ELEC ENG 4BC3
Modelling of Biological Systems
Course Outline
Please refer to course website for updated information.

COURSE DESCRIPTION

Introduction to mathematical and engineering methods for describing and predicting the behaviour of biological systems; including sensory receptors, neuromuscular and biomechanical systems; statistical models of biological function; kinetic models of biological thermodynamics.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): One of ELEC ENG 3EJ4, ENGINEER 3N03 or PHYSICS 3B06; and registration in Electrical & Biomedical Engineering Level IV, or permission of the instructor.

SCHEDULE

Lectures: Tuesday 7:00-10:00pm, T13-105
Tutorial: Tuesday 1:30pm-2:20pm, ABB-163
Labs: none

INSTRUCTOR

Dr. Michael Noseworthy
Office: SJH-F130A
Email: nosewor@mcmaster.ca
Phone: 905-525-9140, ext. 23727
Office Hours: Fridays 10:30am-12:30pm, and by appointment

TEACHING ASSISTANTS

Taylor Devet (**devett@mcmaster.ca**)
Ethan Danielli (**daniee4@mcmaster.ca**)

Contact information and office hours for the TAs can be found on the course website.

COURSE WEBSITE

All course lecture and tutorial materials will be available on http://avenue.mcmaster.ca

COURSE OBJECTIVES

The purpose of this course is to understand some of the routine mathematical approaches to modelling biological systems. Linear time invariance (LTI) will be discussed as it applies to biological modelling. The short comings of LTI will be described and a thorough analysis using other approaches including short-time Fourier transform (STFT) wavelets, PCA/ICA and nonlinear dynamics (fractal and chaotic models) will be presented. Real life examples will be presented using real data acquired from various imaging and physiological recording systems.

ASSUMED KNOWLEDGE

You should have a solid knowledge of linear algebra, vector calculus and basic statistics. Also, a thorough mastering of Matlab is critical. Lastly, working knowledge of anatomy and physiology is assumed.

COURSE MATERIALS

Required Texts:
In my opinion there is no one good book (at a reasonable price) that covers all the material for this course fully. Therefore, a number of key review papers that fully complement the course material will be suggested to students throughout the term. Class notes will be posted on the course website before 12noon the day of the lecture
Calculator:
Only the McMaster Standard Calculator (Casio fx-991 MS or MS Plus) will be permitted in tests and examinations. This is available at the Campus Store.
Other Materials:
Throughout the course references to numerous texts and research review articles will be provided. All material is available in the McMaster Library system, or has been validated as open source.

COURSE OVERVIEW

Date/Week	Topic	Readings
1-2	Data from biological systems; error analysis; statistical analysis Advantages and disadvantages of models.	TBD
2	Building Models: e.g. Cardiovascular modeling	TBD
3	Pharmacokinetic modelling (1, 2, and 3 compartments), indicator dilution, diffusion, contrast agents and other tracers used for assessing microvascular and metabolic kinetics.	TBD
4	Multivariate approaches to biological data analysis (e.g. PCA and ICA)	TBD
5	Chronobiology; cosinor analysis	TBD
6	LTI, coherence and correlation of biological signals	TBD
7-8	FT vs. STFT vs. wavelets	TBD
9-12	Nonlinear dynamics, fractal processes, power law scaling, chaos, Logistic equations, embedding	TBD

12-13	Introduction to machine learning in biological systems	TBD

A more detailed time line is available on the course web site.
At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight
Assignment #1 (due Oct 1st, 2019 at 11:59pm)	10%
Midterm (October 8th, 2019 at 7-10pm)	20%
Assignment #2 (due Nov. 1st, 2019 at 11:59pm)*	10%
Analysis Project (due Dec. 5th, 2019 at 11:59pm)*	20%
In class group presentation	10%
Final Exam (2.5hrs, date TBA)	30%
Total	100%

There will be a combination of assignments, midterm, presentation, a major modeling project and a final exam over the course of the semester. Groups (3 students per group) will be required to make a presentation based on group learning of the lecture materials. The course is taught in 3 hour blocks of formal presentations for half the semester (5 lectures). In the remaining 8 lectures, groups will give one in-class oral presentation of 15 minutes (+ 5min for questions) on different dates. These will take place in the last hour of each class. All materials presented and discussed in student presentations will be part of the course notes and included as questions on the final exam, and/or assignments. The presentation is worth 10% of final grade. Grading will be done by the instructor and TA and group self assessment will be done and submitted to the TA the day after the presentation.

