CURRICULUM

3rd – 8th Semester July 2018 admission onwards

APPROVED BY

BOARD OF STUDIES (BOS)

11th MEETING, February 07, 2019

B. TECH. in BIOTECHNOLOGY:

Revised Teaching Scheme

DEPARTMENT OF BIOTECHNOLOGY

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY,

Jalandhar

Phone: 0181-2690301, 02 (Ext. 2101, 2104), Fax: 0181-2690932 Website: www.nitj.ac.in

B.Tech in BIOTECHNOLOGY

Programme Core (PC): 87, Programme Elective (PE): 21, Open elective (OE): 09, Core Institute (CI): 63 (1st Year 47, 3rd Semester Mathematics course 04, 4th Semester HM Course 03, Major project 06, Industrial lecture 01, Practical Training: 02), Total Credit: 180

First and Second Semester, Total Credit: 47

I Semester (Already Finalized)

Course Code	Subject	L	T	P	Contact hours	Credits
CYCI-102	Applied Chemistry-B	3	1	0	4	4
MACI-101	Applied Mathematics - I	3	1	0	4	4
HMCI-102	English Communication & Report	3	0	0	3	3
CYCI-104	Environmental Studies	3	0	0	3	3
IPCI-101	Manufacturing Processes	2	0	0	2	2
MECI-101	Elements of Mechanical Engineering	3	1	0	4	4
HMCI-103	English Communication Laboratory	0	0	2	2	1
CYCI-103	Applied Chemistry-B Laboratory	0	0	2	2	1
IPCI-102	Product Realization through Manufacturing Laboratory	0	0	4	4	2
Total		**17**	**3**	**8**	**28**	**24 Total**

II Semester (Already Finalized)

Course Code	Subject	L	T	P	Contact hours	Credits
PHCI-103	Applied Physics-B	3	1	0	4	4
MACI-102	Applied Mathematics - II	3	1	0	4	4
CSCI-101	Computer Programming	3	0	0	3	3
CSCI-103	Data Structure	3	1	0	4	4
HMCI-101	Management, Principles and Practice	3	0	0	3	3
MECI-102	Engineering Graphics & CADD	1	0	4	5	3
PHCI-104	Applied Physics-B Laboratory	0	0	2	2	1
CSCI-102	Computer Programming Laboratory	0	0	2	2	1
Total		**16**	**3**	**8**	**27**	**23 Total**

III Semester

Course Code	Subject	L	T	P	Contact hours	Credits
BTPC- 201	Microbiology	3	0	0	3	3
BTPC- 203	Biochemistry	3	0	0	3	3
BTPC- 205	Bioprocess Calculations	3	1	0	4	4
BTPC- 207	Bioprocess Engineering	3	1	0	4	4
MACI- 204	Probability and Statistics	3	1	0	4	4
CHPC-281	Fluid and Particles Mechanics	3	0	0	3	3
BTPC- 209	Microbiology Laboratory	0	0	4	4	2
BTPC- 211	Biochemistry Laboratory	0	0	4	4	2
Total		**18**	**3**	**8**	**29**	**21 Core** **25 Total**

IV Semester

Course Code	Subject	L	T	P	Contact hrs	Credits
BTPC- 202	Cell and Molecular Biology	3	0	0	3	3
BTPC-204	Genetic Engineering	3	0	0	3	3
BTPC-206	Biochemical Reaction Engineering	3	0	0	3	3
CHPC-282	Heat and Mass Transfer	3	1	0	4	4
CSPC-203	Object Oriented Programming	3	0	0	3	3
HMCI-202	Entrepreneurship Development and Management	3	0	0	3	3
BTPC- 210	Bioprocess Engineering Laboratory	0	0	4	4	2
BTPC- 212	Molecular Biology and Genetic Engineering Laboratory	0	0	4	4	2
CSPC-223	Object Oriented Programming Lab	0	0	2	2	1
Total		**18**	**1**	**10**	**29**	**21 Core** **24 Total**

BTPC: Biotechnology Programme Core, BTCI: Biotechnology Institute Core,
BTPE: Biotechnology Programme Elective, BTOE: Biotechnology Open Elective

V Semester

Course Code	Subject	L	T	P	Contact hours	Credits
BTPC-301	Enzyme Engineering and Technology	3	0	0	3	3
BTPC-303	Animal and plant tissue culture	3	0	0	3	3
BTPC-305	Separation Methods in Biotechnology	3	1	0	4	4
BTPC-307	Immunology	3	0	0	3	3
BTPC-309	Industrial Biotechnology	3	0	0	3	3
BTPC-311	Biological Waste Treatment	3	0	0	3	3
BTPC-313	Cell and Tissue Culture Laboratory	0	0	2	2	1
BTPC-315	Separation process Laboratory	0	0	4	4	2
BTPC-317	Immunology Laboratory	0	0	2	2	1
BTCI-301	Minor Project, Phase-I	0	0	2	2	0*
Total		**18**	**1**	**10**	**29**	**23 Core, 23 Total**

*** Minor Project will be allotted in 5th Semester, will be evaluated after 6th Semester**

VI Semester

Course Code	Subject	L	T	P	Contact hours	Credits
BTPC-302	Bioinformatics	3	1	0	4	4
BTPC-304	Bioprocess Modeling and Simulation	3	0	0	3	3
BTPC-306	Analytical Methods in Biotechnology	3	0	0	3	3
BTPE-3XX	DE - I	3	0	0	3	3
BTPE-3XX	D E – II	3	0	0	3	3
	Open Elective-I	3	0	0	3	3
BTPC-308	Bioinformatics Laboratory	0	0	2	2	1
BTPC-310	Biological waste treatment Laboratory	0	0	2	2	1
BTCI-302	Minor Project, Phase-II	0	0	2	2	2*
Total		**18**	**1**	**6**	**25**	**12 Core, Total 23**

*** Minor Project will be allotted in 5th Semester, will be evaluated after 6th Semester**

List of Departmental Electives

(A) Semester VI: Departmental Elective I, II

02 subjects out of following group:

S.No	Course Code	Course Title	L	T	P	C
1	BTPE-322	Bioprocess Equipment Design and Economics	3	0	0	3
2	BTPE-324	Protein Engineering	3	0	0	3
3	BTPE-326	Advanced cell biology	3	0	0	3
4	BTPE-328	Biomaterials	3	0	0	3

Open Electives Courses to be offered by the Department in 6th Semester

S No	Course No	Course Title	L	T	P	Credits	Semester
1.	BTOE- 302	Bioprocess Engineering in Biofuel Production	3	0	0	3	VI

VII Semester

Course No.	Subject	L	T	P	Contact hours	Credits
BTPC-401	IPR in Biotechnology	3	0	0	3	3
BTPE - 4XX	D E- III	3	0	0	3	3
BTPE - 4XX	D E – IV	3	0	0	3	3
CHPC-481	Instrumentation and Process Control	3	0	0	3	3
	Open Elective - II	3	0	0	3	3
BTPC-403	Bioprocess Modeling and Simulation Laboratory	0	0	2	2	1
BTCI-300	Industrial Practical Training	0	0	0	0	2*
BTCI-400	Major Project (Phase –I)	0	0	4	4	0
Total		**15**	**0**	**6**	**21**	**07 Core, Total 18**

*** Industrial Practical Training will be held during summer vacation after sixth semester**

List of Departmental Electives

(B) Semester VII: Departmental Elective III , IV

02 subjects out of following group:

S.No	Course Code	Course Title	L	T	P	C
1	BTPE-411	Biopharmaceuticals	3	0	0	3
2	BTPE-413	Stem Cell Engineering	3	0	0	3
3	BTPE-415	Nano Biotechnology and Nano Science	3	0	0	3
4	BTPE-417	Tissue Engineering	3	0	0	3
5	BTPE-419	Secondary Metabolites in Plants & Microbes	3	0	0	3
6	BTPE-421	Biostatistics	3	0	0	3

Open Electives Courses to be offered by the Department in 7th Semester

S No	Course No	Course Title	L	T	P	Credits	Semester
1.	BTOE- 401	Introduction to Bioinformatics	3	0	0	3	VII
2.	BTOE- 403	Applied Biotechnology & Bioengineering	3	0	0	3	VII

VIII Semester

Course No.	Subject	L	T	P	Contact hours	Credits
BTPC 402	Food Process Biotechnology	3	0	0	3	3
BTPE- 4XX	D E –V	3	0	0	3	3
BTPE- 4XX	D E –VI	3	0	0	3	3
BTPE-4XX	D E –VII	3	0	0	3	3
	Open Elective-III	3	0	0	3	3
BTCI-402	Industrial Lecture	1	0	0	1	1
BTCI-400	Major Project (Phase –II)	0	0	8	8	4*
Total		**16**	**0**	**8**	**24**	**03 Core, Total 20**

*** Major Project will be allotted in 7th Semester, will be evaluated after 8th Semester**

Total credits = 87 PC + 21 PE + 09 OE + 63 CI = 180

List of Departmental Electives

(C) Semester VIII: Departmental Elective V, VI and VII

03 subjects out of following group:

S.No	Course Code	Course Title	L	T	P	C
1	BTPE-422	Environmental Biotechnology & Bioengg.	3	0	0	3
2	BTPE-424	Drug design and molecular modeling	3	0	0	3
3	BTPE-426	Metabolic Engineering	3	0	0	3
4	BTPE-428	Bioenergy & Bioresource Technology	3	0	0	3
5	BTPE-430	Biosensors and Biotechnology	3	0	0	3
6	BTPE-432	Bioprocess Safety and Bioethics	3	0	0	3
7	BTPE-434	Agricultural Biotechnology	3	0	0	3
8	BTPE-436	Biofilm Engineering	3	0	0	3
9	BTPE-438	Biological Transport Phenomena	3	0	0	3

Open Electives Courses to be offered by the Department in the 8th Semester

S No	Course No	Course Title	L	T	P	Credits	Semester
1.	BTOE-402	Environmental Biotechnology	3	0	0	3	VIII
2.	BTOE- 404	Biosensor	3	0	0	3	VIII

Six Theory Courses for "Minor degree in Biotechnology, for other Department students":

S No	Course No	Course Title	L	T	P	Credits	Semester
1.	BTMI- 201	Microbiology	3	0	0	3	III
2.	BTMI-202	Cell and Molecular Biology	3	0	0	3	IV
3.	BTMI-301	Separation Methods in Biotechnology	3	0	0	3	V
4.	BTMI-302	Bioinformatics	3	0	0	3	VI
5.	BTMI-401	Bioprocess Engineering	3	0	0	3	VII
6.	BTMI-402	Biological Waste Treatment	3	0	0	3	VIII

BTMI: Biotechnology Institute Minor

DETAIL SYLLABUS

(Departmental Subjects)

Programme Educational Objectives

PEO-1. Understand and apply the concepts of Biotechnology, Chemical Engineering, computational techniques, instrumentation and related aspects of science and technology for pursuing higher studies and successful careers in industry.

PEO-2. Apply the acquired practical skills and broad biotechnological training in product, process and techniques development to meet the societal demands.

PEO-3. Participate in individual and team oriented, open-ended activities aiding constructive thinking to provide opportunity for students to manage and work on multidisciplinary projects.

PEO-4. Demonstrate professional and ethical attitude with awareness of current issues and think about the social entailment of their work, especially its impact on safety, health and environment for sustainable development.

PEO-5. To promote student awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice.

Programme Outcomes (POs)

a) An ability to apply knowledge of Engineering, Science, and mathematics
b) An ability to design and conduct experiments, as well as to analyze and interpret data
c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) An ability to identify, formulate and think critically to analyze results and discussions of the experimental outcome to solve engineering problems
e) An ability to use the techniques, skills and modern engineering tools necessary for engineering practice
f) An ability to function with multidisciplinary teams and maintain integrity in performing work as a member or leader
g) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
h) An understanding of professional and ethical responsibility and to articulate debate and analyze scientific problems with clarity
i) An ability to engage in lifelong learning to envisage recognition in future
j) A knowledge of contemporary issues and being inquisitive in understanding cutting edge areas of Biotechnology
k) An ability to communicate effectively in articulating concepts, hypothesis and problems eloquently

DEPARTMENT OF BIOTECHNOLOGY: Detailed syllabus 3rd Semester

BTPC- 201 Microbiology [3 0 0 3]

Course objectives: The course aims at providing an overview of the physiology, metabolism and growth of microbes. To understand the fundamentals of microbial interaction, mechanisms. Deep understanding of advantages and hazards of microbial world.

Unit-I

Scope and History of Microbiology: Scope and history of microbiology, Classification, Characterization, Identification and nomenclature of microorganisms, Microscopy, Morphological, Structural and Biochemical characteristics of prokaryotes and eukaryotes (bacteria , yeast, mold, algae, protozoa, actinomycetes)

Cultivation of Microorganisms: Microbiological media, physical conditions required for growth.

Reproduction and Growth of Microorganism: Modes of cell division, growth curve of microbes, Quantitative measurement of growth.

Unit-II

Methods in Microbiology: Chemical, Physical and Biological methods of selection of microorganisms, Methods of isolating pure cultures, Maintenance and preservation of pure cultures, Microbial mutation.

Microbial Metabolism: Metabolic pathways and Bioenergetics, Aerobic and Anaerobic growth, Transport of nutrients across cell membranes

Physical and Chemical Control of Microorganism: Major groups of antimicrobial agents, Mode of action and practical applications

Energy Transduction Mechanisms in Microbial Cell: Aerobic and anaerobic respiration, Microbial photosynthesis, Transduction, Transformation, Conjugation

Unit-III

Microbial Interaction: - Roles of microbes in Nitrogen, Carbon and Sulphur cycle

Application of Microorganism in various Field: - Agriculture, food, environment, medicine, public health and industry.

Viruses: Classification, morphology and composition, DNA and RNA bacteriophages, Lysogeny and lytic cycle

Course Outcomes:

1. After studying this subject, students would be able to measure microbial growth, types of microbial interactions, growth rates etc. for microbiological processes.
2. Ability to analyze the mechanism of microbial growth and its control parameters
3. The student would understand the physical, chemical and biological properties
4. The student can apply microbial processes for various application & energy production.

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√				√			√	
2	√		√				√			√	
3	√	√	√	√	√		√	√	√	√	
4	√	√	√		√	√	√		√	√	√

Books Recommended

1. Pelczar M J, Chan E C S and Krieg N R "*Microbiology*, 5th Edition, " Mc Graw Hill, New York (1995)
2. Salle A J, "*Fundamental Principles of Bacteriology"* , 7th Edition, Tata McGraw Hill, New Delhi (1984)
3. Stanier R Y, "*Text in Microbiology*" McMillan Press London (1995)
4. Casida L E, "*Industrial Microbiology",* New Age International Publishers, New Delhi (2003)

BTPC-203 Biochemistry [3 0 0 3]

Course Objectives:	The course aims at providing an overview of molecular basis of carbohydrates, proteins and fats. To understand the fundamentals of nucleic acids, nucleotides, vitamins, hormones, enzymes, biological membranes, metabolism, bioenergetics. To develop analytical and critical thinking skills in biological phenomena through scientific methods.

Unit-I

Molecular basis of life, study of macromolecules

Carbohydrates: Their structure and biological functions, Monosaccharides disaccharides and polysaccharides Glycoproteins.

Amino Acids and Proteins: Their structure and function, Types of amino acids, Fibrous proteins and globular proteins, Separation of proteins

Fats and Lipids: Their structure and biological functions, Types of lipids, triacylglycerol, Waxes, Phospholipids, Sphingolipids, Lipoproteins

Unit-II

Nucleic acid and Nucleotides: DNA, Structure of chromosomes and genes, Replication and transcription of DNA, RNA Protein synthesis and its regulation, Genetic recombination and cloning

Vitamins and Hormones: Types, Structure and functions

Photosynthesis: Chlorophylls, Kinds and roles of photosystems, Calvin cycle

Enzymes: Properties and types, Kinetics of enzyme action, Enzyme inhibition, Allosteric enzymes, Assay of enzymes, Regulation of enzyme activity

Unit-III

Bioenergetics and Metabolism: Metabolism, basic concepts and design, Glycolysis citric acid cycle oxidative phosphorylation pentose phosphate pathway and gluconeogenesis glycogen and disaccharide metabolism amino acid degradation and urea cycle

Biological Membranes: Characteristics of biological membranes components of membranes types of membranes fluid mosaic model membrane asymmetry

Course Outcomes:	1. After studying this subject, students would be able to measure extent of biochemical growth, types of biochemical interactions for living processes. 2. Ability to analyze the composition of proteins, carbohydrates and fats 3. The student would understand the physical, chemical and biological properties of nucleotides, enzymes, hormones, vitamins 4. The student can apply biochemical processes for energy production.

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√				√			√	
2	√		√				√			√	
3	√	√	√	√	√		√	√	√	√	
4	√	√	√		√	√	√		√	√	√

Books Recommended

1. Stryer L, "*Biochemistry"* , 5th Edition, W.H.Freeman and Company (2002)
2. Lehninger, A L **"***Principles of Biochemistry*", 4th Edition Butterworth Publishers, New York (2003)
3. Conn E E and Stump P K *"Outlines of Biochemistry*" ,John Wiley and Sons, New York (1987)
4. Walsh G , " *Proteins Biochemistry and Biotechnology"* John Wiley and sons (2003)
5. Rastogi," *Biochemistry"*, 2nd Edition, Tata Mc Graw Hill (2003).

BTPC-205 Bioprocess Calculation [3 1 0 4]

Course Objectives: The course aims at providing an overview of bioprocess calculations and materials balance. To understand the fundamentals of different biomolecules for calculation of mass and energy balances in different biochemical processes.

Unit-I

Introduction to Biochemical Engineering Calculations: Units and dimensions, mole concept, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equations and stoichiometry, limiting and excess reactant, conversion and yield. Mass and energy balances in bioprocesses, flow sheet and process calculations, metabolic stoichiometry of growth and product formation, material balance and energy balance with recycle, by pass and purge streams.

Unit-II

Material Balance: Material balance, program of analysis of material balance problems, solving material balance problems that do not involve chemical reactions, solving material balances problems involving chemical reactions, multiple subsystems, recycle, bypass, and purge calculations.

Gases Vapors, Liquids and Solids: Ideal gas law calculations, real gas relationships, vapor pressure and liquids, saturation, partial saturation and humidity.

Unit-III

Energy Balances: Concepts and units, calculation of enthalpy changes, application of the general energy balance without reactions occurring energy balances that account for chemical reaction, reversible processes and the mechanical energy balances, heats of solution and mixing, psychometric charts and their use.

Course Outcomes:

1. Understand the units and dimensions of physical and derived quantities
2. Understand the mole concept, biochemical equations and stoichiometry
3. Understand the material and energy balances of bioprocesses
4. Perform material and energy balances on biochemical processes/equipment without and with reactions

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√			√					√		
2	√			√							
3	√	√	√	√	√		√			√	√
4	√	√	√	√	√	√	√	√			√

Books recommended

1. Himmelblau D M, *"Basic Principles and Calculations in Chemical Engineering,"* Prentice Hall (1998).
2. Haugen O A, Watson K M and Ragatz R A, "*Chemical Process Principles (Part-I): Material and Energy Balances*", Asia Publishing House (1995).
3. Bhatt B I and Vora S M, "*Industrial Stoiciometry*": Tata McGraw Hill Publishing, New Delhi (1987).
4. Reklaitis G V, "*Introduction to material and energy balances"* Wiley, New York (1983)

BTPC-207 Bioprocess Engineering [3 1 0 4]

Course Objectives:	The course aims at providing an overview of bioprocess engineering and materials balance. To understand the fundamentals of design of fermenter for efficient production of biomolecules and monitoring of bioprocesses in industry. Plan a research career or to work in the biotechnology industry with strong foundation about bioreactor design and scale-up. Apply modeling and simulation of bioprocesses to reduce costs and to enhance the quality of products and systems.

Unit-I

Media Sterilization: Methods of heat sterilization of media, thermal death kinetics, design criteria, batch and continuous sterilization.

Air Sterilization: Methods of air sterilization, mechanism of air sterilization, filter design.

Unit-II

Types of reactors: Stirred tank reactor, plug flow reactor (PFR), fluidized bed reactor, bubble column, air lift reactor etc;

Microbial Growth Kinetics: Different modes of operation of reactors, batch, continuous and fed batch, kinetics of microbial growth and product formation.

Agitation and Aeration: Mechanical agitation, power consumption in agitation, bubble aeration, transport phenomena in bioprocess systems; gas-liquid mass transfer, oxygen transfer to microbes and respiration, measurement of oxygen transfer coefficients, correlation between oxygen transfer coefficient and operating variables, factors affecting volumetric oxygen transfer, rheology of fermentation fluids

Unit-III

Scale Up: Scale up concepts, criteria for bioreactors scale up.

