Department of Bioengineering / BIEN 570
Active Mechanics in Biology / Fall 2023

Instructor:
Prof. Allen Ehrlicher (**bioeng570@gmail.com**) **Please use this email as the way to contact Prof Ehrlicher**

Office Hours: Often I am free to talk immediately following lecture, otherwise by appointment, generally by zoom. My McGill office is McConnell 358, UQAM SB-5458.

Topic: Teaching Office
Time: This is a recurring meeting Meet anytime

Join Zoom Meeting
https://mcgill.zoom.us/j/87610891829?pwd=ZGt6WEIveEhoeXpPak5BdjRET0JQUT09

Meeting ID: 876 1089 1829
Passcode: 145370

Lecture Schedule:

Tuesdays and Thursdays days, 11:35 PM-12:55 PM, LEA 110

Courses will be held in person, slides will be distributed **after** sessions. In the event of COVID restrictions or other circumstances, courses will move online to zoom and will be recorded.

Tutorial Schedule:

Thursdays 14:35 AM-16:25 PM; RPHYS 115

TA: Clayton Molter (clayton.molter@mcgill.ca)

Clayton is your first point of contact for the class- please ask him about any mycourses issues.

Course Information:

Audience: undergraduate & graduate engineering, science, and/or biomedical students
Prerequisites: BIEN320 or similar and permission from instructor.
Website: McGill MyCourses

Course Description:

This course will focus on developing and applying our understanding of biophysical measurements to complex systems in biology. Students will review basic concepts underlying these principles, and then work in a team of two to provide a detailed tutorial on a selected methodology in cellular biophysics. The class will culminate in team-based design projects where groups develop and apply new or combinations of existing biophysical techniques to create a new methodology.

Course Objectives & Graduate Attributes

1. High-level competency in understanding and applying diverse quantitative biophysical techniques, obtained through assigned readings, lectures, and peer tutorials. (**KB.I, ET.I, PA.D, EE.I**)
2. Detailed expertise in one particular methodology obtained through partner-based tutorial (**KB.D, CS.A, ET.D, IT.A, DE.I, EE.D**)

3. Detailed expertise and understanding in designing a novel cell biophysics methodology (**DE.A, PA.A, IN.A, CS.A, ET.D, IT.A, EE.A**)

This course contributes to the acquisition of graduate attributes as follows:
I = Introduced; **D** = Developed; **A** = Applied
KB - Knowledge Base for Engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
PA - Problem Analysis: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.
IN - Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.
DE - Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.
ET - Use of Engineering Tools: An ability to create, select, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.
IT - Individual and Team Work: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
CS - Communication Skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.
PR - Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.
IE - Impact of Engineering on Society and the Environment: An ability to analyse social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.
EE - Ethics and Equity: An ability to apply professional ethics, accountability, and equity. EP - Economics and Project Management: An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.
LL - Life-Long Learning: An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.

Motivation and Rationale:

Over the past decades the subject of biomechanics has undergone significant growth and is now an important branch of the bioengineering field, where significant strides have been made to understand the complex material properties of biological systems. We read papers, we marvel at what they have measured and found, but while we often understand the results, we may struggle with their analysis and how they got there. These leaps are predicated on advanced concepts and methods, largely developed by engineers.

Building on concepts from molecular and cellular biology courses and engineering mechanics, this 500 level course focuses in on the detailed methods involved in performing and understanding the measurements, from “concept to conclusion”, to provide a firm foundation for working in the field, and in completing the course you will understand how to apply these principles to study mechanics in biology. Generally, the course will focus on animal life, but methods learned are exportable to other plant and fungi systems in biomechanics.

Students will develop expertise on a singular topic by developing a detailed tutorial on a particular methodology, complete with quantitative analysis. To offer a broad exposure to other methods, they will benefit from their peers presenting other methodologies, and they will take these tools with them at the end of the course.

The course will culminate in design projects working in groups of 4-5 where students will propose a design project that takes advantage of this expertise to quantitatively solve challenges in biophysics. Students will examine data (synthesized or real), develop software to apply calculations you have learned, to quantify biophysical properties of the system. It is allowed and encouraged to bring data and questions from students’ research as applicable (see Course Assignments- NB1).

