DEPARTMENT OF BIOTECHNOLOGY

M.Tech. - Biotechnology

CURRICULUM AND SYLLABUS

2022 REGULATION

KALASALINGAM ACADEMY OF RESEARCH AND EDUCATION
(Deemed to be University)
Anand Nagar, Krishnankoil - 626126

Institute Vision	**Institute Mission**
To be a University of Excellence of International Repute in Education and Research	1. To provide a scholarly teaching learning ambience which results in creating graduates equipped with skills and acumen to solve real-life problems 2. To promote research and create knowledge for human welfare, rural and societal development 3. To nurture entrepreneurial ambition, industrial and societal connect by creating an environment through which innovators and leaders emerge.
Department Vision	**Department Mission**
To be a department of excellence in quality education and research in the multidisciplinary areas of Biotechnology.	1. To imbibe the ability of critical thinking, scholastic attitude and provide solutions for critical problems. 2. To embed acumen of life-long learning and zeal to pursue research in various disciplines of Biotechnology. 3. To nurture the ability to create sustainable solutions with a blend of socio-ethical understanding.

Program Educational Objectives (M.Tech – Biotechnology)

Graduates with M.Tech. degree in Biotechnology in five years after graduation are expected to have:

1. Established themselves as competent professionals excelling in various fields of biotechnology or in allied industries.

2. Demonstrated their ability in problem solving skills and act with global, ethical, ecological and commercial awareness in the service of the society.

3. To appreciate the significance of team work and collaborations in designing, planning, and implementing solutions for practical problems and facilitate the modern biotechnology with national research and academic organizations.

Program Outcomes (M.Tech – Biotechnology)

1. An ability to independently carry out research /investigation and development work to solve practical problems.
2. An ability to write and present a substantial technical report/document.
3. Students should be able to demonstrate a degree of mastery over various areas in biotechnology.
4. Capability to recognize problems, provide solutions related to industrial biotechnological processes that involve production of sustainable bioproducts.
5. Demonstrated ability to address issues related to environmental and health care biotechnology using modern computational and analytical tools.

M.Tech. BIOTECHNOLOGY CURRICULUM STRUCTURE

S. No	Category		Credits
1.	Supportive Core Courses		5
2.	Program Core Courses		40
	a. Theory Courses	30	
	b. Laboratory Courses	10	
3.	Experiential Elective		15
4.	Experiential Core		20
	Total		**80**

Supportive Core Courses

S. No	Course Code	Course Name	Course Type	L	T	P	C
1.	221MAT1101	Statistics and Computational Techniques	T	3	0	0	3
2.	221BT1101	Research Methodology	T	2	0	0	2
		Total					5

Program Core Courses

Theory Courses

S. No	Course Code	Course Name	Course Type	L	T	P	C
1.	222BT1101	Bioprocess and Bio-separation Technology	T	3	0	0	3
2.	222BT1102	Advanced Bioinformatics	T	3	0	0	3
3.	222BT1103	Immunotechnology	T	3	0	0	3
4.	222BT1104	Enzyme Technology	T	3	0	0	3
5.	222BT1105	Industrial Wastewater Treatment and Management	T	3	0	0	3
6.	222BT2108	Genomics and Proteomics	T	3	0	0	3
7.	222BT2109	Bioprocess Modeling and Simulation	T	3	0	0	3
8.	222BT2110	Stem Cell Technology	T	3	0	0	3

9.	222BT2111	Cell Signaling	T	3	0	0	3
10.	222BT2112	Biomaterials	T	3	0	0	3
		Total					30

Laboratory Courses

S. No	Course Code	Course Name	Course Type	L	T	P	C
1.	222BT1206	Advanced Immunology Laboratory	L	0	0	4	2
2.	222BT1207	Bioinformatics and Drug Design Laboratory	L	0	0	4	2
3.	222BT2213	Recombinant DNA Technology Laboratory	L	0	0	6	3
4.	222BT2214	Bioprocess Engineering Laboratory	L	0	0	6	3
		Total					10

Experiential Elective

S. No	Course Code	Course Name	Course Type	L	T	P	C
1	224BT4201	Internship	L	0	0	30	15

Experiential Core

S. No	Course Code	Course Name	Course Type	L	T	P	C
1	223BT4201	Project	L	0	0	40	20

SUPPORTIVE CORE COURSES

221MAT1101	STATISTICS AND COMPUTATIONAL TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objective(s):

The purpose of this course is to acquire more knowledge in statistics and its applications to engineering fields.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the types of probability distributions and their properties
CO2: Analyse the correlation and regression
CO3: Analyse the estimation for given data.
CO4: Analyse the appropriate test for given data.
CO5: Distinguish various designs of experiments.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M				
CO2	M	M	L		
CO3	M	M	L		
CO4	M	M	L	L	L
CO5	M	M	L	L	L

Unit 1: PROBABILITY DISTRIBUTIONS **9 hours**

Probability basic concepts - Binomial, Poisson, Geometric, Normal, Uniform, Exponential, Gamma and Weibull - distributions - Mean, Variance, Moment generating functions.

Unit 2: CORRELATION AND REGRESSION ANALYSIS: **9 hours**

Bivariate correlation – correlation in multivariate systems; Bivariate linear regression – statistical optimization – principle of least squares – reliability of the regression equation – reliability of point estimates of regression coefficients – confidence interval of the regression equation – correlation versus regression - Multiple Regression Analysis: Matrix solution of the standardized model - criteria for evaluating a multiple regression model – Analysis of residuals

Unit 3: ESTIMATION THEORY **9 hours**

Estimation of parameters - Principles of least squares - Maximum likelihood estimation - Method of moments - Interval estimation

Unit 4: TESTING OF HYPOTHESIS **9 hours**

Sampling distribution, large sample tests - Mean and Proportion, Small sample tests - t -test, F-test and Chi-Square test. -Goodness of fit -Independence of attributes.

Unit 5: DESIGN OF EXPERIMENTS **9 hours**

Design of Experiments: Basic Designs, Factorial Design, ANOVA

TEXT BOOK(S):

1. Jay, L. Devore, Probability and Statistics for Engineering and Sciences, Brooks Cole Publishing Company, Monterey, California, 1982.
2. Gupta, S.C. and Kapoor, V.K, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi, 12th Edition, 2014.
3. Paul Mac Berthouex and Linfield C. Brown, "Statistics for Environmental Engineers", , Lewis Publishers, Washington D.C., 2nd Edition 2002

REFERENCES:

1. Trivedi, K.S., Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI, 2nd edition, 2001.
2. Kapur, J.N. and Saxena, H.C, Mathematical Statistics, S. Chand and Co. Ltd., 18th Revised Edition, 1997.
3. Douglas C. Montgomery, Design and analysis of experiments, John Wiley and sons, 7th edition, 2010.

