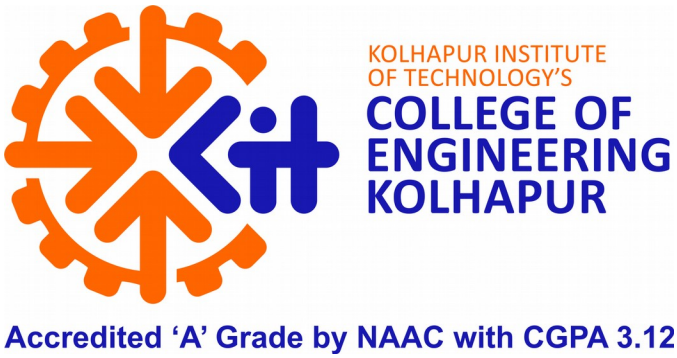
Kolhapur Institute of Technology's College of Engineering, Kolhapur



(Structure & Syllabus)

for

M. Tech Biochemical Engineering & Biotechnology

(Post- Graduate Programme)

Academic Year 2017-2018

Dr. M. R. Sanandam	**Dr. M.S. Chavan**	**Dr. V. V. Karjinni**
B.O.S. Chairman	**Dean Academics**	**Director**

M. Tech. Biochemical Engineering & Biotechnology

Vision of the Department

- **To develop as a Center of Excellence in Biotechnology Engineering and the preferred choice of Faculty, Student, Industry and Society at global level**

Mission of the Department

- To use sophisticated techniques of modern biotechnology to strengthen and develop human resources and institutional capacity.
- To transfer know how and develop appropriate facility and training in biotechnology related subjects considering safety in biotechnology by assessing management risk.

Program Outcomes

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

PO2: An ability to write and present a substantial technical report/document

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

Program Educational Outcomes

PEO1: The Biochemical Engineering & Biotechnology students will be able to independently carry out research /investigation and development work to solve practical problems

PEO2: The Biochemical Engineering & Biotechnology students will be able to write and present a substantial technical report/document

PEO3: The Biochemical Engineering & Biotechnology Students will be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

M . Tech. Program in BIOCHEMICAL ENGINEERING & BIOTECHNOLOGY, Semester-I

Course Code	Course	Teaching Scheme				Evaluation Scheme			
		L	T	P	Credits	Scheme	Weightage		
							Max	Min For Passing	
PBEB0101	Advanced Bioreaction Engineering	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB0102	Advanced protein Engineering	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB0103	Advanced Microbiology & Biochemistry	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB0161	Research Methodology (Audit Course)	2	-	-	-	ISE-I	-	-	40
						ISE-II	-		
						MSE	-		
						ESE	100	40	
PBEB01**	Professional Elective-I	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB01 **	Professional Elective-II	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB0131	Laboratory-1	-	-	2	1	ISE	50	20	20
						ESE POE	50	20	20
PBEB0132	Laboratory-2	-	-	2	1	ISE	50	20	20
						ESE POE	50	20	20
PBEB0141	Seminar I	-	-	2	1	-	-	-	
						ISE	100	40	40
	Total	**18**	**5**	**6**	**23**				

Total Credits: 23

Total Contact Hours/Week: 28Hrs

Note: ESE: End Semester Examination, MSE: Mid Semester Examination, ISE: In Semester Evaluation.

M . Tech. Program in BIOCHEMICAL ENGINEERING & BIOTECHNOLOGY, Semester-II

Course Code	Course	Teaching Scheme				Evaluation Scheme			
		L	T	P	Credits	Scheme	Weightage		
							Max	Min For Passing	
PBEB0204	Bioreactor Design	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB0205	Advanced Enzyme Technology	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB0206	Bioseparations	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB0262	Biological Thermodynamics (Audit)	2		-	-	ISE-I	-	-	40
						ISE-II	-		
						MSE	-		
						ESE	100	40	
PBEB02**	Professional Elective III	3	1	-	4	ISE-I	10	20	40
						ISE-II	10		
						MSE	30		
						ESE	50	20	
PBEB02**	Professional Elective IV	3	1	-	4	ISE-I	10	20	40
						ISE-II	10	20	
						MSE	30	20	
						ESE	50	20	
PBEB0233	Laboratory - 3	-	-	2	1	ISE	50	20	20
						ESE POE	50	20	20
PBEB0234	Laboratory -4	1	-	2	2	ISE	50	20	20
						ESE POE	50	20	20
PBEB0241	Seminar II	-	-	2	1	ISE	100	40	40
PBEB0242	Miniproject			2	1	ISE	100	40	40
Total		18	5	8	25				

Total Credits: 25
Total Contact Hours/Week: 31Hrs

Note: ESE: End Semester Examination, MSE: Mid Semester Examination, ISE: In Semester Evaluation.

M . Tech. Program in BIOCHEMICAL ENGINEERING & BIOTECHNOLOGY, Semester-III

Course Code	Course	Teaching Scheme				Evaluation Scheme			
		L	T	P	Credit	Scheme	Weightage		
							Max		Min For Passing
PBEB0343	Industrial training	-	-	-	2	ISE	50	20	20
PBEB0351	Dissertation I	-	-	-	2	ISE-I	50	20	20
		-	-	-	4	ISE-II	100	40	40
PBEB0352	Dissertation II	-	-	-	4	MSE			
						ESE(OE)	100	40	40
	TOTAL			-	12				

Total Credits: 12

Note: ESE: End Semester Examination, MSE: Mid Semester Examination, ISE: In Semester Evaluation

M . Tech. Program in BIOCHEMICAL ENGINEERING & BIOTECHNOLOGY, Semester-IV

Subject Code	Subject	Teaching Scheme				Evaluation Scheme			
		L	T	P	Credit	Scheme	Weightage		
							Max		Min For Passing
PBEB0453	Dissertation III	-	-	-	4	ISE-III	100	40	40
		-	-	-	4	ISE-IV	100	40	40
PBEB0454	Dissertation IV	-	-	-	8	MSE	-	-	
						ESE(OE)	200	80	80
					16				

Total Credits: 16

Note: ESE: End Semester Examination, MSE: Mid Semester Examination, ISE: In Semester Evaluation

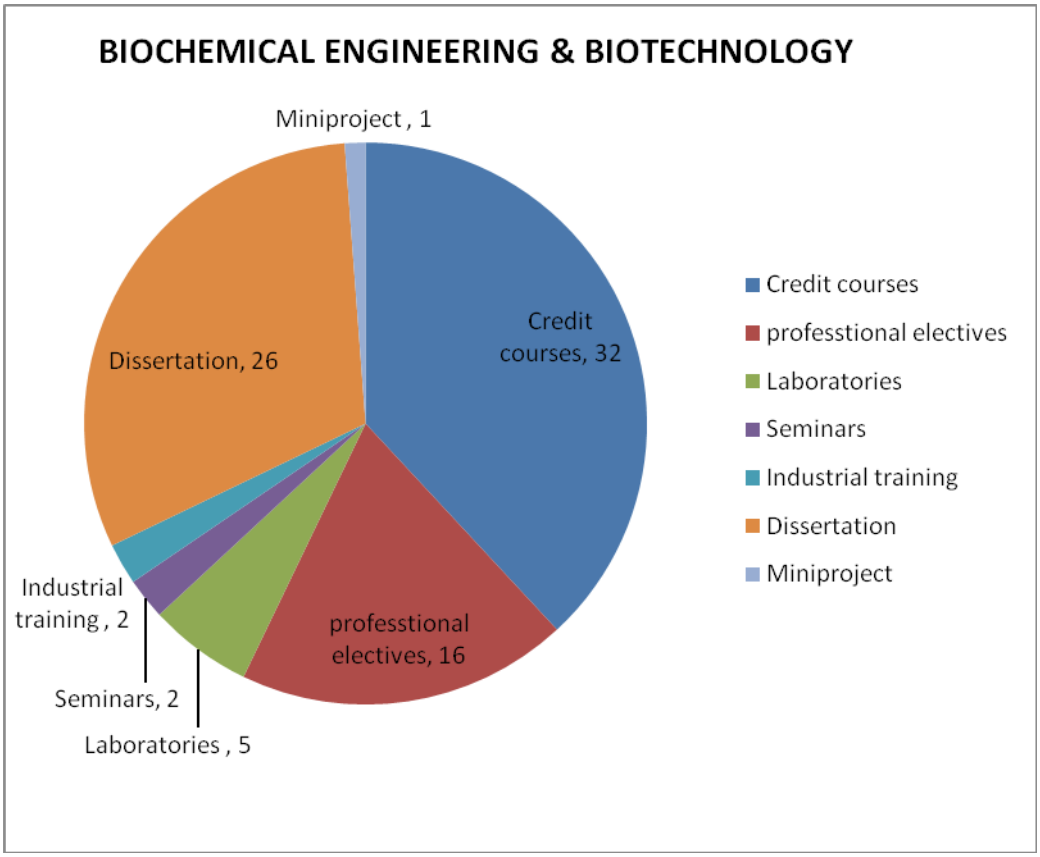
Course Code**	**Professional Elective**
Elective – I	
PBEB0121	Immunotechnology
PBEB0122	Advanced Food Technology

PBEB0123	Environmental Biotechnology
Elective – II	
PBEB0124	Plant Biotechnology
PBEB0125	Pharmaceutical Biotechnology
PBEB0126	Advanced Bioinformatics
Elective – III	
PBEB0221	Animal Biotechnology
PBEB0222	GMP, IPR Biosafety & Bioethics
PBEB0223	Advanced Genetic Engineering
Elective –VI	
PBEB0224	Project management & plant design
PBEB0225	Modeling & simulation of Bioprocesses
PBEB0226	Metabolic Engineering

Kolhapur Institute of Technology's College of Engineering, Kolhapur
Proposed Program Credit Distribution

Curriculum Component	Credits
Credit courses	32
Professional Electives	16
Lab courses	5

Seminar	2
Industrial training	2
Dissertation	26
Miniproject	1
Total	**76**



Title of the Course: Advanced Bioreaction Engineering	**L**	**T**	**P**	**Credit**
Course Code: PBEB0101	**3**	**1**	**-**	**4**

Course Pre-Requisite:

1. The students should have the basic understanding of reactor, reaction kinetics and thermodynamics. The students should know the basic mathematical calculations.
2. The students must be aware of the types of reactor and their applications
3. The student should have the basic knowledge of unit operations.

Course Description:

This course is designed to study reaction kinetics and various parameters of kinetics. It will also elaborate reactor performance with respect to kinetics.

Course Objectives:

1. To introduce reaction rate theory, general reaction kinetics of biological system
2. To study enzyme and cell kinetics
3. To explain heterogeneous reaction kinetics

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	To describe reaction rate theory, general reaction kinetics of biological system	Cognitive	Select
CO2	Explain principles involved in enzyme kinetics and techniques for analyzing rate data. Describe basic concepts in microbial process kinetics.	Cognitive	Demonstrate
CO3	Study heterogeneous reaction kinetics	Cognitive	Explain

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	1	3
CO2	1	1	3
CO3	1	1	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Basic reaction theory Basic reaction theory: Reaction Thermodynamics, Reaction yield, Reaction rate, Reaction kinetics, Effect of temperature on reaction rate. Calculation of Reaction Rates from Experimental Data: Average Rate –Equal area method, Mid-point slope method.	**10 Hrs.**
Unit 2:--- General reaction Kinetics for biological system General reaction Kinetics for biological system: Zero –order kinetics, First-order kinetics, Michaelis-Menten Kinetics, effect of conditions on enzyme reaction rate. iv. Determining enzyme kinetic constant from batch data: Michaelis-Menten plot, Lineweaver Burk plot, Eadie-Hofstee plot. Langmuir plot, Direct linear plot. Kinetics of enzyme deactivation.	**10 Hrs**
Unit 3:--- Microbial Kinetics Yield in cell culture: Overall and Instantaneous yields. Theoretical and observed yields. Cell growth kinetics: Batch Growth, Balanced growth, Effect of substrate concentration. Growth kinetics with plasmid instability. Production kinetics in cell culture: Product formation directly coupled with Energy	4 **Hrs.**

metabolism, product formation indirectly coupled with energy metabolism. Product formation not coupled with energy metabolism. Kinetics of substrate uptake in cell culture: Substrate uptake in the absence of product formation. Substrate uptake with product formation. Effect of culture condition on cell kinetics Determining cell kinetic parameters from batch data: Rates of growth, product formation and substrate uptake, μmax and Ks Effect of Maintenance on Yields: Observed yields, Biomass yield from substrate, Product yield from Biomass, Product yield from substrate. Kinetics of cell death.	
Unit 4:--- Heterogeneous reaction in bioprocessing. Introduction, Concentration gradients and reaction rates in solid Catalysts: True and observed reaction rates, interaction between mass transfer and reaction. **Internal mass transfer and reaction**: Steady state shell mass balance, concentration profile: First-order kinetics and spherical geometry, concentration profile: zero –order kinetics and spherical geometry. Concentration Profile: 4 Michaelis –Menten Kinetics and spherical Geometry, Concentration profiles in other geometries, Prediction of observed reaction rate	8 **Hrs.**
Unit 5:--- The Thiele modulus and effectiveness factor First order kinetics, zero order kinetics Michaelis-Menten Kinetics, The observable Thiele modulus, Minimum Intracatalyst Substrate concentration.	8 **Hrs.**
Unit 6:--- External mass transfer, Liquid solid mass transfer correlations: Free moving spherical particles. Experimental Aspects: Observed Reaction rate, effective diffusivity. Minimizing mass transfer effects: Internal mass transfer, external mass transfer. Evaluating the true kinetic parameters. General comments on Heterogeneous reactions in Bioprocessing.	8 **Hrs.**

Textbooks:

1. Chemical Reaction Engineering- Levenspile, O. (Wiley)
2. Chemical Engineering Kinetics- Smith, J. ((McGraw Hill, New York)
3. Reaction Kinetics for Chemical Engineers- Walas, S.M. (McGraw Hill, New York)
4. Elements of Chemical Reaction Engineering- Scott. H. Fogler, (EES publication).
5. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.)

References:

1. Biochemical Engineering Fundamentals- Bailey andOllis, (McGraw Hill, New York)
2. Bioreaction Engineering-Schergeri, K. (John Wiley)
3. Bioprocess Engineering: Basic Concepts – Shuler M.L., Kargi F. (Prentice Hall of India)
4. Process Biotechnology Fundamentals, Mukhopadhaya, S.N. (Viva Books Pvt. Ltd.)
5. Biochemical Engineering- Blanch H.W. and Clark, D. S. (CRC Press)

Unit wise Measurable students Learning Outcomes:

Students are able to

1. Find reaction yield and rate.
2. Explain enzyme kinetics
3. Develop various kinetic equations for microbial reactions.
4. Determine reaction rate for Heterogeneous reaction in bioprocessing
5. Evaluate effectiveness factor for Heterogeneous reaction in bioprocessing
6. Estimate external mass transfer parameters.

Title of the Course: Advanced Protein Engineering	**L**	**T**	**P**	**Credit**
Course Code: PBEB0102	**3**	**1**	**-**	**4**

Course Pre-Requisite:

1. The students should have the basic understanding of the physiological unit of life- the cell
2. The students should know basic biophysics and bioorganic chemistry in order to follow the physicochemical properties and functions of proteins
3. The students know the concept of amino acids and their contribution to protein function.
4. The students should know the biosynthesis of proteins, post translational modifications of proteins and its significance
5. The students must be aware of the genetic engineering techniques

Course Description:

1. This course is related to design tailor made protein with novel functions

2. This course compares the biochemical properties in natural and engineered protein with respect to its structure, functional property, its production.

