

BIOPROCESS TECHNOLOGY**Course Code : 316304**

Programme Name/s : Chemical Engineering
Programme Code : CH
Semester : Sixth
Course Title : BIOPROCESS TECHNOLOGY
Course Code : 316304

I. RATIONALE

This course is designed to provide a strong foundation in bioprocess technology, focusing on industrial applications in pharmaceuticals, food, and biotechnology. It covers biotechnology vs. bioprocess engineering, microbial diversity, and enzyme kinetics for optimizing industrial processes. It applies bioreactor selection, scale-up strategies, and process optimization for efficient production. Knowledge of downstream processing techniques like filtration and chromatography ensures effective bio-product recovery. Additionally, it emphasizes large-scale production of ethanol, lactic acid, citric acid, baker's yeast, penicillin, and HFCS, aligning with industry needs. This course prepares individuals for real-world applications in process development, quality control, and industrial bioprocess innovation.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcomes through various teaching learning experiences :Apply the basic concept of bioprocess technology to scale-up reactors and produce the different biochemicals.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Apply the basic knowledge of cells and its structure to explain bioprocesses
- CO2 - Measure the different parameters in enzyme kinetics bioprocesses.
- CO3 - Synthesize the bio-products using relevant bioreactors
- CO4 - Perform the different unit operations for purification of bio-products
- CO5 - Plan to manufacture important bioproducts by industrial bioprocesses.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme						Credits	Assessment Scheme										
				Actual Contact Hrs./Week			SLH	NLH	Paper Duration		Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
															Max	Min	Max	Min	Max	Min	
316304	BIOPROCESS TECHNOLOGY	BPT	DSE	3	-	2	1	6	3	03	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 2 Hrs

Abbreviations: CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @\$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Differentiate between biotechnology and bioprocess engineering. TLO 1.2 Explain the different types of cells TLO 1.3 Explain the cell structure and its construction. TLO 1.4 Differentiate between macro and micronutrients TLO 1.5 Differentiate between transcription and translation.	Unit - I An overview of Bioprocess Technology and cells 1.1 Biotechnology and bioprocess technology, preparation of media 1.2 Cells: Microbial diversity, Naming cells, Viruses, Prokaryotes, Eucaryotes 1.3 Cell construction: Amino Acids and Proteins, Carbohydrates and Nucleic Acids, RNA, and DNA 1.4 Cell Nutrients: Macro, Micro and Growth Media 1.5 Working of Cells: central dogma, DNA replication, transcription and translation	Video Demonstrations Presentations Lecture Using Chalk-Board
2	TLO 2.1 Explain the basics of reaction kinetics and work of enzymes TLO 2.2 Explain the different reaction kinetics models. TLO 2.3 Explain the effect of pH and temperature on enzyme kinetics. TLO 2.4 Explain the different methods of enzyme immobilization TLO 2.5 Explain the growth curve of cells	Unit - II Enzyme kinetics 2.1 Basics of reaction Kinetics - rate of a reaction, rate constant and order of the reaction, functioning of enzymes 2.2 Models of enzyme kinetics: Mechanistic model and Michaelis-Menten model 2.3 Effect of pH and temperature 2.4 Immobilized enzyme system: methods of immobilization 2.5 Batch growth and quantification of cell	Video Demonstrations Lecture Using Chalk-Board Presentations

