

Course schedule:

Lecture Mon/Wed 4:05-5:25 CB2202

Lab A10 Fri 11:35-2:25, A20 Wed 08:35-11:25 ME4135 *labs start week of September 9

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

Teaching assistant: TBD

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
- Selected topics (to be determined)

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.

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

Labs will include:

- Making accurate measurements using common lab equipment
- Characterization of a piezoresistive pressure sensor
- Analysis and simulation of a pressure sensor
- Oscillometric blood pressure measurement
- Temperature sensor data acquisition
- 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 COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. 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 still 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: 4th year status 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 attributes: [Graduate-Attributes.pdf \(engineerscanada.ca\)](#) 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: (not compulsory)

Handbook of Modern Sensors, 4th Edition, Jacob Fraden, Springer 2010, ISBN 978-1-4419-6465-6
Electronic resource:

https://ocul-crl.primo.exlibrisgroup.com/permalink/01OCUL_CRL/1gorbd6/alma991022634465205153

Sensors and Signal Conditioning, 2nd Edition, Ramon Pallas-Areny and John G. Webster, Wiley Interscience, 2001. ISBN: 0471332321

https://ocul-crl.primo.exlibrisgroup.com/permalink/01OCUL_CRL/1gorbd6/alma991023151717305153

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| Evaluation : | Labs | 30% | |
| | Quizzes (2) | 20% | October 7, November 11 |
| | Final exam | 50% | |

Additional requirements - Satisfactory performance during the term requires completion of all lab experiments and a combined average grade of >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 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 contact 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](#).

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 (AI): Use of generative AI tools (such as ChatGPT) in course work is prohibited unless explicitly authorized by the course instructor for specific elements of the course. Submission of AI generated work without authorization may lead to an academic integrity investigation.

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. Carleton's Wellness Services Navigator <https://wellness.carleton.ca/navigator/> is designed to help students connect with mental health and wellness resources. If you need to talk to someone, please reach out for assistance: <https://carleton.ca/health/emergencies-and-crisis/>.

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 at equity@carleton.ca. 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

[Academic accommodation](#) refers to educational practices, systems and support mechanisms designed to accommodate diversity and difference. At no time should academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University.

- a) **Academic Accommodations for Students with Disabilities:** The [Paul Menton Centre](#) for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation.
If you are already registered with the PMC, contact your PMC coordinator to initiate a Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with the instructor to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).
- b) **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>
- c) **Pregnancy obligation:** contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form.
- d) **Religious obligation:** contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist.
- e) **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/equity/sexual-assault-support-services>