ELEC ENG 4BD4
Biomedical Instrumentation
Fall/Winter 2018/2019
Course Outline

CALENDAR/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

Lectures: Monday, Wednesday, 11:30 – 12:30, Friday 1:30 – 2:30 HH 305
Tutorial: Monday 12:30 p.m. JHE 326H
Labs*: 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 OFFICE HOURS AND CONTACT INFORMATION

Dr. Hubert de Bruin
ITB-A211
debruin@mcmaster.ca
ext. 24171

Office Hours: Mondays, Wednesdays 2:30 - 3:30

Or by appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Christina Riczu

CHRISTINA RICZU
<riczucl@mcmaster.ca>

Sean Clarke

Sean Clarke
clarks40@mcmaster.ca

Office Hours: To be determined

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

http://www.ece.mcmaster.ca/faculty/debruin/debruin/teaching.htm

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

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

LABORATORY OPERATION

Students will be required to pass a safety test before using laboratory equipment
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

ASSESSMENT

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

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	Evaluate design questions in midterm and final exams

	and determine appropriate data to collect.	
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 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

1. If you are seeking relief for missed academic work because of an absence lasting less than three days in duration, you must use the McMaster Student Absence Form.
2. Absences lasting more than three days must be reported to the Associate Dean's Office (JHE-A214) and appropriate documentation must be provided. For medical absences, the University reserves the right to require students to obtain medical documentation from the Student Wellness Centre.
3. You should expect to have academic commitments Monday through Saturday but not on Sunday or statutory holidays.
4. Students may submit requests for relief using the MSAF once per term. You must report to the Associate Dean's Office (JHE-A214) for any request for relief in a term where the MSAF has been used previously in that term. Relief for missed academic work is not guaranteed.
5. You are responsible to contact your instructor(s) immediately to discuss the appropriate relief. Failure to do so may negate the opportunity for relief.
6. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.

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.

TURNITIN.COM STATEMENT (OPTIONAL)

In this course we will be using a web-based service (Turnitin.com) to reveal plagiarism. Students will be expected to submit their work electronically to Turnitin.com and in hard copy so that it can be checked for academic dishonesty. Students who do not wish to submit their wok to Turnitin.com must still submit a copy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, etc.). To see the Turnitin.com Policy, please go to http://www.mcmaster.ca/academicintegrity/.

ON-LINE STATEMENT FOR COURSES REQUIRING ONLINE ACCESS OR WORK (OPTIONAL)

In this course, we will be using X. 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.

X = e-mail, LearnLink, Avenue to Learn, web pages, capa, Moodle, ThinkingCap, etc.

REFERENCE TO RESEARCH ETHICS (OPTIONAL)

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.

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

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 Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	