Course learning objectives:

1. To introduce the range of proteins with its significance in physiological, medical and industrial sectors and to define protein engineering, its scope and applications.
2. To explain, describe and locate the various structure levels of protein, thermodynamics and kinetics of folding
3. To analyze the conformational stability by optical spectroscopy, gel electrophoresis and immunochemical methods
4. To identify and select strategies for designing novel proteins by chemical modification or genetic manipulation like SDM, DNA shuffling, rational and random mutagenesis

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	**Bloom's Cognitive**	
		Level	**Descriptor**
CO1	List the range of proteins and recognize its significance and need for altering the functionality by protein engineering strategies.	Remembering	Receiving (affective domain)
CO2	Categorize, compare and differentiate amino acids and correlate their physicochemical properties with structure level and functional contribution.	Understanding	Responding (affective domain)
CO3	Use optical spectroscopic, gel electrophoresis, immunochemical techniques to analyze conformational stability and calculate apparent folding	Applying	Valuing (affective domain)
CO4	Plan and design strategies for novel protein synthesis by SPPS, SDM, PCR, RACHITT, DNA shuffling.	Analyzing	Organizing (affective domain)
CO5	Solve problems for enzyme, antibody, therapeutic protein engineering for novel desired functions	Evaluating	Organizing (affective domain)

PEO1: The Biochemical Engineering & Biotechnology students will be able to independently carry out research /investigation and development work to solve practical problems
PEO2: The Biochemical Engineering & Biotechnology students will be able to write and present a substantial technical report/document
PEO3: The Biochemical Engineering & Biotechnology Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Protein Engineering CO-PO Mapping:

CO	**PO1**	**PO2**	**PO3**
CO1	3	1	
CO2	2		2

CO3	2		3
CO4	3	3	3
CO5	3	2	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weight age for course content (normally last three modules) covered after MSE.

Course Contents:

SECTION I **UNIT: 1 Protein Structure, folding and chemical modification methods** Levels of protein structure, amino acids correlation with structure level and functional contribution, protein structure prediction, sequence homology searches, protein folding pathways in prokaryotes and eukaryotes; motifs of protein structure and their packaging: alpha domain, alpha/beta domain, antiparallel beta pleat structure, protein folding of single domain and multi-domain protein; thermodynamics and kinetics of protein folding, solubilization of inclusion bodies and recovery of active proteins, osmolyte assisted protein folding, chemical modification of heterologous proteins.	**6 Hrs.**
UNIT: 2 Protein mapping and conformational analysis Protein mapping; methods of chemical and enzymatic fragmentation of proteins, protein sequencing methods, conformational analysis by optical spectroscopic, gel electrophoresis, immunochemical techniques to analyze conformational stability and calculate apparent folding	**5 Hrs.**
UNIT: 3 Methods of protein engineering Random and Site directed mutagenesis, PCR and error PCR based strategies for protein engineering, DNA/Gene Shuffling, Directed molecular evolution strategy-Phage Display systems, Cell Surface display systems, RACHITT, ITCHY.	**7 Hrs.**
SECTION II **UNIT: 4 Design of Novel proteins** Strategies for the design of structure- Self assembly of Modular Units of secondary structure, Ligand-induced Assembly, Assembly of peptides via Covalent cross linking, Assembly of peptides on a synthetic Template, Protein design by binary patterning of polar and non polar amino acids, Design of catalytically active proteins. All topics will deal with case studies.	**6 Hrs.**
UNIT: 5 Engineering of Therapeutic Proteins Engineering of Human growth hormone (rHGH), human insulin, Tissue plasminogen activator(t-PA), Erythropoietin(EPO), Interferon(IF), HPV vaccine proteins, glucocerebrosidases	**7 Hrs.**
UNIT: 6 Enzyme Engineering Protein engineering to improve enzyme catalytic efficiency, protein engineering to	**5 Hrs.**

improve enzyme stability, protein engineering to improve enzyme enantio selectivity, example subtilisin, lipase.	

TEXT BOOKS:

1. Protein Engineering- Pravin Kaumaya
2. Protein Engineering and design- Paul R. Carey(Academic Press)
3. Novel Therapeutic Proteins-Klaus Demobowsky (Wiley Publications)
4. Microcharacterisation of Proteins- Ronald Kellner (Wiley Publication)
5. Directed Molecular Evolution of proteins- Susane Brakmann (Wiley Publication)
6. Protein Engineering practices and principles-Jeffrey L.Cleland (Wiley Publication)
7. Protein Structure, a practical approach- T.E.Creighton (Oxford University Publication)
8. Protein Function, a practical approach- T.E.Creighton (Oxford University Publication)

References:

1. 1] Lehninger- Principles of Biochemistry by Nelson and Cox – W. H. Freeman and Company Pub.
2. 2] Protein Structure and Function, by David Whitford (Wiley Publications)

Unit wise Measurable students Learning Outcomes:

Unit 1. At the end of the unit the student will be able to-

1) To describe the folding pathways in prokaryotes and eukaryotes
2) To explain protein folding thermodynamics and kinetics
3) To define inclusion bodies and solve its activity loss by analyzing various strategies for IB recovery

Unit 2. At the end of the unit the student will be able to-

1) Identify the effect of amino acids and its predict its contribution towards structure levels and reactivity
2) Carry out analysis to find apparent fraction of folding

Unit 3. At the end of the unit the student will be able to-

1) Explain scope and importance of protein engineering
2) Explain and describe various random and rational methods of mutagenesis

Unit 4. At the end of the unit the student will be able to-

1) Compare and differentiate protein design strategies of self assembly, ligand induced, covalent cross linkages

Unit 5. At the end of the unit the student will be able to-

1) To explain, describe and plan design strategies for engineering of antibodies, human insulin, TPA, Human growth hormone, Interferon

Unit 6. At the end of the unit the student will be able to-

1) To explain, describe and plan design strategies for engineering of enzymes for improving catalytic efficiency, stability, enantioselectivity

Title of the Course: Advanced Microbiology and Biochemistry	**L**	**T**	**P**	**Credit**
Course Code: PBEB0103	**3**	**1**		**4**
Course Pre-Requisite: **1.** The students should have the basic knowledge of microorganisms, structure, applications. **2.** The students should be aware of the properties and application of biomolecules.				
Course Description: 1. It deals with the role of microbial and plant metabolic pathways for growth and bioproduct formation. 2. Application and production of biomolecules for biomedical, food, pharmaceutical, agriculture sectors.				
Course Learning Objectives: 1. To identify the microbial diversity, their growth and factors influential in its growth. 2. To learn making use of biomolecules like polysaccharides, lipids and proteins for biotechnological applications. 3. To analyze the fermentative pathways- primary and secondary - that are growth linked and non growth linked for product formation. 4. To plan and select substrate utilization for fermentative pathways. 5. To study bacterial genetics and its application for recombinant genetic engineering.				

Course Learning Outcomes:

CO	After the completion of the course the student should be able -	Bloom's Cognitive level	Descriptor
CO1	To identify the microbial diversity, their growth and factors influential its growth	Understanding	Receiving (affector domain)
CO2	To make use of bacterial genetics and its application for genetic engineering	Applying	Responding (affector domain)
CO3	To analyze biomolecules like polysaccharides, lipids and proteins for biotechnological applications	Analyzing	Valuing (affector domain)
CO4	To choose the fermentative pathways- primary and secondary - that are growth linked and non growth linked for product formation	Evaluating	Organizing (affector domain)
CO5	To plan and select substrate utilization for fermentative pathways	Synthesizing	Organizing (affector domain)

PEO1: The Biochemical Engineering & Biotechnology students will be able to independently carry out research /investigation and development work to solve practical problems
PEO2: The Biochemical Engineering & Biotechnology students will be able to write and present a substantial technical report/document
PEO3: The Biochemical Engineering & Biotechnology Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Adv. Microbiology and Biochemistry CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	1	
CO2	2		2
CO3	3	3	3
CO4	3		3
CO5	3	1	3

Assessments :
Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content

(normally last three modules) covered after MSE.	
Course Contents:	
SECTION I **Unit 1:--- Microbial Cell Structure (Special emphasis on Cell Wall & Membrane) and Microbial Diversity** Microbial diversity in environmental samples, Structural differences between different microbial cell types and cellular organelles; Biochemical/Microscopic methods used to differentiate between archae, eubacteria and eukaryotes; Cell wall of prokaryotes; Outer membrane of Gram –ve and Gram +ve bacteria and control of its synthesis; Potential targets for drug design.	4 **Hrs.**
Unit 2:--- Biomolecules, Principles of Microbial Nutrition and growth Importance of macromolecules and their organization; Microbial nutrition; Different types of culture medium; C/N/P balance, Vitamins and coenzymes; and making of culture medium, Concept of limiting nutrient and its effect on cell growth, Microbial growth curve, effect of environmental factors on microbial growth. Metabolism of substrates other than Glucose, i. Lactose, Mannitol, Fucose, Rhamnose ii. Pectin, Cellulose and Starch, lignin, iii. Metabolism of aromatic compounds. iv. Energy from oxidation of inorganic electron donors; Iron oxidation; Nitrate and Sulfate reduction; Acetogenesis; Methanogenesis; Chlorophylls and other pigments involved in microbial photosynthesis; Autotrophic CO_2 Fixation: Calvin cycle	11**Hrs.**
Unit 3:--- Microbial genetics and metabolic regulation & engineering Bacterial Genetics, DNA exchange, Modes of recombination, mutagenesis, repair. Mutations and their chemical basis; Mutagens and their use in Biotechnology; **Gene Regulation** Gene regulation in prokaryotes. The operon model – lac, ara, trp operons and gene regulation. **Metabolic regulation and engineering-** Regulatory mechanisms for control of enzyme synthesis - an overview; compartmentalization, catalytic repression and expression, Control of enzyme activity- proteolysis, covalent modification and ligand binding; feedback inhibition and concept of metabolic flux; Pathway engineering; Strategies to overcome regulatory mechanisms for over-production of several industrially important enzymes and therapeutic proteins.	7 **Hrs.**
SECTION II **Unit 4:--- Carbohydrates** Introduction, Molecular structure of polysaccharides, Enzymes degrading polysaccharides, Physical properties of polysaccharides, Production of microbial Polysaccharides, Food usage of exopolysaccharides, Industrial Usage of exopolysaccharides, Medical applications of exopolysaccharides.	8 **Hrs.**
Unit 5:--- Lipids Molecular structure of lipids, Physical properties of lipids, Oleaginous microorganisms and their principal lipids, Production of microbial lipids, Modification of lipids for commercial applications, Extracellular microbial lipids and biosurfactants, Micelles and reverse micelles in biology, Liposomes in drug delivery.	-8 **Hrs.**
Unit 6:--- Plant Secondary metabolites: Biosynthesis of terpenes, phenylpropanoids and nitrogenous compounds (Alkaloids) and their ecological roles.	-8 **Hrs.**

Metabolic engineering of plant secondary metabolites in plants. Secondary metabolites as phytomedicines and phytoalexins.	

Textbooks:

i. Pelczar, M.J., Chan, E.C.S. and Krein, N.R., “Microbiology”, Tata, 1997.
ii. McGraw PublicationNelson DL- Principles of Biochemistry, 5th edition, W.H. Freeman, 2009.
iii. EL- Mansi- Fermentation Microbiology and Biotechnology.
iv. Prescott, L.M., Harley, J.P. and Klein, D.A., “Microbiology”, W. C. Brown publications,1996
v. Schlegel Hans G -General microbiology 7th edn. Cambridge university press,1993.
vi. Lincoln, Taiz., & Eduardo, Zeiger.,“ Plant Physiology” 5 th Edn., Publisher: Sinauer Associates, Inc. , 2010.
vii. Hari Shankar Srivastava “Plant Physiology” Rastogi publications, 2005.
viii. Horton, H.R., Moran, L.A., Ochs R.A., Rawn, J. D. and Scrimgeor, R.S., “Principles of Biochemistry” 3rd edition Prentice Hall,.

References:

1] Microbial physiology by Moat
2] Watson, J.D., Baker, T. A., Bell, S. P., Gann, A., Levine, N. and Lovisk, R., “Molecular Biology of the gene “5th Edition, Pearson Education, 2004.

Unit wise Measurable students Learning Outcomes:

1. The student will be able to identify the microbial diversity, their structure and biosynthesis of cell wall and membrane with respect to drug targets.
2 The student will be able to analyze the utilization of various substrates like carbohydrates , aromatic compounds for fermentative pathways that are growth linked and non growth linked product formation
3 The student will be able relate the bacterial genetics, metabolic regulations and engineering for enzymes and therapeutic protein expressions.
4 The student will be able to make use of biomolecules like polysaccharides for biotechnological applications
5 The student will be able to make use of biomolecules like lipids and proteins for biotechnological applications
6 The student will be able relate plant secondary metabolites and its applications

Title of the Course: Research Methodology	**L**	**T**	**P**	**Credit**
Course Code: PBEB0161	**2**	-	-	

Course: There are no Pre-Requisite for this course

Course Description: This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches.

Course Objectives:

1. Defending the use of Research Methodology
2. Judging the reliability and validity of experiments
3. Perform exploratory data analysis
4. Draw conclusions from categorical data
5. Using computer-intensive methods for data analysis
6. compare statistical models

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Defend the use of Research Methodology	Affective domain	Defend
CO2	Judge the reliability and validity of experiments	Psychomotor	Judge
CO3	perform exploratory data analysis	Psychomotor	analysis

CO4	draw conclusions from categorical data	Psychomotor	conclude
CO5	Use computer-intensive methods for data analysis	Psychomotor	data analysis
CO6	Drawing conclusions from statistical test results & compare statistical models	Psychomotor	compare

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	1	1
CO2	3	1	1
CO3	1	1	2
CO4	1	3	2
CO5	3	1	1
CO6	3	1	1

Assessments :
Teacher Assessment:
One End Semester Examination (ESE) having 100% weightage.

Assessment	Marks
ISE 1	-
MSE	-
ISE 2	-
ESE	50

ESE: Assessment is based on 100% course content

Course Contents:

Unit I: Introduction to Research An Introduction, Meaning of Research , Objectives of Research, Motivation in Research, Types of Research, Research Approaches , Significance of Research , Research Methods versus Methodology Research and Scientific Method , Importance of Knowing How Research is Done , Research Process Criteria of Good Research, Problems Encountered by Researchers	5 **Hrs.**
Unit II: Research Design Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs	4 **Hrs.**
Unit III: Sampling Design Need for sampling, Population, Sample, Normal distribution, Steps in sampling, Systematic bias and Sampling error, Characteristics of good sample design, Probability sampling and Random sampling, Determination of sample size	4 **Hrs.**
Unit IV: Results and Analysis Importance and scientific methodology in recording results, importance of negative results, Different ways of recording, industrial requirement, artifacts versus true results, types ofanalysis (analytical, objective, subjective) and cross verification, correlation with published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc	4 **Hrs.**

Unit V : Measurement and Scaling Techniques Introduction, Concept of measurement - Measurement of scale, Developing measurement scale, Criteria of good measurement tools, Error measurement. Concept of Scaling, Classification, Approaches of scale construction, Types of scales - Rating scale, Ranking scale, Arbitrary scale, Differential scale, Summated scale, Cumulative scale, Factor scale	3 **Hrs.**
Unit VI: Data Collection and Analysis of Data Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Data Processing Operations, Problems in Processing, Elements/Types of Analysis	4 **Hrs**

Textbooks:

1. Books: C. R. Kothari, "Research Methodology", New Age international, 2004.
2. Deepak Chopra and Neena Sondhi, "Research Methodology : Concepts and cases", Vikas Publishing House, New Delhi, 2008.
3. Ranjit Kumar, "Research Methodology: A Step by Step Guide for Beginners", 2nd Edition, Sage Publisher, 2011.

