ACADEMIC REGULATIONS
COURSE STRUCTURE
AND
DETAILED SYLLABUS
For

MASTER OF TECHNOLOGY IN BIOTECHNOLOGY

(FULL TIME POST GRADUATE PROGRAMME)

(Effective for the students admitted into I[st] year from the Academic Year 2021-22 and onwards)

CENTRE FOR BIOTECHNOLOGY

INSTITUTE OF SCIENCE AND TECHNOLOGY

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

Kukatpally, Hyderabad-500 085,

Telangana State, India.

CENTRE FOR BIOTECHNOLOGY

INSTITUTE OF SCIENCE AND TECHNOLOGY

COURSE SCHEME FOR M. TECH 2021-22 & ONWARDS

M. TECH SEMESTER - I

Course Number	Subject	Scheme of Studies Per Week			Credits	Int. Marks	Ext Marks
		L	T	P			
1BTPC01	**Program Core – I** Biochemistry & Metabolic Engineering	3	0	0	3	30	70
1BTPC02	**Program Core – II** Bioreaction Engineering	3	0	0	3	30	70
1BTPE03	**Program Elective- I** 1. Molecular Biology and Genetic Engineering 2. Process Engineering Principles 3. Immunotechnology	3	0	0	3	30	70
1BTPE04	**Program Elective- II** 1. Basic Mathematics 2. Fermentation Technology 3. Animal Cell Culture & Tissue Engineering	3	0	0	3	30	70
1A01	Research Methodology & Intellectual Property Rights	2	0	0	2	30	70
1A02	**Audit course-I**	2	0	0	0	0	0
1BTL05	**Lab -I** Unit operations in biotechnology Lab	0	0	4	2	30	70
1BTL06	**Lab- II** Biochemistry and molecular biology Lab	0	0	4	2	30	70
TOTAL		**16**	**0**	**08**	**18**	**210**	**490**

(L: Lecture periods, T: Tutorial periods, P: Practical periods)

NOTE:

1) Basic Mathematics and Process Engineering Principles are mandatory for all the students joining with their Masters in Life Sciences.

2) B. Tech (Biotechnology/Biochemical Engineering/ Agriculture engineering) and B. Pharmacy students have the freedom to select any elective of their choice.

M.TECH SEMESTER – II

Course Number	Subject	Scheme of Studies Per Week			Credits	Int. Marks	Ext Marks
		L	T	P			
2BTPC07	**Program Core – III** Downstream Processing	3	0	0	3	30	70
2BTPC08	**Program Core – IV** Bioprocess Engineering	3	0	0	3	30	70
2BTPE09	**Program Elective - III** 1. Bioinformatics and Systems biology 2. Bio-nanotechnology 3. Cancer Biology	3	0	0	3	30	70
2BTPE10	**Program Elective – IV** 1. Plant Biotechnology & Molecular Pharming 2. Stem cell technology 3. Protein Engineering	3	0	0	3	30	70
2A03	**Audit Course - II**	2	0	0	0	0	00
2BTL11	**Lab- III** Cell culture Techniques Lab	0	0	4	2	30	70
2BTL12	**Lab – IV** Bioprocess Engineering Lab	0	0	4	2	30	70
2BT13	**Mini project with Seminar**	0	0	4	2	30	70
TOTAL		**14**	**0**	**12**	**18**	**210**	**490**

(L: Lecture periods, T: Tutorial periods, P: Practical periods)

*Students can be encouraged to go to Industrial Training/ Internship for at least 2-3 months during semester break.

M.TECH SEMESTER - III

Course Number	Subject	Scheme of Studies Per Week			Credits	Int. Marks	Ext. Marks
		L	T	P			
3BTPE14	**Program Elective - V** 1. Bioreactor Design and Analysis 2. Modeling and Simulation in Bioprocess 3. Bioprocess Instrumentation and Control	3	0	0	3	30	70
3BTOE15	**Open Elective** 1. Biologics and Vaccine Technology 2. Food Science & Technology 3. Pharmaceutical Biotechnology 4. Waste to Energy 5. Neurobiology 6. Bioanalytical Techniques	3	0	0	3	30	70
3BT16	**Project work review-I**	0	0	20	10	100	0
TOTAL		**06**	**0**	**20**	**16**	**160**	**140**

(L: Lecture periods, T: Tutorial periods, P: Practical periods)

* Students going for Industrial Project/Thesis will complete these courses through MOOCs.

LIST OF AUDIT COURSES

"1A02/2A03" English for Research Paper Writing

"1A02/2A03" Disaster Management

"1A02/2A03" Sanskrit for Technical Knowledge

"1A02/2A03" Value Education

"1A02/2A03" Constitution of India

"1A02/2A03" Pedagogy Studies

"1A02/2A03" Stress Management by Yoga

M.TECH SEMESTER - IV

Course Number	Subject	Scheme of Studies Per Week			Credits	Int. Marks	Ext. Marks
		L	T	P			
4BT17	**Project work review – II and Viva- Voce**	0	0	32	16	30	70
TOTAL		**0**	**0**	**32**	**16**	**30**	**70**

(L: Lecture periods, T: Tutorial periods, P: Practical periods)

TOTAL CREDITS OF THE PROGRAMME- 68

FIRST SEMESTER (Program Core - I)

PO1	PO2	PO3	PO4
M	S	S	S

BIOCHEMISTRY AND METABOLIC ENGINEERING

UNIT-I: BIOMOLECULES: Classification, physical and chemical properties of carbohydrates, lipids, amino acids and proteins; protein structural hierarchy, Ramachandran plot; nucleotides and nucleic acids; Pigments and storage materials.

UNIT-II: METABOLISM OF BIOMOLECULES: Carbohydrates metabolism – Glycolysis, TCA cycle, Pentose phosphate pathway, Glycogenolysis. Glycogen synthesis. Lipids – β-oxidation of Fatty acids – saturated fatty acids. Synthesis of Fatty acids. Proteins - Transamination, Deamination & Decarboxylation of amino acids. Metabolism of Amino acids: Glutamate, Tryptophan, Cysteine & Proline

UNIT-III: THERMODYNAMICS AND COMPRHENSIVE MODELS FOR CELLULAR PROCESS: Thermodynamic aspects of metabolism, Regulation & Role of key enzymes in metabolic pathway control, allosteric control and control by phosphorylation, Control at transcription and translation level. Genetic circuits-Jacob and monad model.

UNIT-IV: MATERIAL BALANCE & DATA CONSISTENCY: Material and heat balances-black box model, elemental balances, analysis of under determined and over determined systems, sensitivity analysis, Comprehensive models for cellular reactions-stoichiometry of cellular reactions, dynamic mass balance, yield coefficients, enhancement of product yield, extension of substrate and product range

UNIT-V: METABOLIC FLUX ANALYSIS: Flux generation aspects of metabolic pathways, Metabolic network pathways, Experimental determination method of flux distribution, optimization and control of metabolic flux, metabolic flux analysis of citric acid fermentation

COURSE OUTCOMES:

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

CO1- Understand the fundamentals of biochemistry and bioenergetics

CO2- Assess the importance of bio molecules

CO3- Evaluate the metabolism of bio molecules

CO4- Classify the membrane transport and signal transduction mechanisms

CO5- Apply the strategies for metabolic control

TEXT BOOKS:

1. Lehninger, A. L. (1982). Principles of biochemistry (4th ed.). New York, NY: Worth.
2. Voet, D., & Voet, J. G. (2004). Biochemistry (4th ed.). Hoboken, NJ: J. Wiley & Sons. Biochemistry and Molecular Biology, Third Edition by William H. Elliott and Daphne C. Elliott, Oxford University press.
3. Stryer, L. (1988). Biochemistry. New York: Freeman.

REFERENCE BOOKS:

1. Biochemistry White, Handler and R.B. Smith 7th Ed. Fundamentals of Biochemistry by J.L. Jain, Sunjay Jain AND Nitin Jain, S. Chand and Company Ltd.
2. Donald Voet & Judith G. Voet Biochemistry second edition.
3. Bacterial Physiology and Metaboloism BH Kim, GM Gadd.

FIRST SEMESTER (Program Core - II)

PO1	PO2	PO3	PO4
M	M	S	S

BIOREACTION ENGINEERING

UNIT-I: OVERVIEW OF CHEMICAL REACTION AND INTRODUCTION TO ENZYMES: Classification of reactions, variables affecting the rate of reaction, concept of order, molecularity of a reaction, definition of reaction rate, concentration dependent term of rate equation, Temperature dependent term of rate equation. Introduction, Nomenclature and Classification of enzymes. Enzyme isolation and purification. **Specificity Of Enzyme Catalyzed Reactions:** Type of specificity, Active sites, Principles of catalysis-Collision theory, Activation energy and Transition state theory.

UNIT-II: ENZYME SINGLE SUBSTRATE REACTIONS AND ENZYME INHIBITION KINETICS:

Kinetics of single-substrate reactions, Michaelis - Menten equations, Brigg's Haldane equation & estimation of constants using graphical techniques, Turnover number (k_{cat}), Kinetics for reversible reactions. **Enzyme Inhibition Kinetics:** Reversible and irreversible inhibition, substrate, product and toxic substances inhibition.

UNIT-III: PRE-STEADY–STATE AND MULTI-SUBSTRATE ENZYME KINETICS:

PRE-STEADY–STATE KINETICS: Determination of rate constants: Rapid mixing, Stopped flow and Relaxation techniques, Determination of the number of active sites of enzyme. **Enzyme Kinetics at Limiting Conditions:** Dilute substrates, solid substrates and enzyme activity at interfaces. **KINETICS OF MULTI-SUBSTRATE REACTIONS:** Mechanism for two substrates reactions, compulsory order, random order reactions and Ping-Pong mechanism. **Kinetics of Biphasic Liquid Systems:** stabilization of biphasic aqueous-organic systems and equilibrium in biphasic aqueous-organic systems.

UNIT-IV: FACTORS AFFECTING ENZYME ACTIVITY & ACTIVE SITE STUDIES:

Factors affecting enzyme activity: Temperature and pH effects, thermal deactivation of enzymes**.**

pH dependence: Ionization of Acids and Bases. **Active site studies:** The identification of binding sites and catalytic sites, Trapping the enzyme substrate complex, the use of Substrate analogues, Enzyme modification by chemical procedures affecting amino acids side chains, the enzyme modification by treatment with proteases and site-directed mutagenesis. **Allosteric enzymes:** binding of ligands to proteins, the Monod Changeux-Wyman model, the Koshland- Nemethy Filmer model, Examples of cooperative binding kinetics. Temperature and pH effects.

UNIT-V: ENZYME IMMOBILIZATION & KINETICS OF IMMOBILIZATION:

Enzyme immobilization & kinetics of immobilization: Immobilization of Biocatalysts an Introduction, Electrostatic effect, Effect of charged and uncharged support, Effect of external and internal mass transfer, Effect of Intra-particle diffusion with uncharged supports, Simultaneous external and internal mass transfer resistances and partitioning effects. Dam Kohler number and effectiveness factor.

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COURSE OUTCOMES:

CO1: This unit helps to understand the commercial enzymes applications, enzymes catalyzed reactions.

CO2: At the end of this unit students understand the specificity, kinetics of industrially important enzymes.

CO3: At the end of this unit students understand substrate enzyme intereactions, steady state and multi substrate enzyme kinetics.

CO4: At the end of this unit students learn enzyme activity effects by different factors and active site analysis.

