**CENTRE FOR BIOTECHNOLOGY**
**INSTITUTE OF SCIENCE AND TECHNOLOGY**
**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**
**Kukatpally, Hyderabad-500 085, Telangana State, India**

# MASTER OF TECHNOLOGY
# in
# BIOTECHNOLOGY
# (Full Time PG)

## COURSE STRUCTURE
## &
## DETAILED SYLLABUS
## W.E.F.2019

**EACH SEMESTER IS APPROXIMATELY 20-21 WEEKS DURATION INCLUDING EXAMINATIONS. EACH PERIOD IS ABOUT 50 MINITUES DURATION. THERE WILL BE NORMALLY FOUR SESSIONS PER DAY EACH OF ABOUT 100 MINITUES DURATION. TWO SESSIONS OF LABORATORY IS EQUIVALENT TO ONE SESSION OF THEORY**

**CENTRE FOR BIOTECHNOLOGY**
**INSTITUTE OF SCIENCE & TECHNOLOGY (AUTONOMOUS)**
**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD**
**M.Tech. (BT), COURSE STRUCTURE AND SYLLABUS (CBCS)-2019**

## M.TECH SEM-I

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits | Int Marks | Ext Marks |
|---|---|---|---|---|---|---|---|
| | | L | T | P | | | |
| 1BT01 | **Program Core – I**<br>Biochemistry and Metabolic pathways | 3 | 0 | 0 | 3 | 30 | 70 |
| 1BT02 | **Program Core – II**<br>Process Engineering Principles | 3 | 0 | 0 | 3 | 30 | 70 |
| 1BT PE1 | **Program Elective - I**<br>1. Molecular Biology and r-DNA technology<br>2. Immunotechnology<br>3. Bio nanotechnology | 3 | 0 | 0 | 3 | 30 | 70 |
| 1BT PE2 | **Program Elective - II**<br>1 .Engineering Mathematics<br>2. Fermentation Technology<br>3. Bioanalytical techniques | 3 | 0 | 0 | 3 | 30 | 70 |
| 1BT03 | Process Engineering Principles Laboratory | 0 | 0 | 4 | 2 | 30 | 70 |
| 1BT04 | Biochemistry and molecular biology Laboratory | 0 | 0 | 4 | 2 | 30 | 70 |
| 1ABT1 | Research Methodology and IPR | 2 | 0 | 0 | 2 | 30 | 70 |
| 1ABTx | Audit Course | 2 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | **16** | **0** | **08** | **18** | **210** | **490** |

## M.TECH SEM-II

| Course Number | Subject | Scheme Of Studies Per Week | | | Credits | Int Marks | Ext Marks |
|---|---|---|---|---|---|---|---|
| | | L | T | P | | | |
| 2BT05 | **Program Core – III**<br>Plant Biotechnology & Molecular Pharming | 3 | 0 | 0 | 3 | 30 | 70 |
| 2BT 06 | **Program Core – IV**<br>Bioprocess Engineering | 3 | 0 | 0 | 3 | 30 | 70 |
| 2BT PE3 | **Program Elective - III**<br>1. Bioinformatics and Systems biology<br>2. Biologics and Vaccine Technology<br>3. Animal Cell and Tissue Engineering | 3 | 0 | 0 | 3 | 30 | 70 |
| 2BT PE4 | **Program Elective - IV**<br>1. Downstream processing<br>2. Stem cell technology and Regenerative medicine<br>3. Metabolic engineering | 3 | 0 | 0 | 3 | 30 | 70 |
| 2BT 07 | Cell culture Techniques Laboratory | 0 | 0 | 4 | 2 | 30 | 70 |
| 2BT 08 | Bioprocess Engineering Laboratory | 0 | 0 | 4 | 2 | 30 | 70 |
| 2BT09 | Mini project with Seminar | 2 | 0 | 0 | 2 | 30 | 70 |
| 2ABTx | Audit Course | 2 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | **16** | **0** | **08** | **18** | **210** | **490** |