1. Kothari C.K., Research Methodology- Methods and Techniques (New Age International, New Delhi), 2004..

Unit wise Measurable students Learning Outcomes:

1. Recall research terminology
2. Be aware of the ethical principles of research, ethical challenges and approval processes
3. Describe quantitative, qualitative and mixed methods approaches to research
4. Identify the components of a literature review process
5. Critically analyze published research
6. Discuss Research Methodology

Title of the Course: Immunotechnology **(Professional Elective –I)** **Course Code:** PBEB0121	**L**	**T**	**P**	**Credit**
	3	**1**	**-**	**4**

Course Pre-Requisite: Students admitted for this course will be expected to have sufficient background knowledge of Cell biology , general biology and Basic immunology.

Course Description: The course covers central topics in immunoTechnology .The focus is on the immune system in health & disease situations where faulty B:T cell interactions are involved.and Ag-Ab interactions in immunotechnology. Furthermore, attempts to manipulate the immune response are described. The topics are presented as lectures, and the students are required to read review articles, write Tutorials as well as a textbook in immunobiology. Each student presents a research article for the group.

Course Objectives:

1. To write the structure, component, function and mechanism of immune system.
2. Primary emphasis of this course is to explain mechanisms involved in immune system development and responsiveness
3. To demonstrate the advanced concepts of immunotechnology and the associated vocabulary
4. To identify & apply immunotechnological knowledge to solving new problem
5. To become proficient with selection & the use of the major investigation tools in immunotechnology
6. To become comfortable discussing immunotechnology ideas with various audiences

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Students will be able to recall the immune System , the immunotechnology and its applications to Biotechnology	Knowledge	Recall
CO2	Students will be able to explain the immune System & the immunotechnology applications	Comprehension	Explain
CO3	Students will be able construct the immunodiagnostics setup for a industry or diagnostic kit	Application	construct
CO4	Students will be able to justify to innovate and patent a immunodiagnostic idea, instrument or kit	Analysis	Justify & Innovate
CO5	Students will be able to combine antigen – antibody interactions, work in immunology R & D Lab, Industry	Synthesis	develop
CO6	Students will be comfortable discussing immunological ideas with various audiences such as evaluate, defend, criticize, conclude & summarize	Evaluation	Discussing such as evaluate, defend, criticize, conclude & summarize

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	1	1
CO2	3	1	1
CO3	1	1	2
CO4	1	2	2
CO5	3	1	1
CO6	3	1	1

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Hybridoma techniques and monoclonal antibody production-myeloma cell lines-fusion of myeloma cells with antibody producing B-cells-fusion methods- selection and screening methods for positive hybrids-cloning methods-production, purification and characterization of monoclonal antibodies. Application of monoclonal in biomedical research, in clinical diagnosis and treatment. Production of human monoclonal antibodies and their applications.	7**Hrs.**
Unit 2:--- T-Cell Cloning-mechanism of antigen recognition by T and B-lymphocytes. Structure, function and synthesis of lymphokines-Importance of antigen presentation and MHC class II molecules in T-cell cloning- antigen specific and alloreactive T-cell cloning-use of T-cell cloning in understanding the immunologically relevant antigens and T-cell eptiopes-application of T-cell cloning in vaccine development.	7 **Hrs.**
Unit 3:--- Immunity to viruses, bacteria and parasites Genetic control of immune response-MHC associated predisposition to diseases-infectious disease, leprosy, tuberculosis, malaria, filariasis, amoebiasis, rabies, typhoid, hepatitis, AIDS	7 **Hrs.**
Unit 4:--- Principles and strategy for developing vaccines, Newer methods of vaccine preparation-Conventional and modern types of vaccines-virus vaccines, DNA vaccines and specific vaccines. Techniques of preparation of vaccines, Human recombinant antibodies and their applications in medicine and industry.	7 **Hrs.**
Unit 5:--- Immunodiagnosis of infectious diseases. Polyclonal antibodies, their production and application, Western blot analysis, Immunohistochemistry, Immunoenzymatic ferritin technique , Elisa principle and application , Radioimmunoassay ,Chemiluminosis.	7 **Hrs.**
Unit 6:--- Characterization of animal cells and their implication on process design:	7**Hrs.**

Nutritional requirements and serum free culture of mammalian cells, Kinetics of growth and product formation. Reactor systems for large scale production using animal cells. Purification of antibodies.	

Textbooks:

1. "Monoclonal antibodies: Principle and practice" by J.W.Goding Academic Press.
2. "Hybridoma Technology in the Biosciences and Medicine" T.A.Sringer (Editor) Plenum Press, N.Y.
3. "Hybridoma Techniques: A Laboratory Course" by VR.Muthukkaruppan,S. Baskar and F.Sinigagalia, Macmillan India Ltd.
4. "Basic and Clinical Immunology" by D.P Stites,J.D.Stobo, H.H.Fudenberg J.V. Wells.5th Edition Large Medical Publications.
5. Isolation,Characterization and Utilization of T-lymphocyte clones" by C.Garrison Fathman,F.W.Fitch academic Press.
6. "Immunotechnology: Principle, Concepts and applications" by Anthony Moran, Publisher John Wiley and Sons,2006.
7. Kuby,J-Immunology,5th edn.(W.H.Freeman & Co,N.Y.2003).
8. Abdul,K. Abbas, Andrew K Lightman, Jordan S Pober, Cellular and Molecular Immunology (Saunders College Pub,,1998.

References:

1. Principles of gene manipulation Old & Primrose.
2. Garrison Fathman,C.and Fitch,F.W.-Isolation,Characterization and utilization of T lymphocyte clones.
3. Ivan Roitt,Jonathan Brostoff and David Male –Immunology,3rd Edn.(Mosby Year Book Europe.Ltd,.England,1993)
4. Paul W.E.(Eds)-Fundamentals of Immunology,(Raven Press, New York,1998)
5. Harlow and David Lane –Antibodies: A laboratory manual, 1998 (old spring harbor laboratory).
6. Silverstein, Arthur M-A history of Immunology,(Academic Press ISBN: 021643770X).
7. Fernandex-Botran, Rafael-Advanced Methods in Cellular Immunology,(CRC Press ISBN:0849321255)
8. Roderick Nairn and Mathew Helbert-Immunology for Medical Students, (Mosby Intl.Ltd.2002.

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Unit wise Measurable students Learning Outcomes:

After completing the course you will:

1. Have recall how B and T cells encounter antigen and develops in different locations.
2. Know MHC antigen presentation and autophagy on a detailed molecular level

3. Understand immunology of mucosal surfaces and the interplay between commensal flora and and the immune system in the gut
4. Have a in depth knowlege of the Genetic basics cellular and molecular basis for disease.
5. Have basic knowlegde of tumor immunology and the development of novel recombinant antibodies for treatment of cancer and autoimmune disease
6. Gain in depth knowlegde of a relevant field of immunotechnological research and critically discuss this with the group.

Title of the Course: ADVANCED FOOD TECHNOLOGY (Professional Elective –I) **Course Code:** PBEB0122	**L**	**T**	**P**	**Credit**
	3	**1**	**-**	**4**
Course Pre-Requisite: Biochemistry, bioprocesses				
Course Description: Course emphasizes on food analysis, processing, packaging and preservation.				
Course Objectives: 1. Process manufactured food. 2. Outline the process of red and white meat slaughter, explain meat structure and inspect meat quality parameters 3. Identify the areas of concern in the processing of milk, meat, fish products, in relation to process control, undesirable microbes. 4. Explain chemical and physiological structure of different food. 5. Demonstrate food processing, preservation and packaging techniques				
Course Learning Outcomes:				

CO	After the completion of the course the student will be able to	Bloom's Cognitive level	Descriptor
CO1	1. Process manufactured food	Cognitive	Outline
CO2	2. Outline the process of red and white meat slaughter, explain meat structure and inspect meat quality parameters.	Psychomotor	Process
CO3	3. Identify the areas of concern in the processing of milk, meat, fish products, in relation to process control, undesirable microbes.	Cognitive	Identify
CO4	4. Explain chemical and physiological structure of different food.	Psychomotor	Explain
CO5	5. Demonstrate food processing, preservation and packaging techniques	Psychomotor	Demonstrate

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit: 1 Food Chemistry	**4 Hrs.**
Chemistry of the major organic constituents of food their properties and function. ii. Minor components of sensory importance in food including flavor compounds and pigments. iii. Milk products, detailed chemistry of the major components and their behavior during processing. Milk constituents and their significance. iv. Dairy products, chemistry and technology of dairy products including liquid milk products, cheese and fermented milks, concentrated and dehydrated milk products, butter and breads, Analysis of milk. v. Fresh and processed meat products, definition of meat, composition of muscles, myofibrillar proteins, regulatory and cytoskeleton proteins, conversion of muscle into meat. Normal and preserved conditions cold shortening. Thaw vigor, myoglobin and meat color. Factors affecting meat color, meat flavor, sausage manufacture, Myofibrillar protein functionality and effect of salt and phosphates on functionality, low fat meat products	
Unit: 2 Food Microbiology	**8 Hrs.**

i. Microbiology in food and factors affecting their growth. ii. Preservation of food iii. Food Spoilage iv. Food poisoning and food borne diseases v. Sanitation of food plants vi. Bacteriology of water-Sampling, inspection	
Unit 3: Preservation Technology : i. Canning, dehydration, sterilization ii. Emulsification, sterilization, drying iii. Role of Lactic acid in food preservations in Sauerkraut iv. Waste treatment.	**8 Hrs.**
Unit 4: Improved technology for food processing i. Enzymes in bakery and cereal products ii. Enzymes in fruit juice production iii. Enzymes in cheese making and beverage production.	**8 Hrs.**
Unit 5: Analysis of major food ingredients i. Analysis of preservatives-natural and synthetic ii. Food colors. iii. Food flavor enhancing agents. iv. Chemical measurements Detection and measurement-heavy metals, fungal toxins, bacteria-toxins, herbicides, Pesticides, toxins.	**8 Hrs.**

References:

1. Hamm, Wolf and Hamilton, R, J. “Edible Oil Processing”, Blackwell / Ane Books, 2004. 2. Morris, Peter C and Bryce, J.H. “Cereal Biotechnology”, CRC / Wood Head, 2000.

3. Arthey, David and Ashwat P.R. “Fruit Processing: Nutrition, Products, and Quality Management”, 2nd Edition, Springer, 2005.

4. Eckles, C.H., W.B. Combs and H. Macy “Milk and Milk Products”, 4th Edition, Tata McGraw-Hill, 1973.

5. Singh, I.S. “Post-Harvest Handling and Processing of Fruits and Vegetables” Westville Publishing, 2009.

6. Srivastava, A.P. et al., “Mechanisation of Vegetable Production and Post-Harvest Management”. Westville Publishing, 2009.

Fortin, N.D. “Food Regulation : Law, Science, Policy, and Practice”. John Wiley, 2009.

7. Lightbourne, Muriel “Food Security, Biological Diversity and Intellectual Property Rights” Ashgate, 2009.

8. Mehta, Rajesh and J. George “Food Safety Regulation Concerns and Trade : The Developing Country Perspective”. Macmillan, 2005.

9. Robertson, G.L. “Food Packaging : Principles and Practice”. 2nd Edition. Taylor & Francis, 2006.

10. Han, Jung H. “Innovations in Food Packaging”. Elsevier, 2005.

11. Ahvenainen, Raija. “Novel Food Packaging Techniques”. Wood Head Publishing, 2003.

12. Mathlouthi, M. “Food packaging and Preservation”. Aspen Publications, 1999.

13. Rao, M.A. et al., “Engineering Properties of Foods”. 3rd Edition. CRC/Taylor& Fransis, 2005.

14. Gopala Rao, Chandra “Essentials of Food Process Engineering”. BS Publications, 2006.
15. McCabe, W.L., J.C. Smith and P.Harriot “Unit Operations of Chemical Engineering”, 7thEdition, Mc Graw Hill, 2007.
16. Geankoplis, C.J. “Transport Processes and Separation process Principles”, 4th Edition, PHI, 2006.
17. Subbulakshmi, G., and Shobha A. Udipi “Food Processing and Preservation”.New Age Publications, 2006.

Unit wise Measurable students Learning Outcomes:
At the end of Unit Students will be able to –
1. Process manufactured food.
2. Outline the process of red and white meat slaughter, explain meat structure and inspect meat quality parameters
3. Identify the areas of concern in the processing of milk, meat, fish products, in relation to process control, undesirable microbes.
4. Explain chemical and physiological structure of different food.
5. Demonstrate food processing, preservation and packaging techniques

Title of the Course: Environmental Biotechnology	**L**	**T**	**P**	**Credit**
Course Code: PBEB0123	**3**	**1**	**-**	**4**

Course Pre-Requisite: Nil

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

Course Objectives:
After completing the course students are able to,
1. To develop knowledge and skills to know the nature and source of waste water, and treatment objectives, influence the type, number and sequence of unit processes.
2. To understand the fundamental, scientific basis governing the design and performance of the treatment technologies reviewed in the module
3. To apply their knowledge of the principles of biotechnology and its treatments to the design of each unit process reviewed in the module.

Course Learning Outcomes:

1) To acquaint the students the scientific and engineering principles of Microbiological treatment Technologies to clean up contaminated Environment

2) To explain soil, air, water pollution and waste management and various Environmental laws and policies

3) Explain the techniques for biological waste treatment

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Define Microbial diversity and its isolation techniques.		
CO2	Understand and treat soil, air, water pollution and waste management through Biotechnological methods.		
CO3	Develop bioremediation techniques for non degradable pollutants.		
CO4	Design experiments for biofuel production		
CO5	Evaluate Environmental laws and policies for the global environmental problems.		

CO-PO Mapping:

CO	1	2	3
CO1	1	2	3
CO2	2	2	3
CO3	0	1	3
CO4	0	2	3
CO5	0	1	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

UNIT I- ACTIVATED SLUDGE PROCESS-PROCESS ANALYSIS AND SELECTION Characteristics of Activated Sludge (aerobic and anaerobic); Reactors used in waste water treatment- Up Flow, Anaerobic Sludge Blanket (UASB), and Fluidized Aerobic Bio – Reactor (FAB).	6 **Hrs.**

UNIT II-AEROBIC FIXED-FILM & ANAEROBIC TREATMENT PROCESSES Biofilm process considerations; Trickling Filters and Biological Towers; Rotating Biological Contactors; Granular – Media Filters; Fluidized – Bed & Circulating Bed- Biofilm reactors. Hybrid Biofilm/suspended growth processes. Anaerobic Processes: Methanogenesis, process chemistry and microbiology; process kinetics and factors for the design of anaerobic digestors.	**12 Hrs.**
UNIT III- RECYCLING TECHNOLOGY FOR WASTES Recycling of Industrial wastes : paper, plastics, leather and Chemicals, waste water, Bioremediation, phyto-remediation Technology.	4 **Hrs.**
UNIT IV-BIOLOGICAL PHOSPHORUS REMOVAL Nitrification & Denitrification Processes: Biochemistry and Physiology of Nitrifying Bacteria; Common process considerations; Physiology of Denitrifying Bacteria; One- sludge denitrification. Normal Phosphorus Uptake into Biomass; Mechanism for Biological Phosphorus Removal; Enhanced Biological Phosphorus Removal by Bacteria and Algae.	9**Hrs.**
UNIT V- ADVANCED WASTE WATER TREATMENT Technologies used in advanced treatment – Classification of technologies; Removal of Colloids and suspended particles – Depth Filtration – Surface Filtration – Membrane Filtration Absorption – Ion Exchange – Advanced oxidation process - Activated Carbon, Air Stripping, Heavy Metals Removal, Steam Stripping, Chemical Precipitation, and Electrolysis.	9 **Hrs.**
Unit 6: ENVIRONMENTAL CONCERNS Environmental regulations and technology- Regulatory Concerns, Technology; Laws, regulations and permits- Air, Water, Solid Waste, National Environmental Policy act, Occupational Safety and Health Act (OSHA).	6 **Hrs.**

Textbooks:

1. General Microbiology, H.G. Schlegel, 7th Ed.(Cambridge University Press)
2. Manual on Solid Waste Management (CPHEEO, Govt. of India).
3. Microbial Ecology: Fundamentals and applications- Atlas Bartha, 4th Ed.(Dorling Kinderley , India Pvt. Ltd).