CO5: At the end of this unit students learn immobilization kinetics.

TEXT BOOKS:

1. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker 1987.
2. Enzymes, Biochemistry, Biotechnology Clinical Chemistry: Trevor Palmer.2001

REFERENCE BOOKS:

1. Bailey JE, Ollis, DF: Biochemical Engineering Fundamentals, Prace and Stevens,
2. Handbook of Enzyme Biotechnlogy, 3rd Edition, Ellis Horwood Publication.

FIRST SEMESTER (Program Elective- I)

PO1	PO2	PO3	PO4
S	M	S	S

1. MOLECULAR BIOLOGY AND GENETIC ENGINEERING

UNIT-I: MOLECULAR BIOLOGY FUNDAMENTALS: Genome organization in Prokaryotes and Eukaryotes, Nucleic acids (DNA & RNA) Structure, Classes, and Function. DNA replication, Regulatory elements, DNA Damage and repair mechanisms. Transposable Elements.

UNIT-II: REGULATION OF GENE EXPRESSION: Regulation of gene Expression in prokaryotes. Prokaryotic transcription, Operon Concept, Inducible and Repressible Operon. Eukaryotic Transcription: Basal Transcription Apparatus, Regulatory Elements, Transcription Factors and Motifs. Transcriptional controls in Eukaryotes. Post transcriptional Modifications. Translation in Prokaryotes and Eukaryotes, Translational Machinery, Post translational Modifications.

UNIT-III: INTRODUCTION TO GENETIC ENGINEERING: Molecular Tools in Genetic Engineering - Restriction enzymes and DNA Modifying enzymes. Restriction mapping of DNA fragments and Map construction, Nucleic acid Amplification, PCR analysis and its applications, Real Time PCR, RACE- PCR.

UNIT-IV: GENE CLONING AND DIRECTED EXPRESSION: Gene Cloning vectors, Gene Cloning strategies, Construction of DNA libraries (Genomic library and cDNA library) and their screening. Map based cloning. **Gene Expression:** Study of introduced Gene expression – Hybridization techniques and Nucleic acid microarrays. Gene expression in bacteria, Yeast, insects and insect cells, mammalian cells and in plants, Characterization of recombinant proteins, Phage display, Yeast Two- and three Hybrid system.

UNIT-V: TRANSGENICS, GENE SILENCING, GENOME EDITING AND PROTEIN ENGINEERING:
Gene tagging (T-DNA tagging and Transposon tagging). Transgenics, Gene Knockouts and Gene knock down Technologies (Antisense technology, RNAi in gene silencing, mi RNA). Gene Therapy, Strategies of gene delivery (Direct and Indirect). Genome editing (CRISPR-Cas, ZFNs, and TALENs) and its applications. Site-directed Mutagenesis and Protein Engineering.

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COURSE OUTCOMES:

CO1: The goal of the instructor in this course is to introduce the students to the concept of molecular biology viz. regulation of gene expression, posttranscriptional, post translational modifications.
CO2: Acquire sufficient knowledge of molecular tools and techniques in genetic engineering.
CO3: Impart students an understanding of various gene cloning vectors and gene cloning strategies.
CO4: Acquire advanced level knowledge of techniques involved in gene expression and protein engineering.
CO5: Understand the role of transgenic technology, antisense technology and CRISPER technology.

TEXT BOOKS:

1. "Molecular Biology of the gene" by Waston et al 4th edition.
2. "Genes VII" by Benjamin Lewis
3. Molecular Biology: Principles of Genome Function 2nd Edition by Nancy Craig , Rachel Green , Carol Greider , Gisela Storz , Cynthia Wolberger , Orna Cohen-Fix
4. Principles And Techniques Of Biochemistry And Molecular Biology, Wilson And Walkers 8Ed (Sae) (Pb 2018)
5. Gene Cloning and DNA Analysis: An Introduction 7th Edition by T. A. Brown
6. An Introduction to Genetic Engineering 3rd Edition by Desmond S. T. Nicholl

REFERENCE BOOKS:

1. Biochemistry and Molecular biology, William H. Elliott and Daphne C. Elliott, Third Edition, Indian edition, Oxford University press, 2005.
2. Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000.

3. Principles of Gene manipulation, Introduction to Genetic Engineering : R W Old, S B Primrose.

FIRST SEMESTER (Program Elective- I) (Based on the Educational Background)

PO1	PO2	PO3	PO4
M	M	S	S

2. PROCESS ENGINEERING PRINCIPLES

UNIT-I: PROCESS CALCULATIONS & THERMODYNAMICS: Overview of Chemical Engineering, Concepts of Unit operations & Unit processes with examples, Units & Dimensions, Stoichiometric principles, Law of conservation of mass.

Thermodynamics: Scope of Thermodynamics, Force, Temperature, Volume, Pressure, Work, Energy, Heat, Heat capacities, Enthalpy, Law of thermodynamics.

UNIT-II MATERIAL & ENERGY BALANCE:

Material Balance Calculations: Law of conservation of mass, General material balance equation, Material balance calculations without chemical reactions, Material balance calculations with chemical reactions, Recycling, Bypass, Purge, Analysis of degrees of freedom.

Energy Balance Calculations: General energy balance equation, Internal energy, Enthalpy, Heat capacity of gases, liquids, and solids, Latent heats, Heats of formation, combustion, reaction and dissolution, Enthalpy-concentration chart, Fuel heating value, Theoretical flame temperature, Energy balance calculations in unit operations and systems with and without chemical reactions,

UNIT-III: UNIT OPERATION & FLUID MECHANICS:

Unit Operation: Introduction, Characterization of solid particles, Screen analysis, Size reduction – law of crushing, various types of size reduction equipment.

Fluid Mechanics: Fluid Flow, Newton's law of viscosity, Classification of Fluids, Hydrostatic Pressure, Manometers, Continuity equation, Bernoulli's equation & Its applications, Navier-stoke's equation and Euler equation. Metering & Transportation of fluids using orifice meter, venture meter & Rota meter, Stream function, potential function.

UNIT-IV: HEAT TRANSFER: Modes of heat transfer with examples, Conduction – Fourier's law, one dimensional conduction through plane wall, composite wall, cylinder and spherical system. **Convection:** Introduction, natural and forced convection, Concept of heat transfer coefficient, relationship between Individual and overall heat transfer coefficient. **Radiation:** Introduction, Black body, Laws of black body radiation; Kirchoff's law, Stefan-Boltzmann law, Wein's displacement law.

UNIT-V: MASS TRANSFER: Introduction, Molecular diffusion, Fick's law of diffusion, diffusivities of gases and liquids, Theories of mass transfer, Concept of mass transfer coefficients, Principles of Absorption, Adsorption, extraction, Distillation and Drying.

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COURSE OUTCOMES:

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

CO1: Understand the basic process engineering concepts of unit operations, unit processes and concept of thermodynamic principles.

CO2: Apply and analyze theories in unit operations and fluid flow machineries.

CO3: Evaluate the heat transfer rate in different modes of heat transfer systems.

CO4: Apply various laws of radiation in heat transfer equipment.

CO5: Apply various theories of mass transfer in mass transfer equipment.

TEXT BOOKS:

1. Unit operations of Chemical Engineering, by W.L. McCabe, J.C. Simth and Harriott, McGraw Hill publishers.

REFERENCE BOOKS:

1. Bioprocess Engineering principles By Pauline M Doran, Academic Press.
2. Unit Operations-1, K. A. Gavhane, Nirali Prakashan Publication.

3. Introduction to Biochemical Engineering, Second edition, By D.G. Rao, Tata McGraw Hill Publications.

FIRST SEMESTER (Program Elective- I)

PO1	PO2	PO3	PO4
S	S	M	S

3. IMMUNOTECHNOLOGY

UNIT- I: IMMUNE SYSTEM

Phylogeny of Immune System - Innate and acquired immunity - Clonal nature of immune response, antigens, immunogens, super antigens. MHC. Cells and Organs of the immune system. Hematopoiesis and differentiation, Macrophages, Dendritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils and Mast-Cells. Lymphoid Organs: Lymphoid follicle, Thymus, Lymph node, Spleen, MALT, GALT, SALT.

UNIT- II: HUMORAL IMMUNITY

B cell types, B cell receptors and activation, Immunoglobulin diversity, Antibody structure and function, Antigen-Antibody Interactions (including ADCC), CDC antibodies in diagnosis, Hybridoma technology, B cell memory.

UNIT - III: CELL MEDIATED IMMUNITY

MHC restriction, Antigen presentation, T cell subsets and functions of each, T cell activation and regulation, Cell mediated immune functions-cytotoxicity, Interferon; T cell memory - Central and peripheral.

UNIT - IV: IMMUNO DISEASES

Immune response to infectious diseases (humoral & cell-mediated examples), Autoimmune disorders: Rheumatoid arthritis, Insulin dependent Diabetes Mellitus, cells and organs transplantation, Graft rejection and psoriasis.

UNIT - V: IMMUNOTHERAPY, VACCINES AND ADJUVANTS

Vaccines – Types, Technologies, Adjuvants–Function, Mechanism of action, New generation adjuvants, Immunotherapy – antibodies (polyclonal & monoclonal), Cytokines, Cell therapy & diseases (HIV, HCV).

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COURSE OUTCOMES:

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

CO1: Classify innate immunity, nature of antigens and cells and organs of immune system

CO2: Equipped with the knowledge of humoral immunity, antigen – antibody interactions and hybridoma technology

CO3: Thorough understanding of MHC and cell mediated immunity

CO4: Classify and evaluate autoimmune disorders and the role of immune system in transplantation

CO5: Evaluate role immune system in infectious diseases and immunotherapy

TEXT BOOKS:

1. Kuby Immunology (Kindt, Kuby Immunology) - Thomas J. Kindt, Barbara A. Osborne, Richard A. Goldsby, publisher: W. H. Freeman, 2006.
2. Immunology- David Male, Jonathan Brostoff, David Roth, Ivan Roitt, publisher: Mosby, 2006.

REFERENCE BOOKS:

1. Fundamental Immunology- William E Paul, publisher: Lippincott Williams & Wilkins, 2008
2. Immunology, Infection, and Immunity - Gerald B. Pier, Jeffrey B. Lyczak, Lee M. Wetzler, publisher: ASM Press, 2004
3. Lecture Notes: Immunology, 5th Edition- Ian Todd, Gavin Spickett, publisher: Wiley-Blackwell, 2005
4. Immunology: A Short Course- Richard Coico, Geoffrey Sunshine, publisher: Wiley-Blackwell, 2009

5. Cellular and Molecular Immunology- Abul K. Abbas MBBS, Andrew H. Lichtman MD PhD, Shiv Pillai MD, publisher: Saunders, 2007.

FIRST SEMESTER (Program Elective- II) (Based on the Educational Background)

O1	PO2	PO3	PO4
M	L	S	S

1. BASIC MATHEMATICS

UNIT-I: DIFFERENTIAL CALCULUS:

Functions, limits, continuity and differentiation (only basics). Differentiation of sum, product and quotient of function. Differentiation of implicit, explicit, trigonometric, inverse trigonometric functions; Partial differentiation (Basics).

UNIT-II: INTEGRAL CALCULUS:

Basics, Methods of substitution integration by parts. Integration of rational, irrational, trigonometric functions (Basics), Definite integrals (Basics); Trapezoidal rule, Simpsons 1/3 rule, Simpsons 3/8 rule.

