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DEPARTMENT OF CHEMICAL ENGINEERING
College of Engineering
University of the Philippines Diliman, Quezon City

COURSE SYLLABUS
ChemE 170 Introduction to Bioprocess Engineering

A. Course Catalogue Description

1. **Course Number:** ChemE 170
2. **Course Title:** Introduction to Bioprocess Engineering
3. **Course Description:** Mass and energy balance in biological systems; kinetics of bioprocesses; heat and mass transfer applications to bioreactor design and downstream processes
4. **Prerequisite:** ChemE 128 Chemical Reaction Engineering and
   ChemE 132 Separation Processes I
5. **Semester Offered:** Second Semester
6. **Course Credit:** 3u
7. **Number of Hours:** 3h
8. **Meeting Type:** lecture
9. **Course Goals:** To discuss the application of different chemical engineering principles in the analysis of biological systems, and to design bioreactors and downstream processes for recovering products of biological activities

B. Rationale

Bioprocess engineering is an essential, fast-growing field of chemical engineering study. This course covers the application of chemical engineering principles to biological processes and products.

C. Course Outline

1. **Course Outcomes (CO)**

   Upon completion of the course, students must be able to:

   CO 1. identify important industries of chemicals that are produced using biological agents;
   CO 2. perform mass and energy balance calculations in biological systems;
   CO 3. model the kinetics of cell growth, thermal sterilization, enzymatic and fermentation processes;
   CO 4. design a basic bioreactor;
   CO 5. compare various bioprocess configurations in terms of operation, productivity, and application;
   CO 6. apply principles of separation processes in the downstream processing of bioreactor products; and
   CO 7. discuss various strategies of enhancing and intensifying bioprocesses.

Course Outcomes and Relationship to Program Learning Objectives

Course Outcomes	Program Learning Objectives*				
	A	B	C	D	E
Identify important industries of chemicals that are produced using biological agents	■			■	
Perform mass and energy balance calculations in biological systems	■				
Model the kinetics of cell growth, thermal sterilization, enzymatic and fermentation processes	■				
Design a basic bioreactor	■	■	■		■
Compare various bioprocess configurations in terms of operation, productivity, and application	■	■		■	
Apply principles of separation processes in the downstream processing of bioreactor products	■				
Discuss various strategies of enhancing and intensifying bioprocesses	■	■		■	■

* **A** Equip students with strong technical education in chemical engineering necessary to succeed in their chosen careers and to become responsive citizens.
B Develop the students' ability to effectively communicate technical information to any audience.
C Train students to function in multidisciplinary teams, manage projects, and take leadership roles in their respective fields.
D Engage students in research, innovation, and life-long learning to identify opportunities, and address issues and challenges in their respective spheres of influence.
E Instill in students a strong commitment to the ethical practice of their profession; to health, safety, and environment; and to service to society.

2. Course Content

Lecture Topics	No. of Hours
Essential biological concepts 1. Cell biology 2. Cellular processes 3. Biochemical products and fine chemicals	6
Bioprocesses 1. Mass and energy balance in biological systems 2. Cell growth kinetics 3. Sterilization and thermal death kinetics 4. Enzyme kinetics 5. Fermentation kinetics	18
Long Examination 1	
Bioreactor design and operation 1. Various bioprocess configurations (batch, fed batch, chemostat, chemostat with recycle, multi-stage chemostat, etc.) 2. Bioreactor design considerations 3. Mass transfer considerations in bioreactor design 4. Downstream processing	21

Lecture Topics	No. of Hours
5. Process intensification through immobilization technologies	
Special Topics 1. Mixed culture bioprocesses: basic principles, applications, bioprocess design considerations 2. Other industrial applications	3
Group Design Project	
Long Examination 2	
Total number of hours	48

3. Course Coverage

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
1-2	1,2,3	**Essential biological concepts** 1. Cell biology 2. Cellular processes 3. Biochemical products and fine chemicals	What are examples of products of bioprocesses? Which cellular activities are considered relevant in the context of biochemical engineering? What are the functions of the various elements that must be present in cell culture or fermentation media?	lecture; classwork	quiz
3-8	2,3,5,6,7	**Bioprocesses** 1. Mass and energy balance in biological systems 2. Cell growth kinetics 3. Sterilization and thermal death kinetics 4. Enzyme kinetics 5. Fermentation kinetics	How can cells be treated and analyzed as a chemical engineering system? What are the different kinetic models for quantifying biological activity?	lecture; classwork	quiz
					Long Examination 1
9-15	1,4,5,6,7	**Bioreactor design and operation** 1. Various bioprocess configurations (batch, fed batch, chemostat, chemostat with recycle, multi-stage chemostat, etc.) 2. Bioreactor design considerations 3. Mass transfer considerations in bioreactor design	What is a bioreactor? What are the general considerations for designing a bioreactor? How would you formulate the fermentation media and flow rate given a production rate?	lecture; classwork	quiz, group discussion

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
		4. Downstream processing 5. Process intensification through immobilization technologies			
16	1,4,5,6	**Special Topics** 1. Mixed culture bioprocesses: basic principles, applications, bioprocess design considerations 2. Other industrial applications	What are the emerging topics and developments in bioprocessing?	lecture; classwork	quiz, group discussion
					group design project
					Long Examination 2

3. Course Requirements

1. Long examinations (2)
2. Group design project
3. Quizzes
4. Group discussions

REFERENCES:

Antonio, B. S. (2013). Production of lovastatin from crude glycerol via fermentation using *Aspergillus terreus* ATCC 20542 (Doctoral dissertation). University of the Philippines Diliman.

Doran, P. M. (2012). *Bioprocess Engineering Principles* 2nd Ed. London, UK: Academic Press.

Liu, S. (2016). *Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design* 2nd Ed. Elsevier, Oxford, UK.

Shuler, M. L. Kargi, F., and DeLisa, M. (2017). *Bioprocess Engineering: Basic Concepts* 3rd Ed. London, UK: Pearson Higher Education.