# ELEC ENG 2FH4
## Electromagnetics I

COURSE OUTLINE

Please refer to course website for updated information.

## COURSE DESCRIPTION

Mathematical foundations of electromagnetics (selected topics of vector calculus); electrostatics, magnetostatics and conduction; introduction to time-varying fields through Faraday's law and the wave equation.

## PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): ELECENG 2CI5 and PHYSICS 1E03; registration in Electrical Engineering or the Integrated Biomedical Engineering and Health Sciences (IBEHS) Program

## SCHEDULE

Lecture: Mondays, Wednesdays, Thursdays, 10:30 am – 11:20 am, ITB AB102
Tutorial: Mondays and Wednesdays, 5:30pm – 6:20pm, ITB AB102
Lab: (None)

## INSTRUCTOR

Dr. Mohamed Bakr
Email: mbakr@mcmaster.ca
Office: ITB-A219
Phone: 905-525-9140 ext. 24079
Office Hours**:** Mondays, Wednesdays, and Thursdays 2:30 pm - 3:30 pm ; and by appointment

## TEACHING ASSISTANTS

Ying Chen, Tamaghua Gupta, Mohamed Bagheri, Mohamed Abdelmagid, Mina Naguib, Imaad Ali-Mohammed

Contact information and office hours are provided on Avenue To Learn.

## COURSE WEBSITE/S

http://avenue.mcmaster.ca

## COURSE OBJECTIVES

By the end of this course, students should be able to:

- Ability to link the electric field strength and orientation to the distance to charge distributions and charge configurations or distributions (Indicators 1.2, 1.3, 8.1).
- Ability to link the magnetic field strength and orientation to the distance of electric current configurations or distributions (Indicators 1.2, 1.3, 8.1).
- Understanding the field theoretical origins of Kirchhoff's voltage and current laws and these laws' limitation when applied to high-frequency fields (Indicators 1.2, 1.3, 2.1).
- Understanding the principle of superposition and the difference between the superposition of scalar field quantities and that of vectorial field quantities (Indicators 1.2, 1.3).
- Understanding the limitations of the superposition principle as applicable to linear media only (Indicators 1.3, 2.1.)
- Understanding the impact of metals on static electric fields and the use of metals for shielding and electrical isolation (Indicators 1.3, 2.1, 8.1).
- Understanding the phenomenon of dielectric polarization and ability to predict the capacitance of simple structures (Indicators 1.2, 1.3).
- Understanding the phenomenon of electrical conduction and the concept of resistance (or conductance). Understanding the difference between conductors and superconductors. Ability to predict the resistance of simple structures (Indicators 1.2, 1.3).
- Basic understanding of the interaction of the electric and magnetic field with matter and the concepts of heterogeneity, anisotropy and nonlinearity (Indicators 1.2, 1.3).
- Understanding the fundamental importance of the conservation of charge and its implications in circuit analysis and charge relaxation (Indicators 1.2, 1.3).
- Understanding the nature of electric energy, magnetic energy, power, and power dissipation (Indicators 1.2, 1.3).
- Understanding the link between the electric and magnetic field as the two sides of the same phenomenon, the electromagnetic field (Indicators 1.2).
- Ability to apply vector calculus to the solution of simple electric and magnetic analysis in the three basic orthogonal coordinate systems: rectangular, spherical, and cylindrical (Indicators 1.2, 5.2).
- Ability to create simple software for the calculation of electric and magnetic fields through the principle of superposition provided the charge or current sources are specified (Indicator 5.2).
- Understanding the process of discretization as an approximation of continuous media and field distributions. Understanding the impact of the discretization mesh on the accuracy of the solutions (Indicators 2.1, 5.2).

• Ability to understand the process of implementing an engineering idea and the associated labor and material costs (Indicators 6.1, 11.3).

## ASSUMED KNOWLEDGE

Mathematics: Calculus, basic matrix operations, ordinary differential equations.
Physics: Electric field of a point charge, Coulomb's law, Magnetic field of a straight wire with current, Ampère's law
Electrical Engineering: Kirchhoff's laws, resistors, capacitors, inductors

## COURSE MATERIALS

Required Texts:
1. Matthew N.O. Sadiku, *Elements of Electromagnetics*, 7th edition, Oxford University Press.
2. M.H. Bakr, *Matlab Experiments Manual for EE2FH3*, electronic manual, 2019.

Calculator:
Only the McMaster Standard Calculator (Casio fx-991 MS or MS Plus) will be permitted in tests and examinations. This is available at the Campus Store.

