CHEE 380
BIOCHEMICAL ENGINERING

Course Syllabus – Fall 2019

This is your course syllabus. Please download the file and keep it for future reference.

TEACHING TEAM

COURSE INSTRUCTOR

Louise Meunier, PhD
Chemical Engineering
Queen's University

E-mail: louise.meunier@queensu.ca
Office: Dupuis 211

Please check the course website for an up-to-date list of Teaching Assistants (TAs) and other course personnel.

COURSE INFORMATION

COURSE DESCRIPTION

Biochemical Engineering involves the application of Chemical Engineering principles and approaches to biologically-based systems and processes. Biochemical Engineering is central to the area of environmental engineering, and to biotechnology processes which produce pharmaceuticals, fine chemicals, and genetically-engineered products. The course involves a systematic and quantitative description of medium formulation and sterilization, microbial kinetics and bioreactor design, product isolation and purification, and examples of current industrial practices and processes (0/0/0/30/12).

COURSE LEARNING OUTCOMES (CLO)

The objective of this course is to develop a systematic and quantitative description of medium formulation, medium and equipment sterilization, cell growth kinetics, bioreactor and bioprocess design, and product isolation and purification. Students will be introduced to several current biochemical engineering-based processes.

Specific course learning outcomes include:

CLO	DESCRIPTION	INDICATOR
CLO 1	Design culture medium based on nutritional requirements of microbial cells.	KB Bio (a) KB Bio (b) KB TrPh (c)
CLO 2	Specify design criteria for medium sterilization and solve problems involving both batch and continuous sterilization.	
CLO 3	Apply the principles of microbial growth kinetics in bioreactors.	
CLO 4	Simulate and evaluate bioreactor performance.	
CLO 5	Apply mass and heat transfer correlations to bioreactor design.	DE (c)
CLO 6	Design a complete bioreactor based on targets, constraints and physical properties.	
CLO 7	Identify suitable process instrumentation for monitoring and control of bioreactors.	
CLO 8	Know and select process unit operations for product recovery and purification.	

This course assesses the following attributes at the third year level:

Knowledge base (**KB**): **Bio (a)** Applies knowledge of cellular processes to engineering problems. **Bio (b)** Applies foundations of science and engineering to analyze and solve biological, physiological, pharmaceutical, and/or environmental problems or processes. **TrPh (c)** Analyzes convective transport of fluids in closed conduits and external flows.

Design (**DE**): **(c)** Design a product, process or system to resolve a problem, that meets specified needs (with appropriate attention to health, safety, environmental, economic, regulatory, cultural, societal and stakeholder needs), and subject to appropriate iterations.

Relevance to the Program

CHEE 380 is a core course for Chemical Engineering students. It is an introductory course in Biochemical Engineering and builds upon principles of fluid mechanics, thermodynamics, heat and mass transfer (CHEE 223, 210, 330), and cell biology introduced in CHEE 229. The concepts learned in this course are utilized in subsequent courses dealing with environmental and biochemical processes.

Course Structure and Activities

3 lecture hours + 1 tutorial hour per week. Please refer to SOLUS for times and locations.

Expectations for Lectures/Tutorials

Lecture slides (incomplete – areas left blanks for students to fill out during class) and relevant handouts are posted in advance on Queen's Learning Management System (LMS, online). Lectures include examples and problem solutions not contained in the posted slides. Students are expected to bring lecture slides to class. Attending lectures is recommended because material posted online is incomplete and is intended to support notetaking during lectures. Full lecture notes and worked examples will not be posted online. Problem sets and solutions will be posted to help students apply course concepts. Tutorials are geared toward solving problems relevant to biochemical engineering and design. For tutorial sessions, students are expected to bring a copy of the relevant tutorial problem, their draft solution, and any additional information, notes and handouts. Maximum benefits can be gained only if students come prepared for tutorial sessions by studying the questions in advance. Abbreviated solutions may be posted online following each tutorial session for cases where a problem solution was not presented during tutorial.