REFERENCES

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

Unit wise Measurable students Learning Outcomes:

Unit: 1 UNIT I- ACTIVATED SLUDGE PROCESS-PROCESS ANALYSIS AND SELECTION

ULO -

1) To acquaint the students Microbial diversity on earth, nitrogen fixation and Environmental genomics.
2) To understand the various isolation techniques of bacteria and fungi
3) To analyze the process of release of genetically engineered organisms in environment

UO –

The students will able to
1) Define Microbial diversity and its isolation techniques
2) Understand nitrogen fixation and Environmental genomics.
3) Analyze the process of release of GMO in environment

Unit: 2 AEROBIC FIXED-FILM & ANAEROBIC TREATMENT PROCESSES

ULO -

1) To analyze the decontamination of polluted air by Bio-filters and Bio-scrubbers Treatment technologies.
2) To apply the knowledge of Bio-filters and Bio-scrubbers at industrial level ETP

UO –

The students will able to
1) Analyze the decontamination of polluted air by Bio-filters and Bio-scrubbers Treatment technologies.
2) Apply the knowledge of Bio-filters and Bio-scrubbers at industrial level ETP

Unit: RECYCLING TECHNOLOGY FOR WASTES

ULO -

1) To understand solid Waste management by composting, Biogas production etc.
2) To apply the knowledge of agricultural soils Management by Biofertilizers and Bioinsecticides
3) To analyze Waste water characteristics, and waste Water quality testing

UO –

The students will able to
1) Understand solid Waste management by composting, Biogas production etc.
2) Apply the knowledge of agricultural soils Management by Biofertilizers and Bioinsecticides
3) Analyze Waste water characteristics, and waste Water quality testing

Unit: 4 BIOLOGICAL PHOSPHORUS REMOVAL

ULO -

1) To define bioremediation *In-situ* and *Ex-situ* bioremediation techniques
2) To understand the Factors affecting bioremediation.
3) To explain Biodegradation of xenobiotic compounds

UO –

The students will able to
1) To define bioremediation *In-situ* and *Ex-situ* bioremediation techniques
2) To understand the Factors affecting bioremediation.
3) To explain Biodegradation of xenobiotic compounds

Unit: 5 ADVANCED WASTE WATER TREATMENT

ULO -

1) To explain the techniques for Waste water Treatment

UO –

The students will able to
1) Explain the techniques for Waste water Treatment

Unit: 6 ENVIRONMENTAL CONCERNS

ULO -

1) To explain the waste management and various Environmental laws and policies

UO –

The students will able to
1) Explain the waste management and various Environmental laws and policies

Title of the Course: Plant biotechnology (Professional Elective –II) Course Code: PBEB0124	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite: Biochemistry, genetic engineering, molecular biology

Course Description: Course emphasizes on genetic manipulation of plants.

Course Objectives:

1. Use basic biotechnological techniques to explore molecular biology of plants
2. Understand how biotechnology has been used to develop knowledge of complex processes that occur in the plant.
3. Use basic biotechnological techniques to explore molecular biology of plants
4. Discuss the ethical implications of plant biotechnology
5. Explain how biotechnology is used for plant improvement.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive level	Descriptor
CO1	Use basic biotechnological techniques to explore molecular biology of plants	Cognitive	Use
CO2	2. Understand how biotechnology has been used to develop knowledge of complex processes that occur in the plant.	Cognitive	Understand
CO3	3. Use basic biotechnological techniques to explore	Cognitive	Use

	molecular biology of plants		
CO4	4. Discuss the ethical implications of plant biotechnology	Cognitive	Discuss
CO5	5. Explain how biotechnology is used for plant improvement.	psychomotor	Explain

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
CO6	3	3	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1. Introduction to PTC technology - History & methodology. **8 Hrs.**

Special features and organization of plant cells: Totipotency, Regeneration of plants – leaves, roots , stems . Plant biodiversity.

i.Biodiversity hotspot in India

ii.Characterization of biodiversity through different biochemical and molecular methods (Chemical printing of biodiversity)

iii.Conservation strategies of biodiversity including tissue culture methods

iv.Bioprospecting of biodiversity for product development

Unit: 2 Plant Products of industrial importance i. Biochemistry in brief of major metabolic pathways and products ii. Kinetics for growth, product formation, large scale production of secondary metabolites from suspension culture and nutrient optimization.	**6 Hrs.**
Unit 3: Different types of plant cultures- i.Meristem/shoot tip/nodal segment-virus free plants/ clonal propagation. ii.Anther, pollen, ovule-double haploid plant production. iii.Cell/callus/suspension-artificial seed production Embryo-distant hybrid plant production..Protoplast technology	**6 Hrs.**
Unit4: Pathways of regeneration and micro propagation i.Axillary shoot proliferation ii.Organogenesis iii.Somatic embryogenesis	**6 Hrs.**
Unit 5: . Micro techniques for plant tissue culture i.Development of callus and suspention culture of plant cell ii.Shear sensitivity of cell culture growth and product formation. iii.Kinetics in suspension culture production on secondary metabolites	**6 Hrs.**
8. **Unit 6** Plant Transformation technology i. Ti and Ri plasmids, CaMv, 35s promoter, shuttle, vector, Agrobacterium and reporter gene. ii. Methods of plant transformation :particle gun, Agrobacterium mediated gene transfer iii. Progress in Plant genetic engineering. Molecular marker-aided breeding i. Different types of DNA markers ii. Generation of mapping population iii.Tagging of genes with specific molecular markers.	**8 Hrs.**

References:

1. An introduction to plant tissue culture by Rajdan M.K. (2003) Science publisher in field USA.

2. Text book of Plant Biotechnology, by Chawala P.K. (2002) Oxford press and IBH New Delhi.

3. Plant Tissue Culture theory and practice Bhojwani, S.S. and Rajdan M.K. (1999)Elsevier publisher

4. Plant Tissue Culture Laimer and Rucker W. (2003) Springer-Verag
5. Hand book of plant biotechnology (2 Vol.) Christou P. and Klee, H.eds. (2004) Wiley Publishing U.K.
6. Plant Tissue Culture K.K. De (2008) New central book agency.

Unit wise Measurable students Learning Outcomes:
At the end of Unit Students will be able to –
1.Use basic biotechnological techniques to explore molecular biology of plants
2. Understand how biotechnology has been used to develop knowledge of complex processes that occur in the plant.
3. Use basic biotechnological techniques to explore molecular biology of plants
4. Discuss the ethical implications of plant biotechnology
5. Explain how biotechnology is used for plant improvement.

Title of the Course: pharmaceutical Biotechnology (Professional Elective –II) **Course Code:** PBEB0125	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Pre-Requisite: Biochemistry**,** genetic engineering, molecular biology, immunology

Course Description: Course emphasizes on different biopharmaceuticals.

Course Objectives:
1. Understand the properties of different biopharmaceutical drugs.
2. Describe biopharmaceutical drug administration kinetics & Bioavailability.
3. Discuss the biopharmaceutical drugs for different diseases.
4. Describe the relative advantages and disadvantages of biopharmaceutical drugs strategies.
5. Describe Gene therapy for HIV & Cancer

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive level	Descriptor
CO1	List the properties of different biopharmaceutical drugs.	cognitive	List
CO2	Describe biopharmaceutical drug administration kinetics & Bioavailability.	cognitive	Describe
CO3	Describe biopharmaceutical drug administration kinetics & Bioavailability.	cognitive	Describe
CO4	Describe the relative advantages and disadvantages of biopharmaceutical drugs strategies.	cognitive	Describe

CO5	Describe the principles underpinning gene therapies with particular emphasis on current clinical strategies.	cognitive	Describe

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
CO6	3	3	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit: 1 Drug targets classification DNA, RNA, post-translational processing enzymes, metabolic enzymes involved in nucleic acid synthesis, G-protein coupled receptors (monomeric transmembrane proteins), small molecule receptors, neuropeptide receptors, ion channels (monomeric multi-transmembrane)proteins, ligand-gated ion channels (Oligomeric transmembrane proteins), transporters (multi-transmembrane proteins	**8 Hrs.**
Unit: 2 Concepts of Bio availability Process of drug absorption, Pharmacokinetic processes, Timing for optimal therapy, Drug delivery considerations for the new biotherapeutics, Parenteral delivery-intravenous, intramuscular, interperitoneal. Oral delivery and systemic delivery through oral route-Structure and physiology of Gastro Intestinal tract, Impediments against oral availability, Advantages and disadvantages of oral drug delivery .Drug targeting to CNS –Blood-Brain barrier, physiological and physiochemical factors for delivering to CNS ,current and new technologies in CNS delivery, Pulmonary drug delivery, Cell specific drug delivery, topical and	**6 Hrs.**

intraocular drug delivery.	
Unit 3: Oligonucleotides, Cancer immunotherapy: Gene therapy in cancer treatment and in HIV infection, Antisense therapy, Ribozymes, Cancer immunotherapy	**8 Hrs.**
Unit 4 Oligosaccharides: Oligosaccharide synthesis, Heparin, Glycoproteins, Polysaccharide bacterial vaccines, Approaches to carbohydrate-based cancer vaccines	**6 Hrs.**
Unit 5:--- Cardiovascular Drugs: Myocardial infarction agents, Endogenous vasoactive peptides, Hematopoietic agents. Anticoagulants, anthrombotics and hemostatics	**8 Hrs.**
Unit 6:--- Chemotherapeutic Agents: Synthetic antibacterial agents, Anthelminitic agents, Antiamebic agents, Antiviral agents, Endocrine Drugs: Female sex hormones and analogs, Agents affecting the immune response	**4 Hrs.**
References: 1. Understanding Biopharmaceuticals: Manufacturing and Regulatory Grindley, Jill E. Ogden 2. Pharmaceutical Biotechnology, 2nd Ed. By Crommelin D.J.A. & Sindelar R. D (WileyBlackwell) 3. Protein Purification: Principles and Practice - Scopes Robert K. (Springer – Verlag Pub.)	
Unit wise Measurable students Learning Outcomes: **At the end of Unit Students will be able to –** 1. Understand the properties of different biopharmaceuticals. 2. Describe protein drug formulation and administration. 3. Discuss the role of genes in degenerative disease and cancer 4. Describe the relative advantages and disadvantages of viral and non viral gene delivery strategies. 5. Explain Endocrine Drugs	

Title of the Course: Advanced Bioinformatics **(Professional Elective –II)** **Course Code:** PBEB0126	**L**	**T**	**P**	**Credit**
	3	**1**	**-**	**4**

Course Pre-Requisite: Biochemistry, molecular biology, chemistry, and mathematics and computer language.

Course Description: Bioinformatics is integration of biology, chemistry, and mathematics and computer science. This subject provides information of various biological databases and tools available for life science field.

Course Objectives:

1. To introduce students to list the importance of Bioinformatics and chemo informatics
2. To impart the basic tools of Bioinformatics and also discuss the problems in biotech associated areas like medical, diagnostic, pharmaceutical sectors.
3. To learn and demonstrate tools of bioinformatics like BLAST, FASTA, Genbank etc to access various sequences for study.
4. To plan and interpret the problems associated in biotechnology and use various tools to understand various interactions.
5. To provide the opportunity to think, design the best solution for industrial purpose.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Explain scope of Bioinformatics and chemoinformatics in Biotechnology	Cognitive	Explain
CO2	Compare various tools of Bioinformatics and also discuss the problems in biotech associated areas such as medical, diagnostic, pharmaceutical sectors.	Cognitive	Compare
CO3	Apply techniques of Bioinformatics to design tools to solve various problems such as cancer, AIDS etc.	Cognitive	Apply
CO4	Construct tools for research purpose such as protein	Cognitive	Construct

	interactions in modeling diseases		
CO5	Identify key concepts and tools of Bioinformatics and Design the best solution to solve industrial needs.	Psychomotor	Identify

CO-PO Mapping:

CO/PO	1	2	3
CO1	3	3	1
CO2	3	3	1
CO3	3	3	1
CO4	3	3	2
CO5	3	3	1

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Biological Sequence Database Overview of various primary and secondary database that deals with protein and nucleic acid sequences. Databases to be covered in detail are GenBank, EMBL, DDBJ, SwissProt, PIR and MIPS for primary sequences. Various specialized database like TIGR, Hovergen, TAIR, PlasmoDB, ECDC etc., will also be discussed. Preliminary ideas of query and analysis of sequence information.	4 **Hrs.**
Unit 2:--- Sequence Comparison Methods Method for the comparison of two sequences viz. Dot matrix plots, Needleman-Wusch & SmithWaterman algorithms. Analysis of computational complexities and the relative merits and demerits of each method. Theory of scoring matrices and their use for sequence comparison	8 **Hrs.**
Unit 3:--- .Database Search Algorithms Methods for searching sequence database like FASTA and BLAST algorithms. Statistical analysis and evaluation of BLAST results.	10 **Hrs.**
Unit 4:---Molecular Modeling Methods of molecular modeling including homology modeling, threading and ab initio protein structure prediction together with their relative merits and demerits. Methods for structure comparison of macromolecules with special reference to proteins.	10 **Hrs**

Unit 5:--- Drug Design General ideas of drug designing, 2D and 3D QASR, concept of pharmacophore and pharmacophore based searches of ligand database. Concepts of COMFA. Methods for simulated docking	8 **Hrs.**
Unit 6:--- Introduction to phylogenesis and structural bioinformatics: Phylogenetics, Building phylogenetics trees, Evolution of macromolecular Sequences, Amino acids, Polypeptide Composition, Secondary Composition Backbone flexibility Ramchandran Plot Tertiary & Quaternary Structure, Hydrophobicity, Disulphide bonds, Active Sites	8 **Hrs.**

Textbooks:

1. Introduction to bioinformatics – T.K. Attwood and Parry-Smith D.J.
2. Bioinformatics: sequence and genome analysis by David Mount, cold springer harbour press, 2004.
3. Bioinformatics: Methods and Applications- Rastogi S. C., N. Mendiratta., P Rastogi.
4. Fundamentals of Molecular Evolution by D. Graur and W-H Li, 2nd Edition, Sinauer Associates.

