ELEC ENG 3BB3
Cellular Bioelectricity

COURSE OUTLINE

COURSE DESCRIPTION

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.

PRE-REQUISITES AND ANTI-REQUISITES

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

SCHEDULE

Lecture: Tuesday, Thursday & Friday 8:30am – 9:20am
Tutorial: Wednesday 1:30pm – 2:20pm
Lab: (None)

INSTRUCTOR

Dr. Ian Bruce
ITB-A213
e-mail: ibruce@mail.ece.mcmaster.ca
e-mail alias: ibruce@ieee.org
For MSAF use: brucei@mcmaster.ca
Phone: 905-525-9140 ext. 26984
Office Hours: T.B.D. or by appointment

TEACHING ASSISTANTS

Contact information and office hours are provided on the course website.

- Taylor, Larissa
- Yayli, Melih

COURSE WEBSITE

http://www.ece.mcmaster.ca/~ibruce/courses/EE3BB3_2019.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:

[1] R. Plonsey and R. C. Barr, “Bioelectricity: A Quantitative Approach,” 3rd Edition, Springer, 2007.

Secondary References:

[2] D. Johnston and S. M.-S. Wu, “Foundations of cellular neurophysiology,” MIT Press, 1994.
[3] A. C. Guyton and J. E. Hall, “Textbook of Medical Physiology,” 10th Edition, W. B. Saunders, 2001. (12th Edition now available.)
[4] C. Koch, “Biophysics of computation: information processing in single neurons,” Oxford University Press, 1998.
[5] P. L. Nunez and R. Srinivasan, “Electric fields of the brain: the neurophysics of EEG,” 2nd Edition, Oxford University Press, 2005.
[6] B. Hille, “Ion Channels of Excitable Membranes,” 3rd Edition, Sinauer Associates, 2001.

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:

Lecture notes will be posted on the course web site

COURSE OVERVIEW

Week	Topic	Readings
1	Introduction to Bioelectricity and Excitable Cells	
2	Bioelectric Potentials and Currents	P&B Ch. 3
3	Membrane Channels	P&B Ch. 4
4	Action Potentials	P&B Ch. 5
5	Impulse Propagation	P&B Ch. 6
6	Electrical Stimulation of Excitable Tissue	P&B Ch. 7
7	Extracellular Fields	P&B Ch. 8
8	Neural Electrophysiology	
9	Cardiac Electrophysiology	P&B Ch. 9
10	The Neuromuscular Junction & Skeletal Muscle	P&B Chs. 10 & 11
11	Applications of Biopotential Measurement	
12	Functional Electrical Stimulation	P&B Ch. 12

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
Computer Lab Assignment	10%
Take-home Math & Computer Programming Assignment #1	5%
Take-home Math & Computer Programming Assignment #2	5%
Take-home Math & Computer Programming Assignment #3	5%
Take-home Math & Computer Programming Assignment #4	5%
Take-home Math & Computer Programming Assignment #5	5%
Take-home Math & Computer Programming Assignment #6	5%
Midterm Quiz #1	15%
Midterm Quiz #2	15%
Final Exam	30%
Total	100%

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 .

Outcomes	Indicators	Measurement Methods(s)
be able to develop an electrical-circuit model of the membrane of an excitable cell such as a neuron or muscle cell		
be able to solve differential equations describing the response of ion channel gating particles and of the transmembrane potential to a stimulus		
be able to use a neural membrane simulator program to explore the dynamical behaviour of neural excitability	5.2	Computer Lab Assignment
understand the principles behind the propagation of electrical potentials along the cellular membrane		
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 & EMG and understand the limits of what can be inferred from such measurements	2.3	Midterm Quiz or Final Exam Question
understand how different neural elements will respond to electrical stimulation depending on the electrode-neuron geometry and the current waveform	1.4	Midterm Quiz or Final Exam Question
appreciate the technical and clinical issues faced in the development of implantable medical electronics	1.4	Midterm Quiz or Final Exam Question
apply the engineering code of ethics to issues of sustainability in the development and use of implantable electronics	9.3 & 10.1	Midterm Quiz or Final Exam Question

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 www.mcmaster.ca/academicintegrity .

The following illustrates only three forms of academic dishonesty:

- Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- Improper collaboration in group work.
- Copying or using unauthorized aids in tests and examinations.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca . For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

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.

www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

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 laboratories, please contact 24103.

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

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca