

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	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

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

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

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

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

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.

Attribute	Indicators	Learning Outcomes
1. Knowledge	1.4 Competence in specialized engineering knowledge	LO.03
3. Investigation	3.1 Able to recognize and discuss applicable theory and knowledge base	LO.01, LO.02, LO.03, LO.05
3. Investigation	3.3 Can estimate outcomes, uncertainties and determine appropriate data to collect.	LO.05

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. Design	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>

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. 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.
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.
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.
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.
5. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.
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: <http://www.eng.mcmaster.ca/current/documents.html>

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

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

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/>.