221BT1101	RESEARCH METHODOLOGY	L	T	P	C
		2	0	0	2

Course Outcomes:

After successful completion of course, the students will be able to,

CO1: Understand the basic concepts of research and hypothesis development in biological research.

CO2: Retrieve relevant research articles and documents through literature survey

CO3: Understand the process of designing the research

CO4: Develop the art of reporting the research and publishing

CO5: Apply basic statistical methods used in biology research.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H				
CO2	H		M		
CO3	H		M		
CO4	M	H			
CO5	M		H	M	

Unit 1: INTRODUCTION TO RESEARCH METHODOLOGY

Definition of Research - Basic and applied research, essentials steps in research, plural inductivism vs empirical falsification, defining the research problem, Deriving hypothesis in biological research, Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. Ethics in research.

UNIT 2: LITERATURE SURVEY

Literature citation, research report: components, Search engines. Format of thesis and dissertation, manuscript/research article, Review monographs, bibliography and reference, significance of research

UNIT 3: RESEARCH DESIGN

Concept and Importance in Research – Features of a good research design –Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. Drafting research proposal.

UNIT 4: RESEARCH REPORTING

Journals, Impact factors, H-index, Eigen factor score, Scientific index. Components of a research paper – title, authorships and affiliations, abstract, graphical abstract, acknowledgements, references, tables and illustrations, foot notes, legends, Submission of manuscript, Oral and poster presentation of research papers in conferences/symposia. Conflict of interest, podcast Plagiarism, Retraction.

Unit 5: STATISTICAL METHODS

Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); sampling distribution; difference between parametric and non-parametric statistics; confidence interval errors levels of significance; regression and correlation; t-test; analysis of variance; X2 test; basic introduction to multivariate statistics.

REFERENCE

C.R. Kothari, Research methodology, Methods and Techniques New Age International (P) Ltd, Publishers New Delhi, 2nd Edition, 2004.

PROGRAM CORE COURSES

THEORY COURSES

222BT1101	BIOPROCESS AND BIO-SEPARATION TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

To provide an insightful overview on the fermentation process, basic design of fermenter, sterilization, kinetics of growth and product formation and the fundamental concepts and applications of several downstream processes used in recovery of biochemical products.

Course Outcomes:

At the end of the course, students would be able to

CO1: Understand the fermentation process, bioreactors and its design features, instrumentation

CO2: Describe the microbial media, optimization, kinetics of living cells and to develop a strategy to solve the issues emerging during fermentation processes.

CO3: Summarize various cell disruption methods and identify appropriate isolation techniques

CO4: Express the principles and methods used for product purification viz electrophoresis and chromatography

CO5: Understand the importance of unit operations involved in polishing units

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	H	M
CO2	H	M	H	H	L
CO3	H	H	H	H	L
CO4	H	M	H	H	
CO5	H	M	M	H	

Unit 1: OVERVIEW OF FERMENTATION PROCESSES AND BIOREACTOR CONFIGURATIONS 9 hours

Range of fermentation processes - The chronological development of the fermentation industry- The component parts of a fermentation process- Process show sheeting- Role of bioprocess engineer- outline of an integrated bioprocess and the various upstream and downstream process- Unit operations involved in bioprocess-Introduction to bioreactors- The structural components of the fermenter- Basic functions of a fermenter- Design of a basic fermenter, design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for online monitoring- Different configurations of fermenter- acetators and cavitators-tower fermenter-cylindro-conical vessels-air-lift fermenters-deep-jet fermenter-cyclone column-The packed tower- bubble columns

Unit 2: MICROBIAL MEDIA, METABOLIC STOICHIOMETRY AND KINETICS **9 hours**

Media for industrial fermentations- Media optimization- batch growth, balanced growth, effect of substrate concentration. Monod model- Production kinetics in cell culture- Determining cell kinetic parameters from batch data- Kinetics of cell growth- Batch and Fed-batch bioreactors- Continuous Bioreactors- Metabolic Stoichiometry- mass balances and energy balances-The oxygen requirements of industrial fermentation- Oxygen supply- determination of kLa- Factors affecting oxygen transfer rate in fermenters like bubble size, gas hold up, gas velocity, temperature, pressure etc- Power required for sparged and agitated vessels- The relationship between power consumption and operating variables. Role of shear in stirred fermenters.

Unit3: CELL DISRUPTION AND PRODUCT ISOLATION **9 hours**

Types of cells and cell-wall architectures: Plant, Animal, Bacterial and Fungal – Intracellular location of product and kinetics of product, Removal of insolubles: Biomass and particulate debris separation techniques–flocculation – sedimentation- centrifugation and filtration methods. Adsorption: Principles – Langumir- Freundlich isotherms – Extraction: Basics-Batch and continuous, aqueous two-phase extraction-supercritical extraction- Precipitation: Methods of precipitation with salts-organic solvents and polymers

Unit4: PRODUCT PURIFICATION **9 hours**

Electrophoresis and chromatograph principles for product purification; Different electrophoresis techniques viz. Isoelectric focusing, chromatographic techniques viz, Paper gel, column, ion exchange, affinity, GLC, HPLC, pseudo-affinity chromatography, IMAC chromatography, Dialysis, ultrafiltration.

Unit5: PRODUCT FORMULATION AND POLISHING **9 hours**

Product Polishing: Crystallization – Principles and crystal growth kinetics, drying – Principles and water in biological materials, Freeze drying; Purification of cephalosporin, aspartic acid, Recombinant Streptokinase, Monoclonal antibodies, Tissue plasminogen activator, Taq Polymerase and Insulin

TEXT BOOKS

1. Peter, F., Stanbury., Stephen, J., Hall and A. Whitaker., Principles of Fermentation Technology, Elsevier, Science and Technology Books, New Delhi, 2nd Edition, 2005.
2. Doran, P.M., Bioprocess Engineering Principles, 2nd Edition, Academic Press (An Imprint of Elsevier), New Delhi, 2nd Edition, 2013.
3. Harrison, R.G, Todd, P., Todd, P.W, Petrides, D.P, Rudge, S.R., Bioseparations Science and Engineering, Oxford University Press, USA, 2015.
4. Belter, P.A. Cussler, E.L. and W.S. Hu, Bioseparations; Downstream Processing for Biotechnology, John Wiley, New York,1988.

REFERENCES

1. Doran, P.M., Bioprocess Engineering Principles, 2nd Edition, Academic Press (An Imprint of Elsevier), New Delhi, 2nd Edition, 2013.
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Macel Dekker Inc., 1st Edition, 1997.
3. Sivasankar B., Bioseparations: Principles and Techniques, PHI Learning Pvt. Ltd. - 2005.

