



ENGG*4380 Bioreactor Design

01

Fall 2020

Section(s): C01

School of Engineering

Credit Weight: 0.75

Version 1.00 - September 08, 2020

1 Course Details

1.1 Calendar Description

Topics in this course include: modeling and design of batch and continuous bioreactors based on biological growth kinetics and mass balances; gas-liquid mass transfer for aeration and agitation; instrumentation; and control.

Pre-Requisites:

ENGG*3160

Restrictions:

This is a Priority Access Course. Enrolment may be restricted to the BIOE specialization in the BENG and BENG:C programs. See department for more information.

1.2 Course Description

This course introduces students to modelling and design of batch and continuous bioreactors based on biological growth kinetics and mass balances. Additional design topics include: mass transfer, biological reaction, instrumentation and control. The students will put into practice what they learn in the classroom through a group design project that combines research study, experimental work, mathematical modeling, equipment design, and project management.

1.3 Timetable

Lectures

Monday, Wednesday

11:30 am - 12:50 pm (Room Virtual)

Laboratory

Tuesday: 3:30 pm - 5:20 pm (Room THRN 1104 / Virtual)

Thursday: 3:30 pm - 5:20 pm (Room THRN 1104 / Virtual)

1.4 Final Exam

There is no final exam for this course.

2 Instructional Support

2.1 Instructional Support Team

| | |
|----------------------|--|
| Instructor: | Manickavasagan Annamalai Ph.D., P.Eng. |
| Email: | mannamal@uoguelph.ca |
| Telephone: | +1-519-824-4120 x53499 |
| Office: | THRN 2401 |
| Office Hours: | |

Non-lecture contact hours

Monday: 2:00 pm to 3:00 pm

Wednesday: 2:00 pm to 3:00 pm

| | |
|------------------------|------------------------|
| Lab Technician: | Jacqueline Fountain |
| Email: | fountain@uoguelph.ca |
| Telephone: | +1-519-824-4120 x56676 |
| Office: | THRN 1102 |
| Office Hours: | During lab time |

2.2 Teaching Assistants

| | |
|----------------------------|---------------------|
| Teaching Assistant: | Sindhu Sindhu |
| Email: | ssindhu@uoguelph.ca |
| Office Hours: | During lab time |

3 Learning Resources

3.1 Required Resources

Course Website (Other)

Course material, news, announcements, and grades will be regularly posted to the ENGG*4380 Courselink site. You are responsible for checking the site regularly.

3.2 Recommended Resources

1. Bioreactors - Design, Properties and Applications. P.G. Antolli and Z. Liu. 2012. Nova Science Publishers Inc, NY, USA.
2. Basic Bioreactor Design. K. Riet and J. Tramper. 1991. CRC Press, NY, USA.
3. Principles of Fermentation Technology (Third Edition). F. Stanbury, A. Whitaker and S.J. Hall. 2017. Elsevier Ltd., Cambridge, MA, USA.
4. Fermentation Technology. K. K. Machve. Mangalam Publications, New Delhi, India.
5. Industrial Microbiology: An Introduction. M. J. Waites, L. Morgan, J. S. Rockey and G. Higton. 2001. Blackwell Science Ltd, London, United Kingdom.

3.2 Additional Resources

Lecture Information:

All lecture notes will be posted on CourseLink.

Project Information:

The project requirements and information will be discussed in class/lab, and posted on CourseLink.

4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Describe and specify reactors used in the industrial bioprocesses
2. Develop mathematical models for bioreactors, and analyze their behaviour (dynamic and steady state)
3. Specify operating parameters for optimal performance of ideal bioreactor systems
4. Design complete bioreactor systems including instrumentation and control components
5. Plan and conduct biological experiments with the aim of generating engineering data for process design
6. Work in a team environment, designate and accept responsibilities, manage time and resources, and communicate results

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

| # | Outcome | Learning Outcome |
|-----|--|------------------|
| 1 | Knowledge Base | 1, 2 |
| 1.3 | Recall, describe and apply fundamental engineering principles and concepts | 1 |
| 1.4 | Recall, describe and apply program-specific engineering principles and concepts | 1, 2 |
| 4 | Design | 4, 5 |
| 4.4 | Evaluate alternative design solutions based on problem definition | 4 |
| 4.5 | Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping | 4, 5 |
| 5 | Use of Engineering Tools | 3 |
| 5.1 | Select appropriate engineering tools from various alternatives | 3 |
| 6 | Individual & Teamwork | 6 |
| 6.2 | Understand all members' roles and responsibilities within a team | 6 |
| 6.3 | Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude | 6 |
| 6.4 | Apply strategies to mitigate and/or resolve conflicts | 6 |
| 6.5 | Demonstrate leadership through, for example, influencing team vision and process, promoting a positive team culture, and inspiring team members to excel | 6 |
| 7 | Communication Skills | 6 |
| 7.1 | Identify key message(s) and intended audience in verbal or written communication as both sender and receiver | 6 |
| 7.2 | Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode | 6 |
| 7.3 | Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience | 6 |