Monitoring of Bioprocesses: On line data analysis for measurement and control of important physicochemical and biochemical parameters, parameter estimation techniques for biochemical processes, Computer based data acquisition

Course Outcomes:

1. After studying this subject, students would be able to measure extent of biochemical growth, types of biochemical interactions for living processes.
2. Ability to analyze the microbial growth kinetics
3. The student can design fermenter for bioprocessing of different products.
4. The student can scale up the bioprocess for large scale production
5. The students can monitor the bioprocess for higher production efficiency

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√				√		√		√	√
2	√	√		√	√	√				√	√
3	√		√				√	√			√
4	√		√			√	√		√	√	
5	√			√		√			√		√

Books Recommended

1. Shuler M L, Kargi F, " *Bioprocess Engineering- Basic Concepts*" , 2nd ed, Prentice Hall of India Ltd. (2002)
2. Aiba S, Humphrey A E and Millis N F ,"*Biochemical Engineering*" , Academic Press (1973)
3. Stanbury P F and Whitaker A, "*Principles of Fermentation Technology,*" 2nd edition, Elsevier, (1995)
4. Bailey J E and Ollis D F, "*Biochemical Engineering Fundamentals"* , McGraw Hill (1986)
5. Harvey W. Blanch and Douglas S.Clark, "*Biochemical Engineering*", Marcel Dekker (1996).
6. Lee J M, "*Biochemical Engineering*" , Prentice Hall (1992)

MACI – 204 Probability and Statistics [3 1 0 4]

Course objectives: The course aims at providing an overview of the approaches, methods and techniques of Probability and Statistics. To understand the fundamentals and application of Probability and Statistics with reference to biotechnological processes.

Concept of statistics: collection and representation of data, frequency distribution, graphical Representation of data, measure of central tendency and dispersion, coefficient of dispersion, Moments, factorial moments, skewness and kurtosis.

Different approaches of probability: addition and multiplication theorem of probability, Boole's Inequality, conditional probability, Baye's theorem and applications.

Discrete and continuous random variables: distribution function, probability mass function, Probability density function, two dimensional random variables, mathematical expectation of

Discrete and continuous random variables, properties of expectation, conditional expectation, Moment generating functions.
Binomial, Poisson, Normal and exponential probability distributions, correlation analysis, Regression analysis, curve-fitting using least square method.
Sampling and sampling distributions: Chi-square, Student-t and F-test.

Course Outcomes:

1. After studying this subject, students would be able to represent the data and analyze the different frequency distribution
2. Ability to analyze the discrete and continuous random variables, functions
3. The student would understand the physical significance of Binomial, Poisson, Normal and exponential probability distributions.
4. Student will understand correlation analysis and sampling distributions.

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√				√		√		√	√
2	√	√		√	√	√				√	√
3	√		√				√	√			√
4	√		√			√	√		√	√	

Books Recommended:

1. G K Bhattacharya and R A Johnson, "Statistical Concepts and Methods", John Wiley, New Delhi, 2002.
2. R V Hogg and A T Elliot, "Probability and Statistical Inference", Pearson Education, 6th Edition.
3. R V Hogg and A T Craig, "Introduction to Mathematical Statistics", Sixth Edition, Pearson Education, Delhi, India.

CHPC-281 Fluid and Particles Mechanics [3 0 0 3]

Course objectives: The course aims at providing an overview of the approaches, methods and techniques of mechanical operations. To understand the fundamentals of fluid flow phenomena.

Unit-I

Introduction to Fluid flow: Ideal and real fluids, Extensive and Intensive properties, viscosity, surface tension, capillarity, evaporability, vapour pressure, Newtonian and Non-Newtonian fluids.

Fluid Statistics: Hydro statistics law, Pascal's law, Different types of Manometer, centrifugal decanter.

Fluids Kinematics and Dynamics: Classification of fluid flow, streamline, streak line, pathlines, flow rate and continuity equation, Bernaulli's theorem and its application, kinetic energy and momentum correction factor in Bernaulli's equation, concept of friction law in fluid flow, various pumps.

Laminar Viscous flow and flow measurement devices: Reynolds numbers, Hagen Poiseuille Law, Venturi meter, Orifice meter.

Unit-II

Size Reduction: Particle size and shape, particle mass, size and shape distributions, measurement and analysis, concept of average diameter, size reduction, crushing, grinding and law of grindings.

Screening: Equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen.

Settling: Flow around a single particle, drag force and drag coefficient, settling velocity of particles in a fluid, hindered and free settling of particles, thickening gravity separation

Separation of solid from liquid: Classification of filters, various types of cake filters, principle of cake filtration, clarification filters, liquid clarification, centrifugal settling process.

Unit-III

Agitation & Mixing: Agitation of liquids, axial flow impellers, radial flow impellers, velocity and power consumption of agitated vessels, blending & mixing.

Fluidization: Packed beds, bed porosity, flow though a bed of particles, fluidization & fluidized bed, conditions for fluidization minimum velocity, types of fluidization.

Course Outcomes:

1. After studying this subject, students would be able to measure pressure drop, flow rates etc. for incompressible and compressible fluids.
2. Ability to analyze the fluid flow problems with application to momentum balance
3. The student would understand the physical properties, property measurement and handling of solid-solid and solid-fluid mixtures.
4. Student will understand separation processes in solid-solid, solid-fluid mixtures

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√		√				
2	√	√	√		√			√	√	√	√
3	√		√	√				√		√	
4	√				√	√		√	√	√	√

Books Recommended

1. Smith J C, McCabe W L and Harriot P H, *"Unit Operations of Chemical Engineering",* McGraw Hill, 7th edition, (2005).
2. Richardson and Coulson *"Chemical Engineering Vol II", 5th ed.,* Butterworth – Heinemann (2003).
3. Perry's, "*Handbook of Chemical Engineering*", 7th Ed, McGraw Hill (1997).

BTPC- 209 Microbiology Laboratory [0 0 4 2]

Course objectives: The course aims at providing an overview of the physiology, metabolism and growth of Microbes. To understand the identifications of microbial interaction

Course Content

1. To study the microscope.
2. Preparation and sterilization of the medium for bacteria yeast and mold.
3. Preparation of slants /plates /deeps for culture of bacteria yeast and mold.
4. Aseptic transfer of microbial cultures.
5. To study the morphology of bacteria, yeast and mold.

6. Staining of bacteria (Gram's stain).
7. The quantitative bacteriological examination of water/milk.
8. Determination of phenol coefficient.
9. a) Determination of cell mass in a fermentation broth. b) Calibration of cell mass vs. cell Number and cell mass vs optical density
10. Serial dilution to quantify the viable cells.

Course Outcomes:

1. Ability to measure and analyze mechanism of microbial growth and its control parameters
2. The student would understand the physical, chemical and biological properties
3. The student can perform bacteriological examination of liquid samples

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√	√	√				
2	√	√	√		√			√	√	√	√
3	√		√	√				√		√	

BTPC- 211 Biochemistry Laboratory [0 0 4 2]

Course objectives: The course aims at providing molecular basis of carbohydrates, proteins, fats, nucleic acids, nucleotides, vitamins, enzymes, and metabolism

Course Content

1. Determination of reducing sugar by dinitro-salicylic (DNS) method.
2. Protein estimation by Lowry's method.
3. Estimation of DNA by diphenylamine reagent method.
4. Determination of Michaelis constant of enzymes.
5. Determination of isoelectric point of casein.
6. Extraction of lipids from egg yolk.
7. Separation by amino acids by paper electrophoresis
8. Preparation of different buffer solutions for biochemical experiments
9. Determination of pKa values
10. Titration curves of amino acids
11. Ultraviolet absorption of nucleic acids, amino acids and protein
12. Determination of acid value, iodine value and specification value of fat
13. Experimental analysis of biochemical compounds by TLC
14. Estimation of cholesterol.

Course Outcomes:

1. Ability to estimate carbohydrate, protein, fat, DNA, amino acids content
2. The student can perform biochemical examination of liquid samples

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√	√	√	√				
2	√	√	√	√	√			√	√	√	√

DEPARTMENT OF BIOTECHNOLOGY: Detailed syllabus 4th Semester

BTPC 202 Cell and Molecular Biology [3 0 0 3]

Course Objectives:	Students will acquire an advanced level of knowledge on the activity of genes and genomes and the mechanisms of genome regulation at the transcriptional and post-transcriptional level, in the contexts of development, differentiation, cellular homeostasis and cancer. The course aims at providing knowledge of molecular basis of cell organelles, structure and function of nucleus, fundamentals of molecular genetics, nucleotides, cell signaling, genetic code, DNA, gene expression.

Unit-I

Introduction to the Cell: Evolution of cell: Hypotheses and Cell theory, prokaryotic and eukaryotic cell, unicellular and multicellular organisms.

Cell Organelles: Cell wall, cell membranes and cell transport, cytosol, mitochondria, chloroplast, nucleus, nucleolus, ribosome, lysosomes, Golgi body, endoplasmic reticulum, Plastids: Chloroplast and photosynthesis, vacuoles, Cytoskeleton & motility organelles, flagella, pilli, cilia

Structure and function of nucleus: organization of the chromosome; eu-and heterochromatins; nucleosome; cell cycle regulation - CDC mutants, protein kinase; cyclin; synthetic pattern and control of cell divisions; biochemistry of meiosis

Chromosome biology: chromatin, Chromosomal DNA, chromosomal proteins and its packaging, ultra-structure of chromosomes, types of chromosome, Karyotype, chromosomal aberration (Numerical & structural)

Unit-II

Cellular reproduction and growth: Cell cycle, Binary fission in prokaryotes, Mitosis and Meiosis in eukaryotes, cytokinesis, cell cycle and regulation: protein kinase, cyclins, CDC mutants, Cell integration to tissues, Cellular structure-function correlation (both plant and animal)

Cell Signaling: General principles of cell signaling, Classification, Signaling receptors: G-Protein linked and Enzyme-linked cell-surface Receptors, Secondary messengers, role of calcium, Chemotaxis, Apoptosis: extrinsic and intrinsic pathway, target cell adaptation

The biochemical basis of inheritance: DNA as the genetic material; Central dogma of life, DNA structure, Replication, Transcription and Translation in Prokaryotes and eukaryotes; nucleotide sequence composition: unique, middle and highly repetitive DNA; Redundant DNA; Genetic Code; Regulation of gene expression in eukaryotes, *E. coli*-operon concept; hormonal control of gene expression in eukaryotes.

Unit-III

Tools and Technology in cell and molecular biology: Microcopy: Compound, Phase contrast, Fluorescent, Confocal, Electron Microscopy: SEM and TEM, Fractionation: Cell rupture techniques, Fractionation of subcellular organelles by centrifugation, flow cytometry, FACS

Course Outcomes:	Upon successful completion of this course, participants will be able to: 1. Understand the various macromolecular components and compartments of cells, their functions and will apply that knowledge in engineering. 2. Understand the general principles of gene organization and expression in both prokaryotic and eukaryotic organisms.

3. Understand the structure of nucleic acids & proteins and their interactions and the molecular mechanisms of gene regulation in prokaryotes and eukaryotes.
4. Study chromosomal aberrations in humans.

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√						√	√
2	√	√		√	√			√		√	√
3		√	√	√	√			√	√	√	√
4				√	√	√	√		√	√	

Books Recommended

1. De- Robertis, F D P and De Robertis E M F, "*Cell and Molecular Biology",* Saunders, Philadelphia (1991)
2. Lewin B *"Gene IX",* Oxford University Press, Oxford (2008)
3. Sambrook J, Fritsch E F and Maniatis T, *"Molecular Cloning"* ., Cold Spring Harbor Laboratory Press (1989)
4. Gerald Karp, *Cell and Molecular Biology: Concepts and Experiments*, John Wiley & Sons, 2009
5. Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D Johnson, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, *Essential Cell Biology*, 3rd edition (editor: Bruce Alberts), 2009
6. Ricardo V. Lloyd (Editor), *Morphology Methods: Cell and Molecular Biology Techniques*, 2001

BTPC-204 Genetic Engineering [3 0 0 3]

Course Objectives:	The course aims at providing an overview of genetic engineering, recombinant DNA technology. To understand the fundamentals of molecular genetics, cDNA libraries, polymerase chain reaction, application of recombinant DNA technology.

Unit-I

Introduction to Genetic Engineering: Gene its concepts and inheritance, development of Molecular Biology and Genetic Engineering, DNA–structure, forms and replication, RNA–types and functions, ribosome and translation, regulation of transcription and translation

Genome Organization: Genome size and complexity, the super coiling of DNA the structure of prokaryotic and eukaryotic chromosome, satellite DNA, centromere and telomere structure.

Bacteria: Transformation, transduction and conjugation.

Eukaryotes: Transcription, RNA splicing, Retroviruses.

Virus: Bacteriophages, genome its organization and its expression, virus of eukaryotes.

Mutation: Spontaneous versus induced mutations, types of mutations, mechanism of DNA repair, mutations frequency gene transfer and expression in bacteria, eukaryotes and viruses.

Unit-II

Basics of Recombinant DNA: Role of genes within cells, genetic code, genetic elements that control gene expression, method of creating recombinant DNA research, restriction enzymes and mapping in eukaryotes, plasmids, bacteriophage lambda and M-13 molecular biology, RNA tumour viruses- replication and function

Construction of c DNA libraries: Construction of genomic and c DNA libraries, methods of nucleic acid sequencing, expression of cloned genes

Polymerase Chain Reaction: Thermostable DNA Polymerases, PCR technique, Inverse PCR, Nested PCR, RACE PCR, Real-Time PCR, Site directed mutagenesis,

Unit-III

Methods In Genetic Engineering: Restriction and modifying enzymes, Restriction mapping, Southern blot, Northern blot, Western blot.

Application of Recombinant DNA Technology: In agriculture, transgenic plants and animals, gene therapy, synthesis of important molecules like insulin, growth hormone interferon etc

Course Outcomes:	1.	After studying this subject, students would be able analyze DNA structure
	2.	Ability to understand recombinant DNA, cDNA libraries, PCR
	3.	The student can apply recombinant DNA technology

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√						√	√
2	√	√		√	√	√	√	√		√	√
3		√	√	√	√		√	√	√	√	√

Books Recommended

1. De- Robertis, F D P and De Robertis E M F, "*Cell and Molecular Biology",* Saunders, Philadelphia (1991)
2. Lewin B *"Gene XII",* Oxford University Press, Oxford (2017)
3. Sambrook J, Fritsch E F and Maniatis T, *"Molecular Cloning"* ., Cold Spring Harbor Laboratory Press (1989)

BTPC-206 Biochemical Reaction Engineering [3 0 0 3]

Course Objectives:	The course aims at providing an overview of biochemical reaction engineering, kinetics of reactions, interpretation of kinetic data. To understand the fundamentals of Enzymatic reactions in free and immobilized states, kinetics of substrate utilization, product formation and biomass production. To understand different types of bioreactors and kinetics of mixed cultures in bioprocess industries.

Unit-I

Kinetics of homogeneous reactions: Basics of reaction rate, reaction mechanism, temperature dependency from Arrhenius law, kinetics of reactions, theoretical prediction of rate constant, interpretation of batch kinetic data.

Kinetics of enzyme catalyzed reactions in free and immobilized states: Michaelis-Menten equation and its various modifications, heterogeneous reactions in bioprocessing, interaction between mass transfer and reaction, effects of external mass transfer in immobilized enzyme systems; analysis of intraparticle diffusion and reaction.

Unit-II

Kinetics of substrate utilization, product formation and biomass production: Monod growth model and its various modifications, modifying batch and continuous reactors, Chemostat with recycle, multistage Chemostat system, fed-batch operation, bioreactor in immobilized cell systems, and diffusion limitation in immobilized cell system. Solid-state fermentation

Unconventional bioreactors: Hollow fiber reactor, membrane reactor, perfusion reactor for animal and plant cell culture.

Unit-III

Kinetics of mixed cultures: Major classes of interaction in mixed cultures, models describing mixed-culture interactions, reaction dynamics, industrial application of mixed cultures.

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Course Outcomes:	1. After studying this subject, students would be able to measure extent of product formation kinetics, types of biochemical interactions for living processes. 2. Ability to analyze the enzymatic kinetics 3. The student can design bioreactors for bioprocessing of different products. 4. The student can scale up the bioprocess for large scale production

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√				√		√		√	√
2	√	√		√	√	√				√	√
3	√		√				√	√			√
4	√		√			√	√		√	√	

Books Recommended

1. Levenspiel O, *"Chemical Reaction Engineering",* 3rd Ed , John Wiley & Sons, Singapore (1999).
2. Lee J M, "*Biochemical Engineering*" , Prentice Hall (1992)
3. Shuler M L, Kargi F, " *Bioprocess Engineering- Basic Concepts*" , 2nd ed, Prentice Hall of India Ltd. (2002)
4. Aiba S, Humphrey A E and Millis N F ,"*Biochemical Engineering*" , Academic Press (1973)
5. Bailey J E and Ollis D F, "*Biochemical Engineering Fundamentals"* , McGraw Hill (1986)

CHPC-282 Heat and Mass Transfer [3 1 0 4]

Course objectives:	To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries. To learn about the design of heat exchangers and evaporators, reactor heating and cooling systems. To understand Mass Transfer in various systems

Unit-I

Conduction: Fourier's law, steady state heat conduction through a composite solid, cylinders, spheres, different insulating materials for process equipment

Convection: Convection, individual and overall heat transfer coefficient, heat transfer between fluids separated by plane wall and by cylindrical wall (pipes), critical/ optimum insulation thickness, and concepts of heat exchanger.

Heat Transfer with phase change: Boiling phenomena, correlation for nucleate boiling, critical heat flux, condensation phenomena, film condensation on a vertical surface.

Radiation: Blackbody radiation, Planck's law, Wein's displacement law, the Stefan Boltzmann law, Kirchhoff's law.

Evaporation: Single and multiple effect evaporators, capacity and economy, boiling point elevation.

Unit-II

Mass Transfer Coefficient: Local and overall mass transfer coefficient, local two phase mass transfer coefficients, Local overall Mass Transfer coefficients.

Gas Absorption: Choice of solvent, number of ideal stages, height of column, equipment for gas absorption

Drying: Equilibrium in drying, rate of batch drying, time of drying, drying equipments.

Distillation : Raoult's Law and Dalton's law, partial vaporisation condensation, relative volatility, differential & flash distillation, steam distillation, total reflux , minimum and optimum reflux ratios, Lewis Sorel and MaCabe –Thiele methods, Ponchon Savarit method

Liquid – Liquid Extraction: Ternary phase diagrams & choice of solvent, single stage and multistage cross current, co-current and counter current extraction operation

Unit-III

Adsorption: Introduction and the nature of adsorbent, adsorption equilibria, the Langmuir isotherm, BET isotherm and Gibbs isotherm, adsorption equipments.

Crystallization: Formation and properties of crystals, crystallizers

Course Outcomes:

1. Ability to understand and solve conduction, convection and radiation problems.
2. Develop correlations using elementary dimensional analysis and comprehend the laws governing radiation mode.
3. Ability to understand the principles of mass transport.
4. The students are able to comprehend the concepts of co current & counter current processes, cascades and concept of Ideal stage and stage efficiencies, continuous contact equipment's.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√							√			√
2		√	√				√				
3		√			√			√			√
4			√	√	√	√		√	√	√	

Books Recommended:

1. Smith J C, Mccabe W L and Harriot P H, *"Unit Operations of Chemical Engineering",* McGraw Hill, 7th edition, (2005).
2. Richardson and Coulson *"Chemical Engineering Vol II", 5th ed.,* Butterworth – Heinemann (2003).
3. Perry's, "*Handbook of Chemical Engineering*", 7th Ed, McGraw Hill (1997).
4. Geankopolis C J, "*Transport Processes and Separation Process Principles*", Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
5. Treybal R E , "Mass Transfer Operations" 3rd ed. , McGraw Hill (1980)

CSPC-203 Object Oriented Programming [3 0 0 3]

Course objectives:	Able to differentiate between structures oriented programming and object oriented programming. Able to understand and apply various object oriented features like inheritance, data abstraction, encapsulation and polymorphism to solve various computing problems using C++ language.

Object oriented thinking: Need for OOP Paradigm, Procedural programming vs object oriented programming, object oriented concepts.

Functions: Main function, function prototyping, inline functions, reference variables, call by reference, Defaults arguments, function overloading, Math library functions.

Class: Difference between C structure and class, specifying a class, Defining member functions: inside and outside class, scope resolution operator, Array within a class, array of objects, Static data members and member functions, Object as function arguments, returning objects, Friend function, memory allocation for objects ,pointer to members, pointer to object, this pointer local classes.

Constructor and destructor: Constructor, types of constructors: default, parameterized and copy constructor, constructor overloading, constructor with default parameter, dynamic initialization of objects, destructor

Operator overloading and Type Conversion: Defining operator overloading, overloading unary and binary operator, Data Conversion: Basic to User Defined, User defined to basic, Conversion from one user-defined to other.

Inheritance and polymorphism: Base class, derived class, visibility modes, derivation and friendship, Types of inheritance, Containership, virtual function binding, pure virtual functions, Abstract class, pointer to derived class.

Console IO operations: C++ stream classes, Unformatted IO operations, formatted IO operations, managing output with manipulators.

