GUJARAT TECHNOLOGICAL UNIVERSITY
BIOTECHNOLOGY (04)
BIOCHEMICAL ENGINEERING II
SUBJECT CODE:2180408
B.E. 8th Semester

Type of course: B.E. (Biotechnology)

Prerequisite: Basics of Biochemical Engineering-I

Rationale: This subject is designed to help students understand different unit operations used in the recovery of biological products. It will give exposure to biosensor technology and various simulation softwares used in biological processes.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	3	7	70	20	10	20	10	20	150

Course Contents:

Sr. No.	Topics	Teaching Hours	Module Weightage
1	**UNIT I: Media Optimization and Monitoring of bioprocesses:** Plackett – Burman Design, Response surface optimization, simplex search method, Methods of on-line and off-line bio-mass estimation.Flow injection analysis.	**16**	**25%**
2	**UNIT II: Simulation softwares:** Modelling and simulation of bioprocesses: Study of structured models for analysis of various bioprocesses– compartmental models, models of cellular energetics and metabolism, single cell models, plasmid replication and plasmid stability model. Dynamic simulation of batch, fed batch, steady and transient culture metabolism. Model simulation using MATLAB-SIMULINK software packages. Modelling of Recombinant bacterial cultures. Bioreactor strategies for maximising product formation.	**16**	**25%**
3.	**UNIT III: Biosensor Technology:** Principles, Types, elements, characteristics, applications	**6**	**9%**
4.	**Unit IV: Downstream Processing:** Role of downstream processing in biotechnological processes. **Disruption of microbial cells:** Composition and structure of cell walls (Bacteria, yeast and other fungi), Analysis of Disruption (direct and indirect measurement), Laboratory scale disruption techniques (mechanical and non mechanical), large scale disruption techniques (High speed Ball Mills, High pressure homogenizers and others)	**22**	**35%**

	Flocculation: Electric Double layer, Forces between Particles and flocculation by electrolytes, The Schulze Hardy Rule, Flocculation rate. **Sedimentation:** Principle, methods and coefficients, sedimentation at low accelerations. **Centrifugation:** Introduction, Fluid and particle dynamics (Stoke's law, Settling in centrifugal field, Hindered settling), Centrifuge configurations (Tubular Bowl centrifuge, Chamber centrifuges, Decanter Centrifuges, Disc-stack centrifuge), Scale up (Tubular Bowl centrifuge, Decanter Centrifuges, Disc-stack centrifuge), Types of separator (Solid Bowl Machines and Solids discharging Disc separators), Methods for selection of centrifuge and applications **Filtration:** Introduction, filter aids, theory, equipment, Tangential flow filtration, Hollow fiber membranes, Ultra filtration in biotechnology. **Liquid-Liquid Extraction:** Introduction, Principle, biochemical and technical aspects, Solvent selection, Extraction equipment selection, Process Considerations, Analytical applications **Adsorption:** Chemistry, Batch adsorption, Adsorption in continuous stirred tank, adsorption in fixed beds **Precipitation:** Principle, Precipitate formation phenomenon, Precipitation with a non solvent, precipitation with salts, precipitation with temperature, Design of precipitation systems **Chromatographic techniques:** 1) **Molecular sieve chromatography** (Introduction, materials, equipment, theory, operations) 2) **Ion Exchange chromatography** (Introduction, materials, equipment, theory, operations) **3) Affinity Chromatography** (Introduction, matrix, spacer arms, coupling procedures, adsorption, elution, regeneration, theoretical modeling, applications) 4) **Hydrophobic chromatography** (Introduction, structure and synthesis of hydrophobic matrices, theoretical aspects, applications and resolving power) 5) **High Performance Liquid Chromatography** (Introduction, theory and practice, instrumentation, gradient and scale up) **Electrodialysis:** Principle and theory of operation, equipment, applications in biotechnology **Product polishing-Crystallization:** Basic concept, Size distribution, Batch crystallizers, crystallizer scale up and design.-**Drying:** Basic concept, equipments, scales up and design.		
5.	**Unit V: Economics of downstream processing in Biotechnology**, cost-cutting strategies, characteristics of biological mixtures, process design criteria for various classes of bio products (high volume, low value product and low volume, high value product), physico- chemical basis of bio separation processes.	**4**	**6%**

Suggested Specification table with marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
8	12	20	10	8	12

Legends: R= Remembrance**; U=** Understanding**; A=** Application**; N =** Analyze**; E =** Evaluate; **C** = Create and above Levels **(Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Biochemical Methods by S. Sadasivam and A. Manickam, Publisher : New Age International Pvt Ltd
2. Bio separations Science and Engineering, Roger Harrison, Paul Todd, published by Oxford university Press
3. Bio separations by Belter and Cussler published by Wiley interscience
4. Principles of fermentation Technology by P. F. Stanbury, A. Whitaker and S. J. Hall, Elservier Publications.

Course Outcome:

After learning the course, the students should be able to:

1. Understand Bioprocess design and operation
2. Choose correct hiearchy in selection of unit operations for recovery of bioproduct.

LIST OF PRACTICALS:

1. To get familiar with the application of biochemical kinetics simulation software.
2. Analysis & interpretation through time course simulation & steady state analysis
3. To optimize ethanol from *S.Cerevisiae* using simulation software copasi through study of kinetics
4. (a)To Study MATLAB application for engineering tools
   (b)To study array and to check suitability to fit into kinetic data using MATLAB
   (c) To find out syntax error and correcting it to MATLAB experimentation
5. To determine the pattern of inhibition of copper sulphate on enzyme *invertase*
6. To draw the growth kinetics of feed batch culture by constant, linear and exponential feeding patterns
7. To plot the growth curve of *E.coli* strain and to estimate the specific growth rate and biomass yield coefficient from the substrate utilization data
8. To measure oxygen absorption rate by iodine titration method(OAR) under the effect of static and shaking condition
9. To measure oxygen adsorption rate by iodine titration method(OAR) under the effect of different sample volume in similar flask
10. To measure oxygen absorption rate by iodine titration method (OAR) under the effect of different flask size during agitation
11. To determine the oxygen uptake rate by sodium sulphate titration method
12. To generate results of control process for a given input set of controllers by simulink package

Open Ended Problem:
Some suggested projects are listed below:

1. To design downstream processing for crystallization of enzyme
2. To design downstream processing for extraction of enzyme amylase from malt extract.
3. To design process of separating protein from salt using chromatographic technique and dialysis.

List of Open Source Software/learning website:
Students can refer to video lectures available on the websites including NPTEL. Students can refer to the CDs which are available with some reference books.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.