Generation and transmission of bioelectricity in excitable cells; ionic transport in cellular membranes; propagation of electricity within and between cells; cardiac and neural physiology; measurement of extracellular fields; electrical stimulation of excitable cells.

Prerequisite(s): Registration in Level III or greater in Electrical and Biomedical Engineering

Lectures: Tuesday, Thursday & Friday 11:30 am – 12:20 pm
Tutorial: Friday 12:30 pm – 1:20 pm
Labs: (None)

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ext. 26984

Taylor, Larissa  
ETB-432  
taylorla@mcmaster.ca

http://www.ece.mcmaster.ca/~ibruce/courses/EE3BB3_2018.htm
COURSE OBJECTIVES

To develop both a qualitative and a quantitative understanding of the generation and transmission of bioelectricity in and between excitable cells. This will involve circuit analysis and modelling of potentials and currents across the cellular membrane, action potentials, propagation of potentials along the cellular membrane, electrical stimulation of excitable tissue, extracellular fields, neural electrophysiology, cardiac electrophysiology, the neuromuscular junction, skeletal muscle, and functional electrical stimulation.

ASSUMED KNOWLEDGE

- Algebra, trigonometry, functions, and calculus
- Basic cell biology
- Electrical circuit theory
- Introductory electromagnetics
- Basic linear systems theory

COURSE MATERIALS

Required Text:

Secondary References:

Other Materials:
Lecture notes will be posted on the course web site

Calculator:
The only calculator permitted in tests and examinations is the McMaster Standard Calculator (Casio FX-991MS or MS Plus)
### COURSE OVERVIEW

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Readings</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to Bioelectricity and Excitable Cells</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Bioelectric Potentials and Currents</td>
<td>P&amp;B Ch. 3</td>
</tr>
<tr>
<td>3</td>
<td>Membrane Channels</td>
<td>P&amp;B Ch. 4</td>
</tr>
<tr>
<td>4</td>
<td>Action Potentials</td>
<td>P&amp;B Ch. 5</td>
</tr>
<tr>
<td>5</td>
<td>Impulse Propagation</td>
<td>P&amp;B Ch. 6</td>
</tr>
<tr>
<td>6</td>
<td>Electrical Stimulation of Excitable Tissue</td>
<td>P&amp;B Ch. 7</td>
</tr>
<tr>
<td>7</td>
<td>Extracellular Fields</td>
<td>P&amp;B Ch. 8</td>
</tr>
<tr>
<td>8</td>
<td>Neural Electrophysiology</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Cardiac Electrophysiology</td>
<td>P&amp;B Ch. 9</td>
</tr>
<tr>
<td>10</td>
<td>The Neuromuscular Junction &amp; Skeletal Muscle</td>
<td>P&amp;B Chs. 10 &amp; 11</td>
</tr>
<tr>
<td>11</td>
<td>Functional Electrical Stimulation</td>
<td>P&amp;B Ch. 12</td>
</tr>
<tr>
<td>12</td>
<td>Applications of Biopotential Measurement</td>
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Note that dates are approximate.

### ASSESSMENT

<table>
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<tr>
<th>Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Computer Lab Assignment</td>
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<tr>
<td>Take-home Math &amp; Computer Programming Assignment #1</td>
<td>5%</td>
</tr>
<tr>
<td>Take-home Math &amp; Computer Programming Assignment #2</td>
<td>5%</td>
</tr>
<tr>
<td>Take-home Math &amp; Computer Programming Assignment #3</td>
<td>5%</td>
</tr>
<tr>
<td>Take-home Math &amp; Computer Programming Assignment #4</td>
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</tr>
<tr>
<td>Take-home Math &amp; Computer Programming Assignment #5</td>
<td>5%</td>
</tr>
<tr>
<td>Take-home Math &amp; Computer Programming Assignment #6</td>
<td>5%</td>
</tr>
<tr>
<td>Midterm Quiz #1</td>
<td>15%</td>
</tr>
<tr>
<td>Midterm Quiz #2</td>
<td>15%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>30%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
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The instructor reserves the right to choose the format (i.e., written or oral) of any deferred midterm or final exam in this course.

Please note that announcements concerning any type of graded material may be in any format (e.g., announcements may be made only in class, via the course e-mailing list, or on the course web site). Students are responsible for completing the graded material regardless of whether they received the announcement or not.
**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>
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<tbody>
<tr>
<td>be able to develop an electrical-circuit model of the membrane of an excitable cell such as a neuron or muscle cell</td>
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<tr>
<td>be able to solve differential equations describing the response of ion channel gating particles and of the transmembrane potential to a stimulus</td>
<td></td>
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</tr>
<tr>
<td>be able to use a neural membrane simulator program to explore the dynamical behaviour of neural excitability</td>
<td>5.2</td>
<td>Computer Lab Assignment</td>
</tr>
<tr>
<td>understand the principles behind the propagation of electrical potentials along the cellular membrane</td>
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<td></td>
</tr>
<tr>
<td>appreciate how the activity of excitable cells gives rise to electrical potentials that can be measured on the surface of the skin such as EEG, ECG &amp; EMG and understand the limits of what can be inferred from such measurements</td>
<td>2.3</td>
<td>Midterm Quiz or Final Exam Question</td>
</tr>
<tr>
<td>understand how different neural elements will respond to electrical stimulation depending on the electrode-neuron geometry and the current waveform</td>
<td>1.4</td>
<td>Midterm Quiz or Final Exam Question</td>
</tr>
<tr>
<td>appreciate the technical and clinical issues faced in the development of implantable medical electronics</td>
<td>1.4</td>
<td>Midterm Quiz or Final Exam Question</td>
</tr>
<tr>
<td>apply the engineering code of ethics to issues of sustainability in the development and use of implantable electronics</td>
<td>9.3 &amp; 10.1</td>
<td>Midterm Quiz or Final Exam Question</td>
</tr>
</tbody>
</table>

**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](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.
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
Who to Contact

**Emergency Medical / Security:** On McMaster University campus, call Security at extension 88 or 905-522-4135 from a cell phone.

**Non-Emergency Accident or Incident:** Immediately inform the TA on duty or Course Instructor.

**University Security (Enquiries / Non-Emergency):** Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.

**See TA or Instructor:** For problems with heat, ventilation, fire extinguishers, or immediate repairs

**Environmental & Occupational Health Support Services (EOHSS):** For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.

**ECE Specific Instructional Laboratory Concerns:** For non-emergency questions specific to the ECE

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**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>