

Course Outline

1. COURSE INFORMATION

Session Offered	Fall 2023	
Course Name	Bioreactor Processes and Design	
Course Code	BIO TECH 3BP3	
Date(s) and Time(s) of lectures	Tu 12:30PM - 2:20PM MDCL 1010 We 2:30PM - 3:20PM ETB 238	
Program Name	Biotechnology	
Calendar Description	Overview of fermentation technology and bioprocessing, kinetics and thermodynamics of microbial processes, mass transfer in immobilized systems, analysis of batch and continuous processes, bioreactor design and analysis, operation and control, instrumentation, oxygen transfer, and scale up.	
Instructor(s)	Amin R. Rajabzadeh rajaba@mcmaster.ca Lab instructor: Pouria Baghaei baghaeip@mcmaster.ca	Office Hours & Location: Thursdays 9:30-11:30 (upon request) ETB 208

2. COURSE SPECIFICS

Course Description	This course covers the following topics: principles of reactor design, principles, kinetics and immobilization of enzymes; cell growth patterns and calculations for batch and continuous reactors; operating consideration for different types of suspension and immobilized bioreactors; selection, instrumentation, control, and scale-up of bioreactors.		
Instruction Type	Code	Type	Hours per term
	C	Classroom instruction	37
	L	Laboratory, workshop or fieldwork (Mohawk College)	30
	T	Tutorial	
	DE	Distance education	
	Total Hours		67
Resources	ISBN	Textbook Title & Edition	Author & Publisher
	ISBN: 0137062702	Bioprocess Engineering, 3rd Edition, 2017	<i>Michael Shuler et al.</i>
	Other Supplies	Source	
	<ul style="list-style-type: none"> • Biochemical Engineering by James M. Lee • Elements of Chemical Reaction Engineering by Fogler • Chemical Reaction Engineering by Levenspiel 		
Prerequisite(s)	BIOTECH 3B03, 2EC3, 3BC3, and registration in level IV of the Biotechnology program		

Corequisite(s)		
Antirequisite(s)		
Course Specific Policies	If you have missed a test, assignment, quiz, or report, you should submit an MSAF form and let your instructor know. The weight of the MSAF'ed task will automatically be added to the final exam.	
Departmental Policies	<p>Students must maintain a GPA of 3.5/12 to continue in the program.</p> <p>In order to achieve the required learning objectives, on average, B.Tech. students can expect to do at least 3 hours of “out-of-class” work for every scheduled hour in class. “Out-of-class” work includes reading, research, assignments and preparation for tests and examinations.</p> <p>Where group work is indicated in the course outline, such collaborative work is mandatory.</p> <p>The use of cell phones, iPods, laptops and other personal electronic devices are prohibited from the classroom during the class time, unless the instructor makes an explicit exception.</p> <p>Announcements made in class or placed on Avenue are considered to have been communicated to all students including those individuals that are not in class.</p> <p>Instructor has the right to submit work to software to identify plagiarism.</p>	
3. SUB TOPIC(S)		
Week 1	Introduction to chemical reactor design Reaction rates and reactor types	Fogler Textbook Ch. 1-2
Week 2	Reaction rates and reactor sizing	Fogler Textbook Ch. 2-3
Week 3	Reactors in series	Fogler Textbook Ch. 2-3
Week 4	Enzymes: Principles, kinetics (Rapid equilibrium & quasi state-state), Michaelis-Menten Manipulation of experimental data	Bioprocess Engineering Ch. 3
Week 5	Enzymes: Inhibited Enzyme Kinetics, complex enzyme kinetics	Ch. 3
Week 6	Enzymes: Immobilized Enzymes	Ch. 3
Week 7	Mass-Transfer Limitations for Immobilized Enzyme	Ch. 3
Week 8	Continuous cell growth: Growth cycle, yield coefficients	Ch. 6
Week 9	Continuous cell growth: Effect of temperature, pH, oxygen, inhibition	Ch. 6
Week 10	Continuous cell growth: The ideal Chemostat	Ch. 6
Week 11	Bioreactor considerations:	Ch. 9

	Chemostat with recycle, multistage Chemostat, fed-batch operation, perfusion systems	
Week 12	Bioreactor considerations: Chemostat with recycle, multistage Chemostat, fed-batch operation, perfusion systems	Ch. 9
Week 13	Bioreactor selection and scale-up	Ch. 10
Week 14	Review	

Midterm Recess: Monday, October 9 to Sunday, October 15
Classes end: Wednesday, December 6
Final examination period: Friday, December 8 to Thursday, December 21
All examinations MUST be written during the scheduled examination period

List of experiments

Lab 1	Aerobic fermentation in 3L bioreactor
Lab 2	Fermentation and filtration
Lab 3	Oxygen transfer and depletion in bioreactor
Lab 4	15 L Bioreactor: Introduction - Sterilization
Lab 5	15 L Bioreactor: Fermentation
Lab 6	Plate Heat Exchanger
Lab 7	Phosphate Treatment
Lab 8	Copper Precipitation
Lab 9	Carbon Adsorption
Lab 10	Fluid Flow

Note that this structure represents a plan and is subject to adjustment term by term. The instructor and the University reserve the right to modify elements of the course during the term. The University may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes.

4. ASSESSMENT OF LEARNING *including dates*	Weight
Assignments and In-class Problems	10
Quizzes	10
Term Test 1 (Week 6, to be confirmed)	12.5
Term Test 2 (Week 12, to be confirmed)	12.5
Labs	20
Final examination (tests cumulative knowledge)	35
TOTAL	100%

Percentage grades will be converted to letter grades and grade points per the University calendar.

5. LEARNING OUTCOMES

1. Describe the structure, instrumentation, and operation of a traditional bioreactor
2. Distinguish between different bioreactor types and compare their suitability for certain applications
3. Apply chemical kinetic principles to enzymatic reactions
4. Design batch and continuous reactors by combining mass balances and reaction kinetics
5. Explain the challenges of bioreactor scale-up
6. Select a downstream purification method for any given bioreactor setting
7. Operate lab and pilot scale traditional bioreactors

6. COURSE OUTLINE – APPROVED ADVISORY STATEMENTS

ANTI-DISCRIMINATION

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

[http://www.mcmaster.ca/policy/General/HR/Discrimination Harassment Sexual Harassment-Prevention&Response.pdf](http://www.mcmaster.ca/policy/General/HR/Discrimination%20Harassment%20Sexual%20Harassment-Prevention&Response.pdf)

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty: The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster’s use of Turnitin.com, please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their

browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

COMMUNICATIONS

It is the student's responsibility to:

- Maintain current contact information with the University, including address, phone numbers, and emergency contact information.
- Use the University provided e-mail address or maintain a valid forwarding e-mail address.
- Regularly check the official University communications channels. Official University communications are considered received if sent by postal mail, by fax, or by e-mail to the student's designated primary e-mail account via their @mcmaster.ca alias.
- Accept that forwarded e-mails may be lost and that e-mail is considered received if sent via the student's @mcmaster.ca alias.
- Check the McMaster/Avenue email and course websites on a regular basis during the term.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests. <http://www.mcmaster.ca/policy/Students-AcademicStudies/Studentcode.pdf>

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.