Working with files: Classes for file stream operations, opening and closing files, File opening modes, file Pointers, Error handling during file operations, command line arguments. Templates:

Class template, class template with parameter, function template, function template with parameter.

Course Outcomes: After the completion of the course, the students will be able to:
of programming such as variables, conditional and iterative execution, methods, etc.
of object-oriented programming, including defining classes, invoking methods, using

a computer program to solve specified problems.
onment to create, debug and run simple C++ programs.

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√		√	√	√				√
2	√	√	√		√						
3		√	√	√					√		√
4			√	√				√	√	√	

BOOKS AND/OR REFERENCE MATERIAL:

1. Bjrane Stroustrup, "C++ Programming language",3rd edition, Pearson education Asia(1997)
2. Lafore R."Object oriented Programming in C++", 4th Ed. Techmedia, New Delhi(2002).
3. Yashwant Kenetkar, "Let us C++",1stEd.,Oxford University Press(2006)
4. B.A. Forouzan and R.F. Gilberg, Compiler Science, "A structured approach using C++" Cengage Learning, New Delhi.

HMCI-202 Entrepreneurship Development and Management [3 0 0 3]

Course objectives:
- To familiarize with basics of entrepreneurship
- To generate the spirit of entrepreneurship

Course Contents

Entrepreneurial mind for entrepreneurial society, Entrepreneurship vs unemployment, fundamentals of entrepreneurship, entrepreneurial development in emerging markets, entrepreneurial leadership, intrapreneurship, creativity, innovation and business ideas, ideas to opportunity, the entrepreneurial process, entrepreneurial support system, planning small scale industry. business plan, intellectual property rights, human resource plan, recruitment, selection, placement and induction, training and development, marketing plan, operation and production plan, venture team, insights from financial statements, financing venture; role of financial institutions and micro finance, launching a venture, managing growth, from start-up to going public. Women entrepreneurship, rural entrepreneurship. Sickness in small sector; reasons and rehabilitation.

Course Outcomes
- The students will be able to develop and demonstrate entrepreneurial abilities both at work place and at their ventures.

- The students will be able to manage their own enterprises effectively through creative thinking, innovation and leadership.

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1		√	√	√	√	√	√		√	√	√
2	√		√		√			√			

Reference Books:

1. Arya Kumar (2012), Entrepreneurship, Pearson.
2. H Nandan (2013), Fundamentals of Entrepreneurship, PHI.
3. Jeffry A Tommons and Stephen Spinelli (2009), New Venture Creation, Tata McGraw Hill.
4. Sangeeta Sharma (2016), Entrepreneurship Development, PHI.

BTPC- 210 Bioprocess Engineering Laboratory [0 0 4 2]

Course Objectives:	The course aims at providing an overview of bioprocess engineering and materials balance. To understand the fundamentals of design of fermenter for efficient production of biomolecules and monitoring of bioprocesses in industry.

Course Content:

1. Sterilization of bioreactor.
2. To estimate growth kinetic parameters of *Escherichia coli*.
3. To determine Volumetric Oxygen Transfer Coefficient (Kla) in fermentation system by dynamic method.
4. To determine Volumetric Oxygen Transfer Coefficient (Kla) in fermentation system by sulphite oxidation method.
5. To determine mixing time in a stirred tank reactor (STR).
6. Estimation of cell maintenance coefficient and true growth yield by studying the mass and energy balance during cell growth.
7. Comparison between aerobic and anaerobic fermentation.
8. To determine Residence Time Distribution (RTD) for a CSTR.
9. Immobilization of the enzymes over the carriers.
10. Immobilization of the cells over the carriers.
11. Studies on the kinetics of immobilized enzyme and immobilized cells.

Course Outcomes:

1. Ability to measure and analyze mechanism of microbial growth and its control parameters
2. The student would understand the functioning of fermenters in batch and continuous mode
3. The student can perform Volumetric Oxygen Transfer Coefficient in fermentation
4. The students can predict the enzyme kinetics in suspension and immobilized conditions

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√	√	√				
2	√	√	√		√			√	√	√	√
3	√		√	√				√		√	
4	√	√	√	√		√					√

BTPC- 212 Molecular Biology and Genetic Engineering Lab [0 0 4 2]

Course Objectives:	The course aims at providing an overview of genetic engineering, recombinant DNA technology. To understand the fundamentals of molecular genetics, cDNA libraries, polymerase chain reaction, application of recombinant DNA technology.

Course Content:

1. Isolation and purification of genomic DNA from bacteria, plant and animal tissues.
2. Isolation and purification of plasmid DNA.
3. Analysis of DNA by agarose and polyacrylamide gel electrophoresis.
4. Recovery of DNA from gels.
5. Restriction analysis of DNA and restriction mapping.
6. Spectrophotometric estimation of DNA, RNA and proteins.
7. *In situ* gel assays for peroxidase, SOD, acid phosphatase and LDH.
8. Southern, Northern and dot blotting technique
9. Determination of phosphorous content of nucleic acids
10. Analysis of proteins by gel electrophoresis
11. Analysis of proteins by 2D gel electrophoresis
12. Estimation of RNA by means of orcinol reaction

Course Outcomes:

1. Ability to purify genomic and plasmid DNA from bacteria, plant and animal tissues
2. The student can analyze DNA by different gel electrophoresis systems
3. The student can perform restriction analysis of DNA and restriction mapping
4. The students can analyze protein by various gel electrophoresis techniques

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√	√	√				
2	√	√	√		√			√	√	√	√
3	√		√	√				√		√	
4	√	√	√	√		√					√

CSPC- 223 Object Oriented Programming Laboratory [0 0 2 1]

Course Objectives:	To be able to apply an object-oriented approach to programming and identify potential benefits of object-oriented programming over other approaches. To be able to design applications, which are easier to debug, maintain and extend. To be able to apply object-oriented concepts in real world applications.

TOPICS COVERED

1. Write a program to read a matrix of size m x n form the keyboard and display the same using function.
2. Write a Program to make the use of inline function.
3. Write a function power () which raise a number m to a power n. The function takes double value of m and integer value of n and returns the result. Use a default value of n is 2 to make the function to calculate squares when this argument is omitted.
4. Program to show that the effect of default arguments can be alternatively achieved by overloading.
5. Write a class ACCOUNT that represents your bank account and then use it.
6. The class should allow you to deposit money, withdraw money, calculate interest, send you a message if you have insufficient balance.
7. Write a class STRING that can be used to store strings, add strings, equate string, output strings.
8. Create the class TIME to store time in hours and minutes. Write a friend function to add two TIME objects.
9. Create two classes DM and DB. DM stores the distance in meter and centimeters and DB stores the distance in feet and inches. Write a program two add object of DM with the object of DB class.
10. Write a program to create an abstract class named Shape that contains an empty method named number Of Sides ( ).Provide three classes named Trapezoid, Triangle and Hexagon such that each one of the classes inherits the class Shape. Each one of the classes contains only the method number Of Sides ( ) that shows the number of sides in the given geometrical figures.
11. Write Programs to demonstrate the concept of Default constructor, Parameterized constructor, Copy constructor, and Constructor overloading
12. Program to demonstrate the concept of destructor, multiple inheritance, multilevel inheritance, hybrid inheritance, and concept of containership.
13. Program to overload unary operator and overload binary operator
14. Program to show the concept of run time polymorphism using virtual function.
15. Program to work with formatted and unformatted IO operations.
16. Program to read the name and roll numbers of students from keyboard and write them into a file and then display it.
17. Program to copy one file onto the end of another, adding line numbers
18. Write a function template for finding the minimum value contained in an array.
19. Write a class template to represent generic vector (a series of float values). Include member function to perform following tasks.

a. Create vector
b. Modify the value of a given element
c. To multiply by a scalar value
d. To display vector in the form of (10, 20, 30,……)

This is only the suggested list of Practical's. Instructor may frame additional Practicals relevant to the course contents.

Course Outcomes:

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

1. Gain understanding about the object oriented principles in construction of robust and maintainable programs.
2. Have a competence to design, write, compile, test and execute programs using high-level language.
3. Have an awareness of the need for a professional approach to design and the importance of good documentation to finish.

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√	√			√				
2	√	√	√	√	√					√	
3				√		√		√	√		√

DEPARTMENT OF BIOTECHNOLOGY: Detailed syllabus 5th Semester

BTPC-301 Enzyme Engineering and Technology [3 0 0 3]

Course Objectives:	The objective of the course is to provide a deeper insight into the fundamentals of enzyme structure and function and kinetics of soluble and immobilized enzymes. Also it deals with current applications and future potential of enzymes. Envision the working of enzymes, their stability and activity enhancement

Unit-I

Basic concepts of enzyme: Mechanism of Enzyme Action and kinetic of reaction: Concept of active sites, and energetic of enzyme substrate complex formation, Specificity of enzyme action, Estimation of Michaelis-Menten Parameter

Stability of enzymes: PH, Temperature, Mechanical forces, Heterogeneous system.

Production and purification of enzymes: Extract from plant, animal and microbial sources, Methods of characterization of enzymes, Development of enzymatic assays.

Unit-II

Enzyme immobilization: Physical and chemical techniques for enzyme immobilization adsorption, Matrix entrapment, Encapsulation, cross linking, covalent binding, Advantages and disadvantages of different immobilization techniques.

Applications of enzymes: Classification of enzymes, Commercial application of enzymes in food, Pharmaceutical and other industries, Enzymes for analytical and diagnostic application.

Unit-III

Mass transfer effects in immobilized enzymes: Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reaction, Formulation of dimensionless groups,
Calculation of effectiveness factors

Course Outcomes:	After studying this subject: 1. The student will be able to describe structure, functions and the mechanisms of action of enzymes. 2. The student will learn kinetics of enzyme catalyzed reactions and enzyme inhibitory and regulatory process. 3. The student will be able to perform immobilization of enzymes. 4. The student will get exposure of wide applications of enzymes and their potential.

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√	√		√	√	√		
2	√	√	√		√	√				√	
3	√		√				√		√		
4	√	√	√	√	√				√	√	√

Books Recommended

1. Price N C and Stevens L, *"Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins",* 3rd Edition, Oxford University Press (2003).
2. Bailey and Ollis, "*Biochemical Engineering Fundamentals"* , McGraw Hill (1996)
3. Stanbury P F and Whitaker A, "*Principles of Fermentation Technology*, "Pergamon Press (1995)
4. K Buchholz, V. Kasche, and U.T. Bornscheuer. *Biocatalyst and Enzyme Technology*, Willey-VCH Verlag GmbH and Co. Germany. ISBN 3-527-30497-5
5. I.H. Segel, *Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady State Enzyme Systems,* Wiley-Interscience ISBN: 978-0-471-30309-1
6. M.F. Chaplin and C. Bucke, *Enzyme Technology,* Cambridge University Press. ISBN, 0521348846

BTPC-303 Animal and Plant Tissue Culture [3 0 0 3]

Course Objectives:	The objective of the course is to provide research related to animal and plant cell and tissue culture at national and international level. To contribute in industries related to animal and plant cell culture as scientists and researchers.

Unit-I

Basics of Cell and Tissue Culture: Laboratory requirements for tissue culture, substrates for cultures, culture media for animal cell cultures, culture procedures and principles, freeze storing of cells and transport of cultures, Primary culture, secondary culture; Continuous cell lines

Characteristics of Cells in Culture: Contact inhibition, anchorage independence/dependence, cell-cell communication, cell senescence.

Cell Culture Lines: Definition, development and maintenance, 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, cloning of cell lines, cell synchronization, viral sensitivity of cell lines, cell line characterization, stem cell lines.

Unit-II

General Tissue Culture Techniques: Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explanation technique, reactor systems for large-scale production using animal cells.

Organ Culture: Methods, organ explants and utility of organ culture, whole embryo culture.

Methods in Cell Culture: Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection.

Applications of Animal Cell Culture: Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, cloning for production of transgenic animals, cloning for conservation. Application of animal cell culture for *in vitro* testing of drugs

Hybridoma technology: Production of monoclonal and polyclonal antibodies with different types of antigens, antigen preparation and modification, adjuvants dose and route of antigen administration, collection of sera, purification of antibodies, antibodies for diagnosis and therapy, production of virus vaccines, specific vaccines, production of cellular chemicals like Interferons, Interleukin etc. Immunoassay procedures.

Unit-III

Special features of plant cells: totipotency, regeneration of plants, organogenesis, Somatic Embryogenesis, somaclonal variation, its genetic basis and application in crop improvement

Initiation and maintenance of callus and suspension culture, protoplast isolation, fusion and culture, somatic hybridization, production of pathogen - free plants and "synthetic seeds". Overcoming Barriers using Tissue Culture: Pre- and Post-Fertilization barriers, Production and Use of Haploids.

Micro propagation : Techniques, factors affecting morphogenesis and proliferation rate , technical problems in micro propagation, meristem culture for the production of pathogen free plants , applications of micro propagation.

Protoplast technology: Isolation, culture and plant regeneration, protoplast fusion, identification and characterization of somatic hybrids, applications of protoplast technology.

Plant products of industrial importance: Cell suspension culture development and production of secondary metabolites by suspension cultures (case studies of azardiractin, podophyllotoxin)

Transgenic Plants: Genetically Modified Crops, Biotic and Abiotic Stresses, Molecular Farming.

Plant Cell Reactors: Comparison of reactor performance, immobilized plant cell and cell retention reactors.

Course Outcomes: After studying this subject:

1. The student will understand cell and tissue culture technology
2. The student will learn techniques for animal cell line and Hybridoma
3. The student will be able to perform plant cell culture
4. The student will apply cell and tissue culture techniques for making the world a better place to live in

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√	√		√	√	√		
2	√	√	√		√	√				√	
3	√		√				√		√		
4	√	√	√	√	√				√	√	√

Books Recommended

1. Freshney R. Ian, *"Culture of animal cells: A manual of Basic Technique",* Willey-Liss Publisher, 5th edition (2005).
2. Bhojwani S.S. and Razdan M.K., "*Plant Tissue culture Theory and Practice*", Elesevier Science , Netherlands (2004)
3. Razdan M.K., *"*Introduction *to Plant Tissue culture",* 2nd Edition, Science Publishers (2003).
4. Narayanswamy S.,"*Plant Cell and Tissue culture"*, Tata Mc-Graw Hill publishing Co. Ltd. (2002).
5. Dixon R.A., Gonzales R.A., *"Plant Cell Culture: A practical approach"*, Oxford University Press (1994).
6. Ashok Mukhopadhyay, *"Animal Cell Technology",* I.K.International, New Delhi, (2009)

BTPC-305 Separation Methods in Biotechnology [3 1 0 4]

Course Objectives:	The course aims to provide knowledge on the biomolecules separation from various biological systems. Able to critically analyze the biochemical characteristics of the bio products and choose strategy for their purification. Analysis of biomolecules like proteins using various analytical tools such as electrophoresis, spectrophotometer, chromatography, dialysis and mass spectrometry. Able to separate the molecules through chromatography. Able to choose the downstream steps within the constraints of biosafety and process economics.

Unit-I

Separation of insoluble products: sedimentation, sedimentation coefficient, filtration, membrane filtration, centrifugation, micro centrifuge, ultracentrifuge, differential and density gradient centrifugation, coagulation and flocculation.

Cell Disruption: Mechanical methods, Non-mechanical methods.

Dialysis and Filtration: electro-dialysis, ultra-filtration and micro-filtration, cross-flow ultrafiltration and micro-filtration.

Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption, salt and solvent precipitation of protein, recombinant protein purification.

Unit-II

Electrophoresis: Gel electrophoresis (Agarose, PAGE, SDS PAGE), Disc gel electrophoresis, Gradient electrophoresis, pulse field gel electrophoresis, 2 D gel electrophoresis, capillary electrophoresis, isoelectric focusing, Gel capillary electrophoresis, Capillary zone electrophoresis, Autoradiography, Radioimmunoassay.

Chiral separation of biomolecules: Chiral Thin layer chromatography, chiral gas-liquid chromatography, non-chromatographic chiral separation

Chromatography: Method selection; selection of matrix; Adsorption chromatography, Ion exchange chromatography, gel-filtration chromatography, size exclusion chromatography, ion exclusion chromatography, affinity chromatography, hydrophobic interaction chromatography, high pressure liquid chromatography, Co-valent chromatography; IMAC chromatography, Dye ligand chromatography. Chromatography scale-up.

Unit-III

Crystallization: Theory and methods; API-electrospray and MADI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis.

Reverse Micelles: Reverse micelles formation, correlation of miceller size and protein size, Reverse micelles extraction method

Molecular Imprinting: Imprint property, selectivity of molecular imprinting.

Drying: Lyophilization, Spray drying, vacuum drying, air drying.

Course Outcomes:	After studying this subject: 1. Isolate and purify biomolecules from different types of biological samples 2. Characterize biomolecules for their composition, size and structure 3. Design purification strategies for genetically modified industrially important biomolecules. 4. Calculate process-profit cost analysis for any purification techniques.

Mapping of course objectives (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√	√		√	√	√		
2	√	√	√		√	√				√	
3	√		√				√		√		
4	√	√	√	√	√				√	√	√

Books Recommended

1. Willard, H., Meritt,L.L., Dean J.A. and Settle F.A., "*Instrumental Methods of analysis"*, 6th edition, CBS Publishers, (1986)
2. Vogel's, "*Textbook of Quantitative Chemical Analysis"*, 6th Edition, Pearson, (2005).
3. Skoog,D.A. , F.J. Holler and T.A. Nieman., "*Principles of Instrumental analysis"*, 5th Edition , Harcourt Area PTE (1998)
4. Okotore, R.O., "*Basic Separation Techniques in Biochemistry"*, New Age (1998)
5. Sivasankar, B., *"Bioseparation: Principles and Techniques",* Prentice Hall India (2005).
6. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.
7. Belter .P.A and Cussler E, "*Bioseparations*", Wiley, 1985.
8. Roger .G Harrison et al, "*Bioseparation Science and Engineering*" Oxford University Press, 2003.

BTPC-307 Immunology [3 0 0 3]

Course Objectives:	The course is designed to provide basic knowledge of immunology and students are encouraged to understand the fundamentals of immunology. To understand the topics related to health and disease.

Unit-I

The immune system: Components of immune system: Cell of immune system-Lymphocytes, Antigen presenting cells (APCs), NK Cells, Mast Cells, Dendritic Cell, Tissues and Organs of the immune system-Bone marrow, Thymus, Lymph node, Spleen, Lymphoid tissues.

The lymphatic system: Lymphoid cell, heterogeneity of lymphoid cells, primary and secondary lymphoid organs- thymus, bursa of fabricus, spleen, lymph nodes, Conjunctiva-associated lymphoid tissue (CALT), mucosal associated lymphoid tissues (MALT), Gut-associated lymphoid tissue (GALT).

Types of immunity: Innate and acquired immune system, Role of humoral and cell-mediated immunity. Antibodies: immunoglobulin classes and subclasses, structure, function, the genetic basis of antibody diversity, Catalytic antibodies. Antigens: types, source, structure, and characteristics of antigens, Mitogens, Hapten, Immunogen, Adjuvants. Biological aspects of antibody-antigen interaction. Genetic control and production of monoclonal and polyclonal antibodies.

Unit-II

Humoral Immunity: B-lymphocytes and their activation, structure. major histocompatibility complex, complement fixing, antibodies and complement cascade.

Cellular Immunity: Thymus derived lymphocytes (T-cells) activation, role of receptors and cells involved. classification APCs, origin and function of macrophages, mechanism of phagocytosis, Identification of major cell types, immunosuppression and immune tolerance, interferons and their

mechanism of action, interleukins and their functions, JAK/STAT pathway.

Immunity and Infection: Hypersensitivity reactions, role of cytokines in immune response, receptors (T and B-cell), transplantation and rejection, graft rejection, Immunosuppressive drugs, mechanism of immunity, tumour antigens.

Unit-III

Auto Immunity: Auto antibodies in humans, Pathogenic mechanisms, experimental models of auto immune disease, treatment of autoimmune disorders.

Immune Disorders and Diseases: Primary immunodeficiency, secondary immuno-deficiency, Acquired immunodeficiency syndrome (AIDS)

Immunological Techniques and Vaccines: Identification and measurement of antibodies and antigens-Precipitation, agglutination, RIA, ELISA, Immunoelectrophoresis, Immunodiffusion, Radial Immunodiffusion.

Course Outcomes:

1. This course will help students to understand basic immunology principles.
2. Student will be able to identify problems associated with the diseases.
3. This course will help students to understand the immunity, diseases, disorders and other related infections.
4. After completing this course, students will be able to apply their immunology knowledge in health and diagnostic areas for designing novel therapeutics.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√		√		√	√	√		√
2		√	√	√	√	√	√	√	√	√	
3		√		√		√		√		√	
4	√			√				√			

Books recommended

1. Kuby "*Immunology*" J. Punt; S. Stranford; P. Jones; J. Owen 8th Edition (2019).
2. I.M. Roitt "*Essentials of Immunology*", Wiley-Blackwell, 13th Edition (2017).
3. W.E. Paul, *Fundamentals of Immunology*, Raven Press, New York, 7th edition 2013)

BTPC-309 Industrial Biotechnology [3 0 0 3]

Course Objectives: Students will be able to explain the steps involved in the production of various products produced by microbes and methods to improve modern biotechnology. They can apply basic biotechnological principles, methods and models to solve industrial tasks. They can identify and debate the ethical, professional and social issues in the field of biotechnology and can design and deliver useful modern biotechnology products to the Society.

