

## ELEC 4700: The Physics and Modeling of Advanced Devices and Technologies

### Introduction

This course examines the structure, fabrication, physical operation and modeling of semiconductor diodes, bipolar transistors and MOSFETs.

### Course Description and Requirements

#### Course Description:

Fabrication, operation and modeling of advanced devices for information technology. Topics: physics of materials, quantum mechanics of solids, optical transitions, physical analysis and models for state-of-the-art electronic/optical technologies and materials. Technologies: MOS and III-V based transistors, solid-state optical devices, MEMS and nano-technology based devices.

**Prerequisite:** ELEC 3908.

**Lectures:** three hours a week,

**Problem analysis:** two hours a week.

### Instructor

**Professor:** Tom Smy

**Email:** [tomsmy@cunet.carleton.ca](mailto:tomsmy@cunet.carleton.ca)

**Course Webpage:** on Brightspace

### Textbook: Please include price of books

1) N/A

### Lecture Outline

In person, Tues. & Thurs 11:30-1:00 TC 208

The following topics will be covered during the course lectures with an approximate schedule:

Week 1: Introduction

Week 2: Project Description

Week 3: Electromagnetic Simulation I

Week 4: Electromagnetic Simulation II

Week 5: Steady State Diffusion/Conduction

Week 6: Wave Equation and Matrices

Week 7: Time Domain Simulation - Transport

Week 8: Circuit Simulation

Week 9: Compact Models

Week 10: Molecular Dynamics

Week 11: Monte Carlo Modeling

Week 12: Transport through Nanostructures

## Laboratory and Problem Analysis Sessions

2 hours per week with schedule and location posted on Brightspace.

### Notes for Project Work

- The project is run throughout the term. There is supervised help and support for 1.5 hours a week in the second lecture period. Milestones are to be completed each week. A midterm and final reports must be submitted.
- The project is worth 45% with the following breakdown:
  - Milestone completion (10%)
  - 1st Report (15%)
  - Final Report (20%)

### Notes for PA Sessions

- The PA's are 10 tasks dealing with that week's specific topic. They are to be completed by the end of the 2 hour timeslot and are pass/fail.
- The students are required to use source control (Git) to track and organize their work.

### Self-Declaration form and Deferred 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 submitting a self-declaration form no later than three (3) days after the date/deadline of term work including test/midterm, labs, assignments. Any alternate arrangements made with the instructor for submission of term work should be made as soon as possible but within 3 days of the missed due date. If this is not possible after discussion with the instructor, alternate arrangements must be made before the last day of classes in the term as published in the academic schedule.

Instructors can require (or not) the student to submit the self-declaration form. Include the following statement if you require the student to submit a completed self-declaration form:

**Consult with the instructor no later than 3 days after any missed course work or quiz.**

or

**Contact the instructor with the completed self-declaration form no later than 3 days after the date/deadline of term work including test/midterm, labs, assignments.**

## Evaluation and Grading Scheme

The cumulative course grade will be determined as follows:

- PA Session work: 30%
- Project: 45%

- Final Exam: 35%

a) Final Exam: **Final exams are for evaluation purpose and will not be returned to students.**

ii) The final exam is closed book, 3 hours long and a calculator is allowed.

iii) Final exam weight [55%]

iv) Deferred Final Examinations

Students who are unable to write the final examination because of a serious illness/emergency or other circumstances beyond their control may apply for accommodation by contact the Registrar's office. Consult the Section 4.3 of the University Calendar (<https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/examinations/>)

b) Additional requirement(s):

It is mandatory to complete the Labs.

c) Exam format and e-proctoring statement

The final exam is in person.

## Learning Outcomes

Upon successful completion of this course, students will be able to:

- 1) Understand the use of Finite Difference to solve PDE's
- 2) Apply Finite Difference to wave, diffusion and conduction problems.
- 3) Form matrix equations using Finite Difference as applied to PDE's
- 4) Understand time domain, frequency domain and eigenmode analysis using Finite Difference and matrix formulations
- 5) Formulate numerical approaches to circuit simulation
- 6) Understand and apply techniques used in Molecular Dynamics.
- 7) Understand and apply techniques used in Monte Carlo Simulation. In particular with respect to particle simulation.

## Graduate Attributes

N/A

## 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 acknowledgment;
- Submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own;
- Failing to acknowledge sources of information through the use of proper citations when using another's work and/or failing to use quotations marks; and
- Unless explicitly permitted by the instructor in a specific course, the use of generative AI and similar tools to produce assessed content (such as text, code, equations, images, summaries, videos, etc.).

## Academic Accommodations

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

**Pregnancy obligation:** Contact us 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 ([click here](#)).

**Religious obligation:** Contact us 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 more details [click here](#).

**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](mailto:pmc@carleton.ca) for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send us your 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, contact us, if needed, to ensure that accommodation arrangements are made.

You should request your academic accommodations in the [Ventus Student Portal](#), for each course at the beginning of every term. For in-term tests or midterms, please request accommodations at least two (2) weeks before the first test or midterm.

Please consult the [PMC website](#) for the deadline to request accommodations for formally-scheduled exams (if applicable).

**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>

**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 us 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>