

**HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR**  
**SCHOOL OF CHEMICAL TECHNOLOGY**  
**DEPARTMENT OF CHEMICAL TECHNOLOGY - BIOCHEMICAL ENGINEERING**

**M. Tech. Chemical Technology-Biochemical Engineering**

**(Applicable from Session 2020-2021 for new entrants)Year**

**I, Semester-I**

**Course Title: BIOREACTOR DESIGN and ANALYSIS**

**Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PCC	TBE-551	5	3	1	2	15	20	15	50	50	100

**Objective:-** To provide the basic principles of reactor design for bioprocess and biotechnology applications.

**Course outcome:-** On successful completion of the course student will be able to –

CO1	Comprehend the state of the arts in bioreactor technology and its broad range of applications. Techniques to measure and control these parameters.	<b>Apply</b>
CO2	Understand and specify reactors used in industrial bioprocesses, develop mathematical models for bioreactors and analyze their behaviour (dynamic and steady state).	<b>Apply</b>
CO3	Understand basic principles of mass and energy conservation to analyze bioreactor systems, identify the major engineering parameters that characterizes the performance of bioreactors and techniques to measure and control these parameters	<b>Apply</b>
CO4	Understand suitable process instrumentation for monitoring and control of bioreactors	<b>Apply</b>
CO5	Understand analyze the problem of selection of suitable bioreactor configuration.	<b>Apply</b>

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3	2			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>2</b>		<b>2</b>	<b>2</b>					<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

## Syllabus

**Unit 1:** Bioreactors for microbial, animal and plant cell culture. Stirred tank reactor for bio-processing.

**Unit 2:** Design principles, mixing & mass transfer behavior and characterization of plug flow reactor, Air-lift reactor, tubular reactor etc.

**Unit 3:** Bioreactors used for immobilized cells and enzymes.

**Unit 4:** Design and applications of non-conventional bioreactors such as spiral reactor, membrane reactor, photo-bioreactor, tower reactors.

**Unit 5:** Monitoring, on-line measurements & computer control of bioreactors.

References:

1. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill BookCo., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London.
6. T Panda, Bioreactors analysis and design, Tata McGraw Hill, New Delhi, New York, 2011

## Year I, Semester-I

Course Title: Structural and Molecular Biology

### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PCC	TBE-553	4	3	1	0	30	20	-	50	50	100

### Objective:-

To teach and demonstrate the cell organization, function and interaction of cell organelles. To demonstrate the mechanism of transcription, translation and its regulation.

To teach the concept of genes and heredity.

Students will come to know about r-DNA technology and the concepts of gene expression and its control.

**Course outcome:-** On successful completion of the course student will be able to –

CO 1	Understand to improve the microbial strains for their productivity.	<b>Apply</b>
CO2	Understand the fundamentals of molecular biology and genetic engineering.	<b>Apply</b>
CO3	Understand to recent developments in genetic engineering-gene cloning, treatment of various diseases including cancer, diabetes and hereditary diseases.	<b>Apply</b>
CO4	Understand to improve the microbial strains for their productivity.	<b>Apply</b>
CO5		

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											3	3	3
CO2	2	2	2			2						3	3	3
CO3	3											3	3	3
CO4	3					2						3	3	3
CO5	3	2				2						3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>			<b>2</b>						<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

## Syllabus

### Unit-I

Characteristics of living systems, Structure and functions of biomolecules and cell organelles.

### Unit-II

Non covalent interactions in living cells. Taxonomy, Morphology and Physiology of microorganisms.

### Unit-III

Transport across biological membranes. Bioenergetics: energy producing and consuming metabolic processes.

### Unit-IV

Genetic information and its perpetuation. Transcription and translation: mechanism and control. Gene exchange and gene regulation in microbes. The Operon models.

### Unit-V

1. Microscopy of cell organelles.
2. Development of slides for scan electron microscopy.
3. Screening and selection of mutants by exposure of microbial cells to physical agents.
4. Mutation using chemical agents.
5. Estimation of DNA and RNA in microbial cells.
6. Induction and repression of  $\beta$ -galactosidase in yeast.