UNIT-III: MATRICES:

Basics, addition, subtraction, multiplication and Determinants of Matrices (Basic concept). Co-factors of matrix, Adjoint, inverse of a matrix, Real matrices: Symmetric, Skew symmetric and Orthogonal Matrices, Rank of matrix (Basics)-Det Method.

UNIT-IV: INTRODUCTION- DEFINITION AND SCOPE OF BIOSTATISTICS:

Concept of Probability-definition of Probability- addition and multiplication laws of probability (without proofs) and examples. Population – Sample- primary data and Secondary data- graphical and diagrammatic representation of data. Measure of central tendency: Mean, median and mode. Measure of dispersion: Range – standard deviation, Mathematical Expectation, Skewness, Curtosis.

UNIT-V: STATISTICAL OPTIMIZATION TECHNIQUES:

Estimation, types of estimation, estimation of parameters. Testing of Hypothesis: Z-test; Correlation & Regression; Coefficient of correlation – Regression coefficient – The lines of regression (Basics).

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COURSE OUTCOMES:

At the end of the course students will be able to

CO1: Attain knowledge of the Functions, limits, continuity and differentiation

CO2: Analyse integral calculus

CO3: Solve real matrices

CO4: Understand the various concepts of biostatistics

CO5: Evaluate various concepts of statistical optimization techniques.

TEXT BOOKS:

1. Statistical methods S.P.Gupta. S Chand Pubplications
2. Business Statistics by S.P Gupta & M.P.Gupta
3. Engineering Mathematics- N.P. Bali and others.
4. Engineering mathematics - B.V. Ramana
5. Fundamentals of Statistics, Gupta.M.K. Goon A.M, The world press, 2012.
6. Introduction to the theory of statistics, 3rd edition, Mood.A.M. Graybill, F.A & Boes. D.C (2007)
7. Probability and statistics by Rukmangada chari . E, Pearsln publications.

REFERENCE BOOKS:

1. Differential Calculus - Shanthi Narayan
2. Integral Calculus -Shanthi Narayan

PO1	PO2	PO3	PO4
S	S	M	S

FIRST SEMESTER (Program Elective -II)

2. FERMENTATION TECHNOLOGY

UNIT-I: INTRODUCTION AND METHODS IN MICROBIOLOGY: History, Scope & milestones of microbiology, Ultra-structural organization of prokaryotic and eukaryotic cells. Isolation, and screening methods for industrially important microorganisms, Primary screening and secondary screening.

UNIT-II STRAIN IMPROVEMENT & PRESERVATION TECHNIQUES: Strain selection and Strain improvement by selection of induced mutants for primary metabolites, Auxotrophs mutant, induced mutant for secondary metabolites, Isolation of Auxotrophic, Resistant, Revertant mutants. Recombinant DNA techniques, protoplast fusion, conjugation, and transformation for strain development, culture preservation techniques.

UNIT-III: MICROBIAL GROWTH, MEDIA COMPONENTS AND MEDIA DESIGN: Microbial growth: Microbial growth curve - mathematical expression of growth, classification of microbes based on physical factors (pH, temperature, O2 requirement).
Media formulation: Microbial nutrition and types of microbial culture media, Different components of microbial culture medium and their physiological role in microbial growth, raw materials used in preparation of medium.

UNIT-IV: INNOCULUM DEVELOPMENT, STERILIZATION, & FERMENTATION OPERATIONS: Innoculum Development, Sterilization: Introduction, media sterilization, sterilization kinetics decimal reduction time, Design of batch sterilization process & Continuous sterilization process, sterilization of fermentor, sterilization of feed, sterilization of air and filter design. Fermentors: Fermentation equipment and its uses, types of fermentors and different fermentation modes. Perfusion technology.

UNIT-V CASE STUDIES: Antibiotics - Penicillin, Streptomycin; Organic acids – Citric acid, Lactic acid, Alcoholic beverages – Ethanol, Beer, Wine. Monoclonal antibodies (mAb's) and Bio- therapeutics Eg.: Insulin, vaccines. Food industry: Bakers' yeast and bread making, rennet and other proteolytic enzymes in cheese making, production of different cheeses.

COURSE OUTCOMES:

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

CO1: Acquire the knowledge of isolation and identification of microorganisms.

CO2: Determine the mathematical expression of microbial growth kinetics & media formulation

CO3: Design the process of fermentation

CO4: Explain the production process of r DNA based products

CO5: Explain the production process of food and allied products

TEXT BOOKS:

1. "Principles of fermentation technology" by P F Stanbury and A Whitaker, Pergamon press (1984).
2. Industrial Microbilogy by A.H. Patel, Macmillan India Ltd.
3. Industrial Biotechnology by S.N. Jogdand, First edition, Himalaya Publishing House, (2006).

REFERENCE BOOKS:

1. "General Microbiology" 5th Edition Stanier et al.
2. "Enzymes in food processing" by Gerald Reed, Academic press.
3. "Comprehensive Biotechnology" Vols III & IV, Editor M.Moo young.

4. "Industrial Microbiology" by Prescott
5. "Industrial Microbiology" by Casida.

FIRST SEMESTER (Program Elective- II)

PO1	PO2	PO3	PO4
S	S	M	S

3. ANIMAL CELL AND TISSUE ENGINEERING

UNIT-I: BASICS OF ANIMAL CELL CULTURE:

Structure and organization of an animal cell, Types of animal cell culture – cell culture, organ/ tissue culture, organotypic culture and histotypic culture, Equipments and materials needed for animal cell culture technology.

UNIT-II: CELL CULTURE MEDIA AND FEED:

Introduction to the balanced salt solutions and growth medium, Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, Role of carbon-di-oxide and role of serum and its supplements in maintaining cells in culture medium, Serum and protein free defined media and their application.

UNIT-III: BASIC TECHNIQUES OF MAMMALIAN CELL CULTURE:

Primary and established cell lines, Biology and characterization of the cultured cells, growth kinetics. Maintenance of cell culture, Cell separation, Cell transformation, Cell synchronization, Measurement of viability and cytotoxicity, Apoptosis–characteristic features and molecular mechanisms, Measurement of cell death.

UNIT-IV: ENGINEERING ANIMAL CELLS:

Cell culture-based vaccines, Engineering animal cells for recombinant protein expression. Stable cell line generation, expression analysis.

UNIT-V: APPLICATIONS OF ANIMAL CELL CULTURE:

Scaffolds- types, preparation. Three-dimensional culture and tissue engineering, artificial organs. Applications of animal cell culture.

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COURSE OUTCOMES:

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

CO1: Understand I basics of animal cell and its culturing

CO2: Evaluate the preparation of animal cell culture medium and its components and their significance

CO3: Apply and evaluate the basic techniques of mammalian cell culture

CO4: Engineer animal cells for the production of recombinant proteins

CO5: Apply the concepts of animal cell culture in research

TEXT BOOKS:

1) Culture of Animal Cells, (3rd Edition), Fl. !an Froshney. Wiley-Liss.
2) Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD,
3) Cell Growth and Division: A Practical Approach. Ed. R. Basega, IRL Press.

REFERENCES:

1. Cell Culture Lab Fax. Eds. M Butler & M. Dawson, Bios Scientific Publications Ltd..Oxford.
2. Animal Cell Culture Techniques. Ed. Martin Clynes, Springer.
3. Methods in Cell Biology, Vol. 57, Animal Cell Culture Methods. Ed. Jenni P Mather and David Barnes. Academic Press

FIRST SEMESTER

PO1	PO2	PO3	PO4
S	S	M	S

RESEARCH METHODOLOGY AND IPR

Unit I: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit II: Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit III: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit IV: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit V: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

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COURSE OUTCOMES:

At the end of this course, students will be able to

CO1: Understand research problem formulation

CO2: Analyze research related information and Follow research ethics

CO3: Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

CO4: Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

CO5: Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

REFERENCES:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd , 2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.

6. Asimov, "Introduction to Design", Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

FIRST SEMESTER (LABORATORY - I)

PO1	PO2	PO3	PO4
S	S	M	S

UNIT OPERATIONS IN BIOTECHNOLOGY LAB

LIST OF EXPERIMENTS:

Fluid mechanics

1. Reynold's apparatus
2. Bernoulli's Theorem (Verification)
3. Determination of friction factor of Pipeline
4. Determination of Coefficient of Discharge by venturimeter, orifice meter, rotameter and notches

Heat Transfer

1. Thermal Conductivity of insulating material
   a. Concentric sphere
   b. Lagged pipe
2. Heat Transfer coefficient from a vertical tube and free convection
3. Thermal Conductivity of Metal Rod
4. Single Effect Evaporator
5. Shell & Tube Heat Exchanger

Mass Transfer

1. Vapour- liquid equilibrium
2. Vapour in air diffusion apparatus
3. Kinetic of dissolution of benzoic acid

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COURSE OUTCOMES:

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

CO1: Classify the basic concepts of fluid mechanics

CO2: Assess and evaluate heat transfer techniques

CO3: Classify the basic concepts of mass transfer

FIRST SEMESTER (LABORATORY - II)

PO1	PO2	PO3	PO4
S	S	S	S

BIOCHEMISTRY & MOLECULAR BIOLOGY LAB

LIST OF EXPERIMENTS:

1. Estimation of Reducing and Non reducing sugars.
2. Estimation of proteins
3. Estimation of DNA
4. Paper and TLC Chromatography of amino acids.
5. SDS PAGE
6. Isolation of Genomic and Plasmid DNA from E. coli
7. Restriction digestion
8. Ligation
9. Preparation of competent cells
10. Transformation & checking for transformants
11. Electrophoresis of nucleic acids

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COURSE OUTCOMES:

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

CO1: Estimation of bio molecules

CO2: Understand process of DNA, plasmid isolation and their transformation in to host cells

CO3: Analyze the separation of compounds on gels

SECOND SEMESTER (PROGRAM CORE-III)

PO1	PO2	PO3	PO4
S	S	M	S

DOWNSTREAM PROCESSING

UNIT-I: SCOPE OF DOWNSTREAM PROCESSING: Importance of Down Stream Processing (DSP) in Biotechnology, characteristics of products, criteria for selection of bio-separation techniques. Role of DSP methods in bioprocess economics. **Cell Disruption Methods:** Various cell disruption methods, need for cell disruption for intracellular products (Homogenizer, French press, & Dynomill), cell disruption equipment. Applications in bio-processing. Flocculation & coagulation**.**

UNIT-II PHYSICAL METHODS OF SEPARATION: Sedimentation: Principles of particle settling, batch sedimentation equipment viz., thickener. **Filtration:** Principles, filter aids, Types of filtrations, depth filtration, constant volume filtration, constant pressure filtration, specific cake resistance, equivalent cake thickness, filtration equipments viz; plate and frame filter press, vacuum filters, leaf filters. **Centrifugation:** Principles of centrifugation, centrifuge effect, g-number, sigma factor, various centrifuges viz., basket centrifuge, tabular centrifuge, disc-bowl centrifuge, scale –up of centrifuges.

UNIT-III: ISOLATION OF PRODUCTS: Precipitation: Principles of precipitation, precipitation equipment, applications in bio- processing. **Adsorption:** adsorption equilibria and isotherms, principles of adsorption, adsorption equipment, applications **Liquid-liquid Extraction;** Extraction process and principles, phase equilibrium and distribution, batch and continuous extraction, co-current and counter current extraction processes, L-L-E equipment. Applications in bio-technology. Basic principles of membrane separation, membrane characteristics, different types of membranes, criteria for selection of membranes.

