Faculty of Engineering and Applied Science

CHEE 340 – BIOMEDICAL ENGINEERING

Course Syllabus – Winter 2021

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

TEACHING TEAM

COURSE INSTRUCTOR

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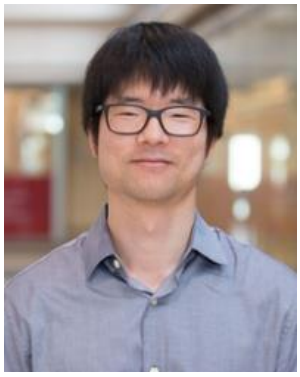

Please check the course website for an up-to-date list of TAs and other course personnel.

COURSE INFORMATION

COURSE DESCRIPTION

This course will provide students with a fundamental understanding of cell biology, human physiology and the application of engineering principles (momentum and mass transfer, mechanics, materials) for the solution of medical problems. Topics include: Cell Biology, Anatomy and Physiology, Transport Phenomena in the Body, Biomechanics, Materials in Medicine, and Regenerative Medicine and Tissue Engineering. (0/12/0/30/0)

COURSE LEARNING OUTCOMES (CLO)

The objective of this course is to introduce students to the fundamentals necessary to understand and appreciate the issues involved in engineering in the body and to provide a framework for upper level studies in the area.

Specific course learning outcomes include:

CLO	DESCRIPTION	INDICATOR
CLO 1	Describe the organization of cells, proteins and macromolecules into tissues and organs as well as the function of major organ systems within the body, including the cardiovascular, musculoskeletal, renal and immune systems.	KB-ES (Biochemical)
CLO 2	Analyze and solve problems involving transport phenomena in the body in the context of the design and application of biomedical devices for the treatment of injury and disease.	KB-ES (Biochemical) PA-Formulate PA-Solve
CLO 3	Apply the principles of mechanics to competently analyze gross movement of the human body.	KB-ES (Biochemical) PA-Formulate PA-Solve
CLO 4	Apply the principles of materials properties and engineering for the design and application of biomedical devices.	KB-ES (Biochemical) PA-Formulate PA-Solve
CLO 5	Apply the principles of cell biology and engineering for the design and application of tissue engineering, bioreactors and regenerative medicine.	KB-ES (Biochemical) PA-Formulate PA-Solve

This course assesses the following program indicators:

Knowledge Base (KB)

KB-Engineering Science Apply mathematics, natural science and engineering science to engineering problems.

Problem Analysis (PA)

PA-Formulate Develop appropriate frameworks for solving complex engineering problems.
PA-Solve Implement solutions for complex engineering problems.

Relevance to the Program

CHEE 340 is a core course in the Biochemical Engineering (CHE2) option and a Chemical Process Engineering (CHE1) Group A technical elective. It builds upon aspects of core chemical engineering principles of thermodynamics, mass transport and fluid mechanics taught in 2nd and 3rd year (CHEE 210, 223, 330), and fundamental cell biology introduced in CHEE 229.

Course Structure and Activities

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

Expectations for Lectures/Tutorials

Asynchronous learning: Lectures slides and video lectures will be posted in the course learning management system (LMS).

Synchronous sessions: to support the asynchronous material, remote live sessions will be held each week at scheduled lecture and tutorial times via web conferencing software (Zoom). These sessions will cover content from lectures and tutorials.

Tutorial problem sets will be posted, with the solutions posted the following week. These problem sets are not marked. Students are expected to undertake these problem sets to gain understanding of the course material.

Course Materials

Optional Textbooks

- *Principles of Biomedical Engineering*, SV Madihally, Artech House, 2010. (Available at the Stauffer Library)
- *Biomaterials Science: An Introduction to Materials In Medicine*, 3rd Edition. Ratner, Hoffman, Schoen, Lemons, 2013. (Available as an ebook through the University Library).
- *Transport Phenomena in Biological Systems*, Second Edition. George A. Truskey, Fan Yuan, and David F. Katz, 2004. (Available at the Engineering & Science Library)
- *Principles of anatomy and physiology.* Twelfth Edition. Gerard J. Tortora and Bryan H. Derrickson. 2009. (Available at the Bracken Health Science Library)

Other Material

All course lecture slides, videos, tutorials and problem sets will be posted on the CHEE 340 OnQ pages.

