Engineering, 2nd Indian Edition, Academic press, 2005.

REFERENCE(S)

1. R.Anandanatarajan, "Biomedical Instrumentation", PHI Learning, 2009.
2. M. Arumugam, "Biomedical Instrumentation", Anuradha Agencies Publishers, Vidayal Karuppar, 612 606, Kumbakonam, R.M.S: 1992

P13BTE403	BIOREACTOR DESIGN	3	0	0	3

OBJECTIVE(S)

- To make the students to understand the concepts of bioreactors and their design

UNIT I BASICS OF BIOREACTORS 9 h

Overview of bioreactions, Elements in bioreactor design, Rate expression in biological systems, Basic concept of material and energy balances, Development and significance of bioreactors, Bioreactor configurations, Classification of bioreactors, Bioreactors for solid-state fermentation, plant and animal cell cultures

UNIT II BIOREACTOR OPERATION 9 h

Common operations of bioreactor, Identification of common factors for smooth operation of bioreactors, Spectrum of basic bioreactor operations, Bioreactor operation for immobilized systems, plant and animal cell cultures

UNIT III BATCH AND SEMICONTINUOUS BIOREACTORS DESIGN 9 h

Overview of bioreactor design, Batch and semicontinuous bioreactors for submerged fermentation of microbes

UNIT IV CONTINUOUS BIOREACTORS DESIGN 9 h

Continuous flow stirred tank and plug flow tubular bioreactors for submerged fermentation of microbes, Recycle bioreactors, Multistage bioreactors, Bioreactors for enzyme reactions and immobilized systems

UNIT V CASE STUDIES AND SCALE-UP 9 h

Design of packed bed, fluidized bed, airlift, hollow fibre, plant cell, mammalian cell bioreactors for various applications, Scale=up – Criteria, Similarity criteria, Methods, Generalized approaches.

TOTAL 45 h

COURSE OUTCOME(S):

CO1.students would have understand the concepts of bioreactors and their design

TEXT BOOK(S):

1. Tapobrata Panda, (2011). *Bioreactors: Analysis and Design*, Latest Edition, New Delhi: Tata McGraw Hill Education Private Limited.

REFERENCE BOOK(S):

1. Moser, Anton.(1988) *Bioprocess Technology: Kinetics and Reactors*, Latest Edition, New York: Springer Verlag.
2. Forment, G. F.(1990), *Chemical Reactor Analysis and Design*, Latest Edition, New Delhi: Wiley India Pvt Ltd.
3. Rawlings, J. B. and Ekerdt, J. G., (2002), *Chemical Reactor Analysis and Design Fundamentals*, Latest Edition, San Francisco:Nob Hill Publisher.
4. Levenspiel, O.,(1998), *Chemical Reaction Engineering*, Latest Edition, New Delhi: John Wiley Eastern Ltd.

P13BTE404	BIOPROCESS MODELING AND SIMULATION	3	0	0	3

OBJECTIVE(S)

To make the students to understand the applications of optimization, modelling and simulation in bioprocess industries

UNIT I OPTIMIZATION **9 h**

Concepts of optimization, single variable optimization, Linear and Non Linear Programming Methods, Specialized Optimization techniques – Genetic Algorithm, Artificial Neural Network etc, Case Studies

UNIT II MODELLING **9 h**

Concept of modelling, Unstructured and structured modelling, Meaning and interpretation through Deterministic and stochastic models, Segregated and unsegregated models, Shu's segregated models for Lactic acid fermentation, Details of Structured kinetic models: Compartmental models, Product formation, Unstructured and structured models, Genetically structured models

UNIT III CASE STUDIES IN MODELLING **9 h**

Stochastic model for thermal sterilization of the medium, Modelling for activated sludge process, Model for anaerobic digestion, Models for ethanol fermentation and antibiotic production, Case studies

UNIT IV SIMULATION **9 h**

Process simulation techniques, Equation oriented approach, Equation oriented simulators (SPEED UP, ASCEND, FLOWSIM, QUASILIN, DYNSIM), Simulation programs based on Euler's methods, Newton – Raphsen methods, Runga – Kutta methods, Simulation of biochemical system models.

UNIT V SIMULATION PACKAGES **9 h**

Simulation packages for bioprocess industries: Bio Process Simulator, Bio Pro Designer, Biotechnology Design Simulator, BATCHES, Intelligen Super Pro, Aspen Batch Plus and gepasi, Case studies

TOTAL 45 h

COURSE OUTCOME(S):

CO1. Students would have understand the applications of optimization, modelling and simulation in bioprocess industries

TEXT BOOK(S):

1. Bailey, James E. and Ollis, (1986) David F. *Biochemical Engineering Fundamentals*, Latest Edition, McGraw Hill, Inc.
2. Luyben, Michael L. and Luyben, William L. (1989), *Process Modeling, Simulation, and Control for Chemical Engineers*, Latest Edition, New Delhi: Tata McGraw Hill Education Private Limited.

REFERENCE BOOK(S):

1. Harrison, Roger G., Todd, Paul W., Rudge, Scott R. and Petrides, Demetri,(2002), *Bioseparations Science and Engineering*, Latest Edition, USA: Oxford Universities Press.
2. Felder, R. M. and Rousseau, R. W., *Elementary Principles of Chemical Processes*, (2005), Latest Edition, Hoboken/New Jersey:John Wiley & Sons.
3. Franks, R. G. E., *Mathematical Modelling in Chemical Engineering*,(1967), Latest Edition, Hoboken/New Jersey:John Wiley & Sons.
4. Ramirez, W., (1997), *Computational Methods in Process Simulation*, Latest Edition, Oxford: Butterworth Publisher.