Carleton University Department of Electronics

Winter 2026

ELEC 3909 ELECTROMAGNETIC WAVES

Introduction

ELEC3909 provides students with a solid foundation in electromagnetics. The course covers Maxwell's equations, EM wave propagation, polarization, and energy flow through the Poynting vector. Students also explore transmission lines, impedance matching, and Smith charts, concluding with an introduction to guided waves and the slab waveguide. By bridging theory and practical applications, this course equips students with critical analytical skills essential for advanced studies and careers in electromagnetics, wireless communication, and photonics.

Course Description and Requirements

Maxwell's equations and EM wave solutions. Polarization. Poynting vector. EM waves in dielectrics and conductors; skin depth. Reflection and refraction. Standing waves. Fresnel relations, Brewster angle. Transmission lines. Line termination, basic impedance matching and transformation. Smith charts. Introduction to guided waves; slab waveguide.

Precludes additional credit for PHYS 3308.

Prerequisite(s): ELEC 3105 or permission of the Department.
Lectures 3 hours per week.
Laboratory and problem analysis 3 hours per week alternate weeks.

Instructor

Professor Winnie Ye, Room MC3074
Email: winnie.ye@carleton.ca
Course Webpage: on Brightspace
Office hour: Wednesdays @4:00-5:00pm MC3074

Teaching Assistants:

Email: @cmail.carleton.ca
Email: @cmail.carleton.ca

Textbook

1) Lecture notes are provided on Brightspace

2) Recommended (but not necessary) textbook: M.N.O. Saidiku, **Elements of Electromagnetics**, (Oxford University Press, 5th, or 6th, or 7th). Carleton bookstore has the textbook for $305.25 (hardcopy) or $95.37 (digital copy). There are also digital rental versions available at the bookstore. Additional material can be found in:

S. M. Wentworth, **Applied Electromagnetics: Early Transmission Lines Approach**, (Wiley). Both of these textbooks are also on reserve for 2-hour in-library use. The books can also be ordered on Amazon or other web storefronts in either paperback or hardcover, new or used, probably for less money.

Lecture Outline

In person, Mondays & Wednesdays & Fridays 17:35-18:55, SA403
The following topics will be covered during the course lectures with an approximate schedule.

Week 1: Introduction; transmission lines
Week 2: Transmission lines
Week 3-4: Impedance matching, Smith Charts, Transients, and S-parameters
Week 5-6: Plane EM Waves in infinite media
Week 7-8: Plane EM Waves reflection and transmission
Week 9-10: Guided Waves
Week 11-12: Waveguides

Laboratories and Problem Analysis Sessions

3 hours alternate weeks as per schedule. PAs start the week of January 20th (Week 3).

L1O (TA:): Fridays 08:35 - 11:25 (Odd, starts on Jan 23rd) CB3101

L2E (TA:): Fridays 08:35 - 11:25 (Even, starts on Jan 30th) CB3101

L3O (TA:): Fridays 14:35 - 17:25 (Odd, starts on Jan 23rd) CB3101

Notes on the course Project:

A course project that uses a software **Ansys High Frequency System Simulator (HFSS)** will be assigned at the beginning of the term. A tutorial on **HFSS** will be available online. More details on the deliverables will be available on Brightspace.

Notes for PA Sessions

- Several problems will be assigned each week as homework to help understand the lecture material, prepare for the midterm exam 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 provided prior to the PA sessions.
- The first 1.5 hour of the PA session will be focused on the PA problem sets. The TAs will answer questions and help with the problem sets. The next 30 minutes can be dedicated to the Ansys High Frequency System Simulator (HFSS) project, based on student requests. During this time, students may also choose to continue working on course material with TA support.
- Missing a quiz without a valid reason will result in a mark of zero for that quiz. If you know in advance that you cannot attend a quiz, and can support it with a valid reason, then we can possibly arrange for an accommodation.
- No discussions between students allowed. Any evidence of discussions, cheating, or something similar, during both the final exams or quizzes, will have serious consequences.
- Students are NOT ALLOWED to attend the PA session they are not registered in – NO EXCEPTIONS.

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.

Evaluation and Grading Scheme

The cumulative course grade will be determined as follows:

- 55% Final Exam on campus during normal scheduled exam period. Final exams are for evaluation purposes only and will not be returned to the student.
- 32% 2 Midterm exams on campus scheduled on**,** in Room
- 13% Course HFSS Project

To pass the course you need:

- Minimum overall grade of 50%
- Minimum of 50% on the final exam.
- Grades will be assigned based on the criteria listed above ONLY and converted into a letter grade as defined in the Carleton Course Calendar.

Students must review their project and grades as soon as they are given back to them. Any marking concerns, and clarifications must first be directly addressed to the TA. In the case TA's clarifications are not sufficient or students are not satisfied with their markings, they must bring this to the instructor's attention as soon as possible. This MUST be done before **April 4, 2025**.

Learning Outcomes

1) Apply basic concepts of electromagnetic theory, fields and waves, to problem solving.
2) Apply basic concepts of transmission lines, to problem solving.
3) Analyze impedance matching, Smith Charts, Transients, and S-parameters, to design transmission lines.
4) Apply Plane EM Waves in infinite media.
5) Analyze Guided Waves in rectangular waveguides and optical fibers.
6) Given a specifically designed question indicating an engineering problem to solve, the course design project uses a commercial design software HFSS to provide an engineering solution.

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		**Indicators**	**Methods used to Evaluate**
1. A knowledge base for Engineering	Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.	Percentage is applied to questions assessing knowledge base in discipline specific knowledge area such as Electrical Engineering. DOE-6;	Dedicated quiz/exam questions
2. Problem Analysis	An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.	1. Problem definition 2. Approach to the problem 3. Use of assumptions 4. Interpreting the solution, validity of results	Dedicated quiz/exam questions
4. Design	An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.	4.1 Design: Clear design goals, 4.2 - Design: Detailed design specifications and requirements, 4.4 - Design: Design solution(s), 4.5 - Design: Design implementation / task(s) definition, 4.6 - Design: Alternate solution(s) definition, 4.7 - Design: Evaluation based on engineering principles	HFSS course project

Copyright

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

- "Carleton University Medical Form" (see the "Downloads" section at the bottom of this page)
- https://carleton.ca/registrar/academic-consideration-coursework-form/