In group assignments, each group member is expected to contribute fairly and equitably. In the event of serious deficiencies in the contributions (*e.g.* observed by instructor, through peer assessments, or through complaints from other group members and/or teaching assistants), the student will be issued a written warning, stating the expectations and timeline for remediation and compliance. The student may be assigned individual work to compensate for the lack of contribution. If the student does not comply within the specified time frame, a second written warning will be issued (with a copy to the Associate Head and Undergraduate Chair). Failure to comply will result in automatic expulsion from the group, and possibly a failing mark in the

assignment and/or in the course. A peer evaluation form is available through the LMS. This form may be filled out by a group member at any time during the semester. The form must be submitted to the instructor, who will take appropriate action in response to this submission (response may include a request for each group member to fill out a peer evaluation, individual meetings, group meetings, and follow up action as described above).

COURSE MATERIALS

Textbook and Resources

The following textbook is recommended for CHEE 380:

- *Bioprocess Engineering: Basic Concepts*, 3rd Edition. ML Shuler, F Kargi and M. DeLisa, 2017 (available at Queen's campus bookstore, or may be purchased online; may also be consulted online through Queen's Library – however there are only three simultaneous licences).

The following textbooks are available at Stauffer Library on reserve – 3-hour loan:

- *Biochemical Engineering Fundamentals*, JE Bailey, DF Ollis, 1986;
- *Bioprocess Engineering: Basic Concepts*, 2nd Edition. ML Shuler and F Kargi, 2002;
- *Bioprocess Engineering Principles*, PM Doran, 1995;
- *Biochemical Engineering.* HW Blanch, DS Clark, 1997.

Other Material

All course material is accessible through the course LMS.

Learning Support

- Instructor and TAs are available by appointment (through e-mail).
- Additional review and help session may be scheduled as required during the term.

COURSE EVALUATION

Deliverable	Week or Date	Weight%	CLOs
Quizzes (2)	Weeks 4, 10	2 x 15	1,2,3,5
Written Assignments (2) assignments may be completed individually or in groups of up to 4 students	Weeks 6, 11	2 x 10	All
Final Exam	Exam period	50	All

Students are expected to complete their work on time. The course instructor will provide notification (during lectures and/or on the course LMS) of due dates and any revisions thereof.

Submissions after the due date will not be accepted without prior arrangement and may be

penalized at up to 20% per day (24-hour period following due date/time) unless a suitable justification is provided.

Students must pass the individual examination component (combined mark on quizzes + final) to pass the course, as stated in Departmental Policy. Attendance at quizzes and final exam is mandatory. No make-up mid-terms will be provided. Marks assigned to the mid-term may be transferred to the final exam for a medical reason supported with proper documentation following the stipulations of the departmental policy.

Practice problems, tutorials, and assignments will be completed during the term. The aim of these exercises is to apply the theory presented in the course. Assignments completed on paper (see specific assignment instructions) may be handed in at the end of tutorial, or in the drop-off box on the 2nd floor of Dupuis Hall (see detailed schedule below). Only one submission per group, with the name of each group member clearly indicated. Assignment solutions and reports may be hand-written (pen or pencil), or typed, but must be complete and fully support the answers.

To be eligible for mark reassessment (of assignments or tests), all work must be written in permanent ink, and a request must be submitted within two weeks of the initial return date along with a mark reassessment form (available on the course LMS) and the complete original submission. Please note that a selection of marked assignments and quizzes will be photocopied and archived.

All assessments in this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to the established Grade Point Index.

HOW TO DO WELL IN THIS COURSE

This course introduces important concepts in biochemical engineering that range from simple to complex. Students are expected to apply the concepts taught in class to solve the problems in assignments, quizzes and the exam. Solving of the problems in all the problem sets is necessary, and students are encouraged to ask any questions they may have to tackle them.

To obtain full marks, problem solutions must include the complete methodology, as well as clearly labeled diagrams where appropriate. For questions involving multiple parts, partial credit may be given for correct methodology, but the final answer must also be correct. If the answer does not reflect the expected outcome, or if it is not physically representative, then the student is encouraged to provide comments, using critical analysis skills, to point out any outstanding issue. All relevant assumptions must be stated and proper units must be included.

COURSE POLICIES

Please review the following policies:

COPYRIGHT

Unless otherwise stated, the material on the course website is copyrighted and is for the sole use of students registered in this course. The material on the website may be downloaded for a registered student's personal use but shall not be distributed or disseminated to anyone other than students registered in this course.