Course Notes and Assignments Guide:
Available for download from Avenue
Videos available through Dr. Bakr's YouTube Channel:
**http://www.youtube.com/channel/UCFQ_5eallhvHplhf9pdsVsw**

## COURSE OVERVIEW

| Week | Topic | Readings |
|---|---|---|
| 1 | Vector Algebra | Text Chs. 1 and 2, lecture notes |
| 2 | Vector Calculus | Text Ch. 3, lecture notes |
| 3 | Vector Calculus | Text Ch. 3, lecture notes |
| 4 | Electrostatic Fields | Text Ch. 4, lecture notes |
| 5 | Electrostatic Fields | Text Ch. 4, lecture notes |
| 6 | Fields in Different Materials | Text Ch. 5, lecture notes |
| 7 | Electrostatic Boundary Value Problems | Text Ch. 6, lecture notes |
| 8 | Magnetostatic Fields | Text Ch. 7, lecture notes |
| 9 | Magnetic Forces and Materials | Text Ch. 8, lecture notes |
| 10 | Magnetic Materials and Inductances | Text Ch. 8, lecture notes |
| 11 | Maxwell's Equations | Text Ch. 9, lecture notes |
| 12 | Maxwell's Equations | Text Ch. 9, lecture notes |

A more detailed time line is available on the course website. At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

## ASSESSMENT

| Component | Weight |
|---|---|
| Vector Calculus Test (January 27th and January 29th) | 10% |
| First Midterm | 10% |
| Second Midterm | 10% |
| Quizzes | 10% |
| MATLAB Assignments | 10% |
| Final Exam | 50% |
| Total | 100% |

## ACCREDITATION LEARNING OUTCOMES

Note: The *Learning Outcomes* defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: http://www.engineerscanada.ca .

| Outcomes | Indicators | Measurement Methods(s) |
|---|---|---|
| Ability to link the electric field strength and orientation to the distance to charge distributions and charge configurations or distributions. | 1.2, 1.3, 8.1 | Midterm, final and assignment |
| Ability to link the magnetic field strength and orientation to the distance of electric current configurations or distributions. | 1.2, 1.3, 8.1 | Final and assignments |
| Understanding the field theoretical origins of Kirchhoff's voltage and current laws and these laws' limitation when applied to high-frequency fields. | 1.2, 1.3, 2.1 | Final and assignments |
| Understanding the principle of superposition and the difference between the superposition of scalar field quantities and that of vectorial field quantities. | 1.2, 1.3 | Quizzes and final |

| | | |
|---|---|---|
| Understanding the limitations of the superposition principle as applicable to linear media only. | 1.3, 2.1 | Quizzes |
| Understanding the impact of metals on static electric fields and the use of metals for shielding and electrical isolation. | 1.3, 2.1, 8.1 | Final exam |
| Understanding the phenomenon of dielectric polarization and ability to predict the capacitance of simple structures. | 1.2, 1.3 | Midterms and Final |
| Understanding the phenomenon of electrical conduction and the concept of resistance (or conductance). Understanding the difference between conductors and superconductors. Ability to predict the resistance of simple structures. | 1.2, 1.3 | Quiz and final |
| Basic understanding of the interaction of the electric and magnetic field with matter and the concepts of heterogeneity, anisotropy and nonlinearity. | 1.2, 1.3 | Quiz |
| Understanding the fundamental importance of the conservation of charge and its implications in circuit analysis and charge relaxation. | 1.2, 1.3 | Midterm and final |
| Understanding the nature of electric energy, magnetic energy, power, and power dissipation. | 1.2, 1.3 | Midterm and final |
| Understanding the link between the electric and magnetic field as the two sides of the same phenomenon, the electromagnetic field. | 1.2 | Midterm and final |
| Ability to apply vector calculus to the solution of simple electric and magnetic analysis in the three basic orthogonal coordinate systems: rectangular, spherical, and cylindrical. | 1.2, 5.2 | Vector Test |
| Ability to create simple software for the calculation of electric and magnetic fields through the principle of superposition provided the charge or current sources are specified. | 5.2 | Assignments |
| Understanding the process of discretization as an approximation of continuous media and field distributions. Understanding the impact of the assumptions made on the accuracy of the electromagnetic solution. | 2.1, 5.2 | Assignments |
| Ability to understand the process of implementing and engineering idea and the associated labor and material costs. | 6.1, 11.3 | Assignments |

## ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.
Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university.
It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at www.mcmaster.ca/academicintegrity .
The following illustrates only three forms of academic dishonesty:
• Plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained.
• Improper collaboration in group work.
• Copying or using unauthorized aids in tests and examinations.

## ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca . For further information, consult McMaster University’s Academic Accommodation of Students with Disabilities policy.

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students requiring a RISO accommodation should submit their request to the Engineering Student Services office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations.

Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

## STUDENT ABSENCE AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar “Requests for Relief for Missed Academic Term Work”.

## EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be

communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

## AUTHENTICITY / PLAGIARISM DETECTION

In this course we will be using a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work.
Students will be expected to submit their work electronically either directly to Turnitin.com or via Avenue to Learn (A2L) plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.
Students who do not wish to submit their work through A2L and/or Turnitin.com must still submit an electronic and/or hardcopy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com or A2L. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). To see the Turnitin.com Policy, please go to www.mcmaster.ca/academicintegrity.

www.eng.mcmaster.ca/ece