Spring 2023 **Syllabus**

Physics 401: Electricity & Magnetism I

MW 5:00-6:20 pm in Small Hall room 110 (or 111)

Undergraduate prerequisites: PHYS 208 (Classical Mechanics 1)

Instructors

Prof. Seth Aubin
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Office hours: Aubin: Tuesday 3-4 pm; Sturzu: Monday 3-4 pm

Course Objectives

The primary purpose of this course is to introduce the basic physics and applications of electrostatic and magnetostatic fields.

The course will cover the following topics:

- Vector calculus, divergence, curl, Laplacian.
- Boundary value problems.
- Electrostatics, Coulomb's law, electric fields, potentials.
- Method of images, separation of variables, multipoles.
- Electric fields in matter, conductors, dielectrics.
- Capacitance, bound charge, Ohm's law.
- Magnetostatics, magnetic fields, Lorentz force law.
- Biot-Savart law, Ampère's law, magnetic vector potential.
- Magnetization, bound currents, the auxiliary field.
- Basic electrodynamics, Faraday's law, inductance.

Textbook

Most of the course materials and problem sets will be taken from the following required text for the course:

Introduction to Electrodynamics by D. Griffiths, Pearson (4th ed.).

Other useful texts:
Modern Electrodynamics, by A. Zangwill
The Feynman Lectures on Physics, by R. Feynman, R. Leighton, M. Sands.

Evaluations

Your final grade for the course will be determined from the following grading weight distribution:

Problem sets:	45%
Participation:	10%
Midterm:	15%
Final Exam:	30%

Problem sets: The problem sets are the main evaluation of learning for the course and also serve as a significant means of learning the material. Students are expected to do the problems on their own (not as a team effort with other students), though discussion and limited oral consultation with other students is encouraged. The solution manual for the main text is not an acceptable source for solving problem sets before they are due.

Participation: The classroom presentation of course material will involve class discussions. All students are expected to participate in these discussions, since they will help elucidate the course material. Participation also reflects class attendance and the occasional quiz.

Midterm: The midterm will cover course material from the first half of the course.

Final exam: The final exam will cover all the material in the course, but with an emphasis on the second half of the course.

Important academic deadlines

Add/drop deadline: Friday, February 3, 2023
Withdraw deadline: Monday, March 27, 2023

Weekly Schedule (tentative)

Week 0: 1/25 **Review of Vector Calculus, part 1**
Vector fields, scalar and vector products, gradient, divergence, curl, Laplacian.

Week 1: 1/30-2/1 **Review of Vector Calculus, part 2**
Gauss's theorem, Stokes's theorem, curvilinear coordinates, Dirac delta function.

Week 2: 2/6-8 **Electrostatics, part 1**
Coulomb's law, charge distributions, Gauss's law, electric potential, Earnshaw theorem.

Week 3: 2/13-15 **Electrostatics, part 2**
Poisson's equation, electrostatic energy, perfect conductors, capacitors.

Week 4: 2/20-22 **Method Images & Separation of Variables**
Laplace's equation, uniqueness theorem, method of images, separation of variables.

Week 5: 2/27-3/1 **Separation of Variables**
Cartesian symmetry, series solutions, spherical symmetry, Legendre polynomials.

Week 6: 3/6-8 **Multipole Expansion & Dipoles -- Midterm**
Multipole expansion, dipole fields.
----- Midterm on March 8 -----

Week 7: 3/13-15 **Spring Break !!!**

Week 8: 3/20-22 **Electric Fields in Matter, part 1**
Dipole forces, dielectrics, bound charges, polarizability, electric displacement field.

Week 9: 3/27-29 **Electric Fields in Matter, part 2**
Linear dielectrics, dielectric constant, capacitors, energy, separation of variables.

Week 10: 4/3-5 **Magnetostatics, part 1**
Magnetic fields, Lorentz force law, current density, Biot-Savart law, Ampère's law.

Week 11: 4/10-12 **Magnetostatics, part 2**
Ampère's law, vector potential, multipole expansion, magnetic dipoles, forces on dipoles.

Week 12: 4/17-19 **Magnetic Fields in Matter**
Diamagnets, paramagnets, bound currents, auxiliary field, magnetic susceptibility.

Week 13: 4/24-26 **Faradays' Law**
Ohm's law, electromotive force, induced electric field, inductance, magnetic energy.

Week 14: 5/1-3 **Maxwell's Equations**
Ampère's improved law, electromagnetic waves.

May 9, 2023, 7-10 pm **Final Exam**