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Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Explain the basic types of bioreactors TLO 3.2 Describe the different sub-basic types of bioreactors TLO 3.3 Explain the scale up and scale down procedure of bioreactor TLO 3.4 Explain the influence of different parameters on bioreactors. TLO 3.5 Explain the procedure for sterilization of fluids.	Unit - III Selection and scale-up of Bioreactor 3.1 Overview of reactor types: mechanical agitation, bubble column and loop reactors 3.2 Types of sub-basic types of bioreactors: stirred tank reactor, bubble column reactor, airlift loop, propeller loop and jet loop 3.3 Concept of scale up and scale down of bioreactor, scale up challenges 3.4 Bioreactor instrumentation and control: influence of various bioprocess parameters viz. pH, temperature, medium components on product synthesis. 3.5 Sterilization of process fluids: Liquid, Gas	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board
4	TLO 4.1 Explain the different operations involved in downstream processing. TLO 4.2 Separate the soluble and insoluble products by appropriate unit operations. TLO 4.3 Explain the different cell disruption methods	Unit - IV Bio-product purification (Downstream processing) 4.1 Strategies to recover and purify products, determination of microbial contaminations by Culture-Based Methods 4.2 Separation of insoluble products: by filtration, coagulation and flocculation 4.3 Cell disruption: Separation of dead cells by mechanical and non mechanical methods 4.4 Separation of soluble products: by Extraction, Precipitation, Dialysis, Adsorption, Ultrafiltration, Microfiltration, Chromatography 4.5 Crystallization and drying of final product	Video Demonstrations Presentations Lecture Using Chalk-Board Demonstration
5	TLO 5.1 State the different types of industrial bioprocess. TLO 5.2 Describe the ethanol and lactic acid production bioprocess TLO 5.3 Describe the citric acid and baker's yeast production TLO 5.4 Describe the penicillin production bioprocess TLO 5.5 Describe the High-Fructose Corn Syrup (HFCS) production process.	Unit - V Industrial Bioprocess 5.1 Bioprocess: Types, Anaerobic and Aerobic. 5.2 Raw material, reaction, flowsheet, process description and application of the following as case studies: 5.2.1 Ethanol and lactic acid 5.2.2 Citric acid and Bakers Yeast 5.2.3 Penicillin 5.2.4 High-Fructose Corn Syrup (HFCS)	Video Demonstrations Presentations Case Study

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Prepare and sterilize the different media.	1	*Sterilization of the appropriate medium for given application.	2	CO1
LLO 2.1 Observe and, identify microorganisms using microscopy techniques.	2	*Identification of the different samples of Micro-organisms using microscope	2	CO1
LLO 3.1 Prepare the Phases of Bacterial Growth	3	*Preparation of the Bacterial growth curve for given culture	2	CO2
LLO 4.1 Understand Microbial Growth and Factors Affecting It	4	*Preparation and quantification of the microorganism for the given sample	2	CO2
LLO 5.1 Apply the Different Methods of Immobilization	5	*Immobilization of the given set of enzymes as a whole cell using suitable method	2	CO2
LLO 6.1 Maintaining sterile environments and preventing contamination in microbiological work.	6	Preparation of the aseptic techniques to prevent contamination in microbiological work	2	CO3
LLO 7.1 Understand the principal of enzyme activity LLO 7.2 Measure the rate of an enzyme-catalysed reaction by measuring the assay and enzyme activity.	7	*Determination of the rate at which an enzyme catalyses a reaction	2	CO3
LLO 8.1 Determine the Reaction Rate of an Enzyme-Catalysed Reaction LLO 8.2 Understand the Michaelis-Menten Model	8	*Determination of the rate of reaction using Michaelis-Menten Equation	2	CO3
LLO 9.1 Determine the effect of pH, temperature, substrates on enzyme activity	9	*Determination of the effect of Temperature on enzyme activity	2	CO3
LLO 10.1 Estimate the oxygen transfer coefficient KLa.	10	*Determination of the oxygen transfer coefficient KLa for the given enzyme reaction	2	CO3
LLO 11.1 Identify Sources of Antibiotic-Producing Organisms	11	Isolation of the Antibiotic producing organism from the given sample	2	CO4
LLO 12.1 Apply the different methods of Detecting Microbial Contamination	12	*Determination of microbial contaminations by Culture-Based Methods	2	CO4
LLO 13.1 Evaluation of bioproduct using UV vis spectroscopy	13	*Quantification of the bioproducts using UV vis spectroscopy	2	CO4
LLO 14.1 Prepare the citric acid using bioprocess	14	Demonstration of citric acid production using <i>Aspergillus niger</i> in an aerobic fermentation process.	2	CO5
LLO 15.1 Prepare the ethanol using sugar fermentation	15	*Preparation of ethanol by using Fermentation.	2	CO5
LLO 16.1 Cultivate the Bakers yeast using simple fermentation	16	Cultivation of the Baker's yeast (<i>Saccharomyces cerevisiae</i>) using a simple fermentation process	2	CO5

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
Note : Out of above suggestive LLOs - '*' Marked Practicals (LLOs) Are mandatory. - Minimum 80% of above list of lab experiment are to be performed. - Judicial mix of LLOs are to be performed to achieve desired outcomes.				

