IBEHS 4FO4
Biomedical Instrumentation and Measurement
Fall 2020
Course Outline

CALENDAR/COURSE DESCRIPTION

An introduction of engineering principals applied to the design of biomedical instrumentation including: electrodes, mechanical, chemical and other transducers; signal processing and data acquisition; safety; neuromuscular; cardiovascular, biochemical, biomechanical and other clinical instrumentation.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): IBEHS 3A03, or registration in the Integrated Biomedical Engineering and Health Sciences (IBEHS) Cross-List(s): ELECENG 4BD4

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

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

Office Hours by Team:
Monday 10:00 am – 12:00
Wednesday 10:00 am – 12:00
Or by appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Andrew Lofts  Mahnaz Tajik Jr.  Martin Villegas  Lianne Ladouceur  Office Hours: TBD
JHE 456  JHE 456  JHE 456
a@mcmaster.ca  b@mcmaster.ca  c@mcmaster.ca
ext. 67890  ext. 67890  ext. 67890

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

http://avenue.mcmaster.ca/

COURSE OBJECTIVES

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

| LO.01 | Analyze a measurement/instrumentation problem and propose a solution |
| LO.02 | Apply the principles of electronic circuits and devices to design instrumentation |
LO.03 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

LO.04 Apply current safety standards in the design

LO.05 Understand the principles and efficacy of instrumentation used in cardiopulmonary, neurological, surgical and rehabilitation areas of medicine

MATERIALS AND FEES


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
3. Design and Development of Medical Electronic Instrumentation, D. Prutchi and M. Norri, Wiley-Interscience, 2005

COURSE OVERVIEW

All lectures will be given synchronously during the scheduled time slots and also recorded and placed in Avenue to Learn

General Overview of Instrumentation
Lecture 1 Introduction to Measurement Systems
Lecture 2 Coherent and Other Noises in Measurements
Lecture 3 Sensors and Elementary Circuit Theory
Lecture 4 Designing Amplifiers and other Analog Circuitry

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-Ocularogram (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 CO₂ (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

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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, Filters; DAQ / DSP**
Key Concepts: Discrete Signals, Acquisition, Amplifiers, Frequency Domain

**Lab 2: ECG / Heart Rate**
Key Concepts: Biopotentials, Electrocardiogram, Einthoven’s Triangle, Noise Artifact, Measuring heart rate, 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, Effects of Fatigue, Bio-instrumentation amplifier for EMG

**Lab 5: Estimation of Position, EOG and Accelerometry**
Key Concepts: DC Signals, DC Amplifiers, Frequency component of blinking, Determining eye angle from EOG, Bio-instrumentation amplifier for EOG, Processing
Accelerometry signal to determine position.

**LABORATORY OPERATION**

- Students will be assigned to lab sections, with each section having a lab every other week. Each lab will involve a significant amount of pre-lab work. All students with sections in that week will submit individual pre-lab reports detailing the design of your instrumentation on Avenue to Learn on the Monday of that week by 5:00 pm.
- A video of that lab involving a TA and the instructor will be posted on Avenue to Learn at 2:30 pm that Monday and Excel files of data collected during the lab will be posted on Avenue to learn for processing and inclusion in the final report.
- The final report will be due and submitted on Avenue to Learn on the Monday of the following week by 5:00 pm.
- The pre-lab work will be weighted as 1/3 of the total lab mark and the final report as 2/3. The penalties for late reports are as follows: 20% reduction for each day late if handed in after 5:00 pm.

To pass the course students will have to submit all pre-labs and lab reports. TAs will be assigned to each lab section and have scheduled office hours.

**ASSESSMENT**

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<thead>
<tr>
<th>Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Labs</td>
<td>30%</td>
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<tr>
<td>Assignments</td>
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<tr>
<td>Midterm Exam</td>
<td>20%</td>
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<tr>
<td>Final Exam</td>
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<td>Total</td>
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**ACCREDITATION LEARNING OUTCOMES**

The Learning Outcomes defined in this section are measured for Accreditation purposes only, and will not be directly taken into consideration in determining a student’s actual grade in the course.

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<thead>
<tr>
<th>Attribute</th>
<th>Indicators</th>
<th>Learning Outcomes</th>
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<tbody>
<tr>
<td>1. Knowledge</td>
<td>1.4 Competence in specialized engineering knowledge</td>
<td>LO.03</td>
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<tr>
<td>3. Investigation</td>
<td>3.1 Able to recognize and discuss applicable theory and knowledge base</td>
<td>LO.01, LO.02, LO.03, LO.05</td>
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<tr>
<td>3. Investigation</td>
<td>3.3 Can estimate outcomes, uncertainties and determine appropriate data to collect.</td>
<td>LO.05</td>
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8. Professionalism

| 8.1 Demonstrates an understanding of the role of the engineer in society, especially in protection of the public and public interest | LO.04, LO.05 |

4. Design

| 4.2 Recognizes and follows engineering design principles including appropriate consideration of environmental, social and economic aspects as well as health and safety issues. | LO.04, LO.05 |

| 4.6 Determines and employs applicable standards and codes of practice | Evaluate design questions in final exam |

For more information on Accreditation, please visit: [https://www.engineerscanada.ca](https://www.engineerscanada.ca)

### 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 contacted 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.

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<tr>
<th>NOTIFICATION OF STUDENT ABSENCE AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK</th>
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<tbody>
<tr>
<td>1. The McMaster Student Absence Form is a self-reporting tool for Undergraduate Students to report absences DUE TO MINOR MEDICAL SITUATIONS that last up to 3 days and provides the ability to request accommodation for any missed academic work. Please note this tool cannot be used during any final examination period.</td>
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<td>2. You may submit a maximum of 1 Academic Work Missed request per term. It is YOUR responsibility to follow up with your Instructor immediately (NORMALLY WITHIN TWO WORKING DAYS) regarding the nature of the accommodation. Relief for missed academic work is not guaranteed.</td>
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<td>3. If you are absent for reasons other than medical reasons, for more than 3 days, or exceed 1 request per term you MUST visit the Associate Dean's Office (JHE/A214). You may be required to provide supporting documentation.</td>
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<td>4. This form must be submitted during the period of absence or the following day, and is only valid for academic work missed during this period of absence.</td>
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<td>5. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.</td>
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<td>6. You should expect to have academic commitments Monday through Saturday but not on Sunday or statutory holidays. If you require an accommodation to meet a religious obligation or to celebrate an important religious holiday, you may submit the Academic Accommodation for Religious, Indigenous and Spiritual Observances (RISO) Form to the Associate Dean’s Office. You can find all paperwork needed here: <a href="http://www.eng.mcmaster.ca/current/documents.html">http://www.eng.mcmaster.ca/current/documents.html</a></td>
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<th>NOTICE REGARDING POSSIBLE COURSE MODIFICATION</th>
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<td>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.</td>
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<td>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 work 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 <a href="http://www.mcmaster.ca/academicintegrity/">http://www.mcmaster.ca/academicintegrity/</a>.</td>
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| ON-LINE STATEMENT FOR COURSES REQUIRING ONLINE ACCESS OR WORK |
In this course, we will be using e-mail and Avenue to Learn. 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.

**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 Ethics at McMaster University, please go to [https://reo.mcmaster.ca/](https://reo.mcmaster.ca/).