ENCH 482/682: Biochemical Engineering – Fall 2018

Instructor:
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Class Schedule:
Class will meet on TU/TH 13:00-14:15 PM (Fine Arts 215).

Office hour:
Thursday 5pm to 6pm. Other time is generally welcome.

Course contents:

Overview to Biotechnology

Biochemistry and molecular cell biology fundamentals

Microorganisms and biological molecules; Structure and function of carbohydrates, amino acids, proteins, DNA and RNA; Metabolic Pathways and Cell energetics, Molecular genetics, protein synthesis and genetic engineering; Genetic regulation (repression and activation).

Enzyme catalysis, cell growth and bioreactor design

Principles of enzyme catalysis and enzyme-substrate reactions; Michalis-Mention equation; Enzyme inhibition kinetics, pH and temperature effects; Enzyme immobilization and the relative contributions of mass transfer and enzyme kinetics; Microbial growth kinetics; Arrhenius equation and sterilization; Structured and unstructured growth models; Integration of Logistic equation; Yield, Substrate consumption and production formation kinetics; Maintenance coefficient; Gaden category of fermentation kinetics; Bioreaction engineering; Fed-batch and Continuous Stirred Tank Reactor (CSTR) and Plug Flow Reactor (PFR); Stability of CSTR, Reactor design.

Prerequisites:
ENCH 427 (Transport Processes II: Mass Transfer) and
ENCH 440 (Chemical Engineering Kinetics) OR
Permission of the instructor.

Required Textbooks:
1. "Bioprocess Engineering, Basic Concepts," 3nd Edition, Michael L. Shuler and Fikret Kargi and Matthew Delisa. Prentice Hall, 2017.
2. "Essential Cell Biology," 4rd Edition, Alberts, et al. Eds., Garland Science, New York, 2014.

Helpful Textbooks in the Library:

1. Bailey, James E. & Ollis, David F.. *Biochemical Engineering Fundamentals 2nd ed*. New York. McGraw-Hill Book Company. 1986.
2. Blanch, Harvey W. & Clark, Douglas S.. *Biochemical Engineering*. New York. Marcel Deller, Inc.. 1996.

Course Objectives:

By the end of the course the student will be able to

1. Understand and discuss basic biological principles and techniques in molecular biology relevant to biochemical engineering and production of microbially derived products ranging from primary metabolites (ethanol, amino acids, organic acids) to secondary metabolites (antibiotics) and protein drugs (vaccines).
2. Students explain pseudo steady state and derive Michaelis-Menten and three type of inhibition kinetics; calculate kinetic parameter (K_m, V_{max}, K_I) & predict enzyme activity under kinetic-limited or diffusion-limited conditions.
3. Students apply mass balance & basic kinetics to derive the analytical solutions of various reactors at steady state; and evaluate the best bioreactor configuration and operation mode to manufacture a specific product.
4. Understand how principles of transport (heat, mass, momentum) and microbial kinetics are relevant in the design of bioreactors.
5. Student understand gene regulation and essentials of metabolic engineering and synthetic biology, lays the foundation for students to model and design complex biological systems for biomanufacturing, environmental and biomedical applications.
6. Literature discussion: students can use biochemical engineering, biochemistry and molecular biology language to discuss, summarize, understand and analyze literature data/content. Critically comment the strength and weakness of relevant research/review articles.

Topics Covered (Chapters correspond to Text #1 above):

1. Biochemical & Bioprocess Engineering (Ch 1)
2. Basic Biology & Biochemistry of Cells (Ch 2)
3. Enzyme Kinetics & Immobilization (Ch 3)
4. Genetics & Cellular Control Systems (Ch 4)
5. Metabolism (Ch 5)
6. Cell Growth Kinetics (Ch 6)
7. Stoichiometry (Ch 7)
8. Genetic Engineering (Ch 8, 14)
9. Bioreactor Operation (Ch 9)
10. Bioreactor Selection, Scale-up, Operation, and Control (Ch 10)

Professional Component Contribution:

Students will become familiar with biological terms, languages and concepts commonly used in the bioprocessing industry, allowing them to successfully interact with co-workers from biological disciplines. In addition, they will learn how to apply basic biochemical/biomolecualr engineering principles related to biological kinetics, reactor design, and transport phenomena to solve relevant problems and interpret data. In addition, they will be introduced to the biochemical engineering literature and will begin to understand how to read, interpret and write technical journal articles.

