

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

Semester wise Course Structure

B. Tech. Chemical Technology – Biochemical Engineering
(Applicable from Session 2017-2018 for new entrants)

Year I, Semester-I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks					ESE	Total Marks
					L	T	P	MSE	AT	TA	Lab.	Total		
1	BSC	Chemistry	BCY 101	4	3	0	2	15	10	10	15	50	50	100
2	BSC	Mathematics I	BMA 101	4	3	1	0	30	10	10	-	50	50	100
3	ESC	Electronics Engineering	EET 101	3	3	0	0	30	10	10	-	50	50	100
4	ESC	Engineering Graphics	ECE 101	3	0	0	6	30	10	10	-	50	50	100
5	ESC	Computer Concept & Programming	ECS 101	4	3	0	2	15	10	10	15	50	50	100
6	ESC	Workshop Practice	EWS 101	2	0	0	4	00	10	10	30	50	50	100
7	MC(Non-Credit)	Environment & Ecology	ECE 103	0	2	0	0	30	10	10	-	50	50	100
Total Credits 20														700*

* 100 marks will not be added as given in Sr. No. 7(Non-Credit)

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

Semester wise Course Structure

B. Tech. Chemical Technology – Biochemical Engineering
(Applicable from Session 2017-2018 for new entrants)

Year I, Semester-II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks					ESE	Total Marks
					L	T	P	MSE	AT	TA	Lab	Total		
1	BSC	Physics	BPH 102	4	3	0	2	15	10	10	15	50	50	100
2	BSC	Mathematics II	BMA 102	4	3	1	0	30	10	10	-	50	50	100
3	ESC	Electrical Engineering	EEE 102	4	3	0	2	15	10	10	15	50	50	100
4	ESC	Engineering Mechanics	EME 102	3	3	0	0	30	10	10	-	50	50	100
5	HSMC	English Language & Comprehensive	HHS 102	2	2	0	0	30	10	10	-	50	50	100
6	HSMC	Professional Communication	HHS 104	3	2	0	2	15	10	10	15	50	50	100
Total Credits 20														600

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

Semester wise Course Structure

B. Tech. Chemical Technology- Biochemical Engineering
(Applicable from Session 2018-2019 for new entrants)

Year II, Semester-III

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	BSC	Mathematics III	BMA 201	4	3	1	0	30	20	-	50	50	100
2	ESC	Materials & Energy Balance	TCH 201	5	3	2	0	30	20	-	50	50	100
3	PCC	Fluid Flow & Unit operation	TCH 203	5	3	1	3	15	20	15	50	50	100
4	PCC	Microbiology	TBE 201	5	3	0	6	15	20	15	50	50	100
5	HSMC	Organisational Behaviour	HHS 203	3	3	0	0	30	20	-	50	50	100
6	MC (Non-Credit)	Cyber Security (Audit course)	ECS 205	0	2	0	0	30	20		50	50	100
Total Credits 22												600*	

* 100 marks will not be added as given in Sr. No. 6 (Non-Credit)

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

Semester wise Course Structure

B. Tech. Chemical Technology- Biochemical Engineering
(Applicable from Session 2018-2019 for new entrants)

Year II, Semester-IV

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	BSC	Modern Analytical Techniques	BCY 202	4	3	0	3	15	20	15	50	50	100
2	BSC	Computer Oriented Numerical Methods	BMA 206	5	3	1	3	15	20	15	50	50	100
3	ESC	Heat Transfer Operations	TCH 202	3	3	0	0	30	20	-	50	50	100
4	PCC	Chemical Engineering Thermodynamics	TCH 204	3	3	0	0	30	20	-	50	50	100
5	PCC	Biochemistry	TBE-202	4	3	0	3	15	20	15	50	50	100
6	HSMC	Engg Economics & Management	HHS 202	3	3	0	0	30	20	-	50	50	100
7	MC (Non-Credit)	Indian Constitution (Audit course)	HHS 206	0	2	0	0	30	20		50	50	100
Total Credits 22													700*

* 100 marks will not be added as given in Sr. No. 7(Non-Credit)

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

Semester wise Course Structure

B. Tech. Chemical Technology- Biochemical Engineering

(Applicable from Session 2019-2020 for new entrants)

Year III, Semester-V

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Mass Transfer Operations	TCH 301	4	3	1	0	30	20	-	50	50	100
2	PCC	Chemical Reaction Engineering	TCH 303	4	3	1	0	30	20	-	50	50	100
3	PCC	Molecular Biology & Genetic Engineering	TBE 301	3	3	0	0	30	20	-	50	50	100
4	PCC	Bioprocess Engineering	TBE 303	5	3	0	6	15	20	15	50	50	100
5	OEC (Mechanical)	Energy Conversion Systems and Devices	EME 325	3	3	0	0	30	20	-	50	50	100
6	OEC (Humanities)	Entrepreneurship Development	HHS 341	3	3	0	0	15		15	50	50	100
Total Credits					22								600

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

Semester wise Course Structure

B. Tech. Chemical Technology Biochemical Engineering
(Applicable from Session 2020-2021 for new entrants)

Year III, Semester-VI

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
1	PCC	Instrumentation & Process Control	TCH 302	5	3	1	3	15	20	15	50	50	100
2	PCC	Down Stream Processing	TBE- 302	4	3	1	0	30	20	-	50	50	100
3	PCC	Fermentation Technology	TBE- 304	5	3	0	6	15	20	15	50	50	100
4	PCC	Environmental Biotechnology	TBE 306	5	3	0	6	15	20	15	50	50	100
5	OEC (Maths)	Operations Research	BMA 302	3	3	0	0	30	20	-	50	50	100
Total Credits					22								500

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

Semester wise Course Structure

B. Tech. Chemical Technology- Biochemical Engineering
(Applicable from Session 2020-2021 for new entrants)

Year IV, Semester-VII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Enzyme Engineering & Technology	TBE 401	4	3	0	3	15	20	15	50	50	100
2	PEC	Programme Elective Course I Bioreactor Design Bioprocess Modelling and Simulation	TBE 403 TBE 405	3	3	0	0	30	20	-	50	50	100
3	PEC	Programme Elective Course II Plant Cell Biotechnology Bioreaction Engineering	TBE 407 TBE 409	2	2	0	0	30	20	-	50	50	100
4	PEC	Programme Elective Course III Novel Bioproducts Food Biotechnology	TBE 411 TBE 413	2	2	0	0	30	20	-	50	50	100
5	OEC (BE)	Principles of Biochemical Engineering	TBE 415	3	3	0	0	30	20	-	50	50	100
6		Industrial Training	TBE 461	2	0	0	4		25		25	25	50
7		Seminar	TBE 471	2	0	0	4		25		25	25	50
8		Project	TBE 497	4	0	0	8		50		50	50	100
9		Educational Tour	TBE 417	0	0	0	0						
Total Credits					22								700

