

Course schedule:

Lecture Tue/Thu 8:35-9:55 ME4236

Lab A10 Fri 2:35-5:25, A2O Wed 2:35-5:25 ME4135 *labs start week of September 14

Instructor: Niall Tait, Niall.Tait@carleton.ca

Teaching assistant: to be determined

Course description:

Calendar description - Overview of sensor technologies with emphasis on devices suitable for integration with silicon integrated circuits. Sensor design and fabrication principles including signal conditioning; discussion of automotive, biomedical, and other instrumentation applications.

The emphasis in the course will on sensors that can be integrated in silicon technology, including principles of operation and application examples. There will also be some fundamental material on dealing with low signal levels in the presence of noise, as this problem is often encountered in working with sensors. Sensors for consumer, biomedical and industrial applications will be considered. Specific topics include:

- Measurement principles; uncertainty, precision and accuracy
- Signals and interfaces
- Fabrication technologies for silicon ICs and sensors; micromachining
- Mechanical sensors (strain and pressure)
- Temperature sensors
- Sensors for visible and infrared radiation, including imagers
- Sensors for ionizing radiation (x-rays, gamma rays, etc.)
- Magnetic sensors
- Chemical sensors

Labs: Labs are intended to provide practical experience in working with integrated sensors. Labs typically require design and simulation of simple circuits, sensor measurements, and analysis. One lab will also use finite element numerical analysis (FEA) software (COMSOL) in the design of an integrated sensor.

Lab instructions will be available on the course web page during the term. Due to lab station limitations labs this year will be completed in self-organized groups of 2 students. Students are expected to contribute equally to submissions and will receive a group grade. Lab reports will be due at 11:59 pm on the second day following the lab session.

In most cases design work is required prior to attending the lab. Several labs require circuit simulation using KiCad with results verified by experimental measurements.

Labs will include:

Lab 1	Sept. 16, 18	Making accurate measurements using common lab equipment
Lab 2	Sept 30, Oct 2	Characterization of a piezoresistive pressure sensor
Lab 3	Oct 14, 16	Analysis and simulation of a pressure sensor
Lab 4	Nov 4, 6	Oscillometric blood pressure measurement
Lab 5	Nov 18, 20	Temperature sensor data acquisition
Lab 6	Dec 2, 4	Optical signal generation and sensing

Health and Safety: Respecting lab safety precautions and following directions of lab staff is essential to keep everyone safe.

It is important to remember that a number of potentially serious respiratory illnesses can spread on-campus in the fall as groups of people work together indoors. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a

mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

General lab safety precautions are always important and can be found at
<https://carleton.ca/ehs/programs/working-lab/laboratory-health-and-safety/>

Outcomes: On successful completion of the course, a student is expected to be able:

- To understand integrated sensor specification and selection.
- To explain the process of physical design of a sensor element.
- To design signal conditioning circuitry suitable for interfacing sensor output with digital or analog readout or data logging.
- To identify and resolve sources of noise and signal artifacts in sensor measurements.
- To relate sensor signals to physical quantities of interest.

Precluded courses: none

Prerequisites: ELEC 2507 and 4th year standing in Engineering. The course assumes 2nd year-level knowledge of circuits and signals including passive DC and AC circuit analysis, simple filters, transistor and op-amp circuits normally covered in ELEC2501 and ELEC2507.

Accreditation units: Accreditation units (AU's) are used by the Canadian Engineering Accreditation Board (CEAB) to determine if an Engineering program meets a minimum number of class hours required for accreditation in each of 5 components: math, natural science, engineering science, engineering design, and complementary studies. Accreditation metrics are based on courses common to all students in a program. ELEC4709 is an elective course and is not included in AU counts.

Graduate attributes: The Canadian Engineering Accreditation Board requires graduates of undergraduate engineering programs to possess 12 graduate attributes or [GA's](#). Courses in all four years of our programs evaluate students' progress towards acquiring these attributes. Aggregate data (typically, the data collected in all sections of a course during an academic year) is used for accreditation purposes and to guide improvements to programs. Some of the assessments used to measure GAs may also contribute to final grades; however, the GA measurements for individual students are not used to determine the student's year-to-year progression through the program or eligibility to graduate. Accreditation metrics are based on courses common to all students in a program. ELEC4709 is an elective course and does not include GA assessments.

