# Lahore University of Management Sciences

# ChE 318 – Fundamentals of Biochemical Engineering / ChE 512 – Biochemical Engineering

Fall 2022

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| Instructor | Dr. Shahana Khurshid |
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| Office Hours | TBA |
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| Telephone | 3739 |
| Teaching Assistant | TBA |

| Course Teaching Methodology |
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| Teaching Methodology: The class is designed to be taught synchronously in person. |

| Course Basics | | | | |
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| Credit Hours | 3 | | | |
| Lecture(s) | Nbr of Lec(s) Per Week | 2 | Duration | 75 minutes each (T Th 10:00-11:15) |
| Recitation/Lab (per week) | Nbr of Lec(s) Per Week | | Duration | |
| Tutorial (per week) | Nbr of Lec(s) Per Week | 1 | Duration | 60 min |

| Course Distribution | |
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| Core | No |
| Elective | Yes |
| Open for Student Category | |
| Close for Student Category | Not for freshmen students |

| COURSE DESCRIPTION |
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| Biochemical engineering is the application of chemical engineering to biological systems. Biological systems are complex. They obey the rules of chemistry and physics and are susceptible to engineering analysis. Biochemical engineers use living cells on commercial scales in the biotechnology, food, and pharmaceutical industries, to develop new medicines, semisynthetic organs, nutritious foods, degrade pollutants, etc. As a biochemical engineer you would engineer and operate systems that contain living cells and biomolecules, design and operate bioprocesses to manufacture biomolecules and drugs, and apply biological principles to the engineering of living cells. This course will give you the foundational knowledge of biochemical engineering which will opens doors for pursuing careers or graduate studies in biotechnology, bioengineering and the pharmaceutical industry. No preliminary knowledge of chemical engineering is assumed in this course and we will build on the concepts taught in freshmen chemistry and biology. We will cover enzyme technology; design of bioreactors and microbial fermentations; separations of biological products; microorganisms in chemical and biochemical syntheses. These will include concepts of heat and mass transfer, as well as the application of quantitative engineering principles to the analysis of biological processes, including thermodynamics, kinetics and stoichiometry. We also aim to cover cell culture and cellular engineering including genetic manipulation of cells by classical and recombinant DNA techniques. |

| COURSE PREREQUISITE(S) | |
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| • | CHEM 101 Principles of Chemistry and BIO 101 Introductory Biology. Or graduate standing. |

| COURSE OBJECTIVES | |
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| • | Provide an introduction to the core topics in biochemical engineering connecting to the concepts taught in freshmen science courses. |
| • | Cover topics in enzyme kinetics and industrial utilization of enzymes; microbial growth kinetics; cell culture and cellular engineering. |
| • | Explain how to design bioreactors and microbial fermentations. |
| • | Apply quantitative engineering principles to the analysis of biological processes, including thermodynamics, kinetics and stoichiometry. |

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| Learning Outcomes | |
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| CLO1 | **Explain** how enzymes work and how they can be used in industrial applications |
| CLO2 | **Describe** cellular growth kinetics in batch cultures |
| CLO3 | **Compare** different types of bioreactors |
| CLO4 | **Apply** knowledge of cell culture to bioreactor design and genetic engineering |
| CLO5 | **Analyze** biochemical engineering literature and identify the biochemical engineering methods utilized |

Relation to program outcomes

| CLO's | Related PLO's | Level of learning | Teaching methods | CLO attainment check |
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| CLO1 | PLO 1 | C2 | Instructions, problem solving | Homeworks, quizzes and exams |
| CLO2 | PLO 1 & 2 | C2 | Instructions, problem solving | Homeworks, quizzes and exams |
| CLO3 | PLO 1, 2 & 3 | C4 | Instructions, problem solving | Homeworks, quizzes and exams |
| CLO4 | PLO 1 & 2 | C3 | Instructions, problem solving | Homeworks, quizzes and exams |
| CLO5 | PLO 4 & 10 | C4 | Instructions | Assignments and quizzes |

