ENGG*4390 Bio-instrumentation Design

Fall 2019
Section(s): C01

School of Engineering
Credit Weight: 0.75
Version 1.00 - June 29, 2020

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1 Course Details

1.1 Calendar Description

Theory and selection criteria of devices used in measurements in biological systems; design of complete measurement systems including transducers, signal conditioning and recording components; error analysis. Differences between measurements in biological and physical systems.

Pre-Requisites: ENGG*3450

1.2 Timetable

Lectures:

Wednesday	7:00 PM – 9:50 PM	ROZH 102

Laboratory:

Tuesday	Sec 02	12:30 PM - 2:20 PM	RICH 1504A
Wednesday	Sec 01	12:30 PM - 2:20 PM	RICH 1504A
Thursday	Sec 03	12:30 PM - 2:20 PM	RICH 1504A
Thursday	Sec 04	3:30 PM - 5:20 PM	RICH 1504A

1.3 Final Exam

There is no final exam in this course.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: John Buozis
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Office: THRN 3102
Office Hours: TBA on course link or by appointment only

Lab Co-ordinator: Ahmed Mezil
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Lab Technician: Hong Ma
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Office: THRN 1506

2.2 Teaching Assistants

Teaching Assistant: Calvin Young
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Teaching Assistant: Saipriya Ramalingam
Email: sramalin@uoguelph.ca

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
http://courselink.uoguelph.ca
Course material, news, announcements, and grades will be regularly posted to the ENGG*4390 Courselink site. You are responsible for checking the site regularly.

Medical Instrumentation – Application and Design, 4th Edition, John G. Webster (Textbook)

3.2 Recommended Resources

Measurement Systems: Application and Design, 5th Edition, Ernest O. Doebelin (Textbook)

Introduction to Biomedical Equipment Technology, 4th Edition, J.J. Carr and J.M. Brown (Textbook)

3.3 Additional Resources

Lecture Information (Notes)
All the lecture notes are posted on the web page (week #1-#12).

Lab Information (Lab Manual)
The handouts for all the lab sessions reside within the lab section of the course website. All types of resources regarding tutorials, links to web pages can be found in this section.

Assignments (Other)
Download the assignments according to the schedule given in this handout. All the solutions will be posted as indicated.

Miscellaneous Information (Other)
Other information related to the laboratory experiments, interesting articles, and project ideas will be posted on the courselink web page.

3.4 Communication & Email Policy

Please use lectures and lab help sessions as your main opportunity to ask questions about the course.

Major announcements will be posted to the course website. **It is your responsibility to check the course website regularly.** As per university regulations, all students are required to check their <mail.uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its students.

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4 Learning Outcomes

4.1 Course Learning Outcomes

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

1. Apply knowledge of interdisciplinary sciences and mathematics to develop solutions to problems at the interface of biology and engineering
2. Demonstrate and apply knowledge on the use of sensors and electronic instruments to measure physical, chemical and biological signals
3. Interpret and contrast principles of instrumentation used to measure factors that characterize biological, physical or chemical factors that have a profound effect of

biosystems

4. Design and development of biological, and biomedical instrumentation through application of electrical device theory, sensor theory, and signal conditioning.
5. Design and evaluate the performance of bio-instrumentation systems through calibration, signal conditioning, testing and error analysis
6. Interpret and present results of experimental measurements of physiological signals and assess potential sources of error that affects the quality of results

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2, 4, 5
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1, 2, 4, 5
1.2	Recall, describe and apply fundamental principles and concepts in natural science	1, 2, 4, 5
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2, 4, 5
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2, 4, 5
2	Problem Analysis	1, 2, 4, 5
2.1	Formulate a problem statement in engineering and non-engineering terminology	1, 2, 4, 5
2.2	Identify, organize and justify appropriate information, including assumptions	1, 2, 4, 5
2.3	Construct a conceptual framework and select an appropriate solution approach	1, 2, 4, 5
2.4	Execute an engineering solution	1, 2, 4, 5
2.5	Critique and appraise solution approach and results	1, 2, 4, 5
3	Investigation	2, 4, 5, 6
3.1	Propose a working hypothesis	2, 4, 5
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	2, 4, 5, 6