5 Teaching and Learning Activities

5.1 Lecture

| | |
|--------------------------|--|
| Week 1 | |
| Topics: | Introduction to bioreactor |
| Learning Outcome: | 1 |
| Week 2 | |
| Topics: | Microbial growth kinetics |
| Learning Outcome: | 2, 3 |
| Week 3 | |
| Topics: | Microbial growth kinetics |
| Learning Outcome: | 2, 3 |
| Week 4 | |
| Topics: | Bioreactor design |
| Learning Outcome: | 1, 2, 3 |
| Week 5 | |
| Topics: | Bioreactor design |
| Learning Outcome: | 1, 2, 3 |
| Week 6 | |
| Topics: | Bioreactor design |
| Learning Outcome: | 1, 2, 3 |
| Week 7 | |
| Topics: | Instrumentation and control in bioreactors |
| Learning Outcome: | 3, 4 |
| Week 8 | |
| Topics: | Instrumentation and control in bioreactors |
| Learning Outcome: | 3, 4 |
| Week 9 | |
| Topics: | Aeration and agitation in bioreactors |
| Learning Outcome: | 3, 4, 5 |
| Week 10 | |
| Topics: | Aeration and agitation in bioreactors |
| Learning Outcome: | 3, 4, 5 |
| Week 11 | |
| Topics: | Heat and mass transfer in bioreactors |
| Learning Outcome: | 4, 5 |
| Week 12 | |
| Topics: | |

Project presentation and report submission

Learning Outcome: 5, 6

5.2 Tutorial/Demo Lab Schedule

| Week | Activity |
|-------------|---|
| 1 | Teammate selection and project overview |
| 2 | Design project: Problem identification and work distribution |
| 3 | Design project: Proposal |
| 4 | Design project: Proposal |
| 5 | Design project: Proposal presentation |
| 6 | Design project: Design and fabrication (if required) |
| 7 | Design project: Design and fabrication (if required) |
| 8 | Design project: Experiments and data collection (if required) |
| 9 | Design project: Experiments and data collection (if required) |
| 10 | Design project: Data analysis and report writing |
| 11 | Design project: Data analysis and report writing |
| 12 | Design Project: Final presentation |

5.3 Other Important Dates

Thursday, September 10: Classes commence

Monday, October 12 • Holiday--NO CLASSES SCHEDULED -- classes rescheduled to Friday, December 4

Tuesday, October 13 • Fall Study Break Day - NO CLASSES SCHEDULED -- classes rescheduled to Thursday, December 3

Wednesday, December 2 • Last day for regularly scheduled classes

Thursday, December 3 • Classes rescheduled from Tuesday, October 13, Tuesday schedule in effect

Friday, December 4 • Classes rescheduled from Monday, October 12, Monday schedule in effect

6 Assessments

6.1 Assessment Details

Test 1 (25%)

Date: Wed, Oct 14

Learning Outcome: 1, 2, 3, 4

Introduction to bioreactor

Microbial growth kinetics

Bioreactor design

Test 2 (25%)

Date: Wed, Nov 18

Learning Outcome: 1, 2, 3, 4

Instrumentation and control in bioreactors

Aeration and agitation in bioreactors

Heat and mass transfer in bioreactors

Design Project: Proposal (10%)

Date: Tue, Oct 13

Learning Outcome: 5, 6

Design Project: Proposal Presentation (10%)

Date: Tue, Oct 13

Learning Outcome: 5, 6

Design Project: Final Presentation (10%)

Date: Tue, Dec 1

Learning Outcome: 5, 6

Design Project: Final Report (20%)

Date: Fri, Dec 4

Learning Outcome: 5, 6

6.2 Note

Partner and Project Selection Process

Project work will be completed in teams of 3 to 4 students

7 Course Statements

7.1 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: In order to pass the course, you must pass the final exam portion of the course portions. Students must obtain a grade of 50% or higher on the exam portion of the course in order for the remaining portions of the course to count towards the final grade.

Missed quiz/test: If you miss a quiz/test due to grounds for granting academic consideration or religious accommodation, the weight of the missed quiz/test will be added to the final presentation and report. There will be no makeup quizzes/tests.

Lab Work: You must attend and complete all laboratories. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the instructor to complete a makeup lab.

Late Lab Reports: Not applicable

7.2 Relationships with other Courses & Labs Previous Courses

ENGG*2560: reactor type, analysis techniques, mass balance.

ENGG*2660 and ENGG* 3160: mass and energy balances; mass transfer, reactions in biological systems; bio-processing applications.

ENGG*3830: Analysis and design of unit processes, rheology and non-Newtonian fluid dynamics of biological materials.

8 School of Engineering Statements

8.1 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 but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. 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 labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. 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.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

Graduate Calendar - Grounds for Academic Consideration

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
<https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml>

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml>

Graduate Calendar - Registration Changes
<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml>

Associate Diploma Calendar - Dropping Courses
<https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml>

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least 7 days in advance and not later than the 40th Class Day.

For Guelph students, information can be found on the SAS website
<https://www.uoguelph.ca/sas>

For Ridgetown students, information can be found on the Ridgetown SAS website
<https://www.ridgetownc.com/services/accessibilityservices.cfm>

9.6 Academic Integrity

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 encourages academic integrity. 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 or faculty advisor.

Undergraduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml>

Graduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

9.7 Recording of Materials

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

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars

<https://www.uoguelph.ca/academics/calendars>

9.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings and academic schedules. Any such changes will be announced via CourseLink and/or class email. All University-wide decisions will be posted on the COVID-19 website (<https://news.uoguelph.ca/2019-novel-coronavirus-information/>) and circulated by email.

9.10 Illness

The University will not normally require verification of illness (doctor's notes) for fall 2020 or winter 2021 semester courses. However, requests for Academic Consideration may still require medical documentation as appropriate.
