SEMESTER S6

DOWNSTREAM PROCESSING

Course Code	**PCBTT601**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

At the end of the course students will be able to

1. Assess the significance of downstream processing in a bio- product separation.
2. Apply the knowledge of unit operations for the separation of insoluble from fermentation broth.
3. Propose and design recovery and purification of biomolecules by applying concepts of mass transfer operation.
4. Examine skills needed to function in modern bio separation engineering.
5. Design and demonstrate adsorption and chromatography processes for the purification of bio molecules.
6. Demonstrate the skills and techniques to design a process for product purification.

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to downstream processing** Introduction to the various downstream processing steps and their significance in biotechnology, Economics of downstream processing, cost-cutting strategies, Process design criteria for various classes of bioproducts (high volume, low-value products, and low volume, high-value products) with suitable problems. Physico-chemical basis of different bio separation	11

	processes	
2	**Primary Separation and Recovery Processes** Cell disruption by chemical, mechanical, and enzymatic methods; Centrifugation and Filtration: basic principles, design characteristics Ultracentrifuges, problems based on the laws governing filtration and centrifugation; Flocculation, and sedimentation.	**11**
3	**Enrichment Operations Extraction:** Basic equations of extraction, Aqueous two-phase extraction, batch extraction, staged extraction and differential extraction, Supercritical fluid extraction, problems related to the extraction; Adsorption and Leaching, Precipitation methods; Membrane-based purification: Ultrafiltration and Microfiltration, Reverse osmosis, Dialysis.	**11**
4	**Product Resolution / Fractionation and Polishing** General chromatography theory and the different chromatographic techniques like adsorption, partition, ion exchange, affinity, gel filtration and HPLC, Dialysis, Crystallization, and Drying. Any Emerging Technologies in downstream processing in biotechnology industries	**11**

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Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Internal Ex	Evaluate	Analyse	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. • Each question carries 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Recognize the basis for various steps in downstream processing and their economics, to design a strategy for the purification of a product.	**K1**
CO2	Apply the basic laws governing downstream processing unit operations to solve practical problems in industry and research.	**K3**
CO3	Assess techniques such as precipitation, membrane separation and chromatographic technique for the purification of a targeted protein(s) or any other biological material.	**K3**
CO4	Propose a technique to give final polishing to the isolated product.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										**2**
CO2	2	2	**2**									**2**
CO3	2	2	**2**									**2**
CO4	2	2	2									**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

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Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Downstream Process Technology - A New Horizon in Biotechnology	N. K. Prasad	Prentice Hall of India, New Delhi	2012
2	Bioseparations Engineering: Principles, Practice and Economics	M. R. Ladisch	Wiley Interscience	1st Edn., 2001
3	Bioseparations: Principles and Techniques,	Sivasankar B,	Prentice-Hall of India Pvt. Ltd.	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioseparation: Downstream Processing for Biotechnology,	P. A. Belter, E. L. Cussler, and W.S. Hu,	Wiley-Interscience	2nd Edn., 1994
2	Separation Process Principles	J. D. Seader and E.J. Henley,	Wiley	3rd Edn., 2010.

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Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt27/preview https://archive.nptel.ac.in/courses/102/106/102106022/
2	
3	