#	Outcome	Learning Outcome
3.3	Analyze and interpret experimental data	2, 4, 5, 6
3.4	Assess validity of conclusions within limitations of data and methodologies	2, 4, 5, 6
4	Design	4, 5, 6
4.1	Describe design process used to develop design solution	4, 5
4.2	Construct design-specific problem statements including the definition of criteria and constraints	4, 5
4.3	Create a variety of engineering design solutions	4, 5
4.4	Evaluate alternative design solutions based on problem definition	4, 5
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	4, 5, 6
5	Use of Engineering Tools	3, 4, 5, 6
5.1	Select appropriate engineering tools from various alternatives	3, 4, 5, 6
5.2	Demonstrate proficiency in the application of selected engineering tools	3, 4, 5, 6
5.3	Recognize limitations of selected engineering tools	3, 4, 5, 6
6	Individual & Teamwork	4
6.2	Understand all members' roles and responsibilities within a team	4
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	4
6.4	Apply strategies to mitigate and/or resolve conflicts	4
6.5	Demonstrate leadership through, for example, influencing team vision and process, promoting a positive team culture, and inspiring team members to excel	4
7	Communication Skills	4, 5, 6
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	4
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	4, 5, 6
7.3	Construct the finished elements using accepted norms in English, graphical	4, 5

#	Outcome	Learning Outcome
	standards, and engineering conventions, as appropriate for the message and audience	
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	4, 5, 6
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	4, 5
8	Professionalism	4
8.3	Demonstrate professional behaviour	4
9	Impact of Engineering on Society and the Environment	4
9.1	Analyze the safety, social, environmental, and legal aspects of engineering activity	4
9.2	Evaluate the uncertainties and risks associated with engineering activities	4
9.3	Anticipate the positive and negative impacts of introducing innovative technologies to solve engineering problems	4
11	Economics and Project Management	4
11.1	Apply project management techniques and manage resources within identified constraints	4
11.3	Estimate economic impact and feasibility of an engineering project or design using techniques such as cost benefit analysis over the life of the project or design	4

5 Teaching and Learning Activities

5.1 Lecture Schedule

Week 1:

Review of basic electronics - Bioinstrumentation - Definition, Bioelectronics, bio optics, biomaterials, biosystems, medical imaging - Precision vs Accuracy; Resolution vs sensitivity, Temperature (Thermistor vs Thermocouple) Sensors

Week 2:

Linear Circuit Analysis - Kirchoff's Laws KCL; KVL; Series and parallel combination; First and second order instruments; Thevenin and Norton equivalents

Week 2 and 3:

Basic Sensors: Displacement, strain and pressure - Wheatstone bridge – Microcontroller based biomedical instruments

Week 4:

Sensors and control elements: Inductive, Capacitive, Piezoelectric, - Amplifiers and Active Linear Circuits for Signal Processing - Amplifiers and signal processing - Analysis of linear active circuits with IDEAL opamps – Application of Microcontrollers

Week 5:

Comparators, timers and digital circuits; Overview of variety of sensors

Week 6:

Biopotentials- ECG, EMG, EEG - Nernst potential - Action potential - Volume conduction - Alpha, beta, gamma, delta, theta brain waves; Biopotential electrodes - polarization - polarizable, non-polarizable electrodes

Week 7:

Biopotential sources and signals - Biosignal recording - Deep brain simulation electrodes - Blood pressure measurement - Bandwidth requirements - Blood volume and flow measurement

Week 8 and 9:

Measurement of flow and volume of blood; respiratory system

Week 10:

Electrochemical Biosensors - pH P02, and PCO2 - Chemical biosensors - Severinghaus electrode

Week 11 and 12:

Ion selective and Optical Biosensors - Optical transduction - Ion Sensitive FET - Electrical safety and physiological effects - parameters of susceptibility - point of entry - Design for protection, grounded vs ungrounded examples, protection of power distribution

5.2 Lab Schedule

Week	Topic
1	Lab Safety Orientation, Introduction to Lab Equipment and Safety Training, Form Design Groups in Lab
1 & 2	Analog Sensor Pre-Lab
2 & 3	Analog Sensor Lab
4	Digital Sensor Pre-lab
5, 6	Digital Sensor Lab
7, 8, 9, 10	Final Design Project / Instrumentation System Development
11, 12	Final Design Project Review and Presentations

5.3 Other Important Dates

First day of class: Thursday September 5, 2019

Thanksgiving: Monday, October 14, 2019 - no classes

Fall Study day: Tuesday October 15, 2019 - no classes/labs

Thursday, November 28, 2019: Make up for Fall Study Day (Tuesday Schedule)

Last day of class: Friday November 29, 2019 (Monday Schedule - Make up for Thanksgiving Day)

Please refer to the undergraduate calendar for semester scheduled dates.

