SRM
UNIVERSITY
(Under section 3 of UGC Act 1956)

M.Tech. (Full-time) - Biotechnology
Curriculum & Syllabus
2013 – 2014

FACULTY OF ENGINEERING AND TECHNOLOGY
SRM UNIVERSITY
SRM NAGAR, KATTANKULATHUR – 603 203

M.Tech. (Full Time) - Biotechnology
Curriculum & Syllabus 2013 – 2014
(Applicable for students admitted from the academic year 2013-14 onwards)

COURSE CODE	COURSE NAME				
SEMESTER I		**L**	**T**	**P**	**C**
BT2001	Biomolecules	3	0	2	4
BT2002	Bioprocess Technology	3	0	2	4
BT2003	r-DNA Technology	3	0	2	4
SEMESTER II		**L**	**T**	**P**	**C**
BT2004	Bioprocess modeling and simulation	3	0	2	4
BT2005	Molecular Immunology	3	0	2	4
BT2006	Advanced Bioanalytical Techniques	3	0	2	4
SEMESTER III		**L**	**T**	**P**	**C**
BT2047	Seminar	0	0	1	1
BT2048	Industrial Training	0	0	1	1
BT2049	**Project work Phase I**	0	0	12	6
SEMESTER IV		**L**	**T**	**P**	**C**
BT2050	**Project work Phase II**	0	0	32	16
SEMESTER I-III		**L**	**T**	**P**	**C**
	Supportive course (1 course of 3 credits in Ior II or III sem.)	3	0	0	3
	Program Electives (6 Courses of 3 credits each n semesters I – III)	--	--	--	18
	Interdisciplinary Electives (1 course of 3 credits in I or II or III sem.)	3	0	0	3
	Total number of credits to be earned for the award of M.Tech degree: 72				

Program Electives

Course Code	Name of the course	L	T	P	C
BT2101	Biology of Cancer	3	0	0	3
BT2102	Stem cell Technology	3	0	0	3
BT2103	Clinical Trial Management	3	0	0	3
BT2104	Plant Production Technology	3	0	0	3
BT2105	Animal cells as Bioreactors	3	0	0	3
BT2106	Bioprocess plant design	3	0	0	3
BT2107	Pharmaceutical Biotechnology	3	0	0	3
BT2108	Biological Treatment of waste water	3	0	0	3
BT2109	Green Energy Technology	3	0	0	3
BT2110	Microbial technology	3	0	0	3

Supportive Courses

Course Code	Name of the course	L	T	P	C
MA2014	Applied mathematics for Biotechnologists	3	0	0	3
MC2510	Statistical Techniques for Bioengineers	3	0	0	3
MB2208	Marketing Research for Engineers	2	2	0	3

CONTACT HOUR/CREDIT:
L: Lecture Hours per week **T: Tutorial Hours per week**
P: Practical Hours per week **C: Credit**

SEMESTER I

Course code	Course Title	L	T	P	C
BT2001	**BIOMOLECULES**	**3**	**0**	**2**	**4**
	Total Contact Hours - 75				
	Prerequisite				
	Nil				

PURPOSE	
To strengthen the knowledge about various biomolecules, their structure, function and metabolic disorders.	
INSTRUCTIONAL OBJECTIVES	
1.	To educate the students about the various biomolecules at structural and functional level.
2.	To provide understanding on the metabolic pathways and their effects.
3.	To update knowledge about various metabolic disorders.

UNIT I-STRUCTURE AND FUNCTION OF BIOMOLECULES

(10 hours)

Classification, characteristics and functions of carbohydrates - monosaccharides, complex carbohydrate. Lipids – types of membrane lipids, phospholipids and glycolipids. Protein structure and functions – primary, secondary, tertiary and quaternary structures. Nucleic acids – structure and functions.

UNIT II-BIOENERGETICS AND METABOLISM (10 hours)

Energetics-ATP as energy currency, biologic oxidation, structural organization and electron flow of respiratory chain, chemiosmotic theory of oxidative phosphorylation. Mitochondrial membrane transporters- shuttle systems.

UNIT III-METABOLISM OF CARBOHYDRATES AND PROTEINS

(9 hours)

Carbohydrate metabolism - Glycolysis, Glucogenesis, Citric acid cycle and Glycogen metabolism.Protein metabolism - Urea cycle, degradation of amino acids.

UNIT IV-FATTY ACID AND NUCLEIC ACID METABOLISM

(8 hours)

Overview of Fatty Acid Metabolism - synthesis and degradation of fatty acids. Nucleotides - De novo and salvage pathways.

UNIT V-BIOMOLECULES AND DISEASE (8 hours)

Disease and control measures for Glycogen storage disease – hypoglycemia.Amino acids – phenylketonuria. Lipids – sphingolipids storage disease. Nucleic acids – gout disease.

REFERENCES

1. Donald Voet, Judith G. Voet and Charlotte W. Pratt, "*Fundamentals of Biochemistry – Life at the molecular level*". John Wiley and Sons, Inc., Asia, 2006.
2. Robert K. Murray, Daryl K. Granner and Victor W. Rodwell, "*Harper's Illustrated Biochemistry*". McGraw Hill Education (Asia), 2006.
3. Jeremy M. Berg, John L. Tymozko and LubertStryer, "*Biochemistry*", Fifth edition, W.H. Freeman and Company, New York, 2002.
4. David L. Nelson and Michael M. Cox, "*Lehninger Principles of Biochemistry"* Fourth Edition, W H Freeman and Company, New York, 2005.

BIOMOLECULES LABORATORY (30 hours)

1. Determination of protein concentration by various methods: Lowry's, Bradford etc.
2. Extraction of protein by different methods: salt precipitation, solvent precipitation etc.
3. Separation and purification of proteins by gel filtration chromatography.
4. Determination of molecular weight of proteins by SDS-PAGE
5. Assay of enzyme activity such as protease, amylase and lipase.
6. Estimation of alkaline phosphatase activity in blood plasma.
7. Separation of amino acids by TLC.
8. Separation of proteins by 2D gel electrophoresis.

REFERENCES

Lab manual

Course code	Course Title	L	T	P	C
BT2002	BIOPROCESS TECHNOLOGY	3	0	2	4
	Total Contact Hours - 75				
	Prerequisite				
	Nil				

PURPOSE	
To understand the biological systems; and to understand the role of microorganisms in the upstream processing and importance of downstream processing in biotechnology.	
INSTRUCTIONAL OBJECTIVES	
1.	To evaluate the kinetics and mechanism of enzymatic process
2.	To understand the metabolism and microbial growth kinetics
3.	To evaluate the bioreactors, design features and the instrumentation and control of bioreactors
4.	To understand the role of downstream processing in biotechnology

UNIT I-ENZYME TECHNOLOGY (9 hours)

Introductions: Enzymes- Michaelis-Menten kinetics. Kinetics and Statistics- Inhibition- Effect of pH and temperature- Enzymology- Immobilized enzymes: Methods, Mass transfer considerations and Industrial enzymes.

UNIT II-METABOLISM, STOICHIOMETRY AND MICROBIAL GROWTH KINETICS (9 hours)

Introduction to metabolism- Nutrient transport- Glycolysis - TCA cycle and other pathways - Control of metabolism. Factors affecting microbial growth – Stoichiometry- mass balances and energy balances. Growth kinetics- Measurement of growth.

UNIT III-BIOREACTORS, STERILIZATION, SENSORS AND INSTRUMENTATION (9 hours)

Introduction to bioreactors - Batch and Fed-batch bioreactors, Continuous bioreactors, Immobilized cells.Bioreactor operation, Sterilization, Aeration, Sensors. Instrumentation, Culture - specific design aspects: plant/mammalian cell culture reactors.

UNIT IV-PRIMARY SEPARATION PROCESS (9 hours)

Biomass removal - Biomass disruption – Membrane based techniques. Extraction -solvent, aqueous two phases, super critical, and Adsorption.

UNIT V-SECONDARY SEPARATION PROCESS (9 hours)

Chromatography, Precipitation (Ammonium Sulfate, solvent), Electrophoresis (capillary), Crystallization, Drying and Freeze drying.

REFERENCES

1. Michael Shuler and FikretKargi. "*Bioprocess Engineering: Basic Concepts"*, 2nd Edition, Prentice Hall, and Englewood Cliffs, NJ, 2002.
2. Pauline Doran. "*Bioprocess engineering principles"*, Academic Press, 1995.
3. Colin Ratledge, Bjorn Kristiansen, "*Basic Biotechnology"*, 2nd Edition, Cambridge University Press, 2001.
4. Roger Harrison et al., "*Bioseparation Science and Engineering"*, Oxford University Press, 2003.
5. Harrison R.G. Todd P., Rudge S.R. "*Bioseparation Science and Engineering"*, Oxford Press 2003.