UNIT-IV PRODUCT PURIFICATION:
Chromatography: Principles of chromatographic separation methods, different types of chromatographic methods, viz., adsorption chromatography, ion – exchange chromatography (Anion and cation), Size-exclusion chromatography (SEC), affinity chromatography, Hydrophobic interaction chromatography, (HIC), with applications in bio-processing. Protein refolding methods.

UNIT-V: FINAL PRODUCT FORMULATION AND FINISHING OPERATIONS:
Crystallization: Principles of crystallization, crystallization equipment. Applications in bio-processing. **Drying:** Various types of drying methods, principles of drying, EMC-RH data, drying curves, various types of industrial dryers and their criteria for choice. Freeze drying technique and its advantages over other methods. Applications in bio-processing.

COURSE OUTCOMES:
At the formal end of the course student will be able to
CO1: Understand the fundamentals downstream purification steps, role of bioprocess economics and cell disruption methods.
CO2: Classify solid liquid separations techniques
CO3; Understand the techniques used for product isolation
CO4: Evaluate the product purification techniques
CO5: Evaluate evaporation, crystallization, and drying methods.

TEXT BOOKS:
1. Genekopolis, Transport phenomena and Unit Process Third edition.
2. Bailey and Ollis, Biochemical Engineering Principles, Second Edition
3. Blanch, Biochemical Engineering, Second Edition,1996

4. Mc Cabe and Smith, Unit Operations in chemical Engineering Seventh Edition
5. Principles of Fermentation Technology by Peter F Stan bury, Allan Whitaker and Stephen J Hall, Pergamon Publications. Second Edition

REFERENCE BOOKS:

1. Separation Process in Biotechnology edited by Juan A. Asenjo, Taylor & Francis Group

SECOND SEMESTER (PROGRAM CORE-IV)

PO1	PO2	PO3	PO4
S	M	S	S

BIOPROCESS ENGINEERING

UNIT-I: INTRODUCTION TO ENGINEERING CALCULATIONS & MATERIAL BALANCE:

Introduction to engineering Calculations; physical variables, dimensions and units, force & weight, measurement conventions, standard conditions and ideal gas. Procedure for Material Balance calculations, Material Balance worked examples, Material Balances with Recycle, Bypass and Purge streams, Stoichiometry of cell growth and product formation.

UNIT-II: ENERGY BALANCES:

Basic Energy concepts, General Energy Balance Equations, Enthalpy calculation procedures, Enthalpy change in non-reactive processes, procedure for Energy Balance calculations without reaction. Energy Balance worked Examples without reaction, Enthalpy change due to reaction, Heat of reaction for process with biomass production, Energy Balance calculation for cell culture, cell culture Energy Balance worked Examples.

UNIT-III: MEDIA OPTIMIZATION AND STERILIZATION:

Media Optimization: Optimization techniques with special emphasis on statistical techniques, Placket-Burman design, ANOVA, central composite design, response surface methodology.

Sterilization: Media sterilization, Kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization, coupling of Arrhenius equation and cell death kinetics, sterilization of air and filter design, Radiation and Chemical sterilization.

UNIT-IV: UNSTRUCTED MODEL FOR MICROBIAL GROWTH:

The development of different microbial growth kinetics like Malthus, Pearl and reed, Monad Model, Konark Model. The limitation of Monod model and development of other constitutive models of growth. Multi-substrate models, inhibition models for substrate, Product and toxic substances. Development of logistic equation. Maintenance and endogenous metabolism kinetics.

UNIT-V: STRUCTURED MODELS OF MICROBIAL GROWTH:

Kinetics based on molecular mechanism, Compartmental models, Model of Cellular Energetics and Metabolism, Models of product formation, single cell model, Models of gene expression and regulation, Plasmid Expression and Replication, Model of plasmid stability, parameter estimation, Model validation and bioprocess optimization.

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COURSE OUTCOMES:

At the end of this unit students understand

CO1: thermodynamic principles, Material balance and stoichiometry.
CO2: the knowledge about energy balances calculations, heat reactions.
CO3: expertise in Sterilization process, kinetics and media optimization techniques.
CO4: microbial growth for unstructured models and its kinetics.
CO5: microbial growth for structured models and its kinetics.

TEXT BOOKS:

1. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker (1987)
2. Pauline M. Doran: Bioprocess Engineering Principles, Elsevier Publications.

REFERENCE BOOKS:

1. Biochemical Engineering Principles and functions by Syed Trnveer Ahmed Inamdar, PHI Learning Private

limited.
2. Wiseman, A: Handbook of Enzyme Biotechnology, 3rd Edition, Ellis Horwood Publication (1999)
3. Moser, A; Bioprocess technology, kinetics and reactors; Springer Verlag, (1988)
4. Schugerl K: Bellgart K H (Eds); Bioreaction Engineering, Modeling and control; Springer – verlog, berlin (2000)
5. Introduction to Biochemical Engineering by D G Rao. Tata, McGraw Hill, New Delhi.
6. Bailey JE, Ollis DF; Biochemical Engineering fundamentals (1986).

PO1	PO2	PO3	PO4
S	S	M	S

SECOND SEMESTER (PROGRAM ELECTIVE-III)

1. BIOINFORMATICS AND SYSTEMS BIOLOGY

UNIT-I: INTRODUCTION TO BIOINFORMATICS & SEQUENCING ALIGNMENT CONCEPTS: Need of Computers in Biotechnology Research; File Transfer Protocol (FTP), Bioinformatics- Introduction, Scope, Applications; Pair wise Alignment-Local, Global alignment; Gap- Gap penalty; Comparison of Pairwise and Multiple alignment.

UNIT-II: BIOLOGICAL DATABASES AND DATAMINING: Biological Information on the web, Introduction to databases; Classification of Biological databases; Information retrieval from Databases; Sequence database search- FASTA, BLAST; Amino acid substitution matrices- PAM and BLOSUM; Data Mining and Visualization (PyMOL). **Phylogenetic Analysis and Prediction:** Common Multiple Sequence alignment methods; Phylogenetic analysis: Methods, Tools (Clustal W).

UNIT-III: GENOME MAPPING AND PREDICTION: Genome sequencing; Genome Mapping; Comparative Sequence Analysis; Gene Prediction Methods &Tools, Gene Annotation; Human Genome project (HGP). **RNA SEQUENCE AND STRUCTURE ANALYSIS** - si-RNA design and development, micro RNA identification strategies, RNA secondary structure, RNA structure Prediction Methods.

UNIT-IV: PROTEIN STRUCTURE PREDICTION METHODS: Basics of Protein biology (Classification, Structural Organization, Domains & Motifs); Protein Structure Prediction Concepts : Secondary & Tertiary Structure Predictions (Chou-Fasman Method, GOR Method, Neural Network method, Homology Modeling, Abintio method, Threading methods).

UNIT V: INTRODUCTION TO SYSTEMS AND SYNTHETIC BIOLOGY: Genomics, transcriptomics, proteomics and metabolomics as a foundation for Systems Biology, Objectives of Systems Biology – holistic approach to solve biological problems, Strategies relating to *in silico* modeling of biological processes, Gene, protein and metabolic networks, Signal transduction pathways, Gene expression patterns, Synthetic Biology – Introduction and Artificial synthesis of DNA, peptides and chromosomes – Applications.

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COURSE OUTCOMES:

At the formal end of the course students will be able to

CO1: Understand the specific features of computational and bioscience and evaluate the computational fundamentals which are useful for bioinformatics programming.

CO2: Classify different Databases, data retrieval process, data mining and important Visualization tools in Proteomics.

CO3: Evaluate the evolutionary relationships between species and the sequence alignment tools and process for sequence comparisons to know the relationship between the species

CO4: Evaluate the sequencing and mapping of genomes and RNA design and development

CO5: Design Protein modeling and structure prediction of unknown proteins.

TEXT BOOKS:

1. Bioinformatics: Methods and Applications- SC Rastogi, N Mendiratta & P Rastogi.
2. Bioinformatics Basics, Applications in Biological Science and Medicine- Hooman

3. Bioinformatics: Genome and sequence analysis by David W Mount.
4. Principles of biological Databases by P. B. Kavi kishor and L.N. Chavali.

REFERENCE BOOKS:

PO1	PO2	PO3	PO4
S	S	M	S

1. Computational Molecular Biology – An Introduction by Peter Clote, Rolf Backofen, John Wiley & Sons.
2. Essential Bioinformatics: by Jin Xiong, Cambridge University Press
3. Bioinformatics Principles & Applicatrions by Zhumur Ghosh, Oxford University Press.

SECOND SEMESTER (PROGRAM ELECTIVE-III)

2. BIO NANOTECHNOLOGY

Unit–I: Micro/Nanomachining and Fabrication of Materials for Biomedical Applications: Introduction, Overview of Ion Implantation Process, Micro/Nanomachining of Soft Polymeric Biomaterials, Micro/Nanomachining of Hard Metallic Biomaterials, Novel Biocompatible Photoresists, Three-Dimensional Lithography.

Unit–II: Nanotechnology and Drug Delivery: Introduction, Advantages of Nanostructured Delivery Systems, Activation and Targeting of Nanotechnology-Based Drug Delivery Systems (Externally and Internally), Drug Targeting through Targeting Molecules, Multifunctional Nanoparticle Systems, Exploiting Inherent Material Properties.

Unit–III: Cell Behavior Toward Nanostructured Surfaces: Introduction, Nanotopographic Surfaces: Fabrication Techniques, Cell Behavior Toward Nanotopographic Surfaces Created by: Electron Beam Lithography, Photolithography,Composed of Aligned Nanofibers by Electrospinning, Nanoimprinting, Self-Assembly,Phase Separation, Colloidal Lithography, Composed of Random Nanofibers, Electrospinning, Chemical Etching, Incorporating Carbon Nanotubes/Nanofibers, Polymer Demixing.

Unit–IV: MultiscaleCoculture Models for Orthopedic Interface Tissue Engineering: Introduction, Cellular Interactions and the Soft Tissue-to-Bone Interface, Types of Coculture Models, Coculture Models for Orthopedic Interface Tissue Engineering, Macro- and MicroscaleCoculture, Two-Dimensional (2D) and Three-Dimensional (3D) Cocultures, Mechanism of Cellular Interactions During Coculture.

Unit–V: Nanostructures for Tissue Engineering/Regenerative Medicine: Introduction, Nanofibrous Scaffolds, Surface Patterned Scaffolds, Relevance of Nanostructured Scaffolds in Regenerative Medicine, Role of Nanostructured Scaffolds in Tissue Engineering

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COURSE OUTCOMES:

CO1: Students can able to develop deep understanding of Biomedical Application.

CO2: Student can able to compile all the Drug Delivery Systems.

CO3: To know the importance of Cell Behavior Toward Nanostructured Surfaces.

CO4: To prioritize the role of Orthopedic Interface.

CO5: To gain the improvements in Tissue Engineering/Regenerative Medicine and the Nanostructures for Cancer Diagnostics.

TEXT BOOKS:

1. Bio-Medical nanostructures edited by Kenneth Gonsalves, Craig R Halberstadt, Wiley Interscience A John Wiley & Sons, Inc., Publication
2. Introduction to Nanotechnology by Charles. P.PooleJr and Frank J. Owens, Wiley India Pvt Ltd.
3. Nano Technology, A gentle introduction to the next big idea by Mark Ranter and Daniel Ranter, Pearson education.