Grading break up: Component Details and weightages

Home Work: 20% (4 homeworks)
Quizzes and assignments: 25% (3 quizzes, 1 assignment to read and present a journal article in biochemical engineering)
Midterm Examination: 25%
Final Examination: 30%

| Examination Detail | |
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| Midterm Exam | Yes/No: Yes<br>Combine Separate:<br>Duration: 75 min<br>Preferred Date:<br>Exam Specifications: Closed book |
| Final Exam | Yes/No: Yes<br>Combine Separate:<br>Duration: 120 min<br>Exam Specifications: Closed book |

**COURSE OVERVIEW** (subject to modification)

| Week | Topics | Recommended Reading | Objectives/ Application |
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| Week # 1 | Introduction to Biochemical Engineering<br>Enzymes | S&K Chapter 1<br>S&K Chapter 3 | Describing what is a Biochemical Engineer |
| Week # 2 | Enzyme Kinetics, Measurements. | S&K Chapter 3 | Describing basics of enzymes |
| Week # 3 | Immobilized Enzyme Kinetics | S&K Chapter 3 | Describing enzyme technology |
| Week # 4 | Applications of enzyme catalysis. | S&K Chapter 3 | Using enzymes in industry |
| Week # 5 | Microbial Growth. Batch Cultivation. | S&K Chapter 6 | Learning how cells grow |
| Week # 6 | Models of Microbial Growth. | S&K Chapter 6 | Learning how to use cell growth |
| Week # 7 | Microbial Growth. Continuous Culture. | S&K Chapter 6 | Learning how to use cell growth |
| Week # 8 | Stoichiometry of Microbial Growth and Product Formation<br>**Midterm Exam** | S&K Chapter 7 | Learning how to use cell growth |
| Week # 9 | Bioreactor Design for suspension cultures | S&K Chapter 9 | Learning principles of bioreactor design |
| Week # 10 | Bioreactor Design for immobilized cultures | S&K Chapter 9 | Learning principles of bioreactor design |
| Week # 11 | Selection and Scale-up of Bioreactors | S&K Chapter 10 | Learning mass and heat transfer concepts for bioreactor design |

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| Week # 12 | Operation and Control of Bioreactors<br>Cell Culture | S&K Chapter 10<br>S&K Chapter 12 | Learning bioreactor design<br>Describe basics of cell culture |
| Week # 13 | Cell Culture and Mixed Culture | S&K Chapter 12 and 16 | Describe basics of cell culture |
| Week # 14 | Cellular Engineering<br>Student Presentations on Journal Articles | S&K Chapter 14 | Utilizing genetically engineered organisms<br>Analyzing biochemical engineering literature |
| Week # 15 | Medical Applications of Biochemical Engineering | S&K Chapter 15 | Linking to medical devices, tissue engineering, and other aspects of medicine |
| Week # 16 | **Final Exam** | | |

## Textbook

Required Textbook: Bioprocess Engineering: Basic Concepts, 3rd Edition, Prentice Hall, by Michael Shuler, Fikret Kargi, Matthew DeLisa, 2017. ISBN-10: 0137062702

## Teaching Philosophy

I expect students to come prepared for lectures by reading the recommended material beforehand. To incentivize students to do this, I will occasionally hold a short quiz (usually at the start of class) to test some basics of the chapter/sections. Reading the material before prepares you to better absorb the material taught in class.

I will not be able to cover every topic in detail in the lectures. This is also why you are responsible for reading all the recommended material. If you don't understand any of the material, make use of the office hours of the instructor(s)/teaching assistant(s). I believe that 2-way interaction between the instructor and the students leads to better learning and will also try to facilitate that to the extent that our class time permits.