### References :

1. "Principles and Techniques of Biochemistry and Molecular Biology" (7th edition), Keith Wilson and John Walker, Cambridge University Press (2010).
2. "Molecular Biology of the Gene", J.D. Watson, Menlo Park, California.
3. "Lewin's GENES XII", Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning, (2017).
4. "Molecular Cell Biology", Harvey Lodish et al; W. H. Freeman (2016)
5. "Cell Biology : A laboratory hand book", Julio E. Celis, Academic Press (2006)

## Year I, Semester-I

### Course Title: ADVANCED BIOPROCESSES

#### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-555	4	3	1	0	30	20	-	50	50	100

**Course Objective:** To demonstrate ability to plan and execute experiments, and analyze and interpret outcomes.

**Course outcome:-** On successful completion of the course student will be able to –

CO 1	Identify and analyse biotechnological processes.	<b>Apply</b>
CO2	Select and process various raw materials for valuable products formation.	<b>Apply</b>
CO3	Manipulate/ improve bioprocesses used in industries for yield enhancements.	<b>Apply</b>
CO4	Establish continuous processes for solid and liquid media.	<b>Apply</b>
CO5	Apply the engineering concept in fermentation processes.	

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					3	3					3	3	3
CO2	3			2		3						3	3	3
CO3	3	3		2		3			2			3	3	3
CO4	3	3	3	2	2	3			2			3	3	3
CO5	3	3	3	2	2	3			2			3	3	3
<b>Total</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>3</b>		<b>2</b>			<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

## SYLLABUS

### UNIT I

An overview of traditional and modern applications of biotechnological processes, General requirements of fermentation processes, Different raw materials used in fermentation industry and their pretreatment, Medium for plant cell culture and animal cell culture, Medium design of commercial media for industrial fermentations. Tools for media optimization .

### UNIT II

Stoichiometry of Cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, maintenance coefficients Energetic analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth.

### **UNIT III**

Mass transfer includes transport phenomena in bioprocesses, Factors affecting oxygen transfer rate in bioreactors, Techniques for measurement of volumetric oxygen transfer coefficient, Fluid rheology and factors affecting bioreactor processes, Flow Patterns in agitated tanks, Mechanism & Power requirements of mixing, Scale up of mixing systems. Continuous Processes: Submerged and SSF.

### **UNIT IV**

Different regulatory mechanisms involved in controlling the catabolic and anabolic processes of microbes, Induction, nutritional repression, carbon catabolite repression, Crabtree effect, feedback inhibition and feedback repression, Concept of Overproduction of metabolites.

### **UNIT V**

Case studies on production of Lactic acid, Glutamic acid, Penicillin, Microbial Lipase and Protease, Recombinant Insulin, Interferons, Hepatitis Vaccines etc. Case studies should deal with strain improvement, medium designs, process optimization technology.

#### Text Books:

1. Bioprocess Technology - Kinetics & Reactors" by A Moser, Springer-Verlag.
2. Biochemical Engineering and Biotechnology Handbook" by B. Atkinson & F. Mavituna, 2ndEd. Stockton Press.
3. Bioprocess Engineering Principles" by Pauline M. Doran, Academic Press.
4. Lee J.M, Biochemical Engineering 2nd ed, Prentice Hall, 2000.
5. Biotechnology" Vol.4 Meaning Modelling and Control Ed. K.Schugerl, VCH (1991).

## Year I, Semester-I

### Course Title: ANALYTICAL METHODS in BIOPROCESSES

#### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-557	4	3	1	0	30	20	-	50	50	100

**Course Objective:** To demonstrate ability to plan and execute experiments, and analyze and interpret outcomes.

**Course outcome:-** On successful completion of the course student will be able to –

CO 1	Understand and identify metabolites.	<b>Apply</b>
CO2	Understand the process for solid - liquid separation.	<b>Apply</b>
CO3	Understand basic principles important instruments frequently used in bioprocess industries.	<b>Apply</b>
CO4	Understand and analyze raw materials used in fermentation based industries	<b>Apply</b>
CO5	evaluate a large group of fermentation products.	