References:

1. Developing Bioinformatics computer skills – Gibas C and Jambeck P
2. Baxevanis, A. D. and Ouellette, B, F, F.: Bioinformatics: A practical guide to the analysis of genes and Proteins. 2nd Ed..2002. John wiley and ons, Inc. publications, New York.
3. Eidhammer, IngeJonassen, William R. Taylor: protein Bioinformatics. 2003 John Wiley and Sons L

Unit wise Measurable students Learning Outcomes:

1. Students will be able to understand tools for protein structure prediction and modeling
2. Students will be able to understand various sequence formats in Bioinformatics and Chemoinformatics
3. Students will be able to understand the scope of Bioinformatics and Chemoinformatics in Biotechnology
4. Students will be able to understand various databases to access nucleotide and protein sequences
5. Students will be able to understand databases for protein-protein and protein –DNA interactions
6. Students will be able to understand tools and databases for protein-small molecules interactions

Title of the Course: Laboratory- 1	**L**	**T**	**P**	**Credit**
Course Code: PBEB0131	**-**	**-**	**2**	**2**

Course Pre-Requisite: Biochemistry, Microbiology, Enzyme technology

Course Description: Laboratory course I includes practical based on isolation of microorganisms and assay of enzymes

Course Objectives:

1.To study different steps involved in production of bioproducts and control of microorganisms.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	analyze different steps involved in production of bioproducts and control of microorganisms	Cognitive	Analyze

CO-PO Mapping:

CO	**1**	**2**	**3**
CO1	3	3	3

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:--- Isolation of industrially important microorganisms for microbial processes **Aim and Objectives:** To Isolate industrially important microorganisms for microbial processes **Outcomes:** Students will be able to isolate industrially important microorganisms for microbial processes	**02 Hrs.**
Experiment No. 2:--- Determination of thermal death point (TDP) and thermal death time of microorganism **Aim and Objectives:** To determine thermal death point (TDP) and thermal death time	**02 Hrs.**

of microorganism **Outcomes:** Students will be able to determine thermal death point (TDP) and thermal death time of microorganism	
Experiment No. 3:--- Determination of growth curve of supplied microorganism and substrate degradation process. **Aim and Objectives:** To Determine of growth curve of supplied microorganism and substrate degradation process **Outcomes:** Students will be able to determine growth curve of microorganism and substrate degradation process	**02 Hrs.**
Experiment No. 4:--- Microbial production of antibiotic **Aim and Objectives:** To produce penicillin using *Penicillium chrysogenum* on laboratory scale. **Outcomes:** Students will be able to produce penicillin using *Penicillium chrysogenum* on laboratory scale.	**02 Hrs.**
Experiment No. 5:--- Use of alginate for cell immobilization **Aim and Objectives:** To immobilize cells using alginate **Outcomes:** Students will be able to immobilize yeast cells using gel entrapment method.	**02 Hrs.**
Experiment No. 6:--- Production and estimation of alkaline protease **Aim and Objectives:** To produce and estimate alkaline protease **Outcomes:** Students will be able to produce and estimate alkaline protease.	**02 Hrs.**
Experiment No. 7:--- Construction of computational model of a molecule **Aim and Objectives:** To Construction of computational model of a molecule **Outcomes:** Students will be able to Construct computational model of a molecule	**02 Hrs.**
Experiment No. 8:--- Effect of heat & pH on color & texture of green vegetables **Aim and Objectives:** To study the Effect of heat & pH on color & texture of green vegetables **Outcomes:** Students will be able to analyze the effect of parameters on food processing	**02 Hrs.**

Title of the Course: Laboratory -2	**L**	**T**	**P**	**Credit**
Course Code: PBEB0132	**-**	**-**	**2**	**2**

Course Pre-Requisite: Biochemistry, Fermentation, Enzyme technology

Course Description: Laboratory course I includes practical based on kinetics

Course Objectives:

1. To study kinetics of cell growth and product formation.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	analyze kinetics of cell growth and product formation	Cognitive	Analyze

CO-PO/PEO Mapping:

CO	**PO1**	**PO2**	**PO3**
CO1	3	2	3

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:--- Determination of oxygen transfer rate **Aim and Objectives:** To determine oxygen transfer rate **Outcomes:** Students will be able to determine oxygen transfer rate in a bioreactor	**02 Hrs.**
Experiment No. 2:--- Determination of mixing time in bioreactors **Aim and Objectives:** To determine mixing time in bioreactors **Outcomes:** Students will be able to determine mixing time in bioreactors	**02 Hrs.**
Experiment No. 3:--- Determination of specific growth rate (M) and growth yield (Yx) , Specific Product formation rate (Q1) and substrate consumption rate **Aim and Objectives:** To determine specific growth rate (M) and growth yield (Yx) , Specific Product formation rate (Q1) and substrate consumption rate	**02 Hrs.**

Outcomes: Students will be able to determine specific growth rate (M) and growth yield (Yx) , Specific Product formation rate (Q1) and substrate consumption rate	
Experiment No. 4:--- Study of Kinetics of cell Growth **Aim and Objectives:** To study of Kinetics of cell Growth **Outcomes:** Students will be able to analyze growth phases	**02 Hrs.**
Experiment No. 5:--- Study of kinetics of product formation **Aim and Objectives:** To study of kinetics of product formation **Outcomes:** Students will be able to comprehend kinetics of product formation	**02 Hrs.**
Experiment No. 6:--- Animal cell culture in static phase **Aim and Objectives:** To culture animal cell in static phase **Outcomes:** Students will be able to culture animal cell in static phase.	**02 Hrs.**
Experiment No. 7:--- Study of fed-batch cultivations **Aim and Objectives:** To study of growth kinetics under fed-batch mode **Outcomes:** Students will be able to operate and analyze the fed-batch reactor.	**02 Hrs.**
Experiment No. 8:--- Study of batch kinetics with immobilized enzymes **Aim and Objectives:** To study of immobilized enzyme kinetics under batch mode **Outcomes:** Students will be able to do the batch kinetics with immobilized enzymes.	**02 Hrs.**
Experiment No. 9:--- Study of packed bed reactor **Aim and Objectives:** To study the performance of packed bed reactor with suitable example **Outcomes:** Students will be able to analyze the dynamics of packed bed reactor.	**02 Hrs.**

Title of the Course:Seminar-1	**L**	**T/S**	**P**	**Credit**
Course Code: PBEB0241	**0**	**2**	**0**	**1**

Course Pre-Requisite: No Pre-Requisite

Course Description: The student should deliver a seminar (each 15 to 20 minutes) and submit Seminar report to the department. The topic of the seminar may be chosen from different technical subjects being studied during the semester.

Course Objectives:

1. Knowledge: Students: - Remember methodology of applied biological sciences & Engineering; - Apply principles to current problems; - recall theoretical framework for methods applied to biological sciences & Engineering
2Practical Skills: Students: - Integrate knowledge provided from interdisciplinary sources to solve research problems; - Evaluate data and results using critical thinking skills; - Can revise and present scientific case studies in multimedia presentation in English

3. Social Competence: Students: - Effectively collaborate with other students in analyzing results, and preparing oral presentations; - Are able to find appropriate sources that can be summarized and integrated into multimedia presentation; - Are aware of importance of access to data, knowledge and results of scientific studies; - Are aware of importance and role of scientific honesty, data reliability, intellectual property rights and rules of access to data and scientific information; - Accept the importance of quality of research results presentation for effective scientific communication

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Remember methodology of applied biological sciences & Engineering; - Apply principles to current problems; - recall theoretical framework for methods applied to biological sciences & Engineering	Cognitive	Remember
CO2	Practical Skills: Students: - Integrate knowledge provided from interdisciplinary sources to solve research problems; - Evaluate data and results using critical thinking skills; - Can revise and present scientific case studies in multimedia presentation in English	Affective	solve
CO3	Social Competence: Students: - Effectively collaborate with other students in analyzing results, and preparing oral presentations; - Are able to find appropriate sources that can be summarized and integrated into multimedia	Psychomotor	analyzing

	presentation; - Are aware of importance of access to data, knowledge and results of scientific studies; - Are aware of importance and role of scientific honesty, data reliability, intellectual property rights and rules of access to data and scientific information; - Accept the importance of quality of research results presentation for effective scientific communication		

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	3	3
CO2	2	1	2
CO3	1	1	2

Assessments :
Teacher Assessment:
One component of In Semester Evaluation (ISE) having 100% weights respectively.

Assessment	Marks
ISE	100
ESE	-

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination

Course Contents:

The assessment shall be based on - 1. Performance of the seminar delivery. 2. Details provided in seminar reports and 3. Performance during discussions on the seminar topic The faculty member / s shall guide the students for: 1. Selecting the seminar topics 2. Information retrieval (literature survey) 3. Source of information i.e. names of the journals, reports books etc 4. Preparation of the seminar report as per the guidelines of department 5. Presentations on Powerpoint	36 **Hrs.**

Measurable students Learning Outcomes:

1. Knowledge: Students: - Understand methodology of applied biological sciences & Engineering; -
2. Apply principles to current problems; -
3. Understand theoretical framework for methods applied to biological sciences & Engineering;
4. Practical Skills: Students: - Integrate knowledge provided from interdisciplinary sources to solve research problems; -
5. Evaluate data and results using critical thinking skills; -
6. Can revise and present scientific case studies in multimedia presentation in English.
7. Social Competence: Students: - Effectively collaborate with other students in analysing

results, and preparing oral presentations; -

8. Are able to find appropriate sources that can be summarized and integrated into multimedia presentation; -
9. Are aware of importance of access to data, knowledge and results of scientific studies; -
10. Are aware of importance and role of scientific honesty, data reliability, intellectual property rights and rules of access to data and scientific information; - Accept the importance of quality of research results presentation for effective scientific communication

Title of the Course: Bioreactor Design	**L**	**T**	**P**	**Credit**
Course Code: PBEB0204	**3**	**1**	**-**	**4**

Course Pre-Requisite:

4. The students should have the basic understanding of reactor, reactor kinetics and reaction thermodynamics. The students should know the basic mathematical calculations.
5. The students must be aware of the types of reactor and their applications
6. The student should have the basic knowledge of unit operations.

Course Description:

This course is designed to study reaction kinetics and various parameters of kinetic. It will also elaborate reactor performance with respect to kinetics.

Course Objectives:

4. To introduce simple kinetic expressions for cell-and enzyme-based bioconversions and develop the reaction kinetics by analyzing lab data.
5. To understand concept behind ideal bioreactors and their transient analysis using material balance
6. To develop skills in selecting the most useful reactor type for a given bioconversion

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Select type of reactor mode for desired product formation in multiple reactions	Cognitive	Select
CO2	Demonstrate, develop and analyze model non-ideal behavior of reactors	Cognitive	Demonstrate
CO3	Explain principles involved in enzyme kinetics and techniques for analyzing rate data. Describe basic concepts in microbial process kinetics.	Cognitive	Explain
CO4	Design rate equations for various types of enzyme-catalyzed reactions. Construct insight into interactions between substrate utilization, cell growth and product formation	Cognitive	Design
CO5	Select type of reactor mode for desired product formation in multiple reactions	Psychomotor	Select
CO6	Demonstrate, develop and analyze model non-ideal behavior of reactors	Psychomotor	Demonstrate

CO-PO Mapping:

CO	**1**	**2**	**3**
CO1	1	1	2
CO2	1	1	1
CO3	2	2	1

CO4	2	1	1
CO4	1	1	1
CO5	2	2	1

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Ideal Bioreactors: - Fed batch reactors, enzyme-catalyzed Reactions in CSTRs, CSTR reactors with Recycle and wall growth. The ideal plug flow tubular reactor.	**10 Hrs.**
Unit 2:--- Mass transfer and Bioreactor design: Gas-liquid mass transfer in cellular systems, determination of oxygen transfer rates, mass transfer for freely rising or falling bodies, forced convection mass transfer, Overall Kla estimates and power requirements for sparged and agitated vessels, mass transfer across free surfaces, factors affecting mass transfer coefficient.	**10 Hrs**
Unit 3:--- Bioreactor Instrumentation and control: Temperature control, Control of gas supply, Control of pH, Control of dissolved oxygen, Antifoam control; Additional sensorsRedox, Air flow, Weight, Pressure, On-line measurement of biomass	4 **Hrs.**
Unit 4:--- Mechanically Agitated and pneumatically agitated or Sparged reactors: Effect of bubble size, sparger design, sparger location, liquid head and other design and operation parameters for Bubble column, airlift reactor, and gas induced mechanically agitated reactors, Hydrodynamics and mass transfer of sparged reactors. Applications of sparged reactors in biotechnology.	8 **Hrs.**
Unit 5:--- Photo bioreactors: Growth kinetics in photo bioreactor, effect of light intensity on growth, metabolite production. Design and operation parameter, types of photo bioreactors, novel photo bioreactors, considerations for scale up	8 **Hrs.**
Unit 6:--- Solid state fermentation (SSF) Bioreactors: growth kinetics in SSF systems, heat and mass transfer in SSF bioreactors, well mixed SSF	8 **Hrs.**

bioreactors, tray bioreactors, packed bed bioreactors, various modes of operation of SSF bioreactors, scale up challenges for SSF bioreactors,	

Textbooks:

1. Chemical Reaction Engineering- Levenspile, O. (Wiley)
2. Chemical Engineering Kinetics- Smith, J. ((McGraw Hill, New York)
3. Reaction Kinetics for Chemical Engineers- Walas, S.M. (McGraw Hill, New York)
4. Elements of Chemical Reaction Engineering- Scott. H. Fogler, (EES publication).

References:

1. Bailey J.E and D.F.Ollis “Biochemical Engg.Fundamentals”.
2. O.Levenspiel “ Chemical Reaction Engg”
3. Pauline M. Doran. “Bioprocess Engineering Principles”.
4. Atkinsen,B; Brochemical reactor.
5. Nielson,J. and Villadsen; Bioreaction Engineering principles.
6. D.A. Mitchell, Solid-State Fermentation Bioreactors.
7. Chisti, M.Y., 1989. Airlift bioreactors, Elsevier applied science, London and New York.

Unit wise Measurable students Learning Outcomes:

7. Apply reaction kinetics principles and analyze data.
8. Do transient analysis of various enzyme and cell bioreactors using material balance
9. Describe multiple reactor systems
10. Differentiate reactions with respect to various types of reactors and design rate equations for reactions
11. Select best reactor system for multiple reactions
12. Describe non-ideal behavior of bioreactors and develop, analyze model for non-ideal behavior of bioreactors

Title of the Course: Adv. Enzyme technology Course Code: PBEB0205	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:

1. The students should have the basic understanding of the definition, physiological and commercial significance of proteins especially with respect to enzymes.
2. The students should have a good knowledge of the physicochemical properties of amino acids and their contribution to basic structure levels of protein (enzymes) and reactivity of side chains in proteins.
3. The students should know the role of catalyst and its significance

Course Description:

This course is related to the enzyme introduction, properties and its industrial applications.

Course learning objectives:

1. Define enzyme/activity and state its chemical nature, structural domains, coenzyme, and cofactor role.
2. Explain mechanism of enzyme catalysis and factors influencing it
3. Identify the applications of enzymes in biotechnological sector
4. Analyze enzyme inhibition kinetics for drug discovery and enzyme modulators for bioprocess development

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive Level	Descriptor
CO1	List the general properties of enzymes and their mechanism of catalysis.	Knowledge	List
CO2	Describe the basic principle methods of enzyme production, isolation, and purification.	Comprehension	Describe
CO3	Relate the applications of enzymes in food, beverages, pharmaceuticals, medical, diagnostics, biotransformation, bioremediation.	Application	Relate
CO4	Analyze and select the enzymes in biotransformations	Analysis	Analyze

CO-PO-PSO Mapping:

CO	PO1	PO 2	PO 3
CO1	1	2	1
CO2	2	2	1
CO3	2	3	1
CO4	3	2	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 60-70% weight age for course content (normally last three modules) covered after MSE.

Course Contents:

SECTION-I	**9 Hrs.**
Unit 1:--- Introduction to enzyme Introduction, Classification, Enzyme in action & specificity, Enzyme stability, monomer & oligomeric enzymes. Structure of enzymes-X-ray crystallography of enzymes, Extraction & Purification of enzymes, control of Enzyme activity.	
U Unit 2:--- Enzyme kinetics & modeling of enzymatic systems Kinetics of single substrate, multi-substrate enzyme catalyzed reaction, relation of kinetic parameters, micro environmental effects on enzyme kinetics, Mathematical modeling in E-kinetics with example.	**6 Hrs.**
Unit 3:--- Immobilized enzymes Introduction, Methods of immobilization, kinetics of immobilized , Enzymes & application in production of L-amino acids, & other uses, enzyme biosensors (design of E electrodes & application.).	**9 Hrs.**
SECTION – II	**6 Hrs.**
Unit 4:--- Regeneration of co-factors for enzyme biocatalysis Introduction, NADP (H) regeneration, ATP/NTP regeneration, sugar nucleotide regeneration, acetyl CoA enzyme regulator etc.	
Unit 5:--- Enzyme catalyzed organic synthesis Introduction, solvent systems, enzyme inactivation in organic solvents, effects on enzyme activity enzyme for mutation, organic solvents, effects on enzyme activity, enzyme formulation in organic media, lymphoid enzyme, absorbed, entrapped etc. & Applications-Kinetic resolution, asymmetric synthesis.	**10 Hrs.**
Unit 6:--- Biotransformation with enzymes Biocatalyst selections, biocatalyst treatment & mode of operation (Immobilization) & application steroids terpenes etc. Productions of molecules with flavoring properties.	**8 Hrs.**

Textbooks:

3. Price and Lewis Stevens. Fundamentals of Enzymology
4. T. Palmer. Enzyme, Biochemistry and Clinical Chemistry

Ashok Pande, Colin Webb, Carlos Richard, Cristian Larroche. Enzyme Technology.

References:

5. 1] Lehninger- Principles of Biochemistry by Nelson and Cox – W. H. Freeman and Company Pub.
6. 2] Biochemistry by Berg, Tymoczko and Stryer - W. H. Freeman and Company Pub.

Unit wise Measurable students Learning Outcomes:

Unit 1. Define enzymes and recognize the importance of enzyme applications

Unit 2. To understand the significance of enzyme kinetics study

Unit 3. To study the properties of immobilized enzymes

Unit 4. Describe various direct and indirect methods of enzyme assay and interpret data

Unit 5. Explain methods of large scale enzyme production and purification

Unit 6. To describe the legislative and safety issues associated with enzyme applications

Title of the Course: Adv. Biological Thermodynamics	**L**	**T**	**P**	**Credit**
Course Code: PBEB0262	2	-	-	-

Course Pre-Requisite:

1) The students should have a basic knowledge of terminologies like energy, work, force etc.
2) The students should be aware of the concept of thermodynamics which they have learnt in 12^{th} std.
3) The students should be acquainted with standard basic unit and conversions.

Course Description: Thermodynamics is a crucial part of biotechnology and biological sciences. Thermodynamic principles are applied in Bioenergetics. Thermodynamics helps biologists to evaluate which biochemical reaction is feasible and what is the concerned energy (or ATP) consumption. It encompasses all the metabolic activities, cellular respiration, growth and development processes, membrane transport systems, enzymatic reactions and much more. It can be used to state whether this reaction would occur or not, and if not then why not. For biotechnological aspect this would help how to transform the biological process so that a non-spontaneous reaction becomes spontaneous. It helps the scientist to evaluate how a selectively permeable biomemberane shows its selectivity. Similarly, how enzymes acts as a biological catalysts.

Course Objectives:

1. List and explain the basic concepts of thermodynamics like heat, enthalpy, internal energy, work, energy and power etc.
2. To justify the basic principles of thermodynamics in Biotechnology and also study the calculations of basic terminologies.
3. To solve and evaluate problems based on the laws of thermodynamics and their applications to biological systems.

Course Learning Outcomes:

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

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	List the basic terminologies and recognize its importance in biological applications.	Cognitive	List
CO2	Illustrate need of heat pump and heat engine.	Cognitive	Illustrate
CO3	**Apply** the basics principles of biological thermodynamics in different biochemical processes.	Cognitive	Apply
CO4	**Analyze** energy requirements for process and study the effect on the process.	Cognitive	Analyze
CO5	**Evaluate** energy calculation for different biochemical processes.	Psychomotor	Evaluate
CO6	**Calculate** obtainable work for engineering and biological systems	Psychomotor	Calculate

CO-PO Mapping:

	PO1	**PO2**	**PO3**
CO1	2	1	2
CO2	3	2	3

CO3	3	2	3
CO4	3	2	3
CO5	3	2	3
CO6	3	2	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Reviews of Laws of Thermodynamics First law of thermodynamics- Enthalpy, Standard state, Heat capacity, energy, conservation.Second Law of Thermodynamics- Entropy, Entropy of the Universe, Isothermal system, protein denaturation, Irreversibility and life.	4- **Hrs.**
Unit 2:--- Gibbs free energy Equilibrium, Reversible processes, Phase transitions,Chemical potential, Equilibrium constant. Gibbs free energy application	4-- **Hrs.**
Unit 3:--- Statistical thermodynamics Boltzmann distribution, Partition function, Multistate equilibria, Protein heat capacity function , Helix – coil transition theory	5-- **Hrs.**
Unit 4:--- Binding Equilibrium: i. Single site model ii. Oxygen transport iii. Scatchard plots and Hill plots iv. Allosteric regulation v. Proton Binding	4-- **Hrs.**
Unit 5:--- Biochemical Thermodynamics i. Acidity of solutions ii. Ionization of Biochemical's iii.Solubilities of weak acids, weak bases, and pharmaceuticals as a function of pH 6 iv. Binding of a ligand to a substrate v.Other examples of Biochemical reactions. vi.Protein concentration in an ultracentrifuge vii.Gibbs-Donnan equilibrium and membrane potentials viii.Coupled chemicals reactions. ix.Thermodynamic analysis of Fermentor and other Bioreactors.	5-- **Hrs.**
Unit 6:--- Thermodynamic application Practical thermodynamic approach to study aerobic and anaerobic fermentation process	2

Textbooks:

1. Biological Thermodynamics – D.T. Haynie (Cambridge University Press)
2. A textbook of Chemical Engineering Thermodynamics – K. V. Narayanan (Prentice Hall of

India)

References:

1. Introduction to Chemical Engineering Thermodynamics – Smith, Van Ness, Abbott (TMH)

2. Chemical, Biochemical and Engineering Thermodynamics – Stanley I. and Sandler (Wiley India Edition)

3. Chemical engineering thermodynamics – Y.V.C. Rao (New Age international)

Unit wise Measurable students Learning Outcomes:

Unit 1: Students should understand common basic concepts like Force, pressure and energy, Equilibrium state and the phase rule, Temperature and Zeroth law of thermodynamics, Heat reservoirs and heat engines, reversible and irreversible processes

Unit 2: Students should understand procedure for how to apply first law for non-flow process, first law for flow process.

Unit 3: Students should understand, apply and solve the sums by applying The CARNOT principle, Entropy –A state function, statistical explanation for entropy, Mathematical statement of the second law of thermodynamics, Third law of thermodynamics.

Unit 4 :Students should able to classify the different Classification of thermodynamic properties.

Unit 5: Students should apply the theoretical concept of gibb's free energy for Equilibrium, Reversible processes, Phase transitions, Chemical potential, Effect of solutes on boiling points and freezing points, Ionic solutions, Equilibrium constant, Standard state in biochemistry.

Unit 6: Students should understand application of gibb's free energy Photosynthesis, Oxidative phosphorylation, Osmosis, Dialysis, Donnan equilibrium, Membrane transport, Enzyme-substrate interaction, Molecular pharmacology, hemoglobin

Title of the Course: ANIMAL BIOTECHNOLOGY (Professional Elective –III) **Course Code:** PBEB0221	**L**	**T**	**P**	**Credit**
	3	**1**	**-**	**4**

Course Pre-Requisite: Students admitted for this course will be expected to have sufficient background knowledge of Cell biology & general biology.

Course Description: The course covers central topics in Animal biotechnology .The focus is on IVF , Animal cell culture, Cell & Tissue Engineering. Furthermore, attempts to manipulate the animal cells are described. The topics are presented as lectures, and

the students are required to read review articles as well as a textbook in Animal Biotechnology. Each student presents a research article for the group.

Course Objectives:

1. To list various applications of Animal Biotechnology for product development, social use, industry, environment and medical use.
2. To define cells structure , physiology & terminology generally used in cell culture.
3. To prepare(setup) laboratory for cell culture, organ culture and embryonic c cell culture
4. To identify cell lines, collect the information of cell lines.
5. To illustrate types of cell cultures and their application.
6. To apply cell & tissue engineering.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	List various applications of Animal Biotechnology and its benefit of human beings	Knowledge	List
CO2	Define IVF , embryo transfer and its applications to Test tube Baby	Comprehension	Explain
CO3	Prepare(setup) laboratory of Animal tissue culture and its applications to Biotechnology & industry and medicine	Application	construct
CO4	Identify problems related to industrial production and biotechnological solutions	Analysis	Justify
CO5	apply research skills to postgraduate research and industrial investigation	Synthesis	Application to R&D
CO6	Design cell engineering , tissue engineering , Animal bioreactor in industry (scale up)	Evaluation	Design

CO-PO Mapping:

CO	**PO1**	**PO2**	**PO3**
CO1	**3**	**3**	**3**
CO2	**3**	**3**	**2**
CO3	**3**	**3**	**3**
CO4	**1**	**1**	**3**
CO5	**1**	**1**	**3**
CO6	**1**	**1**	**3**

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

1. **Unit 1:**--- Introduction, history and scope History, Application, Objectives, Advantages .	8 **Hrs.**
2. **Unit 2:**--- Balanced salt solutions and simple growth media, serum and its quality, medium sterilization	7 **Hrs.**
3. **Unit 3:**--- Basic techniques of animal cells culture & their application. I. Cell bank , II. Techniques III. Equipments and material. IV. Primary and established cell line cultures. V. Tissue culture media, balanced salt solutions and simple growth medium, chemical, physical and metabolic functions of different constituents of culture medium , Role of carbon dioxide, Role of serum and supplements, Measurement of viability and toxicity.	**7** Hrs.
Unit:4 In Vitro fertilization and embryo transfer,Molecular biological techniques for rapid diagnosis of genetic diseases and gene therapy. Chemical carcinogenesis, transfection, oncogenes and antioncogenes. Preservation and maintenance of animal cell lines, cryopreservation and transport	7 **Hrs.**
6. **Unit 5:**--- Transgenic animal technology Outline , Rodent Cloning and transgenesis, Expression of foreign gene. Use of transgenic animal , Transgenic mice as a model Genetic Engineering	**7** Hrs.
Unit 6:--- Cell and Tissue Engineering: Review of Cell source, Cell and Media, Chondrocytes M5CS. Biomaterial scaffold and seeding. Bioreactors for animal cell culture and Cultivation, Monoclonal antibodies scale up in animal cell culture. Cell and tissue engineering.	7 **Hrs.**

Textbooks:

1. Animal Cell Culture by John R.W. (Masters Oxford University Press)
2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts (Plenum Press, New York and London)
3. Molecular Biotechnology : Primrose

4. Animal Cell Biotechnology: R.E. Spier and J.B Griffiths (1988), Academic press.
5. Living resources for Biotechnology, Animal cells: A Doyle,R.Hay and B.E. Kirsop (1990), Cambridge University Press, Cambridge.
6. Animal Biotechnology: Murray Moo-Young (1989), Permagon Press, Oxford.
7. Ranga, M. M Animal Biotechnology.

Srivastava, A.K.-Animal Biotechnolog

References:

1. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988),(Academic press EACC Handbook).
2. Culture of animal cells; a manual of basic techniques, Freshney R. I. (1995) (John Wiley And Sons, USA)

Unit wise Measurable students Learning Outcomes:

After completing the course you will be able:

1. To define cells structure , physiology & terminology generally used in cell culture.
2. To prepare(setup) laboratory for cell culture, organ culture and embryonic cell culture
3. To identify cell lines, collect the information of cell lines.
4. To illustrate types of cell cultures and their application.
5. To apply research skills to postgraduate research and industrial investigation
6. To discuss IVF, Embryo transfer etc. in research and industrial investigation

Title of the Course: GMP, IPR Biosafety & Bioethics **(Professional Elective –III)** **Course Code:** PBEB0222	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Pre-Requisite: No Pre-Requisite

Course Description: This course helps to adhere to the ethical practices appropriate to the discipline at all times and to adopt safe working practices relevant to the bioindustries & field of research, IPR

Course Objectives:

1. To describe GMP in pharmaceutical industry and food industry.
2. To identify how GMP are integrated part of management system
3. To assess the applications of the GMP in Pharmaceutical and food industry.
4. To analyze the concept of validation, elements of validation in Pharmaceutical industry.
5. To evaluate the requirements of regulatory guidelines for pharmaceutical and food industry

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1.	Define the concept of GMP in food and pharmaceutical industry.	Cognitive	Define
CO2.	Apply concept of quality control and quality assurance in pharmaceutical and food industry.	cognitive	Apply
CO3.	Analyze the scope and importance of validation process in pharmaceutical and food industry.	Psychomotor	Analyze
CO4.	Compare and evaluate the good and substandard manufacturing practices.	Psychomotor	Compare
CO5.	Summarize and discuss the regulatory requirements of pharmaceutical and food industry	Affective	Summarize
CO6.	describe the concept of GMP in food and pharmaceutical industry.	cognitive	describe

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	1	1
CO2	1	1	1
CO3	1	1	1
CO4	1	1	1
CO4	1	1	1
CO5	1	1	1
CO6	1	1	1

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Engineering Ethics & Bioethics : Senses of "Engineering Ethics"' - variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - consensus and controversy – Models of	7 **Hrs.**

Professional Roles - theories about right action - Self-interest - customs and religion - uses of ethical theories.	
Unit 2:--- **Regulatory Affairs** : Regulation, national and international guidelines of Biosafety, rDNA guidelines, Regulatory requirements for drugs and Biologics GLP and GMP	7 **Hrs.**
Unit 3:--- **Safety, Responsibilities and Rights**: Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk – the three mile island and case studies. Collegiality and loyalty - respect for authority - collective bargaining - confidentiality - conflicts of interest - occupational crime - professional rights - employee rights.	7**Hrs.**
Unit 4:--- Global Issues : Multinational corporations - Environmental ethics - computer ethics - weapons development and bioterrorisms - engineers as managersconsulting engineers - engineers as expert witnesses and advisors - moral leadership-sample code of Ethics	7 **Hrs.**
Unit 5:--- **Introduction to Bioethics**. Social and ethical issues in Biotechnology Definition of Biosafety. Biosafety for human health and environment. Social and ethical issues. Use of genetically modified organisms and their release in to the environment. Special procedures for r-DNA based products, Transgenic plants and Animals.	7**Hrs.**
Unit 6:--- **Intellectual Property Rights** : Intellectual property rights and protection, patents and methods of application of patents, Trade Secrets copyrights, Trade Marks, legal implications, farmer's rights, plant breeder's rights. International and National conventions on biotechnology and related areas, WTO guidelines.	7 **Hrs.**
Textbooks: 1. Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw-Hill, New York 1996. 2. Govindarajan M, Natarajan S, Senthil Kumar V. S, " Engineering Ethics", Prentice Hall of India, New Delhi, 2004.	
References: 1. Sasson A, Biotechnologies and Development, UNESCO Publications, 1988. 2. Sasson A. Biotechnologies in developing countries present and future, UNESCO publishers, 1993. 3. John R Boatright, "Ethics and the Conduct of Business", Pearson Education, New 4. Edmund G Seebauer and Robert L Barry, "Fundamentals of Ethics for Scientists and Engineers", Oxford University Press, Oxford, 2001. 5. Singh K. "Intellectual Property Rights on Biotechnology", BCIL, New Delhi..	
Unit wise Measurable students Learning 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 in the use of genetically modified organisms and its	

effect on human health
5. They will gain more insights into the regulatory affairs.
6. Differentiate between Intellectual property rights and protection, patents

Title of the Course: Advanced Genetic Engineering **(Professional Elective –III)** **Course Code:** PBEB0223	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Pre-Requisite: Students admitted for this course will be expected to have sufficient background knowledge of Cell biology & general biology.