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

Semester wise Course Structure

B. Tech. Chemical Technology- Biochemical Engineering
(Applicable from Session 2020-2021 for new entrants)

Year IV, Semester-VIII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Transport Phenomenon*	TCH 402	3	3	0	0	30	20	-	50	50	100
2	PEC	Programme Elective Course IV*		3	3	0	0	30	20	-	50	50	100
		Process Modeling & Simulation	TCH 404										
		Process Equipment Design	TCH 406										
3	PEC	Programme Elective Course V*		4	3	1	0	30	20	-	50	50	100
		IPR & Biosafety Regulation	TBE 402										
		Instrumentation And Control Bioprocesses	TBE 404										
4	PEC	Programme Elective Course VI*		4	3	1	0	30	20	-	50	50	100
		Bioprocess Equipment Design	TBE 406										
		Biomaterial Science & Engineering	TBE 408										
5		Project	TBE 498	8	0	0	16	-	50	-	50**	-	100
Total Credits					22								600

***These courses are either MOOC/Neptal online courses of equal weightage and similar title available at the start of the semester**

OR regular courses in case students do not opt industry based project

*** Project Viva-Voice will be conducted by External Examiner.**

Harcourt Butler Technical University

DEPARTMENT OF CHEMICAL TECHNOLOGY – BIOCHEMICAL ENGINEERING

SCHOOL OF CHEMICAL TECHNOLOGY

I. Vision

The department of Biochemical Engineering aspires to be globally recognized center to develop professionals with technical knowledge and skills, leadership qualities and strong ethical values for successful career in Biochemical and allied industries, research and development organizations.

II. Mission

The mission of the Department of Chemical Technology Biochemical Engineering -

- M1** : To develop state-of-the-art facilities to impart technical knowledge and skill to the graduate and post graduate students for Biochemical and allied industries and research organizations.
- M2** : To be a center of research and development for betterment of society in sustainable manner.
- M3** : To develop state-of-art the technologies for testing and consultancy for industry and society.
- M4** : To cultivate strong ethical values to be a successful professionals and to become life-long learners.

III. Program Educational objectives (PEOs) for B.Tech. Chemical Technology- Biochemical Engineering -

IV. The educational objectives of B.Tech. Chemical Technology- Biochemical Engineering program are:

- PEO1** : To produce globally competent technical manpower in the field of Biochemical, products , processing and allied areas to cater the need of country
- PEO2** : To impart knowledge for development of innovation designs production materials and processes for sustainable development of society
- PEO3** : To serve the industry to meet the challenges in terms of quality assurance and standardization to with stand the global competitiveness
- PEO4** : To be able to discharge duties with professional attitudes and ethics

Program outcomes (POs) of B.Tech. Chemical Technology - Biochemical Engineering

Graduating Students of B.Tech. Chemical Technology- Biochemical Engineering program will be able to:

Program Outcomes (POs)		Graduate Attributes(GAs)
PO1	Apply the knowledge of mathematics, science engineering fundamentals and Engineering concepts for the solution of complex engineering problems	Engineering Knowledge
PO2	Identify formulate, review literature and analyze complex problems related to Chemical Technology- Biochemical Engineering reaching substantiated conclusions using first principles of mathematics and engineering sciences	Problem Analysis
PO3	Design solution for complex problems in Chemical Technology- Biochemical Engineering and design system components or process that meet the specified needs with appropriate consideration for the public health and safety, and cultural, societal and environmental considerations	Design/ Development of solutions
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	Conduct Investigations of complex problems
PO5	Create, select and apply appropriate techniques, resources and modern engineering tools such as optimization techniques, simulations, including predication and modeling to complex process engineering problems with an understanding of their limitations.	Modern Tool Usage
PO6	Apply contextual knowledge with justification to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering and Chemical Technology- Biochemical Engineering professional practice	The Engineer & Society
PO7	Understand the impact of the professional engineering and Chemical Technology- Biochemical Engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development	Environment and sustainability
PO8	Apply ethical principles and commit to professional ethics adhering to the norms of the engineering and Chemical Technology- Biochemical Engineering practice	Ethics
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	Individual and team work
PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective	Communication

	presentations, and give and receive clear instructions.	
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Project management and finance
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Life-long learning

Program specific outcomes (PSOs) for B.Tech. Chemical Technology Biochemical Engineering

program are:

Graduating Students of B.Tech. Chemical Technology Biochemical Engineering program will be able:

- PSO1** : to apply practical skills, technical knowledge in major streams such as Biology, manufacturing, processing, and applications areas of engineering and technology in Biochemical Engineering and allied industries
- PSO2** : to take-up career in research organizations or to pursue higher studies in Biochemical Engineering and interdisciplinary programs with high regard for ethical values, environmental and social issues.

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

B. Tech. Chemical Technology (Specialization in Biochemical Engineering)
Year II, Semester-III
(Applicable from Session 2018-2019 for new entrants)
Course Title : MICROBIOLOGY (TBE-201)

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-201	5	3	0	6	15	20	15	50	50	100

Objective:-

The objective of this course is to enable the students to understand importance of microorganisms in Biochemical Engineering to acquaintance them with scope and basic techniques of microbiology.

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

CO 1	Understand difference between bacteria, yeast and molds on the basis of their morphology, physiology and nutritional requirements.	Apply
CO2	Understand cultivation techniques and growth kinetics	Apply
CO3	Understand Isolation and maintenance of pure cultures and quantitative estimation of growth.	Apply
CO4	Understand various physical and chemical methods for control of microorganisms. Defense mechanisms of human body against microorganisms.	Apply
CO5	Understand occurrence of microorganisms in soil, water, air and food.	Apply

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

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

SYLLABUS**UNIT-I**

Microbiology and its scope, microscopy, classification, morphology and physiology of bacteria, yeast, molds, algae and virus. Microscopic observation of bacteria, yeast and mould, Gram staining, counting of cells (both direct and indirect), growth curve, MPN.