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

**M.TECH SEM-III**

| Course No. | Subject | Scheme of Studies Periods Per Week | | | Credits | Int Marks | Ext Marks |
|---|---|---|---|---|---|---|---|
| | | L | T | P | | | |
| 3BT PE5 | **Program Elective V-**<br>1.Bioreactor Design and analysis<br>2. Modelling and Simulation in Bioprocess<br>3. Bioprocess instrumentation and control | 3 | 0 | 0 | 3 | 30 | 70 |
| 3BT OE | **Open Elective**<br>1. Business Analytics<br>2. Industrial safety<br>3. Operations Research<br>4. Cost Management of Engineering Projects<br>5. Composite Materials<br>6. Waste to Energy | 3 | 0 | 0 | 3 | 30 | 70 |
| 3BT10 | **Dissertation – I** /Industrial Project | 0 | 0 | 20 | 10 | 0 | 0 |
| | a) Project review-I | | | | 0 | 0 | 0 |
| | b) Project review-II | | | | 0 | 100 | 0 |
| **Total** | | **06** | **0** | **20** | **16** | **160** | **140** |

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

**M.TECH SEM-IV**

| | **Subject** | **Scheme of Studies Per Week** | | | **Credits** | **Int Marks** | **Ext Marks** |
|---|---|---|---|---|---|---|---|
| | | L | T | P | | | |
| | **Dissertation II** | 0 | 0 | 32 | 16 | 0 | 0 |
| | a) Project review-III | | | | 0 | 30 | 0 |
| | b) Project Evaluation (Viva-Voce) | | | | 0 | 0 | 70 |
| **Total** | | **0** | **0** | **32** | **16** | **30** | **70** |

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

## Total credits of the Programme - 68

**List of Audit courses 1 & 2**

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

**FIRST SEMESTER (**CORE -I)

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
| M | S | S | S |

## 1. BIOCHEMISTRY AND METABOLIC PATHWAYS

**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: CATABOLISM OF BIOMOLECULES:** Carbohydrates metabolism – Glycolysis, TCA cycle, Pentose phosphate pathway, Glycogenolysis. Lipids – β-oxidation of Fatty acids – saturated and unsaturated fatty acids. Proteins - Transamination, Deamination & Decarboxylation of amino acids. Catabolism of Amino acids: Glutamate, Tryptophan, Cysteine & Proline.

**UNIT-III: ANABOLISM OF BIOMOLECULES:** Gluconeogenesis, Glycogenesis, Biosynthesis of lipids-phospholipids (Cardiolipin) Sphingo lipids (Sphingo myelin) and cholesterol Biosynthesis of amino acids – Glutamate, Tryptophan, Cysteine & Proline.

**UNIT-IV: MEMBRANE TRANSPORT AND SIGNAL TRANSDUCTION: Plasma Membrane:** Transportation of molecules across plasma membrane (Active & Passive Transport), Electron Transport Chain, Oxidative Phosphorylation, Group translocation, Antiporters, Uniporters, Symporters & Ionophores.
**Signal Transduction:** Intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior; Modes of cell signalling, Types of receptors used for cell signalling, pathway of intracellular signal transduction using secondary messengers.

**UNIT-V: STRATEGIES FOR METABOLIC CONTROL:** Thermodynamic aspects of metabolism, Flux generation aspects of metabolic pathways, Metabolic network pathways, Regulation & Role of key enzymes in metabolic pathway control, allosteric control and control by phosphorylation. Hormonal control of metabolism.

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**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 (**CORE- II)

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
| M | S | 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, Metering & Transportation of fluids using orifice meter, venture meter & Rota meter.

**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 | M | S | S |

## 1. MOLECULAR BIOLOGY AND r-DNA TECHNOLOGY

**UNIT-I: MOLECULAR BIOLOGY FUNDAMENTALS:** Genome organization, DNA structure , Different classes of DNA and RNA and their Function. Regulatory elements, DNA replication and repair , RNA: Different classes of RNA and their functions. RNA synthesis and other post transcriptional modifications.

**UNIT-II: REGULATION OF GENE EXPRESSION :** Regulation of gene expression in prokaryotes (Operon model), Transcription and Translation. Transcriptional controls in Eukaryotes , Motifs of Protein synthesis Post transcriptional and post-translational modifications. Translational controls. Transposons.

**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; Alternative strategies of Gene cloning, Map based cloning, Cloning of differentially expressed genes. **Gene Expression:** Study of introduced Gene expression – Hybridization techniques, Northern blot analysis, Nucleic acid microarrays. Gene expression in bacteria,Yeast, insects and insect cells, mammalian cells and in plants – characterization of recombinant proteins, stabilization of proteins; Phage display, Yeast Two- and three Hybrid system.

**UNIT-V: TRANSGENICS, GENOME EDITING AND GENE SILENCING AND PROTEIN ENGINEERING:** Gene tagging (T-DNA tagging and Transposon tagging). Transgenic and Gene Knockouts and Gene knock down Technologies, Gene Therapy, Strategies of gene delivery, gene correction, Antisense technology, RNAi in gene silencing, mi RNA. Genome editing (**CRISPR-Cas**, ZFNs, and TALENs)**.** 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. Biochemistry and Molecular biology, William H. Elliott and Daphne C. Elliott, Third Edition, Indian edition, Oxford University press, 2005.
4. Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000.
5. DNA Cloning: a Practical Approach, .M. Glover and B.D. Hames, IRL Press, Oxford, 1995.
6. Principles of Gene manipulation, Introduction to Genetic Engineering : R W Old, S B Primros

**REFERENCE BOOKS:**

1. "Genetics" by Ursula Goodenough
2. "Cytogenetics" by lGarl P. Swanson, Mertz & Young
3. "General Virology" by Luria & Darnell
4. "Biochemistry" by Stryer.
5. Molecular and Cellular Methods in Biology and Medicine, P.B. Kaufman, W. Wu. D. Kim and L.J; Cseke, CRC Press, Florida, 1995.

6. Route Maps in Gene Technology, M.R. Walker and R. Rapley, Blackwell Science Ltd., Oxford, 1997.
7. Methods in Enzymology vol. 152, Guide to Molecular Cloning Techniques, S.L. Berger and A.R. Kimmel, Academic Press, Inc. San Diego, 1998
8. Methods in Enzymology Vol 185, Gene Expression Technology, D.V. Goeddel, Academic Press, Inc., San Diego, 1990
9. DNA Science. A First Course in Recombinant Technology, D, A. Mickloss and G.A. Froyer. Cold Spring Harbor Laboratory Press, New YorK, 1990.
10. Molecular Biotechnology (2nd Edn.), S.B. Primrose. Blackwell Scientific Publishers, Oxford, 1994
11. Milestones in Biotechnology. Classic papers on Genetic Engineering, J.A. Davies and W.S. Reznikoff, Butterworth-Heinemann, Boston, 1992.

**FIRST SEMESTER (Program Elective- I)**

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
| S | S | M | S |

## 2. IMMUNOTECHNOLOGY

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

**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- I)**

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
| S | S | M | S |

## 3. 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.

**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).

**FIRST SEMESTER (**ELECTIVE II**) (Based on the Educational Background)**

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
| M | L | S | S |

## 1. ENGINEERING 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, Rank of matrix (Basics); solution of linear system of equations: Jacobi's , Gauss-seidal 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.

**UNIT-V:STATISTICAL OPTIMIZATION TECHNIQUES:** Estimation, types of estimation, estimation of parameters – confidential intervals. 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.Apply matrices
CO4.Understand the various concepts of biostatistics
CO5.Evaluate various concepts of statistical optimization techniques.