PO1	PO2	PO3	PO4
S	S	M	S

REFERENCE BOOKS:

1. Encyclopedia of Nanotechnology by H.S.Nalwa
2. Encyclopaedia of Nanotechnology by M.BalakrishnaRao and K.Krishna Reddy (Vol I to X).

SECOND SEMESTER (PROGRAM ELECTIVE-III)

3. CANCER BIOLOGY

UNIT I: Introduction: Cancer Definition, History of Cancer Research, Overview of the hallmarks of cancer, Warburg effect, Types of growth: Hyperplasia, Dysplasis, Anaplasia and Neoplasia. Nomenclature of neoplasms. Differences between benign and malignant tumors. Tumor microenvironment from monolog to dialog, Stem cells and epigenetics, Cell cycle control, regulation of the cell cycle by cyclins, cyclin-dependent kinases, Cdk inhibitors

UNIT II: Carcinogenesis: Radiation and chemical carcinogenesis, Stages in chemical carcinogenesis- Initiation, promotion and progression. Freeradicals, Antioxidants in cancer. Telomerases, Tumor suppressor genes, Molecular tools for identifying cancer genes

UNIT III: Oncogenes and cell signaling: Tumor markers, cellular proto oncogenes, Mechanisms of oncogene activation, growth factors and receptors as oncogenes, Retroviruses and Oncogenes, G-protein coupled receptors in development of cancer, Apoptosis, RAS signaling in cancer.

UNIT IV: Angiogenesis, Metastasis & Cancer stem cells: Metastasis, Principles of cancer metastasis, Classic theory of tumor Metastasis, Metastatic cascade, Epithelial-Mesenchymal Transition and Dissemination from the Primary Tumor, Cancer in Transit: Dynamics and Behaviors of Circulating Tumor Cells (CTCs), Cancer stem cells, Case study: Breast cancer & Colon cancer

UNIT V: Cancer Diagnosis & Treatment Strategies: Familial cancer syndromes, Genomic Screening, Biomarkers technology and nanotechnology in screening, traditional chemotherapy, Mode of action and metabolism of chemotherapeutic drugs, Immunotherapy, targeted therapy, Chemoprevention.

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COURSE OUTCOMES:

At the end of the course student will be able to

Understand the basic concepts of cancer, types of tumors and concept of cell cycle regulation.

CO1. Evaluate the impact of tumor suppressor genes, physical, chemical carcinogens and free radicals impact on carcinogenesis

CO2. Estimate the role of oncogenes and their mechanisms

CO3. Analyze principles of metastasis and cancer stem cells

CO4. Understand various cancer syndromes, screening approaches and treatment strategies for cancer.

CO5. Understand various cancer syndromes screen approaches and treatment strategies for cancer

TEXT BOOKS:

1. The Biological Basis of Cancer: R. G. McKinnell, et al 2nd Ed, Cambridge University Press, 2006.
2. The Biology of Cancer: R.A.Weinberg. GarlandScience. 2006.

3. The Molecular Biology of Cancer: S. Pelengaris, M.Khan. Blackwell Publication.
4. Introduction to modern Virology, Dunmock N.J and Primrose.S.B.,Blackwel Scientific Publications.Oxford,1988.

PO1	PO2	PO3	PO4
S	S	M	S

REFERENCE BOOKS:

1. An Introduction to Cellular & Molecular Biology of Cancer, Oxford Medical publications,1991
2. Gene expression systems. JosephM.Fernandez & JamesP.Hoeffler. AcademicPress,1999.
3. Cancer Biology IV Ed Volume2 Raymond WRuddon M.D.(2007)
4. Cancer Biology(3rd_Edition)Roger J.B. etal(2006)
5. Advances in Cancer Stem Cell Biology, Roberto Scatena, Alvaro Mordente & BrunoGiardina(Ed) Springer(2012).

SECOND SEMESTER (PROGRAM ELECTIVE-IV)

1. PLANT BIOTECHNOLOGY AND MOLECULAR PHARMING

UNIT I APPLICATIONS OF PLANT BIOTECHNOLOGY: Totipotency, Techniques, Chemical and Physical Requirements, Micropropagation (Somatic Embryogenesis, Organogenesis, Shoot tip culture) Applications. Production of Haploids, isogenic lines and Applications. Germplasm Conservation, Somaclonal Variations.

UNIT II SOMATIC HYBRIDIZATION AND SECONDARY METABOLITE PRODUCTION: Protoplast isolation, culture and regeneration. Protoplast fusion techniques and applications, Selection systems for somatic hybrids, Characterization of somatic hybrids. Production of Secondary Metabolites by Plant Cell Cultures, Technology for Yield Enhancement, Bioreactor Models for scale up of various type of plant cell cultures. Metabolic Engineering of Secondary Metabolic Pathways.

UNIT III TRANSGENIC TECHNOLOGY: Genetic Transformation Techniques for production of transgenic plants: Direct gene transfer techniques, *Agrobacterium* mediated Transformation, Chloroplast transformation for production of transplastomics, Transient transformation and *In Planta* transformation.

UNIT IV GENETIC ENGINEERING OF PLANTS: Production of Genetically Modified Plants/Crops for Biotic Stress (Insect, herbicide, Bacteria, Fungi and Viruses) and Abiotic Stress, Hybrid seed production, Carbohydrate metabolic engineering, Improvement of Plant Oils, Production of Biodegradable Plastics in Plants.

UNIT V MOLECULAR PHARMING: APPLICATION AS PROTEIN FACTORIES:

Molecular Pharming Strategies, Relevance and Bottlenecks. Production of Industrial Enzymes, Edible Vaccines, Plantibodies, Lysosomal Enzymes and Therapeutic Proteins and Applications.

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COURSE OUTCOMES:

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

CO1: The goal of the instructor in this course is to introduce the students to the concept of totipotency in plants and its various applications in development of pure breeding lines, germplasm conservation and production of variants.

CO2: Impart students an understanding of somatic hybridization for production of hybrid plants and advantages of plant cell cultures for production of pharmaceutically important secondary metabolites.

CO3: Acquire advanced level knowledge of Transformation techniques for transgenic plant production with their advantages and limitations

CO4: Impart students advanced level of knowledge of genetically modified plants for various traits for enhancing the productivity of the crops and quality traits.

CO5: Understand the role of plants as expression systems for production of therapeutic proteins viz. edible

vaccines, plantibodies and lysosomal enzymes. The course shall expose students to the challenges encountered in the area of plant biotechnology.

TEXT BOOKS:

1) Plant Cell, Tissue, and Organ culture" by J Reinert and Y P S Bajaj.
2) Plant Tissue Culture Theory and Applications Bhojwani SS and Razdan , Elsevier Publication.
3) Molecular Farming in Plants: Recent Advances and Future Prospects 29 Nov 2013 by Aiming Wang (Editor),
Shengwu Ma (Editor)
4) Molecular Farming Hardcover – Import, 3 Jun 2016 by Holly Philips (Editor)

REFERENCE BOOKS:

1) Plant Biotechnology New Products and Applications. Hammond PM and Yusibov V. Springer, International Edition.
2) "Plant Tissue Culture" Thorpe, T.A. (Ed.).
3) "Handbook of Plant Cell Culture" Eds. Sharp et al.

SECOND SEMESTER (PROGRAM ELECTIVE-IV)

PO1	PO2	PO3	PO4
S	S	M	S

2. STEM CELL TECHNOLOGY

UNIT I: STEM CELLS & TISSUE ENGINEERING: Introduction to stem cells & Tissue Engineering, Cell sources and stem cell, Cell isolation and selection, Human tissue culture media, Culturing of cell lines-monolayer and suspension types of cultures, Biology and characterization of cultured cells, Maintenance and management of cell lines.

UNIT II: SOMATIC AND GERM CELL DERIVED STEM CELLS: Germline stem cells and germ line---derived pluripotent cells, Stem cell niche, epithelial stem cells, mesenchymal stem cells, neural stem cells, haematopoitic stem cells, cardiac stem cells, Cancer stem cells, Markers, molecular and evolutionary mechanisms addressing origin and maintenance of cancer stem cells.

UNIT III: REGULATORY MECHANISMS IN EMBRYONIC AND ADULT STEM CELLS: Core regulatory circuitry, DNA methylation, histone modifications, histone modifiers, chromatin remodelers, RNA PolII code, post transcriptional control of gene expression in ESC: role of miRNAs, LincRNAs and RNA binding proteins. Spatial organization of genome during ESC development and differentiation.

UNIT IV: STEM CELL THERAPIES AND BIOREACTORS: Generation of induced pluripotent cells, and molecular mechanism of iPSCs reprogramming. Direct differentiation. Bioreactor design on tissue engineering – Hollow fibre systems, Micro carrier-based systems.

UNIT V: STEM CELL TECHNOLOGIES: Generation of chimeric animals and animal cloning; Pro---nuclear injection of blastocysts, transplantation of blastocystes into pseudo---pregnant mice and generation of chimeric and knockout animals. Potential application of transgenic animals: Reprogramming of the nuclei and generation cloned animals. Gene editing technologies --- TALEN, CRISPR Cas9.

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COURSE OUTCOMES:

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

CO1: Understand the basic concepts of Stem cells and Tissue engineering

CO2: Attain the knowledge about somatic and germ stem cells.

CO3: Analyze the regulatory mechanism in Embryonic and adult stem cells.

CO4: Understand Stem cell therapies and Bioreactors

CO5: Applications of Stem cell technologies

TEXT BOOKS:

1. Tissue Engineering Methods and Protocols (Methods in Molecular Medicine, 18) by Jeffrey Robert Morgan (Editor), Martin L. Yarmush (Editor),
2. Tissue Engineering [Hardcover] Bernhard O. Palsson (Author), Sangeeta N. Bhatia (Author).
3. Tissue Engineering (Academic Press Series in Biomedical Engineering) by Clemens van Blitterswijk, Peter Thomsen, Jeffrey Hubbell and Ranieri Cancedda (Apr 8, 2008)

REFERENCE BOOKS:

1. Lanza R, Gaerhart J, Hogan B, Melton R, Thomas D, Thomas J, and Wilmut S. Essentials of Stem Cell Biology. Elsevier Inc.
2. Stillman B, Stewart D and Grodzicker T, Control and Regulation of Stem Cells.
3. Tursen Kursad, Stem Cell Biology and Regenerative Medicine, Humana Press.

SECOND SEMESTER (PROGRAM ELECTIVE-IV)

PO1	PO2	PO3	PO4
S	S	M	S

3. PROTEIN ENGINEERING

Unit – I: The Relationship between Protein Structure and Function: Protein synthesis, protein structure, families of protein structures: alpha, alpha/beta, and beta, etc., protein function and structure function relationships. Ramachandran plot; Motifs of protein structures and their packing. Protein folding pathways in prokaryotes and eukaryotes; Structure of chaperones and role of chaperones in protein folding; Folding of single domain and multi-domain proteins; Inclusion bodies and recovery of active proteins.

Unit – II: Methods in Protein Engineering: Strategies for protein engineering; Protein Engineering with Random Mutation, Protein Engineering with site-specific mutation, PCR based methods for engineering proteins, Role of low-fidelity enzymes in protein engineering; Gene shuffling and Directed evolution of proteins; Antibody engineering.

