

ELEC 3105: Electromagnetic Fields

Introduction

In this course you will learn the foundations of electromagnetism, a field of study which is at the heart of both our understanding of the universe and countless technologies central to our societies. The bulk of the course will focus on electrostatics and magnetostatics, in free space and in matter. Towards the end of the term, we will consider time varying fields, introducing Maxwell's equations and seeing how accelerating electric charges produce electromagnetic waves.

Course Description and Requirements

Course Description: Vector calculus: gradient, divergence, curl, integration of vector fields. Electrostatics, magnetostatics. Boundary conditions. Poisson's and Laplace's equations: method of images, separation of variables, iterative method. Electric and magnetic properties of matter. Magnetic circuits. Lorentz force. Motional emf, electromagnetic induction. Maxwell's equations.

Prerequisite(s): MATH 1005, MATH 2004, and (PHYS 1004 or PHYS 1002), and second-year status in Engineering.

Lectures: 3 hours a week.

Laboratory and problem analysis: 3 hours alternate weeks.

Instructor

Professor: Hubert Jean-Ruel (Minto 7068)

Email: hubertjeanruel@cunet.carleton.ca

Course Webpage: on Brightspace

Textbook and other learning material

- 1) Required textbook: M. Sadiku, "Elements of Electromagnetics", 7th edition, ISBN 9780190698614, \$61.99 to \$305.25 (depending on whether you rent or purchase it, and in the latter case whether you chose a digital or hardcopy).
- 2) Course notes: provided on Brightspace.
- 3) Slides presented during the lectures: provided on Brightspace.
- 4) Documentation for lab preparation: provided on Brightspace.

Lecture Outline

In person, January 6th to April 8th, Tuesday and Thursday, 11:35 am - 12:55 pm, LA B146.

The topics covered during the course lectures will include the following (approximate schedule):

Week 1: Introduction and vector calculus part 1

Week 2: Vector calculus part 2, electrostatic field, and Coulomb's law

Week 3: Gauss' law and electric dipole

Week 4: Electric potential and conducting materials part 1
Week 5: Conducting materials part 2
Week 6: Insulating materials part 1
Week 7: Insulating materials part 2 and introduction to magnetostatics
Week 8: Biot-Savart law and Ampere's law
Week 9: Magnetic dipole and magnetic vector potential
Week 10: Magnetization and magnetic materials
Week 11: Magnetic circuits and time varying fields
Week 12: Maxwell's equations and prediction of electromagnetic waves

Laboratory and Problem Analysis (PA) Sessions

3 hours (alternate weeks) as per schedule. Labs and PA sessions usually "alternate" from week to week and will be held according to the schedule posted on Brightspace. Labs will be held in Room ME4275 (which does not correspond to the location specified in Carleton Central). PAs will be held in the location specified in Carleton Central for your registered session.

Notes for Labs

- There are 5 labs as follows:
 - Lab 0: Orientation to Multisim Live (Simulation lab)
 - Lab 1: Numerical Solution to Laplace's Equation (Simulation lab)
 - Lab 2: Numerical Solution of Magnetostatic Problems (Simulation lab)
 - Lab 3: Cable impedance (Hardware lab)
 - Lab 4: Near-field induction communication (Hardware lab)
- You must attend your lab in the session you are registered. Changing sessions is not allowed without the instructor's permission. A TA will take attendance at each lab session.
- If for some reason a Lab needs to be rescheduled OR a Lab falls on one of the University holidays, students in those sections must try to rearrange their schedule to make up the lab in another of the regularly scheduled lab sessions, as arranged by the instructor.
- Attend each lab punctually and be prepared. Carefully read the lab documentation and pre-lab requirements in advance of your lab session. Some labs require that the pre-lab be completed prior to the lab. When it is the case, TAs will examine that the pre-lab is completed at the start of the lab. Should you not have your prelab completed, or with you, you will be asked to leave the lab and return when you have completed the prelab.
- A lab report will be submitted online for each lab and by each student. Each lab report is due 72 hours from the end of your lab session; there is a penalty of 20% per day for late lab reports. The reports should be high-quality documents (neat, legible, and coherent) submitted in PDF file format. The students have the choice of software to prepare the reports. The reports should convey all data, calculations, graphs, conclusions, and discussions. The reports will be graded based both on the content and on the presentation quality. Please retain records of your graded lab reports until the end of term in case they are needed to confirm your grades.

Notes for PA Sessions

- Several problems will be assigned as homework to help understand the lecture material, prepare for the midterm exams and final exam. To learn the course material, **it is essential that you attempt solutions for these problems before the PA session.** Solutions to these problems will be reviewed in the PA sessions.

- Due to a shortage of TAs this term, certain PA sessions may consist of video recordings. If it is the case, more office hours will be provided on these weeks to help answering questions.

Self-Declaration form and Deferred Term work

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for a missed lab 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 of the lab. You will need to request a makeup lab session, as lab exemptions cannot be granted. 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.

Evaluation and Grading Scheme

The cumulative course grade will be determined as follows:

- | | |
|--|-----|
| • 4 laboratories (Labs 1-4): | 20% |
| • 2 assignments | 15% |
| • 2 midterms (best one worth 15%, the other 10%) | 25% |
| • Final Exam | 40% |

To pass the course you need:

- A minimum overall grade of 50%.
- A minimum of 50% on the final exam.
- To have completed all labs and submitted all 4 lab reports.

Notes for assignments

- You are expected to solve and understand all the problems in the Assignments.
- You are allowed and encouraged to work with other classmates on the problem sets, this is for the benefit of understanding the material. Please credit your collaborators if there are any.
- You will be required to submit your assignment on the due dates soon to be listed on Brightspace (there is a penalty of 20% per day for late assignments).
- Please retain records of your graded assignments until the end of term in case they are needed to confirm your grades.

Notes for midterms

- Held during lecture time; dates soon to be posted on Brightspace.
- Closed book but a formula sheet will be provided.
- Non-programmable university exam approved calculator will be permitted.
- No collaborations of any sort permitted will be permitted; it will be flagged as plagiarism.

Notes for final exam

- Will be scheduled through examination services.
- Closed book but a formula sheet will be provided.
- Non-programmable university exam approved calculator will be permitted.
- Final exams are for evaluation purposes only and will not be returned to the student

Self-Declaration form and Deferred Term work

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for a missed midterm 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 of the midterm. You will need to request a weight transfer. 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.

Learning Outcomes

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

- 1) Apply vector calculus in different coordinate systems to solve electromagnetic problems.
- 2) Calculate the electric field and electric potential for various discrete and continuous charge distributions.
- 3) Explain the effects of placing a conductor or dielectric in an external electric field, describe capacitance, and solve associated problems.
- 4) Calculate the magnetostatic field for various distributions of DC currents.
- 5) Explain magnetization, describe magnetic materials and inductance, and solve associated problems.
- 6) Explain the implications of time varying fields, describe Maxwell's equations, and solve associated problems.

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.

This following list provides the GAs that will be measured in this course, along with the indicators that are intended to develop and assess these attributes.

Graduate Attribute and Level	Indicators or Area for Specialization	Methods used for Evaluation
GA-1 Knowledge base for Engineering Level A--->D	DOE-6 Electromagnetics	Dedicated exam questions
GA-2 Problem Analysis Level D	2.1 Problem definition 2.2 Approach to the problem 2.3 Use of assumptions 2.4 Interpreting the solution, validity of results	Dedicated assignment questions

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 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>