222BT1102	ADVANCED BIOINFORMATICS	L	T	P	C
		3	0	0	3

Course Objective:

Objective of this course is to impart in students a depth and breadth of knowledge of bioinformatics including recent advancements in this field. Knowledge on bioinformatics databases, sequence and structure analysis, molecular dynamics and functional analysis is demonstrated to students through this course along with a glimpse of practical part.

Course Outcomes:

At the end of the Course Students would be able to,

CO1: Access various databases and tools to retrieve and analyze biological data

CO2: Compare and analyze sequences to infer the evolutionary relationship among the corresponding organisms

CO3: Understand the aspects molecular structure representation and dynamics

CO4: Recapitulate various structure prediction algorithms and tools

CO5: Understand the use of various tools and methods for prediction of protein functions

CO and PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H		L		H
CO2	H		L		H
CO3	H		L		H
CO4	H		L		H
CO5	H		L		H

Unit1: DATABASES **9 hours**

Primary and Secondary Databases; GenBank, EMBL, DDBJ, Swissplot, MIPS, PIR, TIGR, Hovergen, TAIR, PlasmoDB, ECDC; Databases - mapping, sequence, structure, non-redundant

Unit 2: SEQUENCE ANALYSIS AND DATABASE SIMILARITY SEARCHING 9 hours

Scoring Matrices and their use: Computational complexities; Analysis of Merits and demerits; Sequence pattern; - pattern recognition, hidden Markov models - neural networks; Pattern databases; PROSITE, PRINTS, Viterbi algorithm; Baum-Welch algorithm; FASTA and Blast Algorithm: Needleman-Wusch & Smith-Waterman algorithms –Overview of Molecular Phylogenetics

Unit 3: REPRESENTATION AND DYNAMICS OF MOLECULAR STRUCTURES 9 hours

Representation of molecular structures; External and internal coordinates; Concept of free energy of molecules; Introduction to various force fields; Molecular energy minimization techniques - intra molecular interactions; Monte Carlo and Molecular Dynamics simulation; Physicochemical parameters - Ionization constants, chelation, solubility and partition Co-efficient - Over view of Molecular Descriptors

Unit 4: STRUCTURE PREDICTION **9 hours**

Molecular structure Determination - Principles of X-ray crystallography and NMR spectroscopy; 2D Protein Data bank and Nucleic Acid Data bank; Storage and Dissemination of molecular structures; Methods for predicting secondary structure- Chau and Fasman Method, GOR method and Neural Networks; Homology Modeling, *ab initio* and Threading

Unit 5: FUNCTION PREDICTION **9 hours**

Gene Ontology; Enzyme Classification; Structure Based, Homology based and Sequence motif-based methods of Function Prediction of proteins; Detecting functional sites in DNA – ORF Finder; Promotor Prediction

TEXT BOOKS

1. Baxevanis, A.D. Ouellette, B.F.F. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley Inderscience, New York, 3rd Edition, 2005.
2. David W. Mount, Bioinformatics: Sequence and Genome Analysis, CSHL Press, New York, 2nd Edition, 2004.

REFERENCES

1. Jonathan, P., Bioinformatics and Functional Genomics, Wiley-Blackwell, 2nd Edition, 2009.
2. Merz, K.M., Ringe, D. Reynolds, C.H., Drug Design: Structure- and Ligand-Based Approaches, Cambridge University Press, 2010.
3. Branden, C. and J. Tooze, J., Introduction to Protein Structure, 2nd Edition, Garland Publishing, 1999.

222BT1103	IMMUNOTECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

To provide an in-depth knowledge on the functioning of the immune system and to inculcate knowledge in various immunological assays and treatment strategies

Course Outcomes:

At the end of the course, students would be able to

CO1: Elaborate the concept of antigen processing and presentation and understand the role of cytokines in immune response.

CO2: Explain the classes of antibodies and to understand the production and applications of polyclonal and monoclonal antibodies.

CO3: Describe various kinds of vaccines used in the prevention of infectious diseases

CO4: Summarize the concepts of immunotherapy for the treatment of immune mediated diseases.

CO5: Comprehend various immunoassays that are used in the diagnosis of diseases

CO and PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	M	H
CO2	H	M	H	M	H
CO3	H		H	M	M
CO4	H		H		M
CO5	H		H		M

Unit 1: ANTIGEN PRESENTATION AND CYTOKINES 9 hours

Cells of the immune system, Cellular basis of immunity, T cell receptor - Antigen processing and presentation: MHC - class I and class II, measurement of MHC-peptide interaction; Cytokines: Interleukins, Interferons: types, production and role in immune system

Unit 2: ANTIBODIES AND ANTIBODY ENGINEERING 9 hours

Active and passive immunization; Immunoglobulin: classes and subclasses, structure-function relationship, isotypes, idiotypes and allotypes; Production of Polyclonal antibodies with different types of antigens: antigen preparation and modification, adjuvants (Freund's complete and incomplete); does and route of antigen administration, collection of sera and purification of antibodies; Hybridoma technology: production and applications of monoclonal antibodies for diagnosis and therapy; Culturing of lymphocytes - Characteristics of animal cells and their implication on process design - Nutritional requirements and serum free culture of mammalian cells - Kinetics of growth and product formation; Reactor systems for large-scale production using animal cells - Antibody Engineering; Catalytic antibodies, Commercial production of antibodies

Unit 3: INFECTIOUS DISEASES AND VACCINES 9 hours

Immunity to infections by viruses, bacteria, fungi and parasites - Vaccines: live and attenuated; Subunit vaccines, recombinant vaccines, Vaccines directed against viruses and bacteria, DNA vaccines. Anti-fertility vaccines

Unit 4: IMMUNOTHERAPY FOR INFLAMMATORY DISEASES 9 hours

Concept of immunotherapy, immune mediate diseases - Allergy, tumor and autoimmune diseases: aetiology, pathogenesis and treatment - Auto immune diseases - Animal model for autoimmune diseases; mechanism for the induction of autoimmunity; treatment of autoimmune diseases -tumor antigens, tumor evasion of the immune system and cancer immunotherapy.

Unit 5: IMMUNOASSAYS 9 hours

Immunological Assays: Immuno-diffusion, Immunoelectrophoresis, ELISA, RIA, Immunofluorescence, FACS, complement fixation, T cell assays: CTL assay, cytokine secretion - ELISpoT, ICS, Tetramer staining, HLA Typing, western blot

TEXT BOOKS

1. Murphy, K., Weaver, C. Janeway's Immunobiology, Garland Science, New York, 9th Edition, 2016.
2. Coico, R., Sunshine, G. Immunology: A Short Course, Wiley-Blackwell, 7th Edition, 2015.