UNIT-II

Microbial growth kinetics, growth curve , diauxic growth factors influencing growth, continuous and synchronous culture, Microbial nutrition and reproduction.

UNIT-III

Pure culture technique – microbial culture media, isolation, identification and maintenance of cultures, characteristics of pure culture, enumeration techniques.

UNIT-IV

Physical and chemical method of control of microorganisms, immune response, antigen-antibody interaction. Microbial defense mechanism under adverse conditions.

UNIT-V

Microbial ecology, incidence of microorganism in soil . water, air, food and sewage , food spoilage organisms, food borne infections and poisoning.

UNIT-VI

Experimental:

Handling of Microscope, Smear preparation and observation of bacteria, yeast, moulds and algae, simple and differential staining , use of haemocytometer for cell count and plate count method, other direct and indirect growth measurement methods. Streak and spread plate method, serial dilution technique, methods for control of microorganisms, microbiological examination of water.

Reference-

1. “ Microbiology ” by M.J. Pelezar , Jr. E.C.S. Chan and N.R. Krieg, 5th Ed., TMH Book Company.
- 2 “ Foundation in Microbiology”, Kathleen Talaro & Arthur Talaro , W.C.B.Wm.C. Brown Publishers (1994)

Year II, Semester-IV
Course Title: BIOCHEMISTRY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-202	4	3	0	3	15	20	15	50	50	100

Objective:- Biochemistry focuses on understanding the biochemical control of biological processes, particularly in the microbial cell, and the tools for investigating these mechanisms.

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

CO 1	Understand the polymeric bio-molecules and their monomeric building blocks.	Apply
CO2	Understand the specificity of enzymes (biochemical catalysts), and the mechanism involved in enzyme action.	Apply
CO3	Understand the metabolism of glucose, leads ultimately to the generation of large quantities of ATP. Describe the metabolism of fats and amino acids, and explain their role for energy generation. Describe the replication of DNA, and explain the transfer of genetic information.	Apply
CO4	Understand the RNA and protein synthesis.	Apply
CO5	Understand the control of protein synthesis at the level of transcription and translation.	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
CO6	3	3	2	2		2			2			3	3	3
Total	3	3	2.5	2		2			2			3	3	3

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

Syllabus**Unit I**

Introduction-aims and scope. Structure and function of biomolecules: carbohydrates, proteins, lipids, nucleic acids, vitamins and coenzymes.

Unit II

Structure and function of enzymes, mechanism of enzymatic catalysis and enzyme kinetics.

Unit 3:

Biological membranes and transport across them. Bioenergetics. Metabolic pathways for breakdown of carbohydrates-glycolysis, pentose phosphate pathway, citric acid cycle, electron transport chain, Photophosphorylation. Lipid metabolism. Nucleic acid metabolism: mechanism and biosynthesis of DNA and RNA.

Unit 4:

Protein metabolism; out lines of amino acid metabolism. Protein biosynthesis, inhibitors of protein synthesis.

Unit 5:

Biochemistry Lab

1. Estimation of carbohydrates.
2. Estimation of proteins.
3. Estimation of nucleic acids:
4. Separation of amino acids by paper chromatography.
5. Thin layer Chromatography.
6. Assay of enzyme activity and enzyme kinetics.

References:

1. "Principles of Biochemistry", A.L. Lehninger, D.L. Neston, N.M. Cox, CBS Publishers & Distributors.
2. "Biochemistry", Lubert Stryer, W.H. Freeman & Co. , New York.
3. "General Biochemistry", J.H. Weil, New Age International (PLD).
4. "An Introduction to Practical Biochemistry", David T. Plummer, Tata McGraHill Co. Ltd., New Delhi.

Year-III, Semester-V**Course Title: MOLECULAR BIOLOGY AND GENETIC ENGINEERING****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-301	3	3	0	0	30	20	-	50	50	100

Objective:-

- Students will understand concept of transcription, translation and its regulation.
- Students will understand about the concept of genes and heredity.
- Students will come to know about r-DNA technology and the concepts of gene expression and its control.
- Students will understand the concept of DNA sequencing and gene cloning.

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

CO 1	Understand to apply concepts of molecular genetics to develop new techniques in various fields like medical, pharmaceuticals, food production etc.	Apply
CO2	Understand the fundamentals of molecular biology and genetic engineering.	Apply
CO3	An exposure to recent developments in genetic engineering-gene cloning, treatment of various diseases including cancer, diabetes and hereditary diseases.	Apply
CO4	Understand to improve the microbial strains for their productivity.	Apply
CO5		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			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
Total	3	2	2	2		2	2					3	3	3

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

SYLLABUS

Unit-I

Development of Molecular Biology. Nucleic acids: forms, structure and functions. Gene: Its concept, construction and inheritance. Inter and intra molecular non-covalent interaction in living system.

Unit-II

Replication of DNA. Transcription and its regulation. Genetic codes: their identification, characteristics and function. Repression and inhibition mechanism. Prokaryotic translation process.

Unit-III

Controlling of Prokaryotic Gene Expression: control circuit of operon. Construction and control of Lac operon and Tryptophan operon.

Unit-IV

r-DNA Technology: Principles, construction, properties of vectors. Restriction enzyme: properties, function and application. Techniques used in r-DNA Technology. Strategy of Gene cloning, expression of gene and selection of genetically modified cells.

Unit-V

Case studies for genetic modification in *E. coli* and yeast. Restriction mapping and DNA sequencing.

References :

1. "Molecular Biology of the Gene", J.D. Watson, Melnopak, California.
2. "Lewin's GENES XII", Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning (2017).
3. "Biochemistry", A.L. Lehninger, Worth Publication, New York.
4. "Recombinant DNA Technology", Dhillon J.R., John Wiley & Sons, New York.
5. "Genetics", P.K. Gupta, Rastogi Publication, Meerut.

Year III, Semester-V**Course Title: BIOPROCESS ENGINEERING****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-303	5	3	0	6	15	20	15	50	50	100

Objective:- To introduce the engineering principles of bioprocesses including microbial kinetics, sterilization principles and design considerations.

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

CO 1	Understand biological terms to describe and analyze phenomena/problems in bioprocesses, apply engineering principles to address issues in bioprocesses.	Apply
CO2	Understand and identify limiting factors in a bioprocess and propose solutions to address biological and engineering problems. analyze kinetics of cell growth or enzyme-catalyzed reactions.	Apply
CO3	Understand the environmental conditions that influence cell growth and means to achieve optimal cell growth.	Apply
CO4	Understand suitable sterilization process/module for media and air. calculate the air requirement in a bioreactor system	Apply
CO5	Understand scale up criteria for large scale production of biomolecules.	Apply

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
CO6	3	3	3	2	2	3	3		3			3		
Total	3	3	3	2	2	3	3		3			3	3	3

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

Syllabus**Unit 1**

Stoichiometry and kinetics of microbial growth, substrate utilization and product formation in batch and continuous reactors.