**TEXTBOOKS:**

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 TEXT BOOKS:**

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

**FIRST SEMESTER (**PROGRAM ELECTIVE II)

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
| S | S | M | S |

## 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 micro organisms, 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, $O_2$ 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, the design of batch sterilization process, the design of 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

**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

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**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 | M | S | S |

## 3. 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 proteinsequence (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).

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**COURSE OUTCOMES:**

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

**TEXTBOOKS:**

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 Publishing house,ISBN.
6. Principles & Techniques of Practical Biochemistry 5th edition. K. Wilson & J.Walker, Cambridge University Press, 2000.

**FIRST SEMESTER**

| PO1 | PO2 | PO3 | PO4 |
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## 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 |
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## PROCESS ENGINEERING PRINICPLES 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 |
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## 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 aminoacids.
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- Analyse the separation of compounds on gels

**SECOND SEMESTER** (CORE III)

| PO1 | PO2 | PO3 | PO4 |
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## PLANT BIOTECHNOLOGY AND MOLECULAR PHARMING

**UNIT I APPLICATIONS OF PLANT BIOTECHNOLOGY:** Micropropagation, Techniques,Chemical and Physical Requirements, Production of Haploids and Applications, Germplasm Conservation, Somaclonal Variations.

**UNIT II SOMATIC HYBRIDIZATION AND SECONDARY METABOLITE PRODUCTION:** Protoplast isolation, culture and regeneration. Protoplast fusion technique 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 GENETIC ENGINEERING OF PLANTS:** Genetic Transformation Protocols for Production of Transgenic Plants (*Agrobacterium* Mediated Transformation, Direct Gene Transfer Methods). Production of Genetically Modified Plants/Crops for Biotic Stress, Abiotic Stress, Agronomic Traits and Quality traits.

**UNIT IV :MOLECULAR PHARMING: APPLICATION AS PROTEIN FACTORIES**

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

**UNIT V: PLANT MOLECULAR PHARMING OTHER APPLICATIONS:** Carbohydrate and Lipid molecular farming. Improvement of Plant Oils. Production of Biodegradable Plastics in Plants.

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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 applications in science, agriculture and industry.

CO2- Acquire sufficient knowledge of role of cell cultures in development of pure breeding lines, germplasm conservation and production of variants.

CO3- 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.

CO4- Acquire advanced level knowledge of Transformation techniques for transgenic plant production with their advantages and limitations

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.
4. "Plant Biotechnology" Eds. Mantell & Smith.

**SECOND SEMESTER** ( CORE IV)

| PO1 | PO2 | PO3 | PO4 |
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## BIOPROCESS ENGINEERING

**UNIT-I: ENZYME CATALYSIS:** Introduction, Nomenclature, Classification and Applications of enzymes. **Principles of catalysis:** Arrhenius theory, Collision theory, Transition state theory, Approximation reactants, Covalent catalysis, General acid base catalysis, Energetic of substrate binding.

**Kinetics of single substrate reaction:** Michaelis - Menten equations, Brigg's Haldane equation & estimation of constants using graphical techniques, Turnover number ($k_{cat}$), Kinetics for reversible reactions, Graphical representation of kinetic data.

**UNIT-II: ENZYME INHIBITION:** Competitive, uncompetitive, non competitive and mixed inhibition, substrate inhibition. **Pre steady state kinetics**: Rapid mixed methods, relaxation techniques. **Enzyme kinetics at limiting conditions:** Dilute substrates, solid substrates, enzyme activity at interfaces. **Kinetics of mult-substrate reactions:** Mechanisms for two substrate reaction. **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-III: IMMOBILIZED BIOCATALYSIS:** Introduction, rationale and applications. Methods of immobilization; Enzymes, whole cells, **Kinetics of immobilized enzymes :** effects of electrostatic potential of the microenvironment, effects of external mass transfer, effects of intraparticle diffusion with uncharged supports, simultaneous external and internal mass transfer resistance and partitioning effects. Intraparticle diffusion and immobilized enzyme stability.