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Prelab 1 (Analog Sensor Interfacing)	2.5
Lab Report 1 (Analog Sensor Interfacing)	10
Prelab 2 (Digital Sensor Interfacing)	2.5
Lab Report 2 (Digital Sensor Interfacing)	10
Design Component 1	2
Design Component 2	2
Design Component 3	2
Design Component 4	2
Design Component 5	2
Midterm Exam	20
Presentation	15
Final Design Project Report	30
Assignments (A total of 6)	0
Ethics CORE Training	0
Total	100

6.2 Assessment Details

Prelab 1 (Analog Sensor Interfacing) (2.5%)
Date: Mon, Sep 16
Learning Outcome: 1, 2, 3, 4, 5, 6

Lab Report 1 (Analog Sensor Interfacing) (10%)
Date: Fri, Oct 4
Learning Outcome: 1, 2, 3, 4, 5, 6

Prelab 2 (Digital Sensor Interfacing) (2.5%)
Date: Mon, Oct 7
Learning Outcome: 1, 2, 3, 4, 5, 6

Lab Report 2 (Digital Sensor Interfacing) (10%)
Due: Mon, Oct 21
Learning Outcome: 1, 2, 3, 4, 5, 6

Design Component 1 (2%)
Date: Fri, Sep 27
Learning Outcome: 1, 3, 4, 5

Design Component 2 (2%)
Date: Fri, Oct 11
Learning Outcome: 1, 3, 4, 5

Design Component 3 (2%)
Date: Fri, Oct 25
Learning Outcome: 1, 3, 4, 5

Design Component 4 (2%)
Date: Fri, Nov 1
Learning Outcome: 1, 3, 4, 5

Design Component 5 (2%)
Date: Fri, Nov 15
Learning Outcome: 1, 3, 4, 5

Midterm Exam (20%)
Date: Wed, Oct 30, RICH 2529
Learning Outcome: 1, 3, 4, 5
19:00 PM to 21:00 PM

Presentation (15%)
Date: Fri, Nov 22
Learning Outcome: 1, 2, 3, 4, 5, 6

Final Design Project Report (30%)
Date: Fri, Nov 29
Learning Outcome: 1, 2, 3, 4, 5, 6

Assignments (A total of 6) (0%)
Learning Outcome: 3, 4

Ethics CORE Training (0%)
Depending on the scope of the design project

6.3 Design Component Schematics – Final Design Project

Submission	Description	Due
1	*Design Component 1* – One Page Proposal & Project Pitch – Accompanied with Oral Presentation of the Group – During Lab Hours	September 27, 2019
2	*Design Component 2* – Two Page Report - Background literatures from journal articles (or) News Magazines (or) from the Internet	October 11, 2019
3	*Design Component 3* – Alternate Design – Two Page Report	October 25, 2019
4	*Design Component 4* – Full Design of the Final Circuit of Prototype – Two page Report	November 1, 2019
5	*Design Component 5* – Project Progress Update –Demo of the Prototype - Accompanied with an Oral Presentation of the Group – During Lab Hours	November 15, 2019
None	Oral Presentation in SOE Atrium – Show case of your design instrument prototype (Trade Show)	November 22, 2018

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement

due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: Students must obtain a grade of 50% or higher overall to pass this course.

Missed midterm tests: If you miss the midterm with grounds for academic consideration or religious accomodation, contact the instructor as early as possible to arrange a time to write a make-up test.

Lab Work: You must attend and complete all laboratories. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistants to complete a makeup lab.

Late Lab Reports: Late submissions of lab reports will not be accepted.

7.2 Ethics Compliance Statement

IF you plan on testing your design project on a participant **YOU MUST COMPLETE THE CORE ETHICS ONLINE COURSE available through courselink**. Furthermore, the design team must complete and submit an ethics consent form for approval prior to carrying out testing. If there is evidence that you have conducted non-approved testing of your design project, you will receive a **grade of zero for your final presentation AND design report (45% of the final course mark)**. Ethics and integrity are essential components of this course and will be taken seriously.

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

Associate Diploma Calendar - Dropping Courses

https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least 7 days in advance and not later than the 40th Class Day.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars
