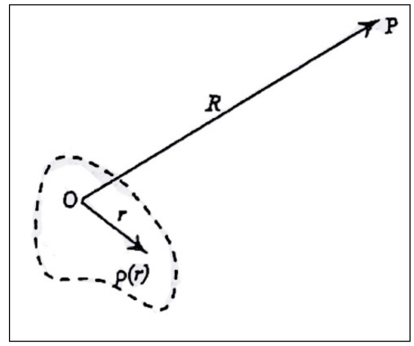
Physics 342
Electromagnetic Fields
Lafayette College
Fall 2023



Instructor

Instructor name: Prof. Salina Ali
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Meeting Times

Class meets MWF 10:00-10:50 AM in Hugel Science Center 017. At the start of the semester, we will schedule "fourth hour" meetings for small-group problem-solving.

Office hours

My office hours will be Monday 2:00-3:00 PM, Tuesday 11:00-12:00 PM, and Wednesday 1:30 PM-2:30 PM (any updates to office hours will be posted on Moodle). I am often available to meet at other times (including on Zoom), so feel free to email any time you would like to talk.

Required Texts

We will use the following texts:

- *Introduction to Electrodynamics* by David Griffiths, 4th edition, ISBN 9781108420419.
- *Div, Grad, Curl, and All That* by H. M. Schey, 4th edition, ISBN 9780393925166.

The texts are required, but you may access them however you wish. You can use a printed copy (used or new), an eText, or maybe you can find a pdf of the text somewhere. Skillman Library has a reserve desk from which you can borrow these books over short periods of time.

Prerequisites

Math 264, Physics 132/133/152, and Physics 218 are prerequisites for this course, but can be waived with permission of instructor.

Course Description

This one-semester course will cover electricity and magnetism at the junior/senior undergraduate level. The physics of electricity and magnetism seems to be explained extremely well by current theory (unlike some other fields of physics). Thus, almost all electromagnetic phenomena can be described using Maxwell's equations plus the Lorentz force law. This means that some parts of this course will look familiar – after all, you have already learned Maxwell's equations. This upper level course uses more rigorous mathematics as a tool to expand the range of problems we are able to solve in electrodynamics.

Although the fundamental physics of electromagnetism is well-understood, that does not make it trivial or uninteresting! On the contrary, it is one of the most relevant fields of physics to our daily lives. Almost all forces you encounter on a daily basis, besides gravity, are electromagnetic in nature. Friction and the normal force are some examples. Chemical bonds and biological processes are also electromagnetic in nature. The very powerful devices you use on a daily basis, such as smartphones, computers, and hard drives, rely on an understanding of electromagnetism inside materials.

Course grade

Your course grade will be determined based on a professional judgment of your work on the following:

Class Participation	10%
Homework	30%
Midterm Exam #1	15%
Midterm Exam #2	15%
Final Exam	30%

I will post homework and exam grades on Moodle. The exam grades may be re-scaled depending on the difficulty of the exam. I will use the following numerical score when setting letter grades:

A	93 and higher	B−	80 − <83	D+	67 − <70
A−	90 − <93	C+	77 − <80	D	63 − <67
B+	87 − <90	C	73 − <77	D−	60 − <63
B	83 − <87	C−	70 − <73	F	<60

Class Participation

Class participation includes taking notes, being engaged in class actively and regularly, asking questions, and maintaining a professional atmosphere during lecture.

Homework

Homework this semester will be posted on Moodle and handed out in class. There will be weekly homework assignments. You are expected to show the work on each problem including appropriate units.

Homework assignments will be due before class starts on Wednesdays, unless otherwise noted.

Normally there will be ten points per problem. Neatness, readability, and organization will count for 20% of the scores on these problems. Late work will be accepted through the end of the day on Wednesday. Late homework may be penalized by 50%.

I encourage you all to work together on the homework assignments - they are the heart of this course!

If you are having difficulty completing an assignment on time, please contact me. I can make accommodations in cases of illness, personal difficulties, etc.

Exams

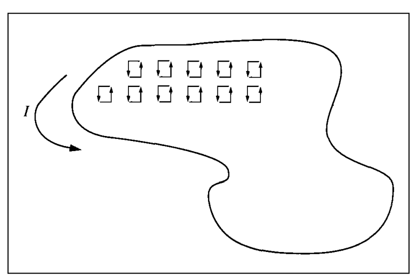
There will be two midterm exams:

- Midterm exam #1. Friday, October 6 (the day before fall break)
- Midterm exam #2. Monday, November 20 (Thanksgiving week)

Each midterm exam will be on the material covered in the preceding weeks of class (i.e., since the previous hour exam). Further details will be given before each exam.

There will be a comprehensive final exam during finals week covering all material in the course. The final exam will be three hours and will be scheduled by the Registrar.
Details of exam logistics (e.g., reference materials allowed during the exam) will be given in advance of each exam.

Course goals



The goals of this course are to develop a deep understanding of the fundamentals of electromagnetism and to learn and apply mathematical techniques applicable to a wide range of vector and field problems. We will achieve these goals by coverage of the topics listed on the next page.

Topic Coverage

The table below is an approximate weekly schedule of topic coverage. This will evolve over the course of the semester. A weekly list of topics will be given on each homework set.