**UNIT-IV: UNSTRUCTED MODEL FOR MICROBIAL GROWTH:**

Phases of batch growth cycle, Unstructed , monod, other constitutive , multiple substrate and inhibition models, specific nutrient uptake rates, models of growth and non growth associated product formation, models of product inhibition. **Growth of eukaryotic cells** : Fungi, animal and plant cells.

**UNIT-V: STRUCTURED MODELS OF MICROBIAL GROWTH**

**Structured Models of Metabolism and Growth:** Compartmental models, Model of Cellular Energetics and Metabolism, Models of product formation, single cell model, **Models of gene expression and regulation**; Dynamics of the epigenetic system, Plasmid Expression and Replication.

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**COURSE OUTCOMES:**

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

CO1- Classify enzymes and apply different theories for enzyme catalytic reactions.
CO2- Analyse the different enzyme inhibitions and kinetics of enzymes
CO3- Estimate effectiveness factor in enzyme immobilization kinetics with internal and external mass transfer resistance.
CO4- Develop and evaluate the models for single and multi substrate cellular growth reactions.
CO5- Estimate the kinetic parameters for different models based on molecular mechanisms such as gene expression and plasmid expression.

**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. Bailey JE, Ollis DF; Biochemical Engineering fundamentals (1986)

**SECOND SEMESTER** (PROGRAM ELECTIVE III)

| PO1 | PO2 | PO3 | PO4 |
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## 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 evaulate 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. Bioinformatics: A practical guide to analysis of genes and proteins by Baxevanis, Andreas D Wiley – Interscience publishers.
5. Principles of biological Databases by P. B. Kavi kishor and L.N. Chavali.

**REFERENCE BOOKS:**

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)

| PO1 | PO2 | PO3 | PO4 |
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## 2. 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; 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.

**SECOND SEMESTER** (PROGRAM ELECTIVE III)

| PO1 | PO2 | PO3 | PO4 |
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## 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.

**REFERNCES:**

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.

**SECOND SEMESTER** (PRORAM ELECTIVE IV)

| PO1 | PO2 | PO3 | PO4 |
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## 1. 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:** Principles of flocculation, various flocculating agents, applications in bio-processing. **Coagulation:** Principles of coagulations and its applications in bio-processing.

**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, gel chromatography, affinity chromatography etc. 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.

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**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
2. Comprehensive Biotechnology Vol.2 Edition, M. Moo –young (1985).
3. Product Recovery in Bioprocess technology, BIOTOL series, Butterworth –Heinemann first Edition

**SECOND SEMESTER** (PROGRAM ELECTIVE IV)

| PO1 | PO2 | PO3 | PO4 |
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## 2. STEM CELL TECHNOLOGY & REGENERATIVE MEDICINE

**UNIT-I: STEM CELLS & TISSUE ENGINEERING:** Introduction to stem cells & Tissue Engineering, Cell sources and stem cells, media. Embryonic and adult stem cells, Cell isolation and selection; Tissue preservation.

**UNIT-II: STRUCTURE AND ORGANIZATION OF TISSUES:** Extracellular matrices; Cell-matrix interactions. Cell synthetics surface interactions and the ensuing effects on cell growth, cell adhesion, cell migration, and cell-cell communication.

**UNIT-III: PROPERTIES OF BIOLOGICAL TISSUES:** Cell and Tissue Culture, Cell characterization, cell separations, Mechanical properties of biological tissues. Transport properties of biological tissues.

**UNIT-IV: CELL BIOMATERIAL INTERACTIONS & TRANSPLANTATION:** Cell-Biomaterial Interactions and Host Integration. Biomaterial processing for TE, Scaffolds and Tissue Engineering. Transplantation of engineered cells and tissues, Immunomodulation and Immunoisolation.