Course Description: The course covers central topics in Genetic Engineering.

Course Objectives:

1.To have the overview Of Genetic Engineering .
2.To list cells Gene Cloning Methods
3. To prepare Nucleic Acid Sequencing And Gene Silencing
4.To identify PCR types
5.To illustrate Application.
6.To apply cell & tissue engineering.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	the overview Of Genetic Engineering	Knowledge	List

CO2	To list cells Gene Cloning Methods	Comprehension	Explain
CO3	To prepare Nucleic Acid Sequencing And Gene Silencing	Knowledge	List
CO4	To identify PCR types	Comprehension	Explain
CO5	To illustrate Application	Knowledge	List
CO6	To apply cell & tissue engineering.	Comprehension	apply

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	**3**	**3**	**3**
CO2	**3**	**3**	**2**
CO3	**3**	**3**	**3**
CO4	**1**	**1**	**3**
CO5	**1**	**1**	**3**
CO6	**1**	**1**	**3**

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- **Overview Of Genetic Engineering** Vectors-Artificial chromosome vectors (YAC and BAC), Viral vectors (Lambda, M13 and SV-40), Expression vectors and Shuttle	**7 Hrs.**

vectors; Restriction Enzymes; DNA ligase; Linkers; Adaptors; Labeling of DNA- Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques-Northern, Southern and Colony hybridization, Fluorescence in situ hybridization, Chromatin Immunoprecipitation; DNaseI footprinting.	
Unit 2:--- **Gene Cloning Methods** Construction of libraries-cDNA and genomic DNA; cloning of PCR products; Expression cloning; Jumping and hopping libraries; Southwestern and Far-western cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display.	**7 Hrs.**
Unit 3:--- **Nucleic Acid Sequencing And Gene Silencing** Sequencing methods- Enzymatic DNA sequencing, Chemical sequencing of DNA, Automated DNA Sequencing, RNA sequencing; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing.	**6 Hrs.**
Unit 4:--- **PCR** Primer design; Fidelity of thermostable enzymes; DNA polymerases- different types; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR,; PCR in gene recombination; Deletion; addition; Overlap extension;	**7 Hrs.**
Unit 5:--- **PCR Applications** PCR in molecular diagnostics- Viral and bacterial detection; PCR based mutagenesis, Mutation detection- SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test).	**7 Hrs.**
Unit 6:--- **Gene Knockouts And Genetherapy** Creation of knockout mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting.	**6 Hrs.**
Textbooks: 1. Primrose, S. B., Twyman, R. M. and Old, R.W., “Principles of gene manipulation”, 6th edition, Blackwell Sciences Ltd, 2002. 2. Brown, T.A.,”Gene Cloning-An Introduction”, VNR (U.K) Co. Ltd, England, 2006.	
References: 1. Watson, J.D., “Molecular Biology of Gene”, 5th Edition, Pearson Education, New Delhi, 2004. 2. Glick, B. and Pasternak, J.J. “Molecular Biotechnology and applications of recombinant DNA”, ASM Press, Washington DC, 2001. 3. Benjamin Lewin, “Gene IX”, Oxford University Press, Cambridge, U.K. 2011.	

4. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001..

Unit wise Measurable students Learning Outcomes:

1.To have the overview Of Genetic Engineering .
2.To list cells Gene Cloning Methods
3. To prepare Nucleic Acid Sequencing And Gene Silencing
4.To identify PCR types
5.To illustrate Application.
6.To apply Genetic Engineering.

Title of the Course: Project Management and Plant Design (Professional Elective –IV) **Course Code:** PBEB0224	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Pre-Requisite: Industrial work flow , Bioprocess Equipment Design , Drawing

Course Description: It describes the basics of plant design and managing project from ithier inception to erection, commissioning and final runs.

Course Objectives:

1 Student will learn basic fundamentals of general plant design
2 Students will acquire knowledge about flow sheet development
3 Student will design and analyze costing strategy
4 Student will be able to analyze cost
5 Students will learn basics of investments
6 Students will have knowledge about profitability

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	learn basic fundamentals of general plant design	Cognitive	Learn
CO2	acquire knowledge about flow sheet development	Cognitive	Acquire

CO3	design and analyze costing strategy	Psychomotor	Design
CO4	to analyze cost	Psychomotor	Learn
CO5	learn basics of investments	Cognitive	Learn
CO6	Gain knowledge about profitability	Cognitive	gain

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO4	3	3	3
CO5	3	3	3
CO6	3	3	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- General Plant Design Considerations Pre-project objectives, Project classification, Plant location, Plant Layout, Health and Safety , Loss Prevention, Environmental Protection, Plant operation and control, patent consideration	**10 Hrs.**
Unit 2:--- Flow sheet synthesis and development – Process Information, Input/output structure, Functions diagrams, Operations diagram, process flow sheet, use of softwares in process design	**6 Hrs.**
Unit 3:--- Design and costing strategy-Optimum design, material selection and costing, equipment design and costing and design reports.Comprehensive case studies	**8 Hrs.**
Unit 4:--- Analysis of Cost Estimation – Industrial Cash flow, Factors affecting investment and production cost,Capital Investment, estimation of capital investment, cost indexes, cost components in capital investment, methods for estimating capital investment, estimation of total product cost, gross profit, net profit and cash flow	**10 Hrs.**
Unit 5:--- Interest, Time value of Money, Taxes and fixed charges– Interest, cost of capital, time value of money, cash flow patterns, Income taxes, fixed charges	**6 Hrs.**
Unit 6:--- Profitability, Alternative investments and Replacements – Profitability standards, methods for calculating profitability,	**8 Hrs.**

alternative investments, replacements, practical factors in alternative investment and replacements analysis.	

Textbooks:

1. Plant Design & Economics for Chemical Engineers-M. S. Peters , K. D. Timmerhaus, R.E. West (McGraw Hill) Fifth edition
2. Chemical Engineering Design, Coulson & Richardson's Volume 6 – R.K. Sinnott (Elsevier Pub.)
3. Contemporary Engineering Economics – Chan S. Park (Perason Pretice Hall)

References:

4. Bioseparation Science and Engineering – Harrison R.G., Todd P., Rudge S.R., Petrides D.P.(Oxford University Press)
5. Principles of Fermentation Technology – Stanbury P.F., Whitaker A, Hall S. J. (Aditya Books)
6. Biochemical Engineering Fundamentals, Bailey&Ollis. (McGraw Hill Book Co.)
7. Conceptual Design of Chemical Processes, Douglas, James M., (McGraw-Hill,International Editions)
8. A Guide to chemical Engg. Process Design & Economics" Gael D .Ulrich, (John Wiley & Sons)
9. Chemical Project Economics, Mahajani, V.V., (Macmillan Indian Ltd.)
10. Systematic Methods of Chemical Process Design, Biegler, L.T., I.E. Grossmann and A.W. Westerberg, (Prentice Hall ,Pearson Education)
11. Chemical Process: Design and Integration, Smith, R., (John Wiley and Sons, West Sussex, UK)
12. Chemical Engineers Handbook 5th ed R.H. Perry& C.H. Chilton, (McGraw-Hill Book Company).

Unit wise Measurable students Learning Outcomes:

1 Student will learn basic fundamentals of general plant design
2 Students will acquire knowledge about flow sheet development
3 Student will design and analyze costing strategy
4 Student will be able to analyze cost
5 Students will learn basics of investments
6 Students will have knowledge about profitability

Title of the Course: Modeling and Simulation of Bioprocesses (Professional Elective –IV) **Course Code:** PBEB0225	**L**	**T**	**P**	**Credit**
	3	**1**	**0**	**4**

Course Pre-Requisite: Knowledge of different modes of reactor operations and their kinetics, solving of ODE, unit operations and basic mathematical calculations

Course Description: It describes the basic knowledge of various models, skills for model building, application of numerical methods, simulation techniques and successive usage of it in bioprocess and cellular level modeling.

Course Objectives:

1. To explain concept of modeling and simulation.
2. To explain application and scope of modeling in bioprocess industry.
3. To compute the model parameters by analyzing set of experimental data.
4. To construct the design equations of various types of reactors used in bioprocess industry.
5. To identify model development and simulation potential in students.
6. To learn various case studies of bioprocess and cellular level models

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Conceptualize the basics of modeling and simulations	Cognitive	Conceptualize
CO2	Acquire knowledge about numerical methods and their usage in process modeling	Cognitive	Acquire
CO3	Demonstrate dynamics of different fermentation modes	Psychomotor	Demonstrate
CO4	Learn various case studies of industrially important fermentation processes	Affictive	Learn

CO-PO Mapping:

CO	1	2	3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3
CO4	3	3	3
CO5	3	3	3
CO6	3	3	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Fundamentals of Modeling and Simulation Introduction of modeling and simulation, scope and applications of modeling and simulation in biotechnology, model building process, Use of fundamental laws: Continuity equation, energy equation, equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics, Process simulation, Scope of processsimulation, Formulation of problem, Process simulation approaches for steady state simulation, Strategies, Process simulator, Structure of process simulator, Simulation tools	**10 Hrs.**
Unit 2:--- Analytical and Numerical methods Newton's Method, Milne-Simpson Method, Euler method, Runge-Kutta method, Henn's Method, Polygon Method, Adams-Bashforth-Moulton Method	**7 Hrs.**

Unit 3:--- Model classification Types of Models with one case study each –Physical theory based versus empirical models, Steady state versus unsteady state models, linear versus non-linear models, Unstructured versus structured models, Segregated versus non-segregated models, Lumped versus distributed models, Deterministic versus stochastic models	**7 Hrs.**
Unit 4:--- Modeling of Bioprocess Systems Gravity flow tank and variations, Stirred tank heater, Batch fermentation and its variations (normal, substrate inhibited, product inhibited), Continuous / chemostat fermentations and its variations (normal, fed-back control, multistage), Fed batch bioreactor, Plug flow bioreactor, Bubble column bioreactor, Packed bed bioreactor, Fluidized bed reactor, Heat exchanger	**12 Hrs.**
Unit 5:--- Modeling of Bioprocess Case Studies Modeling of fermentation processes (lactic acid, antibiotic, ethanol), Modeling for activated sludge process, Modeling for anaerobic digestion	**6 Hrs.**
Unit 6:--- Modeling at cellular level Introduction to Biochemical Networks, Metabolic flux analysis, Elementary mode analysis, Modeling of gene regulation and Genetic switches	**6 Hrs.**
Textbooks: 1. Process Modelling Simulation and Control for Chemical Engineers- W L Luyben (McGraw-Hill). 2. 'Bioprocess Engineering Principles' P M Doran, Elsevier Science & Technology Books, May 1995. 3. 'Bioreaction Engineering Principles' J Nielsen, J Villadsen, G Lidén, Springer Books, 2003.	
References: 1] 'Bioprocess Engineering: Basic Concepts' M L Shuler, F Kargi, 2 illustrated, Prentice Hall, 2002. 2] Modeling and Control of fermentation Processes-J R Leigh (Peter Peregrinus). 3] Biochemical Engg Fundamentals- J.E. Bailey and D F Ollis (McGraw Hill). 4] Biological reaction engineering: Dynamic modeling fundamentals with simulation examples- J E Prenosil, E Heinzle, J Ingham, I J Dunn (Science).	
Unit wise Measurable students Learning Outcomes: **1** Student will learn basic fundamentals of modeling and simulation **2** Students will acquire knowledge about various analytical and numerical methods **3** Student will learn different types modeling methods **4** Student will be able to do modeling and simulation of important bioprocess systems **5** Students will learn various bioprocess case studies along with modeling and simulation **6** Students will have knowledge about biochemical networks, switches and their modeling	

Title of the Course: Metabolic Engineering **(Professional Elective –IV)** **Course Code:** PBEB0226	**L**	**T**	**P**	**Credit**
	3	**1**	**-**	**4**
Course Pre-Requisite: The students should have a basic knowledge of genetic engineering, Metabolic pathways and cellular physiology				
Course Description: Overview to the field with illustrating examples; Methods for metabolic characterization and modification Comprehensive models for cellular reactions; Regulation of metabolic Pathways; Metabolic flux analysis; Applications of metabolic flux analysis; Methods for the experimental determination of metabolic fluxes, Metabolic control analysis; Metabolic design: gene amplification, gene-disruption, randomized and targeted strain development; Metabolic Engineering in Practice: actual examples from research and industrial biotechnology				
Course Objectives: 1. To explain medical and agricultural importance of secondary metabolites and metabolically engineered products. 2. To describe up metabolic regulation and its control 3. To demonstrate about material and energy balances 4. To describe metabolic flux analysis 5. To evaluate and select strategies for genetic regulation of metabolic flux 6. To explain the role of metabolic engineering in pharmaceuticals, Fermentation industries				

and environmental bioremediation

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Understand and explain importance of metabolically engineered products	Comprehension	Understanding
CO2	Able to identify various control measures for metabolic regulation	Knowledge	Evaluating
CO3	Able to carry out material and energy balances	Application	Applying
CO4	Apply suitable methods to do flux analysis	Analysis	Remembering
CO5	Identify and select strategies for genetic regulation of metabolic flux	Synthesis	Creating
CO6	Able to interpret the role of metabolic engineering in pharmaceuticals, Fermentation industries and environmental bioremediation	Evaluation	Evaluating

CO-PO Mapping:

PO	1	2	3
CO2	2	3	1
CO3	3	1	1
CO4	3	3	3
CO5	3	3	3
CO6	1	3	3

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

SECTION – I

Unit: 1- Basic concepts of metabolic engineering • Introduction to metabolic engineering: Overview to the field with illustrating examples. • Central Metabolism: Fueling metabolism, Supply of biomass precursors, Anabolism, Anaplerosis.	**2Hrs.**
Unit: 2 - Application of metabolic engineering • Product over production examples: amino acids, polyhydroxyalkanoic acids, By-	**13Hrs.**

product minimization of acetate in recombinant *E. coli*, Extension of substrate utilization range for organisms such as *S. cerevisae* and *Z. mobilis* for ethanol production • Metabolic engineering of *Clostridium autoethanogenum* for selective alcohol production • Process optimization to improve production and secretion of fatty acids	
Unit: 3- Genetic regulation of metabolic flux • Gene expression in response to environmental stimulus, • genetic tools for altering gene expression	**3 Hrs.**
SECTION – II	
1. Unit: 4 – Control measures for metabolic regulation • Improvement of cellular properties, Altering transport of nutrients including carbon and nitrogen and xenobiotic degradation.	**2Hrs**
Unit: 5 - Material and energy balances • Comprehensive models for cellular reactions: Stochiometry of cellular reactions, Reaction rates, Dynamic mass balance. • Material and energy balances, Basis for simplification of reaction; elementalbalances; component balances and the link with macroscopic measurements; • Examples of construction of elemental and component balances, thermodynamics of cellular processes – new concepts for quantitative bioprocess research and development**.**	**8Hrs.**
Unit: 6 - Metabolic flux analysis • 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, Methods for experimental determination of metabolic fluxes by isotope labeling	**8Hrs.**
Text and Referencebooks:- 1. Metabolic Engineering - Principles and Methodologies Publisher: cbspd (Elsiver); First edition (21 November 2005) by Stephanopoulos 2. Systems Metabolic Engineering Publisher: Springer; 2012 by Christoph Wittmann 3. Computational Modeling of Genetic and Biochemical Network, by James M Bower & Hamid Bolouri. 4. Metabolic Flux analysis, by Valino. 5. Comprehensive Biotechnology, Vol-3, By Moo & Young. 6. Fundamentals of Biochemical Engg. by Baily & Olis. 7. Principles of Biochemical Engg. By Aiba & Humphery. 8. Metabolic Engineering Volume 40, March 2017, Pages 104-111	
Unit wise Measurable students Learning Outcomes: **2.** Understand and explain importance of metabolically engineered products **3.** Able to interpret the role of metabolic engineering in pharmaceuticals, Fermentation industries and environmental bioremediation	