Week	Dates	Topic	Text
1	Aug. 28–Sep. 1	Vector calculus; Electrostatic fields 1	Griffiths §1.2–1.3; §2.1–2.2; Schey
2	Sep. 4–Sep. 8	Electrostatic fields 2	Griffiths §2.1–2.2
3	Sep. 11–15	Potential, work, energy	Griffiths §2.3–2.5
4	Sep. 18–22	Calculating potentials 1	Griffiths §3
5	Sep. 25–Sep. 29	Calculating potentials 2	Griffiths §3
6	Oct. 2–6	Electric fields in matter 1; *Midterm #1*	Griffiths §4
7	Oct. 9–13	*Fall break*; Electric fields in matter 2	Griffiths §4
8	Oct. 16–20	Magnetostatics 1	Griffiths §5
9	Oct. 23–27	Magnetostatics 2	Griffiths §5
10	Oct. 30–Nov. 3	Magnetic fields in matter 1	Griffiths §6
11	Nov. 6–10	Magnetic fields in matter 2	Griffiths §6
12	Nov. 13–17	Electrodynamics 1	Griffiths §7
13	Nov. 20–24	*Midterm #2*; *Thanksgiving break*	
14	Nov. 27–Dec. 1	Electrodynamics 2	Griffiths §7
15	Dec. 4–8	Electromagnetics waves	Griffiths §9

Learning Outcomes: General

- Build on earlier material: Students should deepen their understanding of introductory electromagnetism material.
- Maxwell's Equations: Students should see the various laws in the course as part of a coherent theory of electromagnetism: i.e. Maxwell's equations.
- Math/physics connection: Students should be able to translate a physical description of an advanced undergraduate level electromagnetism problem into the mathematics necessary to solve it. Students should be able to explain the physical meaning of the mathematical formulation and achieve physical insight through the mathematics of a problem.
- Visualization: Students should be able to sketch the physical parameters of a problem.
- Communication: Students should be able to justify and explain their thinking and/or approach to a problem or physical situation.
- Problem-solving techniques: Students should be able to choose and apply problem- solving technique(s) appropriate to a given problem:
  - Approximations
  - Symmetries
  - Superposition and Integration
- Expecting and checking solution: When appropriate, students should be able to articulate their expectations for the solution to a problem and justify the reasonableness of a solution they have reached.
- Intellectual maturity: Students should be able to accept responsibility for their own learning. They should be aware of what they do and don't understand about physical phenomena

and types of problems. This is evidenced by asking sophisticated, specific questions, being able to articulate where in a problem they experienced difficulty, and taking action to move beyond that difficulty.

Learning Outcomes: Content-Specific

Student's will be able to:

- Compute gradient, divergence, curl, and Laplacian
- Evaluate line, surface, and volume integrals
- Apply the fundamental theorem for divergences (Gauss' Theorem) in specific situations
- Apply the fundamental theorem for curls (Stoke's Theorem) in specific situations
- Apply Coulomb's Law and superposition principle to calculate electric field due to a continuous charge distribution (uniformly charged line segment, circular or square loop, sphere, etc.)
- Apply Gauss' Law to compute electric field due to symmetric charge distribution
- Calculate electric field from electric potential and vice versa
- Compute the potential of a localized charge distribution
- Determine the surface charge distribution on a conductor in equilibrium
- Use method of images to determine the potential in a region
- Solve Laplace's equation to determine the potential in a region given the potential or charge distribution at the boundary (Cartesian, spherical and cylindrical coordinates)
- Use multipole expansion to determine the leading contribution to the potential at large distances from a charge distribution
- Calculate the field of a polarized object
- Find the location and amount of all bound charges in a dielectric material
- Apply Biot-Savart Law and Ampere's Law to compute magnetic field due to a current distribution
- Compute vector potential of a localized current distribution using multipole expansion
- Calculate magnetic field from the vector potential
- Calculate the field of a magnetized object
- Compute the bound surface and volume currents in a magnetized object
- Compute magnetization, H field, susceptibility and permeability
- Compute the electric field and emf due to a changing magnetic field (Faraday's law)
- Compute the magnetic field due to a changing electric field (time-dependent term of Ampere's law)
- Use Maxwell's equations to derive the wave equation

Course policies

Intellectual honesty

You are expected to abide by the principles of intellectual honesty outlined in the Lafayette Student Handbook available at http://conduct.lafayette.edu.

Learning is a collaborative process, I encourage you to discuss and collaborate with other students on homework. "Collaboration" does not mean "copying." You must understand and individually write out your answer to each problem, and cite clearly any outside resources used.
Exams must be done on your own, using only materials specifically allowed.

Accommodation

My policy. It is important to me that you do well in this class. If you have any disabilities which you feel may interfere with your ability to succeed and prosper in this class, please contact me to discuss ways of accommodating them.

Mandatory statement for any Lafayette course with a disability policy. In compliance with Lafayette College policy and equal access laws, I am available to discuss appropriate academic accommodations that you may require as a student with a disability. Requests for academic accommodations need to be made during the first two weeks of the semester, except for unusual circumstances, so arrangements can be made. Students must register with the Office of the Dean of the College for disability verification and for determination of reasonable academic accommodations.

Mandatory Moodle privacy statement

Moodle contains student information that is protected by the Family Educational Right to Privacy Act (FERPA). Disclosure to unauthorized parties violates federal privacy laws. Courses using Moodle will make student information visible to other students in this class. Please remember that this information is protected by these federal privacy laws and must not be shared with anyone outside the class. Questions can be referred to the Registrar's Office.

Mandatory credit hour statement

The student work in this course is in full compliance with the federal definition of a four credit hour course.