ACADEMIC INTEGRITY

Information on policies concerning academic integrity is available in the Queen's University Code of Conduct, in the Senate Academic Integrity Policy Statement, on the Faculty of Engineering and Applied Science website, and from your instructor.

ABSENCES (ACADEMIC CONSIDERATION) AND ACADEMIC ACCOMMODATIONS

Please review the information on the FEAS website.

TECHNICAL SUPPORT

No specialized computer-related technical skills are required for this course. If you require technical assistance, please contact Technical Support.

PERSONAL SUPPORTIVE COUNSELLING

If at any time you find yourself feeling overwhelmed, anxious, sad, or distressed, consider confidential supportive counselling offered by the Faculty of Engineering and Applied Science.

COURSE OVERVIEW

CHEE 380 || Module overview			
Course learning outcomes (CLO): Students will be able to: **1. Design culture medium based on nutritional requirements of microbial cells.** **2. Specify design criterion for medium sterilization and solve problems involving both batch and continuous sterilization.** **3. Apply the principles of microbial growth kinetics in bioreactors.** **4. Simulate and evaluate bioreactor performance.** **5. Apply mass and heat transfer correlations to bioreactor design.** **6. Design a complete bioreactor based on targets, constraints and physical properties.** **7. Identify suitable process instrumentation for monitoring and control of bioreactors.** **8. Knowledge and selection of process unit operations for product recovery and purification.**			
Students are expected to augment lecture material through applied work in tutorials, and to practice execution of course principles by completing posted problem sets			
Time	Lecture approach* and content	Practice**	Assessment***
Weeks 1-4	**MODULE 1: Medium Formulation, Batch and Continuous Sterilization.** • Nutritional requirements and sources. • Cellular elemental composition and cell yields. • Microbial death kinetics. Design criterion for sterilization. • Batch and continuous sterilization of medium. Air sterilization. Lectures: 1. Outline 2. Introduction 3. Products and Background Review 4. Medium Formulation 5. Sterilization	Tutorials 1,2,3 Problem Sets 0,1,2	*Material is included in Quiz 1 and on final exam (CLO 1,2)*
Quiz 1 (Week 4)	**Covers weeks 1-4**	Review	*CLO 1-2*

Time	Lecture approach* and content	Practice**	Assessment***
Weeks 5-7	**MODULE 2: Growth Kinetics.** • Phases of batch growth. • Monod kinetics. • Volumetric rates, specific rates and yields. • Continuous bioreactors and bioreactor performance. Lectures: 6. Growth Kinetics	Tutorials 4,5 Problem Set 3	*Material is included in Quiz 2 and on final exam (CLO 3,4)* Assignment #1
Weeks 8-9	**MODULE 3: Transport Phenomena in Bioreactors. Design of Bioreactors.** • Oxygen transport. • Agitation and power requirements for mixing. • Bioreactor design based on oxygen demand and supply. • Heat transfer. • Solving bioreactor design problems Lectures: 7. Transport in Bioreactors	Tutorials 6,7 Problem Set 4	*Material is included in Quiz 2 and on final exam (CLO 5,6)*
Quiz 2 (Week 10)	**Covers weeks 5-9**	Review	*CLO 3-5*
Weeks 10-12	**MODULE 4: Bioreactor Monitoring and Control. Product Recovery.** • Physical and chemical sensors for monitoring and control. • Cell separation. • Product isolation and purification. • Examples of Industrial processes. Lectures: 8. Monitoring, Control and Design Considerations 9. Recovery 10. Industrial Processes (examples) **11.** Process Validation and Good Manufacturing Practices	Tutorials 8,9 Problem Sets 5,6	*Material is included on final exam (CLO 7,8)* Assignment #2
Final Exam	**Covers the entire semester**	Review	*All CLOs*

* Lecture content delivery through lecture materials available in power-point, in-class examples and solutions, true or false trivia.

** Review lectures are sometimes presented during the tutorial time slots. Quizzes will be held during Tutorial periods.

*** Course Learning Objective addressed; Quizzes and Final Exam may include multiple choice, true or false, definitions, short answers, as well as problems requiring full procedural solutions and calculations.