ELECTROMAGNETIC THEORY I

Phys 311 Fall 2025

Instructor:	Professor David Collins
Office:	WS 228B
Phone:	248-1787
email:	dacollin@coloradomesa.edu

Office Hours:	M 1 – 2pm, T 1 – 2pm, W 9 – 10am, Th 11am – 12noon, F 2 – 3pm
Class Meetings:	TTh 2:00pm – 3:15pm, EH 129
Course Website:	Phys 311 Website, Fall 2025
Required Text:	D. J. Griffiths, *Introduction to Electrodynamics,* 5$^{\text{th}}$ ed, Cambridge University Press (2024).
Prerequisites:	Phys 132/132L, Math 236 or Math 260

Overview

Electromagnetism provides a complete description of electric and magnetic forces, which determine all interactions between charged objects. Much of the material world consists of charged particles and the combination of the range and strength of electric and magnetic forces means that these are the dominant interactions which govern our everyday experience. Maxwell's unified description of electric and magnetic forces and the link that he established between electromagnetic waves and light were the crowning glory of 19$^{\text{th}}$ century physics. Much of our understanding of the physical world and our abilities for manipulating it stem from the body of work which he synthesized.

Physics 311 offers detailed coverage of the key concepts and techniques of classical electromagnetism, leading up to Maxwell's equations and using the full tools of vector algebra and calculus. One goal of this course is to expose you to the fundamental concepts and mathematical techniques of this theory, which plays an important role in theoretical discussions in most subfields of physics. But electromagnetism is more than a mere theoretical endeavor; it enters into the majority of experiments in the physical sciences. The second goal of this course is to equip you with the theory which is crucial for understanding and managing experimental and applied aspects of the physical sciences.

The course covers:

1. Mathematical tools: vector algebra, calculus in three dimensions.
2. Electrostatics, Coulomb's law, Gauss' law.
3. Work and energy in electrostatics, electric potential, Poisson's equation, Laplace's equation.

4. Multipoles.
5. Magnetic fields and forces, Biot-Savart law, Ampère's law, magnetic vector potential.
6. Induction, Faraday's law.
7. Maxwell's equations.
8. Electric fields in matter, polarization, dielectrics.

Assignments

An undergraduate student should expect to spend on this course a minimum of two hours outside the classroom for every hour in the classroom. The outside hours may vary depending on the number of credit hours or type of course. More details are available from the faculty member or department office and in CMU's Curriculum Policies and Procedures Manual.

1. **Homework:** There will typically be one homework assignment per class meeting. This will be due by 5pm on the date indicated on the assignment. Late homework will be subject to a penalty of at least a 2% reduction in maximum grade for each hour that the work is late. It is in your best interests to work by yourself on the homework problems but collaboration is acceptable. You can discuss the broad outlines of problem solutions with your colleagues but must write your final solutions independently. You are also encouraged to consult me for help with homework problems.

Exams and Quizzes

1. **Class Exams:** There will be two exams during class on the following days:

   Exam 1: October 2, 2025
   Exam 2: November 13, 2025

   Exams will be closed book and closed notes although you will be able to bring a formula sheet. Calculators will be allowed.

2. **Final Exam:** There will be a final exam at **2:00pm on Tuesday, December 9, 2025**. The final will last one hour and 50 minutes and be comprehensive and closed book although a formula sheet will be allowed. Calculators will be allowed.

Grades

Individual assignments and exams will be graded using suitable scales. In general, to get full credit (100%) for a problem your solution must be correct and well justified. Partial credit will be given for incomplete or partly correct solutions. No credit (0%) will be given for problems not attempted, assignments not turned in or quizzes and exams missed without good reason.

The numerical grades for each component will be totaled and a final numerical grade will be computed according to the following distribution.

Homework	30%
Class Exams	40%
Final Exam	30%

The following final numerical scores will guarantee letter grades:

90%	A
80%	B
70%	C
60%	D

Policies

1. **Helpful Resources:**The Center for Academic Support (CAS) provides FREE tutoring and writing support across all disciplines to CMU and CMU Tech students in a variety of subject areas. Peer tutors are available to support your learning and help you with your questions. CAS offers four different tutoring options to students: in-person tutoring (one-on-one), online tutoring, group tutoring, and writing help. Check out the CAS website or or email tutoring@coloradomesa.edu with any questions.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students should contact Educational Access Services at 970-248-1856 or Houston Hall 108 as soon as possible. Please visit Educational Access Services for additional information.

2. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **September 2, 2025.** Please consult the CMU academic calendar and catalog for more details about adding and dropping courses.