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					3	3					3	3	3
CO2	3			2		3						3	3	3
CO3	3	3		2		3			2			3	3	3
CO4	3	3	3	2	2	3			2			3	3	3
CO5	3	3	3	2	2	3			2			3	3	3
<b>Total</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>3</b>		<b>2</b>			<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

#### Syllabus

**Unit 1:** Nature & properties of biochemical metabolites.

**Unit 2:** Principle and application of Chromatography, Hydrodynamic methods, sedimentation, Ultracentrifugation.

**Unit 3:** Spectrophotometry, Mass spectrometry and HPLC.

**Unit 4:** Analysis of raw materials, Quality control of bioproducts.

**Unit 5:** Assay of vitamins, Antibiotics, Steroids, Vaccines, Amino acids, Nucleic acids.

## Year I, Semester-I

### Course Title: BIOCHEMICAL ENGINEERING

#### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-559	4	3	1	0	30	20	-	50	50	100

**Course Objective:** To demonstrate ability to plan and execute experiments, and analyze and interpret outcomes.

**Course outcome:-** On successful completion of the course student will be able to –

CO 1	Understand present unit operations together with the fundamental principles for basic methods in production technique for biologically based products.	<b>Apply</b>
CO2	Calculate the need for oxygen and oxygen transfer in a biological production process.	<b>Apply</b>
CO3	Understand TO explain how microorganisms and biochemical processes can be applied in engineered systems and processes.	<b>Apply</b>
CO4	Understand an account of measurement and control of parameters in a bioreactor.	<b>Apply</b>
CO5	Calculate yield and production rates in a biological production process, and also interpret data.	

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3		1									2	3	3
CO2	3	2	1									2	3	3
CO3	3	2	1									2	3	3
CO4	3	2	1	1	2	1						2	3	3
CO5	3	2										2	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>						<b>2</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

**Unit 1:** Biochemical Engineering and its role in the development of bioprocesses.

**Unit 2:** Kinetics of microbial growth and product formation, kinetics of enzyme reactions.

**Unit 3:** Batch, continuous and fed-batch processes.

**Unit 4:** Media and air sterilization. Aseptic operation. Aeration and agitation. Scale-up criteria. **Unit 5:** Immobilization of enzymes and cells. Operation, measurement of parameters and control of bioreactors.



**Year I, Semester-II**  
**Course Title : BIOSEPARATION and DOWN STREAM PROCESSING**

**Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PCC	TBE-552	4	3	1	2	15	20	15	50	50	100

**Objective:-**

The objective of this course is to acquaint students with necessity, complexities, and suitable methodology for recovery of bioproducts in desired degree of purity and form,

**Course outcome:-** On successful completion of the course student will be able to –

CO1	Understand necessity of DSP and factors influencing choice of methods for DSP	<b>Apply</b>
CO2	Understand principle and technique for primary separation methods.	<b>Apply</b>
CO3	Understand various primary isolation technique.	<b>Apply</b>
CO4	Understand various purification methods.	<b>Apply</b>
CO5	Understand final isolation methods.	<b>Apply</b>

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					1	2					3	3	3
CO2	3					1	2					3	3	3
CO3	3					1	2					3	3	3
CO4	3	2	1			1	2					3	3	3
CO5	3					1	2					3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>1</b>			<b>1</b>	<b>2</b>					<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

**SYLLABUS**

**Unit-I**

Introduction : Characteristics of fermentation broth, conditioning of broth, major consideration in DSP design, Isolation and purification of recombinant proteins.

**Unit-II**

Solid liquid separation method. cell disruption methods.

**Unit-III**

Protein Precipitation, Adsorption, Aqueous two-phase extraction.

**Unit-IV**

Membrane based separation processes,, Chromatography techniques.

**Unit-V**

Finishing operations: crystallization , drying, and formulation.

**REFERENCE:**

1. “Biochemical Engineering Fundamentals ” by J.E. Bailey and D.F.Ollis, McGraw –Hill BookCo., New York.
2. “ Basic Biotechnology ” , J. Bu’lock , B. Krishtiansen, Academic Press
- 3 “ Comprehensive Biotechnology” ; Vol.2, Murray-Moo-Young , Pergamon Press, New York.