This project will take a form similar to a method-focused grant proposal, and extensively outline a novel application of or experiment on biomechanics, focusing on both the rationale of the measurement, and a very detailed methodology protocol of the measurement.

Course Material:

No required text purchase: Reading materials will be distributed.

Course Assignments and Grading:

	Points	**Percentage**	**Estimated time**
2 person partner tutorial	25	25	~10 hours
Peer evaluations	15	15	~15 min per evaluation =6.7hours
Weekly timed quizzes	20	20	~15 min per quiz, 13 quizzes= 3 hours
Team design project outline	5	5	~ 5 hours of preparation and research
Team design project proposal	5	5	~ 5 hours additional preparation and research
Team design project	25	25	~ 15 hours beyond outline and proposal
Team-self evaluation	5	5	~10 minutes
total	**100**	**100**	total for class: ~136 hours, 10 hours per week (consistent with 3-2-4 expectation)

Up to 5 bonus points will be awarded at the instructor's discretion based on contributions to classroom discussions. Bonus points may also be awarded by the instructor at other times during the semester.

It's 2023 & we're STILL living in a pandemic. In the event of intergalactic invasion, extraordinary circumstances, or instructor & class agreement, the content and/or evaluation scheme in this course is subject to change.

Course assignments:

NB:

1) **graduate and undergraduate students should "phase separate" in assignments, as they must be evaluated by slightly different rubrics.**
2) **You may build upon prior work or interest (previous class, research subject) however, your work in BIEN 570 must present a substantial advance from previous work and may not copy your previous text or work. You must clearly state that you are building on prior work and include a copy of your previously related work to avoid any potential questions of plagiarism.**

As a reference for the tutorial and project, you may consult the presentations and methodologies in publications from sources such as the Journal of Visualized Experiments (JoVE), nature protocols, nature methods, or methods in cell biology. Example articles will be provided.

Partner Tutorial (PT) **(Depending on enrollment, this will be done in pairs or 3 people)**

Students will create a tutorial from a selected group of methodologies, or they may suggest another that must be approved by the instructor. The goal of this is for students to develop sufficient expertise in a methodology to the point where they are able to apply it in research and clearly instruct their peers in the process. Students will draw from multiple reputable resources to distill a comprehensive description, noting consensus and disagreement, and they must cite all use and not plagiarize.

The students will be responsible for a ~2500 +/- 250 word paper (figures, references, and appendices are not counted) which describes in detailed functional steps the protocol for performing the measurement, rationale behind the steps,

potential pitfalls and alternative strategies, and analysis of results. The protocol should also address any ethical benefits or concerns in the methodology.
The partnered students will also be responsible for a ~30 minute in-class presentation (~25 minutes for presentation, ~5 minutes for questions), the exact duration of which will be set by enrollment. Presentations may be pre-recorded. During the in class presentation, the PT presenters will be expected to accurately answer questions from the class and instructors. *Excellent presentations will offer a degree of completeness and clarity that allows someone to follow the protocol to perform, analyze, and interpret the measurement.*
*Graduate students (optional for undergrads): you must also include an analysis of simulated or real (preferred) data as available to you.

Peer evaluation will represent approximately half of the tutorial grade component.
The rest of the class peers will grade the tutorial based on utility, accuracy, and clarity. This will be done on mycourses in a combination of quantitative metrics, and a freeform anonymous paragraph (required) for any recommended improvements. The instructor and/or TA will perform the same evaluation, which will make up the remaining half of the grade.

*Partners may then resubmit a revised tutorial slide-deck, report, and any other materials that address these improvements for up to 5 bonus points.

PT assignment reports will be due by midnight the day before in class presentation so that your peers can have the document before your presentation.