Unit 2

Mass and energy balance in a typical bioconversion process and yield concepts etc.

Unit 3

Sterilization of media: principles, batch and continuous sterilization processes. Sterilization of air: principles, methods of air sterilization.

Unit 4

Aeration and agitation: Oxygen transfer in microbial systems, oxygen demands, mass transfer theories, measurements of volumetric oxygen transfer coefficient, rheology of fermentation fluids.

Unit 5:s

Design and execution of simple laboratory scale experiments on the following topics:

1. Effect of physical and chemical environment on growth; selected biochemical tests.
2. Growth kinetic studies of yeast in a bench top lab fermenter under controlled conditions.
3. Studies on settling characteristics of various microbial cultures.
4. Study the solid state fermentation with suitable example.

References:

1. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
2. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
3. Bioprocess Engineering – P.M. Doran
3. "Biochemical Engineering", Shuichi Aiba, Arthur E. Humphrey, Nancy F. Millis; University of Tokyo Press.
- 4.. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.

Year III, Semester-VI
Course Title : DOWN STREAM PROCESSING (TBE-302)

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-302	4	3	1	0	30	20	-	50	50	100

Objective:-

Objective of this course is to enable the student to understand importance of Down Stream Processing in Industrial fermentation .

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

CO 1	Understand complex nature of fermentated broth and , complexities in isolation and purification of bioproducts	Apply
CO2	Understand solid-liquid separation methods, cell disruption methods.	Apply
CO3	Understand precipitation methods , aqueous two phase extraction , adsorption and membrane based separation.	Apply
CO4	Understand principle, practice and applications of chromatographic techniques, Electrophoresis.	Apply
CO5	Finishing operations – crystallization, drying and formulation	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			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
Total	3	2	2	2		2	2					3	3	3

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

UNIT-I

Characterization of bioproducts: flocculation and conditioning of broth.

UNIT-II

Mechanical separation : Filtration, centrifugation ,Cell disruption

UNIT-III

Membrane based separation, , Protein precipitation and its separation; Aqueous two phase extraction , Adsorption.

UNIT-IV

Chromatographic separation based on size, charge, hydrophobic interaction, metal ion affinity. Electrophoresis.

UNIT-V

Crystallization and drying.

REFERENCES:-

1. “Biochemical Engineering Fundamentals ” by J.E. Bailey and D.F.Ollis, McGraw –Hill Book Co., 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 III, Semester-VI**Course Title: FERMENTATION TECHNOLOGY****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-304	5	3	0	6	15	20	15	50	50	100

Objective:- :To introduce the students to the various concepts of fermentation and acquire experimental knowhow of microbial production of various industrial products such as alcohol, organic acids, enzymes, amino acids etc.

Course Outcome:- On successful completion of the course student will be able to -

CO 1	Understand the various concepts of fermentation, analyze the industrial aspect of the field of microbiology.	Apply
CO2	Understand the industrial aspect of the field of microbiology and know the differences between aerobic and anaerobic fermentation.	Apply
CO3	Understand to produce some industrially important liquid fermentation products e.g. ethanol, vinegar etc,produce some industrially important biomass based fermentation products e.g. baker's yeast etc.	Apply
CO4	Understand solid and submerged fermentations.	Apply
CO5	Understand distinguish primary and secondary metabolites analyze finished microbial products.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2				3						3	3	3
CO2	3	2				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	2				3						3	3	3
CO6	3	2	2	3	1	3			3			3	3	3
Total	3	2	2	3	1	3			3			3	3	3

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

SYLLABUS

UNIT-I

Alcoholic fermentation and related products. Glycerol fermentation. Malting and brewing: beer production, wine manufacturing and other distilled liquors.

UNIT-II

Microbial production of organic acids and fermentation processes. Biomass as a fermentation product: Baker's yeast, Bioinsecticides, Biofertilizers. Amino acids: Lysine and glutamic acid.

UNIT-III

Commercial enzymes: solid and submerged fermentation, recovery etc. Secondary metabolites such as antibiotics and vitamins.

UNIT-IV

Microbial transformations, vaccines, recombinant therapeutic proteins.

UNIT-V

Design and execution of simple laboratory scale experiments on the following topics:

1. Analysis of molasses.
2. Determination of fermentation efficiency of yeast for batch production of ethanol.
3. Effect of substrate concentration on biomass yield for baker's yeast production and its characterization.
4. Fermentation efficiency for vinegar production.
5. Citric acid production by (a) solid state and (b) submerged fermentation.
6. Microbial production of enzymes by (a) solid state and (b) submerged fermentation.
7. Analysis of finished products (rectified spirit, beer etc.).

References:

1. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc. New York.
2. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.
3. "Microbial Technology", Vol.II, H.J. Pepler and D. Perlman, Academic Press, New York.
4. Official methods of analysis of AOAC.
5. BIS booklets for various products.
6. "An Introduction to Practical Biochemistry", David T. Plummer, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Year III, Semester-VI
Course Title : ENVIRONMENTAL BIOTECHNOLOGY (TBE-306)

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-306	5	3	0	6	15	20	15	50	50	100

Objective:-

The objective of this course is to enable the students to understand necessity for treatment of waste water and various physical , chemical and biological methods of waste water treatment

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

CO1	Understand characteristics of waste water , classification of treatment methods and bioprocess kinetics applied to waste treatment.	Understand
CO2	Understand various aerobic methods and their design aspects of waste water treatment. viz. ASP ponds and lagoons, TF,RBC.	Apply
CO3	Understand theory of anaerobic digestion and digester design.	Apply
CO4	Understand biological removal of nitrogen and phosphorous and other advanced treatment methods. Case studies.	Apply
CO5	Understand methods to estimate DO, BOD , COD, solids and determination of other water pollutants, evaluation of treatment process performance.	Apply

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2				3						3	3	3
CO2	3	2				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	2				3						3	3	3
CO6	3	2	2	3	1	3			3			3	3	3
Total	3	2	2	3	1	3			3			3	3	3

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

SYLLABUS**Unit-I**

Source and Characteristics of waste, Physical and chemical methods of waste treatment. Bioprocess Kinetics applied to waste treatment.