Unit-I

Introduction to industrial biotechnology: Introduction and scope of industrial biotechnology, historical overview of industrial fermentation processes, unit operations involved, products and market economics.

Microorganisms: Isolation of industrially important microorganisms, isolation methods utilizing selection of desired characteristics, methods not utilizing selection of desired characteristics, preservation and maintenance of microorganisms, improvement of industrial microorganisms for overproduction of primary and secondary metabolites, improvement of strains by modifying properties other than the yield of products.

Unit –II

Raw materials for fermentation process: Media requirements for fermentation processes, simple and complex media, medium formulation, carbon sources, nitrogen sources, minerals, vitamins and other nutrients, precursor, induces, chelator, growth factors, antifoams.

Unit-III

Commercially important products: Alcohol, alcoholic beverages beer and wines etc, enzyme and proteins, bio pesticides, biofertilizer, single cell proteins, baker's yeast, high fructose corn syrup, organic acids, acetone, butanol etc., secondary metabolites antibiotics etc.

Effluent treatment: Concepts of BOD and COD, treatment and disposal of effluents, overview of aerobic and anaerobic processes.

Course Outcomes:

1. Understand the basic bioprocesses operated at industrial scale
2. Identify and analyze the role of microorganisms in fermentation
3. Comprehend processes of growth related and non-growth related products
4. Understand the biological wastewater treatment strategies

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√		√	√	√		√		
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√	√	√	√		√	√		√	√
4	√	√			√		√			√	

Books Recommended

1. Crueger W and Crueger A, "*Biotechnology: A Text book of Industrial Microbiology*" Sinouer Associate, Inc. Sunderland MA, USA(1990)
2. Casida L E, "*Industrial Microbiology"* , New Age International Publishers Ltd.(2003)
3. Reed G, "*Prescott and Dunn's Industrial Microbiology*" CBS publishers and distributors, New Delhi (1987). ,
4. Mansi E M T EL, Bryce C F A, "*Fermentation Microbiology and Biotechnology*". Ane Books Publishers and Distributors (2003)
5. Shuler M L, Kargi F, " *Bioprocess Engineering- Basic Concepts*" , 2nd ed, Prentice Hall of India Ltd. (2002)

BTPC-311 Biological Waste Treatment [3 0 0 3]

Course Objectives: Conduct basic laboratory experiments and employ standard observational strategies for treating biological wastewater. Develop requisite skills to work in water quality testing, environmental pollution control labs, textile industries etc.

Unit-I

Characteristics of waste water: Physical, chemical and biological; BOD, COD

Primary Treatment: Screening, Grit Chamber, removal of oil and grease.

Aerobic processes of secondary treatment: activated sludge, lagoons, stabilization ponds, suspended growth, nitrification, trickling filters, rotating biological contactors, anoxic suspended growth and fixed film denitrification.

Unit-II

Anaerobic processes of treatment: biological concepts, suspended growth and fixed film processes and reactor configuration, Sequential batch reactor for combined processes (aerobic and anaerobic)

Tertiary Treatment: Effluent disposal and reuse.

Bioenergy from biological waste: Production of biogas and bio hydrogen from various biological wastes by fermentative processes.

Unit-III

Solid waste management: Using biomass, production of Bioenergy from the solid waste

Designing Wastewater treatment plant, anaerobic biogas generation plant.

Course Outcomes:

1. Understand the biological treatment techniques for waste water
2. Understand the principles of waste management
3. Describe the use of biotechnological processes to protect the environment
4. Approaches to anaerobic digestion of wastes and solve related problems

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√		√	√	√		
2	√		√		√	√				√	
3	√	√				√	√		√		
4	√	√	√	√	√				√	√	√

Books recommended

1. Metcalf & Eddy, *"Wastewater Engineering"*, 4th edition, TATA-McGraw Hill (2003).
2. Hammer M J, *"Water and Wastewater Technology",* 2nd edition, John Wiley & Sons (1989)
3. Davis M L, Corwell D A, *"Introduction to Environmental Engineering",* 2nd edition, Mc Graw Hill (1991).
4. Peavy H S, Rowe D R, *"Environmental Engineering",* Mc Graw Hill (1985).
5. Eckenfelder W W, "*Industrial Water Pollution Control",* 2nd edition, Mc Graw Hill (1991)

BTPC-313 Cell and Tissue Culture Laboratory [0 0 2 1]

Course Objectives: Students will be able to understand and practice skills of isolating explants from plant and animal sources and further culturing *in vitro* to grow and develop. Students will be able to practice tools and techniques to culture and maintain contamination free environment.

1. Introduction to Tissue Culture Laboratory facilities
2. Preparation of medium and sterility tests
3. Principles and Technique for monolayer and suspension culture
4. Subculture of animal cell line and cell preservation
5. Genetically engineered cell
6. Mass cell cultivation
7. Preparation of Culture Media for plant cell, Sterilization of Culture Media

8. Explant selection, sterilization and inoculation;
9. Various media preparations; MS, B5, SH PC L-2;
10. Callus and cell suspension culture
11. Plant regeneration from embryo, meristem and callus culture.

Course Outcomes:	Students will be able to: 1. Isolate explant followed by cells and tissues from plant and animal sources. 2. Understand the environmental conditions for the optimal growth and multiplication of these cells. 3. Understand the principle and design of tools and techniques engaged in cell culture laboratory. 4. Know the different sterilization technique at different phases of cellular growth and morphogenesis.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1		√	√		√			√	√	√	√
2	√	√	√	√	√					√	√
3	√	√			√					√	√
4	√				√					√	√

BTPC-315 Separation Process Laboratory [0 0 4 2]

Course Objectives:	Students will be able to understand and practice skills of isolating explants from plant and animal sources and further culturing *in vitro* to grow and develop. Students will be able to practice tools and techniques to culture and maintain contamination free environment.

List of Experiment:

1. Harvesting of fermentation broth and its processing for product purification.
2. Solid-liquid separation
3. Liquid-liquid separation
4. Disruption of microbial cells
5. Separation by precipitation through adding salts and solvents.
6. Dialysis
7. Ultrafiltration
8. Vacuum evaporation
9. Drying and crystallization
10. Separation of proteins and other biomolecules by various Chromatography techniques

Course Outcomes:	Upon completion of this course students would be able to 1. Choose proper methods to release the intracellular product. 2. Analyze purity and yield of biomolecules by using chromatographic and electrophoretic methods. 3. Analyze the activity of the enzymes 4. Purify and harvest biomolecules from complex mixtures

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√	√	√		√	
2	√	√	√	√	√	√	√	√	√	√	
3	√	√	√	√	√			√	√		√
4	√			√				√			√

BTPC-317 Immunology Laboratory [0 0 2 1]

Course Objectives: The purpose of the immunology lab is to demonstrate antigen-antibody interaction and to learn various diseases prognosis and diagnosis based on it.

List of Experiment:

1. Agglutination
2. Immunodiffusion
3. Radial immunodiffusion
4. Immunoelectrophoresis
5. Rocket Immunoelectrophoresis
6. Production of monoclonal antibodies and testing,
7. Antigen – Antibody reactions (Blood type determination, Rh factor)
8. RBC & WBC count by haemocytometer
9. Sandwich ELISA
10. Immunochemical assay techniques

Course Outcomes: After completion of this course students would be able to

1. Understand the interaction between antigen-antibody.
2. Prognosis and diagnosis of several diseases based on ag-ab interaction.
3. Learn use the modern immunology techniques
4. Develop skills by learning modern immunology tools, which is necessary for the health and diagnostic practices.

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√	√	√		√	
2		√	√	√	√	√	√	√	√	√	
3		√	√	√	√			√	√		√
4	√			√				√			√

BTCI-301 Minor Project, Phase-I [0 0 2 0]

In the beginning of the 5th Semester, every student will be assigned the minor project, divided in 2 phase; one in 5th semester and end phase in 6th semester. The students under guidance of faculty member may select the topic. The final evaluation will be done after 6th semester. The project report is to be submitted in a typed form, The project work on the topic will consist of either some investigational work, computer simulation or design problem or experimental set up of some development work of or prototype equipment. Every student has to give a presentation in the topic incorporated in the project and in the related area of specialization.

DEPARTMENT OF BIOTECHNOLOGY: Detailed syllabus 6th Semester

BTPC-302 Bioinformatics [3 1 0 4]

Course Objectives:	This course is designed to integrate basic concepts of bioinformatics. This course imparts knowledge of biological databases and pairwise alignment. The student should acquire knowledge about models and software related to bioinformatics..

Unit-I

Information search and data retrieval: Biological information resources and retrieval system; data characteristics and presentation, major databases, data management & analysis, data mining.

Biological Data bases and their management: Introduction to SQL (Sequence Query Language), Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools.

Pairwise alignment: Pair wise and multiple sequence alignment, Scoring matrices, Secondary Structure predictions, Fold recognition.

Multiple sequence alignment and Phylogenic analysis: Gene identification methods; data mining (Genome databases) and phylogenetic analysis; tree evaluation, Predictive methods using nucleic acids and protein sequences.

Unit-II

Genome analysis and gene mapping: Analysis Tools for Sequence Data Bank, sequence homology searching using BLAST and FASTA, FASTA and BLAST Algorithms comparison.

Profiles and Hidden Markov Models: Explanation and application of the tools

Gene identification methods: Genomics and Human genome project; Pattern recognition, Gene prediction methods, Strategy of genome sequencing.

Gene Expression and Microarrays: DNA Microarrays, clustering gene expression profiles, tools for microarray analysis, application of microarray technology.

Unit-III

Bioinformatics Software: Molecular structure drawing tool (Chemdraw); VMD/Rasmol/Insight-II; Clustal X1.8; OLIGO; PERL, Molecular modeling/ Docking (CAChe); Clustal W, oligoprimer. ALSCRIPT, MOLSCRIPT, Rasmol, Phylip, Submitting sequence to databases, and Computational tools for DNA sequence analysis: GCG: The Wisconsin package of sequence analysis programs; Web-based interfaces for the GCG sequence analysis programs.

Course Outcomes: After completion of this course students would be able to

1. Understand and manage the different biological data and databases.
2. Learn use the pairwise alignment and multiple sequence alignment
3. Can analyze and map genome and identify gene
4. Develop skills for using different bioinformatics software and models

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√	√	√		√	
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√	√	√	√			√	√		√
4	√			√		√		√			√

Books Recommended

1) Brgeron Bryan, *"Bioinformatics Computing",* Prentice Hall of India (2003).
2) Rastogi S.C., Mendiratta N., Rastogi P., Bioinformatics, 2nd edition, Prentics Hall (2006).
3) Attwood T K, and Parry- Smith *"Introduction to Bioinformatics",* Pearson Education, Singapore (2000).
4) David W. Mount, Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
5) P. E. Bourne and H. Weissig, Structural Bioinformatics, 2nd Edition, Wiley, 2008.
6) Westhed D R , Parish J H and Twyman R M, *"Bioinformatics"* ,Viva Books Pvt. Ltd. , New Delhi (2003).
7) Jonathan Pevsner, Bioinformatics and Functional Genomics,1st Edition, Wiley-Liss, 2003.

BTPC-304 Bioprocess Modeling and Simulation [3 0 0 3]

Course Objectives:	Student will be able to design or optimize a system. To achieve rewarding careers in bioprocess engineering and related fields after graduation.

Unit-I

Simulation: basics, discreet event simulation, conducting a simulation project, building a system model, model verification and validation, Simulation of batch pharmaceutical manufacturing systems

Batch process simulation: concept, goals and capabilities.

Software: SuperPro Designer, K-Tops, Aspen

Modeling: basic process operations with SuperPro Designer, chemical reactions, separation operations

Unit-II

Study of Structured Models: Analysis of various bioprocesses; Model simulation using MATLAB-SIMULINK and ISIM software packages.

Fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics.

Examples of Mathematical Models: Modeling of gene regulation (Genetic switches), Modeling of signal transduction in prokaryotes and eukaryotes, Insilico microorganisms, metabolic flux analysis.

Unit-III

Elementary mode analysis: Heat and Mass Transfer Equipment such as Heat exchangers, evaporators, flash distillation, differential distillation, continuous binary distillation in tray and packed column, vaporizers, single phase separation adsorption, absorbers and strippers, agitated vessels, mixing process. Reaction Equipment: Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.

Course Outcomes:	1. Understand the modeling and simulation principles 2. Understand and analyze chemical and biological modeling 3. Develop and analyze bioprocess unit operations 4. Understand batch operation, semi-continuous and continuous operation

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√	√	√		√		
2	√	√	√	√	√		√	√	√	√	√
3	√	√	√	√	√			√		√	√
4	√	√	√	√	√	√	√			√	√

Books recommended

1. Harrell, C., Ghosh, B., Bowden, R*., "Simulation Using Promodel"*, McGraw Hill (2004). *Software:* ProModel v.6.1 (incl. with the textbook) SuperPro Designer v. 6.0 or higher.
2. Luyben W L, "*Process Modeling Simulation and Control for Chemical Engineers", international* ed. McGraw Hill (1990).
3. Rose L M, "The *Application of Mathematical Modeling to Process Development and Design",* First Ed. Applied Science Publisher Limited. London (1974).
4. Bequette, "Process *Dynamics- Modeling, Analysis and Simulation*", PHI International (2003).
5. Rase H F, "*Chemical Reactor Design for Process Plants, Vol II: Case Studies and Design Data*", 1st Ed., John Wiley and Sons, New York (1997)
6. Denn M Morton, *"Process Modeling",* First Ed. Longman Publisher (1986).
7. J.R. Leigh, Modeling and Control of fermentation Processes, Peter Peregrinus, London, 1987.

BTPC-306 Analytical Methods in Biotechnology [3 0 0 3]

Course Objectives:	This course is designed to enable students to understand the theory and practical aspects of bio-analytical techniques and to the detailed interpretation of results.

Unit-I

Absorption and emission spectroscopy: Properties of electromagnetic radiation, interaction with matter

UV and visible spectrophotomerty: Principle, Beers-Lamberts law, application of UV spectroscopy

Nephelometery, turbidance and reflectance: Principles, parameters involved, correlation of nephelometry with spectroscopy

Fluorescence and phosphorescence spectrophotomerty: Principle, methodologies and application

Flame emission and atomic absorption spectrometry: Flames and flame temperature, disadvantage of flame Ionization, burners, interferences. Flame spectrometric technique, flame absorption spectrophotomerty and atomic absorption spectrophotomerty, comparison of flame emission and atomic absorption techniques.

Unit-II

Inductively coupled plasma atomic emission spectrophotomerty: Plasma emission sources, inductively coupled argon plasma, direct current argon plasma

IR Spectrophotomerty: Vibrational spectroscopy, principle, methodologies and application
X-rays techniques: X-ray diffraction, images analysis by Fourier transformation, symmetry elements, determination of 3 dimensional structures of organic and inorganic molecules
NMR spectroscopy: Principles and methodologies followed, utilities, effectivity of the method for determining 3 dimensional structure of organic and inorganic molecules
Electro analytical techniques, voltamtery, conductimetry, polargraphy: Current voltage relationship, diffusion current and factors affecting diffusion current, half-wave potential, voltametric and polarographic technique, electrolyte conductivity measurement of electrolytic conductance, conductance cells, conductometric titration, measurement of dielectric constants.
Gas Chromatography: Gas solid and gas liquid chromatography, detectors- TCD and FID, column efficiency, Van Deemter equation, application of gas chromatography.

Unit-III
Karl Fischer moisture analysis: Principles of methodologies, utilities of the method
HPLC: Mobile phase , elution , normal phase and reverse-phase HPLC, column packing material, efficiency of column ,types of HPLC – principles of methodologies ; HPLC pumps - efficiency and suitability, Different injectors and Detectors.

Course Outcomes: Upon completion of the course, students will be able to:
1. Explain the working principles and design components of analytical instruments used in biotechnology and pharma industries.
2. Evaluate the accuracy, repeatability and error in analysis by instruments.
3. Separate the biomolecules and characterize their physico-chemical properties using analytical instruments
4. Use the knowledge to select among different analytical techniques by understanding their strengths, limitations and creative use for problem solving.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√					√	
2	√	√	√	√							√
3	√					√				√	
4		√	√								√

Books Recommended:

1. Willard, H., Meritt,L.L., Dean J.A. and Settle F.A., Instrumental Methods of analysis, 6th edition, CBS Publishers, (1986)
2. Vogel's, "*Textbook of Quantitative Chemical Analysis"*, 6th Edition, Pearson, (2000).
3. Skoog,D.A. , F.J. Holler and T.A. Nieman., 'Principles of Instrumental analysis', 5th Edn, Harcourt Area PTE (1998)
4. Okotore, R.O., Basic Separation Techniques in Biochemistry, New Age (1998)
5. Braun, R.D., Introduction to Instrumental Analysis, McGraw Hill (1987).

BTPC-308 Bioinformatics Laboratory [0 0 2 1]

Course Objectives: The prime objective of this course is to understand the genome sequencing and create evolutionary relationships. To learn to used various software related to techniques and solve the problems.

1. Various tools related to Bioinformatics, MATLAB Bioinformatics Toolbox
2. Handling of different primary databases and retrieval of primary data of both protein and nucleotide (Expasy, Entrez) of a particular group or type of an enzyme.
3. Nucleotide sequence of specific organs of specific organism, Analysis and comparison of nucleotide sequence for specific gene between 2 animals or plants or microbes.
4. Sequence based and structure-based approaches to assignment of gene functions e.g. sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification, etc.
5. Handling of different specialized databases: Pathway, protein folding classification, Comparison of amino acid sequence of specific protein between different animals or plants or microbes.
6. Different approaches of Prediction of Genes: Promoters, splice sites, regulatory regions, application of methods to prokaryotic and eukaryotic genomes and interpretation, gene expression profiling.
7. Different approaches for analysis of ligand-protein and protein- protein interactions.
8. Study to find out potential drug targets for cardio vascular, neurological diseases etc. using proprietary and public domain software's *(eg. VEGAZZ) (ligand design, optimization and improvement)*

Course Outcomes: After the successful completion of this course, students would be able to:

1. Explain the basic concepts of databases working.
2. Understand sequencing methods and establish evolutionary relationship between species.
3. To find new gene, by gene identification methods.
4. To understand working of various software involved in techniques.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√	√				
2	√	√	√	√	√	√	√	√	√		√
3	√	√	√		√			√			√
4			√					√	√	√	√

BTPC-310 Biological Waste Treatment Laboratory [0 0 2 1]

Course Objectives: Conduct basic laboratory experiments and employ standard observational strategies for treating biological waste water. Develop requisite skills to work in water quality testing, environmental pollution control labs, textile industries etc.

1. Determination of Solids in waste water
2. Determination of Alkalinity of water
3. Determination of specific gravity of sewage sludge

4. Determination of organic nitrogen in sewage sample
5. Determination of sludge volume and Index
6. Bacteriological analysis of water
7. Determination of sulphates and chloride in given sample of waste water
8. Determination of total iron by spectrophotometer method
9. Determination of Dissolved Solid content of waste water
10. Determination of BOD and COD
11. Determination of total hardness of a given waste water sample

Course Outcomes:
1. Perform the estimation analysis of different solids in given water sample
2. Perform the titration analysis to estimate different entities given water sample
3. Perform biological tests to estimate the quality of given water sample
4. Handling of analytical instruments to detect specific entities in given sample

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√		√				√
2	√	√	√	√	√	√	√		√		
3	√	√	√	√	√	√			√		
4	√			√				√		√	√

BTCI-302 Minor Project, Phase-II [0 0 2 2]

In continuation of 5th semester, the students will continue the minor project, phase-II in the 6th Semester. The students under guidance of faculty member may select the topic. The final evaluation will be done after 6th semester. The project report is to be submitted in a typed form, The project work on the topic will consist of either some investigational work, computer simulation or design problem or experimental set up of some development work of or prototype equipment. Every student has to give a presentation in the topic incorporated in the project and in the project and in the related area of specialization. The final grade will be given on the combined work of 5th and 6th semester of 2 credits.

BTPC-322 Bioprocess Equipment Design and Economics [3 0 0 3]

Course Objectives: This course is designed to integrate basic concepts of bioprocess engineering gained in earlier courses to mechanical aspects while designing a bioprocess plant. This course also imparts knowledge of scale up of bioprocesses for the production of biochemical products.

Unit-I

General considerations: Plant location, plant layout, plant operation and control, processes design, flow diagram.

Cost estimation: Capital investments (Fixed and working capital), Types of capital cost estimates, Cost Indexes, Estimating equipment costs by scaling 6/10 Factor Rule, Methods of Estimating Capital Investment, Estimation of total product cost, Different costs involved in the total product for a typical Chemical Process plant.