## Year I, Semester-II

### Course Title: BIOPROCESS TECHNOLOGY

#### Evaluation

#### Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PCC	TBE-554	4	3	1	0	30	20	-	50	50	100

#### Objective:-

The objective of this course is to acquaint students to understand the biological systems; and to understand the role of microorganisms in the upstream processing and importance of downstream processing in biotechnology.

**Course outcome:-** On successful completion of the course student will be able to –

CO1	To evaluate the kinetics and mechanism of enzymatic process	<b>Apply</b>
CO2	To understand the metabolism and microbial growth kinetics	<b>Apply</b>
CO3	To evaluate the bioreactors, design features and the instrumentation and control of bioreactors	<b>Apply</b>
CO4	To understand the role of downstream processing in biotechnology	<b>Apply</b>
CO5	To understand advanced separation processes Chromatography, Electrophoresis, Crystallization, drying and freeze drying.	<b>Apply</b>

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					1	2					3	3	3
CO2	3					1	2					3	3	3
CO3	3					1	2					3	3	3
CO4	3	2	1			1	2					3	3	3
CO5	3					1	2					3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>1</b>			<b>1</b>	<b>2</b>					<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

## SYLLABUS

### UNIT I-ENZYME TECHNOLOGY

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

### UNIT II-METABOLISM, STOICHIOMETRY AND MICROBIAL GROWTH KINETICS

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

### **UNIT III-BIOREACTORS, STERILIZATION, SENSORS AND INSTRUMENTATION**

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

### **UNIT IV-PRIMARY SEPARATION PROCESS**

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

### **UNIT V-SECONDARY SEPARATION PROCESS**

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

### **REFERENCES**

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

## Course Title: BIOLOGICAL WASTE TREATMENT

### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PCC	TBE-556	4	3	1	0	30	20	-	50	50	100

### Objective:-

To acquaintain the student with impacts of environmental pollution and use of engineering and Biotechnology in abatement of pollution.

**Course outcome:-** On successful completion of the course student will be able to –

CO1	Understand about sources and nature of air pollutants and necessity of legislation for their control.	Apply
CO2	Understand strategies and methods for control of air pollutants.	Apply
CO3	Understand characteristics of waste water and various treatment technologies.	Apply
CO4	Understand about elements of solid waste management and its implementation.	Apply
CO5	Understand experimental aspects involved in environmental studies.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3				2						3	3	3
CO4	3	3				2						3	3	3
CO5	3	3	3	2		2						3	3	3
<b>Total</b>	<b>3</b>	<b>3</b>	<b>2.5</b>	<b>2</b>		<b>2</b>			<b>2</b>			<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

### SYLLABUS

#### Unit-I

Air pollution sources and effect on living and nonliving bodies, classification and characteristics of air pollutants and their distribution, air pollution control legislation.

#### Unit-II

Control strategies and methods for control of air pollutants.

#### Unit-III

Water pollution- sources and impact of major pollutant of concern in water, aerobic, anaerobic and advanced waste water treatment methods.

#### Unit-IV

Solid waste- sources type and effects of solid wastes . Solid waste management treatment and disposal.

**Unit-5**

Laboratory exercise DO,BOD,COD, and solids determination, colour and odour measurement, evaluation of performance of aerobic and anaerobic reactor.

**REFERENCE:**

1. "Environmental Engineering" by Peavy & Row
- 2 " Waste water Engineering: Treatment, Disposal and Reuse", Metcalf & Eddy, Inc.; TataMcGraw-Hill Publishing Company Ltd., New Delhi.
3. " Water supply and Pollution Control ", Warren Viessman Jr. and Mark J. Hammer; Harper&Row Publishers; New York.
4. Waste water Treatment :Rational Methods of Design & Industrial Practices Rao &Dutta published by Oxford & IBH Publishing Company Private Ltd. II Edison

Year-I, Semester-II

Course Title: PLANT BIOTECHNOLOGY

**Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-558	4	3	1	0	30	20	-	50	50	100

**Course Objectives:**

- Students will understand about tissue culture techniques.
- To familiarize the students with applied aspects of plant biotechnology.
- To make the students aware of transgenic plants.
- To teach the students production of secondary metabolites of plant origin.