Example suggested PT candidate topics (you are not restricted to this list- please confirm choices with TA):
1)Shear rheology for measuring reconstituted network mechanics
2)Micro-contact protein patterning
3)Optical tweezers for cell cytoplasm measurements
4)AFM for adherent cell stiffness measurements
5)Osmotic stress for cell stiffness measurements
6)Measuring cell migration, velocity, and persistence of motion
7)Measuring internal and external cell forces with FRET
8)Traction force microscopy (continuous substrate)
9)Traction force microscopy (microposts)
10) Inter-cellular stress measurements
11)Microfluidics for cell stress
12)Measuring cell pushing forces

Team design project:

Students will work in groups of 4-5 and design a novel methodology, experimental system, device, or instrument to measure a relevant mechanical property of a biological system, or create a new biomimetic system. An analysis of the literature justifying their project, the theoretical approach they propose to build the instrument, the measurements that could be quantified by the theoretical instrument, and the potential implications to the biomechanics community their instrument would provide will be included in a ~5000 +/- 500 words double-spaced report (figures, references, and appendices are not counted). The project should focus on the methodology quantitative feasibility and clarity (as in the tutorial) and also include the innovation of the design, drawing on diverse skills from each team member. Please do not be tempted to pursue any project whose outcome is not quantitatively predictable and calculable; you are encouraged to focus on the engineering rather than the biochemistry, and to discuss your ideas early with TA and instructor to ensure you are developing an appropriate project. The project should also address any ethical benefits or concerns, and sustainability impact. The contributions of each member should be clearly identified.

Substantial freedom will be afforded the concept, and you are welcome to bring your existing research questions. The team is also responsible for an approximate 30 minute in-class presentation of their project, the specific duration of which will be set by enrollment, followed by 5-10 minutes of questions. During the in-class presentation, the team will be expected to accurately answer questions from the class and instructors.

*Graduate students (optional for undergraduates): you should also include a software component written in a language such as ImageJ (FIJI), matlab, or python to implement your measurement and analysis. The software should analyze of simulated or real (preferred) data as available to you. "Scientific Data" is one journal that publishes data for reader use, which may be helpful: https://www.nature.com/sdata/

Peer class evaluation will represent approximately half of the design project grade component.
The rest of the class peers will grade the tutorial based on novelty, utility, accuracy, and clarity. This will be done on mycourses in a combination of quantitative metrics, and a freeform anonymous paragraph (required) for any recommended improvements. The instructor and/or TA will perform the same evaluation, which will make up the remaining half of the grade.
*An additional 5 points will be assessed by team-mates to describe the relative contributions of their team members.

Tentative Course Schedule

Week	Date	Assignments	Topic
1	31/08	Introduction	Overview
2	05/09-07/09		Biological & Mechanics primer, Example partner tutorial in TA session
3	12/09-14/09	PT selections due	Biological & Mechanics primer
4	19/09-21/09		Lecture (mon) & 2 Partner Tutorials (PT) (wed)
5	26/09-28/09		Lecture (mon) & 2 PT (wed)
6	03/10-05/10	Team project outline due	Lecture (mon) & 2 PT (wed)
7	10/10-12/10		Fall break
8	17/10-19/10		Lecture (mon) & 2 PT (wed)
9	24/10-26/10	Team project proposal due	Lecture (mon) & 2 PT (wed)
10	31/10-02/11		Lecture (mon) & 2 PT (wed)
11	07/11-09/11		Lecture (mon) & 2 PT (wed)
12	14/11-16/11		Lecture (mon) & 2 PT (wed)
13	21/11-23/11	Team projects due	Team presentations
14	28/11-30/11		Team presentations, recap

As a general guide, the majority of the course will proceed like this:
Every week:
1)On Tuesday I will lecture on the application and insight gathered from a measurement methodology
2) On Wednesday @ 11:59pm, the partner tutorial **reports** are due on mycourses; they will be distributed to the class the following morning @ 9am.
3)Every Thursday two partner groups will present the details of how to perform those measurements (30 minutes, 10 minutes of questions)
4)Every week between by Friday 5pm you must complete your peer evaluation.
5)In your TA tutorial on Tuesday, you will do a timed **15 minute** online quiz on material from the **PREVIOUS** week. You will discuss any further questions related to the protocol and lecture of the current week, and the TA will present additional selected materials.
6)Every Thursday/Friday you will be assigned a paper to read that will form the basis of next week's lecture and partner tutorials

Language of Written Work:
In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

Academic Integrity:
McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see www.mcgill.ca/students/srr/honest/ for more information).

Disabilities:
If you have a disability, please contact the instructor to arrange a time to discuss your situation. It would be helpful if you contact the Office for Students with Disabilities at (514) 398-6009 before you do this.