Unit-II

Interest & investment Costs: Types of interest (simple & compound interest), Nominal & Effective Rates of interest, Continuous interest, Present worth & discounts, perpetuities, ccapitalized costs, Interest & Investment costs.

Depreciation: Types of depreciation, depletion, service life, salvage value, present value, methods of determining depreciations.

Profitability, alternative investments, and replacements: Profitability standards, methods for calculating profitability, alternative investments

Unit-III

Optimum design and design strategy: Defining optimization problem, selecting objective function, programming optimization problems, Optimization solution methodologies, procedure with one variable, procedure with two or more variables, break-even chart for production schedule and its significance for optimum analysis, optimization applications in a chemical process plant.

Process equipment design: Mechanical fittings in a bioreactor, vessel, agitation system materials, piping and valves for biotechnology, case study in process equipment design and cost in bioprocess industries.

Course Outcomes: Students will be able to

1. Comprehend important mechanical aspects in designing bioprocess equipment.
2. Compare the design considerations of various types of bioreactor.
3. Evaluate effect of process variables on bioreactor performance while scaling up
4. Recognize and choose suitable P&I symbols used in P&IDs for the bioprocess plant design.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√		√	√	√		
2	√	√	√		√					√	
3	√	√	√				√		√	√	
4	√	√	√	√	√	√			√	√	√

Books Recommended

1. Text Books: 1. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers (5th Ed), McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (2003)
2. Sinnott R. K.; "Coulson and Richardson's Chemical Engineering Series", Vol. VI, 4th Ed., Butterworth-Heinemann.
3. D.Q.Kern, Process Heat Transfer, McGraw Hill, 1950.
4. Bhattacharya B. C; "Introduction of Chemical Equipment Design", CBS Publisher, 2003.
5. Seader J. D. and Henley E. J., "Separation Process Principles", 2nd Ed., Wiley-India.
6. Brownell L. E. and Young H. E., "Process Equipment Design", John Wiley.
7. Stanbury P F and Whitaker A, "*Principles of Fermentation Technology*," 2nd edition, Elsevier, (1995)

BTPE-324 Protein Engineering [3 0 0 3]

Course Objectives:	The aim of this course is to introduce methods and strategies commonly used for designing novel and recombinant protein without compromising the structural and functional stability.

Unit-I

Structure of protein: Primary, secondary, tertiary, quaternary structure, Protein folding, molten globule structure, characterization of folding pathways. Post translation modification.

Methods to alter primary structure of protein: Random mutation Site directed mutation, Catalytic activity.

Protein modification: thermal, enzymatic, physical, pressure, solvents, interactions.

Protein raw materials: cereals, legume, oil seeds and pseudo cereals. Muscle protein, Milk protein, Egg protein, Hemoglobin, Collagen, Keratin. Nutritive role of food proteins.

Sequence and 3Dstructure analysis: Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design.

Unit-II

Methods to determine structure of proteins: Protein structure determination, X-Ray analysis of protein, NMR and mass Spectroscopy, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, MALDITOF. Protein characterization, 2 D Gel Electrophoresis.

Structure and function prediction: Protein Bimolecular interaction, Drug protein interaction Thermal properties of proteins and application of DSC. Protein denaturation, aggregation and gelation. Flow properties of proteins and sensory properties of pertinacious foods.

Protein engineering: definition, application; Features or characterstics of proteins that can be engineered (definition and Electives methods of study)–affinity and specificity Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc.

Unit-III

Methods of measuring the stability of a protein: Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UVCD; Fluorescence; UV absorbance; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation

Course Outcomes:	At the end of the course students will, 1. Knowledge about miscellaneous topics such as searches in bioinformatics databases, isolation, expression or purification of novel proteins. 2. Get an overview of several biophysical techniques used for analysis of secondary, tertiary and quaternary structure, as well as of screening methods used for selection of novel protein variants with improved properties. 3. Analyze protein structures to correlate their function, dynamics and stability 4. Evaluate an effect of mutation on a protein function

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√		√		√		
2	√	√	√		√	√		√		√	
3	√	√	√	√		√	√		√		
4	√	√	√	√	√			√	√	√	√

Books recommended

1. *Protein Stucture and Function*, G. A. Petsko & D. Ringe, New Science Press, 2004
2. *Computational Structural Biology: Methods and Applications*, T. Schwede & M. C. Peitsch, World Scientific Publishing Company, 2008
3. *Textbook Of Structural Biology*, A. Liljas, L. Liljas, J. Piskur, G. Lindblom, P. Nissen, M. Kjeldgaard, World Scientific Publishing Company, 2009
4. *Structural Bioinformatics*, J. Gu &P. E. Bourne, Wiley-Blackwell, 2009.,

BTPE-326 Advanced Cell Biology [3 0 0 3]

Course Objectives:	The objective of the course is to provide students with further advanced knowledge cell biology. To impart knowledge of structural and functional aspects of cells as unit of living systems. To understand functions of various organelles and transport of information and matter across cell membrane.

Unit I

Cell Theory & Methods of Study: Light, phase contras, interference, Fluorescence, Confocal and Electron (TEM and SEM) Microscopy, Electron tunneling and Atomic Force Microscopy.

Membrane Structure and Function: Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, Carriers and channels; Membrane Carbohydrates and their significance in cellular recognition; Structure and functional significance of plasmodesmata.

Organelles: Nucleus, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; cell cycle and control mechanisms; Mitochondria – Structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast- Structure function Relationship; Chloroplast DNA and its significance; Chloroplast biogenesis and evolution.

Unit II

Endo-membrane System and cellular Motility: Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization of microtubules and microfilaments; Cell shape and motility; Actin binding proteins; Muscle function; Molecular motors; Intermediate filaments; Extracellular matrix in plants and animals.

Cellular Movements and Pattern Formation: Laying of body axis planes; Differentition of germ layers; Model plants like Fucus and Volvox; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in Caenorhabditis.

Unit -III

Specialized Cells: Stem cell differentiation; Blood cell formation; Fibroblasts and their differentiation; cellular basis of immunity; proto-oncogenes; Phase changes in salmonella; Surface antigen changes in Trypanosimes; Sex determination in Drosophila. **Plant Meristem organization and differentiation**: Organization of shoot Apical Meristem (SAM); Organization of Root Apical Meristem (RAM); Pollen germination, pollen tube guidance; phloem differentiation; Self-incompatibility: its genetic control; Embryo and endosperm development; Heterosis and apomixes.

Course Outcomes: At the end of the course students will,

1. Acquire knowledge about functional aspects of cell and cell organelles.
2. Learn about the interactions of the cells with outside environment through exchange of information and transport of molecules.
3. Understand how proteins are synthesized, modified and transported to their respective target and organelles in a cell, based on structure of the protein.
4. Understand how cell biology mechanisms play important roles in cellular signaling pathways and in several aspects of our immune system.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√	√		√	√			
2	√	√			√	√			√	√	
3	√	√	√			√	√	√	√		
4	√	√	√	√	√					√	√

Books recommended

1. Bruce Alberts et al., Essential cell biology, Garland Science (Taylor & Francis Group)
2. H Lodish et al., Molecular Cell Biology (4th edition), WH Freeman

BTPE-328 Biomaterials [3 0 0 3]

Course Objectives: This course provides information on different classes and properties of biomaterials, the characterization and modification techniques and applications thereof for the development of artificial organs and biomedical devices.

Unit I:

Introduction to Materials in Medicine: Overview, structural characteristics of solid material: atomic structure and bonding, crystalline structures and defects;

Biomaterials classification and properties: Metal, Ceramic, Polymer, and Composites,

Metallic biomaterials: Basic structure and types of alloys (ferrous and nonferrous), mechanical properties (stress-strain behavior, hardness, impact energy, fracture toughness, fatigue), Degradation of metallic surfaces;

Bioceramics: Glasses and Glass-ceramics, mechanical properties and processing methods, Bioresorbable and bioactive ceramics, Alumina, Zirconia and Calcium phosphate;

Biopolymers: Natural versus synthetic, Inert versus bioactive polymers, Biodegradable polymers, Hydrogel;

Biocomposites: Engineering material properties, Different combinations and logistic applications.

Unit II:

Characterization of biomaterials: Physical and physicochemical surface characterization: Mechanical, Optical and Electrochemical characterization.

Biocompatibility and hemo-compatibility: foreign body response to implanted biomaterials, allergy, infection, and sterilization. Surface modification to control biological response; Nanomaterials.

Unit III:

Biomaterials applications: Structure-property relationships of biological materials

Soft tissue replacement: Skin, Sutures, Maxillofacial implants and Blood interfacing implants

Hard tissue replacement: Long bone repair-wires, pins, screws, fractures plates, intramedullary devices, joint replacement-knee and hip joint, dental restorations and spinal implants

Cardiovascular treatment: stents and pacemaker; drug delivery, biosensors, and tissue engineering.

Course Outcomes: On completion of the course the student shall be able to:

1. Understand commonly used different classes of biomaterials, its chemical structure, properties and morphology.
2. Explain surface modification to tailor biomaterials for desired biological response.
3. Understand the interaction between biomaterial and tissue for short term and long term implantations, distinguish between reactions in blood and in tissue.
4. Explain biomedical applications for tissue regeneration, drug delivery, biosensors and other biomedical applications.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1										√	√
2	√	√		√	√						
3	√	√		√	√						√
4	√		√	√	√	√			√	√	

Books Recommended

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2012
2. Joon Park, R. S. Lakes, Biomaterials: An Introduction, Springer Science & Business Media, 3rd Ed., 2007
3. L. L. Hench, Julian R. Jones (Editors), Biomaterials, Artificial Organs and Tissue Engineering, Volume 1, CRC Press, 2005
4. Qizhi Chen, George Thouas, Biomaterials: A Basic Introduction, CRC Press, 15-Dec-2014
5. Murugan Ramalingam, Ashutosh Tiwari, Seeram Ramakrishna, Hisatoshi Kobayashi, Integrated Biomaterials for Biomedical Technology, Wiley & Sons, 2012

OPEN ELECTIVE-I

BTOE-302 Bioprocess Engineering in Biofuel Production [3 0 0 3]

Course Objectives: This course will apply basic concepts of bioprocess engineering in biofuel production. The students will acquire knowledge of microbial production of biofuels, e.g. ethanol, biogas, biohydrogen, microbial fuel cell, in designing bioprocess plant.

Unit-I

Introduction: Energy world demand, sustainability, climate changes, greenhouse gas effect

Alternate source of energy: Various Biofuels production processes from renewable energy sources, merits and demerits of different biofuels production processes

Microbial Biofuels Production process: Various microbes involved, Different biochemical routes for the Biofuels production, Molecular biological approaches for the improvement of Biofuels production, Effect of physico-chemical parameters on the Biofuels production
Engineering aspects in Biofuels production: Thermodynamics and kinetics, Scale-up of bioreactors and Case studies on the different Biofuels production processes, Economic analysis

Unit-II
Bioethanol and biogas production: By fermentation of vegetable wastes, Methane from anaerobic digestion: metabolic processes, practical aspects
Biodiesel production: current perspective, Biodiesel production by microalgae
Biological Hydrogen production: Hydrogen from microorganisms: biophotolysis of water, Hydrogen from microorganisms: dark and photo fermentation, integrated systems, Conversion of light energy into Hydrogen energy by Photosynthetic microorganisms, Different Case studies: Photobioreactor design and light conversion
Algal Biorefinery: Concepts and processes, potentiality towards zero discharge

Unit-III
Microbial Electrochemical Cells: Principles, their applications, Microbial fuel cells (MFC); Microbial electrolysis cells (MEC)
Biodegradable Plastics production by microorganisms: polyesters, polylactic acid, poly hydroxyl butyrates, poly hydroxyl alkaloids, polysaccharides, their possible uses

Course Outcomes: On completion of the course the student shall be able to:
1. Understand microbial production of commonly used different types biofuels
2. Explain bioprocess engineering methods to produce desired biofuels
3. Understand the concept of microbial fuel cells.
4. Explain different Biorefinery concepts using microbes and algae

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1										√	√
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√		√	√						√
4	√		√	√	√	√			√	√	

Recommended Books:

1. "*Biofuels from algae*", 2nd edition, Elsevier (2018), Editors: Duu Jong Lee, Ashok Pandey, Jo-Shu Chang, Yusuf Chisti, Carlos Soccol, Paper back ISBN-13: 978-04446421922
2. "*Process synthesis for fuel ethanol production*", CRC Press (2009), C.A.Cardona, O.J.Sanchez, L.F. Gutierrez, ISBN-13: 978-1439815977
3. "*Biohydrogen Production: Fundamentals and Technology Advances*", CRC Press (2014), Debabrata Das, Namita Khanna, Chitralekha Nag Dasgupta, ISBN-13: 978-1466517998
4. "*Algal Biorefinery: In Integrated Approach*", Edited *by* Debabrata Das, Springer (2015), ISBN 978-3-319-22813-6
5. "*Microbial Fuel Cell Technology for Bioelectricity*", Springer (2018), Editors: Sivasankar Venkataraman, Mylsamy Prabhakaran, Omine Kiyoshi, ISBN-13: 978-3-319-92904-0

DEPARTMENT OF BIOTECHNOLOGY: Detailed syllabus 7th Semester

BTPC-401 IPR in Biotechnology [3 0 0 3]

Course Objectives:	To make the students familiar with basics of IPR and their implications in research, development and commercialization.

Unit-I

Introduction: General Introduction., Patent Claims, the Legal Decision-Making Process, Ownership of Tangible and Intellectual Property.

Basic Requirements of Patentability: Patentable Subject Matter. Novelty and the Public Domain. Nonobviousness.

Unit-II

Special Issue in Biotechnology Patents: Disclosure Requirements, Collaborative Research, Competitive Research, Plant Biotechnology, Foreign Patents.

Patent Litigation: Substantive Aspects of Patent Litigation, Procedural Aspects of Patent Litigation. Recent Developments in Patent System and Patentability of Biotechnological Invention, IPR issues in the Indian Context.

Unit-III

Biotechnology and intellectual properties: Intellectual property rights (IPR) and protection (IPP), patents, trade secrets, copyrights, trademarks, GATT and TRIPS.

Course Outcomes:	1. Students will gain awareness about Intellectual Property Rights (IPRs) to take measure for the protecting their ideas 2. They will able to devise business strategies by taking account of IPRs 3. They will be able to assists in technology upgradation and enhancing competitiveness. 4. They will acquire adequate knowledge on regulatory frame work governing for GMO's, products and crops.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**D**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√		√			√	
2	√	√	√		√	√		√		√	√
3	√		√			√		√			
4	√				√			√			√

Books Recommended

1. *The Law & Strategy of Biotechnology Patents*, Sibley Kenneth.
2. Beier, F.K., Crespi, R.S. and Straus, T. *Biotechnology and Patent protection*-Oxford and IBH Publishing Co. New Delhi.
3. Sasson A, *Biotechnologies and Development*, UNESCO Publications.
4. Singh K, *Intellectual Property rights on Biotechnology*, BCIL, New Delhi.

BTPC-403 Bioprocess Modeling and Simulation Laboratory [0 0 2 1]

Course Objectives:	Student will be able to design or optimize a system. To achieve rewarding careers in bioprocess engineering and related fields after graduation.

All relative practical as mentioned in the theory classes

Course Outcomes:

1. Apply designer software to simulate a biochemical process
2. Apply sensitivity, design and optimization tools using software
3. Carry material and energy balances for bioprocesses
4. Simulate biochemical processes using different software

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**D**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√		√			√	√	
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√	√	√	√		√	√			√
4	√	√	√	√							

BTCI-400 Major Project, Phase-I [0 0 4 0]*

*** Major Project will be allotted in 7th Semester, will be evaluated after 8th Semester**

In the beginning of the 7th Semester, every student will be assigned the Major Project, divided in 2 phase; one in 7th semester and end phase in 8th semester. The students under guidance of faculty member may select the topic. The final evaluation will be done after 8th semester. The project report is to be submitted in a typed form, The project work on the topic will consist of either some investigational work, computer simulation or design problem or experimental set up of some development work of or prototype equipment. Every student has to give a presentation in the topic incorporated in the project and in the related area of specialization.

CHPC-481 Instrumentation and Process Control [3 0 0 3]

Course objectives:	The course aims to analyse of the response of chemical process systems in terms of block diagram and the stability of the process.

General principles of measurement

Static and dynamic characteristics of instruments, Temperature Measurement: Thermocouples, resistance thermometers, thermistors, optical and radiation pyrometers. Pressure Measurement: Use of manometers, Bourdon gauge, bellows type gauge, measurement of vacuum and pressure transducers. Flow Measurement: Variable area meters. Pressure probes, positive displacement type meters. Liquid level Measurement: Direct and differential method, measurement in open and pressure vessels, measurement of liquid.

Process control

Laplace Transform: Transforms of simple function, Transforms of Derivative, Initial value theorem and Final value theorem, Transform of Integral

Response of First order systems and higher order systems

Mercury thermometer & its transfer function, Forcing functions, Liquid Level System, Liquid Level Process with constant flow out let, Linearization, Mixing tank & R.C. Circuit**,** Response of First order system in series: Non interacting System and Interacting Systems. Transfer function of second order system, under damped System, Impulse function, Sinusoidal function, Transportation lag

Controllers and final control element

Control Valve, Proportional controller, Integral & Derivative controller, Comparison of P, PI and PID controllers.

Transient response of control system

Components of control system, block diagram, Negative and Positive feedback, Servo problem and Regulation Problem, Development of Block diagram. Proportional control for set point change, Proportional control for load change, Proportional Integral control for load change, Proportional Integral Control for set point change

Stability of the system

Concept of stability, Stability Criteria, Routh test for stability. Introduction to frequency response: Bode diagram for first order, Bode diagram for proportional, Integral and derivative control, Second order system. Control System Design by frequency response: Bode stability criteria, Gain and phase Margin, Ziegler Nichols Controller settings.

Course Outcomes:

1. To understand the chemical process in terms of block diagram
2. The students will able to understand the effect of various forcing function on first and higher order systems.
3. The students will able to understand the transient response of various controllers.
4. The students can identified the stability of control systems and be able to design the control system for chemical and allied industries.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√				√	√		√	
2		√	√	√	√		√	√	√	√	
3		√		√	√	√		√	√		
4	√			√		√		√			√

Recommended books:

1. Coughanower D. R., "*Process System Analysis and Control*", 2nd Edition, McGraw Hill. (1991).
2. Seborg, E., Mellichamp, "*Process Dynamics & Control*", 2nd Edition, John Wiley, (2004).
3. Stephanopoulos, "*Chemical Process Control-An Introduction To Theory & Practice*",1st Edition, Prentice Hall Inc.
4. Eckman D. P., "*Industrial Instrumentation*", Wiley Eastern Ltd., (1975).
5. Kerk F. W., Rimboi W., Tarapore R., "I*nstrumentation*", Wiley and Sons, (1983).

BTPE-411 Biopharmaceuticals [3 0 0 3]

Course objectives: This course is to enable students to understand the basic concepts and procedures involved the discovery of new drug, production and regulatory procedures to market it. The content of course also includes the quality check of various biopharmaceutical products during production and further application for the diagnosis and treatment of disorders.

Unit-I

Introduction to Biopharmaceutical: Pharmaceuticals, biologics, and Biopharmaceuticals; Past, present and future prospects.

Drug development process: Drug discovery basic steps, Product characterization, Patenting, Delivery of pharmaceutical, Preclinical trials: Pharmacokinetics and pharmacodynamics; Clinical trials: design and study, Drug regulatory authorities: American, European, Japanese and Indian drug regulations, Global harmonization of drug approval.

Unit-II

Drug manufacturing process: Manufacturing practice, Facilities, Analysis of products.

Pharmaceutical products: Interleukins, interferon, Growth factor, Hormones, Therapeutic enzymes, Antibodies, Vaccines, Nucleic acid therapeutics, Antibiotics.

Molecular medicine: Genomics, Proteomics, and Pharmagenetics, Rational drug design, Gene testing, Gene therapy. Genetic diseases and DNA based diagnosis of genetic diseases.

Unit-III

Development of genetically engineered pharmaceuticals: Drug Design, Novel Drug Delivery Systems, Improved Formulation

Course Outcomes: Upon completion of this course students will be able to:

1. Explain the strategies for the discovery of new drug discovery and the various steps involved with the explanation of the pharmacodynamics and pharmacokinetics of discovered drug
2. Apply the gained information for production of biopharmaceuticals products
3. Evaluate the quality of product and the quality control procedures in the biopharmaceuticals production
4. Understand regulatory aspects in development of biopharmaceuticals.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√				√			√			√
2		√			√					√	
3	√	√			√					√	√
4			√			√	√	√			

Recommended books:

1. Gary Walsh, *Pharmaceutical Biotechnology*: Concepts and Applications, John Wiley & Sons, 2013

2. Oliver Kayser, Heribert Warzecha, *Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications*, John Wiley & Sons, 2012

3. S. S. Purohit, H. N. Kakrani, A. K. Saluja, *Pharmaceutical Biotechnology*, 2010

4. Syed Imtiaz Haider, *Cleaning Validation Manual: A Comprehensive Guide for the Pharmaceutical and Biotechnology Industries*, CRC Press, 2010

BTPE-413 Stem Cell Engineering [3 0 0 3]

Course Objectives: This course is designed for students to provide an introduction to the role of stem cells in tissue growth and repair, the stem cells based therapy and *in vitro* construction of tissue and organ replacements, and the ethics and regulations in stem cells applications and research.