REFERENCES

1. Moran, A., Gosling, J. and Gosling, J.P. Immunotechnology: Principles, Concepts and Applications, John Wiley & Sons, 2008.
2. George, A.J.T. and Urch, C.E. Diagnostic and Therapeutic antibodies (Methods in Molecular Medicine) Humana Press, 2000.
3. Coligan, J.E., Bierer, B.E., Margulies, D.H., Shevach, E.M. and Strober, W. Current Protocols in Immunology, John Wiley & Sons, 2017.

222BT1104	ENZYME TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

To understand the basics of catalysis, classification of enzymes and its mechanisms, kinetics of enzymes, production and application of enzymes in various field

Course Outcomes:

At the end of the course, students would be able to:

CO1: Understand the catalysis and classification of enzymes
CO2: Articulate the concepts of active site, mechanism and the stability of enzymes
CO3: Describe the kinetics and parameters on enzyme activity
CO4: Design enzyme reactors and analyze parameters affecting its performance
CO5: Describe enzyme production and its applications

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M	M			
CO2	H	M	M		
CO3	M	H	M		
CO4	M	H			
CO5	H	H	H	M	

CATALYSIS AND CLASSIFICATION OF ENZYMES **9 hours**

Basics of catalysis-Transition state theory -The significance and the application of transition state theory-The Hammond postulate -Principles of catalysis- General-acid-base catalysis-Intramolecular Catalysis-Electrostatic Catalysis-Metal ion catalysis-Covalent catalysis-Electrophilic Catalysis-Nucleophilic Catalysis-Classification of enzymes- oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases.

MECHANISM AND STABILITY OF ENZYMES **9 hours**

Active site characterization - The role of metal ions and cofactors like pyridoxal phosphate, Thiamine -pyrophosphate, folate, biotin, flavin, nicotinamide nucleotides and lipoate in enzyme catalytic mechanisms- mechanism of enzyme action-Chemical modifications and site directed

mutagenesis - Integration of kinetic, chemical, and structural data towards enzyme mechanisms - Protein engineering to improve enzyme stability

CONCEPTS OF RATE PROCESSES IN BIOLOGICAL SYSTEMS **9 hours**

Factors contributing to enzyme catalytic rates - Single and multi-substrate system - Regulatory enzymes - Steady-state kinetics - Initial velocity, product inhibition, enzyme activation analysis - Effect of pH and temperature on enzyme rates - Modeling of rate equations for single and multiple substrate reactions- kinetics of immobilized enzymes

DESIGN AND ANALYSIS OF ENZYME REACTORS **9 hours**

Types of Reactors - General design of enzyme reactors under Ideal conditions, Batch and continuous mixed reactors, continuous packed bed reactor under plug flow regime, Parameters affecting the performance of enzyme reactors, Reactor dynamics, Operational stability and optimization- design and configuration of immobilized enzyme reactors

ENZYME PRODUCTION AND APPLICATIONS **9 hours**

Production of enzymes, Chemical modification of enzyme to improve physico-chemical properties and enzymatic reaction, Enzymes in industrial production of drugs and natural products, fine chemicals and chiral intermediates - analytical applications of enzymes

TEXT BOOKS

1. Fersht, A.R., Enzyme Structure and Mechanism, W.H. Freeman & Co, New York, 5th Edition, 2000.
2. Segel, I.H., Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems, Wiley Interscience, New York, 6th Edition, 1994.

REFERENCES

1. Plownan, K.M., Enzyme Kinetics, McGraw-Hill & Co, London, 4th Edition, 1972.
2. Walsh, C.S., Enzymatic Reaction Mechanisms, W.H. Freeman & Co, New York, 4th Edition, 1978
3. Trevan, M.D., Immobilized Enzymes, John Wiley & Sons, New York, 3rd Edition, 1980

222BT1105	INDUSTRIAL WASTEWATER TREATMENTAND MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

This course acquaints students to biological processes to remove organic material, nutrients from wastewaters of municipal and industrial origin. The course evaluates microorganism interactions, metabolism, nutrient requirements, substrate requirements, environmental conditions controlling growth, and other factors that are important to understanding microbial activity in biological wastewater treatment.

Course Outcomes:

At the end of the course, students would be able to

- **CO1:** Differentiate the characteristics of distinct industrial wastewater and develop and relationship between measuring parameters
- **CO2:** Use stoichiometric and kinetic relationships to estimate net degradation of contaminants, consumption of electron acceptors and carbon sources, and production of cells over a biological treatment process
- **CO3:** Understand the biochemical reactions and design criteria pertaining to anaerobic treatment processes
- **CO4:** Differentiate and estimate the applicability of suspended and attached microbial growth processes
- **CO5**: Summarize the importance of combination of physico-chemical and biological treatment for emerging and persistent pollutants

CO and PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	H		M	M	M
CO2	H		H	H	H
CO3	H		H	M	M
CO4	H		M	M	H
CO5	H		M	M	M

WASTEWATER CHARACTERISITCS **9 hours**

Measurement of Organic Pollutant: Parameters - BOD, COD &TOC, Factors affecting on BOD, BOD equations, methods of estimating BOD, Biological v/s Physicochemical analysis, importance of ratios such as BOD/COD and C/N, Sources and type of industrial wastewater, Effects of industrial effluents on sewers and natural water bodies Regulatory requirements for treatment of industrial wastewater

AEROBIC BIOLOGICAL TREATMENT PROCESS **9 hours**

Types of biological processes for wastewater treatment, suspended and attached growth systems, Municipal wastewater treatment, Unit operations of Pre and primary treatment, Aerobic biological oxidation, rate of utilization of soluble substrates, rate of biomass growth with soluble substrate, rate of oxygen uptake, effects of temperature, total volatile suspended solids and active biomass, net biomass yield and observed yield.

ANAEROBIC BIOLOGICAL TREATMENT PROCESS **9 hours**

Anaerobic process description; Comparison with the aerobic processes - Types of anaerobic reactors; Mechanism of anaerobic fermentation – a multistep process, Microbiology and biochemistry of anaerobic processes, Production of biogas and energy balances, substrate inhibition, Anaerobic digesters, anaerobic filters, Up flow anaerobic sludge blanket reactor

ATTACHED AND MEMBRANE TREATMENT SYSTEMS 9 hours

Introduction to attached aerobic and anaerobic growth systems, Mass transfer limitations, trickling filtrations, Oxygen transfer and utilization, Applications of rotating biological contactors, Bio-Towers, Process description considerations -Membrane bioreactors; MBR System Features, Fouling and fouling control, Membrane Module Design Considerations.

COMBINED BIOLOGICAL AND CHEMICAL METHODS 9 hours

Electro-coagulation and electro-oxidation process, Theory of advanced oxidation, Types of oxidizing agents, ozone based and non-ozone-based processes, Fenton and photo Fenton Oxidation, Solar Photo Catalytic Treatment Systems, Nutrient removal – nitrogen and phosphorous.

TEXT BOOKS

1. Metcalf and Eddy, Wastewater Engineering, Treatment and Reuse. Tata McGraw-Hill Publishing Company Limited, Third Edition, New Delhi, 4th edition, 2003.

REFERENCES

1. Qasim, S.R., Wastewater Treatment Plant; Planning, Design and operation, Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, McGraw Hill Publishers, New Delhi, 2nd Edition, 2004.
2. Arceivala, S.J. Wastewater Treatment for Pollution Control, TMH Publishers, New Delhi, 2008.

222BT2108	GENOMICS AND PROTEOMICS	L	T	P	C
		3	0	0	3

Course Objectives:
To provide an overview of the organization of genomes and the analysis of genome and proteome, differential expression analysis and various tools used in proteomics

Course Outcomes:
At the end of the course, students would be able to

CO1: Explain the organization and sequencing of genome and list various sequencing technologies.
CO2: Summarize the role of structural and functional genomics.
CO3: Describe the principles of DNA microarrays
CO4: Apply the principles of proteomics in assessing and analyzing the proteomic data.
CO5: Explore the advanced topics in proteomics.

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	M	H
CO2	M	L	M	M	H
CO3	M	M	H	M	H
CO4	H	M	M	M	H
CO5	H	M	M	M	H

Unit 1: ORGANIZATION AND SEQUENCING OF GENOME 9 hours

Organization of genome – Introns, Pseudogenes, Retropseudogenes, Transposons, Retrotransposons; Sequencing of genome – History of sequencing of DNA, RNA and whole genomes; DNA sequencing methods - Basic methods of sequencing (Maxam-Gilbert, C-termination); Shot gun sequencing; MPSS, Polony, 454, IIlumina, SOLiD, Ion Torrent, SMRT, nanopore; Genome sequence databases; applications of next generation sequencing – molecular, evolutionary biology, metagenomics, medicine and forensics; Genome analysis.

Unit 2: STRUCTURAL AND FUNCTIONAL GENOMICS 9 hours

Introduction to structural genomics – *de novo* methods, *ab initio* modeling, sequence-based modeling, threading, protein structural databases and classification; Functional genomics – Genomics age, epigenetics, forward against reverse genetics; Genome examination – Genome editing methods, transcriptomics; Comparative genomics –Genomics and evolution, outcome of comparative genomics.

Unit 3: DNA MICROARRAYS 9 hours

Principle; Uses and classifications – manufacturing process, spotted and *in situ* synthesized arrays, 2 and 1 channel recognition; generation of heat map, Bioinformatics – experimental design, standardization, data analysis, annotation, data warehousing; optional technologies; Multi-stranded DNA microarray.

Unit 4: PROTEOME ANALYSIS 9 hours

Basics of proteins and proteomics- Introduction to amino acids and proteins, protein folding/mis-folding, introduction to proteomics; Gel-based proteomics- preparation of samples and pre-analytical dependencies, protein purification and estimation; 1-D electrophoresis; 2-D electrophoresis- 2^{nd} dimension, staining, destaining, gel examination, uses and difficulties; DIGE and systems biology- introduction, data analysis, uses, systems biology and proteomics; Basics of MS and sample preparation- fundamentals, techniques, LC-MS, MALDI, In-gel/In-solution digestion.

Unit 5: ADVANCED TOPICS IN PROTEOMICS 9 hours

Introduction to quantitative proteomics- SILAC, iTRAQ, TMT, phosphoproteome, data analysis; Applications of proteomics; difficulties in proteomics; OMICS and translational exploration

TEXT BOOKS

1. Saccone, C. and Pesole, G., Hand book of Comparative Genomics – Principles and Methodology, John Wiley and Sons Publication, New Jersey, 1^{st} Edition, 2003.
2. Lesk, A.M., Introduction to Protein Science. Architecture, Function and Genomics, Oxford University press, New York, 3^{rd} Edition, 2016.
3. Primrose, S. B. and Twyman, R.M., Principles of Genome Analysis, Blackwell Publishing, Singapore, 3^{rd} Edition, 2002.

REFERENCES

1. Creighton, T.E., Protein Structure – A Practical Approach, Oxford University Press, New York, 4^{th}Edition, 2004.
2. Brown, T.A., Genomes IV, Garland Science, Taylor and Francis Group, New York, 4^{th} Edition, 2017.

222BT2109	BIOPROCESS MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

Course Objectives:
To introduce the different aspects of modeling and analysis in bioprocess system and to familiarize the simulation of bioprocess modeling

Course Outcomes:
At the end of the course, students would be able to
CO1: Explain the basic modeling principles and fundamentals of bioprocess modeling
CO2: Apply numerical methods to derive solutions for model equations
CO3: Understand various models in bioprocesses
CO4: Explain the basics of MATLAB, data analysis and interpretation of data
CO5: Apply MATLAB and SIMULINK in simulation of bioprocess systems

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	H	H
CO2	H	M	H	M	M
CO3	H	M	H	H	M
CO4	H	H	H	H	H
CO5	H	M	H	H	H

Unit 1: BASIC MODELING PRINCIPLES 9 hours
Introduction to process modeling - Basic modeling principles- Systematic approach to model building- classification of models- Conservation principles, thermodynamic principles of process systems- continuity equation - equations of motion -transport equations - equations of state - chemical and biochemical kinetics-examples- Development of steady state and dynamic lumped and distributed parameter models based on first principles- Deterministic and Stochastic models.

Unit 2: ANALYSIS OF MATHEMATICAL MODELS 9 hours
Analysis of ill-conditioned systems- Models with stiff differential equations - Examples involving algebraic equations- ordinary differential equations- partial differential equations, integral equations - Euler's methods, Newton – Raphsen methods, Runga – Kutta methods- Solution methods for initial value and boundary value problems

Unit 3: BIOPROCESS MODELING 9 hours
Unstructured models- examples- Monod model-Study of structured models for analysis of various bioprocesses – Compartmental models (two and three), cybernetic models - Models of cellular energetic and metabolism - Single cell models, plasmid replication and plasmid stability model - Models for Product formation- Genetically structured models- Stochastic model for thermal sterilization of the medium- Modeling for activated sludge process- Model for anaerobic digestion- Models for lactic acid fermentation and antibiotic production.

Unit 4: MATLAB BASICS AND DATA ANALYSIS **9 hours**

Basics-Data analysis-curve fittings, Input and Output in MATLAB- Solving problems using MATLAB- Euler and Fourth order Runge Kutta methods.

Unit 5: SIMULATIONOF BIOPROCESS **9 hours**

Dynamic simulation of batch, fed batch, steady and transient culture metabolism using Berkeley Madonna software - Simulation of biochemical system models – Simulation of batch reactor using MATLAB, SIMULINK for dynamic systems- Simulation of non- isothermal CSTR-Simulation of chemostat.

TEXTBOOKS:

1. Harvey W. Blanch., Douglas S. Clark, "Biochemical Engineering", Marcel Decker Inc. 2007.
2. Bequette W.B. "Process Dynamics- Modeling analysis with simulation", Prentice Hall; 1st edition, 1998.
3. Singiresu S. Rao, Applied Numerical Methods for Engineers and Scientists, Prentice Hall, Upper Saddle River, NJ, 2001

REFERENCES:

1. Luben W.L. "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill, International New York, 1990.
2. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall of India, 2nd Edition, 2011
3. http://www.mathworks.com

222BT2110	STEM CELL TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

To introduce students the basics of stem cell biology and to make them understand classification, characterization, culturing and therapeutic applications of stem cells.

Course Outcomes:

At the end of the course, students would be able to

CO1: Describe the fundamental concepts and characteristics of stem cell biology.

CO2: Classify stem cells and conceptualize somatic cell nuclear transfer and generation of iPS cells

CO3: Explain the methods of isolating stem cells from various tissues.

CO4: Discuss the role of stem cells in therapeutics and tissue regeneration.

CO5: Summarize various issues and ethical considerations in stem cell research and applications.

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	M	H	M	M
CO2	H	M	H	M	M
CO3	H	M	M	M	M
CO4	H	M	M	M	M
CO5	H	M	H	M	M

Unit 1: FUNDAMENTALS OF STEM CELL BIOLOGY 9 hours

Embryo -Formation and developmental stages - Stem cells- History of stem cell research- Definition of terms (Renewal, Plasticity, Redifferentiation and Dedifferentiation, Pluripotency, Totipotency, Multipotency)- Properties of stem cells - Identification and characterization of pluripotent stem cells in animal and humans.

Unit 2: STEM CELLS CLASSIFICATION AND CHARACTERIZATION 9 hours

Embryonic Stem Cells-Properties -Isolation of human embryonic stem cells-Culturing of embryos -Growing ES cells -Adult stem cell and its types-Somatic stem cells and its properties -SCNT, iPS - Adult stem cell differentiation - Transdifferentiation- Methods for identification of adult stem cells-Germ Line Stem Cell- Properties- Identification, Characterization and Purification of Germ Line Stem cells- Germline Stem cell Niche- Establishment of Germ Line cells *in vitro.*

Unit 3: SOURCES OF STEM CELLS 9 hours

Adult cardiac stem cells -Epithelial stem cells - Hematopoietic stem cells -Bone marrow stromal stem cells -Neural stem cells – Cancer Stem cells.

Unit 4: STEM CELLS IN THERAPEUTICS AND TISSUE ENGINEERING 9 hours

Stem cells in gene therapy- Application of Stem cells for the treatment of Parkinson disease – Cardiac and neurological disorders - Spinal cord injuries - Diabetes - Alzheimer's Disease- Mechanisms for stem cell manipulation in controlled micro-environments- Growing organs from stem cells in kidney, eyes, heart and brain.

Unit 5: ISSUES AND ETHICAL CONSIDERATIONS IN STEM CELL RESEARCH 9 hours

Establishment of human stem cell bank- Commercialization of human stem cells -Recent ethical controversies about embryonic stem cell research and legal issues- Government policies on stem cell research and applications.

TEXT BOOKS

1. Panno, J., Stem Cell Research: Medical Applications and Ethical Controversy, Infobase Publishing. 1st Edition, 2014.
2. Humber, J.M., Almeder, R.F., Stem Cell Research, Totowa, N. J., Humana Press, 1st Edition 2004.
3. Viegas, J., Stem Cell Research, The Rosen Publishing Group. 1st Edition, 2003.

REFERENCES

1. Turksen, K., Embryonic Stem cells - Protocols, 2nd Edition, Humana Press, 2002.
2. Stem cell and future of regenerative medicine, By committee on the Biological and Biomedical applications of Stem cell Research, 1st Edition, National Academic Press. 2002

222BT2111	CELL SIGNALLING	L	T	P	C
		3	0	0	3

Course Objectives:

To provide an understanding of various cellular events and the importance of signal transduction in facilitating these events

Course Outcomes:

At the end of the course, students would be able to

- **CO1:** Understand the role of various transport molecules
- **CO2:** Explain the organization of eukaryotic genome and intra-nuclear processes
- **CO3:** Elucidate the role of various receptors and their role in communication
- **CO4:** Demonstrate the mechanism of various signal transduction events
- **CO5**: Describe the structure and function of components involved in cellular adhesion

CO and PO Mapping

	PO1	PO2	PO3	PO4	PO5
CO1	M		M		L
CO2	M		M		L
CO3	M		M		L
CO4	M		M		M
CO5	M		M		M

Unit1: PROTEIN SORTING IN ORGANELLES 9 hours

Overview of major protein-sorting pathways in eukaryotic cells, signal sequences, The transport of protein molecules between *nucleus and cytosol, mitochondria, chloroplast, endoplasmic reticulum* and folding proteins - Transporter and active membrane transport, ABC transporter – Vesicular trafficking, various types of vesicle formation, clathrine coated vesicles, trafficking of SNARE complex - Transcriptional regulation, helix turn helix motif, Zn finger motif, leucine zipper motif - cytoskeleton filament, actin, microtubule assembly, molecular motor proteins kinesin and dyanin regulation.

Unit2: MACROMOLECULES IN NUCLEUS 9 hours

Forces stabilizing nucleic acid structures, DNA denaturation and renaturation, nucleic acids are and ionic interactions, RNA structure are highly variable – Eukaryotic chromosome structure, histones, DNA coils around histone to form nucleosomes, chromatin forms higher order structures, differences of prokaryotic and eukaryotic replications, DNA mutations, DNA damage can be directly reversed – transcription in eukaryotes, types of RNA polymerase, recognizing promoters, transcription factors required to initiate transcription.