Unit-II

Anaerobic treatment systems, UASB. Sludge digestion theory, digester design, high rate digestion, heat transfer in digester.

Unit-III

Theory of activated sludge process design, operation and control, BOD reduction and biomass relationship , Sequential Batch Reactors, Membrane Bioreactors, Modification, operational and design aspects.

Unit-IV

Nitification- denitrification, Phosphorous removal. Treatment and disposal of sewage and waste of the industries e.g. distilling and brewing, antibiotics and sugar etc. Bioremediation.

1

Unit-V

Experimental determination of various organic and inorganic pollutants-: DO, BOD, COD, solids-total , suspended, volatile and fixed. Evaluation of the effect of process, variables on the performance of ASP, and anaerobic digesters.

REFERENCE:

1. “ Waste water Engineering: Treatment, Disposal and Reuse”, Metcalf & Eddy, Inc.; Tata McGraw-Hill Publishing Company Ltd., New Delhi.
2. “ Water supply and Pollution Control ”, Warren Viessman Jr. and Mark J. Hammer; Harper& Row Publishers; New York.

Year IV, Semester-VII
Course Title : ENZYME ENGINEERING & TECHNOLOGY(TBE-401)

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-401	4	3	0	3	15	20	15	50	50	100

Objective:-

The objective of this course is to enable the students to understand basics of enzyme kinetics and production and industrial application of enzymes.

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

CO1	Understand importance of enzymes , their classification and nomenclature.	Apply
CO2	Understand kinetics of single and multiple substrate, inhibition kinetics and activation.	Apply
CO3	Understand immobilization kinetics and methods of whole cell immobilization and enzyme immobilization, enzyme reactors.	Apply
CO4	Understand production technology of industrial enzymes.	Apply
CO5	Understand enzyme assay methods, immobilization methods, purification methods,operational feature of enzyme reactors.	Apply

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				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	3				3						3	3	3
CO6	3	3	3	3	3	3	1		3			3	3	3
Total	3	2.5	3	3	3	3	1		3			3	3	3

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

Unit-I

Introduction and scope, mechanism of enzymatic catalysis, characterization of active sites and ligand binding sites.

Unit-II

Enzyme Kinetics of single and multiple substrates. Kinetics of inhibition and activation, King and Altman Method, allosteric enzymes.

Unit-III

Immobilization of enzymes and cells. Methods of Immobilization. Effect of micro and macro environmental parameters on the immobilized enzymes; External film and internal pore diffusion partitioning and electrostatic interaction. Performance of soluble and immobilized enzyme reactors , operational strategies, carrier life and cycle time.

Unit-IV

Production and application of selected industrial enzymes.

Unit-V

Assay of enzyme activity and specific activity, Kinetics analysis of an enzyme catalysed reaction Immobilization of enzymes , Salt precipitation of an enzyme, immobilization of microbial cells, Comparative study of performance of soluble and immobilized enzyme reactors.

Reference:

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

Year IV, Semester-VII**Course Title: BIOREACTOR DESIGN****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-403	3	3	0	0	30	20	-	50	50	100

Objective:- To provide the basic principles of reactor design for bioprocesses.

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

CO1	Understand comprehend the state of the arts in bioreactor technology and its broad range of applications,develop mathematical descriptions of reaction kinetics in cellular systems and their relationships with bioreactor design.	Apply
CO2	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.	Apply
CO3	Understand complete bioreactor based on targets, constraints and physical properties.	Apply
CO4	Understand suitable process instrumentation for monitoring and control of bioreactors.	Apply
CO5	Understand the problem of selection of suitable bioreactor configuration.	Apply

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
Total	3	2	1	1	2	1						2	3	3

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

SYLLABUS**UNIT-I**

Design equations for batch, continuous and fed batch reactors. Non-ideal flow behaviour of Batch and continuous flow reactors.

UNIT-II

Novel bioreactor configuration such as fluidized bed reactor, air-lift reactor, bubble column, membrane bioreactor etc.

UNIT-III

Bioreactor operation measurement and control: Aseptic operations, measurement and control of process variables (pH, dissolved oxygen, viscosity, temperature, NADH), agitative power and foam control.

UNIT-IV

On-line analysis, bioprocess control and computer coupled bioreactors. Bioprocess economics.

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 Book Co., 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,

Year IV, Semester-VII**Course Title : BIOPROCESS MODELLING AND SIMULATION****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ES E	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-405	3	3	0	0	30	20	-	50	50	100

Objective:- To introduce the different aspects of modeling in bioprocess system and to familiarize the simulation of bioprocess modeling.

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

CO1	Understand about the principles of bioprocess modeling and simulation.	Apply
CO2	Understand the mathematical models in biochemical engineering systems	Apply
CO3	Understand the basics of MATLAB, data analysis and interpretation of data.	Apply
CO4	Understand the application of MATLAB and SIMULINK in the bioprocess systems	Apply
CO5	Understand to apply theoretical knowledge in solving problems relevant to bioprocess Modelling and simulation.	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
Total	3	2	2			2						3	3	3

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

SYLLABUS**UNIT I-BASIC MODELLING PRINCIPLES**

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

UNIT II-MATHEMATICAL MODELS FOR BIOCHEMICAL ENGINEERING SYSTEMS Mathematical models for Biochemical engineering systems - continuous flow tanks-enclosed enclosed vessel-mixing vessel - mixing vessel mixing with reaction - reversible reaction. Steam jacketed vessel - boiling of single component liquid-open and closed vessel-continuous boiling system – batch,distillation.

UNIT III-SUPERPRO DESIGNER

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

UNIT IV-MATLAB BASICS AND DATA ANALYSIS

Basics-Data analysis-curve fittings, Numerical integration, Euler and fourth order RungeKutta method, Input and Output in MATLAB. BT-M.TECH-E&T-SRM-2013-14

UNIT V-MATLAB AND SIMULINK: APPLICATION IN BIOPROCESS SYSTEMS

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

REFERENCES

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

Year-IV, Semester-VII**Course Title: PLANT CELL BIOTECHNOLOGY****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-407	2	2	0	0	30	20	-	50	50	100

Objective:-

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

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

CO 1	Understand about cell and tissue culture techniques.	Apply
CO2	Understand to modify plant cells for better performance.	Apply
CO3	Understand to work in industry producing transgenic plants	Apply
CO4	Understand to produce secondary metabolites at lab and pilot scale.	Apply
CO5		

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			2						3	3	3
CO3	3		2			2						3	3	3
CO4	3	2	2			2						3	3	3
CO5	3	2	2	1		2						3	3	3
Total	3	2	2	1		2						3	3	3

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

UNIT-I

Special features and organization of plant cells; totipotency and regeneration of plants, examples of regeneration from leaves, roots, stem etc.