Unit-I

Introduction to Stem Cells: Properties, Classification and Sources

Embryonic Stem Cells: Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology

Adult Stem Cells: Stem cell differentiation and aging, Nuclear reprogramming and gene editing

Stem cells Cryopreservation: Basic techniques, Cryoinjury, Cord blood cells cryopreservation

Unit-II

Clinical Applications of Stem cells: Immune barriers of stem cell therapy, Engineering stem cell niche, Neurological disorders: Parkinson's, Alzheimer's, Huntington's, Amyotrophic Lateral Sclerosis, Spinal Code Injury; Tissue systems failures: Organ failure, Diabetes, Cardiomyopathy, Hemophilia, Cancer

Tissue Engineering: Introduction, Biomaterials, Biomaterial-tissue interface, Micro-scale technologies, Tissue repair and regeneration, Clinical applications and case studies

Unit-III

Stem cells research ethics and guidelines: Human embryonic stem cells and society,

Controversies and ethical considerations, human embryonic and induced pluripotent stem cells: clinical trials and uncertainty, Stem cell research guidelines

Course Outcomes: Upon completion of the course, students will be able to understand the key principles to integrate stem cells with regenerative medicine and design the stem cells based treatment of disorders.

1. Classify stem cells and understand the process of isolation and identification of stem cells
2. Apply the concept of stem cell therapy and tissue engineering for regenerative medicine
3. Interplay of stem cells and the society
4. The Indian and global scenario of human stem cell research

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**D**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√				√		√		√	√
2	√	√		√	√	√				√	√
3			√				√	√			√
4			√			√	√		√	√	

Recommended books:

1. Mirjana Pavlovic, Bela Balint, *Stem Cells and Tissue Engineering*, Springer, 2012
2. Song Li, Nicolas L'Heureux, Jenniffer Ellisseeff, *Stem cell and Tissue Engineering,* , World Scientific, 2011
3. Gerhard M. Artmann, Stephen Minger, Jürgen Heschele, *Stem Cell Engineering: Principles and Applications*, Springer, 2010

4. Robert Lanza, Robert Langer, Joseph P. Vacanti, *Principles of Tissue Engineering*, Academic Press, 2011
5. Insoo Hyun, *Bioethics and the Future of Stem Cell Research*, Cambridge University Press, 24-Jun-2013

BTPE-415 Nano Biotechnology and Nano Science [3 0 0 3]

Course Objectives: Nano Biotechnology and nanoscience are the new frontiers for Biotechnology with important applications in Medicine. It bridges areas in Physics, Chemistry, and Biology and is a testament to the new areas of interdisciplinary science those are dominant in the twenty-first century

Unit-I

Nanotechnology: Materials Analysis using traditional and nontraditional techniques, Interaction of x-rays, ions, and electrons. Imaging, diffraction, scattering and spectroscopic methods of characterization, Applications of metrology in nanotechnology, biotechnology, semiconductor processing, and other Silicon Valley growing technical areas. Nanobiotechnology: biological problems; Nanocrystals in Biological Detection.

Unit-II

Microfluidic Meets Nano: Potential for Nanobiotechnology; Protein based Nanocrystals; Microbial nanoparticle production; DNA based nanostructures and Gold nanoparticle conjugates; Luminescent quantum dots for biological imaging; Emerging Nanotechnologies: Nano labels, biosensors, Nano medicine, molecular imaging

Unit-III

Application: proteinomics; genomics, cancer therapy, drug delivery.

Course Outcomes: On completion of the course the student shall be able to:

1. Evaluate applications of various concepts & techniques of nano-biotechnology to facilitate biotechnological advancement and innovations
2. Describe and explain how nanoparticles are fabricated and characterized
3. Describe the principles of loading small molecule drugs, proteins or nucleic acids (DNA/RNA) into nanoparticles.
4. Understand the importance of nanomaterials in the field of medicine.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**D**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√	√				√	√
2	√	√	√	√	√	√	√	√	√		
3	√	√	√		√		√				√
4	√	√	√		√		√		√	√	√

Recommended books:

1. Hornyak G.L., Tibbals H. F., Dutta J., Moore J. J. *"Introduction to Nanoscience and Nanotechnology"*, CRC Press (2008), ISBN 9781420047790
2. Greco R. S., Prinz F. B., and Smith, R. L. (eds.), "*Nanoscale Technology in Biological Systems*", CRC Pres (2005), ISBN: 0849319404
3. Ratner, M. and Ratener, D, "*Nanotechnology A Gentle Introduction to the Next Big Idea*", Prentice Hall (2003), ISBN: 0131014005

BTPE-417 Tissue Engineering [3 0 0 3]

Course objectives: The course will enable students to understand the fundamentals of tissue engineering, engineering aspects of fabrication, characterization, and evaluation for applications to repair the damage, modify the function, and regenerate the lost or dysfunctional body parts.

Unit I:

Introduction to Tissue Engineering: Origins, engineering principles, and triad, Acellular and cellular prostheses, Vascularization, cell signalling, stem cells; Biomaterials: different classes and forms; Bioscaffold: Design, fabrication, properties and characterization; In vitro cell-material study: bioreactors for tissue engineering; In vivo cell-material study: tissue microenvironment; In situ cell differentiation and tissue regeneration: physico-chemical and mechanical determinants. Growth Factors.

Unit II:

Tissue engineering applications: Hard tissue engineering: Bone, Cartilage, Tendon, and Ligament; Soft tissue engineering: Skin, Cardiovascular, Corneal, Pancreas, Liver, Kidney, Muscle, Tympanic membrane, Nerve; Musculoskeletal system, Cancer models, Immunomodulation: designer tissue.

Unit III:

Challenges and regulatory considerations: Cryopreservation of tissue construct: Principle and methodology, Immunoisolation: engineering challenges. Ethical considerations, Product development, evaluation, and regulatory process, FDA.

Course Outcomes: Upon completion of this course, students will be able to:

1. Explain the basic structural organization of tissues and the cellular microenvironment
2. Understand the mechanism of cell based wound healing and tissue repair
2. Describe the components and development of artificial organs of different classes and properties.
4. Design the artificial matrix components and their properties to suit desired tissue engineering applications.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1				√						√	√
2				√						√	√
3	√	√			√					√	
4	√	√	√	√	√	√					

Recommended books:

1. Robert Lanza, Robert Langer, Joseph P. Vacanti, *Principles of Tissue Engineering*, Elsevier, 2000
2. John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, *Tissue Engineering*, CRC Press, 2007
3. Ulrich Meyer, Thomas Meyer, Jörg Handschel, Hans Peter Wiesmann, *Fundamentals of Tissue Engineering and Regenerative Medicine*, Springer, 2009
4. B. Palsson, S. Bhatia, *Tissue Engineering*,, Pearson Prentice Hall , 2003
5. G. Vunjak-Novakovic, R. Ian Freshney, *Culture of Cells for Tissue Engineering*,, WIS , 2006

BTPE-419 Secondary Metabolites in Plants and Microbes [3 0 0 3]

Course Objectives: Genetically modify the plants and microbes to get medicinally important secondary metabolites. Utilize secondary metabolites in industrial microbiology to obtain amino acids, develop vaccines and antibiotics.

Unit-I

Introduction to primary & secondary metabolism: structure, biosynthesis and metabolism of important secondary products; Glycosides, isoprenoids, cardenolides, alkaloids, phenylpropanoids and antibiotics.

Unit-II

Important groups of secondary metabolic enzymes: Significance of secondary metabolism and products for the producer organism.

Regulation and expression of secondary metabolism: regulation of enzyme activity; regulation of enzyme amount; integration with differentiation and development; action of inducers; coordinated enzyme expression and sequential gene expression.

Unit-III

Metabolic pathway engineering: Enzymes involved in various metabolic pathways, Analysis of metabolic control and the structure metabolic network.

Course Outcomes:

1. Understand the overview of cellular metabolism and connection between metabolic pathways
2. Understand primary and secondary metabolic pathways and its products
3. Understand the significance of different enzymes and its regulation
4. Engineer the metabolic pathway regulation at transcription and translation level

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√				√			√	
2	√		√				√			√	
3	√	√	√		√		√		√	√	
4	√	√	√		√		√		√	√	√

Books recommended

1. Ramawat KG and Merillon J M (eds.), *"Biotechnology secondary metabolite: plants and microbes",* 2nd edition, Science Publishers, USA (2007).
2. Lehninger A L, **"***Principles of Biochemistry*", 3rd edition, Butterworth, New York (2000).
3. Harvey L, Berk A, Zipursky S L, Matsuidaira P, Baltimore D, Darnell J E, *"Molecular Cell biology",* 4th edition, W.H.Freeman, New York (2000).

BTPE-421 Biostatistics [3 0 0 3]

Course Objectives: The main objective of this course is to understand and interpret results obtained from mathematical and statistical methods to compare between two or more than two independent populations. Also, course encompasses the methodology and theory of statistics as applied to problems in the life and health sciences.

Unit-I

Applications of statistics in biological sciences and genetics: Descriptive statistics; Mean; Variance; Standard deviation and coefficient of variation (CV); Comparison of two CVs; Skewness; Kurtosis

Probability: axiomatic definition; Addition theorem; Conditional probability; Bayes theorem; Random variable; Mathematical expectation; Theoretical distributions — Binomial, Poisson, Normal, Standard normal and Exponential distributions; Sampling- \ parameter, statistic and standard error; Census - sampling methods; Probability and non-probability sampling; Purposive sampling; Simple random• sampling;, Stratified sampling.

Unit-II

Testing of hypothesis: Null and alternative hypothesis; Type I and type II errors; Level of ,significance; Large sample tests; Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test — testing of single mean; Testing of two sample means using independent t test, paired t test; Chi square test: Test for goodness of fit - association of attributes — testing linkage — segregation ratio.

Correlation: Pearson's correlation coefficient and Spearman's rank correlation; Partial and multiple correlation — regression analysis; Sample linear and non linear regression; Multiple regression.

Unit-III

Analysis of variance: definition — assumptions — model; One way analysis of variance with equal and unequal replications; Two way analysis of variance; Non parametric tests — sign test — Mann Whitney 'U' test — Kruskal Wallis test.

Course Outcomes: After the successful completion of this course, students would be able to:

1. Able to explain the basic concepts of probability and to apply probability distributions in their field.
2. Able to use statistical techniques for analyzing biological data.
3. Apply the hypothesis test and design of experiment regarding biostatistics.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**D**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√			√		
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√	√	√	√		√	√			√

Books Recommended

1. Jerrold H. Zar, Biostatistical Analysis, 4th Edition, Pearson Education, 1999.
2. Wayne W. Daniel, Biostatistics, 7th Edition, Wiley India, 2005
3. P.S.S. Sundar Rao, P.H.Richard, J.Richard, An introduction to Biostatistics, Prentice Hall of India (P) Ltd., New Delhi, 2003.
4. Rangaswamy, R, A textbook of Agricultural Statistics, New Age International (P) Ltd., 2000.
5. Panse V.G.Panse, Sukhatme P.V, Statistical methods for Agricultural Workers, ICAR Publications, New Delhi, 2000

Open Electives Courses-II, to be offered by the Department in 7th Semester

BTOE-401 Introduction to Bioinformatics [3 0 0 3]

Course Objectives: This course is designed to integrate basic concepts of bioinformatics. This course imparts knowledge of biological databases and pairwise alignment. The student should acquire knowledge about models and software related to bioinformatics..

Unit-I

Information search and data retrieval: Biological information resources and retrieval system; data characteristics and presentation, major databases, data management & analysis, data mining.

Biological Data bases and their management: Introduction to SQL (Sequence Query Language), Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools.

Pairwise alignment: Pair wise and multiple sequence alignment, Scoring matrices, Secondary Structure predictions, Fold recognition.

Multiple sequence alignment and Phylogenic analysis: Gene identification methods; data mining (Genome databases) and phylogenetic analysis; tree evaluation, Predictive methods using nucleic acids and protein sequences.

Unit-II

Genome analysis and gene mapping: Analysis Tools for Sequence Data Bank, sequence homology searching using BLAST and FASTA, FASTA and BLAST Algorithms comparison.

Profiles and Hidden Markov Models: Explanation and application of the tools

Gene identification methods: Genomics and Human genome project; Pattern recognition, Gene prediction methods, Strategy of genome sequencing.

Gene Expression and Microarrays: DNA Microarrays, clustering gene expression profiles, tools for microarray analysis, application of microarray technology.

Unit-III

Bioinformatics Software: Molecular structure drawing tool (Chemdraw); VMD/Rasmol/Insight-II; Clustal X1.8; OLIGO; PERL, Molecular modeling/ Docking (CAChe); Clustal W, oligoprimer. ALSCRIPT, MOLSCRIPT, Rasmol, Phylip, Submitting sequence to databases, and Computational tools for DNA sequence analysis: GCG: The Wisconsin package of sequence analysis programs; Web-based interfaces for the GCG sequence analysis programs.

Course Outcomes: After completion of this course students would be able to

1. Understand and manage the different biological data and databases.
2. Learn use the pairwise alignment and multiple sequence alignment
3. Can analyze and map genome and identify gene
4. Develop skills for using different bioinformatics software and models

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√	√	√		√	
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√	√	√	√			√	√		√
4	√			√		√		√			√

Books Recommended

1) Bergeron Bryan, *"Bioinformatics Computing",* Prentice Hall of India (2003).
2) Rastogi S.C., Mendiratta N., Rastogi P., Bioinformatics, 2nd edition, Prentices Hall (2006).
3) Attwood T K, and Parry- Smith *"Introduction to Bioinformatics",* Pearson Education, Singapore (2000).
4) David W. Mount, Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
5) P. E. Bourne and H. Weissig, Structural Bioinformatics, 2nd Edition, Wiley, 2008.
6) Westhead D R , Parish J H and Twyman R M, *"Bioinformatics"* ,Viva Books Pvt. Ltd. , New Delhi (2003).
7) Jonathan Pevsner, Bioinformatics and Functional Genomics,1st Edition, Wiley-Liss, 2003.

BTOE-403 Applied Biotechnology & Bioengineering [3 0 0 3]

Course Objectives:	To introduce the concepts of biological sciences and its' engineering aspects. This course is for relating multi-disciplinary engineering fields with Biotechnology.

Unit I: Fundamental Concepts of Biology

The building blocks of life: Structure and function of Carbohydrates, Proteins, Amino Acids and Peptides, Nucleic Acids and Nucleotides, Lipids and Enzymes.

Cell: Prokaryotic and Eukaryotic cell with short description of Bacterial cell, plant cell and animal cell.

Cell characterization techniques: Microscopes, Cell counting methods.

Human physiology: Cardiovascular System, Respiratory System, Nervous System.

Unit II: Industrial Relevance

Industrial microbiology: Lactic acid production, Vinegar production, Insulin, Alcohol fermentations, Antibiotic Production, Enzyme production.

Microbiology of foods: Microbial spoilage of food, Microbial Examination of foods, Preservation of foods and fermented foods.

Deterioration of materials: Paper, Textiles, Painted surfaces, Prevention of microbial deterioration.

Eco-friendly bio-products: Bio pesticides, Bio fertilizers, Biodegradable Plastics.

Bioremediation: Introduction, Advantages and Applications of Bioremediation. Biological control of air pollution. Biological treatment of wastewater. Bacterial examination of water for portability.

Unit III: Interdisciplinary Applications

Biosensors: Principles, components, and applications; Biomaterials: Metal, Ceramic, Polymer, Composites, Biocompatibility and biodegradability, Bioinformatics, Bio-concrete, Bioelectricity: Electric effect of plasma membrane, bioelectric tissues and organs; Biofuels.

Course Outcomes:	1. Understand the fundamental concepts of cell biology and recognize its association to daily life 2. Understand the concepts of fermentation and various other bioprocesses

3. Comprehend, analyze, and apply the foundational principles related to human health and environment
4. Develop creative ideas/thoughts in an interdisciplinary engineering perspective linking principles of bio sciences to societal and industrial applications

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√			√		√			√		
2	√			√		√	√	√	√		√
3	√	√	√	√	√		√	√		√	√
4	√	√	√	√	√	√				√	

Books recommended

1. Pelczar M J, Chan E C S and Krieg N R "*Microbiology, 5th Edition*," Mc Graw Hill, New York (1995).
2. Stanley A S "*Cell Biology for Biotechnologists*" Narosa Book Distributors Pvt. Ltd (2010).
3. Chatterjee A K "*Introduction to Environmental Biotechnology*" Phi Learning Private Limited (2011).
4. Lehninger, A L "*Principles of Biochemistry*", 4th Edition Butterworth Publishers, New York (2003).
5. **"***Biotechnology for Beginners"*, 2nd Edition. Reinhard RennebergViola Berkling Vanya Loroch, Academic Press.
6. "*An Engineering Introduction to Biotechnology*". J. Patrick Fitch

DEPARTMENT OF BIOTECHNOLOGY: Detailed syllabus 8th Semester

BTPC-402 Food Process Biotechnology [3 0 0 3]

Course Objectives: The objective of this course is to know how to apply the biotechnological tools to food industry. Specifically,

i) Develop students' knowledge, understanding and skills in food biotechnology at an advanced level
ii) Appreciate the positive role and benefits of biotechnological tools in food production, processing, and preservation
iii) Enhance students' ability to identify current and future research directions in food biotechnology

Unit-I

Introduction to Food Biotechnology: Biotechnological processes in conventional and nonconventional food, safety aspects, food industry wastes

Food Biotechnology Products: Dairy products, cereal products, fruit and vegetable products, meat and fish, food ingredients , High Fructose Corn Syrup , Mycoprotein etc. Flavors and Pigments, New protein food,- SCP, mushroom; food yeasts, algal proteins

Unit-II

Biotechnology and Food Preservation : Different techniques in food preservation, canning, drying, freezing encapsulation and controlled release of food components, microwave food processing , super critical fluid extraction , accepting processing of food. Organisms and their use of pickling; alcoholic beverages and other products. Mechanism of enzyme functions and reactions in process techniques starch and sugar conversion processes or baking by amylases; de-oxygenation and desugaring by glucose oxidase; beer mashing and chillproofing or cheese making by proteases and various other enzyme catalytic actions in food processing.

Genetically Modified and Transgenic Food: Development, processing, nutrition and safety aspects.

Unit-III

Bioreactors in Food Biotechnology: Use of different bioreactors (e.g membrane bioreactors) for various food productions, Modeling , simulation and optimization of industrial processes, use of sensor and biosensors ,process control.

Course Outcomes:

1. Ability to understand the basic food safety issues in the food market
2. To develop and evaluate quality of new food products using objective and subjective methodologies.
3. Gain understanding of the basic concepts in food chemistry and food analysis.
4. Students will also learn how to convert food waste to value added products.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√		√				
2	√	√	√	√	√			√			√
3	√		√	√				√			
4	√			√	√			√		√	√

Books Recommended

1. *Food Biotechnology*, Second Edition, Book by Anthony Pometto
2. *Food Science and Food Biotechnology*, Book by Gustavo F. Gutierrez-Lopez

Introduction to Food Biotechnology. Author; Perry Johnson-Green. Publisher; CRC Press. Year; 2002

BTCI-402 Industrial Lecture [1 0 0 1]

In 8th semester, the students will attend one hour expert lecture (in every week), to be delivered by the eternal experts from Industry or academia of repute. After the lectures, the students will be evaluated by the questions, consisting of MCQ or quizzes. The final evaluation will be done, by taking the average of the performance in entire semester.

BTCI-400 Major Project (Phase-II) [0 0 8 4*]
*** Major Project will be allotted in 7th Semester, will be evaluated after 8th Semester**

In continuation of 7th semester, the students will continue the major project, phase-II in the 8th Semester. The students under guidance of faculty member may select the topic. The final evaluation will be done after 8th semester, in presence of external experts. The project report is to be submitted in a typed form, The project work on the topic will consist of either some investigational work, computer simulation or design problem or experimental set up of some development work of or prototype equipment. Every student has to give a presentation in the topic incorporated in the project and in the project and in the related area of specialization. The final grade will be given on the combined work of 7th and 8th semester of 4 credits.

The student will be required to submit three copies of his/her project report to the department office for record. One copies each for the department library, participating faculty and students own copy.

BTPE-422 Environmental Biotechnology & Bioengineering [3 0 0 3]

Course Objectives:	To explain the importance of microbial diversity and of molecular approaches in environmental microbiology and biotechnology. To describe existing and emerging technologies those are important in the area of environmental biotechnology. To describe biotechnological solutions to address environmental issues including pollution, mineral resource winning, renewable energy and water recycle.