LIST OF EXPERIMENTS (30 hours)

1. Microbial growth and product formation kinetics
2. Enzyme kinetics
3. Effects of inhibitor on microbial growth
4. Enzyme immobilization techniques
5. Batch stertilization kinetics
6. Kla Determination by dynamic degassing method
7. Cell disruption by Sonication
8. Precipitaion of protein by salting out method
9. Extraction of protein by aqueous two phase Extraction
10. Chromatographic techniques

REFERENCE

Lab manual

Course code	Course Title	L	T	P	C
BT2003	r - DNA TECHNOLOGY	3	0	2	4
	Total Contact Hours - 75				
	Prerequisite				
	Nil				

PURPOSE	
This course helps the student to understand about the different types of vectors and their use in preparing recombinant DNA.	
INSTRUCTIONAL OBJECTIVES	
1.	To make the student understand the basic tools in genetic engineering
2.	To make them understand cloning and expression vectors
3.	Preparation of genomic and cDNA libraries
4.	To make them understand the production and downstream processing of recombinant proteins

UNIT I-CLONING VECTORS (9 hours)

Ideal features of cloning vectors – plasmids and bacteriophages – cloning vectors for *E.coli* ; pBR322, pUC vectors, M13 and other plasmid vectors – Cosmids, Phagemids – vectors for Bacillus, Streptomyces Restriction mapping and analysis

UNIT II-ENZYMES AND TECHNIQUES FOR CLONING (9 hours)

DNA modifying enzymes – ligases – Nucleic acid probe preparation; Radioactive and nonradioactive labels – Hybridization techniques – PCR; different types and applications – DNA sequencing – DNA fingerprinting – RFLP, RAPD – chromosome walking.

UNIT III-EXPRESSION VECTORS (9 hours)

Expression vectors in prokaryotes – Expression vectors in Eukaryotes-Yeast cloning vectors – selectable markers for eukaryotes – SV40, Papilloma, Retrovirus, Baculoviral vectors – mammalian cell expression system – Gene transfer techniques – Agrobacterial plasmids – Ti plasmid and viral vectors – cloning in plants.

UNIT IV-GENOMIC AND cDNA LIBRARY (9 hours)

Different strategies for in vitro and in vivo cloning – Preparation of rDNA, Preparation of cDNA and genomic DNA libraries – screening procedures – linkers, adapters, homopolymer tailing and TA cloning – gene transfer technologies – Mutagenesis – site directed mutagenesis – application.

UNIT V-APPLICATION OF GENE CLONING (9 hours)

Fusion protein- down-stream processing of recombinant proteins- Applications in medicine – Gene therapy- Diagnostics, pathogenesis, recombinant vaccines –humanized antibodies and their applications genetically modified food – bioremediation with recombinant micro organisms– forensic science – genetic diversity – Agriculture, crop improvement – production of biosensors, enzymes – safety guidelines in rDNA research – containment and disposal.

REFERENCES

1. Jeremy W. Dale, Malcolm von Schantz, Nicholas Plant. From Genes to Genomes: Concepts and Applications of DNA Technology-3rd Edition. 2011. Wiley-Blackwell.
2. Michael R. Green and Joseph Sambrook. Molecular Cloning: A Laboratory Manual (Fourth Edition). 2012. Cold Spring Harbor Press.
3. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick. Lewin's GENES XI. 2012. Jones & Bartlett Learning.
4. Sandy B. Primrose and Richard Twyman. Principles of Gene Manipulation and Genomics. 2009. Wiley.
5. T. A. Brown. Gene Cloning and DNA Analysis: An Introduction, 6th Edition. 2010. Blackwell.

LABORATORY EXPERIMENTS (30 hours)

1. Isolation and characterization of genomic DNA from Animal and plant
2. Isolation and characterization of RNA
3. Preparation cDNA and amplification
4. Preparation genomic library
5. GFP cloning and expression analysis
6. Preparation DNA probes
7. Screening recombinant colonies with probes.
8. Hybridization -southern
9. Hybridization-western
10. DNA Finger printing
11. RAPD analysis of different strains of bacteria.

REFERENCES

Lab manual

SEMESTER II

Course code	Course Title	L	T	P	C
BT2004	**BIOPROCESS MODELING AND SIMULATION**	**3**	**0**	**2**	**4**
	Total Contact Hours - 75				
	Prerequisite				
	Nil				

PURPOSE	
To introduce the different aspects of modeling in bioprocess system and to familiarize the simulation of bioprocess modeling	
INSTRUCTIONAL OBJECTIVES	
1.	To learn about the principles of bioprocess modeling and simulation
2.	To understand the mathematical models in biochemical engineering systems
3.	To know the basics of MATLAB, data analysis and interpretation of data
4.	To study the application of MATLAB and SIMULINK in the bioprocess systems

UNIT I-BASIC MODELLING PRINCIPLES (9 hours)

Basic modeling principles - uses of mathematical modeling - classification of modeling techniques. Fundamental laws - energy equations - continuity equation - equations of motion -transport equations - equations of state - equilibrium states and chemical kinetics-examples.

UNIT II-MATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMS (9 hours)

Mathematical models for Biochemical engineering systems - continuous flow tanks-enclosed enclosed vessel-mixing vessel - mixing vessel mixing with reaction - reversible reaction. Steam jacketed vessel - boiling of single component liquid-open and closed vessel-continuous boiling system - batch distillation.

UNIT III-SUPERPRO DESIGNER (9 hours)

Introduction to SuperPro Designer for Material and Energy Balance with and without reaction.

UNIT IV-MATLAB BASICS AND DATA ANALYSIS (9 hours)

Basics-Data analysis-curve fittings, Numerical integration, Euler and fourth order RungeKutta method, Input and Output in MATLAB.

UNIT V-MATLAB AND SIMULINK: APPLICATION IN BIOPROCESS SYSTEMS (9 hours)

Solving problems using MATLAB by numerical integration, Euler and fourth order RungeKutta methods. Simulation - Simulation of gravity flow tank – Simulation of CSTR in series- Simulation of non isothermal CSTR- Simulation of batch reactor using MATLAB,SIMULINK for dynamic systems.

REFERENCES

1. Luben W.L. "*Process Modelling Simulation and Control for Chemical Engineers"*, McGrawHill, International New York, 1990.
2. Franks RGE. "*Mathematical Modeling in Chemical Engineering"*, John Wiley and Sons, Inc., New York, 2004.
3. Biquette W.B. "*Process Dynamics- Modeling analysis with simulation"*, Prentice Hall; 1 edition January 15, 1998.
4. William J. Palm. "*Introduction to Matlab 7 for Engineers*", III, McGraw Hill 2005.
5. Kenneth J. Beers. "*Numerical Methods for Chemical Engineering Applications in MATLAB*®", Massachusetts Institute of Technology, Cambridge University press 2007 edition
6. http://www.mathworks.com

LIST OF EXPERIMENTS (30 hours)

1. Material Balance without Reaction using superpro designer
2. Material Balance with Reaction using superpro designer
3. Energy Balance using superpro designer
4. Solving Linear equations using MATLAB
5. Solving polynomial equations using MATLAB
6. Optimization Techniques using MATLAB
7. Parameter Estimation in kinetics using MATLAB
8. Modeling of Batch, Fed Batch and Continuous using Berkeley Madonna software
9. Simulation of Batch Reactor by SIMULINK
10. Simulation of Continuous Reactor by SIMULINK

REFERENCES

Lab manual

Course code	Course Title	L	T	P	C
BT2005	MOLECULAR IMMUNOLOGY	3	0	2	4
	Total Contact Hours - 75				

PURPOSE	
The purpose of this course is to provide thorough grounding in immunology	
INSTRUCTIONAL OBJECTIVES	
1.	To strengthen the knowledge of students about immune system and how they fight against pathogens.
2.	To impart knowledge on the usage of various immunological techniques to assess the functions of the immune system.
3.	To provide knowledge about the cellular and molecular aspects of various inflammatory diseases.

UNIT I-INTRODUCTION TO THE IMMUNE SYSTEM (9 hours)

Introduction to the Immune system – Various components of the immune system – Innate immune response - Inflammatory response. Cellular and Molecular aspects of the immune system- Recognition of pathogens and activation of Toll-like receptors- complement system and innate immunity.

UNIT II-ADAPTIVE IMMUNE RESPONSES (10 hours)

Antibody structure and functions – Antibody mediated and cell mediated immunity – components of cell-mediated immunity. Antigen possessing and presentation. MHC – structure and function. Antigen processing and presentation to TLymphocyte- effector mechanism of adaptive immunity. Antigen receptors and accessory molecules of T lymphocytes- B- cell development and activation – Mechanism of immunoglobulin – gene arrangement – T-cell development – Generation of diversity – TCR – Biology of Cytokines.

