University of Guelph
School of Engineering
ENGG*4390 Bio-Instrumentation Design
Fall 2012

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Textbook:

Practical Interfacing in the Laboratory: Using a PC for Instrumentation, Data Analysis and Control, Author: Stephen E. Derenzo.

Medical Instrumentation: Application and Design. Editor: John G. Webster

The Measurement, Instrumentation and Sensors Handbook edited by J.G. Webster (CRC Press/IEEE Press). It is a huge comprehensive handbook in two volumes and do not be intimidated by it. Obviously, we will not cover everything in this book.

Schedule:

Lectures: CRSC Room 116

Mondays: 11:30 Am to 12:50 Pm
Wednesdays: 11:30 Am to 12:50 Pm

Labs/Tutorials: THRN 2196

Wednesdays: 3:30 PM to 5:20 PM

Course 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. Topics also include overview of bio-imaging, and sensors.

Learning Objectives:

- To develop the ability to apply knowledge of science and mathematics to solve problems at the interface of biology and engineering
- To appreciate the issues and considerations involved in the design and development of biological and biomedical instrumentation
- to understand the principles of instrumentation used to measure factors that characterize biological, physical or chemical factors that have a profound effect of biosystems
- to quantify the performance of bio-instrumentation systems through calibration, testing and error analysis

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Graduate Attributes:

- Ability to engage in independent and reflective learning, addressed by the group project and laboratory tasks
- Effective communication through presentation and project reports
- Analytical and critical thinking and creative problem solving skills

Learning Outcomes:

- Demonstrate and apply knowledge on the use of sensors and electronic instruments to measure physical, chemical and biological signals.
- Interpret and present results of experimental measurements of physiological signals and assess potential sources of error that affects the quality.

Laboratory:

The laboratory component of the course comprises 3 parts. The first part is an assigned laboratory exercise that is completed by each student independently. The **first part** involves making and test your own thermocouple sensor. The **second part** of the lab component consists of the evaluation of two different transducers that is carried out by teams of 2 students working together over the semester. There is a variety of sensors available, but others can be sourced if the one you have a particular interest in is not in the initial selection. Ask the technician or TA or the instructor for any clarifications. The **third part** of the lab component will be your final design project. Final design project will be an individual work (Not a group project).

A laboratory proposal will be required for your final design project detailing the approach to be taken, the equipment requirements and safety and operational procedure. Only when your proposal is complete and approved by the instructor can you carry out the experiments during the assigned laboratory periods (and at other times by arrangement with Ms. Hong Ma, the technician in charge of the electrical laboratory or with the TA). This will, of course, be subject to prior lab bookings and any safety concerns. Safety aspects MUST be addressed in the laboratory proposals. More details will be found in the lab handout posted in the course link website.

Design Project:

This is an individual project on a topic chosen by each student in consultation with the instructor. A design proposal is required. The project comprises a preliminary design for an instrumentation system solution in the context of a specific problem that poses biological or biomedical constraints. The final design report will include the complete development of the design, with appropriate justification for the component choices. The system designed will not be constructed in most cases, although given sufficient resources students may assemble prototypes.

Grade Evaluation:

	Due Date	**Grade (%)**
Lab Report 1 (Thermocouple sensor)	September 26, 2012	10
Design Proposal for Lab 3/Final Design Project	October 10, 2012	10
Lab Report 2 (Team project on combination)	October 24, 2012	15
Term Exam	November 12, 2012	20
Presentation	November (14-29, 2012)	15
Lab Report 3 or the Final Design Project Report	November 29, 2012	30

Lab Report I is based on your Thermocouple Laboratory I work, and Lab Report II is based on your team lab work. Safety in the laboratory is a prime concern. Lab proposals must include a safety section. Depending upon the experiment conducted, appropriate safety protection such as gloves and goggles must be worn. University policy forbids working alone in a lab; this will be strictly enforced. Laboratory and design reports will be graded for grammar and writing style as well as technical content.

Syllabus / Lecture Topics:

Week 1:
Review of basic electronics - Bioinstrumentation - Definition, Bioelectronics, bio optics, biomaterials, biosystems, medical imaging - Precision vs Accuracy; Resolution vs sensitivity

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

Week 4:
Sensors and control elements: Inductive, Capacitive, Piezoelectric, Temperature (Thermistor vs Thermocouple) Sensors - Amplifiers and Active Linear Circuits for Signal Processing - Amplifiers and signal processing - Analysis of linear active circuits with IDEAL opamps

Week 5:
Comparators, timers and digital circuits

Week 6:
Biopotentials- ECG, EMG, EEG - Nernst potential - Action potential - Volume conduction - Alpha, beta, gamma, delta, theta brain waves

Week 7:
Biopotential electrodes - polarization - polarizable, non-polarizable electrodes

Week 8 and 9:
Biopotential sources and signals - Biosignal recording - Deep brain simulation electrodes - Blood pressure measurement - Bandwidth requirements - Blood volume and flow measurement

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

Exam Dates:

Term Exam is scheduled for November 12, 2012, Monday. Time: 11:30 AM to 12:30 PM, Location: CRSC Room 116

Student Responsibilities:

- Attend lectures and labs in order to obtain all the course material that you are responsible for.
- Check announcements page (courselink website) on a regular basis.
- Submit assignments on time.
- Regularly, check your marks on the course web page and make sure they are up to date.
- Submission of reports and proposals for re-marking must be done within a week of being returned.

Important Notes:

Communications regarding this course will frequently involve the course web page and email. Students are responsible for checking the course website and the university email account for all instructions and announcements. This must be done at least once every week.

Late Reports/Missed Test Policy:

Generally, when you find yourself unable to meet a course requirement such as an assignment or a test as a result of compassionate, illness or physiological reasons, a formal explanation must be made in writing to the instructor and (where possible) proper documentation must be provided. This should be done prior to an exam or assignment (if possible) or as soon as possible but definitely within a week after the exam or assignment due date. If no explanations are provided, exams receive a grade of zero and assignments/lab reports are subject to the following deductions:

- 25% will be deducted if the assignment/report is up to 24 hours late,
- 50% will be deducted if the assignment/report is 24 to 48 hours late,
- No assignments will be accepted after that.

University Policy on Academic Misconduct:

Academic misconduct, such as plagiarism, is a serious offence at the University of Guelph. Please consult the Undergraduate Calendar and the School of Engineering programs guide, for offences, penalties and procedures relating to academic misconduct.
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Disclaimer:
The instructor reserves the right to change any or all of the above in the event of appropriate circumstances, subject to the University of Guelph Academic Regulations.