# ELEC ENG 4BD4
## Biomedical Instrumentation

COURSE OUTLINE

Please refer to course website for updated information.

## COURSE DESCRIPTION

Generation and nature of bioelectric potentials; electrodes and other transducers; principles of instrumentation; electrical safety; neuromuscular and cardiovascular instrumentation; ultrasonics and other medical imaging

## PRE-REQUISITES AND ANTI-REQUISITES

**Prerequisite(s):** One of ELECENG 3EJ4, ENGINEER 3N03 or PHYSICS 3B06; and registration in Biomedical and Electrical Engineering Level IV, or permission of the Department
**Antirequisite(s):** ELECENG 4EL3

## SCHEDULE

Lecture: Tuesday, Thursday & Friday 8:30am – 9:20am JHE-326H
Tutorial: Friday 11:30am – 12:20pm JHE-326H
Lab: *Every other week:* Mondays 2:30 p.m.- 5:20 p.m.; Tuesdays 2:30 p.m.- 5:20 p.m.; Wednesdays 2:30 p.m.- 5:20 p.m. ITB-153

## INSTRUCTOR

**Dr. Hubert de Bruin**
Email: debruin@mail.ece.mcmaster.ca
Office: ITB-A211
Phone: 905-525-9140 ext. 24171
Office Hours**:** Thursdays 1:30 – 3:30; and by appointment

## TEACHING ASSISTANTS

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

- Ryan Scott
- Sean Clarke

## COURSE WEBSITE/S

http://avenue.mcmaster.ca

## COURSE OBJECTIVES

By the end of this course, students should be able to:

- Analyze a measurement/instrumentation problem and propose a solution
- Apply the principles of electronic circuits and devices to design instrumentation
- Have a knowledge of the principles and use of a variety of electrical and other transducers, analog and digital instrumentation, applied computer signal acquisition and processing
- Apply current safety standards in the design
- Understand the principles of instrumentation used in cardiopulmonary, neurological, surgical and rehabilitation areas of medicine

## ASSUMED KNOWLEDGE

Students are expected to have a basic knowledge of electronic circuit design, the use of operational amplifiers, filters and amplifiers, properties of periodic and stochastic signals including the Fourier transform, frequency spectra and data sampling concepts.

## COURSE MATERIALS

**Optional Text:** Medical Instrumentation: Application and Design, IV edition. John G. Webster

**Calculator:** Only the McMaster Standard Calculator will be permitted in tests and examinations. This is available at the Campus Store.

**Other Materials:** Lecture notes and slides on the course website

1. Introduction to Instrumentation and Measurements; Second Edition; Robert B Northrop; Taylor and Francis; ISBN 0-8493-3773-9
2. Noninvasive Instrumentation and Measurement in Medical Diagnosis; Robert N. Northrop; CRC press; ISBN 0-8493-0961-1
3. Design and Development of Medical Electronic Instrumentation, D. Prutchi and M. Norri, Wiley-Interscience, 2005
4. Biomedical Device Technology Principles and Design, 2nd Edition, A.Y.K. Chan, Charles C Thomas, 2016, ISBN-10: 0398090831
5. Principles of Biomedical Instrumentation, Andrew G. Webb, 2018, Cambridge, ISBN 978-1-107-11313-8

## COURSE OVERVIEW

**General Overview of Instrumentation**
Lecture 1 Introduction to Measurement Systems
Lecture 2 Coherent and Other Noises in Measurements
Lecture 3 General Properties of Sensors
Lecture 4 Analog Instrumentation
**Electrophysiology and Instrumentation Used**
Lecture 5 Origins of Electrophysiological Signals
Lecture 6 Biopotential Electrodes Including Equivalent Circuit Models I
Lecture 6A Biopotential Electrodes Including Equivalent Circuit Models II
Lecture 7 Recording Biopotential Fields on the Body
**Common Electrophysiological Signals Recorded in Biomedicine and Associated Instrumentation**
Lecture 8 Origin of ECG, Standard Recording Systems
Lecture 8A ECG Noise Coupling, Heart Rate Detection
Lecture 9 Muscle Organization and Function
Lecture 10 Electromyography (Recording and Analyzing Muscle Signals)
Lecture 11 Brain Electrical Signal (EEG)
Lecture 11A Other Instrumentation Applications in EEG
Lecture 12 The Electro-Oculargram (EOG)
**Sensors and Instrumentation to Measure Other Variables**
Lecture 13 Temperature Sensors and Instrumentation
Lecture 14 Position and Movement Sensors
Lecture 15 Force and Pressure Measurement using Strain Gauges
Lecture 16 Piezoelectrics and Application
Lecture 17 Chemical Sensors
**Measurement of Cardiopulmonary Function**
Lecture 18 Invasive and Non-Invasive Blood Pressure
Lecture 19 Measuring Blood Oxygen (Pulse Oximeter)
Lecture 20 Measuring $CO_2$ (Capnometry)
Lecture 21 Measuring Blood or Airflow (Plethysmography)
**Application of Therapeutic Electrical Energy**
Lecture 22 General Principles of Electro-Stimulation
Lecture 23 Cardiac Pacing and Pacemakers
Lecture 24 Cardiac Defibrillators
Lecture 25 Muscle Stimulation
Lecture 26 Electrosurgery
**Professional Standards and Safety Codes**
Lecture 27 Electrical Safety I
Lecture 28 Electrical Safety II

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).