Unit-I

Introduction: Environment; Basic concepts; Resources; Eco system: plants, animals, microbes; Ecosystem management; Renewable resources; Sustainability; Microbiology of degradation and decay; Role of Biotech in environmental protection; Control and management of biological processes

Pollution: Environmental pollution; Source of pollution; Air, water as a source of natural resource; Oil pollution; Surfactants; Pesticides; Measurement of pollution; Water pollution; Biofilm; Soil pollution; Radioactive pollution; Radiation; Ozone depletion; Green house effect; Impact of pollutants; Pollution of milk and aquatic animals

Unit-II

Control, remediation and management: Waste water collection; control and management; Waste water treatment; Sewage treatment through chemical, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment; Bioaugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries

Alternate source of energy: Biomass as source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-minearlization; Biofuels; isoethanol and biohydrogen; Solid waste management.

Unit-III

Environment and health in respect to genetics: Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring.

Course Outcomes:

1. Identify environmental problems arising due to engineering and technological activities and the science behind those problems.
2. Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
3. Identify the major pollutants and abatement devices for environmental management and sustainable development
4. Understand the effects of environmental pollution on health and genetics

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	✓					✓	✓	✓	✓	✓	
2	✓					✓	✓	✓		✓	
3	✓			✓		✓	✓	✓		✓	
4	✓			✓				✓	✓	✓	✓

Books recommended

1. Met Calfe and Eddy Inc., "*Wastewater Engineering: Treatment, Disposal and Reuse*", 4th Edition, McGraw Hill Book Co., 2003

2. Mackenzie L. Davis and David A. Cornwell, "*Introduction to Environmental Engineering*", 4th Edition, McGraw Hill Book Co., 2006.

3. R.M.Maier, I.L.Pepper and C.P.Gerba, Elsevier, "*Environmental Microbiology: A Laboratory Manual*", 2nd Edition, Academic Press, 2004.

4. B.C. Bhattacharyya and R. Banerjee, "*Environmental Biotechnology*", Oxford University Press.

BTPE-424 Drug design and molecular modeling [3 0 0 3]

Course Objectives: The objective of this course is to retrieve the information of various biomolecules such as DNA, RNA and protein from different databases, which can help in the development of a new drug. In addition, it covers the methods for predictions, which can be used to make early decisions in the drug discovery and development.

Unit-I

Databases: Primary and Secondary Databases; GenBank, EMBL, DDBJ, Swissplot, MIPS, PIR, TIGR, Hovergen, TAIR, PlasmoDB, ECDC, Protein and Nucleic Acid Sequences.

Search Algorithm: Scoring Matrices and their use; Computational complexities; Analysis of Merits and demerits; Sequence pattern; Pattern database; PROSITE, PRINTS, Markov chains and Markov models; Viterbi algorithm; Baum-Welch algorithm; FASTA and Blast Algorithm; Needleman-Wusch & Smith-Waterman algorithms.

Unit-II

Structure and Analysis: Representation of molecular structures; External and internal co-ordinates; Concept of free energy of molecules; Introduction to various force fields; Molecular energy minimization techniques; Monte Carlo Molecular Dynamics simulation.

Experimental Methods: Molecular structure Determination, Principle of X-ray crystallography and NMR spectroscopy; 2D Protein Data bank and Nucleic Acid Data bank; Storage and Dissemination of molecular structure.

Unit-III

Modeling: Homology modeling; Threading; Structure prediction; Structure-structure comparison of macromolecules; simulated ducking; Drug design; 2D and 3D QASR; Ligand databases.

Course Outcomes: On completion of the course the student shall be able to:

1. Use structure-based and non-linear classification methods in drug design.
2. Understanding the molecular basis of the interaction of small molecules with their targets.
3. An awareness of rational drug design, based on understanding of three-dimensional (3D) structures and physicochemical properties of drugs and receptors will be created.

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√					√
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√		√	√	√	√				√

Books Recommended

1. David W.Mount.Bioinformatics: Sequence and Genome Analysis 2nd Edition,CSH Press, 2004.
2. Baxevanis and F.B.F Ouellette, Bioinformatics: a practical guide to the analysis of genes and proteins, 2nd Edition, John Wiley, 2001.
3. Jonathan Prevsner.Bioinformatics and Functional Genomics, 1st Edition, Wiley-Liss, 2003.
4. C.Branden and J.Tooze, Introduction to Protein Structure, 2nd Edition, Garland Publishing,1999

BTPE-426 Metabolic Engineering [3 0 0 3]

Course Objectives:	The main objective of this course is to make students understand about the cell metabolism and the network involved in the process.

Unit-I

Elements of Metabolic Engineering: Historical perspective and introduction; Importance of metabolic engineering; Paradigm shift; Information resources; Scope and future of metabolic engineering; Building blocks of cellular components.

Review of cellular metabolism: Transport mechanisms and their models; Regulation of enzyme activity versus regulation of enzyme concentration; Regulation of metabolic networks; Regulation of at the whole cell level; Examples of important pathways; Case studies and analytical-type problems.

Unit-II

Material and Energy Balances: Stoichiometric models and representation; The chemical reaction vector and energetic; Material and energy balances revisited; Basis for simplification of reaction; Elemental balances; Component balances and the link with macroscopic measurements; Examples of construction of elemental and component balances.

Metabolic Flux Analysis and control theory: The theory of flux balances; Derivation of the fundamental principle; Degree of freedom and solution methods; Moore-Penrose inverse and Tsai-lee matrix construction; Examples of applications of flux analysis introduction Metabolic Control Theory; Control coefficients; Elasticity coefficients; Summation and connectivity theorems; Case Studies and examples.

Unit-III

Metabolic Engineering Practice: The concept of metabolic pathway synthesis; Need for pathway synthesis, Examples for illustration; Overall perspective of MFA, MCA and MPA and their applications; Three success case studies

Course Outcomes: After the successful completion of this course, students will be able to:

1. Understand the importance of cellular metabolism.
2. Learn about the pathway and network related to the metabolism.
3. Know about the flux analysis involved the cellular metabolism.
4. Apply various metabolism engineering for the betterment of human as well as other living organisms.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√	√	√	√			
2	√	√			√			√			
3	√		√				√	√		√	
4	√				√			√			

Books recommended

1. Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen, Metabolic Engineering — Principles and Methodologies, 1st Edition, Academic Press, 1998
2. Gerhard Gottschalk, Bacterial Metabolism, 2nd Edition, Springer Verlag, 1986
3. S. A. Teukolsky, W. T. Vellerling, B. P. Flannery, W. H. Press, Numerical Recipes in Metabolic Engineering.

BTPE-428 Bioenergy & Bioresource Technology [3 0 0 3]

Course Objectives:	This course will apply basic concepts of bioprocess engineering in biofuel production. The students will acquire knowledge of microbial production of biofuels, e.g. ethanol, biogas, biohydrogen, microbial fuel cell, in designing bioprocess plant.

Unit-I

Introduction: Energy world demand, sustainability, climate changes, greenhouse gas effect

Alternate source of energy: Various Biofuels production processes from renewable energy sources, merits and demerits of different biofuels production processes

Microbial Biofuels Production process: Various microbes involved, Different biochemical routes for the Biofuels production, Molecular biological approaches for the improvement of Biofuels production, Effect of physico-chemical parameters on the Biofuels production

Engineering aspects in Biofuels production: Thermodynamics and kinetics, Scale-up of bioreactors and Case studies on the different Biofuels production processes, Economic analysis

Unit-II

Bioethanol and biogas production: By fermentation of vegetable wastes, Methane from anaerobic digestion: metabolic processes, practical aspects

Biodiesel production: current perspective, Biodiesel production by microalgae

Biological Hydrogen production: Hydrogen from microorganisms: biophotolysis of water, Hydrogen from microorganisms: dark and photo fermentation, integrated systems, Conversion of light energy into Hydrogen energy by Photosynthetic microorganisms, Different Case studies: Photobioreactor design and light conversion

Algal Biorefinery: Concepts and processes, potentiality towards zero discharge

Unit-III

Microbial Electrochemical Cells: Principles, their applications, Microbial fuel cells (MFC); Microbial electrolysis cells (MEC)

Biodegradable Plastics production by microorganisms: polyesters, polylactic acid, poly hydroxyl butyrates, poly hydroxyl alkaloids, polysaccharides, their possible uses

Course Outcomes:	On completion of the course the student shall be able to: 1. Understand microbial production of commonly used different types biofuels 2. Explain bioprocess engineering methods to produce desired biofuels 3. Understand the concept of microbial fuel cells. 4. Explain different Biorefinery concepts using microbes and algae

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1										√	√
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√		√	√						√
4	√		√	√	√	√			√	√	

Recommended Books:

1. "*Biofuels from algae*", 2nd edition, Elsevier (2018), Editors: Duu Jong Lee, Ashok Pandey, Jo-Shu Chang, Yusuf Chisti, Carlos Soccol, Paper back ISBN-13: 978-04446421922
2. "*Process synthesis for fuel ethanol production*", CRC Press (2009), C.A.Cardona, O.J.Sanchez, L.F. Gutierrez, ISBN-13: 978-1439815977
3. "*Biohydrogen Production: Fundamentals and Technology Advances*", CRC Press (2014), Debabrata Das, Namita Khanna, Chitralekha Nag Dasgupta, ISBN-13: 978-1466517998
4. "*Algal Biorefinery: In Integrated Approach*", Edited *by* Debabrata Das, Springer (2015), ISBN 978-3-319-22813-6
5. "*Microbial Fuel Cell Technology for Bioelectricity*", Springer (2018), Editors: Sivasankar Venkataraman, Mylsamy Prabhakaran, Omine Kiyoshi, ISBN-13: 978-3-319-92904-0

BTPE-430 Biosensors and Biotechnology [3 0 0 3]

Course objectives: This course provides basic information of biosensing and the principles to design biosensors for analyte detection. It includes the information of analytes, related biorecognition elements with a secondary transducing elements. The course also outlines different classes of biosensors, designing and evaluating performance of biosensor for biomedical applications.

Unit-I

Overview of Biosensors: Fundamental elements of biosensor devices, Fundamental engineering aspects of biosensors, Signal processing for biosensors. Fundamentals of measurement science: applied to optical, electrochemical, mass, and pressure signal transduction. Theoretical analysis of biosensor: design and performance.

Unit-II

Electro chemical biosensors: Electrochemical principles, Amperometric biosensors and charge transfer pathways in enzymes, Glucose biosensors, engineering electrochemical biosensors, Other than electrochemical or optical sensing schemes. Optical Biosensors: Optics for biosensors, Attenuated total reflection systems, Non-invasive optical sensors

Unit-III

Mass and Acoustic Biosensors: Saubrey formulation, Acoustic sensor formats, Quartz crystal microbalance, Whole cell biosensors

Course Outcomes: Upon completion of this course the students will be able to

1. Understand different biosensing and transducing techniques to detect analytes
2. Understand the principles behind correlating cellular components and biochemical pathways for transduction, sensing and detection
3. Demonstrate the technical limitations of biosensor performance
4. Apply the principles to design and develop biosensors device for the diagnosis of disorders

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√			√			√
2	√					√					
3	√	√		√							√
4	√	√	√	√	√	√				√	√

Recommended books:

1. Anthony E.G.C., Cooper J.M., "Biosensors", Oxford University Press (2004)
2. Roger K R, Mulchandani A, "Enzyme and Microbial biosensors", Humana Press (1998)
3. Bilitewsk U, Turner A P F, "Biosensor in Environmental Monitoring", Taylor & Francis (2000)
4. Donald G B, "Biosensors: Theory and Applications", CRC Press (1993)
5. Donald L W, "Bioinstrumentation and Biosensors", CRC Press (1991)
6. Donald L W, Wingard L B, "Biosensors with fiber optics", Humana Press (1991)

BTPE-432 Bioprocess Safety and Bioethics [3 0 0 3]

Course Objectives: The main objective of this course is to make students to get acquainted with principles of biosafety and understand the ethical perspective of handling potentially harmful biomaterials including transgenic plants and animals. At the end of the course students will also be aware of the general guidelines for research in microorganisms, animals and plants

Unit-I

Biosafety: Introduction and historical Backround**;** GMOs & LMOs; Environmental release of GMOs Classification and description of biosafety levels; Biological safety cabinets; Risk assessment and containment levels; Biosafety guidelines and regulations; Biosafety regulatory frame work for GMOs in India and at International level; Cartagena Biosafety Protocol (CAB).

Unit II:

Socioeconomic Impacts of Biotechnology: Challenges for the Biotechnological research and industries; Biological weapons; Bioterrorism (planning and response); Public acceptance issues for biotechnology: Case studies/experiences from developing and developed countries.

Unit-III

Bioethics: Introduction and need of bioethics; Ethical Issues involving GMOs; Ethics related to human cloning, Human genome project, Prenatal diagnosis; Bioethics vs Business ethics; Social and ethical implications of biological weapons.

Course Outcomes: After the successful completion of this course, students will be able to:

1. Understand the importance of biosafety cabinets in laboratories and safe handling of genetically engineered materials
2. Understand the risks and benefits of genetically modified food.
3. Have knowledge of various regulatory frame work for GMOs
4. Understand ethical importance in working with harmful biomaterials

Mapping of course objectives (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√							√		√	√
2	√	√	√	√	√	√	√	√	√	√	√
3	√	√		√	√		√	√			
4	√		√	√	√	√			√	√	

Books Recommended:

1. Fleming D O, Hunt D L, *"Biological Safety: Principles and Practices"*, 3rd edition, ASM press (2000).
2. Thomas J A, Fush R L, "*Biotechnology & safety Assessment*", 3rd edition, Academic press (2002).
3. Sateesh, M K, "*Bioethics and Biosafety"*, IK International Publishers (2008).
4. Cartagena Protocol on Biosafety, January 2000.
5. Dano M R, *"Biological Warfare in the 21st century"*, Brassies London, 1994.
6. Traynor P L, "*Biosafety Management"*, Virginia polytechnic Institute Publication, 2000.

BTPE-434 Agricultural Biotechnology [3 0 0 3]

Course Objectives: The main objective of this course is to make students understand about the technologies and their application in the field of agricultural biotechnology.

Unit-I

Production of disease-free plants: shoot-tip cultures, shoot- tip grafting, viricidal compounds.
Tissue culture as a source of genetic variability: somaclonal and gametoclonal variant selection, sources and causes of variation, application in crop improvement.
Protoplast isolation: culture and fusion, selection of hybrid cells and regeneration of hybrid plants, somatic hybridization

Unit-II

Plant cell cultures for useful chemicals: pigments perfumes, flavors, insecticides, anticancer agents and pharmacologically important compounds.
Genetic Engineering in Agriculture: techniques for the insertion of foreign genes into plant cells, Ti-plasmid and vectors, production of transgenic plants, (i) Transgenic plants (ii) gene cloning, restriction fragment length polymorphisms, transposons, and insertional mutagenesis. Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic
value added specialty crops, Use of antisense RNA and other technologies.
Nitrogen fixation: nif-gene transfer, herbicide resistance and stress tolerance in plants. Isolation and characterization of organelle genome (plastome and chonodriosome).

Unit-III

Bioinsecticides and biofertilizers: Preservation of rare plant species germplasm collection and conservation. Soil Reclamation: Phytoremediation

Course Outcomes: After the successful completion of this course, students will be able to:
1. Understand the importance biotechnology in the field of agricultural.
2. Learn about the culturing root, shoot culture and application of crop improvement.
3. To work on detection and removal of various diseases.
4. Apply various technologies related to agricultural.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√	√		√		√	
2	√				√			√	√	√	
3	√						√	√	√		√
4	√				√			√			√

Books recommended:

1. Bhojwani S.S. and Razdan M.K., "*Plant Tissue culture Theory and Practice*" Elesevier Science , Netherlands (2004)
2. Trigiano R.N., Grey D.J., *"Plant Tissue Culture: Concepts and Laboratory Exercises"* 2nd Edition, CRC Press (2000).
3. Lindsey K, *"Plant Tissue culture Manual"*, Kluwer Academic Publ. (1991).
4. Kung S D, Wu R, *"Transgenic Plants Vol. 1 & 2"*, Academic Press, San Diego (1993).5. Lindsey K, Jones M G K, *"Plant biotechnology In Agriculture"*, Prentice hall (1990).

BTPE-436 Biofilm Engineering [3 0 0 3]

Course Objectives: To study biofilms in a variety of natural and engineered systems. The emphasis will be on understanding unique characteristics and on critically evaluating old and new biofilm literature.

Unit I

Introduction to biofilms and EPS • Review of microbial lifestyle/basic concepts in microbiology, adhesion, occurrence and development of biofilms • Biofilm Development (attachment, differentiation and dispersal) • Biofilm Physiology, Viability and Antibiotic Resistance.

Unit II

Environmental Biofilms • Clinical Biofilms • Biofilms in Industry/Engineering (Biofilm Engineering and Biofilms in Drinking Water) • Evolutionary/Population Processes in Biofilms • **Biofilm analysis Techniques** • Biofilm kinetics

Unit III

Beneficial biofilms: Review of biofilm kinetics and biofilm reactors in wastewater and water treatment • Bio electrochemical systems.

Unwanted Biofilms: Drinking water biofilms • Biofouling • Biocorrosion

Course Outcomes: Having successfully completed this module students will be able to:

1. Describe in detail concepts in biofilm life-cycle, including attachment, development, differentiation, and dispersal
2. Understand evolutionary processes within biofilms, such as cooperation and cheating, and their implications for microbial multicellularity;
3. Know the methods for studying microbial biofilms in the natural environment and disease
4. Develop strategies for the control of biofilms in industrial, environmental or public health benefits

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√	√		√			√	
2	√	√	√		√	√		√		√	√
3	√		√	√		√		√			
4	√			√	√			√			√

Books Recommended

1. *The Biofilm Mode of Life: Mechanisms and Adaptations*. Horizon Bioscience, 2007.
2. *Microbial Biofilms: Current Research and Applications.* Caister Academic Press,2012.

BTPE-438 Biological Transport Phenomena [3 0 0 3]

Course Objectives:	The main objective of this course is to make students understand about the energy balances and flow of biological molecules.

Unit-I

Momentum Transport: Viscosity and the mechanism of momentum transport, newton's law of viscosity, non- newton fluids, pressure and temperature dependence of viscosity, theory of viscosity of gases at low density, theory of viscosity of liquids.

Velocity Distributions in Laminar Flow: Shell momentum balances: boundary conditions, flow of a falling film, flow through a circular tube, flow through an annulus, adjacent flow of two immiscible fluids.

The Equations of Change for Isothermal System: To equation of continuity, the equation of motion, the equation of mechanical energy.

Interphase Transport in Isothermal System: Definition of friction factors, friction factors for flow in tubes, friction factors for flow around spheres, friction factors for packed columns.

Unit-II

Thermal Conductivity and the Mechanism of Energy Transport: Fourier's Law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids, theory of thermal conductivity of gases at low density, theory of thermal conductivity of liquids, thermal conductivity of solids.

Temperature Distributions in solids and in Laminar Flow: Shell energy balances; boundary conditions, heat conduction with an electrical heat source, heat conduction with a chemical heat source, heat conduction through composite walls: Addition of Resistance, Forced Convection, Free Convection.

The Equations of change for Non-isothermal systems: The equations of energy, the energy equation in curvilinear coordinates, the equations of motion for forced and free convection in non-isothermal flow, summary of the equations of change, use of equation of change to set up steady – state heat transfer problems.

Diffusivity and the Mechanism of Mass Transport: Definition of concentrations, velocities and mass fluxes, fick's law of diffusion, theory of ordinary diffusion in gases at low density, theory of ordinary diffusion in liquids.

Unit-III

Concentration Distributions in Solid and in Laminar Flow: Shell mass balances: boundary conditions, diffusion through a stagnant gas film, diffusion with heterogeneous chemical reaction, diffusion with homogeneous chemical reaction, diffusion into a falling liquid film l forced – convection mass transfer, diffusion and chemical reaction inside a porous catalyst: the "effectiveness factor". Analogies between Heat, mass, momentum, and transfers.

Course Outcomes:	After the successful completion of this course, students will be able to: 1. Know the energy balances of biological fluid system. 2. Understand the mechanism of energy transport between the system. 3. Learn thermal conductivity, resistance and convection of various fluid types. 4. Create various applications by utilize properties of different fluids and their related pathways.

Mapping of course outcomes (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√	√		√	√		
2	√			√	√			√	√	√	
3	√			√			√	√		√	√
4	√				√			√			√

Books recommended

1. Bird R B, Stewart W E and Light fort R N, "*Transport Phenomena"*, John Wiley (2002).
2. Welty J R , Wilson R E and Wicks C E , "*Fundamentals of Momentum , Heat and Mass Transfer",* 4th ed, John Wiley and Sons (2001).
3. John C. Slattery, "*Momentum, Energy and Mass transfer in continua"*, McGraw Hill, Co. (1972).
4. Bennet C U and Myers J E, "*Momentum, Heat and Mass Transfer*" Tata McGraw Hill Publishing Co. (1975)
5. Robert S Brodkey and Harry C Hersing, " *Transport Phenomena a Unified approach*" McGraw Hill Book Co. (1988).