UNIT-II

Plant product of industrial importance, biochemistry of major metabolic pathways and products, cells suspension culture development.

UNIT-III

Large scale production of secondary metabolites from suspension cultures. Characterization, kinetics of growth and the product formation, examples.

UNIT-IV

Nutrient optimization, cells growth regulators, biological and technological barriers, mutation, somaclonal variation.

UNIT-V

Genetic engineering of plant cell, plant cells reactors and their performance. Immobilized plant cell reactor and novel design concepts.

References:

1. "Plant Tissue Culture and its Biotechnological Application", W. Barz, E. Reinhard and M.H. Zenk (Eds.); Springer-Verlag, Berlin.
2. "Plant Cell Biotechnology", H. Smith and Mantell (Eds); Cambridge University Press, Cambridge.

Year IV, Semester-VII
BIOREACTION ENGINEERING

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-409	2	2	0	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the student to understand basic requirements for production of bioproducts , types of bioreactors .

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

CO1	Understand upstream processing in biotechnological processes.	Apply
CO2	Understand control of process parameters in bioprocesses	Apply
CO3	Understand operational problems encountered and their prevention and control,	Apply
CO4	Understand about constructional and operational features of different types of bioreactors.	Apply
CO5	Understand bioreactors used in treatment of waste water.	Apply

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
CO5	3	2				2	2					2	3	3
Total	3	2				2	2					2	3	3

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

SYLLABUS**UNIT-I**

Bioreaction Kinetics, Food to microorganism ratio, Pure and Mixed culture kinetics

UNIT_II

Instrumentation and process control in biotechnological processes.

UNIT-III

Aseptic operation, Mixing in bioreactors. Foam control in bioreactors. Computer application in bioreactor

UNIT-IV

Membrane bioreactors. Bioreactors with immobilized biocatalyst. Air lift bioreactors. Solid state bioreactors.

UNIT-V

Bioreactors in waste water treatment.

References:

2. "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 Book Co., 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,

Year IV, Semester-VII
NOVEL BIOPRODUCTS

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-413	2	2	0	0	30	20	-	50	50	100

Objective:-

To acquaintance the students with production and application of novel bioproducts with emphasis on use of renewable resources.

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

CO1	Understand production of biopreservatives, biopolymers, xanthan , gum etc.	Apply
CO2	Understand microbial process for production of biopharmaceuticals, bioinsecticides etc.	Understand
CO3	Understand technology for use of renewable resources for production of novel bioproducts.	Apply
CO4	Understand production of liquid and gaseous biofuels, salient features of biofuel cells, biosensors and biomarkers with their application.	Apply
CO5	Understand miscellaneous uses of microorganisms for example in steroid transformations, bioconversion of vegetable oils , bioleaching and MEOR.	Apply

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
Total	3	2	1			1.25						3	3	3

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

SYLLABUS

Unit-I

Production and application of natural Biopreservatives (Bacteriocin/ Nisin). And Biopolymers (Pullulan/Xanthan Gum and PHB) production and application.

Unit-II

Production and application of Biopharmaceuticals and biopesticides production by microorganisms.

Unit-III

Liquid and gaseous biofuels, biofuel cells and application, biosensors and biomarkers.

Unit-IV

Biotransformation, bioleaching, microbiology and enhanced oil recovery.

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 Book Co., 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,

Year IV, Semester-VII
FOOD BIOTECHNOLOGY

Evaluation Scheme:

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-413	2	2	0	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the students causes of food spoilage and its effects , various methods to prevent food spoilage and testing and quality control of food materials.

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

CO1	Understand about food spoiling microorganisms and microbial examination of food,	Apply
CO2	Understand about food borne infections and food poisoning	Understand
CO3	Understand principles and practice of food preservation by various methods	Apply
CO4	Understand about good manufacturing practices, testing and quality control of food.	Apply
CO5	Understand about Production of fermented foods and treatment and disposal of food waste	Apply

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

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

SYLLABUS

Unit 1. Introduction:

Important genera of food borne microorganisms, factors affecting the growth and survival of microorganisms in food Direct examination, culture techniques, MPN count, dye reduction assay,

Unit 2. Microbiological examination of food:

Microbial spoilage of food, common food borne diseases, bacterial agents of food borne illness, non-bacterial agents of food borne illness.

Unit 3. Food preservation:

Principles of food preservation, asepsis, anaerobic conditions, removal of microorganisms, low temperature, high temperature, radiation, drying, chemical preservatives and miscellaneous methods, canning.

Unit 4. Cleaning

Cleaning and disinfection code for good manufacturing practices, microbial and chemical safety of food products, indicator organisms, ISO, hazard analysis and critical control points, sterility testing.

Unit 5. Fermented foods:

Fermented milk, cheese, sauerkraut, fermented meat, beer, vinegar, fish products, products of baking, oriental foods. Role of enzymes in different food products (bakery, cheese, beverage production and cereal products) and industries, utilization of food waste for production of valuables.

Text /Reference Books:

- Modern Food Microbiology by James M. J., CBS Publishers and Publishers.
- Food Microbiology by Freiser.
- Willis Biotechnology, Challenges for the flavour and food industries by Lidsay, Elsevier Applied Science.
- Food Biotechnology by Roger A., Gordan B., and John T.
- Basic Food Microbiology by George J. B., CBS Publishers and Distributors.

Year IV, Semester-VII**Course Title: PRINCIPLES OF BIOCHEMICAL ENGINEERING****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
OEC	TBE-415	3	3	0	0	30	20	-	50	50	100

Objective:- This course introduces the basic aspects of biochemical engineering and bioprocess technology and their commercial implications to the students from various disciplines.

