

## Course Outline

### 1. COURSE INFORMATION

<b>Session Offered</b>	Fall 2015
<b>Course Name</b>	Bioreactor Processes and Design
<b>Course Code</b>	BIO TECH 3BP3
<b>Date(s) and Time(s) of lectures</b>	Lectures: Wed. 2:30PM - 4:20PM ABB 162 Th. 1:30PM - 3:20PM ETB 238 Labs: Fr 9:00AM - 12:00PM Mohawk Campus
<b>Program Name</b>	Biotechnology
<b>Calendar Description</b>	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.
<b>Instructor(s)</b>	Dr. Amin R. Rajabzadeh   E-Mail: <a href="mailto:rajaba@mcmaster.ca">rajaba@mcmaster.ca</a> Office Hours & Location: Wed. 11:00-13:00 ETB/203

### 2. COURSE SPECIFICS

<b>Course Description</b>	This course covers the following topics: 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; downstream processing (cell disruption, separation and purification of product)		
<b>Instruction Type</b>	<b>Code</b>	<b>Type</b>	<b>Hours per term</b>
	C	Classroom instruction	50
	L	Laboratory, workshop or fieldwork	33
	T	Tutorial	
	DE	Distance education	
	<b>Total Hours</b>		83
<b>Resources</b>	<b>ISBN</b>	<b>Textbook Title &amp; Edition</b>	<b>Author &amp; Publisher</b>
	ISBN: 0-13-081908-5	Bioprocess Engineering, 2nd Edition, 2002	M. L. Shuler and F. Kargi, Prentice Hall PTR
	<b>Other Supplies</b>	<b>Source</b>	
	Biochemical Engineering by James M. Lee		
<b>Prerequisite(s)</b>	BIOTECH 2BT3 or 3B03, 3EC3, ENG TECH 1EL3 and registration in level IV of the Biotechnology program		
<b>Corequisite(s)</b>	N/A		
<b>Antirequisite(s)</b>	N/A		
<b>Course Specific Policies</b>	<b>Lab Sessions:</b> Lab coat and safety glasses required for all lab sessions. Coat and glasses must be properly worn at all times while in the lab Lab experiments and rotation, if any, will be outlined during first week of classes. <b>Absence from a lab with an accepted MSAF form will result in a grade of zero for that lab.</b> Students may have to complete a pre-lab report prior to attending certain labs.		

	All lab reports will be due one week from the day of performing the corresponding experiment. Reports submitted late without an acceptable explanation or prior permission will be penalized by 10% per calendar day.	
<b>Departmental Policies</b>	<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>	
<b>3. SUB TOPIC(S)</b>		
Week 1	<u>Introduction</u> <u>Enzymes:</u> Principles, kinetics (Rapid equilibrium & quasi state-state), Michaelis-Menten	Ch. 1-3
Week 2	<u>Enzymes:</u> Manipulation of experimental data, complex enzyme kinetics	Ch. 3
Week 3	<u>Enzymes:</u> Inhibited Enzyme Kinetics <b>Test 1</b>	Ch. 3
Week 4	<u>Enzymes:</u> Immobilized Enzymes	Ch. 3
Week 5	<u>Enzymes:</u> Immobilized Enzymes	Ch. 3
<i>Mid-term recess (Monday, October 12 to Saturday, October 17)</i>		
Week 6	<b>Midterm Test</b>	
Week 7	<u>Continuous cell growth:</u> Growth cycle, yield coefficients	Ch. 6
Week 8	<u>Continuous cell growth:</u> Effect of temperature, pH, oxygen, inhibition	Ch. 6
Week 9	<u>Continuous cell growth:</u> The ideal Chemostat <b>Test 2</b>	Ch. 6
Week 10	<u>Bioreactor considerations:</u> Chemostat with recycle, multistage Chemostat, fed-batch operation, perfusion systems	Ch. 9
Week 11	<u>Bioreactor selection and scale-up</u> <b>Test 3</b>	Ch. 10
Week 12	<u>Bioreactor instrumentation, control, and sterilization</u>	Ch. 10
Week 13	Open – Review	
Classes end – Tuesday December 8, 2015		

Final examination period: Wednesday December, 9, 2015 to Tuesday, December 22, 2015

All examinations MUST BE written during the scheduled examination period.

### List of experiments

Lab 1	Rotating Biological Contractor
Lab 2	Aerobic fermentation in 3L bioreactor
Lab 3	Carbon Adsorption
Lab 4	Fermentation and filtration
Lab 5	Membrane bioreactor

*Mid-term recess (Monday, October 12 to Saturday, October 17)*

Lab 6	Oxygen transfer and depletion in bioreactor
Lab 7	15 L Bioreactor: Introduction - Sterilization
Lab 8	Phosphate precipitation
Lab 9	15 L Bioreactor: Fermentation
Lab 10	Enzyme kinetics

Lab schedule  
Some of the labs will be performed on a rotating basis. The actual lab schedule will be provided by the instructor

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
Term Tests	24
Midterm Test	16
Labs	25
Final Exam	35
<b>TOTAL</b>	<b>100%</b>

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
8. Critique on the validity and applicability of experimental observations and measurements

### 6. POLICIES

#### 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/Anti-Discrimination%20policy.pdf>

#### Academic Integrity

You are required to exhibit honestly and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

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.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, located at: <http://www.mcmaster.ca/policy/Students-AcademicStudies/AcademicIntegrity.pdf>.

The following illustrates only three forms of academic dishonesty:

1. Plagiarism. E.g. the submission of work that is not own or for which other credit has been obtained
2. Improper collaboration in group work
3. Copying or using unauthorized aids in tests and examinations.

### Requests for Relief for Missed Academic Term Work (Assignments, Mid-Terms, etc.)

The McMaster Student Absence Form is a self-reporting tool for **Undergraduate Students** to report absences that last up to 3 days and provides the ability to request accommodation for any missed academic work. Please note, this tool cannot be used during any final examination period.

You may submit a maximum of 1 Academic Work Missed requests per term. It is YOUR responsibility to follow up with your Instructor immediately regarding the nature of the accommodation.

If you are absent more than 3 days or exceed 1 request per term you **MUST** visit your Associate Dean's Office (Faculty Office). You may be required to provide supporting documentation.

This form should be filled out immediately when you are about to return to class after your absence. <http://www.mcmaster.ca/msaf/>

### E-Learning Policy

Consistent with the Bachelor of Technology's policy to utilize e-learning as a complement to traditional classroom instruction, students are expected to obtain appropriate passwords and accounts to access Avenue To Learn for this course. Materials will be posted by class for student download. It is expected that students will avail themselves of these materials prior to class. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail account, and program affiliation may become apparent to all other students in the course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about this disclosure please discuss this with the course instructor. Avenue can be accessed via

<http://avenue.mcmaster.ca>.

### 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.

### Turnitin (Optional)

This course will be using a web-based service (Turnitin.com) to reveal plagiarism. Students submit their assignment/work electronically to Turnitin.com where it is checked against the internet, published works and Turnitin's database for similar or identical work. If Turnitin finds similar or identical work that has not been properly cited, a report is sent to the instructor showing the student's work and the original source. The instructor reviews what Turnitin has found and then determines if he/she thinks there is a problem with the work. Students who do not wish to submit their work to Turnitin.com must still submit a copy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, etc.). To see the Turnitin.com Policy, please go to

<http://www.mcmaster.ca/academicintegrity/turnitin/students/>

### **Protection of Privacy Act (FIPPA)**

The Freedom of Information and Protection of Privacy Act (FIPPA) applies to universities. Instructors should take care to protect student names, student numbers, grades and all other personal information at all times. For example, the submission and return of assignments and posting of grades must be done in a manner that ensures confidentiality.

<http://www.mcmaster.ca/univsec/fippa/fippa.cfm>

### **Academic Accommodation of Students with Disabilities Policy**

Students who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail [sas@mcmaster.ca](mailto:sas@mcmaster.ca). For further information consult McMaster's policy for Academic Accommodation of Students with Disabilities

<http://www.mcmaster.ca/policy/Students-AcademicStudies/AcademicAccommodation-StudentsWithDisabilities.pdf>

Students must forward a copy of the SAS accommodation to the instructor of each course and to the Program Administrator of the B.Tech. Program immediately upon receipt. If a student with a disability chooses NOT to take advantage of a SAS accommodation and chooses to sit for a regular exam, a petition for relief may not be filed after the examination is complete. <http://sas.mcmaster.ca>

### **Student Code of Conduct**

The Student Code of Conduct (SCC) exists to promote the safety and security of all the students in the McMaster community and to encourage respect for others, their property and the laws of the land. McMaster University is a community which values mutual respect for the rights, responsibilities, dignity and well-being of others. The purpose of the Student Code of Conduct is to outline accepted standards of behavior that are harmonious with the goals and the well-being of the University community, and to define the procedures to be followed when students fail to meet the accepted standards of behavior. All students have the responsibility to familiarize themselves with the University regulations and the conduct expected of them while studying at McMaster University.

<http://judicialaffairs.mcmaster.ca/pdf/SCC.pdf>