UNIT III-MUCOSAL IMMUNITY AND DEFENCE AGAINST PATHOGENS (9 hours)

Mucosal immune system-organization- Secretory IgA-mucosal response to infection -Infection and immunity – Defense against infectious agents – Immunity to viruses – Immunity to bacteria and fungi – Immunity to parasites – Immune evasion strategies – Vaccination – Immunotherapy.

UNIT IV-IMMUNE SYSTEM IN HEALTH AND DISEASES (9 hours)

Immunodeficiency diseases-Allergy and hypersensitivity diseases-asthma-Auto immune diseases- pathogenic mechanisms- Transplantation-

mechanism of graft rejection- Tumour immunology- immune response against tumours- immune evasion by tumours.

UNIT V-IMMUNOLOGICAL TECHNIQUES (8 hours)

Antigen – Antibody reactions – Immunoprecipitation – Immuno electrophoresis – immunoassays – Immunocytochemical techniques – Immunofluorescence – Flow cytometry.

REFERENCES

1. A.K. Chakravarty, *"Immunology and Immunotechnolog"y*, Oxford University Press, 2006.
2. Janeway, Kenneth Murphy, Paul Travers, Mark Walport, "*Immunobiology* 7th"Edition, Garland Science, 2008.
3. TakMak and ME Saunders, *"The immune response: Basic and Clinical principles"*, Elseiver, 2005.
4. Peter Wood, *"Understanding Immunology"*, 2nd Edition, Pearson Education Ltd, 2006.
5. B.M Hannigan, C.B.T. Moore and D.G.Quinn, *"Immunology"*, 2nd Edition, Viva Books.

MOLECULAR IMMUNOLOGY LABORATORY (30 hours)

1. Separation of serum and plasma
2. Isolation of monocytes/lymphocytes
3. Culturing of lymphocytes for activation assays
4. Immunoelectrophoresis
5. ELISA–SANDWICH
6. Dot ELISA
7. Assay of cytotoxicity
8. Western Blot
9. Detection of cell surface molecules by Flow cytometry
10. Detection of apoptotic proteins by florescence microscopy

REFERENCES

Lab manual

Course code	Course Title	L	T	P	C
BT2006	**ADVANCED BIOANALYTICAL TECHNIQUES**	**3**	**0**	**2**	**4**
	Total Contact Hours - 75				

PURPOSE

The purpose of this course is to provide the advanced knowledge of spectroscopic instrumentation and methodologies, and with the capability of associating the most appropriate technique to the analytical problem on hand

INSTRUCTIONAL OBJECTIVES

1.	To understand and demonstrate the Imaging Techniques and its applications
2.	To understand and demonstrate the Next Generation Sequence Techniques and its applications
3.	To understand and demonstrate the NMR & MS Techniques and its applications
4.	To understand and demonstrate the LC & GC Techniques and its applications
5.	To understand and demonstrate the Flow Cytometer and other relevant Techniques and its applications

UNIT I-ADVANCED IMAGING TECHNIQUES IN MICROSCOPY

(9 hours)

Live cell imaging, Confocal microscopy and sample preparation for fluorescence microscopy - High content/throughput screening - Basics of SEM & Specimen preparation for SEM - Basics of TEM & Specimen preparation for TEM. **Advanced EM techniques:** Electron tomography and Serial block face imaging using SEM – CryoEM - Methods to study interactions: **FRET,** FCCS and BiFC - **Atomic Force Microscopy** - Dynamics methods: photobleaching and activation – STED - Structured Illumination Microscopy - Multiphoton microscopy and In vivo imaging.

UNIT II-NEXT SEQUENCING GENERATION TECHNIQUES

(9 hours)

High-Throughput Next generation sequencing (HT-NGS) platforms- **First generation sequencing platform:** Sanger DNA sequencing- **Second generation sequencing platforms**: Roche 454 FLX system - IlluminaSolexa and SoLiD next generation genome sequencing- **Third generation sequencing platforms:** Single molecular sequencing: Helico high speed genome sequencing - **Fourth generation sequencing platforms and future sequencing technologies:** Ion Torrant semiconductor sequencer - Nimble

gene–Roche genome capture sequencing and construction of microarray Chip - Comparative genomics in HT-NGS platform - RNA-seq and transcriptome analysis - ChIP- sequencing and epigenomics - **Challenges in next generation sequencing and bioinformatics.**

UNIT III-NMR AND MASS SPECTROSCOPIC TECHNIQUES (9 hours)

NMR: Theory and Principle of NMR - Multi nuclear NMR- Analysis of spectra and Interpretations - Case studies of drugs, peptides and proteins. NMR spectra Analysis Recent advances in protein NMR. **Mass Spectrometer:** Principles of modern ionization methods and mass analyzers (TOF and FT-ICR), hybrid/tandem mass methods (MS-MS) and applications of MS in the analysis of drugs and macromolecules.

UNIT-IV HYBRID TECHNIQUES (9 hours)

Gas chromatography with mass spectrometric detection (GC-MS), liquid chromatography with mass spectrometric detection (LC-MS), inductively coupled plasma with mass spectrometric detection (ICP-MS). Metal analysis by ICP-MS; Analysis of data: **HPLC chromatograms**, including trouble shooting – how to achieve good separation on HPLC; GC-MS data; LC-MS spectra.

UNIT V-SPECIAL TECHNIQUES (9 hours)

Flow Cytometer: Introduction to flow cytometry- Fluorochromes and fluorescence - Experimental design and fluorescence quantitation- Compensation and gating – Normalization - Comparing Univariate Cell Distributions - Probability Binning - Readings on flow cytometry data analysis. isoelectric focusing and 2-Dimensional polyacrylamide gel electrophoresis and their uses in protein research. Protein crystallization; Theory and methods.

REFERENCES

1. Skoog, D.A., Crouch, S.R., and Holler, F.J. *"Principles of Instrumental Analysis"*, 6th edition, Brooks/Cole, USA, 2006.
2. Williams, D. and Fleming, I. *"Spectroscopic Methods in Organic Chemistry"*, 6th edition, McGraw-Hill Higher Education, Maidenhead, UK, 2008.
3. Freifelder D., Physical Biochemistry, "*Application to Biochemistry and Molecular Biology*", 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
4. Keith Wilson and John Walker, "*Principles and Techniques of Practical Biochemistry"*, 5th Edition, Cambridge University Press, 2000.

5. Kwon, Young Min, Ricke, Steven C. (Eds), "*High-Throughput Next Generation Sequencing Methods and Applications*", Volume. 733, Humana Press, 2011.

ADVANCED BIOANALYTICAL TECHNIQUES LABORATORY

(30 hours)

1. Separation and identification of drugs/impurities/related substances by HPLC.
2. Separation and identification of amino acids/flavonoids/sulphonamides by HPLC.
3. Quantitative analysis by HPLC.
4. GC−MS Analysis of Halogenated Volatile Organic Compounds in Aqueous Samples
5. GC-MS Analysis of Volatile Plant Secondary Metabolites.
6. Analysis of Metabolites by LC-MS.
7. Demonstration of NMR
8. Demonstration of Flow Cytometer.
9. Demonstration of Gene Sequencing.

REFERENCES

Lab manual

SEMESTER III

Course code	Course Title	L	T	P	C
BT2047	**SEMINAR**	**0**	**0**	**1**	**1**
PURPOSE					
To train the students in preparing and presenting technical topics.					
INSTRUCTIONAL OBJECTIVE					
The student shall be capable of identifying topics of interest related to the program of study and prepare and make presentation before an enlightened audience.					

The students are expected to give at least two presentations on their topics of interest which will be assessed by a committee constituted for this purpose. This course is mandatory and a student has to pass the course to become eligible for the award of degree.Marks will be awarded out of 100 and appropriate grades assigned as per the regulations

Course code	Course Title				
BT2048	**INDUSTRIAL TRAINING (Training to be undergone after II semester)**	**0**	**0**	**1**	**1**
	3 week practical training in industry				
	Prerequisite				
	Nil				
PURPOSE					
To provide practical exposure in Civil Engineering related organizations.					
INSTRUCTIONAL OBJECTIVES					
1.	Students have to undergo three – week practical training in Civil Engineering related organizations so that they become aware of the practical applications of theoretical concepts studied in the class rooms.				

Students have to undergo three-week practical training in Civil Engineering related organizations of their choice but with the approval of the department. At the end of the training student will submit a report as per the prescribed format to the department.

Assessment process

This course is mandatory and a student has to pass the course to become eligible for the award of degree. The student shall make a presentation before a committee constituted by the department which will assess the student based on the report submitted and the presentation made. Marks will be awarded out of 100 and appropriate grades assigned as per the regulations.