**UNIT-V: THE DESIGN OF BIOMIMETIC ENVIRONMENTS & REGENERATIVE MEDICINE:** Introduction, Scale Up/Reactor Design, Artificial skin, Artificial blood vessels, vascular grafts, and cardiac prostheses, Bone repair, Repair of cartilage, tendon and ligaments, Artificial liver, Nerve regeneration.

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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 cell-cell communication and structure, organization of tissues.
CO3- Evaluate cell, tissue culture and transport phenomena of tissues.
CO4- Classify and design scaffolds, assess cell biomaterial interactions and transplantation.
CO5- Design biomaterials like artificial liver, bone repair etc.

**TEXT BOOKS:**

1. "Future Strategies for Tissue and Organ Replacement" edited by Julia M Polak (Imperial College School of Medicine Hammersmith Hospital, UK) Larry L Hence (Imperial College, UK) & P Kemp (Intercytex, Etherley Dene House, UK).
2. Principles of Tissue Engineering by Robert P. Lanza (Editor), Robert Langer (Editor), William L. Chick (Editor).
3. Tissue Engineering Methods and Protocols (Methods in Molecular Medicine, 18) by Jeffrey Robert Morgan (Editor), Martin L. Yarmush (Editor),
4. Tissue Engineering [Hardcover] Bernhard O. Palsson (Author), Sangeeta N. Bhatia (Author).
5. Tissue Engineering (Academic Press Series in Biomedical Engineering) by Clemens van Blitterswijk, Peter Thomsen, Jeffrey Hubbell and Ranieri Cancedda (Apr 8, 2008)

**REFERENCE:**

1. Bioengineering of the Skin: Methods and Instrumentation, Volume III [Hardcover] enzo Berardesca (Editor), Peter Elsner (Editor), Klaus P. Wihelm (Editor), Howard I. Maibach (Editor).
2. Composite Tissue Transplantation (Tissue Engineering Intelligence Unit-II) [Hardcover] Charles W. Hewitt (Editor), Kirby S. Black (Editor).
3. Tissue Engineering: Engineering Principles for the Design of Replacement organs and Tissues by W. Mark Saltzman (Jul 15, 2004).
4. Tissue Engineering by John P. Fisher, Antonios G. Mikos and Joseph D. Bronzino (May 30, 2007).

**SECOND SEMESTER** (PROGRAM ELECTIVE IV)

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
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## 3. METABOLIC ENGINEERING

**UNIT-I CELLULAR METABOLISM:** Importance of Metabolic Engineering, Transport mechanisms and their models; Enzyme kinetics; Mechanisms and their dynamic representation.
Transport process; passive, facilitated and active transport.

**UNIT- II THERMODYNAMICS AND COMPRHENSIVE MODELS FOR CELLULAR PROCESS:** Thermodynamic principles, Thermodynamic feasibility, Non equilibrium thermodynamics, Application of thermokinetics to metabolic control analysis.
Stoichiometry of cellular reactions, reaction rates, Dynamic mass balances, yield coefficients and linear rate equations.

**UNIT-III MATERIAL BALANCE & DATA CONSISTENCY:**
Stoichiometric models and matrix representation. Material balances ; the black box model, Elemental balances; Component balances and the link with macroscopic measurements; Examples of construction of elemental and component balances. Analysis of overdetermined systems; identification of gross measurement errors.

**UNIT-IV REGULATION AND SYNTHESIS OF METABOLIC PATHWAYS:**
Regulation of enzyme activity; Simple reversible, Irreversible inhibition and Allosteric enzymes.
Regulation of enzyme concentration; control of transcription and translation initiation. Global control; Regulation at the whole cell level, Regulation of metabolic networks. Enhancement of product yield and productivity, Extension of substrate range, Extension of product spectrum and novel products, Improvement of cellular properties, Xenobiotic degradation. Synthesis of metabolic pathways; Case studies and analytical-type Problems.

