ENGG*2660 Biological Engineering Systems I

Winter 2019

(Version: 1, January 02, 2019)

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1 Instructional Support

1.1 Instructor

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Office hours: Monday 4:30 - 5:30 PM

1.2 Teaching Assistant

Divya Ponnambalam

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1.3 Teaching Assistant

Praveena Thirunathan

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Office hours: Thursday 4:30 - 5:30 PM

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2 Learning Resources

2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG*2660 Courselink site. Students are responsible for checking the site regularly.

2.2 Required Resources

Bioprocess Engineering Principles, P. M. Doran, (2nd edition) 2013 Elsevier Ltd. ISBN: 978-0122208515

2.3 Recommended Resources

Molecular Cell Biology, Lodish et al. (6th edition) 2003 W. H. Freeman and Company. ISBN: 978-0716776017

2.4 Additional Resources

Lecture Information: Selected lecture notes will be posted on the web page.

Tutorial Information: The tutorial notes will also be posted on the web page.

Assignments: Download the assignments according to the schedule notified. All the solutions will be posted.

Miscellaneous Information: Other information related to this course may also be posted on the web page.

2.5 Communication & E-mail Policy: Please use lectures and tutorial help sessions as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. **It is the student's responsibility to check the course website regularly.** As per university regulations, all students are required to check their <mail.uoguelph.ca> e-mail account regularly: **e-mail is the official route of communication between the University and its student**.

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3 ASSESSMENT

3.1 Dates and Distribution

Distribution	Grades %	Due dates
Assignment 1	6	January 25, 2019
Assignment 2	6	February 25, 2019
Assignment 3	6	March 08, 2019
Quiz 1	6	January 17 (Sec 1) /January 18 (Sec 2), 2019
Quiz 2	6	February 28 (Sec 1) / March 01 (Sec 2), 2019
Term Project Abstract	2	February 11, 2019
Term Project Presentation	8	March 18 - 22, 2019
Term Project Report	10	March 29, 2019
Final Examination	50	8:30 - 10:30AM, April 11 2019 (Room: TBA)

Assignments will be handed out through Courselink. Students are required to complete all of these assignments. Late assignments will receive a grade of 0. The questions will be marked rigorously – i.e. solutions should be thoroughly and professionally presented. The teaching assistant will provide a review and help with questions before the quiz during tutorial sessions.

3.2 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic consideration: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: Students must obtain a grade of 50% or higher on the exam portion of the course in order for the rest (assignments, quizzes and term project) portion of the course to count towards the final grade.

Tutorial Work: Students must attend and complete all tutorials. If you miss a tutorial due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup tutorial.

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4 Aims, Objectives & Graduate Attributes

4.1 Calendar Description

This course deals with the mathematical description and identification of biological systems through mass and energy balances, reactions in biological systems, biomedical, food, and bio-processing applications.
Prerequisite(s): ENGG*2400, MATH*2270, (1 of BIOL*1030, BIOL*1070, BIOL*1080, BIOL*1090, MICR*1020)

4.2 Course Aims

Bioengineering is a broad discipline that integrates engineering principles with biological sciences. Applications include biochemical, food, bioresource and biomedical engineering. Material balance, energy balance, reaction kinetics, unit operations and downstream processing are common to all of the above areas and form the foundation for bioprocess/biological engineering. We will focus on systems containing biological catalysts (e.g. cells & enzymes) and/or other reacting species. A range of examples will be studied including those pertaining to food, pharma and bioprocessing industries.

4.3 Learning Objectives

Upon successful completion of this course, students will be able to:

1. Identify and analyze mass and energy transformations in biological systems.
2. Understand the principles and application of unit operations and downstream processing techniques.
3. Integrate fundamental principles of microbiology and biochemistry with quantitative analysis to solve engineering problems.

4.4 Graduate Attributes

Successfully completing this course will contribute to the following CEAB Graduate attributes:

S. No.	Graduate attribute	Learning Objectives	Assessment
1	Knowledge Base for Engineering	1,2,3	Quizzes, Assignments, Final Exam, Project
2	Problem Analysis	1,2,3	Assignments, Final Exam and Project
3	Investigation	1,2,3	Project
4	Design	-	-
5	Use of Engineering Tools	1,2,3	Assignments and Final Exam
6	Communication	3	Project & Final Exam
7	Individual and Teamwork	1,2,3	Project
8	Professionalism	-	-
9	Impact of Engineering on Society and the Environment	-	-
10	Ethics and Equity	1,2,3	Assignments, Final Exam and Project

11	Environment, Society, Business, & Project Management	1,2,3	-
12	Life-Long Learning	1,2,3	Quizzes and Project

4.5 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink/D2L but these are not intended to be stand-alone course notes. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and project.