## LABORATORY OVERVIEW

**Laboratory Sessions:**

***Lab 1 : Differential amplifiers; DAQ / DSP / Statistical Analysis***
Key Concepts: Discrete Signals, Acquisition, Amplifiers, Frequency Domain

***Lab 2 : ECG / Heart Rate***
Key Concepts: Biopotentials, Electrocardiogram, Einthoven's Triangle, Noise Artifact, Bio-instrumentation amplifier for ECG

***Lab 3 : EEG***
Key Concepts: Alpha & Beta Waves (Alpha Blockers) – in phase or out of phase. Spectral and time analysis, Irregularities, Bio-instrumentation amplifier for EEG

***Lab 4 : EMG & Motor Control***
Key Concepts: Muscle action potentials, rectification, averaging, RMS, Force vs EMG, Filtering effects on applications of EMG, Bio-instrumentation amplifier for EMG

***Lab 5 : EOG & Environmental Control***
Key Concepts: DC Signals, DC Amplifiers, Frequency component of blinking, Scaling of signals and creation of algorithms to make raw data into useful information, Bio-instrumentation amplifier for EOG

***Lab 6: Accelerometers and the calculation and display of acceleration, velocity and position in 3D***
Key concepts: 3D accelerometers and data acquisition, signal processing to obtain velocity and position, display and analysis of kinematic data

**To pass the course students will have to perform all labs. TAs will be in the laboratory during the scheduled hours**
**The laboratory (ITB-153) will be electronically key accessed and open for use during extended hours**

## LABORATORY OPERATION

- At the beginning of every term, every Undergraduate student using an ECE Lab is required to complete the ECE Lab Safety Quiz (one completed quiz covers every course that term). The quiz and other information is provided on the webpage: https://www.eng.mcmaster.ca/ece/resources#health-safety
- Access to all labs is restricted in the interest of security and safety. Information on accessing and using the lab can be found on the webpage: https://www.eng.mcmaster.ca/ece/labs-and-health-safety#Labs-Access-and-Use
- The labs will be performed in groups of two students
- Each lab will involve a significant amount of pre-lab work. You must submit individual pre-lab reports
- The pre-lab work will be assessed at the beginning of the lab. The penalties for late pre-lab work are as follows. Pre-lab received by TAs before 2:45pm: No penalty. Pre-lab received by TAs between 2:45pm and 3:00pm: A penalty of 50% of the awarded mark will be applied. Pre-lab not submitted before 3:00pm: No marks will be awarded for the pre-lab component, but you will be allowed to attempt the experiments.

- The TAs and the instructor reserve the right to interview students to assess their understanding of the per-lab material. Such interviews will be held at random and we reserve the right to adjust the pre-lab mark based on the outcome of the interview.
- Individual lab reports will be handed in to the laboratory one week after

## ASSESSMENT

| Component | Weight |
|---|---|
| Labs | 20% |
| Midterm | 30% |
| Final Exam | 50% |
| Total | 100% |

Late submissions of laboratory reports are subject to 10% penalty per day (less than one day is counted as one day).
No make-up midterm tests will be granted. Weight of a missed midterm test will be transferred to final exam.

## 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) |
|---|---|---|
| Investigate a measurement problem | 3.1 Able to recognize and discuss applicable theory and knowledge base | Evaluate design questions in midterm and final exams |
| Investigate a measurement problem | 3.3 Can estimate outcomes, uncertainties and determine appropriate data to collect. | Evaluate design questions in midterm and final exams |
| Demonstrates awareness of professional responsibility | 8.1 Demonstrates an understanding of the role of the engineer in society, especially in protection of the public and public interest | Evaluate design questions in midterm and final exams |
| Considers principles of ethics and equity | 10.1 Applies the engineering code of ethics, understanding of the stakeholders: the individual, the employer, and the public. | Evaluate design questions in midterm and final exams |

| | | |
|---|---|---|
| Able to design an effective solution to a given problem | 4.1 Recognizes and follows an engineering design process (This means an iterative activity that might include recognizing the goal, specifying the constraints and desired outcomes, proposing solutions, evaluating alternatives, deciding on a solution, and implementing.) | Evaluate design questions in midterm and final exam |
| Able to design electrically safe system | 4.6 Determines and employs applicable standards and codes of practice | Evaluate design questions in final exam |

## 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 |