Course code	Course Title	L	T	P	C
BT2049	**PROJECT WORK PHASE I (III semester)**	**0**	**0**	**12**	**6**
BT2050	**PROJECT WORK PHASE II (IV semester)**	**0**	**0**	**32**	**16**
PURPOSE					
To undertake research in an area related to the program of study					
INSTRUCTIONAL OBJECTIVE					
The student shall be capable of identifying a problem related to the program of study and carry out wholesome research on it leading to findings which will facilitate development of a new/improved product, process for the benefit of the society.					

M.Tech projects should be socially relevant and research oriented ones. Each student is expected to do an individual project. The project work is carried out in two phases – Phase I in III semester and Phase II in IV semester. Phase II of the project work shall be in continuation of Phase I only. At the completion of a project the student will submit a project report, which will be evaluated (end semester assessment) by duly appointed examiner(s). This evaluation will be based on the project report and a viva voce examination on the project. The method of assessment for both Phase I and Phase II is shown in the following table:

Assessment	Tool	Weightage
In- semester	I review	10%
	II review	15%
	III review	35%
End semester	Final viva voce examination	40%

Student will be allowed to appear in the final viva voce examination only if he / she has submitted his / her project work in the form of paper for

presentation / publication in a conference / journal and produced the proof of acknowledgement of receipt of paper from the organizers / publishers.

PROGRAM ELECTIVES

Course code	Course Title	L	T	P	C
BT2101	BIOLOGY OF CANCER	3	0	0	3
	Total Contact Hours – 45				

PURPOSE

This course will educate students on various genetic and molecular changes normal cells undergo during transformation into malignant cancer cells. These modifications include unregulated cell proliferation, evasion of cell death, and metastasis. This course will describe factors that contribute to cancer development and discuss cancer prevention and currently available therapeutic treatments.

INSTRUCTIONAL OBJECTIVES

1.	Explain the types of gene mutations possible and how these mutations can contribute to cancer formation.
2.	Describe an oncogene and why it is important in cancer development.
3.	Explain the cell cycle, its regulation, and how cell cycle dysfunction can lead to cancer.
4.	List and describe the steps that lead to metastasis.
5.	Explain the role of diet in cancer development and cancer prevention.

UNIT I-INTRODUCTION TO CANCER BIOLOGY (9 hours)

Regulation of Cell cycle - Cell cycle control and pRb tumor suppressor. Apoptosis and p53 tumor suppressor. Mutations that cause changes in signal molecules - effects on receptor - signal switches. Tumor suppressor genes.Modulation of cell cycle in cancer. Different forms of cancers. Diet and cancer.

UNIT II-MUTAGENS, CARCINOGENS AND MUTATIONS (11 hours)

Chemical Carcinogenesis, Metabolism of Carcinogenesis, Natural History of Carcinogenesis, Targets of Chemical Carcinogenesis, Principles of Physical Carcinogenesis, X-Ray radiation – Mechanism of radiation Carcinogenesis. DNA repair mechanisms – DNA repair defects and their relationship to cancer.

UNIT III-ONCOGENE ACTIVATION AND SIGNALLING PATHWAYS IN CANCER (12 hours)

Oncogenes, Identification of Oncogenes, Retroviruses and Oncogenes, detection of Oncogenes, Growth factor and Growth factor receptors that are Oncogenes. Oncogenes / Proto Oncogenes activity.Role of growth factors and receptors in carcinogenesis. RAS, NFkB, Wnt signaling in cancer. Familial cancer syndromes and the discovery of tumor suppressors.Epigeneitcs of cancer – DNA methylation, Histone modification, gene silencing by micro RNA.

UNIT IV-MOLECULAR MECHANISM OF METASTASIS (8 hours)

Clinical significances of invasion, heterogeneity of metastatic phenotype, Metastatic cascade, Basement membrane disruption, Three step theory of invasion, Proteinases and tumour cell invasion. Multi-step tumorigenesis and the evolution of cancer.Tumor-promoting stimuli.Cancer stem cells.

UNIT V-APPLICATIONS OF NEW TECHNOLOGIES IN PREVENTION, ASSESSING RISK, DIAGNOSTICS, AND TREATMENT (5 hours)

Different forms of therapy - Chemotherapy, Radiation Therapy, Immunotherapy. Detection of Cancers.Prediction of aggressiveness of Cancer.Advances in Cancer detection.

REFERENCES

1. King R.J.B., *"Cancer Biology"*, Addision Wesley Longmann Ltd, U.K., 1996.
2. Ruddon.R.W,*"Cancer Biology"*, Oxford University Press, Oxford, 2007.
3. Robert Allan Weinberg, *"The Biology of Cancer"*, Volume 2, Garland Science, 2007.
4. C Athena Aktipis, Randolph M Nesse.*"Evolutionary foundations for cancer biology"*.Evol Appl. 2013 January; 6(1): 144–159.
5. Sandra Demaria, Eli Pikarsky, Michael Karin, Lisa M. Coussens, Yen-Ching Chen, Emad M. El-Omar, Giorgio Trinchieri, Steven M. Dubinett, Jenny T. Mao, Eva Szabo, Arthur Krieg, George J. Weiner, Bernard A. Fox, George Coukos, Ena Wang, Robert T. Abraham, Michele Carbone, Michael T. Lotze.*"Cancer and Inflammation: Promise for Biological Therapy"*. J Immunother. 2010 May; 33(4): 335–351.
6. Leah M. Cook, Douglas R. Hurst, Danny R. Welch. *"Metastasis Suppressors and the Tumor Microenvironment"*.Semin Cancer Biol. 2011 April; 21(2): 113–122.
7. Tabitha M Hardy, Trygve O Tollefsbol. *"Epigenetic diet: impact on the epigenome and cancer"*.Epigenomics. 2011 August 1; 3(4): 503–518.

Course code	Course Title	L	T	P	C
BT2102	STEM CELL TECHNOLOGY	3	0	0	3
	Total Contact Hours - 45				

PURPOSE	
The course aims at imparting basic and advanced topics in Stem Cell Biology and its clinical applications.	
INSTRUCTIONAL OBJECTIVES	
1.	To strengthen the knowledge of students on Stem cell basics and their applications for the benefit of mankind.
2.	To impart knowledge about stem cell culturing and stem cell signaling.

UNIT I-STEM CELLS (8 hours)

Introduction: Tissue organization - Stem cells - Sources -Unique properties of stem cells- classification- Embryonic stem cells-adult stem cells - similarities and differences between adult and embryonic stem cells – Functional characterization.

UNIT II-EMBRYONIC STEM CELLS (10 hours)

Stem cells and their developmental potential. In vitro fertilization-culturing of embryos-blastocyst-inner cell mass-isolation and growing ES cells in lab-Identification and characterization of human ES cells-Cloning and controlled differentiation of human embryonic stem cells. Applications of Embryonic stem cells – Gene knock in – Gene knock out - Ethical issues.

UNIT III-ADULT STEM CELLS (9 hours)

Somatic stem cells-test for identification of adult stem cells- adult stem cell differentiation-trans differentiation-plasticity-different types of adult stem cells-liver stem cells-skeletal muscle stem cells-bone marrow derived stem cells – Stem cell specific transcription factors - Induced pluripotent cells.

UNIT IV-CANCER STEM CELL SIGNALING (8 hours)

Introduction**:** Tumor stem cells - Breast Cancer Stem Cells: Identification - Signalingpathways:Notch signaling – Wnt signaling in stem cells and cancer cells.

UNIT V-STEM CELLS IN TISSUE ENGINEERING (10 hours)

Introduction: Biomaterials – Cell and biomaterial interactions - Haematopoietic Stem Cells -. Mesenchymal stem cells - Bone tissue engineering – Cartilage tissue engineering **–** Cardiovascular tissue engineering – Neural tissue engineering. Therapeutic applications -

Parkinson's disease – Diabetes: Pancreatic cells regeneration. Stem cell based gene therapy and benefits to human.

REFERENCES

1. AriffBongso, EngHin Lee "*Stem Cells: From Bench to Bedside*" World Scientific Publishing Company. 2005.
2. C S Potten "*Stem Cells*" Elsevier,1996.
3. Daniel R. Marshak "*Stem cell biology"* Cold Spring Harbor Laboratory Press.
4. Robert Lanza "*Essentials of Stem Cell Biology*" Elevier, 2009.
5. Peter Quesenberry "*Stem cell biology and Gene Therapy*" Wiley-Liss,1988.

Course code	Course Title	L	T	P	C
BT2103	**CLINICAL TRIAL MANAGEMENT**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				

PURPOSE

Acquaints students with important principles of the acquisition, management, and distribution of data in the clinical research environment. Topics focus on real-world needs of investigators and emphasizes those issues that researchers need to understand to work effectively with other members of study teams, including coordinators, data entry staff, programmers, and data managers.

INSTRUCTIONAL OBJECTIVES

1.	To explain basic and advanced concepts of data management
2.	To make reasonable decisions about how to collect and manage data for studies of various sizes and budgets
3.	To evaluate alternative courses of action and policies regarding data collection and management issues in a trial

UNIT I-INTRODUCTION TO CLINICAL RESEARCH (4 hours)

Definition, Types and Scope of Clinical Research, Good Clinical Practices - Introduction to study designs and clinical trials - Careers in Clinical Research

UNIT II-ETHICS IN CLINICAL RESEARCH (4 hours)

Ethical Theories and Foundations, Ethics Review Committee, Ethics and Historically derived principles - Nuremberg Code, Declaration of Helsinki, Belmont Report, Equipoise, Informed consent, Integrity & Misconduct, fraud in Clinical Research, Conflicts of Interest

UNIT III-REGULATIONS IN CLINICAL RESEARCH (10 hours)

Evolution and History of Regulations in Clinical Research, Patents US Regulatory Structure, IND, NDA, ANDA, Post Drug Approval Activities, PMS, FDA Audits and Inspections EURegulatory Affairs, EMEA Organization and Function, INDIAN Regulatory system, Schedule Y- Rules and Regulations, Description of trial phases (Phase 0, Phase I, II, III, and IV), Trial contexts (types of trials: pharma, devices, etc.), Trial examples

UNIT IV-CLINICAL RESEARCH METHODOLOGY AND MANAGEMENT (15 hours)

Designing of Protocol, CRF, e-CRF, IB, ICF, SOP Pharmaco-epidemiology, BA/BE Studies Report writing, Publication. Study Population and Cohort - Study population - Study cohort - Recruitment (planning, strategies, and sources) - Accrual (problems and solutions) - Inclusiveness and Representation. Study Protocol- Introduction, background, Objectives - Eligibility, Design, Randomization -Intervention details, assessments and data collection, case report forms –Violations -. Amendments. Study/ Trial Design - Phase I designs - Dose-finding designs. Phase II designs - Pilot studies, Single arm, Historical control designs. Phase III designs - Factorial designs, Crossover designs, Multicenter studies, Pilot studies. Phase IV designs- Preparation of a successful clinical study, Study management, Project management Documentation, Monitoring, Audits and Inspections, Pharmacovigilance training in clinical research budgeting in clinical research, Supplies and vendor management

UNIT V-BIOSTATISTICS AND DATA MANAGEMENT (12 hours)

Introduction to Power and Sample Size - Hypothesis testing, P-values, confidence intervals, General power/sample size, estimating effect size, Matching sample size calculations to endpoints. Importance of statistics in clinical research Statistical considerations at the design, analysis and reporting stage**.** Data management - Data collection, Paper or electronic, Parsimony, Data validation, SAE reconciliation, query management Software considerations.Data Monitoring, Trial Conduct - Data quality assurance, Data delinquency, Data Monitoring, d. Trial Conduct, Occurrence and control of variation and bias

REFERENCES

1. Friedman, Furberg, and DeMets. *"Fundamentals of Clinical Trials (4th Edition)"*. Springer,2010. Free text available online at http://dx.doi.org/10.1007/978-1-4419-1586-3
2. Machin and Fayers. *"Randomized Clinical Trials: Design, Practice and Reporting"*. Wiley- Blackwell, 2010

3. Piantadosi S. "*Clinical Trials: A Methodologic Perspective (2nd Edition*)". New Jersey: John Wiley & Sons, 2005.

Course code	Course Title	L	T	P	C
BT2104	**PLANT PRODUCTION TECHNOLOGY**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisite				
	Nil				

PURPOSE

The course is designed to provide an understanding of the *in vitro* techniques for plant propagation and various molecular techniques for genetic manipulation. The student will gain an understanding of theoretical principles related to gene expression which in turn can be applied for genetic manipulation of plants. The course will be relevant for students who wish to explore these principles for improvement of plant production and protection.

INSTRUCTIONAL OBJECTIVES

1.	To present an overview of plant tissue culture and genetic manipulation of plants
2.	To understand the modern technologies underlying plant protection and plant breeding
3.	To explore plant processes for their utilization as production systems

UNIT I-IN VITRO PROPOGATION (9 hours)

Meristem cultures - virus-free plants, virus testing and indexing - assuring plant quality (clonal fidelity and disease diagnostics) -development of haploid &dihaploid plants, anther and ovary culture, pollen and ovule culture -development of pure breeding lines and their applications- hybrid seed production technology and variety development- embryo culture and its applications, embryo rescue - origin and importance, genetic and epigenetic variation, applications of somaclonal variation -mutation breeding - role in plant improvement programmes - somatic hybrids: symmetric asymmetric and cytoplasimic hybrids - selection and screening of hybrid lines management, production optimization, pricing and viability of commercial plant tissue culture unit.

UNIT II-PLANT TRANSFORMATION VECTORS AND METHODS (9 hours)

Plant transformation vectors - T-DNA and viral vectors, direct gene transfer vectors; Selectable marker and reporter genes, Plant transformation by *Agrobacterium* sp., non-*Agrobacterium* sp., and *in planta* transformation, Molecular mechanism of T-DNA transfer; Direct gene transfer methods in plants - Gene gun and other methods; Chloroplast transformation; Transgene analysis, silencing and targeting; Marker-free and novel selection strategies; multigene engineering; Gene knock-down by ribozymes, antisense RNA

UNITIII-PLANT TRANSGENIC TECHNOLOGY I (9 hours)

Transgenic crops for tolerance to abiotic stress - engineering crops for male sterility and modification of flower colour, flowering, fruit ripening and senescence - Dissection of quantitative traits - principles and methods of QTL mapping, fine mapping of QTL - Cloning plant genes -Comparative genomics positional cloning - RNAi-mediated crop improvement

UNIT IV-PLANT TRANSGENIC TECHNOLOGY II (9 hours)

Introduction to plant pathology, effects of pathogens on plant physiological functions, environmental effects on the development of disease - mechanisms of plant pathogen interactions - plant defenses - modern approaches for disease resistance

UNIT V-PHYTOFACTORIES (9 hours)

Plant species used for molecular farming-expression systems for molecular farming- cell culture as an alternative expression system to whole plants - the transgenic chloroplast system- chloroplast derived antibodies, biopharmaceuticals and edible vaccines - from gene to functional protein-processing steps in plants -market potential of plant-derived pharmaceuticals-Global status and bio-safety concerns related to production and release of transgenic plants

REFERENCES

1. George EF, Plant Propagation by Tissue Culture: The Technology, Exegenetics Limited, UK (1993)
2. Hartman, H., Kester, D., Davies, F. and Geneve, R. Plant propagation: principles and practices, 6th edn. New Jersey: Prentice-Hall (1997)
3. Trigiano, R.N. and Gray, D.J. Plant Tissue Culture Concepts and Laboratory Exercises, CRC Press (1999,) 2nd ed
4. Bhojwani SS and Razdan M K, Plant Tissue Culture: Theory and Practice, Elsevier (1996)

5. Gamborg O. L and Phillips G. C. Plant Cell, Tissue and Organ Culture: Fundamental Methods. Springer-Verlag (1995)
6. Slater A. Scott N. and Fowler M. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press Inc. (2008)
7. Chrispeels M. J. and Sadava D. E. Plants, Genes and Crop Biotechnology. Jones and Barlett Publishers (2003)
8. Paterson A. H. Genome mapping in Plants. Academic Press (1992)
9. Satheesh, M.K., Bioethics and Biosafety, IK International Publishing House Pvt. Ltd , India (2008)
10. Vienne D. Molecular markers in Plant Genetics and Biotechnology. INRA (2003)
11. Molecular Farming in Plants: Recent Advances and Future Prospects (2012) Editors: Aiming Wang, Shengwu Ma
12. George N. Agrios, Plant Pathology, Fifth Eds. (2005) Elsevier Academic Press

Course code	Course Title	L	T	P	C
BT2105	**ANIMAL CELLS AS BIOREACTORS**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisite				
	Nil				

PURPOSE

This course helps the student to understand about the production of Industrial products through animal cell culture

INSTRUCTIONAL OBJECTIVES

1.	To make the student understand the basic s of animal cells as bioreactors
2.	To make them understand engineering of cells for maximum expression and Engineering a new medium
3.	To make them understand the production and downstream processing of biopharmaceuticals through cell culture

UNIT I-INTRODUCTION (8 hours)

Introducing animal cells as bioreactors-genetically engineered microbial system –limitations-Animal cell technology for Industrial products-

UNIT II-ENGINEERING OF CELLS (10 hours)

Engineering cells for maximum expression- transient expression system-stable expression system-dominant control regions- Factors governing

heterologous gene expression- production of heterologous protein using lymphoid cell based expression system- improving translational efficiency

UNIT III-GENERATION OF BIOMASS (9 hours)

Generation of Biomass-media for animal cell culture- serum free media-medium design- Engineering a new medium-Fermentor design for animal cell culture-suspension cell culture-Immobilised cells

UNIT IV-CELLULAR METABOLISM AND OPTIMUM YIELD (9 hours)

Cellular metabolism for optimum yields-Effect of culture condition on protein glycosylation-culture parameters that affect yield

UNIT V-DOWNSTREAM PROCESSING (9 hours)

Downstream processing- production of effective and safe biopharmaceuticals-challenges in purification-Characterisation of recombinant protein production-regulatory aspects of using cells as bioreactors-viral contamination of animal cell derived pharmaceuticals and prevention

REFERENCES

1. R.IanFreshney Culture of Animal Cells. 2010. Wiley-Blackwell.
2. Glyn Stacey, John Davis, Medicines from Animal Cell Culture. 2007. John Wiley & Sons, Ltd.
3. Terence Cartwright ,Animal cells as bioreactors. 2009. Cambridge University Press.
4. Basant Kumar Sinha and RineshKumar ,Principles of Animal cell culture. 2008. International book distributing Co.ltd.
5. Jeffrey W.Pollard and John M.Walker, Animal cell culture. 1990. Springer-Verlag.

Course code	Course Title	L	T	P	C
BT2106	BIOPROCESS PLANT DESIGN	3	0	0	3
	Total Contact Hours - 45				
	Prerequisite				
	Nil				
PURPOSE					
To understand the fundamentals of engineering economics, drafting a project budget to develop and apply problem solving and bioprocess plant design techniques.					
INSTRUCTIONAL OBJECTIVES					
1.	To learn about the mass and energy balance of bioprocess				

2.	To develop and optimize the process parameters for the industries
3.	To apply design factors for scale up in the industry
4.	To evaluate the process plant design for regulatory compliance
5.	To design a plant layout for processing of biological materials

UNIT I-MASS AND ENERGY BALANCE (9 hours)

Introduction: General design information - Material and energy balance calculations - Process Flow sheeting**.**

UNIT II-SCALE UP AND SCALE DOWN OF EQUIPMENTS (9 hours)

Heat and Mass Transfer studies: Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply. Bioreactor scale-up - constant power consumption per volume, mixing time, impeller tip speed (shear) - mass transfer coefficients. Scale up of downstream processes - Adsorption (LUB method), Chromatography (constant resolution etc.), Filtration (constant resistance etc.) - Centrifugation (equivalent times etc.) - Extractors (geometry based rules) - Scale-down related aspects.

UNIT III-DESIGN OF EQUIPMENTS (9 hours)

Selection of bioprocess equipment (upstream and downstream) - Specifications of bioprocess equipment - Mechanical design of reactors, heat transfer and mass transfer equipment. Design considerations for maintaining sterility of process streams and process equipment - Piping and instrumentation - Materials of construction for bioprocess plants.

UNIT IV-FACILITY DESIGN (9 hours)

Facility design aspects - Utility supply aspects - Equipment cleaning aspects - Culture cell banks - cGMP guidelines – Validation - Safety.

UNIT V-ECONOMICS AND CASE STUDY (9 hours)

Process economics - Case studies. Commodity chemicals and Production of pharmaceutical products**.**

REFERENCES

1. Robert H. Perry and Don W. Green (eds.). "*Perry's Chemical Engineers' Handbook*", 7th Edition, McGraw Hill Book Co., 1997.
2. Michael Shuler and FikretKargi. "*Bioprocess Engineering: Basic Concepts*", 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.
3. Roger Harrison et al., "*Bioseparations Science and Engineering*", Oxford University Press, 2003.
4. Coulson J.M. and J. F. Richardson (Eds.) R.K.Sinnott. "*Chemical Engineering*, Volume 6: *An Introduction to Chemical Engineering*

Design", 2nd Edition, Butterworth-Heinemann Ltd., UK. (Indian Edition: Asian Books Private Limited, New Delhi)
5. Max S. Peters and Klaus, D. Timmerhaus. "*Plant Design and Economics for Chemical Engineers"*, 4th Edition, McGrawHill Book Co., 1991.
6. Joshi M. V. and V.V.Mahajani. *"Process Equipment Design"*, 3rd Edition, Macmillan India Ltd., 2000.
7. Michael R. Ladisch. "*Bioseparations Engineering: Principles, Practice and Economics"*, 1st Edition, Wiley, 2001.
8. Relevant articles from Bioprocess journals.

Course code	Course Title	L	T	P	C
BT2107	**PHARMACEUTICAL BIOTECHNOLOGY**	**3**	**0**	**0**	**3**
	Total Contact Hours – 45				
	Prerequisite				
	Nil				

PURPOSE

The course is aimed at providing brief knowledge on parameters considered for drug designing. The course also highlights various analytical tools used in industrial sector for parameterization of lead molecule and impart basic introduction on combinatorial design approach with role of computers in it.

INSTRUCTIONAL OBJECTIVES

1.	To understand the required parameters for lead molecule identification and optimization.
2.	To introduce various analytical tools employed in industrial sector during preclinical trials.
3.	To highlight the various drug delivery systems and production of biologicals in pharmaceutical market.

UNIT I-DRUG METABOLISM (10 hours)

Biotransformation of drugs – Microsomal and non-microsomal mechanisms and the enzymes involved. Mode of excretion – Biliary/ fecal excretion, Factors affecting drug metabolism. Drug metabolism in fetus and new born. Models to study drug metabolism, Dose effect relationships, Adverse drug reactions – Toxic reactions, Allergic reactions, Idiosyncrasy, Acute poisoning and treatment.

UNIT II-QSAR AND DRUG DESIGN (10 hours)

Drug Action – physicochemical properties and stereochemistry of compound.Isosterism and bioisosterism – metabolite, antagonist and

structural variations. Methods for variation – Fibonacci search, Topliss tree, Craigsplot, Simplex methods, and Cluster analysis. Hansch's Liner method, Free and Wilson methods, mixed approached principal component analysis.

UNIT III-COMPUTER ASSISTED COMBINATORIAL DESIGN (10 hours)

Combinatorial chemistry – Introduction, Principles, methodology, purification and analytical tools in solid phase synthesis with case studies.Compound library, interactive graphics program – with examples.

UNIT IV-NEW DRUG REGULATIONANDDDS (7 hours)

Rational drug design – phases of preclinical and clinical trials. Role of regulatory authorities.Drug delivery system – Basic concepts and Novel advances. Cell specific drug delivery, Brain specific drug targeting strategies and Pulmonary delivery systems.

UNIT V-BIOLOGICAL PRODUCTS (8 hours)

Properties of biotechnology derived therapeutic products. Production of Human insulin, Interferons, somatotropin, human growth hormone, somatostatin. Gene Therapy, vaccines, Monoclonal Antibody Based Pharmaceuticals, Recombinant Human Deoxyribonuclease

REFERENCES

1. K. D. Tripathi, "*Essentials of Medical Pharmacology*," 6th Edition, Jaypee publications, 2008.
2. Gary Walsh, "*Pharmaceutical Biotechnology-Concepts and Applications*," Wiley, 2007.
3. D. J. A. Crommelin, Robert D. Sindela, "*Pharmaceutical Biotechnology*," - 2nd Edition - 2004.
4. Remington, "*The science and Practice of Pharmacy*," Vol. I and II, 20th Edition, 2007.
5. Medicinal chemistry: A molecular and biochemical approach, 3rd Edition, OUP, 2005.
6. Alfred Burger, "*Guide to Chemical Basis of Drug Design*," by (John Wiley & Sons) 1983.
7. John Smith &Hywel Williams, "*Introduction to the Principles of Drug Design*,"Wright PSG, 1983.

Course code	Course Title	L	T	P	C
BT2108	**BIOLOGICAL TREATMENT OF WASTE WATER**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				
	Prerequisite				
	Nil				

PURPOSE

The purpose of this course is to provide specialized knowledge in the area of wastewater treatment processes. The course will provide fundamental principles of aerobic and anaerobic biological waste treatment processes, and application of microbial systems to the operations and design of waste (domestic, industrial) treatment processes.

INSTRUCTIONAL OBJECTIVES

1.	To develop knowledge and skills to know the nature of source waters and raw wastewaters, and treatment objectives, influence the type, number and sequence of unit processes.
2.	To understand the fundamental, scientific basis governing the design and performance of the treatment technologies reviewed in the module
3.	To apply their knowledge of the principles of water and wastewater treatment to the design of each unit process reviewed in the module.