To succeed in college courses, you should expect to spend 3 hours reading and practicing problems for every 1 hour spent in class. Think about homework problems before you come to office hours to discuss them. Work on your own on homework questions; if you are stuck, then seek help from your peers and instructors. Seeking help without first thinking through the questions on your own will limit your learning which can affect your performance on exams. Study groups can be useful, but view your classmates as fellow teachers, not as a quick way to get the answer.

Keep up with the material. Get help early if you are having trouble.

## Code of Conduct for Class Participation and Group Work with Peers

- Attend classes regularly, come prepared by having done the reading, take good notes, ask questions.
- Be attentive and respectful in class. Consider others' perspective with respect even if you disagree.
- Be proactive and flexible and take ownership of your learning experience as individuals and as a group.

## Homework Policy

Assignments will be given to help you practice your problem-solving skills. I strongly encourage you to attempt problems on your own before working in groups, if all your work is done in a group setting you are not adequately preparing for quizzes and exams. Copying from other students or other sources (e.g. solution manuals, old solutions, etc.) is viewed as academic misconduct and will be dealt with seriously.

Timely submissions of homework help you stay on track. To discourage late submissions, 5% will be deducted from your score per day after the due date (e.g. if you submit homework 2 days late the maximum you can get will be 90%) for the first 3 times you submit homework late. If you submit homework late more than 3 times, your submission may only be accepted for documented cases of family emergency or illness.

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| Grading Policy |
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| • The final grade will be on a relative basis.<br>• We will strive to fairly grade all of your assignments and exams. In all these evaluations, you will be penalized if there is a serious conceptual or mathematical mistake, error in the use of appropriate units, or indication of copying from other students.<br>• If you feel that an assignment or exam has been graded incorrectly you may ask for a re-grade. All requests for re-grading any work must be presented within 7 days of the day the work is returned to the class (note: If a quiz is returned to the class on a Tuesday but you aren't there, re-grades requests still are due by the following Tuesday even though you missed the class when the quiz was returned). Clearly state reasons for requesting a re-grade, enumerating what issues you believe were incorrectly addressed. When work is submitted for a re-grade, the entire document (exam or homework) will be re-graded, NOT just the section or problem for which the re-grade was requested. |

| Academic Honesty |
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| I expect that you:<br>• Take responsibility for your own learning.<br>• Attend classes regularly.<br>• Do not attempt to take credit for any work that you did not prepare yourself.<br>• Be respectful.<br>Any instances of academic dishonesty in this course (intentional or unintentional) will be dealt with swiftly and severely. Potential penalties include receiving a failing grade on the assignment in question or in the course overall. Your work (on homeworks, quizzes, exams, other submitted materials) must comply with the policies described in the LUMS Student Handbook. |

| Harassment Policy |
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| There is absolutely zero tolerance for any behaviour that is intended, or has the expected result of making anyone uncomfortable and negatively impacts the class environment, or any individual's ability to work to the best of his/her potential. In case a differently-abled student requires accommodations for fully participating in the course, students are advised to contact the instructor so that they can be facilitated accordingly.<br>If you think that you may be a victim of harassment, or if you have observed any harassment occurring in the purview of this class, please reach out and speak to the instructor. If you are a victim, it is strongly encouraged to reach out to the Office of Accessibility and Inclusion at *oai@lums.edu.pk* or the sexual harassment inquiry committee at *harassment@lums.edu.pk* for any queries, clarifications, or advice. You may choose to file an informal or a formal complaint to put an end to offending behaviour. You can find more details regarding the LUMS sexual harassment policy at: *https://mgshss.lums.edu.pk/lums-harassment-policy*. To file a complaint, please write to *harassment@lums.edu.pk*. In addition to LUMS resources, SSE's Council on Belonging and Equity is committed to devising ways to provide a safe, inclusive and respectful learning environment for students, faculty and staff. To seek counsel related to any issue, please feel free to approach either a member of the council or email at *cbe.sse@lums.edu.pk*. |