**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 | Max | Max | Min | 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.<br>TLO 1.2 Explain the different types of cells<br>TLO 1.3 Explain the cell structure and its construction.<br>TLO 1.4 Differentiate between macro and micronutrients<br>TLO 1.5 Differentiate between transcription and translation. | **Unit - I An overview of Bioprocess Technology and cells**<br>1.1 Biotechnology and bioprocess technology, preparation of media<br>1.2 Cells: Microbial diversity, Naming cells, Viruses, Procaryotes, Eucaryotes<br>1.3 Cell construction: Amino Acids and Proteins, Carbohydrates and Nucleic Acids, RNA, and DNA<br>1.4 Cell Nutrients: Macro, Micro and Growth Media<br>1.5 Working of Cells: central dogma, DNA replication, transcription and translation | Video<br>Demonstrations<br>Presentations<br>Lecture Using Chalk-Board |
| 2 | TLO 2.1 Explain the basics of rection kinetics and work of enzymes<br>TLO 2.2 Explain the different reaction kinetics models.<br>TLO 2.3 Explain the effect of pH and temperature on enzyme kinetics.<br>TLO 2.4 Explain the different methods of enzyme immobilization<br>TLO 2.5 Explain the growth curve of cells | **Unit - II Enzyme kinetics**<br>2.1 Basics of reaction Kinetics - rate of a reaction, rate constant and order of the reaction, functioning of enzymes<br>2.2 Models of enzyme kinetics: Mechanistic model and Michaelis-Menten model<br>2.3 Effect of pH and temperature<br>2.4 Immobilized enzyme system: methods of immobilization<br>2.5 Batch growth and quantification of cell | Video<br>Demonstrations<br>Lecture Using Chalk-Board<br>Presentations |

| 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<br>TLO 3.2 Describe the different sub-basic types of bioreactors<br>TLO 3.3 Explain the scale up and scale down procedure of bioreactor<br>TLO 3.4 Explain the influence of different parameters on bioreactors.<br>TLO 3.5 Explain the procedure for sterilization of fluids. | **Unit - III Selection and scale-up of Bioreactor**<br>3.1 Overview of reactor types: mechanical agitation, bubble column and loop reactors<br>3.2 Types of sub-basic types of bioreactors: stirred tank reactor, bubble column reactor, airlift loop, propeller loop and jet loop<br>3.3 Concept of scale up and scale down of bioreactor, scale up challenges<br>3.4 Bioreactor instrumentation and control: influence of various bioprocess parameters viz. pH, temperature, medium components on product synthesis.<br>3.5 Sterilization of process fluids: Liquid, Gas | Model Demonstration<br>Video Demonstrations<br>Presentations<br>Lecture Using Chalk-Board |
| 4 | TLO 4.1 Explain the different operations involved in downstream processing.<br>TLO 4.2 Separate the soluble and insoluble products by appropriate unit operations.<br>TLO 4.3 Explain the different cell disruption methods | **Unit - IV Bio-product purification (Downstream processing)**<br>4.1 Strategies to recover and purify products, determination of microbial contaminations by Culture-Based Methods<br>4.2 Separation of insoluble products: by filtration, coagulation and flocculation<br>4.3 Cell disruption: Separation of dead cells by mechanical and non mechanical methods<br>4.4 Separation of soluble products: by Extraction, Precipitation, Dialysis, Adsorption, Ultrafiltration, Microfiltration, Chromatography<br>4.5 Crystallization and drying of final product | Video Demonstrations<br>Presentations<br>Lecture Using Chalk-Board<br>Demonstration |
| 5 | TLO 5.1 State the different types of industrial bioprocess.<br>TLO 5.2 Describe the ethanol and lactic acid production bioprocess<br>TLO 5.3 Describe the citric acid and baker's yeast production<br>TLO 5.4 Describe the penicillin production bioprocess<br>TLO 5.5 Describe the High-Fructose Corn Syrup (HFCS) production process. | **Unit - V Industrial Bioprocess**<br>5.1 Bioprocess: Types, Anaerobic and Aerobic.<br>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<br>Presentations<br>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 |
|---|---|---|---|---|
| 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 |

| Practical / Tutorial / Laboratory Learning Outcome (LLO) | Sr No | Laboratory Experiment / Practical Titles / Tutorial Titles | Number of hrs. | Relevant COs |
|---|---|---|---|---|
| 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<br>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<br>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 Aspergillus niger 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 (Saccharomyces cerevisiae) using a simple fermentation process | 2 | CO5 |

**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-

1. Students are able to perform the fermentation of sugarcane or fruit waste using yeast to produce ethanol.

2. Students are able to cultivate the Lactobacillus strains for yogurt production.
3. Students are able to perform the Acetic acid fermentation using Acetobacter species.
4. Students are grouped to produce bioplastic bacterial polyhydroxy alkanoates. (PHA) .
5. Students are able to perform the bioethanol from kitchen waste.
6. Students are able to perform biofertilizer using nitrogen fixing bacterial cultures
7. Evaluation of microbial efficiency in organic waste decomposition.
8. Visit the distillery and prepare detailed report on ethanol production.
9. 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.

## 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 |

## 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 |
|---|---|---|---|
| 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 |
|---|---|---|

**BIOPROCESS TECHNOLOGY** **Course Code : 316304**

| 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