UNIT I-ACTIVATED SLUDGE PROCESS-PROCESS ANALYSIS AND SELECTION (9 hours)

Characteristics of Activated Sludge (aerobic and anaerobic); Analysis of Data – Mass Balance Analysis. Reactors used in waste water treatment- Up Flow Anaerobic Sludge Blanket (UASB), Two-stage, Aerobic UNI Tank System (TSU-System, Route Zone Treatment, Submerged Aerobic Fixed Film (SAFF) Reactor, and Fluidized Aerobic Bio – Reactor (FAB).

UNIT II-AEROBIC FIXED-FILM & ANAEROBIC TREATMENT PROCESSES (9 hours)

Biofilm process considerations; Trickling Filters and Biological Towers; Rotating Biological Contactors; Granular – Media Filters; Fluidized – Bed & Circulating Bed- Biofilm reactors. Hybrid Biofilm/suspended growth processes. Anaerobic Processes: Methanogenesis, process chemistry and microbiology; process kinetics and factors for the design of anaerobic digestors.

UNIT III-ADVANCED WASTE WATER TREATMENT (9 hours)

Technologies used in advanced treatment – Classification of technologies; Removal of Colloids and suspended particles – Depth Filtration – Surface Filtration – Membrane Filtration Absorption – Ion Exchange – Advanced oxidation process - Activated Carbon, Air Stripping, Heavy Metals Removal, Steam Stripping, Chemical Precipitation, and Electrolysis.

UNIT IV-BIOLOGICAL PHOSPHORUS REMOVAL (9 hours)

Nitrification &Denitrification Processes**:** Biochemistry and Physiology of Nitrifying Bacteria; Common process considerations; One – sludge versus two sludge nitrification. Physiology of Denitrifying Bacteria; Tertiary Denitrification; One- sludge denitrification.Normal Phosphorus Uptake into Biomass; Mechanism for Biological Phosphorus Removal; Enhanced Biological Phosphorus Removal by Bacteria and Algae.

UNIT V-ENVIRONMENTAL CONCERNS & RECYCLING OF WASTES (9 hours)

Environmental regulations and technology- Regulatory Concerns, Technology; Laws, regulations and permits- Air, Water, Solid Waste, Environmental Auditing, National Environmental Policy act, Occupational Safety and Health Act (OSHA), Storm Water Regulations; Technology (waste water); Recycling of Industrial wastes : paper, plastics, leather and chemicals.

REFERENCES

1. Wastewater Engineering: Treatment Disposal Reuse by Metcalf & Eddy
2. Environmental Biotechnology : Principles and Applications by Bruce E. Rittmann
3. Waste water Engineering Treatment and Reuse: McGraw Hill, G. Tchobanoglous,FI Biston, 2002.
4. Industrial Waste Water Managemnet Treatment and Disposal by Waste Water McGraw Hill III Edition 2008.
5. Environmental Biotechnology: Principles and Applications by Bruce E. Rittmann.
6. Biological Wastewater Treatment", Second Edition, Marcel Dekker, Inc., New York,

Course code	Course Title	L	T	P	C
BT2109	GREEN ENERGY TECHNOLOGY	3	0	0	3
	Total Contact Hours - 45				
	Prerequisite				
	Nil				

PURPOSE

Green Energy Technology is a cutting edge material based program designed to equip post-graduates with multi-disciplinary skills and knowledge in the areas of green energy generation, green processes in chemical and construction industries, applications of nanotechnolgy, waste management and environmental sustainability etc. The course will be taught by a team of specialists working in the fields of green energy technology, chemical science, biological science, project management, and environmental policy.

INSTRUCTIONAL OBJECTIVES

1.	To know the new means of generating energy, energy efficiency, storage and distribution of energy.
2.	To study the invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances.
3.	To study the Green nanotechnology applications and green engineering principles to this field

UNIT I-GREEN CHEMISTRY (9 hours)

Introduction to Green Chemistry**:** Principles of Green Chemistry, Reasons for Green Chemistry (resource minimization, waste minimization, concepts), Green reactions solvent free reactions, Catalyzed (heterogeneous/homogeneous) reactions, MW/ Ultrasound mediated reactions, Bio catalysts.

UNIT II-GREEN INNOVATION & SUSTAINABILITY (9 hours)

Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation-, technological/environmental leap-frogging; Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agro ecology and other appropriate green technologies); design for sustainability.

UNIT III-GREEN ENERGY AND SUSTAINABLE DEVELOPMENT (9 hours)

The inseparable linkages of life supporting systems, biodiversity and ecosystem services and their implications for sustainable development: global warming; greenhouse gas emissions, impacts, mitigation and adaptation ; future energy Systems- clean/green energy technologies; International agreements/conventions on energy and sustainability - United Nations Framework Convention on Climate Change (UNFCC); sustainable development.

UNIT IV-GREEN NANOTECHNOLOGY (9 hours)

Nan particles preparation techniques, Greener Nan synthesis: Greener Synthetic Methods for Functionalized Metal Nan particles, Greener Preparations of Semiconductor and Inorganic Oxide Nan particles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods, Green materials: biomaterials, biopolymers, bioplastics, and composites. Nanomaterials for Fuel Cells and Hydrogen; Generation and storage, Nanostrcutures for efficient solar hydrogen production, Metal Nanoclusters in Hydrogen Storage Applications, Metal Nanoparticles as Electrocatalysts in Fuel Cells, Nanowires as Hydrogen Sensors

UNIT V-GREEN MANAGEMENT (9 hours)

Definition; green techniques and methods; green tax incentives and rebates (to green projects andCompanies); green project management in action; business redesign; eco-commerce models. Environmental reporting and ISO 14001; climate change business and ISO 14064; green financing; financial initiative by UNEP; green energy management; green product management

REFERENCES

1. Energy and the Environment, 2nd Edition, John Wiley, 2006, ISBN:9780471172482; Authors: Ristinen, Robert Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A., Publisher: Wiley, Location: New York, 2006.
2. Energy, Ecology and the Environment, Academic Press Inc, B. R Wilson & W J Jones, 2005.
3. Environment – A Policy Analysis for India, Tata McGraw Hill, 2000.
4. Fowler, J.M., Energy and the Environment, 2nd Ed., McGraw Hill, New York, 1984.

Course code	Course Title	L	T	P	C
BT2110	MICROBIAL TECHNOLOGY	3	0	0	3
	Total Contact Hours - 45				

PURPOSE

This course helps the students to study the Microbial Technology and its applications

INSTRUCTIONAL OBJECTIVES

1.	Study the isolation and purification of microbial products
2.	Understand the kinetics of microbial metabolites & their action
3.	Learn about the recovery and purification of products from microbes

UNIT I-MICROBES AND APPLICATION (9 hours)

Introduction, aims and scope: Organization and function of prokaryotes, Isolation of industrially important microorganisms from different sources. Extremophiles and their applications: Characteristics of selected groups of microbes. Control of micro organisms- physical and chemical agents.Culture concept and cultural characteristics.

UNIT II-ISOLATION OF INDUSTRIALLY IMPORTANT MICROOBES (9 hours)

Methods in microbiology- Pure culture techniques, Microbial nutrition and growth principles. Growth measurement techniques: Isolation of microorganisms from various sources, long term preservation and improvement of cultures. Design and Preparation of Media- fermentation processes. Study of various methods of biomass measurement- Growth curve studies of microbes in Batch culture and continuous culture. Determination of yield coefficient and Monod's constant.

UNIT III-INDUSTRIALLY IMPORTANT MICROBIAL METABOLITES (9 hours)

Industrially important microbial metabolites- Process technology for the production of primary metabolites e.g. enzymes (Amylases, Proteases, Lactases, Pectinase and Lipases), baker's yeast, ethanol, citric acid, polysaccharides, nucleosides and bioplastics.Production of secondary metabolites- penicillin, Tetracycline, streptomycin, vitamins etc.

UNIT IV-APPLICATIONS OF GREEN CONCEPTS (9 hours)

Applications of microbial metabolites: Pharmaceutical industry, Therapeutics, and Clinical analysis- glucose isomerase, aminopeptidase; amylase, cellulase, penicillin acylase, lipase, oxido-reductase; protease etc. for the production of different types of drugs and drugs intermediates.

Biogenic synthesis of nanoparticles from microbes- mechanism, characterization, and applications.Microbes in environmental management,Biocontrol, Biofertilizers, and biopesticides.

UNIT V-RECOVERY AND PURIFICATION OF MICROBIAL PRODUCTS (9 hours)

Removal of microbial cells- Precipitation, filtration, centrifugation.Cell distruption- extraction and chromatography, Drying and crystallization.

REFERENCES

1. Michael T. Madigan, John M. Martinko, Paul V. Dunlap, and David P. Clark *"Brock Biology of microorganisms"*, Prentice Hall, 12th Edition, 2008
2. Michael J. Pelczar, S. Chan, and Noel R. Krieg *"Microbiology"*,McGraw Hill, 7th Edition, 2011
3. Davis D. Bernard, Dulbecco Renato, Ginsberg S. Harold, and Eisen N. Herman *"Microbiology"*, Lippincott Williams, 6th Edition, 1990
4. Stanier Y. Roger, Adelberg A. Edward, and Ingraham John *"General Microbiology"*, Prentice Hall, 5th Edition, 1986
5. Geo Brooks, Karen C. Carroll, Janet Butel, and Stephen Morse *"Medical Microbiology"*, McGraw-Hill Medical, 26th Edition, 2012
6. Lansing M. Prescott, Donald A. Klein, and John P. Harley,*"Microbiology"*,McGraw Hill, 5th Edition, 2002
7. G. Reed, Prescott and Dunn's, *"Industrial Microbiology"*, 4th Edition, CBS Publishers, 1987.
8. P. E. Stanbury, A. Whitaker, and S. J. Hall, *"Principles of Fermentation Technology"*, Indian Edition, Hall Books, 2007.

SUPPORTIVE COURSES

Course code	Course Title	L	T	P	C
MA2014	APPLIED MATHEMATICS FOR BIOTECHNOLOGISTS	3	0	0	3
	Total Contact Hours - 45				

PURPOSE

To develop an understanding of the methods of probability and statistics which are used to model engineering problems.

INSTRUCTIONAL OBJECTIVES

1.	To equip themselves familiar with Laplace transform
2.	To apply the basic rules and theorems of probability theory such as Baye's Theorem, to determine probabilities that help to solve engineering problems and to determine the expectation and variance of a random variable from its distribution.
3	To familiarise with numerical solution of equations
4	To appropriately choose, define and/or derive probability distributions such as the Binomial, Poisson and Normal etc to model and solve engineering problems.
5	To learn how to formulate and test hypotheses about means, variances and proportions and to draw conclusions based on the results of statistical tests and how the analysis of variance procedure can be used to determine if means of more than two populations are equal.

UNIT I-LAPLACE TRANSFORMS (9 hours)

Definition - Transform of elementary functions - Properties of Laplace transforms - Existence conditions - Transforms of Derivatives - Transforms of integrals - Derivatives and Integrals of transform - Inverse transforms - Convolution Theorem - Periodic Functions - Application to differential equations with constant coefficients.

UNIT II-PROBABILITY AND RANDOM VARIABLES (9 hours)

Axioms of Probability – Conditional Probability – Total Probability – Baye's theorem - Random variable – Probability mass functions – Probability density function – Properties – Moments – Moment generating functions and their properties.

UNIT III-CURVE FITTING AND BASIC STATISTICS (9 hours)

Principle of Least Squares: Fitting of straight line, parabola, exponential curve and power curve - Data analysis: Measures of Central tendency - Measures of dispersion - Skewness and kurtosis - Correlation and Regression - Applications to Biological Sciences.

UNIT IV-DISTRIBUTION THEORY (9 hours)

Introduction to probability - Random Variables and its characteristics - Binomial, Poisson and normal distributions.

UNIT V-TESTING OF HYPOTHESES AND ANALYSIS OF VARIANCE (9 hours)

Large sample tests based on normal distribution - Test based on t and F distributions - Chi - square tests for independence of attributes and goodness of fit - ANOVA: One way and two way classifications - Applications from Biological Sciences - Case studies.

REFERENCES

1. B. S. Grewal, Higher Engineering Mathematics, 36th Edition, Khanna Publishers, New Delhi, 2003
2. S. Narayanan, T. K. ManickavachagomPillai, G. Ramaniah, Advanced Mathematics for Engineering Students, Volume 3, S. Viswanathan Private Limited, 1986
3. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Co., New Delhi, 2004
4. J. C. Arya. and R. W. Kardber, Mathematics for Biological Sciences, Prentice Hall International Edition, 1979
5. PremNarain, Statistical Genetics, Wiley Eastern, 1990
6. Veerarajan .T, Probability and Random Process, Tata McGraw Hill Company, 2nd Edition, New Delhi, 2003.

Course code	Course Title	L	T	P	C
MC2510	**STATISTICAL TECHNIQUES FOR BIOENGINEERS**	**3**	**0**	**0**	**3**
	Total Contact Hours - 45				

PURPOSE

The course is designed to offer knowledge about the application of Statistical techniques for the analysis of biological data. It provides fundamental ideas on the useful of data analysis, interpretation and inference based on experimental data collected from the conduct of biological experiments. The relevance more on the analysis of biological data.

INSTRUCTIONAL OBJECTIVES

1.	Data characteristics and form of distribution of Data Structure
2.	To understand the exact method of data analysis for the problem under investigation.
3.	For drawing valid inferences and to plan for future investigations.

UNIT I-MEASURES OF AVERAGES AND DISPERSION (9 hours)
Measures Central Tendency, Dispersion, Skewness and Kurtosis.

UNIT II-BASCIS OF PROBABILITY AND STATISTICAL DISTRIBUTIONS (9 hours)
Basic Probability Theory – Probability density function – Mathematical Expectation – Basic Statistical Distributions (Binomial, Poisson and Normal Distributions).

UNIT III-CORRELATION AND REGRESSION ANALYSIS (9 hours)
Correlation – Simple, Partial and Multiple correlation: Regression – Simple Repression Models and Multiple regression models.

UNIT IV-SAMPLING THEORY AND HYPOTHESIS TESTING (9 hours)
Basic Sampling Techniques – Sampling Distribution – Large Sample Tests – Chi-square Distribution – Small Sample Tests.

UNIT V-NON-PARAMETRIC METHODS AND ANALYSIS OF VARIANCE (9 hours)
Non-Parametric Methods – One sample and two sample tests – Analysis of variance – Principles of experimentation and Basic Experimental designs.

REFERENCES

1. S. C. Gupta and V. K. Kapoor, *"Fundamentals of Mathematical Statistics"*, 8th Edition, Sultan Chand & Sons, Delhi, 2003.
2. S. C. Gupta and V. K. Kapoor, *"Applied Statistics"*, 8th Edition, Sultan Chand & Sons, Delhi, 2003.
3. Marcello Pagano and Kimberley Gauvreau, *"Principles of Bio-Statistics"*, 1st Edition, Duxbury: Thomson Learning, USA, 2000.
4. B. L. Agrawal, *"Programmed Statistics"*, 2nd Edition, New Age International (P) Ltd., New Delhi, 199

		L	T	P	C
MB2208	**MARKETING RESEARCH FOR ENGINEERS**	**2**	**2**	**0**	**3**
	Total Contact Hours –45				
	Prerequisite				
	Nil				

PURPOSE

The purpose of learning this course is to equip the students with the skills of designing and implementing the marketing research programs across the spectrum of marketing function in order to introspect, perceive, plan & design methodologies, analyze and solve day to day problems of the organization with regard to their marketing function.

INSTRUCTIONAL OBJECTIVES

1.	To learn, comprehend and apply effective marketing research techniques to solve day to day marketing problems.
2.	To develop and implement a marketing research program for providing solution to the managerial decision making function.

UNIT I - INTRODUCTION
(9 hours)

The Role of Marketing Research- The Marketing Research Process-The Human Side of Marketing Research: Organizational and Ethical Issues.

UNIT II - DESIGNING RESEARCH STUDIES
(9 hours)

Qualitative Research- Secondary Data Research in a Digital Age - Survey Research- Observation-Conducting Marketing Experiments.

UNIT III - MEASUREMENT
(9 hours)

Measurement and Attitude Scaling- Questionnaire Design.

UNIT IV - SAMPLING AND STATISTICAL THEORY
(9 hours)

Sampling Designs and Sampling Procedures- Reviewing Statistical Theory and Determining Sample Size.

UNIT V - ANALYSIS AND REPORTING
(9 hours)

Basic Data Analysis-Testing for Differences Between Groups and for Relationships among Variables-Communicating Research Results.

REFERENCES

1. G.C. Beri, *'Marketing Research'*, Tata McGraw-Hill Education.
2. Harper W. Boyd Jr, Ralph Westfall, Stanley F. Stasch, Richard D. Irwin Inc.,*'Marketing Research – text and cases'*, All India Traveller Book Seller.
3. Raymond Kent, *'Marketing Research – Measurement, Method and application'*, International Thomson Business Press.
4. William G. Zikmund, Barry J. Babin, '*Essentials of Marketing Research, International Edition, 5e*, Cengage Learning
5. William G. Zikmund, Barry J. Babin, Jon C. Carr, Mitch Griffin, '*Business Research Methods, International Edition*, 9e, Cengage Learning

AMENDMENTS

S.No.	Details of Amendment	Effective from	Approval with date