Unit 3: RECEPTORS **9 hours**

Extracellular receptor, G-protein coupled receptor, tyrosine kinase receptor, integrin receptor, Toll gate receptor, ligand gated ion channel receptor - intracellular receptor, NOD like receptor, cytokine and interleukin receptor, Ligand binding nuclear receptor, ion channel coupled receptor, g-protein coupled receptor, and enzyme coupled surface receptors, integrin receptor. EGF and TGF-β growth factor receptor, insulin receptor, GPCR regulate cyclic nucleotide gated ion channels, First messengers and second messengers.

Unit 4: SIGNAL TRANSDUCTION **9 hours**

Mechanism of phosphorylation, phosphorylation of activation and inactivation, Molecular switches, patched and smoothened signaling, wnt – β catenin signaling, notch signaling, src homolog function as tyrosin kinase, structure and function of SH2 domain, ERK pathway, Akt/PKB kinase pathway, ras regulatory pathway, Jak-STAT pathway, MAPK pathway, NF-kβ pathway, signaling pathway in plant ethylene blocks auxin transporter and plant growth phytochrome.

Unit 5: CELL JUNCTION, CELL ADHESION AND EXTRACELLULAR MATRIX 9 hours

Cell–Cell and Cell–Matrix Adhesion: An Overview, Major families of cell-adhesion molecules (CAMs) cadherins, immunoglobulin (Ig) superfamily, integrins, and selectins, adhesion receptors. Junctions and Adhesion Molecules of epithelial tissues and extracellular matrix, adhesive molecules in plant.

TEXT BOOKS

1. Alberts, B., A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter. Molecular Biology of the Cell**,** Garland Science; New York: 6th edition, 2014.
2. Lodish, H., A. Berk, C.A. Kaiser and M. Krieger, Molecular Cell Biology, W. H. Freeman and Company, New York, 6th edition, 2016.
3. Voet, D., J.G. Voet, C.W. Pratt, Fundamentals of Biochemistry Life at molecular level, John Wiley and Sons Inc, New York, 5th edition, 2016.

222BT2112	BIOMATERIALS	L	T	P	C
		3	0	0	3

Course objectives:

The objective of this course is to teach the basic concepts in material science, different type of materials, structure and chemistry of biomaterials. This course encompasses variety of medicinal applications of biomaterials, issues related to it and ways to overcome the medical problems.

Course Outcomes:

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

CO1: Understand the fundamental concepts of material science

CO2: Explain about biological responses to implanted biomaterials.

CO3: Discuss various types of biomaterials used in biomedical field.

CO4: Summarize the methods used for characterizing biomaterials and analysis of medical implants

CO5: Apply principles in designing biomaterials for medicinal applications.

CO and PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	M		M		H
CO2	M		M		H
CO3	M		M	M	H
CO4	M		M		H
CO5	M		M	M	H

BASIC CONCEPTS IN MATERIAL SCIENCE 9 hours

Fundamental concepts in material science – Metals, Ceramics and Polymers - Polymerization reactions - Metals Structure and -Types of alloys (e.g., ferrous and nonferrous) - Ceramics and Glasses: characterization of crystalline and non-crystalline materials - Mechanical properties and processing methods.

BIOLOGICAL RESPONSE TO BIOMATERIALS 9 hours

Familiarity with biocompatibility and hemocompatibility, Mechanisms of the foreign body response to implanted biomaterials-Blood-biomaterials and its interactions- Biodegradation of biomaterials-intentional and un-intentional degradation mechanisms–Techniques in modification of biomaterial surfaces to control the biological response - Instrumentations to examine surface chemistry.

APPLICATIONS OF BIOMATERIALS 9 hours

Classes of materials used in medicine- Design of materials for biomedical application: Cardiovascular-Dental implants- Orthopaedic applications- Skin- Ophthalmologic applications- Wound healing- Sutures- Biosensors- Implantation techniques in soft tissue and hard tissue replacements.

EVALUATION OF BIOMATERIALS 9 hours

Materials Characterization -*In Vitro* and *In Vivo* Methods - Regulation of Medical Devices- Problems and possible solutions in implant fixation- Failure analysis of medical devices and implants.

BIOMATERIALS IN ENGINEERING DESIGN 9 hours

Fundamental principles for designing biomaterials to be used in a various medical application- Familiarity with legal and ethical issues in biomaterials used in medical applications.

TEXTBOOKS

1. Temenoff, J.S. and Mikos, A.G., Biomaterials: The Intersection of Biology and Materials Science by, Pearson Prentice Hall, 2008.
2. Ratner, B.D., Hoffman, A.S., Schoen, F.J., Lemons, J.E., Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 3rd Edition 2012.

REFERENCES:

1. Wong, J.Y., Bronzino, J.D., Peterson, D.R., Biomaterials: Principles and Practices, CRC Press, 2012
2. Park, J., Lakes, R.S., Biomaterials**:** An Introduction, 3rd Edition, Springer, 2007.

LABORATORY COURSES

222BT1206	ADVANCED IMMUNOLOGY LABORATORY	L	T	P	C
		0	0	4	2

Course Objective:
To make students practice various advanced techniques used in immunology

Course Outcomes:
After completing this course, the student will be able to:

CO1: Raise antibodies and conduct assays for estimation of antibody
CO2: Perform techniques for assaying antibody and purification of antibodies
CO3: To isolate splenocytes and make hybridomas
CO4: To design and conduct T cell assays

CO and PO mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	H	L
CO2	H	H	H	H	H
CO3	H	H	H	H	L
CO4	H	H	H	M	L

LIST OF EXPERIMENTS:

1. Routes of immunization and bleeding
2. Kinetics of antibody production – dot blot assay
3. Affinity purification of antibodies
4. Macrophage migration assay
5. Isolation of splenocytes and culture of T cells
6. T cell assays – cytotoxicity assays, ELISPOT
7. Macrophage inhibition assays

222BT1207	BIOINFORMATICS AND DRUG DESIGN LABORATORY	L	T	P	C
		0	0	4	2

Course Objective:
To develop practical skills of the students in the area of bioinformatics and drug design.

Course Outcomes:
At the end of the course, students would be able to
CO1: Retrieve and visualize information from various biological databases.
CO2: Execute and analyze pairwise and multiple sequence alignments and construct phylogenetic trees.
CO3: Access the annotation and functional characterization information of genomes and perform gene, ORF and promotor prediction.
CO4: Predict secondary structure, tertiary structure and active/binding sites of proteins
CO5: Utilize computer aided drug design tools for molecular docking and Pharmacophore modeling and ADMET prediction.