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Prepare the following bio-product with minimum quantity-
 - Students are able to perform the fermentation of sugarcane or fruit waste using yeast to produce ethanol.
 - Students are able to cultivate the Lactobacillus strains for yogurt production.
 - Students are able to perform the Acetic acid fermentation using Acetobacter species.
 - Students are grouped to produce bioplastic bacterial polyhydroxy alkanooates. (PHA) .
 - Students are able to perform the bioethanol from kitchen waste.
 - Students are able to perform biofertilizer using nitrogen fixing bacterial cultures
 - Evaluation of microbial efficiency in organic waste decomposition.
 - Visit the distillery and prepare detailed report on ethanol production.
 - Visit the bakery and prepare detailed report on Baker's yeast production

Note : - Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way. - The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills. - If a microproject is assigned, it is expected to be completed as a group activity. - SLA marks shall be awarded as per the continuous assessment record. - For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences. - If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.				
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VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Titration set up	1
2	Sterile Petri dishes and test tubes	1,3,12
3	Autoclave	1,4,15
4	pH meter	1,5,6,8,11,13,14,16
5	Mixer	1,5,7
6	Hot plate/magnetic stirrer	1,7,9
7	Spectrophotometer	3,5,6,9,10,11,13,14,15,16
8	Incubator	3,6,10,11,12,15
9	Water bath	5,16
10	Bioreactor/fermenter	7

BIOPROCESS TECHNOLOGY**Course Code : 316304****IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	An overview of Bioprocess Technology and cells	CO1	9	4	4	6	14
2	II	Enzyme kinetics	CO2	10	4	6	6	16
3	III	Selection and scale-up of Bioreactor	CO3	9	4	4	6	14
4	IV	Bio-product purification (Downstream processing)	CO4	9	2	6	6	14
5	V	Industrial Bioprocess	CO5	8	2	4	6	12
Grand Total				45	16	24	30	70

X. ASSESSMENT METHODOLOGIES/TOOLS**Formative assessment (Assessment for Learning)**

- Two Class Test of 30 Marks. Each practical will be assessed considering: 60 % weightage to process, 40 % weightage to product.

Summative Assessment (Assessment of Learning)

- End of Term Theory Examination. End of Term Practical Examination

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	2	2	3	2	3			
CO2	2	1	2	2	3	1	3			
CO3	2	2	3	3	3	2	3			
CO4	2	1	2	2	3	1	3			
CO5	2	1	2	2	3	2	3			
Legends :- High:03, Medium:02,Low:01, No Mapping: - *PSOs are to be formulated at institute level										

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
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BIOPROCESS TECHNOLOGY**Course Code : 316304**

Sr.No	Author	Title	Publisher with ISBN Number
1	Ghose T.K	Bioprocess Computations in Biotechnology	Eiils Horwood Ltd
2	Bailey Jams E. and Oils D.F.	Biochemical Engineering Fundamental	McGraw Hill Book Co.
3	Pauline M. Doran	Bioprocess Engineering Principles	Academic Press Limited, London
4	Aiba, Arthur E. Humphery and Nancy F. Millis	Biochemical Engineering	University of Tokyo Press.
5	Biological Thermodynamics	Donald T. Haynie	Cambridge press, 2008.
6	Rodney Boyer	An Introduction to Practical Biochemistry	Pearson Education.
7	by J. Jayaraman	Laboratory Manual of Biochemistry	Wiley Eastern
8	Michael L. Shuler, Fikret Kargi	Bioprocess Engineering Basic Concepts	Prentice Hall PTR

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://nptel.ac.in/courses/102106053	This course on bioreactors, the core of any bioprocess, covers key principles essential for producing biological products in biotech and pharma industries. It's designed for students, teachers, and industry professionals seeking to understand and apply bioreactor concepts effectively.
2	https://nptel.ac.in/courses/102105064	Biochemical Reaction Engineering deals with complex life systems, aiming to mathematically model their behavior. This interdisciplinary course blends biology, physics, chemistry, and mathematics, covering enzyme and microbial cell-based production. It equips students to distinguish between chemical and biochemical reaction engineering and design biochemical processes for industrial applications.
3	https://nptel.ac.in/courses/102106086	This core course is ideal for students in bioprocess or biological engineering. It covers design principles of batch, fed-batch, and continuous bioreactors, along with mass and heat transfer, and scale-up criteria.
Note : Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students		