**UNIT- V: METABOLIC FLUX ANALYSIS & APPLICATIONS**: The theory of flux
balances; overdetermined system analysis, undetermined system analysis and sensitivity analysis. Experimental determination of metabolic fluxes by isotope labelling; direct flux determination from fractional label enrichment, carbon metabolite balances. Applications of metabolic flux analysis; amino acid production by glutamic acid bacteria and metabolic fluxes in mammalian cell cultures.

**COURSE OUTCOMES:**

CO1: Understand importance of metabolic Engineering
CO2: Understand the thermodynamics and comprehensive models for cellular process
CO3: Analyse the Stoichiometric models and matrix representations
CO4: Understand the regulation and synthesis of metabolic pathways
CO5: Analyse the metabolic flux analysis & applications

**REFERENCE BOOKS:**

1. Gregory N. Stephanopoulos, Aristos A. Aristidou, Metabolic Engineering – Principles and Methodologies, 1st Edition, Jens Nielsen Academic Press, 1998 Relevant research papers
2. Gerhard Gottschalk, Bacterial Metabolism, 2nd Edition, Springer Verlag, 1986

**TEXT BOOKS:**

1.S. A. Teukolsky, W. T. Vellerling, B. P. Flannery, W. H. Press, Numerical Recipes in C, Cambridge University Press, 1993

**SECOND SEMESTER** (LABORATORY III)

| PO1 | PO2 | PO3 | PO4 |
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## 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 |
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## 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. $k_La$ 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 |
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## 1. BIOREACTOR DESIGN & ANALYSIS

**UNIT-I: INTRODUCTION TO BIOREACTOR & CLASSIFICATION OF BIOREACTORS:**Batch reactors, continuous stirred tank bioreactors; the ideal CSTR , product formation, substrate inhibition and multiple steady states, enzyme catalysis in the CSTR, Chemostats in series, graphical design procedures. Plug flow and Packed bed reactors, Fed batch reactors, Recycle systems; biological waste water treatment, feed forward control of the activated sludge process.

**UNIT-II: MASS TRANSFER IN BIOREACTOR:** The rheology of fermentation broths, Gas liquid mass transfer; solubility of gases in biological media, mass balaces for two phase bioreactors, Bubble columns; Bubble generation at an orifice, the mass transfer coefficient, gas holdup, interfacial area, $k_L$ and liquid circulation patterns, correlation for $k_La$,agitated tanks ; mass transfer coefficient and the equilibrium bubble size, correlation for $k_La$, Experimental determination of $k_La$, oxygen transfer and shear in fermentation vessels.

**UNIT- III DESIGN OF EXPERIMENTS & STERILIZATION:** Statistical experimental designs overview, Full factorial screening design, Fractional factorials, Placket- Burman screening designs, Response surface design. **Medium & Air sterilization:** sterilization by removal; depth, absolute filters, sterilization by destruction; chemical, radiation and thermal inactivation. Sterilization process design; batch, continuous and aseptic design, Air sterilization; depth filtration, cartridge air filters and process design.

**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: SCALE-UP & DOWN OF BIOREACTOR AND CONTROL OF BIOREACTOR:** 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.

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**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- Design and optimize the media components and evaluate the kinetics of media and air sterilization by using different sterilization methods..

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 |
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## 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 |
|---|---|---|---|
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## 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.
**MULTI LOOP CONTROL SYSTEM:** Feed forward control-Ratio control-Cascade control-Split range-
Multivariable control and examples from distillation column & Boiler system.

**UNIT-VINTRODUCTION 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.

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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.

**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.
4. Patranabis, Process Control year?
5. KR Rogers, M. Mascion, Biosensors for analytical monitoring EP & biosensors year
6. 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 |
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## 1. BUSINESS ANALYTICS

**Unit I: BUSINESS ANALYTICS:** Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.
**Unit II: TRENDINESS AND REGRESSION ANALYSIS:** Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.
**Unit III:**Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.
**Unit IV: FORECASTING TECHNIQUES**: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.
**Unit V: DECISION ANALYSIS:** Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

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**COURSE OUTCOMES:**

CO1-Students will demonstrate knowledge of data analytics.
CO2-Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
CO3-Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
CO4-Students will demonstrate the ability to translate data into clear, actionable insights.
CO5- Students will demonstrate the decision analysis and visual data recovery.

