ELEC ENG 4BC3
Modelling of Biological Systems
Fall 2017
Course Outline

CALENDAR/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 Biomedical and Electrical Engineering Level IV, or permission of the instructor.

SCHEDULE

Lectures: Tuesday 7:00-10:00pm, T13-105
Tutorial: Thursday 12:30pm-1:20pm, ITB-139

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Michael Noseworthy, PhD, PEng
Office: ETB-406
nosewor@mcmaster.ca
905-525-9140, ext. 23727

Office Hours: Fridays 12noon-2:30pm,
(or by appointment)

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Diana Harasym
ETB-303
harasyd@mcmaster.ca
905-522-1155 ext.34102

Office Hours: Thursdays 2:30-4:30pm

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

All course lecture and tutorial materials will be available on “Avenue to Learn”.

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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 fx991) 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

<table>
<thead>
<tr>
<th>Date/Week</th>
<th>Topic</th>
<th>Readings</th>
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<tbody>
<tr>
<td>1-2</td>
<td>Data from biological systems; error analysis; statistical analysis</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td>Advantages and disadvantages of models.</td>
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<tr>
<td>2</td>
<td>Building Models: e.g. Cardiovascular modeling</td>
<td>TBD</td>
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<tr>
<td>3</td>
<td>Pharmacokinetic modelling (1, 2, and 3 compartments), indicator</td>
<td>TBD</td>
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<tr>
<td></td>
<td>dilution, diffusion, contrast agents and other tracers used for</td>
<td></td>
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<tr>
<td></td>
<td>assessing microvascular and metabolic kinetics.</td>
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<tr>
<td>4</td>
<td>Multivariate approaches to biological data analysis (e.g. PCA</td>
<td>TBD</td>
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<tr>
<td></td>
<td>and ICA)</td>
<td></td>
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<tr>
<td>5</td>
<td>Chronobiology; cosinor analysis</td>
<td>TBD</td>
</tr>
<tr>
<td>6</td>
<td>LTI, coherence and correlation of biological signals</td>
<td>TBD</td>
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<tr>
<td>7-8</td>
<td>FT vs. STFT vs. wavelets</td>
<td>TBD</td>
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<tr>
<td>9-12</td>
<td>Nonlinear dynamics, fractal processes, power law scaling, chaos,</td>
<td>TBD</td>
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<tr>
<td></td>
<td>Logistic equations, embedding</td>
<td></td>
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</tbody>
</table>
12-13 Introduction to machine learning in biological systems TBD

LABORATORY OVERVIEW

n/a

LABORATORY OPERATION

n/a

ASSESSMENT

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>Assignment #1 (due Oct 6th, 2017 at 11:59pm)</td>
<td>10%</td>
</tr>
<tr>
<td>Assignment #2 (due Nov. 10th, 2017 at 11:59pm)</td>
<td>10%</td>
</tr>
<tr>
<td>Assignment #3 (due Dec. 8th, 2017 at 11:59pm)</td>
<td>10%</td>
</tr>
<tr>
<td>In class group presentation</td>
<td>10%</td>
</tr>
<tr>
<td>Midterm (3hrs, in class Oct. 17th, 2017)</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam (2.5hrs, date TBA)</td>
<td>40%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

There will be a combination of exams, assignments and presentations 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 presentation up to the midterm (5 lectures total). After the (in-class) midterm there are 7 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. Following the midterm. 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 3 assignments over the semester. These will be based on material learned in lectures, presentations and tutorials. Assignments will require programming in Matlab. If you need access to the student computer lab (ITB-155) please discuss with the TA and you will be provided a login ID and password. Students are encouraged to work on assignments in groups (of up to a maximum of 3 per group). Groups hand in one assignment with all names on the first page. All group members will receive the same grade, which will then be adjusted based on group member self-evaluation.

NOTE: 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.

A midterm exam will be held in class on Tuesday October 17th, 2017. The final exam will cover all material from the midterm onward (time/place TBA). Both the midterm and final exams will be open book.
## 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](http://www.engineerscanada.ca).

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Indicators</th>
<th>Measurement Methods(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
<td>2.1</td>
<td>Assignments and exams</td>
</tr>
<tr>
<td>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.</td>
<td>3.2</td>
<td>Assignments and exams</td>
</tr>
<tr>
<td>To be able to classify and characterize sources of error in biological models. Understand error propagation and sources of error in bio systems.</td>
<td>3.3</td>
<td>Assignments and exams. Questioning during oral presentation</td>
</tr>
<tr>
<td>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.</td>
<td>6.3</td>
<td>Class presentations</td>
</tr>
<tr>
<td>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.</td>
<td>9.1</td>
<td>Assignments and exams; oral presentations</td>
</tr>
</tbody>
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### 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. 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 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 for Academic Accommodation of Students with Disabilities.

### Notification of 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" : http://www.mcmaster.ca/msaf/

### 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
Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles
Good laboratory practice requires that every laboratory worker and supervisor observe the following:
1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

**Fire Extinguisher**
On walls in halls outside of labs

**First Aid Kit**
ITB A111, or dial “88” after 4:30 p.m.

**Telephone**
On the wall of every lab near the door

**Fire Alarm Pulls**
Near all building exit doors on all floors
In Case of a Fire (Dial 88)
When calling to report a fire, give name, exact location, and building.
1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "Fire!" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire
Do not use a fire extinguisher on people
1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.
Equipment Failure or Hazard
Failure of equipment may be indicative of a safety hazard - You must report all incidents.
Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:
1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice
Leave equipment in a safe state for the next person - if you’re not sure, ask!
In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

<table>
<thead>
<tr>
<th>Role</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA</td>
<td>The first point of contact for lab supervision</td>
</tr>
<tr>
<td>ECE Lab Supervisor</td>
<td>Steve Spencer- ITB 147  <a href="mailto:steve@mail.ece.mcmaster.ca">steve@mail.ece.mcmaster.ca</a></td>
</tr>
<tr>
<td>ECE Chair</td>
<td>Tim Davidson- ITB A111  <a href="mailto:davidson@mcmaster.ca">davidson@mcmaster.ca</a></td>
</tr>
<tr>
<td>ECE Administrator</td>
<td>Kerri Hastings- ITB A111  <a href="mailto:hastings@mcmaster.ca">hastings@mcmaster.ca</a></td>
</tr>
<tr>
<td>ECE Course Instructor</td>
<td>Please contact your specific course instructor directly</td>
</tr>
</tbody>
</table>