CO and PO mapping:

CO/PO	1	2	3	4	5
CO1	H	H	M		H
CO2	H	H	M		H
CO3	H	H	M		H
CO4	H	H	M		H
CO5	H	H	M		H

LIST OF EXPERIMENTS:

1. Information retrieval from GenBank, Uniprot, PDB, KEGG, TAIR and GEO.
2. Pairwise and Multiple sequence Alignment- EMBOSS Needle, EMBOSS Water and Clustal Omega.
3. Phylogenetic Analysis using MEGA5 and PHYLIP.
4. Accessing genome annotations and functional characterization data using ASAP.
5. Restriction sites, Promotor, ORF prediction
6. Primer Designing
7. Secondary structure prediction of proteins- GOR, ANN and SOPMA
8. Homology Modeling using Swiss-Model and Modeller; Validation of the model using Ramachandran Plot, What Check and Verify3D.
9. Active site prediction using PyMol
10. Retrieval of drug information from Drug Bank, ChemEMBL and PubChem Compounds databases.
11. Molecular Docking using Autodock.
12. Pharmacophore modeling using PharmaGist
13. ADMET prediction of drug molecules using PreADMET.

REFERENCES:

1. Mohammed, Bioinformatics Practical Manual - Biocuration Info Labs, 2014.
2. Michael Agostino, Practical Bioinformatics- Garland Science, 2013.

222BT2213	RECOMBINANT DNA TECHNOLOGY LABORATORY	L	T	P	C
		0	0	6	3

Course Objectives:
To make students to practice various genetic engineering techniques including cloning of a gene and producing recombinant proteins

Course Outcomes:
After completing this course, the student will be able to:
CO1: Isolation of plasmid and genomic DNA
CO2: Design primers to introduce new restriction enzyme sites
CO3: Manipulate DNA by setting reactions with enzymes and perform transformation
CO4: Identify recombinant clones by PCR or restriction analysis

CO-PO Mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	L	L
CO2	H	H	H	L	H
CO3	H	H	H	L	M
CO4	H	H	H	L	M

LIST OF EXPERIMENTS:

1. Isolation of Genomic DNA
2. Isolation of Plasmid DNA
3. Designing of primers
4. Polymerase Chain Reaction
5. Restriction digestion of PCR product and vector
6. Ligation reaction
7. Preparation of competent cells and transformation
8. Identification of recombinant clones by Blue/White selection
9. Extraction and purification of plasmid DNA from white colonies
10. Restriction enzyme analysis to confirm clones
11. Clone confirmation by PCR and agarose gel electrophoresis

REFERENCE BOOKS:

1. Sambrook, Joseph, Edward F. Fritsch, and Tom Maniatis. Molecular Cloning: a laboratory manual. Cold Spring Harbor Laboratory Press, 2nd Edition,1989.
2. Wilson, Keith, and John Walker; Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, 7th Edition, 2010.

222BT2214	BIOPROCESS ENGINEERING LABORATORY	L	T	P	C
		0	0	6	3

Course Objectives:
To develop practical skills of the students in the area of Bioprocess Engineering with emphasis on upstream and downstream processing in bioprocess.

Course Outcomes:
At the end of the course, students would be able to
CO1: Appreciate upstream processing like media optimization, fermenter conditions and production
CO2: Demonstrate growth, substrate utilization and product formation kinetics and understand design, operation and analysis of bioreactor
CO3: Simulate batch, fed batch and continuous fermentation
CO4: Demonstrate methods of isolation and separation of bioproducts
CO5: Establish product purification techniques

CO & PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	H	H	H	H	H
CO2	H	H	H	H	M
CO3	M	H	H	H	H
CO4	H	H	H	H	M
CO5	H	H	H	H	M

LIST OF EXPERIMENTS:

1. Enzyme Production by batch cultivation, Enzyme kinetics and Enzyme immobilization techniques
2. Microbial Growth and Product Formation Kinetics
3. Media Optimization by Plackett and Burman method and Response Surface Methodology
4. Fermenter Design and its parts; Preparation of Bioreactor and Utilities for Bioreactor operation, integrated process control systems
5. Batch Sterilization Kinetics
6. Estimation of mixing time in batch reactor.
7. Residence time distribution analysis- CSTR and PFR
8. Determination of volumetric mass transfer coefficient k_La: a. Static gassing out Method b. Sulphite Oxidation Method
9. Simulation of Batch, Fed Batch and Continuous fermentation process using Berkeley Madonna software
10. Model Simulation using MATLAB-SIMULINK
11. Cell Disruption: Ultrasonication and Homogenization
12. Product Isolation: Iso Electric Precipitation of Protein
13. Product Isolation: Adsorption Equilibria
14. Product Enrichment: Precipitation of protein by salting out method

15. Product Enrichment: Extraction of protein by aqueous two-phase Extraction
16. Product Purification: Chromatographic techniques

REFERENCES:

1. P.A. Belter, E.L. Cussler and Wei-Houhu – Bioseparations – Downstream Processing for Biotechnology, Wiley Interscience Publications, 1988.
2. P.F. Stanbury, A Whitaker - Principles of Fermentation Technology, 2nd edition, Elsevier Publication, 2008.

EXPERIENTIAL ELECTIVE

224BT4201	INTERNSHIP	L	T	P	C
		0	0	30	15

Course Outcomes

As a result of the internship experience, students will be able to:

1. Describe the nature and function of the industry
2. Apply appropriate workplace ethics in a professional setting.
3. Demonstrate and apply theoretical learning in a practical situation by accomplishing the tasks assigned during the internship.
3. Exhibit evidence of improved knowledge gained through practical experience.
5. Evaluate the internship experience in terms of educational and career needs.

CO & PO Mapping:

CO/PO	1	2	3	4	5
CO1	M	M	M	L	
CO2	M		H	L	
CO3	H	M	H	H	H
CO4	H	H	H	H	H
CO5	H	H	H	H	M

EXPERIENTIAL CORE

223BT4201	PROJECT	L	T	P	C
		0	0	40	20

Course Objective:

To provide sufficient hands-on learning experience and enhance the technical skill sets in the chosen field of biotechnology.

Course Outcomes:

At the end of the course, students would be able to

CO1: Identify and formulate problem statements to address research.

CO2: Collect and analyze relevant scientific literature.

CO3: Understand the rationale of experimental design and conduct experiments in selected areas of biotechnology.

CO4: Present authentic experimental work in a coherent sequence using modern presentation tools.

CO5: Document data meticulously and write a dissertation at the end of the project.

CO & PO Mapping:

CO/PO	1	2	3	4	5
CO1	H	H	H	H	H
CO2	H	H	H	H	H
CO3	H	H	H	H	H
CO4	H	M	H	H	H
CO5	M	H	H	H	H