4. Identify and select strategies for genetic regulation of metabolic flux
5. Able to identify various control measures for metabolic regulation
6. Able to carry out material and energy balances
7. Apply suitable methods to do flux analysis

Title of the Course: Laboratory-3	**L**	**T**	**P**	**Credit**
Course Code: PBEB0133	**0**	**1**	**2**	**2**

Course Pre-Requisite: students must have basic theoretical knowledge of Bioreaction Engineering & Microbiology & Biochemistry,

Course Description:

The course, provides students with a research-inspired laboratory experience that introduces standard biochemical techniques in the context of investigating a current and exciting research topic,. Techniques include Isolation and separation ,Estimation, Adsorption chromatography, TLC, purification, and gel analysis

Course Objectives:

The primary objective of this course is for students to

1. learn fundamental approaches for experimentally investigating biochemical problems,
2. learn the theoretical foundations for the methods used, and
3. understand the applicability of the biochemical methods to realistic situations. Topics covered in this course include methods for the isolation, purification, and characterization of proteins, vitamins, carbohydrates and lipids,

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Recall fundamental approaches for experimentally investigating biochemical problems,	Cognitive	Recall
CO2	Explain the theoretical foundations for the methods used,	Psychomotor	Explain
CO3	Discuss the applicability of the biochemical methods to realistic situations	Affective	Discuss

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	1	1
CO2	3	1	1
CO3	1	1	2

Assessments :
Teacher Assessment:
One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE(POE)	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:--- Estimation of vitamin A and vitamin C from green leafy vegetables **2Hrs.**

Aim and Objectives:

1.To estimate Vitamin A from green leafy vegetables.

2.To determine vitamin C concentration from green leafy vegetables

Outcomes:

1. To estimate Vitamin A from green leafy vegetables.

2.To determine vitamin C concentration from green leafy vegetables

Experiment No. 2:--- Isolation and separation of Polyphenols by chromatography **Aim and Objectives:** To isolate polyphenol from given sample by chromatography **1.** To perform isolation of polyphenol from given sample **2.** To Learn the technique of Adsorption chromatography **Outcomes:** **1.** Students will learn to perform isolation of polyphenol from given sample **2.** Students will learn to the technique of Adsorption chromatography	**2 Hrs.**
Experiment No. 3:--- To find out substrate specificity of enzymes **Aim and Objectives:** To analyze the effect of substrate concentration on the activity of enzymes. **Outcomes:** The students will be able to perform and find the effect of substrate concentration on the activity of enzymes.	**2 Hrs.**
Experiment No. 4:--- Preparation of immobilized enzymes using ion exchange resin CM- cellulose **Aim and Objectives:** To Prepare immobilized enzymes using ion exchange resin CM- cellulose To learn protein purification by ion exchange Chromatography involving the following experiments: Purification of Lysozyme using CM-cellulose, **Outcomes:** The students will be able to perform the immobilization of enzymes using ion exchange resin CM- cellulose The students will be able to Estimate of Lysozyme activity and Estimate of protein concentration	**2Hrs.**
Experiment No. 5:--- Separation of lipids by Thin Layer Chromatography **(TLC)** **Aim and Objectives:** To separate lipids using TLC **Outcomes:** To learn the technique of TLC on the basis of absorption and partition.	2 **Hrs.**
Experiment No. 6:--- Extraction of Protein from milk, eggs and muscles. **Aim and Objectives:** To perform the isoelectric precipitation & salting out of protein present in milk., eggs & muscles **Outcomes:** The students will learn extraction of protein by isoelectric precipitation & salting out	2 **Hrs.**
Experiment No. 7:--- determination of the amount of phosphate in soft drinks	

Aim and Objectives: To determine the amount of phosphate in soft drinks

Outcomes: The students will learn to determine the amount of phosphate in soft drinks

Textbooks:

1. David L. Nelson, Michael M. Cox, Lehninger principles of biochemistry, 4th edition.
2. Trevor Palmer, Enzymes: Biochemistry, Biotechnology and Clinical Chemistry,2nd edition.
3. David T Plummer, An Introduction to practical biochemistry, 3rd edition.
4. R. Eisenthal and M.S.Danson, Enzyme assays ,2nd edition

References:

1. http://www.scribd.com/doc/21572303/Effect-of-Substrate-Concentration-on- %CE%B1-Amylase
2. http://www.biology.hawaii.edu/171L/fall/sample%20lab%20summary.pdf
3. http://www.ucl.ac.uk/~ucbcdab/enzass/substrate.htm
4. http://ccl.northwestern.edu/netlogo/models/EnzymeKinetics]

Experiment wise Measurable students Learning Outcomes:

1. Students will learn the estimation Vitamin A from green leafy vegetables &. determination vitamin C concentration from green leafy vegetables
2. Students will learn the theoretical foundations for the methods used, perform isolation of polyphenol from given sample & Learn the technique of Adsorption chromatography
3. analyze the effect of substrate concentration on the activity of enzymes
4. Students will be learn the understand the applicability of the biochemical methods to realistic situations such as methods for the isolation,
5. Students will learn the immobilization of enzymes using ion exchange resin CM- cellulose purification, and characterization of proteins, vitamins, carbohydrates and lipids
6. Students will learn the immobilization of enzymes using ion exchange resin CM- cellulose purification

Title of the Course: Laboratory-4 **Course Code:** PBEB0134	**L**	**T**	**P**	**Credit**
	0	**0**	**2**	**1**

Course Pre-Requisite: students must have basic theoretical knowledge of Bioreaction Engineering & Microbiology & Biochemistry,

Course Description:

The course, provides students with a research-inspired laboratory experience that introduces standard biochemical techniques in the context of investigating a current and exciting research topic,. Techniques include Isolation and separation ,Estimation, Adsorption chromatography, TLC, purification, and gel analysis

Course Objectives:

The primary objective of this course is for students to

4. learn fundamental approaches for experimentally investigating biochemical problems,
5. learn the theoretical foundations for the methods used, and
6. understand the applicability of the biochemical methods to realistic situations. Topics covered in this course include methods for the isolation, purification, and characterization of proteins, vitamins, carbohydrates and lipids,

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Recall fundamental approaches for experimentally investigating biochemical problems,	Cognitive	Recall
CO2	Explain the theoretical foundations for the methods used,	Psychomotor	Explain
CO3	Discuss the applicability of the biochemical methods to realistic situations	Affective	Discuss

CO-PO Mapping:

CO	1	2	3
CO1	3	1	1
CO2	3	1	1
CO3	1	1	2

Assessments :
Teacher Assessment:
One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	50
ESE(POE)	50

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination

Course Contents:

Experiment No. 1:--- Determination and exhibition of K_m of the amylase from parotid and pancreas **Aim and Objectives:** To Determine and exhibit of K_m of the amylase from parotid and pancreas **Outcomes:** The students will learn the procedure for Determination and exhibition of K_m of the amylase from parotid and pancreas	**2Hrs.**
Experiment No. 2:--- Effect of competitive and non competitive inhibitors on the	**2 Hrs.**

enzyme action. **Aim and Objectives:** To study the Effect of competitive and non competitive inhibitors on the enzyme action. **Students should** 1. Recall that enzymes act as unchanged catalysts to speed up reactions in cells 2. Be able to estimate Vmax and Km from a graph of reaction rate vs. substrate concentration. 3. Explain that rate can be saturated, and that it depends on the concentration of substrate (in the case where [S]>>[E] 4. Distinguish between competitive and non-competitive inhibitors based on changes in Vmax and Km **Outcomes:** The students will learn the procedure for Determination and exhibition of effect of competitive and non competitive inhibitors on the enzyme action.	
Experiment No. 3:--- Molecular weight determination of protein **Aim and Objectives:** To perform method for determining the molecular weight (MW) of an unknown protein. **Outcomes:** The students will learn to perform method for determining the molecular weight (MW) of an unknown protein.	**2 Hrs.**
Experiment No. 4:--- Isolation of enzyme chemotrypin. (Salt precipitation, gel filtration.) **Aim and Objectives:** To isolate chymotrypsin by salt precipitation, Gel filtration **Outcomes:** The students will learn to Perform the isolation **of** enzyme chemotrypin. (Salt precipitation, gel filtration)	**2Hrs.**
Experiment No. 5:--- Determination of c-terminal amino acids by sodium borohydrate- α amino alcohols can be distinguished by chromatography **Aim and Objectives:** Determine of c-terminal amino acids by sodium borohydrate- α amino alcohols can be distinguished by chromatography To Determine of c-terminal amino acids by sodium borohydrate- α amino alcohols can be distinguished by chromatography **Outcomes:** The students will be able to determine of c-terminal amino acids by sodium borohydrate- α amino alcohols can be distinguished by chromatography	**2 Hrs.**
Experiment No. 6:--- Study of Structure of enzyme serine protease by X-ray crystallography. **Aim and Objectives:** To Study of Structure of enzyme serine protease by X-ray crystallography. **Outcomes:** The students will be able to determine the Structure of enzyme serine protease by X-ray crystallography.	**2 Hrs.**
Experiment No. 7:--- Purification of antibodies using ammonium sulphate precipitation **Aim and Objectives:** To study the Purification of antibodies using ammonium sulphate precipitation **Outcomes:** The students will be able to Purification of antibodies using ammonium sulphate precipitation	

Textbooks:

1. David L. Nelson, Michael M. Cox, Lehninger principles of biochemistry, 4th edition.
2. Trevor Palmer, Enzymes: Biochemistry, Biotechnology and Clinical Chemistry,2nd edition.
3. David T Plummer, An Introduction to practical biochemistry, 3rd edition.
4. R. Eisenthal and M.S.Danson, Enzyme assays ,2nd edition

References:

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2. http://www.biology.hawaii.edu/171L/fall/sample%20lab%20summary.pdf
3. http://www.ucl.ac.uk/~ucbcdab/enzass/substrate.htm
4. http://ccl.northwestern.edu/netlogo/models/EnzymeKinetics]

Experiment wise Measurable students Learning Outcomes:

1. Students will learn Determination and exhibition of K_m of the amylase from parotid and pancreas
2. Students will learn the theoretical foundations for the methods used, perform isolation of polyphenol from given sample & Learn the technique of Adsorption chromatography
3. The students will learn to perform method for determining the molecular weight (MW) of an unknown protein
4. The students will learn to Perform the isolation **of** enzyme chemotrypin. (Salt precipitation, gel filtration.)
5. The students will be able to determine of c-terminal amino acids by sodium borohydrate- α amino alcohols can be distinguished by chromatography
6. The students will be able to determine the Structure of enzyme serine protease by X-ray crys
7. The students will be able to Purification of antibodies using ammonium sulphate precipitation

Title of the Course:Seminar-2 **Course Code:** PBEB0242	**L**	**T/S**	**P**	**Credit**
	0	**2**	**0**	**1**

Course Pre-Requisite: No Pre-Requisite

Course Description: The student should deliver a seminar (each 15 to 20 minutes) and submit Seminar report to the department. The topic of the seminar may be chosen from different technical subjects being studied during the semester.

Course Objectives:

1. Knowledge: Students: - Remember methodology of applied biological sciences & Engineering; - Apply principles to current problems; - recall theoretical framework for methods applied to biological sciences & Engineering

2Practical Skills: Students: - Integrate knowledge provided from interdisciplinary sources to solve research problems; - Evaluate data and results using critical thinking skills; - Can revise and present scientific case studies in multimedia presentation in English

3. Social Competence: Students: - Effectively collaborate with other students in analyzing results, and preparing oral presentations; - Are able to find appropriate sources that can be summarized and integrated into multimedia presentation; - Are aware of importance of access to data, knowledge and results of scientific studies; - Are aware of importance and role of scientific honesty, data reliability, intellectual property rights and rules of access to data and scientific information; - Accept the

importance of quality of research results presentation for effective scientific communication

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Remember methodology of applied biological sciences & Engineering; - Apply principles to current problems; - recall theoretical framework for methods applied to biological sciences & Engineering	Cognitive	Remember
CO2	Practical Skills: Students: - Integrate knowledge provided from interdisciplinary sources to solve research problems; - Evaluate data and results using critical thinking skills; - Can revise and present scientific case studies in multimedia presentation in English	Affective	solve
CO3	Social Competence: Students: - Effectively collaborate with other students in analyzing results, and preparing oral presentations; - Are able to find appropriate sources that can be summarized and integrated into multimedia presentation; - Are aware of importance of access to data, knowledge and results of scientific studies; - Are aware of importance and role of scientific honesty, data reliability, intellectual property rights and rules of access to data and scientific information; - Accept the importance of quality of research results presentation for effective scientific communication	Psychomotor	analyzing

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	3	3	3
CO2	2	1	2
CO3	1	1	2

Assessments :
Teacher Assessment:
One component of In Semester Evaluation (ISE) having 100% weights respectively.

Assessment	Marks
ISE	100
ESE	-

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.
ESE: Assessment is based on oral examination

Course Contents:

The assessment shall be based on - 1. Performance of the seminar delivery. 2. Details provided in seminar reports and 3. Performance during discussions on the seminar topic The faculty member / s shall guide the students for: 1. Selecting the seminar topics 2. Information retrieval (literature survey) 3. Source of information i.e. names of the journals, reports books etc	36 **Hrs.**

4. Preparation of the seminar report as per the guidelines of department 5. Presentations on Powerpoint	

Measurable students Learning Outcomes:

1. Knowledge: Students: - Understand methodology of applied biological sciences & Engineering; -
2. Apply principles to current problems; -
3. Understand theoretical framework for methods applied to biological sciences & Engineering;
4. Practical Skills: Students: - Integrate knowledge provided from interdisciplinary sources to solve research problems; -
5. Evaluate data and results using critical thinking skills; -
6. Can revise and present scientific case studies in multimedia presentation in English.
7. Social Competence: Students: - Effectively collaborate with other students in analysing results, and preparing oral presentations; -
8. Are able to find appropriate sources that can be summarized and integrated into multimedia presentation; -
9. Are aware of importance of access to data, knowledge and results of scientific studies; -
10. Are aware of importance and role of scientific honesty, data reliability, intellectual property rights and rules of access to data and scientific information; - Accept the importance of quality of research results presentation for effective scientific communication

Dr. M. R. Sanandam	**Dr. M.S. Chavan**	**Dr. V. V. Karjinni**
B.O.S. Chairman	**Dean Academics**	**Directors**