Relationship to Program Objectives:

Competency in the Discipline

10.1 Assigned problems will require understanding principles from mathematics and biological

sciences. Require basic linear algebra and basic differential calculus knowledge.

10.2 Core Chemical Engineering principles (primarily in transport & kinetics) required to solve problems and to analyze and interpret literature data.

1.4 Spread sheets and other tools will be used to understand mathematical models of biological systems.

1.5 The role of biotechnology in society and related ethics will be discussed.

Critical Thinking Ability

2.1 Review and analysis of literature articles will involve open ended questions/problems.

2.4 There will be a focus on interpretation of industrial fermentation data.

Communication

4.1 Writing assignments will be given to analyze and summarize the state-of-the-art biotech arena.

4.2 Extensive in class discussion will involve analysis and improvement of oral communication.

Capacity for Life-long Learning

5.2 Internet and literature searching required for understanding and analysis of literature articles.

5.3 Understanding supporting literature necessary to solve or analyze some problems or articles.

5.4 In class discussion on assignments will assist in students' self-evaluation.

Grading:

ENCH 482		**ENCH 682**	
Exam I	25%	Exam I	25%
Exam II	25%	Exam II	25%
Homework	30%	Homework	25%
Project report and presentation	20%	Project report and presentation	25%
Total	100%	Total	100%

Exams:

- **Exams are open books, only textbook or class notes are allowed**. You cannot bring computer or homework solutions with you during the exam.
- Miss an exam or quiz without a valid excuse and you get a zero.
- Requests for re-grades must be made within 48 hours of exam or homework being returned.

Homework

- No TA for the class. Home work will be due the next Tuesday (extended to Thursday if Tuesday is a holiday). We will have 7~9 homework during the semester.
- I expect you to work in small groups to complete the homework, but I will not accept outright copies.
- When you hand in your homework, include a cover page that contains only the following: your name, due date (month, day, year), course number, homework number, and problems in the assignment.

Projects

- Project will be assigned at the third week of the semester. 5~6 students work as one group. Each group will be assigned a topic related with genetic circuits, metabolic pathway kinetic

modeling, or synthetic ecological engineering projects. A minimal six page single-line spaced report (without reference) is due for each group at the end of the semester. Milestones including writing mathematical equations (5^{th} and 6^{th}week), write Matlab code (7^{th} week), run the model (8^{th} week), parameter adjustment (9^{th} and 10^{th} week), artwork completion (11^{th} and 12^{th} week), data interpretation (13^{th} week) and report completion (14^{th} week to 19^{th} week) will be discussed and checked with the instructor. Assistance will be provided from the adviser and graduate students. A 15 minutes presentation (split equally among the 5~6 presenters) is required for each group at the end of the class (19^{th} week).

Questions about Homework:

- We'll use the BlackBoard "Discussion Boards" for homework questions. This way, everyone in the class gets to see both your question and my answer. So everyone gets the benefit of the help.
- You should "Subscribe" to the Discussion Boards, "ENCH 482/682 Help Forum" (click the name of the Forum, then click the blue button near the top that says "Subscribe." This way, you'll get an email every time someone posts a question, or I post an answer.
- Please don't email me homework questions… I'll simply point you back to the Discussion Boards.

Attendance:

- I expect you to attend class, although I will not take attendance unless it becomes a problem.

What do I need to do to get an "A" ?

Participate in class and ask questions and think through the problems. Then only way to do this is to keep up with the reading, thinking and calculation. Note that we will cover a relatively large amount of information in a relatively short time, so this is crucial.

Integrity Policy:

By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC Policies section of the UMBC Directory.

You are expressly prohibited from accessing/using old homework, lab reports, programs and test files from previous years. Adequate samples will be provided in class if needed/requested.
Anyone who violates this policy is in automatic violation of Chemical and Biochemical Engineering's policy and the faculty will treat this as a case of academic misconduct.