**Course outcome:-** On successful completion of the course student will be able to –

CO 1	Understand to use cell and tissue culture techniques.	<b>Apply</b>
CO2	Understand to apply gene transfer techniques for improvement of plants.	<b>Apply</b>
CO3	Understand to use secondary metabolites of plant origin at any level.	<b>Apply</b>

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3			1		2	3					3	3	3
CO2	3	2	2	1	1	2	3			3	2	3	3	3
CO3	3									3		3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>3</b>			<b>3</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

**Syllabus**

**UNIT-I**

Special features and organization of plant cells. Totipotency, penetration of plants. Plant products of industrial importance. Biochemistry of major metabolic pathways and products.

**UNIT-II**

Autotrophic and heterotrophic growth. Plant growth regulators and Elicitors: cell suspension culture development: methodology, kinetics of growth and product formation, nutrient optimization.

### **UNIT-III**

Production of secondary metabolites by suspension cultures with a few case studies.

### **UNIT-IV**

Biological & technological barriers- hydrodynamic shear and its quantification and impeller design aspects.

### **UNIT-V**

Plant cell reactors: Comparison of reactor performances. Immobilized plant cell and cell retention reactors. Hairy root cultures and their cultivation.

#### References:

1. "Introduction to Plant Biotechnology", H. S. Chawla, Science Publishers(2002).
2. "Introduction to Plant Tissue Culture", M. K. Razdan, Science Publishers(2003).
3. "Plant Biotechnology: The genetic manipulation of plants", Adrian Slater, Mark R. Fowler & Nigel W. Scott, Oxford University Press (2008).



Course Title: Animal Cell Culture and Tissue Engineering

**Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-560	4	3	1	0	30	20	-	50	50	100

**Course Objectives:**

- Students will prepare and sterilize animal cell culture.
- Students will know about the different techniques for culturing.
- Students will know how to clone.
- To teach different cell culture reactor for different culturing.

**Course outcome:-** On successful completion of the course student will be able to –

CO 1	Students will be able to know the behavior of animal cells in culture conditions.	<b>Apply</b>
CO2	Student will be able to produce metabolic products of animal origin.	<b>Apply</b>
CO3	Students will be able to do different selection for cell cloning.	<b>Apply</b>
CO4	Student will be able to reproduce animals of improved characteristics.	<b>Apply</b>

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											2	3	3
CO2	3					2						2	3	3
CO3	3											2	3	3
CO4	3											2	3	3
<b>Total</b>	<b>3</b>	<b>2</b>				<b>2</b>	<b>2</b>					<b>2</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

**Syllabus**

**Unit-I :** Characteristics of animal cell, metabolism, regulation and nutritional requirement.

**Unit-II:** Effects of shear force and kinetics of cell growth and product formation. Product and substrate transportation. Hybridoma technology; genetic engineering in animal cell culture.

**Unit-III :** Scale-up and large scale operation; Perfusion bioreactors, hollow fiber bioreactor, operational strategies of mass cell culture. Production of metabolic products of animal origin including erythropoietin, MCA etc.

**Unit-IV :** Disaggregation (enzymatic and mechanical) of tissue and primary culture; Cultured cells and evolution of cell lines; Maintenance of cultures – cell lines; Cloning of cell lines; Somatic cell fusion. Tissue culture (slide, flask and test tube cultures); Organ culture; Whole embryo culture;

**Unit-V:** Tissue organization, Tissue Components, Tissue types, Functional subunits. Tissue Dynamics, Dynamic states of tissues. Tissue engineering case studies: Artificial skin, Artificial blood vessels.

References :

1. “Animal Cell Culture and Technology”, Michael Butler, Taylor & Francis (2014).
2. “Animal Cell Culture”, Al-Rubeai, Mohamed, Springer International Publishing (2015).
3. “Principles of Tissue Engineering”, Robert Lanza, Robert Langer, Joseph Vacanti, Academic Press(2013).
4. “Tissue Engineering: Principles and Practices”, John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, Donald R. Peterson, CRC Press (2017).