Students will hand in 2 assignments in approximately the first 2/3 of the semester. These will be based on material learned in lectures, presentations and tutorials. Assignments will require programming in Matlab or Python. Assignments will **not** be done in groups (as per previous years) but must be done individually.

Students will be required to complete a major data modeling and analysis project. These will be done in *groups of up to 3 students*. Data will be anything physiological/biological in nature. There are numerous sites on the internet that are repositories of biological/medical data. It is suggested data from one of these sites be downloaded and used. If you choose to get data from yourselves a student research ethics board application would need to be submitted (see Dr. Noseworthy early in the semester if this interests you). The report will include an introduction about the data and why it might be important. Analysis will include modeling of some form of response and how this was determined as appropriate, proper statistical analysis from multiple subjects and error analysis where appropriate. The report should end with interpretations, conclusions, and possible future directions. The report should be 2000-3000 words and include figures, program code, etc.

NOTE 1: assignments are due digitally (i.e. upload to Avenue) at 11:59pm on the due date. Late assignments will be deducted **0.01389% per minute**.

NOTE 2: No make-up assignments will be granted. The entire weight of missed material will be transferred to the final exam.

The exams will cover everything up to the end of the lecture 1 week prior. The final exam will cover all course materials after the midterm, including materials from student presentations (time/place TBA). Both the final and midterm exams will be open book.

* Due dates for all term work must be on or before the final day of classes for courses with a final examination.

ACCREDITATION LEARNING OUTCOMES

Note: The *Learning Outcomes* defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: http://www.engineerscanada.ca .

Outcomes	Indicators	Measurement Methods(s)
To be able to design a mathematical model for a biomedical or biological problem. To understand how to test the model using computational approaches, mock systems and real life scenarios	2.1	Assignments and exam
To be able to decide upon best mathematical models to investigate a real biological or biomedical problem. Be able to identify ways to simplify model by way of logical choices of assumptions. To know when to use model or data driven approaches.	3.2	Assignments and exam
To be able to classify and characterize sources of error in biological models. Understand error propagation and sources of error in bio systems.	3.3	Assignments and exam. Questioning during oral presentation
Students are asked to work together in groups to critically evaluate a topic in biological modeling as it relates to biomedical engineering. Evaluations are presents as two 20min seminars on the topic, the first an overview and the second detailed mathematically.	6.3	Class presentations
To understand complex systems (chaos theory, temporal and spatial fractals) and how they relate to biological modeling. To understand how complex systems relate to biomedical and environmental problems. Viral/bacterial spreading sustainability of herds/food sources-epidemiology.	9.1	Assignments and exam; oral presentations

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. 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. a 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 types of academic dishonesty please refer to the Academic Integrity Policy, located at
http://www.mcmaster.ca/academicintegrity

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's 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.

ACADEMIC ACCOMMODATIONS

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 contact by phone at 905.525.9140 ext. 28652 or e-mail at sas@mcmaster.ca. For further information, consult McMaster University's Policy: Academic Accommodation of Students with Disabilities.

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students requiring a RISO accommodation should submit their request to the Engineering Student Services 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.

STUDENT ABSENCE AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

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".

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.

AUTHENTICITY / PLAGIARISM DETECTION

In this course we will be using a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work.

Students will be expected to submit their work electronically either directly to Turnitin.com or via Avenue to Learn (A2L) plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty. Students who do not wish to submit their work through A2L and/or Turnitin.com must still submit an electronic and/or hardcopy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com or A2L. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). To see the Turnitin.com Policy, please go to www.mcmaster.ca/academicintegrity .

ONLINE ACCESS OR WORK

In this course we will be using Avenue to Learn. 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 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 this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

NOTICE REGARDING POSSIBLE COURSE MODIFICATION

The instructor and 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. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

REFERENCE TO RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.