Unit – III: Structural Analysis of Proteins: Similar structure and function of homologous proteins; Role of multiple alignment; Homology and ab-initio method for protein structure prediction; Phage display systems; Rational protein design, different databases and their uses.

Unit – IV: Proteome analysis: Introduction to the concept of proteome, components of proteomics, proteomic analysis, importance of proteomics in biological functions, protein identification, protein arrays, protein chips and applications.

Unit – V: Protein identification methods: Cross linking methods, affinity methods, yeast hybrid systems, isotope labeling, protein identification with two-dimensional gel electrophoresis data and mass spectrometry data, Functional proteomics tools.

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COURSE OUTCOMES:

At the formal end the course student will be able to

C01: Familiar about Protein Structure and Function

CO2: Strategies for protein engineering

CO3: Protein Structural Analysis

CO4: Concept of proteome, components of proteomics, and proteomic analysis

CO5: Various protein identification methods

TEXT BOOKS:

1. Protein Engineering and Design, Anton Torres, Syrawood Publishing House, 2017.

2. Protein Engineering: Design, Selection & Applications (Protein Biochemistry, Synthesis, Structure and
Cellular Functions), Mallorie N Sheehan, Nova Science Publishers Inc; UK, 2011.

REFERENCE BOOKS:

1. Protein engineering in Industrial biotechnology, Ed. Lilia Alberghina, Harwood Academic Publishers, 2002.
2. Proteomics: Protein Sequence to Function, Pennington, S.R and M.J. Dunn, Viva Books, 2002.

SECOND SEMESTER (LABORATORY - III)

PO1	PO2	PO3	PO4
S	S	M	S

CELL CULTURE TECHNIQUES LABORATORY

LIST OF EXPERIMENTS

1. Preparation of medium.
2. Surface sterilization & establishment of aseptic culture
3. Micro propagation; callus induction, organogenesis, somatic embryo genesis
4. Cell suspension cultures.
5. Growth and production kinetics for secondary metabolite production
6. Quantification of secondary metabolites by HPLC
7. Genetic transformation studies using Agrobacterium.
8. Molecular characterization of transformants
9. Requirements of animal cell culture lab
10. Culture media preparation and sterilization
11. Cell culture from established cell lines: thawing and passaging
12. Cell counting using hemocytometer
13. Cell viability assays- MTT assay
14. Cryopreservation

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COURSE OUTCOMES:

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

CO1: Design and evaluate medium for cell and organ culture

CO2: Evaluate surface sterilization methods and production kinetics of secondary metabolite

CO3: understand basic needs of cell culture laboratory and familiarize with handling mammalian cells.

CO4: Evaluate the cell viability

SECOND SEMESTER (LABORATORY - IV)

PO1	PO2	PO3	PO4
S	S	M	S

BIOPROCES ENGINEERING LABORATORY

LIST OF EXPERIMENTS

1. Batch growth kinetics for *Saccharomyces cerevisiae*
   a) Yield coefficient
   b) Doubling time
   c) Maintenance coefficient
   d) Maximum specific growth rate
2. kLa measurement
   a) Sodium sulphite oxidation method for determination of mass transfer coefficient
   b) Dynamic gassing method for determination of mass transfer coefficient
3. Free enzyme kinetics
   a) Determination of enzyme activity for CELLULASE
   b) Effect of pH on enzyme kinetics
4. Enzyme inhibition
5. Enzyme immobilization by different methods
   a) Immobilization
   b) Kinetics
6. Precipitation (Protein or nucleic acid)
7. Sonication (Bacterial cell lysis)
8. Chromatography (Ion exchange/GPC/affinity)

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COURSE OUTCOMES:

At the end of the course, the student

CO1: can carry out microbial growth in a batch culture and determine the kinetics

CO2: can determine the enzyme activity in the sample; immobilize them and enzyme inhibition kinetics

CO3: can carry out protein purification from a given sample.

THIRD SEMESTER (PROGRAM ELECTIVE –V)

PO1	PO2	PO3	PO4
S	M	M	S

1. BIOREACTOR DESIGN & ANALYSIS

UNIT-I BIOREACTORS: Bioreactor function, utility, types of bioreactors. Modes of bioreactor operations. Main components of the bioreactor and their functions. Bioreactor design: Batch reactor, cell death in batch reactor, chemostat, endogenous metabolism, maintenance, product & substrate inhibition on chemostat, multiple steady state analysis, enzyme catalysis in CSTR, cascade reactor, plug flow reactor, fed batch reactor, Chemostat with cell recycle.

UNIT-II MASS TRANSPORT IN BIOREACTORS: Introduction of mass transfers, Gas-liquid mass transfer in cellular systems, basics mass transfer concepts, solubility of gases (O_2, CO_2) in biological media, Mass balance for two-phase bioreactor. Bubble column, bubble generation at an orifice, bubble coalescence and breakup, gas holdup, interfacial area, immobile and mobile gas liquid interface, Regimes of bubbles, Design of bubble columns. Experiment determination of k_La, static method, dynamic method and chemical method. Oxygen uptake by cell cultures.

UNIT-III MOMENTUM TRANSPORT IN BIOREACTORS:

Rheology of Fermentation Broths: Rheology Properties, Factors affecting broth viscosity, mixing equipment, Flow patterns in agitated tanks, Mechanism of Mixing, Assessing Mixing effectiveness Power requirement for mixing: Ungassed Newtonian fluids, Ungassed Non-Newtonian fluids. **Momentum transport in Stirred tank Bioreactor:** Agitator Design & Operation- Radial flow impellers, Axial flow impellers, Agitator design for low Viscous and High Viscous fluids. Laminar and turbulent flow in stirred tank bioreactors, kolmogorov eddy size, preventing vortex formation, off centre impellers, baffles. Oxygen delivery systems: Sparger design, Effect of impeller speed.

UNIT-IV: BIOREACTOR OPERATIONS & POWER REQUIREMENTS: Types of cells and bioreactors; roller bottles for cell cultures, WAVE bioreactors, stirred tank reactor, hollow fiber reactors, Airlift bioreactor, **Case Studies:** Design of Packed Bed Bioreactor, Plant Cell Bioreactor, Bioreactors for Solid State Fermentation (SSF). **Power Requirements in Bioreactors:** Power requirements in agitated fermentors, Impeller Reynolds number, and power number, Effect of number of impellers on power, Typical rheological behaviors of fermentation broths.

UNIT-V: NON-IDEAL BIOREACTOR, **SCALE-UP & DOWN OF BIOREACTOR AND CONTROL OF BIOREACTOR:** Reasons for non-ideality, RTD studies, diagnosis of IIIs of flow reactors and modeling of Non-Ideal Behaviour. Scaling up and down of bioreactors, based on rules-of-thumb viz., constant (P/V), K_La etc. Control of bioreactor, sensor used in the bioreactor, pH, O_2, CO_2 electrode.

Cell culture scale up and issues; shear damage, foaming, Issues in the scale up of microbial cultures; Fermentation raw materials issues in scale up.

COURSE OUTCOMES:

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

CO1: understand and develop the design equation for different types of bioreactors.

CO2: analyze mass transfer operation for two phase and bubble column bioreactors.

CO3: Rheology of Fermentation Broths and Momentum transport in Stirred tank Bioreactor

CO4: Design the stirred tank bioreactors for various cell cultures like plant, microbial and animal cells. estimate the mass transfer coefficient and power requirement in multiphase bioreactors.

CO5: Design the equation for scale up and scale down of bioreactor and control of bioreactors.

TEXT BOOKS:

1. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker Year of Publication 1987
2. Bioreactors Analysis and Design: Tapobrata Panda, Tata McGraw Hill Year of publication 2011

REFERENCE BOOKS:

1. Bailey JE, Ollis DF; Biochemical Engineering fundamentals Year of Publication 1986
2. Pauline M. Doran: Bioprocess Engineering Principles, Elsevier Publications.

THIRD SEMESTER (PROGRAM ELECTIVE –V)

PO1	PO2	PO3	PO4
S	M	M	S

2. MODELIING & SIMULATION IN BIOPROCESS

UNIT-I INTRODUCTION AND BALANCE EQUATIONS: Material and energy balance, General form of dynamic models, dimensionless models. General form of linear systems of equations, nonlinear function.

UNIT-II STATE SPACE MODELS FOR LINEAR AND NONLINEAR MODELS: Solution of general state-space form. Solving homogeneous, linear ODEs with distinct and repeated Eigen values. Solving non-homogeneous equation, equation with time varying parameters, Routh stability criterion.

UNIT-III TRANSFER FUNCTION: analysis of first order system, self regulating processes, lead- lag models, transfer function analysis of higher order systems, pole location, Pade approximation for dead time, converting transfer function model to state space form.

UNIT-IV BLOCK DIAGRAMS: system in series, pole-zero cancellation, block in parallel, Feedback system, Routh stability criterion for transfer functions. Discrete time models and parameter estimation. Phase plane analysis, nonlinear system, nonlinear dynamics, cobweb diagram, bifurcation and orbit diagram, stability, cascade of period doubling. Bifurcation behaviour of single ODR system and two state systems. Lorenz equation and stability analysis.

UNIT-V CASE STUDIES-I: related to linear regression and generalization of linear regression technique. Stirred tank heaters: developing the dynamic model, steady state condition. State space model. Adsorption: dynamic model, steady state analysis. Isothermal continuous stirred tank chemical reactors, Biochemical reactors: model equations, steady-state function, dynamic behaviour, linearization, phase plane analysis, multiple steady state, bifurcation behavior.

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COURSE OUTCOMES:

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

CO1: Understand the energy and material balance equations.

CO2: Analyze State Space Models for Linear And nonlinear Models
CO3: Analyze the first order and higher order systems
CO4: Estimate the discrete time models and parameters
CO5: Understand the case studies related to adsorption, continuous stirred tank reactors.

REFERENCE BOOKS:

1. Schugerl K, Bellgardt KH: Bioreaction Engineering, modeling and control: Springer-Verlag, Berlin.
2. Nielsen J and Villadsen J: Bioreaction Engineering Principles, 2nd Edition, Kluwer Academic/ Plennum Publishers, New York, 2003.

TEXT BOOKS:

1. Luyben WL: Process modeling, simulation and control for chemical engineers, 2nd edition, McGraw-Hill International, 1990.
2. Wayne Bequette B: Process Dynamics, modeling, analysis and simulation: Printice Hall, 1998.

THIRD SEMESTER (PROGRAM ELECTIVE –V)

PO1	PO2	PO3	PO4
S	M	M	S

3. BIOPROCESS INSTRUMENTATION AND CONTROL

UNIT-I INTRODUCTION TO INSTRUMENTATION IN BIO-PROCESS:
Process instrumentation: Principles of measurements and classification of process control instruments, measurements of temperature, pressure, fluid flow, liquid weight and weight flow rate, viscosity and consistency, pH, concentration, electrical and thermal conductivity, humidity of gases, composition by physical and chemical properties.

UNIT-II PROCESS DYNAMICS: Process variables-Load variables-Dynamics of simple processes. Flow, level, temperature and pressure. Interacting and non-interacting system, continuous and batch process-self - regulation-Servo and regulator operation problems.

UNIT-III FINAL CONTROL ELEMENT: I/P Converter-pneumatic, electric and hydraulic actuators-valve positioner- control valves-characteristics of control valves-valve body-Globe, butterfly, diaphragm; Ball valves- Control valve sizing-Cavitation, flashing problem. Basic control actions-characteristics of two position, three position, single speed floating.