SUGGESTED TIME COMMITMENT

This course represents a study period of one term spanning 12 weeks. Learners can expect to invest on average 3 hours per week in lectures, 1 hour in a tutorial per week working on practice problems, plus 3 hours of independent study. Learners who adhere to a pre-determined study schedule are more likely to successfully complete the course on time.

COURSE EVALUATION

Please refer to "Assessment Schedule" on the CHEE 340 OnQ pages for exact assessment dates.

Assessment Tool (see Assessment Descriptions for details)	**Due Date**	**Weight**	**Alignment with CLOs**
Quiz 1	Week 3	10%	1
Quiz 2	Week 5	10%	2
Assignment 1 (transport). Deliverable: report	Week 7	15%	1, 2, 5
Quiz 3	Week 9	10%	3, 4
Assignment 2 (biomaterials). Deliverable: report	Week 12	15%	1, 4
Final Exam. Take-home exam, open book, non-proctored.	See Exam Schedule	40%	1, 2, 3, 4, 5
Total Marks		**100%**	

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.

Unless other arrangements have been approved, departmental policies regarding late and missed assignments, and missed quizzes/exams will be followed.

WEEKLY COURSE OUTCOMES

Week	Learning Outcomes
Module 1. Cells, Tissues, Organs, and Systems	
1	**Introduction to Biomedical Engineering. Cell Biology.** After completing this week, learners will be able to • List classes of molecules in a cell and describe their structure and function [CLO1] • Describe chemical and physical properties of cells [CLO1] • Describe the difference between cells in terms of function and organization [CLO1]
2	**Tissues, organs, and systems.** After completing this week, learners will be able to • List types of cell interactions within tissues [CLO1] • Describe how cell interactions affect tissue properties [CLO1] • Describe the structure and function of human tissues and organs [CLO1]
Module 2. Cardiovascular System	
3	**Cardiovascular System. Blood Rheology.** After completing this week, learners will be able to • Describe structure and functions of the cardiovascular system [CLO1] • Explain the role of cardiac cells for heart function in healthy or diseased states [CLO1] • Calculate the mechanical work done by the heart in healthy or diseased states [CLO3] • Calculate rheological properties of blood [CLO2]
4	**Hemodynamics.** After completing this week, learners will be able to • Calculate flow behavior of blood in the body using rheology [CLO2] • Calculate hemodynamic properties for a given blood flow context [CLO2] • Evaluate treatments for cardiovascular diseases using hemodynamics [CLO2]
Module 3. Transport	
5	**Mass Transport in Biological Systems. Transmembrane transport. Renal system.** After completing this week, learners will be able to • Apply transport principles to calculate the movement (flux and rate) of ions and molecules in the body [CLO2] • Discuss how biological factors influence transport properties, and how transport properties affect cell biology and physiology in a given context [CLO2] • Apply transport principles to hemodialysis [CLO2] • Evaluate the effectiveness of organoids, a tissue engineering technique, for drug testing [CLO5]
Module 4. Skeletal System & Biomechanics	
6	**Skeletal system** After completing these weeks, learners will be able to • Describe the components of the skeletal system and their functions [CLO1]