**M. Tech. Chemical Technology-Biochemical Engineering**  
**(Applicable from Session 2021-2022 for new entrants)Year**  
**II, Semester-III**

**Course Title : INDUSTRIAL ENZYMES**

**Evaluation**

**Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PCC	TBE-659	4	3	1	0	30	20	-	50	50	100

**Objective:-**

The objective of this course is to acquaint students with recent development in enzyme engineering and technology.

**Course outcome:-** On successful completion of the course student will be able to –

CO1	Understand enzyme properties and production methods.	<b>Apply</b>
CO2	Understand down stream processing.	<b>Apply</b>
CO3	Understand immobilization techniques and their application feasibility	<b>Apply</b>
CO4	Understand specific role of enzymes in particular industry.	<b>Apply</b>
CO5	Understand reactor configuration and criteria for selection of reactors.	<b>Apply</b>

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											3	3	3
CO2	3	2	1			1						3	3	3
CO3	3	2	1			1						3	3	3
CO4	3	2	1			1						3	3	3
CO5	3		1									3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>1</b>			<b>1.25</b>						<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

**SYLLABUS**

**Unit-I**

Sources and general aspects of productions.

**Unit-II**

Recovery, purification and isolation.

**Unit-III**

Immobilized enzymes and their commercial applications.

**Unit-IV**

Application of enzymes: food, Pharmaceuticals, textiles and leather and for analytical purposes

**Unit-V**

Development in Enzyme reactors , configuration and selection criteria, enzyme reactors.

**Reference:**

1. “ Biochemical Engineering Fundamentals” by J.E. Bailey and D.F.. Ollis, Mcgraw-Hill BookCo, New York.
2. “Immobilized Enzymes” by Trevan.
3. Enzyme Kinetics by Roberts.
4. Enzyme Engineering by Laidler

## Year II, Semester-III

### Course Title: BIOPROCESS PLANT DESIGN

#### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-653	4	3	1	0	30	20	-	50	50	100

**Objective:-** This course is designed to apply biochemical engineering knowledge gained in earlier courses to the complete design of a bioprocess plant for the production of biotech products.

**Course outcome:-** On successful completion of the course student will be able to –

CO1	Understand and identify the important parameters of equipment design.	Apply
CO2	Understand the basic concepts of flow sheeting, material and energy balances and process development	Apply
CO3	gain knowledge of estimation of capital investment, total product costs, depreciation, cash flows, and profitability	Apply
CO4	design special vessels (e.g. fermenter) and various parts, design of equipments based on economics and process considerations.	Apply
CO5	design heat and mass transfer equipment.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3											3	3	3
CO2	2	2	2			2						3	3	3
CO3	3											3	3	3
CO4	3					2						3	3	3
CO5	3	2				2						3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>			<b>2</b>						<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

### SYLLABUS

**Unit 1:** Introduction, general design information, mass and energy balance, flow sheeting, piping and instrumentation.

**Unit 2:** Material of construction for bioprocess plants. Mechanical design of process equipment, vessels for biotechnology applications, design of fermenters, design consideration for maintaining sterility of process streams and processing equipment.

**Unit 3:** Selection and specification of equipment for handling fluids and solids. Selection specification and design of heat and mass transfer equipment used in bioprocess industries.

**Unit 4:** Design of facilities for cleaning of process equipment used in biochemical industries.

**Unit 5:** Utilities for biotechnology production plants. Process economics, bioprocess validation, safety consideration

## Year II, Semester-III

### Course Title: BIOENTERPRENEURSHIP and REGULATORY ISSUES

#### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-655	4	3	1	0	30	20	-	50	50	100

**Course Objective:** This course is designed to understand the entrepreneurial decision making process – from business model design to the launch of the new venture in the biotechnology field. Also to develop a wide range of strategic, financial and human resource planning skills necessary to the new venture planning process.

**Course outcome:-** On successful completion of the course student will be able to –

CO1	Understand and differentiate and relate entrepreneurship and innovation	<b>Apply</b>
CO2	Understand identify the attitudes, values, characteristics, and processes associated with successful entrepreneurial behaviour.	<b>Apply</b>
CO3	understand the fundamentals of marketing practices.	<b>Apply</b>
CO4	understand the fundamentals of finance management for biotechnology industries. analyze the legal and ethical issues in biotechnological practices. acquire a wide source of material that facilitates a continual learning process	<b>Apply</b>
CO5	understand the concepts and practice of bioentrepreneurship.	<b>Apply</b>

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
<b>CO1</b>	3											3	3	3
<b>CO2</b>	3		2			2						3	3	3
<b>CO3</b>	3		2			2						3	3	3
<b>CO4</b>	3	2	2			2						3	3	3
<b>CO5</b>	3	2	2	1		2						3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>		<b>2</b>						<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, put “-”

## Syllabus

**Unit 1:** Overview of biotechnology Industry management: Business of biotechnology, Emerging areas of biotechnology industry, corporate governance and bioethics and societal issues in biotechnology industry; Biotechnology Product Management: Product development, assessment of market potential, testing and lifecycle analysis, preclinical and clinical trial design and conduct, risk analysis, quality control and assurance, fundamentals of validation, good manufacturing practices.

**Unit 2:** Biotechnology Entrepreneurship: Entrepreneurial process and the practicalities of venture creation, specific features of biotechnology-based products and services, human resource management, partnerships with other businesses; negotiation techniques and motivation, leadership skills, communication, conflict resolution, and goal integration, key tasks and challenges faced by biotech entrepreneurs, crisis management principles, strategies, tactics, and communications methods

**Unit 3:** Marketing in biotechnology industry: Marketing practices and application, marketing plan, relationship between the marketing and sales functions, marketing a scientific product and a scientific service, pricing strategies, distribution alternatives, communications, promotion, and the importance of perception. International business and marketing trends in biotechnology; advertising approved products.

**Unit 4:** Finance management for biotechnology industry: Defining and distinguishing the biotechnology industry, competitive forces and impact on strategy, regulation of genetic products, planning under uncertainty, system thinking and system failure, the economic environment, estimating costs and benefits, strategic components, marketing and sales, modeling, costs and benefits, and ratio and break-even analysis, commercializing biotechnology and technology transfer

**Unit 5:** Biotechnology regulatory issues: Regulatory processes and agencies, Legal Aspects of Biotechnology, Intellectual Property Rights- Basis of Patentability, Patent Application Procedure, Compulsory License, Infringement of Patents, Product Registration for Regulated and Non Regulated Markets, Scientific Exchange in Biotechnology research, Treaties/Conventions and regulatory policies relevant to India, International regulatory affairs, regulatory information, drug submissions, biologics submissions, medical device submissions, GLP, GCP, GMP, inventorship and ownership issues in academia and industry.



## Year II, Semester-III

### Course Title: Bioenergy

#### Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab	Total		
PEC	TBE-657	4	3	1	0	30	20	-	50	50	100

**Objective:-** To provide knowledge about various types of bio-energy, processing, production and utilization of various form of biomass; Also aware about the importance of bio-energy for clean environment and about the sustainability.

**Course outcome:-** On successful completion of the course student will be able to –

CO 1	Analyze the importance of various Bioenergy resources and their utilization.	<b>Apply</b>
CO2	Utilize the concept of biogas production, gasohol and biodiesel.	<b>Apply</b>
CO3	Solve the problems related to production process & technology based on bio-energy.	<b>Apply</b>
CO4	Apply techniques for production of bio-energy from biomass at large scale	<b>Apply</b>
CO5	Design and construct biological fuel cell	<b>Apply</b>

COs	Pos												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					3						3	3	3
CO2	3	3	3	2		3						3	3	3
CO3	3	3	3	2		3						3	3	3
CO4	3	3	3	2	2	3			3			3	3	3
CO5	3	3	3	2	2	3			3			3	3	3
<b>Total</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>3</b>		<b>3</b>			<b>3</b>	<b>3</b>	<b>3</b>

1:Slight(Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

### Syllabus

#### Unit-I:

Bioenergetics, Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. Chemical composition and properties of different biomass materials and bio-fuels

– Sugar cane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels- Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass, hydrogen production and biological fuel cell.

**Unit-II:**

Biogas, Technology: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues. Microbial and biochemical aspects: Operating parameters for biogas production. Kinetics and mechanism : Dry and wet fermentation. Digesters for rural application: High rate digesters for industrial waste water treatment.

**Unit-III:**

Bio-Ethanol and Bio-Diesel Technology: Production of Fuel Ethanol by Fermentation of Sugars. Gasohol as a Substitute for Leaded Petrol. Trans-Esterification of Oils to Produce Bio-Diesel.

**Unit-IV:**

Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass – Biomass processing for liquid fuel production - Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, temperature and of introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers.

**Unit-V:**

Combustion of Biomass and Cogeneration Systems: Combustion of Woody Biomass: Theory, Calculations and Design of Equipments. Cogeneration in Biomass Processing Industries. Case Studies: Combustion of Rice Husk, Use of Bagasse for Cogeneration.

**References :**

1. "Introduction to Bioenergy", Vaughn C. Nelson and Kenneth L. Starcher, CRC Press (2016).
2. "Biofuels and Bioenergy", John Love and John A. Bryant", John Wiley & Sons Ltd.(2017).
3. "Bioenergy : Biomass to Biofuels", Anju Dahiya, Academic Press(2014).

**TBE- 695 : SEMINAR**

**L T P C**  
**0 0 4 2**

**OBJECTIVE: The objective of this course is to enable the students**

- to study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic.
- to present a lecture on the topic on power point format.
- to improve the communication skill of the students.

**Course Outcome**

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

<b>CO1</b>	understand a topic of latest developments/innovative technology.	Understand
<b>CO2</b>	Apply the knowledge to prepare a dissertation report on this topic.	Apply
<b>CO3</b>	Deliver a lecture on the topic on power point format.	Apply
<b>CO4</b>	Improve the communication skill of the students.	Communication

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
<b>CO1</b>	3			1		2	3					3	3	3
<b>CO2</b>	3	2	2	1	1	2	3			3	2	3	3	3
<b>CO3</b>	3									3		3	3	3
<b>CO4</b>	3									3		3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>3</b>			<b>3</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

**TBE– 697: PROJECT DISSERTATION**

**L T P C**  
**0 0 8 4**

**OBJECTIVE: The objective of this course is to enable the students**

- to identify a biochemical product and industrial plant design for its production involving experimental studies.
- to prepare a feasibility report for a project based on manufacturing of product.

**Course Outcome**

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

<b>CO1</b>	Understand a topic of latest developments/innovative technology.	Understand Individual & Team Work
<b>CO2</b>	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
<b>CO3</b>	Deliver a lecture on the topic on power point format.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
<b>CO1</b>	3			1		3	3		3			3	3	3
<b>CO2</b>	3	2	2	1	1	3	3		3	3	3	3	3	3
<b>CO3</b>										3		3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>3</b>		<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*

**M. Tech. Chemical Technology-Biochemical Engineering**  
**(Applicable from Session 2021-2022 for new entrants)Year**  
**II, Semester-IV**

**TBE– 698: RESEARCH PROJECT**

**L T P C**  
**0 0 24 12**

**OBJECTIVE:**

- The students select a topic and carry out research oriented experimental work.
- Based on experimental studies the students submits thesis which is evaluated by external expert for award of marks and degree.

**Course Outcome**

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

<b>CO1</b>	Understand a topic of latest developments/innovative technology.	Understand Individual & Team Work
<b>CO2</b>	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
<b>CO3</b>	Carry out research on a topic of latest developments/innovative technology.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
<b>CO1</b>	3			1		3	3		3			3	3	3
<b>CO2</b>	3	2	2	1	1	3	3		3	3	3	3	3	3
<b>CO3</b>										3		3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>3</b>		<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put “-”*