UNIT-IV CONTROL ACTIONS AND CONTROLLERS: Proportional, Integral and derivative control modes- P+I. P+D and P+I+D control modes. Problems on pneumatic, hydraulic and electronic controllers to realize various control actions. States space model and its applications.
MULTI LOOP CONTROL SYSTEM: Feed forward control-Ratio control-Cascade control-Split range-Multivariable control and examples from distillation column & Boiler system.

UNIT-V INTRODUCTION TO FREQUENCY RESPONSE: Bode diagram, Bode stability criteria, Gain and Phase margins. Control systems design by frequency response Tuning process reaction curve method-continuous, oscillation method-damped oscillation method-problems.

COURSE OUTCOMES:
At the formal end of the course student will be able to
CO1: Understand the energy and material balance equations.

CO2: Analyze State Space Models for Linear and Nonlinear Models
CO3- Analyze the first order and higher order systems
CO4: Estimate the discrete time models and parameters
CO5: Understand the case studies related to adsorption, continuous stirred tank reactors.

TEXT BOOKS:

1. Process control, Pollard A. Heinemann, Educational Books. London,1971.
2. Process control, Harriott P., Tata McGraw- publishing Co.New Delhi. Reprint 1991.
3. J.R. Leigh: Modeling and control in bioprocesses.
4. JE Pearson, A Gill and P. Vadgama, Analytical aspects of biosensors, Annual Clinical Biochemistry 37, 119- 145.
5. Patranabis, Process Control year?
6. KR Rogers, M. Mascion, Biosensors for analytical monitoring EP & biosensors year
7. Donald R. Coughanowr, Process Systems Analysis and Control, McGraw-Hill,1991

REFERENCE BOOKS:

1. Automatic process control, Eckman D.P., Wiley Eastern Ltd. New Delhi. 1993.
2. Chemical Process Control Stephanoupoulis, G., Prentice Hall, New Delhi. 1990

THIRD SEMESTER (OPEN ELECTIVE)

PO1	PO2	PO3	PO4
S	S	M	S

1. BIOLOGICS AND VACCINE TECHNOLOGY

UNIT-I: INTRODUCTION TO BIOLOGICS DRUGS: Concept of biologic drugs and their types; Therapeutic indications; Innovator molecules and biosimilars; Antibody structure and function; Therapeutic monoclonal antibodies (mAb) and their nomenclature; fusion proteins; Introduction and mechanism of action of key biologics including Granulocyte-colony stimulating factor (GCSF), Parathyroid hormone (PTH), insulin and key monoclonal antibodies like Adalimumab, Rituximab, Bevacizumab, Ranibizumab, Trastuzumab and Etanercept; novel biologics, bispecific antibodies, drug conjugates.

UNIT-II: UPSTREAM PROCESS DEVELOPMENT : Introduction to cell culture; Expression vectors, codon optimization, gene cloning; Host cells, E. coli, Chinese Hamster Ovary (CHO) cells, Human embryonic kidney (HEK) 293 cells; Cell line development, transient and stable transfection, clone selection, single cell cloning, clone evaluation and expansion of selected clones, cell banking; Process development, design of experiments (DOE), bioreactor operating parameters, feed and media design; Process characterization, scale up and transfer to commercial manufacturing.

UNIT-III: DOWNSTREAM PROCESS DEVELOPMENT AND FORMULATION: Cell culture broth harvesting, centrifugation, depth filtration; Affinity chromatography; Viral inactivation; Polishing steps, anion exchange chromatography, cation exchange chromatography; Viral filtration; Ultra-filtration/ diafiltration (UFDF) and Formulation; Drug substance and drug product; lyophilization.

UNIT-IV: BIOLOGICS DRUG CHARACTERIZATION AND ANALYSIS: Characterization: physicochemical and structural properties, purity, impurities and biologic activity. mAb primary, secondary and tertiary structure analysis; N-terminal amino acid sequencing; Peptide mapping; Sulfhydryl groups and disulphide bridges; Post translational modifications; Glycan profiles; Heterogeneity, purity and variants; Appearance (includes colour, clarity / opalescence), pH, particulates, turbidity, osmolality, sterility and bacterial endotoxins; ELISA; Bioassays.

UNIT-V: VACCINE TECHNOLOGY: History of vaccines; Live-attenuated vaccines; Inactivated vaccines; Pathogen polysaccharide vaccines; Recombinant subunit vaccines; Viral vector Vaccines (Ex: Adenovirus, MVA), Gene therapy (Ex:AAV, Lentivirus), Oncotherapy(Adenovirus, Vaccinia, HSV)), Toxoid vaccines; Conjugate vaccines; virus- like particles (VLPs); DNA vaccines; Structure-Based

Vaccine Antigen Design.

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COURSE OUTCOMES:

At the end of this unit students will be able to

CO1: Evaluate the concepts of biologics drugs and vaccines.

CO2: Understand the process and methods involved in the Upstream development of biologics and vaccines.

CO3: Understand the process and methods involved in the downstream development of biologics and vaccines.

CO4: Analysis and characterization of biologics drugs.

CO5: Understand the Vaccine and technology.

BOOKS/REFERENCES:

1. Cheng Liu and John Morrow Jr. Biosimilars of Monoclonal Antibodies: A Practical Guide to Manufacturing, Preclinical, and Clinical Development. Wiley.
2. Rodney Ho and Milo Gibaldi. Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs. Second Edition.
3. Steven M. Chamow, Thomas Ryll, Henry B. Lowman and Deborah Farson (editors). Therapeutic Fc-Fusion Proteins. Wiley Blackwell.
4. Barney S. Graham, Morgan S.A. Gilman and Jason S. McLellan. Structure-Based Vaccine Antigen Design. Annual Review of Medicine, 2019. 70:91–104.

THIRD SEMESTER (OPEN ELECTIVE)

PO1	PO2	PO3	PO4
S	M	S	S

2. FOOD SCIENCE AND TECHNOLOGY

UNIT-I INTRODUCTION TO FOOD SCIENCE & TECHNOLOGY: Fundamentals and aims of food science and technology. Interdisciplinary approach, Nutritive value of foods, Food as a source of energy, Food Health and disease. Food laws: Overview of Food Safety Standards Act 2006, Food Safety Standards Rules & Regulations, 2011. Overview of other relevant national bodies (e.g., APEDA, BIS EIC, MPEDA, Spice Board) Overview of Codex Alimentarius - development and issue of standards, Committees under Codex, role in maintaining harmony in food standards.

UNIT-2 FOOD CHEMISTRY: Food chemistry-definition and importance, water in food, water activity and shelf Life of food. Carbohydrates- functional properties of sugars and polysaccharides in foods. Lipids: use of lipids in foods, physical and chemical properties, effects of processing on functional properties and nutritive value. Protein and amino acids: physical and chemical properties, distribution, amount and functions of proteins in foods, functional properties, effect of processing. -Losses of vitamins and minerals due to processing.

UNIT-3 FOOD MICROBIOLOGY: Microbial growth pattern, Types of micro-organism normally associated with food mold, yeast, and bacteria. Micro-organisms in natural food products. Contaminants of foods-stuffs, Fisheries, milk and meat during handling and processing. Biochemical changes caused by micro-organisms, deterioration of various types of food product. Food poisoning and microbial toxins, standards for different foods. Food borne intoxicants and mycotoxins.

UNIT-4 FOOD PRESERVATION, PROCESSING AND PACKAGING: Physical chemical and biological methods of preservations. Bioprocessing of meat, Fisheries, vegetables, diary products. Irradiated foods. Overview of food packaging methods and principles including novel packaging materials/techniques.

UNIT-5 GENERAL PRINCIPLES OF FOOD HYGIENE AND FOOD QUALITY ASSURANCE: General

principles of food safety management systems including traceability and recall – sanitation, HACCP, Good production and processing practices (GMP, GAP, GHP, GLP). Principles of Quality assurance and Quality control with reference to food analysis and testing.

COURSE OUTCOMES:

The students will be able to:

CO1: Understand about food science and technology

CO2: To know the chemical properties of food

CO3: Identify the microbiology of food

CO4: Provide solution for pathogenic and spoilage microorganisms associated with different foods and their commercial importance.

CO5: Explain the various principles of food hygiene and food quality assurance.

TEXT BOOKS:

1 Jay J.M. 1986. Modern Food Microbiology. 3rd Edn. VNR, New York

2 Food processing and Preservation PHI private itd, New Delhi

3 Food Microbiology fourth edition William C.Frazier, Tata Mc Graw Hill.

THIRD SEMESTER (OPEN ELECTIVE)

PO1	PO2	PO3	PO4
S	S	S	S

3. PHARMACEUTICAL BIOTECHNOLOGY

UNIT I: PROKARYOTIC AND EUKARYOTIC CELLS IN BIOSIMILARS PRODUCTION: Biosimilars production from actinomycetes, *Saccharomyces cerevisiae* and other fungi. Plants in biosimilars production, transgenic plants as functional foods or neutraceuticals transgenic plants and plant cell culture as bioreactors of secondary metabolites.

UNIT II: BIOTHERAPEUTICS: Pharmacodynamics of protein therapeutics; chemical modification of proteins/ therapeutics; immuno suppressor in antibody therapy; pharmacogenomics**,** molecular modification of lead compounds; assay systems and models (e.g., knockout mice). Antisense technology, small peptides, therapeutic enzymes and bacteriophage therapy.

UNIT III: PHARMACEUTICALS PRODUCTION IN PLANTS: Drugs derived from plants, antitumor agent -etoposide, colchicine, taxol, vinblastine, vincristine. Cardiotonic – convallatoxin, acetyldigoxin, adoniside, anti-inflammatory – aescin, bromelain, choleretic – curcumin, biopharmaceuticals expressed in plants alternative expression systems, three promising examples: tobacco (rhizosecretion, transfection) and moss (glycosylation).

UNIT IV: PROTEIN AND DNA VACCINES: DNA vaccine construction and immunology DNA vaccine expression plasmids delivery of DNA vaccines. Peptide vaccine, gene pharming, cytokines as biopharmaceuticals and T-cell therapy.

UNIT V: BIOGENERIC DRUGS RECOMBINANT THERAPEUTIC PROTEINS: Erythropoietin (EPO), colony stimulating factors (CSFs), human growth hormone (hGH), insulins, factor viii (Fviii), interferons (IFN)**.** Therapeutic hormone- insulin production through recombinant DNA technology, therapeutic monoclonal antibodies.

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COURSE OUTCOMES:

At the end of the course student will be able to

CO1: Understand the basic concepts of Nutraceuticals, microbes and Biotech production strategies at industrial level.
CO2: Evaluate physiochemical properties and pharmacodynamics of biopharmaceuticals
CO3: Estimate the production of plant drugs like antitumor, anti-inflammatory etc.
CO4: Analyse Protein & DNA vaccines.
CO5: Understand biogenerics, and biopharmaceuticals.

TEXT BOOKS:

1. Pharmaceutical Biotechnology; Oliver Kayser, Rainer H. Müller, Wiley Publishers, 2005.
2. Drug Discovery and Clinical Applications; Heinrich Klefenz, 2002.
3. Industrial Pharmaceutical Biotechnology, WILEY-VCH Publication, Germany. Daan Crommelin, Robert D Sindelar, 2002.
4. Pharmaceutical Biotechnology; Tailor and Francis Publications, Newyork. Jay P Rho, Stan G Louie, 2003, Hand.

REFERENCE BOOKS:

1. Pharmaceutical Biotechnology Paperback – 2011 by Kokate
2. Pharmaceutical Biotechnology by Ashutosh Kar.

THIRD SEMESTER (OPEN ELECTIVE)

PO1	PO2	PO3	PO4
S	S	M	S

4. WASTE TO ENERGY

Unit I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

Unit II: Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit III: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit IV: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit V: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

COURSE OUTCOMES:

At the end of the course, the student should be able to

C01: Students should able to classify the wastes as a fuel

CO2: Students should able to understand types of pyrolysis

CO3: Students should able to know the different types of Biomass Gasification

CO4: Student should able to understand the Biomass Combustion

CO5: Student should able to analyze the biogas plant design and types of biogas plant

REFERENCES:

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata
3. McGraw Hill Publishing Co. Ltd., 1983.

TEXT BOOKS:

1. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

THIRD SEMESTER (OPEN ELECTIVE)

PO1	PO2	PO3	PO4
S	S	M	S

5. NEUROBIOLOGY

Unit I: Introduction: Cellular and molecular basis of nervous system and its uniqueness. Neural Development: Turning embryonic stem cells into neurons. Glial guided neuronal migration, path finding, and axon guidance.

Unit II: The Macroscopic Organization of the Brain: Functional anatomy of the brain Cellular heterogeneity of nervous system, Blood Brain Barrier and its disorders.

Unit III: Synaptic Transmission: Electrical and Chemical transmission, Membrane potentials (Resting and Action potentials), Ion channels and Voltage Ogated channels, Synapse formation Neurotransmitters (synthesis, storage and function), Disorders of synaptic transmission.

Unit IV: Cognitive Neuroscience: Role of limbic system in cognition, Cellular and molecular basis for learning and memory, Synaptic plasticity. Special aspects of brain metabolism: Brain specific genes, DNA, RNA and protein synthesis, Amino acid transport.

Unit V: Molecular aspects of neurological dysfunction and neurodegeneration: Mechanism of apoptosis and special aspects of neurodegeneration. Neurodegenerative diseases: Alzheimer's Disease, Parkinson's Disease, Creutzfeldt-Jakob Disease (CJD), Amyotrophic Lateral Sclerosis (ALS), Epilepsy, Schizophrenia. Cerebrovascular Diseases: Stroke, Arteriosclerosis, Arterio Venous Malformations (AVMs), Aneurysms.

COURSE OUTCOMES:

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

PO1	PO2	PO3	PO4
S	M	S	S

CO1: Understand the fundamentals of, and recognize the relationships between, the structure and function of molecules and tissues involved in neurobiological systems at all levels molecular, cellular, and organism.

CO2: Study functional human neuroanatomy and neuronal communication,

CO3: Evaluate synaptic transmission in electrical and chemical transmission

CO4: Classify the Brain specific genes, DNA, RNA and protein synthesis & transport

CO5: Apply the Mechanism of apoptosis and special aspects of neurodegeneration and Neurodegenerative diseases control.

TEXT BOOKS:

1) Kandel E, Schwartz J, Jessell T, Siegelbaum S and Hudspeth A. J. Principles of Neural Science 2000, Fourth Edition, McGraw-Hill Companies USA.
2) Siegel G.J, Agranoff B.W, Albers R.W and Molinoff P.B. Basic Neurochemistry. Raven Press.
3) Brady S, Siegel G and R. Wayne Albers. Basic neurochemistry: Molecular, Cellular and Medical Aspects. Seventh Edition: Raven Press.
4) Purves D, Augustine G.J, Fitzpatrick D, Hall W.C, Lamantia A.S and White L.E. Neuroscience Fourth Edition (2007). Sinauer Associates.

THIRD SEMESTER (OPEN ELECTIVE)

6. BIO ANALYTICAL TECHNIQUES

UNIT-I: SPECTROSCOPIC TECHNIQUES:

Spectroscopy techniques: (Theory of Light) UV, IR, FTIR, CD, NMR, MS, LASER Raman Spectroscopy, Fluorescence Spectroscopy.

UNIT-II: CHROMATOGRPHY TECHNIQUES: Chromatography: HPLC (including ELSD, CAD and DLS detectors), TLC, GLC, FPLC, GC, HPTLC, Adsorption, affinity, Ion exchange, gel permeation.

UNIT-III: MICROSCOPIC:

Microscopy (Theory: Simple and Compound, Types: Light Field, Dark Field, Phase Contrast, SEM, TEM, Fluorescent)

UNIT-IV: ADVANCE TECHNIQUES IN PROTEOMICS, METABOLOMICS & IMMUNOASSAYS: Recent developments in applications to proteomics and metabolomics (SELDI, MALDI, Q- TOF, Triple Quad and Ion trap mass analyzers). Immunoassay: radioimmunoassay (RIA); enzyme-multiplied immunoassay technique (EMIT); fluorescence polarization, immunoassay (FPIA); closed enzyme donor immunoassay (CEDIA); enzyme-linked immunosorbent assay (ELISA).

UNIT-V SEQUENCING TECHNIQUES OF PROTEIN & DNA: N-terminal sequencing for determination of protein sequence (Edman degradation); MALDI-TOF analysis Nucleic acid sequencing automated methods (Sangers Dideoxy and Maxim Gilbert methods), determination technologies and NGS

(Illumina, Pyro and Ion Torrent).

COURSE OUTCOMES:

CO1: Understand Spectroscopic techniques analysis.
CO2: Understand different chromatography techniques for biomolecules separation
CO3: Understand microscopic techniques
CO4: Analyze the advance techniques in proteomics, metabolomics & immunoassays.
CO5: Evaluate different techniques involved in sequencing of proteins and nucleic acids.

TEXT BOOKS:

1. Essentials of Molecular Biology, David Friefilder, Jones and Barllett Publications.
2. Proteins-Structure and Molecular Properties. TE Creighton, WH Freeman and company.
3. Genes VII, B. Lewin, Oxford University Press.
4. Introduction to Protein Structure, C. Branden and J. Tooze, Garland Publishing, New York.

REFERENCE BOOKS:

1. Hobert H Willard D. L. Merritt & J. R. J. A. Dean, Instrumental Methods of Analysis, CBS Publishers & Distributors, 1992
2. Vogal, Text Book of Quantitative Inorganic Analysis, 1990
3. Ewing, Instrumental Methods of Analysis, 1992
4. Pranb kumar Banerjee,Introduction to Biophysics, S.chand Publications,2008.
5. Instrumental methods of chemical analysis-Gurudeep R.ChatwAL 7 Sham K.Anand,Himalaya

AUDIT COURSE
ENGLISH FOR RESEARCH PAPER WRITING

UNIT I: Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing, Redundancy, Avoiding Ambiguity and Vagueness.

UNIT II: Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

UNIT III: Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT IV: Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

UNIT V: Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions, useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

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COURSE OUTCOMES:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission.

REFERENCES:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook.

TEXT BOOKS:

1. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

AUDIT COURSE
DISASTER MANAGEMENT

UNIT I: Introduction Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II: Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

UNIT III: Disaster Prone Areas in India Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.

UNIT IV: Disaster Preparedness and Management Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V: Risk Assessment

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival. **Disaster Mitigation** Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

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COURSE OUTCOMES:

1. Students will be able to:
2. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
3. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
4. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
5. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

REFERNCES:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall Of India, New Delhi.

TEXT BOOKS:

1. Goel S. L., Disaster Administration and Management Text and Case Studies", Deep &Deep Publication Pvt. Ltd., New Delhi.

AUDIT COURSE
VALUE EDUCATION

Unit I: Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements.

Unit II: Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline.

Unit III: Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance.

Unit IV: True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature.

Unit V: Character and Competence –Holy books vs Blind faith. Self-management and good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

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COURSE OUTCOMES

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values

3. Developing the overall personality

REFERENCES:

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi.

AUDIT COURSE
CONSTITUTION OF INDIA

Unit I: History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working). Philosophy of the Indian Constitution: Preamble Salient Features.

Unit II: Contours of Constitutional Rights & Duties: Fundamental Rights. Right to Equality. Right to Freedom. Right against Exploitation. Right to Freedom of Religion. Cultural and Educational Rights. Right to Constitutional Remedies. Directive Principles of State Policy. Fundamental Duties.

Unit III: Organs of Governance: Parliament. Composition. Qualifications and Disqualifications. Powers and Functions. Executive. President. Governor. Council of Ministers. Judiciary, Appointment and Transfer of Judges, Qualifications Powers and Functions.

Unit IV: Local Administration: District's Administration head: Role and Importance. Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments). Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

Unit V: Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

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COURSE OUTCOMES:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

REFERENCES:

1. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
2. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
3. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

TEXT BOOKS:

1. The Constitution of India, 1950 (Bare Act), Government Publication.

AUDIT COURSE
PEDAGOGY STUDIES

Unit I: Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology**.** Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.** Overview of methodology and searching.

Unit II: Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Unit III: Evidence on the effectiveness of pedagogical practices. Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Unit IV: Professional development: alignment with classroom practices and follow-up support. Peer support. Support from the head teacher and the community. Curriculum and assessment. Barriers to learning: limited resources and large class sizes.

Unit V: Research gaps and future directions: Research design Contexts. Pedagogy. Teacher education. Curriculum and assessment. Dissemination and research impact.

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COURSE OUTCOMES

1. Students will be able to understand:
2. What pedagogical practices are being used by teachers in formal and informal classrooms in

developing countries?

3. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?

4. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

REFERENCES:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

AUDIT COURSE
STRESS MANAGEMENT BY YOGA

Unit I: Definitions of Eight parts of yog (Ashtanga).

Unit II: Yam and Niyam. Do`s and Don't's in life.

i) Ahinsa, satya, astheya, bramhacharya and aparigraha.

ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan.

Unit III: Asan and Pranayam

i) Various yog poses and their benefits for mind & body.

ii) Regularization of breathing techniques and its effects-Types of pranayam.

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COURSE OUTCOMES:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency.

REFERENCES:

1. 'Yogic Asanas for Group Tarining-Part-I":Janardan Swami Yogabhyasi Mandal, Nagpur.

AUDIT COURSE
PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Unit I: Neetisatakam-Holistic development of personality; Verses- 19,20,21,22 (wisdom). Verses-29,31,32 (pride & heroism). Verses- 26,28,63,65 (virtue). Verses- 52,53,59 (dont's). Verses-71,73,75,78 (do's).

Unit II: Approach to day to day work and duties. Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48. Chapter 3-Verses 13, 21, 27, 35. Chapter 6-Verses 5,13,17, 23, 35. Chapter 18-Verses 45, 46, 48.

Unit III: Statements of basic knowledge. Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68. Chapter 12 -Verses 13, 14, 15, 16,17, 18. Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17. Chapter 3-Verses 36,37,42. Chapter 4-Verses 18, 38,39. Chapter18 – Verses 37,38,63.

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COURSE OUTCOMES

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life

2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality ofstudents.

REFERENCES:

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata.
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath

TEXT BOOKS:

1. Rashtriya Sanskrit Sansthanam, New Delhi.

PROGRAM OUTCOMES
(PO1 to PO3 Given by NBA and PO4 Defined by Institute)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

P02: Ability to write and present a substantial technical report/document.

PO3: Students will demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Engage in lifelong learning, career enhancement and adopt to changing professional and Societal needs.

(S= Strong, M= Medium, L= Low)