**REFERENCE:**

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education

**THIRD SEMESTER** (OPEN ELECTIVE)

| PO1 | PO2 | PO3 | PO4 |
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## 2. INDUSTRIAL SAFETY

**Unit-I:** Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**Unit-II:** Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**Unit-III:** Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition,
principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**Unit-IV:** Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**Unit-V:** Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

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**COURSE OUTCOMES:**

CO1- Student will understand the industrial safety measures
CO2- Student will understand Fundetamentals of engineering maintence
CO3- Student will understand the prevention measures during lubrication
CO4- Student will understand the concepts of fault tracing
CO5- Student will understand the concepts of Periodic and preventive maintenance

**REFERENCE:**

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.

**TEXT BOOKS:**

1. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
2. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

**THIRD SEMESTER** (OPEN ELECTIVE)

| PO1 | PO2 | PO3 | PO4 |
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## 3. OPERATIONS RESEARCH

**Unit I:**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

**Unit II**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

**Unit III:**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

**Unit IV**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**Unit V**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

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**COURSE OUTCOMES:**

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

C01-Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.

CO2-Students should able to apply the concept of non-linear programming

CO3-Students should able to carry out sensitivity analysis

CO4-Student should able to model the real world problem and simulate it.

**REFERENCES:**

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008

**TEXT BOOKS:**

1. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
2. Pannerselvam, Operations Research: Prentice Hall of India 2010
3. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

**THIRD SEMESTER** (OPEN ELECTIVE)

| PO1 | PO2 | PO3 | PO4 |
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## 4. COST MANAGEMENT OF ENGINEERING PROJECTS

**Unit I:**

Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

**Unit II:**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non- technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

**Unit III:**

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.

**Unit IV:**

Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis.

**Unit V:**

Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

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**COURSE OUTCOMES:**

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

C01-Students should able to understand the cost management concepts
CO2-Students should able to analyse the various stages of projects
CO3-Students should able to carry out Cost Behaviour and Profit Planning Marginal Costing
CO4- Students should able to analyse Pricing strategies
CO5-Student should able to estimate the Budgetary Control permofmance.

**REFERENCES:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting

**TEXT BOOKS:**

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
2. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

**THIRD SEMESTER** (OPEN ELECTIVE)

| PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|
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## 5. COMPOSITE MATERIALS

**UNIT I: INTRODUCTION: Definition** – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT II: REINFORCEMENTS:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT III:** Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT IV:** Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT V:** Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

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**COURSE OUTCOMES:**

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

C01-Students should able to classify the Composite materials

CO2-Students should able to understand the different fibers and their properties

CO3-Students should able to understand the Manufacturing of Metal Matrix Composites

CO4-Student should able to understand the Manufacturing of Polymer Matrix Composites

CO5- Student should able to know the concepts of Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria

**TEXT BOOKS:**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**REFERENCES:**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

**THIRD SEMESTER** (OPEN ELECTIVE)

| PO1 | PO2 | PO3 | PO4 |
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## 6. 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.

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**COURSE OUTCOMES:**

At the end of the course, the student should be able to
CO1-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 analyse 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.

## AUDIT COURSE 1 and 2 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

**REFERCES:**

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 1 and 2: 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 DataFrom 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:**

Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. 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 1 and 2:** **SANSKRIT FOR TECHNICAL KNOWLEDGE**

UNIT I: Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences
UNIT II: Order Introduction of roots Technical information about Sanskrit Literature
UNIT III: Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

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***COURSE OUTCOMES:***

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

***REFERENCES:***

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

**AUDIT 1 and 2** **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 1 and 2** **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 1 and 2** **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**

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. 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 1 and 2** **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 1 and 2 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.

**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)**