ELECTROMAGNETIC THEORY

Phys 311 Fall 2020

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Office Hours: M 11:00am - noon, T 10:00 – 11:00am, W 3:00 – 4:00pm, R 2:00 – 3:00pm, F 11:00am - noon

Class Meetings: MWF 10:00am – 10:50am, WS 366

Course Website: http://www.coloradomesa.edu/~dacollin/teaching/2020Fall/Phys311/index.html

Required Text: D. J. Griffiths, *Introduction to Electrodynamics,* 4th ed, Prentice Hall (2013).

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^{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: 2 October 2020
   Exam 2: 13 November 2020

   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 **10:00 am on Monday 7 December 2020**. 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	40%
Class Exams	30%
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 Tutorial Learning Center (TLC) is a *free* academic service for all CMU students. Tutors are available in Houston Hall 113 on a walk-in basis for many courses. More information is available at www.coloradomesa.edu/tutoring or 248-1392.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students must register with the EAS office to receive assistance. Please meet with the instructor the first week of class for information and/or contact Educational Access Services, directly by phone at 248-1801, or in person in Houston Hall, Suite 108.

2. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **1 September 2020.** Please consult the CMU academic calendar and catalog for more details about adding and dropping courses.

3. **Attendance:** Attendance policies are described in the CMU catalog. You are expected to attend all the class meetings. In case of illness or other emergencies you must be able to produce the appropriate documentation. There are other circumstances under which you can be excused but you must discuss these with me in advance. If you miss a class or lab for a valid reason, turn in any assignments due before the start of the next class. Assignments turned in beyond your return to class will not be accepted.

   If there is an unavoidable conflict with one of the class exams or the final exam, please discuss it with me as soon as possible. In general I will assume that the final exam will have priority, since you know the dates of the exam.

4. **Academic integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from anyone else, 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 CMU catalog.

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 algebra, trigonometry and 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	8/17 – 8/21	Overview, vector calculus (Ch 1.1 – 1.2).
2	8/24 – 8/18	Differential and integral vector calculus (Ch 1.2 – 1.3).
3	8/31 – 9/4	Green's and Stoke's theorems, curvilinear coordinates (Ch 1.3 – 1.4).
4	9/7 – 9/11	Vector fields, electric fields (Ch 1.6, 2.1 – 2.2).
5	9/14 – 9/18	Gauss' law (Ch 2.2).
6	9/21 – 9/25	Electrostatic potential, energy in electrostatics (Ch 2.3–2.4).
7	9/28 – 10/2	Conductors, capacitance, **Exam I** (Ch 2.5).
8	10/5 – 10/9	Laplace's equation, multipole expansion (Ch 3.1, 3.4).
9	10/12 – 10/16	Multipole expansion (Ch 3.4).
10	10/19– 10/23	Magnetostatics, Lorentz force law, Biot-Savart Law (Ch 5.1 –5.2).
11	10/26 – 10/30	Ampère's law, magnetic vector potential (Ch 5.3 –5.4).
12	11/2 – 11/6	Magnetic vector potential, magnetic multipoles (Ch 5.4).
13	11/9 – 11/13	Electromotive force, **Exam II** (Ch 7.1).
14	11/16 – 11/20	Faraday's law (Ch 7.1 – 7.2).
15	11/23 – 11/27	Thanksgiving (no classes).
16	11/30 – 12/4	Electric fields in matter, polarization (Ch 4).