Textbooks: Students are not required to purchase textbooks or other learning materials for this course. These are suggested references only, available as online resources.

Handbook of Modern Sensors, 4th Edition, Jacob Fraden, Springer 2010, ISBN 978-1-4419-6465-6
[Electronic resource through Carleton Library](#)

Sensors and Signal Conditioning, 2nd Edition, Ramon Pallas-Areny and John G. Webster, Wiley Interscience, 2001. ISBN: 0471332321
[Electronic resource through Carleton Library](#)

Evaluation :	Labs (6)	30%	
	Quizzes (2)	20%	October 8, November 17
	Final exam	50%	

Additional requirements - Satisfactory performance during the term requires completion of all lab experiments and a combined weighted average grade of $\geq 40\%$ on lab reports and quizzes.

The final exam must be completed with a minimum grade of 40% to pass the course.

Final Examination -The final exam will be an **in-person exam** during the regular exam period. It is for evaluation purposes only and will not be returned to the student.

Students who are unable to write the final examination due to serious illness, emergency or other circumstances beyond their control may apply for accommodation by contacting the Registrar's office. Consult [Section 4.3 of the University Calendar](#).

Missed term work - Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor. In all cases this must occur no later than three (3) days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. Consult [Section 4.4 of the University Calendar](#). Normally missed term work with an approved excuse will have grade weight transferred to the final exam.

Copyright: The materials (including the course outline and any slides, posted notes, videos, labs, project, assignments, quizzes, exams and solutions) created for this course and posted on the web site are intended for personal class use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).

Generative Artificial Intelligence (GenAI): Use of generative AI tools (such as ChatGPT) can serve you as a valuable learning tool, and may be used to assist in preparation of lab reports. However like any reference, AI generated material should be properly reviewed and cited ([Generative AI / ChatGPT and citations | MacOdrum Library](#)). Claiming AI generated material as your own is a violation of academic integrity. You are accountable for your work, and if you simply parrot AI output it becomes a crutch and not a learning tool. You may be asked to explain or defend output you generate with AI. Exams are intended to assess your individual understanding and competency in the subject, AI tools will not be available to you in your exams.

As our understanding of the uses of GenAI and its relationship to student work and academic integrity continue to evolve, students are required to discuss their use of GenAI in any circumstance not described here with the course instructor to ensure it supports the learning goals for the course. ([Policies and Guidelines - Artificial Intelligence](#))

Academic integrity and plagiarism

a) Please consult the Faculty of Engineering and Design information page about the Academic Integrity policy and our procedures: <https://carleton.ca/engineering-design/current-students/fed-academic-integrity>

Violations of the Academic Integrity Policy will result in the assignment of a penalty such as reduced grades, the assignment of an F in a course, a suspension or, expulsion.

b) One of the main objectives of the Academic Integrity Policy is to ensure that the work you submit is your own. As a result, it is important to write your own solutions when studying and preparing with other students and to avoid plagiarism in your submissions. The University Academic Integrity Policy defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source.

Examples of violations of the policy include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using another's data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own; and
- failing to acknowledge sources of information through the use of proper citations when using another's work and/or failing to use quotation marks.

Advising and Counselling services

a) Engineering Academic Advising

The Engineering Academic Support Service : <https://carleton.ca/engineering-design/current-students/undergrad-academic-support/> assists undergraduate engineering students with course selection, registration, and learning support from first-year through to graduation.

Academic advisors contact information: <https://carleton.ca/engineering-design/current-students/undergrad-academic-support/undergraduate-advisors/>

b) Student Mental Health Service

As a University student you may experience a range of mental health challenges that significantly impact your academic success and overall well-being. If you need to talk to someone, please reach out for assistance: [Wellness - Current Students - Carleton University](#).

Learning and working environment

The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of [Equity and Inclusive Communities | Carleton University](#).

We strive to create an environment of mutual respect for all through equity, diversity, and inclusion within this course. The space which we work in will be safe for everyone. Please be considerate of everyone's personal beliefs, choices, and opinions.

Academic Accommodation

Carleton University is committed to providing academic accessibility for all individuals. You may need special arrangements to meet your academic obligations during the term. The accommodation request processes, including information about the *Academic Consideration Policy for Students in Medical and Other Extenuating Circumstances*, are outlined on the Academic Accommodations website (students.carleton.ca/course-outline).