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

CO1	Understand comprehend the state of the arts in bioreactor technology and its broad range of applications, develop mathematical descriptions of reaction kinetics in cellular systems and their relationships with bioreactor design.	Apply
CO2	Understand basic principles of mass and energy conservation to analyze bioreactor systems. Identify the major engineering parameters that characterize the performance of bioreactors and techniques to measure and control these parameters.	Apply
CO3	Understand complete bioreactor based on targets, constraints and physical properties.	Apply
CO4	Understand suitable process instrumentation for monitoring and control of bioreactors.	Apply
CO5	Understand the problem of selection of suitable bioreactor configuration.	Apply

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
Total	3	2	1			1.25						3	3	3

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

SYLLABUS**UNIT-I**

Introduction: Development and prospects of biochemical engineering. Characteristics of living organisms, classification, morphology and physiology of microorganisms.

UNIT-II

Growth, reproduction and nutritional aspects of micro-organisms. Culture isolation, maintenance. Physical and chemical control of micro-organisms.

UNIT-III

General requirements of the microbial processes. Batch fermentation, growth and product formation kinetics. Sterilization of media and air. Aeration and agitation. Down stream processing.

UNIT-IV

Production of alcohol, glycerol, organic acids, baker's yeast, enzymes.

UNIT-V

Antibiotics, biofertilizers,biopesticides. Concepts of biological waste treatments. New developments in biotechnology.

References:

1. "Biochemical Engineering Fundamentals" by J. E. Bailey & D. F. Ollis (1987) 2nd Ed McGraw Hill International Edition.
2. "Bioprocess Engineering Principles" by P. M. Doran, (1995) Academic Press.
3. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc. New York.
4. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.

TBE-461 - : INDUSTRIAL TRAINING

L T P C
0 0 4 2

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

- make students observe and learn practical knowledge of biochemical processing
- understand professional ethics and discipline required in industry
- Understand and analyze product planning and implementation in industry.
- Communicate their experiences in the form of project report and power point presentation

Course Outcome

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

CO1	acquire practical skills in any biochemical engineering and allied industry.	Understand
CO2	understand professional ethics and discipline required in industry.	Understand & Ethics
CO3	analyze problems in products and process and resolves by working on short term project.	Analyze & Apply
CO4	Understand and analyze product planning and implementation in industry.	Understand and Analyze
CO5	Communicate their experiences in the form of project report and power point presentation.	Apply & Analyze

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

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

TBE - 471 : 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

CO1	understand a topic of latest developments/innovative technology.	Understand
CO2	apply the knowledge to prepare a dissertation report on this topic.	Apply
CO3	deliver a lecture on the topic on power point format.	Apply
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainability

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
CO4	3									3		3	3	3
CO5	3	2				2	3					3	3	3
Total	3	2	2	1	1	2	3			3	2	3	3	3

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

TBE– 497: PROJECT

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.
- 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

CO1	understand a topic of latest developments/innovative technology.	Understand Individual & Team Work
CO2	apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
CO3	deliver a lecture on the topic on power point format.	Apply
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainability

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

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

TPL – 417 : EDUCATIONAL TOUR

Students will be taken to the visit of industries/research organization, in their field of specialization, during the vacation period

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

- to visit industries/research organization in their field of biochemical engineering during the vacation period.
- to demonstrate a variety of product formation and manufacturing processes in industries specialization.
- to learn professional ethics.

Course Outcome

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

CO1	visit industries/research organization in their field of biochemical engineering.	Engineer and Society Life long Learner
CO2	to demonstrate a variety of product formation and manufacturing processes in industries specialization.	Engineer and Society Individual & Team Work
CO3	To learn professional ethics.	Ethics
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology.	Analyze Environment & Sustainability

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					3			1			3	3	3
CO2	3	2				2	2		1			3	3	3
CO3	3							3				3	3	3
CO4	3									3		3	3	3
CO5	3					2	3		1			3	3	3
Total	3	2				3.5	2.5	3	1	3		3	3	3

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

Year-IV, Semester-VIII**Course Title: IPR AND BIOSAFETY REGULATION****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-402	4	3	1	0	30	20	-	50	50	100

Objective:-

- To introduce history and evolution of IPR- like patent, design and copy right, Indian patent act 1970 (amendment 2000), international convention in IPR, major changes in Indian patent system as post TRIPS effects (i) obtaining patent (ii) geographical indication.
- Student will understand various forms of IPR, Requirement of a patentable novelty, invention step and prior art and state of art, procedure.
- To understand the Rights/protection, infringement or violation, remedies against infringement – civil and criminal.
- Detailed information on patenting biological products, Biodiversity, Budapest treaty, Appropriate case studies

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

CO 1	Understand the importance of intellectual property rights.	Apply
CO2	Understand the legal aspects of Rights/protection, infringement or violation, remedies against infringement – civil and criminal.	Apply
CO3	Understand to file patent application and review it.	Apply
CO4	Understand to work as patent review officer and consultant.	Apply
CO5		

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

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

SYLLABUS

UNIT-I

Jurisprudential definition and concept of property, right, duties and their correlation. History and evolution of IPR- like patent, design and copy right etc.

UNIT-II

Indian patent act, international convention in IPR. TRIPS agreement; IPR issues in relation to biotech products/ processes; architecture of patent application.

UNIT-III

Detailed information on patenting biological products, biodiversity, Budapest treaty, appropriate case studies. Biosafety Principles - environment and health risk assessment; biosafety regulatory guidelines and controlling agencies.

UNIT-IV

Environmental law for hazardous microorganisms and GMOs; Biotechnology Related Issues of Public Concern. Bioethics.

UNIT-V

Regulatory issues concerning the global biotechnology & pharmaceutical industries, including Good Laboratory & Clinical Practice (GLP & GCP).

References:

1. "An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology", Padma Nambisan, Academic Press (2017).
2. "IPR, Biosafety and Bioethics", Shomini Parashar, Deepa Goel, Pearson India (2013).
3. "Intellectual property rights in the global economy", Maskus, Keith E, Institute for International Economics, Washington(2000).
4. "Intellectual property rights in India", V. K. Ahuja, Lexis Nexis India (2009)

Year IV, Semester-VIII**INSTRUMENTATION AND CONTROL IN BIOPROCESSES****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-404	4	3	1	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the student to understand basic concepts of biosensors, components of biosensors and their application in industry, medical science and environmental studies.

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

CO1	Understand the basic principles of instrumentation and control	Apply
CO2	Understand about various types of biological sensors and their applications.	Apply
CO3	Understand about various types of transducers, their functioning and criteria for selection.	Apply
CO4	Understand chemical, electrochemical and optical sensing mechanism and tools.	Apply
CO5	Understand applications of Biosensors in industry, medical and environmental studies. Biochips and their application.	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
Total	3	2	2			2						3	3	3

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

SYLLABUS**Unit 1. Introduction**

Parameters required to be measured and controlled in bioprocesses: flow, DO, pH, CO₂, Temperature, level, foam etc. Introduction to instrumentation and control in bioprocesses. Use of PLC, HMI and SCADA in bioprocess control.

Unit 2. Biosensors

Concepts and applications, Biosensing and biosensor technology.

Unit 3. Transduction principles:

Classification of transducers, selection of transducers, Temperature transducers: thermo-resistive transducers, thermoelectric, chemical thermometry. Pressure transducer, photoelectric transducers, flow transducers.

Unit 4. Analytical techniques:

Chemical sensing methods, optical sensing mechanisms and tools, electrochemical sensing mechanisms and tools, mass spectroscopy.

Unit5. Application

Applications of biosensor-based instruments to the bioprocess industry, application of biosensors to environmental samples, introduction to biochips and their application in modern sciences.

Text /Reference books:

- ❑ Transducers for Biomedical Instruments by S.C. Cobbold, Prentice Hall.
- ❑ Principles of Medical Electronics & Biomedical Instrumentation by Rao and Guha, University Press, India.
- ❑ Coughnour and Koppel, " Process Systems Analysis and Control ", McGraw-Hill, New York, 1986.
- ❑ S. K. Singh, " Industrial Instrumentation and Control ", Tata McGraw-Hill, 2008.
- ❑ George Stephanopolous, " Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 1990.
- ❑ Nakra and Chaudhary, " Instrumentation Measurement and Analysis", Tata McGraw Hill, 1978.
- ❑ P. K. Sarkar, " Process Dynamics and Control", Prentice Hall India, 2014.
- ❑ D. N. Considine, "Process Instrumentation and Controls Handbook", Considine, McGraw Hill.

Year-IV, Semester-VIII**Course Title: BIOPROCESS EQUIPMENT DESIGN****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PCC	TBE-406	4	3	1	0	30	20	-	50	50	100

Objective:-

- To introduce the basic design concepts for bioprocess equipments
- Students will know about the design of equipments to facilitate mixing and aeration
- Students will know how to control the temperature of the bioprocess system
- To teach the design of equipments used for downstream processing
- To provide the basic concept of scale up

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

CO 1	Students will be able to know the different materials, pipings and pumps used in bioprocessing	Apply
CO2	Student will be able to understand the design aspects of aerators and agitators	Apply
CO3	Students will be able to conceptualize the application of heating and cooling system in bioprocessing	Apply
CO4	Student will be able to know about the design of various purification techniques	Apply
CO5	Students will gain knowledge about the scale up of bioprocesses	

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
Total	3	2	1			1	2					3	3	3

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

SYLLABUS

Unit 1

Selection of materials, pumps, piping, valves for bioprocess systems

Unit 2

Design of aeration system, design of agitation system, power requirements in gassed and ungasged bioreactors

Unit 3

Heating and cooling systems in bioprocess industries

Unit 4

Design of centrifuge, Design of filtration systems, Design of crystallizer, Design of dryers

Unit 5

Scale-up: criteria, basic concepts and related problems.

References:

- Perry's handbook of Chemical Engineering
- Bioprocess Engineering Principles: Pauline M. Doran ,Publisher Elsevier
- William M(Bill) Huitt, Bioprocessing piping and equipment design: a campaign guide for the ASME BPE standard-Wiley-ASME press series.
- Bioprocess Engineering : Systems Equipment and facilities : Bjorn K Lybersen

Year IV, Semester-VIII**BIO-MATERIALS SCIENCE AND ENGINEERING****Evaluation Scheme:**

Course Type	Subject Code	Credits	Periods			Sessional Marks				ES E	Total Marks
			L	T	P	MSE	TA	Lab.	Total		
PEC	TBE-408	4	3	1	0	30	20	-	50	50	100

Objective:-

The objective of this course is to enable the students with properties of Biomaterials , their characteristics, and applications.

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

CO1	Understand about structure, property characteristics and testing of biomaterials.	Understand
CO2	Understand compatibility of biomaterials with living bodies.	Understand
CO3	Understand production technology of biomaterials such as biopolymers and other materials having specific use for example drug delivery.	Apply
CO4	Understand about materials suitable for implants such as orthopedic and dental implants.	Apply
CO5	Understand about materials suitable for soft tissue replacement for example implants for cardiovascular and ophthalmology and organs transplant. Legal Issues related to use of biomaterials.	Apply

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
CO5	3	2				2	2					2	3	3
Total	3	2				2	2					2	3	3

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

Syllabus**Unit 1. Introduction:**

Introduction and overview of biomaterials, structure and property relation in materials and characterization and testing of biomaterials.

Unit 2. Interactions of materials:

Interactions of materials with human body, bio-compatibility of materials, metals, alloys, ceramics, polymers and composites as biomaterials.

Unit 3. Biopolymers:

Biopolymers, natural materials, material for drug delivery: biodegradable polymers.

Unit 4. Implants:

Materials for hard tissue replacement: orthopedic implants, dental implants.

Unit 5.

Materials for soft tissue replacement: dermal and facial prosthesis, cardiovascular implants, ophthalmology, materials for artificial organs transplant and extracorporeal device. legal issues related to development of biomaterials.

Text/Reference Books:

- ❑ Biomaterials: An Introduction by Park J.B. and Lakes R.S., Plenum Press, New York.
- ❑ Biomaterials, Medical Devices & Tissue Engineering: An Integrated Approach by Silver F.H., Chapman and Hall publication.
- ❑ Biomaterials by Bhat Sujata V., Narosa Publishing House.
- ❑ Biomaterials science: an introduction to materials in medicine by Buddy D. Ratner., Elsevier Academic Press.
- ❑ Biomaterials: A Tantalus Experience by Jozef A. Helsen., Yannis Missirlis Springer.
- ❑ Biomaterials by Temenoff Johnna S., Dorling Kindersley India Pvt Ltd.

TBE – 498 : PROJECT

L T P C
0 0 16 8

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

- to prepare a detailed project report on fabrication of product / equipment/process of a plant for production of biochemical product with complete lay-out or a research problem and conduct experiment.
- to assess the economic analysis and to prepare a feasibility report for a project based on manufacturing of product/equipment/process.
- 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

CO1	understand a topic of latest developments/innovative technology.	Understand Individual & Team Work
CO2	apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
CO3	deliver a lecture on the topic on power point format.	Apply
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainability

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

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