Week	Learning Outcomes
7	• Describe the types of bones and joints, and their functions [CLO1] • Describe the process of bone remodelling [CLO1] • Apply mechanics principles to calculate forces in the human body with or without prosthetics [CLO3]
Module 5. Biomaterials (Biocompatibility)	
8 9	**Biomaterials. Wound Healing. Foreign Body Reaction.** After completing these weeks, learners will be able to • List classes of biomaterials and describe their properties and functions [CLO4] • Describe host response to implantation of different classes of biomaterials [CLO4] • Describe the process of wound healing [CLO1] • Describe the process of foreign body reaction [CLO1] • Describe the process of immune response [CLO1] • Describe biocompatibility [CLO4]
Module 6. Biomaterials (Metals, Ceramics, and Polymers)	
10 11	**Metals, Ceramics, and Polymers.** After completing these weeks, learners will be able to • Evaluate the appropriateness of a biomaterial's physical and chemical properties for a specific biomedical application [CLO4] • Analyze failure properties and affordances for a particular biomaterial [CLO4] • Evaluate the appropriateness of a biomaterial for a biomedical application based on its physical, chemical, and degradation properties [CLO4] • Describe the chemical and physical properties of polymers [CLO4] • Estimate the strength properties of polymers in a given environment [CLO4]
Module 7. Tissue Engineering	
12	**Tissue Engineering. Current Tissue Engineering Approaches.** After completing this week, learners will be able to • Describe the components and processes for creating engineered tissue [CLO5] • Calculate culture parameters for growing cells and tissues outside of the body [CLO5] • Evaluate the effectiveness of techniques for engineering 3D tissue [CLO5]

Assessment Descriptions

Quizzes (Individual)

There are three quizzes in the course. The quizzes are comprised of multiple choice, calculations, and short answer questions that will help to identify gaps in conceptual understanding. These quizzes are taken on the course website.

Assignments (Team)

There are two assignments. These assignments involve addressing complex and open-ended problems in biomedical engineering using the knowledge base and problem solving approaches in the course outcomes. The deliverable for each assignment is a written report. More information about each assignment can be found on the course website.

Final Exam (Individual)

The final exam is a take-home, open book, non-proctored exam. The exam will become available during the final examination period. Students will be given a time window in which to complete the exam. The time window will be scheduled to account for multiple time zones. The exam will be due during the final examination period. Avoid scheduling vacations, appointments, etc. during the exam period. The Term and Session Dates will indicate the final exam period session dates in each term.

Late Policy

Any applicable late penalties are described in the details for each assessment. In the event of extenuating circumstances, you may request an extension to an assignment due date without penalty. Requests must be made to your instructor prior to the original due date of the assignment, and some substantiating documentation is often required. Note that unacceptable reasons include malfunctioning computer, travel plans to go home for holidays, generally behind on schoolwork, etc. In the absence of substantiating documentation, the normal late penalty will apply as described in the assignment or departmental policies.

Grading

Feedback on Assessments

The teaching team will provide feedback on graded activities. You can expect feedback on your assessments within ten days of the due date.

COURSE COMMUNICATION

Questions About Course Material

Questions or comments regarding the course material that can be of benefit to other students should be posted in the Q&A discussion forum on the class website. The instructor, teaching assistants, and students are encouraged to answer these questions directly in the discussion forum for the benefit of everyone in the course.

Course Announcements

The instructor will routinely post course news in the Announcements section on the main course homepage on onQ. Please sign up to be automatically notified by email when the instructor posts new information in the Announcements section. Instructions on how to modify your notifications are found in the **Begin Here** section of the class website.

Office Hours

In addition to interaction in the Q&A discussion forums, you will have the opportunity to interact in a synchronous fashion with either a teaching assistant or the instructor through office hours. The instructor will provide a schedule of availability at the beginning of the term.

Confidential Matters

If you have a confidential matter that you would like to discuss with your instructor, contact your instructor using the email listed at the top of this document. Expect email replies within 48 hours and in some cases within 24 hours.

COURSE POLICIES

Please review the following policies concerning copyright, academic integrity, absences and academic accommodations:

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

For absences and academic accommodations please review the information on the FEAS website.

Technical Support

Students will need to access course material online, including video lectures and online quizzes. This course material is delivered through the OnQ course website. To participate in live lectures, tutorials, and remote office hours, students will require web conferencing software (i.e., Zoom). No other 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, lonely, or distressed, consider confidential supportive counselling offered by the Faculty of Engineering and Applied Science.