4.6 Student's Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and tutorials. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

4.7 Relationship with other Courses & Labs

Previous Courses

ENGG*2120: Materials Science: Fundamentals of materials science are reviewed in this class.
ENGG*2400: Engineering Systems Analysis: This course uses techniques and tools developed in ENGG*2400 to analyse mass, energy and momentum components of biological systems.
BIOL*1070, BIOL*1080, BIOL*1090, MICR*2420: Concepts of biodiversity, cell and molecular biology and microbiology are covered that are helpful for fundamental understanding of this course.

Follow on courses

ENGG*3160: Biological Engineering Systems II: Fundamental learning from ENGG*2660 course is essential to understand mass transfer processes of biological importance.
ENGG*41X: Fourth year engineering design IV projects will integrate bioprocess principles used in ENGG*2660 course.

5 Teaching and Learning Activities

5.1 Timetable

Lectures

Monday Wednesday Friday	09:30AM - 10:20AM	MCKN, Room 224

Tutorial

Thursday (Sec 01) Friday (Sec 02)	08:30AM - 09:20AM	ROZH, Room 107

5.2 Lecture Schedule

Week	Lecture Topics	Learning Objectives
1-2	Introduction to cell mechanisms, characteristics, physiology and growth requirements	2,3
3-5	Bioprocess engineering introduction: ▪ units and dimensions ▪ intensive and extensive properties ▪ concentration definitions Material balances: ▪ steady state and equilibrium conditions ▪ conservation of mass ▪ types of material balance, simplification of the general mass balance equation, procedure for material balance calculations ▪ material balances with recycle, bypass, purge streams ▪ stoichiometry of cell growth and product formation, biomass yield, theoretical oxygen demand	2,3
6-7	Energy balances: ▪ thermodynamics and Entropy ▪ general energy balance	2,3

	▪ enthalpy calculations in non-reactive processes including change in temperature, change of phase, mixing and solution ▪ Steam tables ▪ procedure for energy balance calculations without reaction ▪ enthalpy changes due to reaction ▪ heat of reaction for processes with biomass production including thermodynamics of cell growth ▪ energy balance equation for cell cultures	
8-9	Bioprocess reaction kinetics, system energy analysis: ▪ reaction thermodynamics, yield, and rate ▪ reaction kinetics for biological systems and cell cultures ▪ enzymatic reactions ▪ yields in cell cultures ▪ introduction to bioreactors	2,3
10-11	Overview of unit operation and downstream processing: ▪ introduction to process flow diagrams ▪ mixing (different designs of mixers, mixing in fermenters, effects of mixing on cell cultures) ▪ heat transfer equipment and heat exchangers ▪ extraction cell removal operations (filtration, centrifugation, membrane filtration) ▪ cell disruption, precipitation, drying	2,3
12	Overview on sustainable bioprocessing: ▪ waste and pollutants in bioprocessing ▪ introduction to life cycle analysis ▪ disposable bioreactors	1,2,3

5.3 Other Important Dates

January 07, 2019 (Monday): Classes commence

February 18 - 22, 2019: Winter break (NO CLASSES SCHEDULED THIS WEEK)

February 25, 2019 (Monday): Classes resume

March 08, 2019 (Friday): Drop date – 40th Class

April 05, 2019 (Friday): Classes conclude

April 11, 2019 (Thursday): **Final Examination** (Time: 8:30AM – 10:30AM; Room: TBA)

5.4 Disclaimer

The instructor reserves the right to change any or all of the above in the event of appropriate circumstances, subject to the University of Guelph Academic Regulations.

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6 Academic Misconduct

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member.

6.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml
A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/
Please also review the section on Academic Misconduct in your Engineering Program Guide.
The School of Engineering has adopted a Code of Ethics that can be found at:
http://www.uoguelph.ca/engineering/undergrad-counselling-ethics

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7 Accessibility

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment.

Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact the Centre for Students with Disabilities as soon as possible.

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: http://www.uoguelph.ca/csd/

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8 RECORDING OF MATERIALS

Presentations which are made in relation to course work including lectures cannot be recorded or copied without the permission of the presenter, whether the instructor, classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

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9 RESOURCES

The Academic Calendars are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs:
http://www.uoguelph.ca/registrar/calendars/index.cfm?index
