BSE 3534: Bioprocess Engineering

Syllabus and Course Outline
Spring 2016

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Course (Catalog) Description:

3534: **Bioprocess Engineering**
Study of the engineering concepts for biological conversion of raw materials to food, pharmaceuticals, fuels, and chemicals. Emphasis is placed on enzyme kinetics and technology, bioreaction kinetics, design, analysis, and control of bioreactors and fermenters, and downstream processing of bioreaction products.

Prerequisites and Co-requisites:

Pre: 3154

BSE 3154 Thermodynamics of Biological Systems is a prerequisite to ensure that all students have attained junior level standing in BSE, and thermodynamics concepts are applied to enzyme catalyzed reactions and cell growth early in the course.

Co: 3504, BIOL 2604

BSE 3504 Transport Processes in Biological Systems is listed as a corequisite because heat and mass transfer are addressed at the end of this course. These principles are addressed at the beginning and in the core of BSE 3504.

BIOL 2604 General Microbiology is a corequisite so there is a connection between learning the microbiology of cell growth and fermentation and the mathematical concepts of cell growth and fermentation, which are covered late in the semester in BSE 3534.

Textbook: John Villadsen, Jens Nielsen, Gunnar Lidén. (2011) Bioreaction Engineering Principles, 3rd Edition. Springer Science & Business Media.

Course Objectives: The field of biotechnology is developing very rapidly and needs skilled engineers with bioprocess engineering background to design, build, control, and operate bioreactors and fermenters. This course provides students with basic concepts and prepares them to meet the challenges of the new and emerging biotechnology industry. After successful completion of this course, the student will be able to:

1. Design bioreactors for the production of various products.
2. Analyze and formulate mechanisms for enzymatic reactions.
3. Understand soluble and immobilized enzyme technologies for the production of industrial and medical products.
4. Predict important yield coefficients using the principles of stoichiometry and energetics of microbial growth.
5. Perform simulations of microbial growth and metabolism.
6. Present knowledge about major metabolic pathways and those related to biofuels production from microbes.
7. Analyze metabolic network and metabolic flux.
8. Estimate kinetic parameters from raw fermentation data.
9. Specify required technologies to effectively utilize genetically engineered microorganisms for bioprocessing.

Evaluation and Grading

	BSE 3534
Homework	25%
Exam 1	20%
Exam 2	20%
Final Exam	20%
Participation	15%
Total	100%

Course Outline (Tentative): The following schedule is subject to change.

Date (2016)	**Lecture**	**Bioreaction Engineering Principles, 3rd Edition**
1/20	Introduction	Chapter 1
1/22	The Biorefinery	Chapter 2.1
1/25	Metabolic pathways: Part 1	Chapter 2.2
1/27	Metabolic pathways: Part 2 **(HW1 release)**	Chapter 2.2
1/29	Worked examples of industrial production of chemicals	Chapter 2.3
2/1	Criteria of designing biotech processes **(HW1 Due) (HW2 release)**	Chapter 2.4 & 2.5
2/3	Chapter 2 review/ Mass balance for bioreactor	Chapter 3.1
2/5	Yield coefficients	Chapter 3.2 & 3.3
2/8	Redox balance **(HW2 Due)**	Chapter 3.4
2/10	Chapter 3 review/ Thermodynamics in bioreactors	Chapter 4
2/12	Metabolic network	Chapter 5.1
2/15	Growth energetics: maintenance energy **(HW3 release)**	Chapter 5.2.1
2/17	Growth energetics: energetics of aerobic processes	Chapter 5.2.2
2/19	Growth energetics: energetics of anaerobic processes	Chapter 5.2.3
2/22	Metabolic Flux Analysis **(HW3 Due) (HW4 release)**	Chapter 5.3
2/24	Worked examples of metabolic flux analysis	None
2/26	Chapter 5 review **(HW4 Due)**	None
2/29	**Help session**	None
3/2	**Exam 1, 6:30pm (2 hours)**	None
3/4	Exam 1 review	None
3/7	**Spring break**	None
3/9	**Spring break**	None
3/11	**Spring break (HW5 release)**	None
3/14	Canceled	None
3/16	Canceled	None
3/18	MATLAB 1: How to calculate metabolic fluxes?	None
3/21	Enzyme kinetics: Michaelis-Menten model	Chapter 6.1
3/23	Enzyme kinetics: more complicated models	Chapter 6.2
3/25	Immobilized enzymes	Chapter 6.3.2
3/28	Chapter 6 review/ MATLAB 2: How to determine enzyme kinetics? **(HW5 Due)**	None