3. **Attendance:** Attendance policies are described in the Maverick Guide. You are expected to attend all the class meetings and attendance will be recorded. In case of an absence due to illness, another emergency, or a conflicting CMU-sanctioned event, you must be able to produce the *appropriate documentation from someone other than you* that attests to the conflict or absence. If you miss a class for a *documented* valid reason, turn in any assignments due within two business days after the end of the documented absence period. If you miss more than half of the class meetings in the first week of the semester, you will be dropped from the course.

   The dates of the class exams and final exam are set at the beginning of the semester and these have priority over any other events. If you have an event that conflicts with these **and** that was scheduled before the start of the semester, you must notify the instructor about this prior to **Friday, August 22, 2025**, provide documentation from someone other than you that attests to the event and I will arrange an alternative test time. If you notify the instructor about a conflict after **Friday, August 22, 2025**,

the possibility of taking the test at an alternative time will depend on the nature of the conflict (e.g. illness, CMU athletic events, other emergencies). In this case you must explain the nature of the conflict to the instructor, provide documentation from someone other than you that attests to the conflict and the instructor will decide whether the absence warrants an alternative testing time or arrangement. Alternative testing times will be decided by the instructor.

4. **Academic Integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from any source, particularly in closed book exams, are serious violation of academic norms. CMU has extensive policies on these matters and penalties for infringement can be severe. For more details, consult the academic integrity policies in the Maverick Guide.

   You are prohibited from using sources, of any type, which provide solutions to homework assignment or exam problems. These include AI sources that generate solutions to homework problems. Students who are discovered to have submitted any assignment or exam problem to any such service that provides solutions or have used any such service to obtain or view solutions to any assignment or exam problem will receive zero credit for that entire assignment and the instructor will submit a Report of Academic Dishonesty with the Office of Academic Affairs. Additional penalties may be levied in such cases.

Student Learning Outcomes

A student who has taken this course will demonstrate the ability to:

1. Translate between verbal and mathematical descriptions of physical situations. Apply mathematical reasoning, using vectors and vector calculus, to analyze these situations.
2. Apply Coulomb's Law to obtain the electric field of a system of charged particles and extended objects.
3. Compute electrostatic potentials for various charge distributions.
4. Use Gauss' Law to obtain the electric field of various charge distributions.
5. Apply the technique of multipole expansion to arrive at the approximate electric potential at large distances.
6. Use the Lorentz force law to analyze the motion of a charged particle in various physical situations.
7. Apply Biot-Savart Law to obtain the magnetic field produced by various steady current distributions.
8. Use Ampère's Law to obtain the magnetic field of various steady current distributions.

This course contributes to the fulfillment the following program learning objectives for the BS in Physics degree. A student will have demonstrated the ability to:

1. Show fluency with the major fields of physics (classical mechanics, electromagnetism, statistical physics and quantum theory).
2. Use mathematical representations to analyze physical scenarios. This requires translating back and forth between physical and mathematical problems and using appropriate mathematics to aid in the analysis of the scenario.

Schedule

The following schedule is tentative, except for the dates of the class exams.

Week	Dates	Topic
1	8/18 – 8/22	Overview, vector calculus (Ch 1.1 – 1.2).
2	8/25 – 8/29	Differential and integral vector calculus (Ch 1.2 – 1.3).
3	9/1 – 9/5	Green's and Stoke's theorems, curvilinear coordinates (Ch 1.3 – 1.4).
4	9/8 – 9/12	Vector fields, electric fields (Ch 1.6, 2.1 – 2.2).
5	9/15 – 9/19	Gauss' law (Ch 2.2).
6	9/22 – 9/26	Electrostatic potential, energy in electrostatics (Ch 2.3–2.4).
7	9/29 – 10/3	Conductors, capacitance, **Exam I** (Ch 2.5).
8	10/6 – 10/10	Laplace's equation, multipole expansion (Ch 3.1, 3.4).
9	10/13 – 10/17	Multipole expansion (Ch 3.4).
10	10/20 – 10/24	Magnetostatics, Lorentz force law, Biot-Savart Law (Ch 5.1 –5.2).
11	10/27 – 10/31	Ampère's law, magnetic vector potential (Ch 5.3 –5.4).
12	11/3 – 11/7	Magnetic vector potential, magnetic multipoles (Ch 5.4).
13	11/10 – 11/14	Electromotive force, **Exam II** (Ch 7.1).
14	11/17 – 11/21	Faraday's law (Ch 7.1 – 7.2).
15	11/24 – 11/28	Thanksgiving (no classes).
16	12/1 – 12/4	Maxwell's equations (Ch 7.3 – 7.4).