Open Electives Courses to be offered by the Department in the 8th Semester

BTOE-402 Environmental Biotechnology [3 0 0 3]

Course Objectives:	To explain the importance of microbial diversity and of molecular approaches in environmental microbiology and biotechnology. To describe existing and emerging technologies those are important in the area of environmental biotechnology. To describe biotechnological solutions to address environmental issues including pollution, mineral resource winning, renewable energy and water recycle.

Unit-I

Introduction: Environment; Basic concepts; Resources; Eco system: plants, animals, microbes; Ecosystem management; Renewable resources; Sustainability; Microbiology of degradation and decay; Role of Biotech in environmental protection; Control and management of biological processes

Pollution: Environmental pollution; Source of pollution; Air, water as a source of natural resource; Oil pollution; Surfactants; Pesticides; Measurement of pollution; Water pollution; Biofilm; Soil pollution; Radioactive pollution; Radiation; Ozone depletion; Green house effect; Impact of pollutants; Pollution of milk and aquatic animals

Unit-II

Control, remediation and management: Waste water collection; control and management; Waste water treatment; Sewage treatment through chemical, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment; Bioaugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery,

tannery, sugar and antibiotic industries

Alternate source of energy: Biomass as source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-minearlization; Biofuels; isoethanol and biohydrogen; Solid waste management.

Unit-III

Environment and health in respect to genetics: Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring.

Course Outcomes:

1. Identify environmental problems arising due to engineering and technological activities and the science behind those problems.
2. Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
3. Identify the major pollutants and abatement devices for environmental management and sustainable development
4. Understand the effects of environmental pollution on health and genetics

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√	√	√	√	√	
2	√		√		√	√	√	√	√	√	
3	√	√	√	√	√	√	√	√	√	√	
4	√	√		√				√	√	√	√

Books recommended

1. Met Calfe and Eddy Inc., "*Wastewater Engineering: Treatment, Disposal and Reuse*", 4th Edition, McGraw Hill Book Co., 2003

2. Mackenzie L. Davis and David A. Cornwell, "*Introduction to Environmental Engineering*", 4th Edition, McGraw Hill Book Co., 2006.

3. R.M.Maier, I.L.Pepper and C.P.Gerba, Elsevier, "*Environmental Microbiology: A Laboratory Manual*", 2nd Edition, Academic Press, 2004.

4. B.C. Bhattacharyya and R. Banerjee, "*Environmental Biotechnology*", Oxford University Press.

BTOE-404 Biosensor [3 0 0 3]

Course objectives: This course provides basic information of biosensing and the principles to design biosensors for analyte detection. It includes the information of analytes, related biorecognition elements with a secondary transducing elements. The course also outlines different classes of biosensors, designing and evaluating performance of biosensor for biomedical applications.

Unit-I

Overview of Biosensors: Fundamental elements of biosensor devices, Fundamental engineering aspects of biosensors, Signal processing for biosensors. Fundamentals of measurement science:

applied to optical, electrochemical, mass, and pressure signal transduction. Theoretical analysis of biosensor: design and performance.

Unit-II

Electro chemical biosensors: Electrochemical principles, Amperometric biosensors and charge transfer pathways in enzymes, Glucose biosensors, engineering electrochemical biosensors, Other than electrochemical or optical sensing schemes. Optical Biosensors: Optics for biosensors, Attenuated total reflection systems, Non-invasive optical sensors

Unit-III

Mass and Acoustic Biosensors: Saubrey formulation, Acoustic sensor formats, Quartz crystal microbalance, Whole cell biosensors

Course Outcomes: Upon completion of this course the students will be able to

1. Understand different biosensing and transducing techniques to detect analytes
2. Understand the principles behind correlating cellular components and biochemical pathways for transduction, sensing and detection
3. Demonstrate the technical limitations of biosensor performance
4. Apply the principles to design and develop biosensors device for the diagnosis of disorders

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√			√			√			√
2	√					√					
3	√	√		√							√
4	√	√	√	√	√	√				√	√

Recommended books:

1. Anthony E.G.C., Cooper J.M., “Biosensors”, Oxford University Press (2004)
2. Roger K R, Mulchandani A, “Enzyme and Microbial biosensors”, Humana Press (1998)
3. Bilitewsk U, Turner A P F, “Biosensor in Environmental Monitoring”, Taylor & Francis (2000)
4. Donald G B, “Biosensors: Theory and Applications”, CRC Press (1993)
5. Donald L W, “Bioinstrumentation and Biosensors”, CRC Press (1991)
6. Donald L W, Wingard L B, “Biosensors with fiber optics”, Humana Press (1991)

Six Theory Courses for "Minor degree in Biotechnology, for other Department students":

BTMI- 201 Microbiology, in 3rd Semester [3 0 0 3]

Course objectives: The course aims at providing an overview of the physiology, metabolism and growth of Microbes. To understand the fundamentals of microbial interaction, mechanisms.

Unit-I

Scope and History of Microbiology: Scope and History of Microbiology, Classification, Characterization, Identification and Nomenclature of Microorganisms, Microscopy, Morphological, Structural and Biochemical characteristics of prokaryotes and eukaryotes (bacteria , yeast, mold, algae, protozoa, actinomycetes)

Cultivation of Microorganisms: Microbiological media, physical conditions required for growth.

Reproduction and Growth of Microorganism: Modes of cell division, growth curve of microbes, Quantitative measurement of growth.

Unit-II

Methods in Microbiology: Chemical, Physical and Biological methods of selection of microorganisms, Methods of isolating pure cultures, Maintenance and preservation of pure cultures, microbial mutation.

Microbial Metabolism: Metabolic pathways and Bioenergetics, Aerobic and Anaerobic growth, Transport of nutrients across cell membranes

Physical and Chemical Control of Microorganism: Major groups of antimicrobial agents, Mode of action and practical applications

Energy Transduction Mechanisms in Microbial Cell: Aerobic and anaerobic respiration, Microbial photosynthesis, Transduction, Transformation, Conjugation

Unit-III

Microbial Interaction: - Roles of microbes in Nitrogen, Carbon and Sulphur cycle

Application of Microorganism in various Field: - Agriculture, food, environment, medicine, public health and industry.

Viruses: Classification, morphology and composition, DNA and RNA bacteriophages, Lysogeny and lytic cycle

Course Outcomes: After studying this subject, students would be able to

1. Measure microbial growth, types of microbial interactions, growth rates etc. for microbiological processes.
2. Analyze the mechanism of microbial growth and its control parameters
3. Understand the physical, chemical and biological properties
4. Apply microbial processes for various application & energy production.

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√		√				√			√	
2	√		√				√			√	
3	√	√	√		√		√		√	√	
4	√	√	√		√		√		√	√	√

Books Recommended

1. Pelczar M J, Chan E C S and Krieg N R "*Microbiology*, 5th Edition, " Mc Graw Hill, New York (1995)
2. Salle A J, "*Fundamental Principles of Bacteriology"* , 7th Edition, Tata McGraw Hill, New Delhi (1984)
3. Stanier R Y, "*Text in Microbiology*" McMillan Press London (1995)
4. Casida L E, "*Industrial Microbiology",* New Age International Publishers, New Delhi (2003)

BTMI-202 Cell and Molecular Biology, in 4th Semester [3 0 0 3]

Course objectives:	Students will acquire an advanced level of knowledge on the activity of genes and genomes and the mechanisms of genome regulation at the transcriptional and post-transcriptional level, in the contexts of development, differentiation, cellular homeostasis and cancer.

Unit-I

Introduction to the Cell: Evolution of cell: Hypotheses and Cell theory, Cell types: Prokaryotic and Eukaryotic cell, Unicellular and Multicellular organisms

Cell Organelles: Cell wall, Membranes and cell transport, Cytosol, Endoplasmic Reticulum, Golgi apparatus, Mitochondria and aerobic respiration, Plastids: Chloroplast and photosynthesis, Vacuoles, Ribosome, Lysosomes, Cytoskeleton and cell motility, Nucleus, Nucleolus

Chromosome biology: Chromatin, Chromosomal proteins and DNA packaging, Ultra structure of chromosomes: euchromatins and heterochromatins, Types of chromosome, Karyotype, Chromosomal aberration (Numerical & structural)

Cellular reproduction and growth: Binary fission in prokaryotes, Mitosis and Meiosis in eukaryotes, cytokinesis, Cell cycle and regulation: protein kinase; cyclins, CDC mutants; Cell integration to tissues, Cellular structure-function correlation (both plant and animal)

Unit-II

Cell-cell communication: Cell Signaling and Signal Transduction: General Principles, Classification, Signaling receptors: G-Protein linked and Enzyme- linked cell-surface Receptors, Secondary Messengers, Role of Calcium, Chemotaxis, Apoptosis: Extrinsic and Intrinsic Pathway The molecular basis of inheritance: DNA as the genetic material; Central dogma of life: Replication, Transcription, and Translation in Prokaryotes and eukaryotes; Redundant DNA; DNA Repair, Regulation of gene expression in eukaryotes

Unit-III

Tools and Techniques in cell and molecular biology: Microscopy: Compound, Phase contrast, Fluorescent, Confocal, Electron Microscopy: SEM, TEM; Fractionation and Purification: Cell rupture techniques, Fractionation of subcellular organelles, Flow cytometry, Fluorescence assisted cell sorter (FACS), Centrifugation, Dialysis

Course Outcomes:	Upon successful completion of this course, participants will be able to: 1. Discuss the various macromolecular components and compartments of cells and their functions. 2. Describe the general principles of gene organization and expression in both prokaryotic andeukaryotic organisms.

3. Understand the structure of nucleic acids & proteins and their interactions and the molecular mechanisms of gene regulation in prokaryotes and eukaryotes.
4. Study chromosomal aberrations in humans.

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1		√		√						√	√
2		√		√	√					√	√
3		√		√	√					√	√
4				√	√	√	√		√	√	

Recommended books:

1. Gerald Karp, *Cell and Molecular Biology: Concepts and Experiments*, John Wiley & Sons, 2009
2. Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D Johnson, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, *Essential Cell Biology*, 3rd edition (editor: Bruce Alberts), 2009
3. Ricardo V. Lloyd (Editor), *Morphology Methods: Cell and Molecular Biology Techniques*, 2001

BTMI-301 Separation Methods in Biotechnology, in 5th Semester [3 0 0 3]

Course Objectives:	The course aims to provide knowledge on the biomolecules separation from various biological systems. The detailed study with problematic approach on cell disruption of intracellular components, Filtration, Centrifugation. Analysis of biomolecules like proteins using various analytical tools such as electrophoresis, spectrophotometer, chromatography, dialysis and mass spectrometry.

Unit-I

Separation of insoluble products: sedimentation, sedimentation coefficient, filtration, membrane filtration, centrifugation, micro centrifuge, ultracentrifuge, differential and density gradient centrifugation, coagulation and flocculation.

Cell Disruption: Mechanical methods, Non-mechanical methods.

Dialysis and Filtration: electro-dialysis, ultra-filtration and micro-filtration, cross-flow ultrafiltration and micro-filtration.

Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption, salt and solvent precipitation of protein, recombinant protein purification.

Unit-II

Electrophoresis: Gel electrophoresis (Agarose, PAGE, SDS PAGE), Disc gel electrophoresis, Gradient electrophoresis, pulse field gel electrophoresis, 2 D gel electrophoresis, capillary electrophoresis, isoelectric focusing, Gel capillary electrophoresis, Capillary zone electrophoresis, Autoradiography, Radioimmunoassay.

Chiral separation of biomolecules: Chiral Thin layer chromatography, chiral gas-liquid chromatography, non-chromatographic chiral separation

Chromatography: Method selection; selection of matrix; Adsorption chromatography, Ion exchange chromatography, gel-filtration chromatography, size exclusion chromatography, ion exclusion chromatography, affinity chromatography, hydrophobic interaction chromatography, high pressure liquid chromatography, Co-valent chromatography; IMAC chromatography, Dye ligand chromatography. Chromatography scale-up.

Unit-III

Crystallization: Theory and methods; API-electrospray and MADI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis.

Reverse Micelles: Reverse micelles formation, correlation of miceller size and protein size, Reverse micelles extraction method

Molecular Imprinting: Imprint property, selectivity of molecular imprinting.

Drying: Lyophilization, Spray drying, vacuum drying, air-drying.

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

1. Isolate and purify biomolecules from different types of biological samples
2. Characterize biomolecules for their composition, size and structure
3. Design purification strategies for genetically modified industrially important biomolecules.
4. Calculate process-profit cost analysis for any purification techniques

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√		√	√		√	√	√		
2	√	√	√		√					√	
3	√						√		√		
4	√	√	√	√	√				√	√	√

Books Recommended

1. Belter .P.A and Cussler E, "*Bioseparations*", Wiley, 1985.
2. Roger .G Harrison et al, "*Bioseparation Science and Engineering*" Oxford University Press, 2003.
3. Daniel C Liebler, "*Introduction to proteomics – A tools to new biology*". Humana Press, 2002.
4. Okotore, R.O., "*Basic Separation Techniques in Biochemistry*", New Age (1998)
5. Sivasankar, B., "*Bioseparation: Principles and Techniques*", Prentice Hall India (2005).
6. R. Scopes, "*Protein Purification - Principles & Practices*", 3rd Edition, Springer Verlag, 1994

BTMI-302 Bioinformatics, in 6th Semester [3 0 0 3]

Course objectives: The prime objective of this course is to understand the databases. To understand the method of sequencing and evolutionary relationship between various species.

Unit-I

Information search and data retrieval: Biological information resources and retrieval system; data characteristics and presentation, major databases, data management & analysis, data mining.

Biological Data bases and their management: Introduction to SQL (Sequence Query Language), Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools.

Pairwise alignment: Pair wise and multiple sequence alignment, Scoring matrices, Secondary Structure predictions, Fold recognition.

Multiple sequence alignment and Phylogenic analysis: Gene identification methods; data mining (Genome databases) and phylogenetic analysis; tree evaluation, Predictive methods using nucleic acids and protein sequences.

Unit-II

Genome analysis and gene mapping: Analysis Tools for Sequence Data Bank, sequence homology searching using BLAST and FASTA, FASTA and BLAST Algorithms comparison.

Profiles and Hidden Markov Models: Explanation and application of the tools

Gene identification methods: Genomics and Human genome project; Pattern recognition, Gene prediction methods, Strategy of genome sequencing.

Gene Expression and Microarrays: DNA Microarrays, clustering gene expression profiles, tools for microarray analysis, application of microarray technology.

Unit-III

Bioinformatics Software: Molecular structure drawing tool (Chemdraw); VMD/Rasmol/Insight-II; Clustal X1.8; OLIGO; PERL, Molecular modeling/ Docking (CAChe); Clustal W, oligoprimer. ALSCRIPT, MOLSCRIPT, Rasmol, Phylip, Submitting sequence to databases, Computational tools for DNA sequence analysis: GCG: The Wisconsin package of sequence analysis programs; Web-based interfaces for the GCG sequence analysis programs.

Course Outcomes:

After the successful completion of this course, students would be able to:

1. Explain the basic concepts of databases working.
2. Understand the sequencing methods and establish evolutionary relationship between species.
3. To find new gene by gene identification methods.
4. Learn how to used various software available.

Mapping of course outcomes (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√					√	√				
2	√	√	√	√	√	√	√	√			√
3	√	√	√		√			√			√
4	√	√						√			

Books Recommended:

1. Brgeron Bryan, *"Bioinformatics Computing",* Prentice Hall of India (2003).
2. Rastogi S.C., Mendiratta N., Rastogi P., Bioinformatics, 2nd edition, Prentics Hall (2006).

3. Attwood T K, and Parry- Smith *"Introduction to Bioinformatics",* Pearson Education, Singapore (2000).
4.David W. Mount, Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
5. P. E. Bourne and H. Weissig, Structural Bioinformatics, 2nd Edition, Wiley, 2008.
6. Westhed D R , Parish J H and Twyman R M, *"Bioinformatics"* ,Viva Books Pvt. Ltd. , New Delhi (2003).
7. Jonathan Pevsner, Bioinformatics and Functional Genomics,1st Edition, Wiley-Liss, 2003.

BTMI-401 Bioprocess Engineering, in 7th Semester [3 0 0 3]

Course Objectives:	The course aims at providing an overview of bioprocess engineering and materials balance. To understand the fundamentals of design of fermenter for efficient production of biomolecules and monitoring of bioprocesses in industry.

Unit-I

Microbial Growth Kinetics: Batch, continuous and fed batch, mass balance in series of vessels, recycle system

Media Sterilization: Methods of media sterilization, batch and continuous sterilization, kinetics of sterilization

Air Sterilization: Methods of air sterilization, mechanism of air sterilization, filter design.

Unit-II

Design of Fermenter: Construction materials, Temperature control, Mass transfer and microbial respiration, Baffles, Sterilization of fermenter, different types of fermenter,

Aeration and Agitation: bubble aeration and mechanical agitation, correlation between oxygen transfer coefficient and operating variables, factors affecting volumetric oxygen transfer, the effect of degree of agitation on volumetric oxygen transfer, rheology of fermentation fluids

Scale Up: Scale up concepts, criteria for bioreactors scale up.

Unit-III

Monitoring of Bioprocesses: On line data analysis for measurement and control of important physicochemical and biochemical parameters, parameter estimation techniques for biochemical processes, parameter estimation techniques for biochemical processes, Computer based data acquisition

Course Outcomes: After studying this subject, students would be able to

1. Measure extent of biochemical growth, types of biochemical interactions for living processes.
2. Ability to analyze the microbial growth kinetics
3. The student can design fermenter for bioprocessing of different products.
4. The student can scale up the bioprocess for large scale production
5. The students can monitor the bioprocess for higher production efficiency

Mapping of course outcome (CO) & program outcomes (PO)											
Course Outcomes	**Program Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√				√		√		√	√
2	√	√		√	√	√				√	√
3	√		√				√	√			√
4	√		√			√	√		√	√	
5	√			√		√			√		√

Books Recommended

1. Shuler M L, Kargi F, " *Bioprocess Engineering- Basic Concepts*" , 2nded, Prentice Hall of India Ltd. (2002)
2. Aiba S, Humphrey A E and Millis N F ,"*Biochemical Engineering*" , Academic Press (1973)
3. Stanbury P F and Whitaker A, "*Principles of Fermentation Technology*," 2nd edition, Elsevier, (1995)
4. Bailey J E and Ollis D F, "*Biochemical Engineering Fundamentals"* , McGraw Hill (1986)
5. Harvey W. Blanch and Douglas S.Clark, "*Biochemical Engineering*", Marcel Dekker (1996).
6. Lee J M, "*Biochemical Engineering*" , Prentice Hall (1992)

BTMI-402 Biological Waste Treatment, in 8th Semester [3 0 0 3]

Course Objectives:	Conduct basic laboratory experiments and employ standard observational strategies for treating biological wastewater. Develop requisite skills to work in water quality testing, environmental pollution control labs, textile industries etc.

Unit-I

Characteristics of waste water: Physical, chemical and biological; BOD, COD

Primary Treatment: Screening, Grit Chamber, removal of oil and grease.

Aerobic processes of secondary treatment: activated sludge, lagoons, stabilization ponds, suspended growth, nitrification, trickling filters, rotating biological contactors, anoxic suspended growth and fixed film denitrification.

Unit-II

Anaerobic processes of treatment: biological concepts, suspended growth and fixed film processes and reactor configuration, Sequential batch reactor for combined processes (aerobic and anaerobic)

Tertiary Treatment: Effluent disposal and reuse.

Bioenergy from biological waste: Production of biogas and bio hydrogen from various biological wastes by fermentative processes.

Unit-III

Solid waste management: Using biomass, production of Bioenergy from the solid waste

Designing: Wastewater treatment plant, anaerobic biogas generation plant

Course Outcomes:	1. Understand the biological treatment techniques for waste water 2. Understand the principles of waste management 3. Describe the use of biotechnological processes to protect the environment 4. Contrast approaches to anaerobic digestion of wastes and solve related problems

Mapping of course outcome (CO) & program outcomes (PO)

Course Outcomes	Program Outcomes										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1	√	√	√	√	√		√	√	√		
2	√	√	√		√					√	
3	√	√	√				√		√		
4	√	√	√	√	√				√	√	√

Books recommended

1. Metcalf & Eddy, *"Wastewater Engineering"*, 4th edition, TATA-McGraw Hill (2003).
2. Hammer M J, *"Water and Wastewater Technology",* 2nd edition, John Wiley & Sons (1989)
3. Davis M L, Corwell D A, *"Introduction to Environmental Engineering",* 2nd edition, Mc Graw Hill (1991)
4. Peavy H S, Rowe D R, *"Environmental Engineering",* Mc Graw Hill (1985)
5. Eckenfelder W W, *"Industrial Water Pollution Control",* 2nd edition, Mc Graw Hill (1991)