3/30	General structure of growth kinetics **(HW6 release)**	Chapter 7.2
4/1	Growth kinetics: The Monod Model	Chapter 7.3.1
4/4	The influence of Temperature and pH on growth kinetics; Transport through the cell membrane	Chapter 7.3.3 & 7.7
4/6	Worked examples of modeling fermentation kinetics problems **(HW6 Due)**	None
4/8	Chapter 7 review/ MATLAB 3: How to determine growth rate? **(HW7 release)**	None
4/11	Design fermentation processes: Batch reactor	Chapter 9.2.1
4/13	Design fermentation processes: CSTR	Chapter 9.1.1-9.1.5
4/15	Design fermentation processes: Fed-batch reactor	Chapter 9.2.2
4/18	Worked examples of fermentation optimization **(HW7 Due)**	None
4/20	**Help session**	Chapter 6-9
4/22	**Exam 2**	Chapter 6-9
4/25	Exam 2 review/MATLAB 4: How to measure kinetic parameters in bioreactors?	None
4/27	The physical processes involved in mass transfer; Experimental techniques for measurement of O_2 transfer	Chapter 10.1 & 10.3
4/29	Worked examples for optimizing mass transfer	None
5/2	**Help session**	Chapter 1-11
5/6	**Final Exam (10:05 am-12:05 pm, SEITZ 313)**	Chapter 1-11

Course Policies

Scholar: The course syllabus, lectures, schedule, and other relevant materials will be placed on the Scholar website developed for this course. Students unable to access this website should contact the instructor immediately. https://scholar.vt.edu/portal

Homework: Assignments will be posted on Scholar at least one week before the due date. Students are encouraged to work in teams and consult with classmates regarding homework problems. However, each student must submit his or her own homework assignments. Any assignment submitted with two or more names will not be graded. Even though teamwork is encouraged, all submitted homework assignments must be the student's own work. In other words, no two homework assignments should be identical. Homework assignments must be turned in at the beginning of class on the due date. Half of the points deduced from the original homework will be returned if 1) all the mistakes in the homework are corrected; and 2) the corrected homework is submitted as a pdf file to the instructor by the end of the day that the homework is gone over on the class.

Class Attendance: It is strongly recommended that students attend all class periods and participate in class discussions. This will be reflected in the student's grade through better performance on homework assignments and exams. Spontaneous class discussions may not appear in the pre-prepared lecture notes posted on the Scholar website; however, this material may appear in a homework or exam question. Class attendance is not formally considered in the student's final grade; however, class participation is formally considered.

Class Participation: Talking in class by asking questions or answering questions is considered class participation. The class participation grade will be assessed by the instructor and cannot be disputed. Students should contribute in class every at least once every week to receive a good class participation score.

Privacy: It is against Virginia Tech policy for the instructor to retain any document (or email) containing the student's identification number. Do not include this on any assignments or in any emails. The instructor is authorized to only discuss a student's grades or performance with the student him/herself.

Plagiarism: To avoid plagiarism, students are encouraged to never copy from another work. The use of vocabulary terms coined in other works (e.g., "systems biology") is widely accepted. However, the use of long phrases (not to mention sentences or paragraphs) from other works is technically considered plagiarism. This section is particularly relevant to BSE 5504G students in preparing the writing assignments.

Wireless Devices: Wireless communications on electronics (e.g., laptop) used during an exam must be disabled (e.g., airplane mode).

Virginia Tech Honor System: As a University requirement, all incidents of cheating and plagiarism must be reported by the course instructor to the VT Honor Code Panel. This includes the use of unapproved wireless devices during tests and multiple students submitting identical homework assignments. Any incidence of suspected plagiarism must be reported. For more information, please see: http://www.honorsystem.vt.edu/.

Late Assignments: Homework assignments are due at the beginning of class on the due date. Homework assignments received on the due date but after the start of class will receive at 10% penalty. Homework assignments received after the due date will receive at penalty of 10% per day. Late assignments must be turned into Dr. Feng directly (or placed under his office door in HABB1). Assignments must NOT be placed in Dr. Feng's mailbox in the mailroom. This is now a violation of student privacy guidelines at Virginia Tech.

Students with Disabilities: Any student who feels he or she may need accommodation because of a disability (e.g., learning disability, attention deficit disorder, psychological, physical, etc.), please make an appointment to see me during office hours.

Principles of Community: A learning environment will be created strictly adhering to the Virginia Tech Principles of Community. http://www.vt.edu/diversity/principlesofcommunity.html

Pledges of the Instructor

1. Mutual respect to all students.
2. To provide all lecture materials before they are discussed in class.
3. To return graded homework assignments and exams within 2 class periods. In most cases, graded work will be returned by the next class period.
4. Provide up-to-date and relevant "real world" examples for materials covered in class.
5. To enable every student to have a voice in the class.
6. To provide each student an honest assessment on how they can improve their performance in this class (office hours appointment required).
7. To provide adequate help with homework assignments and test preparation.
8. To routinely summarize important points and provide adequate reviews for exams.
9. To give challenging exams and homework assignments.