Ph. 213 Electromagnetic Phenomena
Cooper Union Albert Nerkin School of Engineering
Section D: Tuesday 6–8, Thursday 6–8, Room 105

Prof. Michael Hahn
Email: michael.hahn@cooper.edu
Course website: **Moodle** `https://moodle.cooper.edu/`.
Office Hours: before or after class or online by appointment

Last Updated August 19, 2025

Course Description: (4-credits) In Mechanics, we studied how objects move under the influence of forces. This semester, the focus will be on one particular force: Electromagnetism. To start, though, we will study mechanical waves, the wave equation, interference, Doppler shift, and Fourier transforms. Next comes electrostatics, where we study the force due to stationary electric charges and charge distributions. This introduces the concept of a "field" as well as the electric potential. Later, we allow the charges to move and see that moving charges produce magnetic fields and magnetic forces. The properties of electric and magnetic fields are described by Maxwell's equations. Using those equations, we will study electric circuits and see how light waves arise from the interaction of electric and magnetic fields. This brings us full circle back to the subject of waves.

Prerequisite(s): Successful completion of PH 112 Physics I. Mechanics. Co-requisite MA 223 Vector Calculus. Of note – we will be using more integral calculus and making more explicit use of vectors than in PH 112.

Goals and Objectives: The objective of this course is for you to understand the basic principles of waves and electromagnetism. More specific objectives can be found in the **Objectives** document posted on Moodle, which can also serve as a comprehensive study checklist for you. Your ability to meet these goals will be assessed via quizzes and exams.

ABET Outcomes: ABET is an organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology. As part of the accreditation process, engineering programs are required to assess student outcomes that are acquired by students who are enrolled in the program. Student outcomes are succinct statements that describe what students are expected to know and be able to do by the time of graduation. These outcomes relate to skills, knowledge and behaviors that students acquire as they progress through the program. The outcomes most closely associated with this course (taken from the ABET website) are: (1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. (5) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives. (7) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Textbooks and Other Resources:
The required text is ***Fundamentals of Physics*, 9th Edition Holliday, Resnick, and Walker (HRW)** A pdf copy of the 9th edition should be available online.

Below are some resources you might consult for an alternative perspective, but they are not required. Everything you need for class is in HRW or notes presented in lecture.

Matter and Interactions by Ruth Chabay and Bruce Sherwood - This is an introductory physics textbook that takes a very different approach from HRW. It emphasizes fundamental principles and the dynamics at a microscopic level (what are the atoms/protons/electrons doing?).

Fundamentals of Physics vols. I and II (The Open Yale Courses Series) by R. Shankar - These are written in a rather breezy conversational style and cover mechanics, electricity and magnetism, and special relativity. The best thing about them is that they are physically small and relatively inexpensive. They could be a good option if you have some time to read on the subway and don't want to lug around HRW. Also, the free website is a good source of problems and solutions for study.

The Internet - Many schools have online introductory physics courses (MIT, Yale, etc.). They often post problem sets for those online courses and the accompanying solutions. You can find good practice problems there.

A Student's Guide to Waves by Daniel Fleisch and Laura Kinnaman - Has a nice discussion of phasors and derivations of the wave equation.

Homework, Quizzes, and Exams

Homework: Homework will be assigned and posted on Moodle each week. I will not collect homework, but you will need to do it in order to be fully prepared for quizzes and exams. You may need also need additional practice beyond what is assigned.

(1) Reading assignments - you should read the chapters before we discuss the topic in class. Lectures will make more sense if you are not seeing the material for the first time. I would like to spend class time discussing more interesting or challenging material and will omit some basic topics, because I expect you to have read them in the book. While you are reading, pick 1 or 2-dot problems from each section to check your understanding. Reading the chapter with the aim of figuring out how to do the problem can help you identify the important information.

(2) Problems. I will assign problems from HRW as well as some problems that tend to be more challenging. Try some 2-dot or 3-dot problems in HRW first and work your way up in difficulty.

You are encouraged to work together on any aspect of the homework. Talking about physics is a good way to clarify your understanding and identify things you don't understand so that you can focus on those.

Quizzes: A quiz will be given weekly at the beginning of class on Thursday, so please arrive on time. Each quiz will have 1–3 problems selected from the assigned homework problems. Quizzes will be **closed notes**. There are no make-up quizzes. Missing a quiz will not count against you, but if you miss three or more quizzes, additional missed quizzes may be counted as zeros.

Exams: I am planning for 3 exams with Exam 1 to cover waves, Exam 2 to cover electrostatics, and the Final Exam to cover everything else from electromagnetism. Exams will not be explicitly cumulative, but the course implicitly builds on earlier material. Exams will be **open notes**, but not open book and no electronics will be permitted. If you take notes electronically, you'll have to print them out if you want to refer to them on the Exams. Make-up exams will be conducted orally.

Class Attendance and Participation

Attendance: Class attendance is **required**. Attending class is important for your success. Class not only gives you an opportunity to ask questions and discuss physics, but there will also be additional background information, examples, discussion, and topics presented that are not in the textbook.

If you know ahead of time that you will not be able to attend class, it would be helpful to let me know by email. We can arrange to meet during office hours to review what you've missed. Missing a class or two can happen, that is reasonable. If absenteeism becomes unreasonable, I will ask to discuss the issue with you and if it continues your final grade may be adversely affected.

Participation: You are encouraged to participate in class discussions and ask questions. It is helpful to me to know what topics you find interesting so that we can do more with them, or when there is a problem with understanding so that I do not just plow ahead with the next thing. As usual, we should all aim to create a mutually respectful, civil, and supportive environment. If you have concerns about classroom dynamics, please speak to me, the dean, or your advisor.

Grade Distribution:

Quizzes	25%
Exam 1	25%
Exam 2	25%
Exam 3	25%

There is no extra credit.

Letter Grades

Letter grades will be assigned based on a curve. Cooper Union's guidelines state that a "B" represents "above average" work, therefore, the average score in will be on the border between a "B" and a "C". For a large class, scores are typically distributed following a normal (Gaussian) distribution. In this case, the relevant quantities to consider are the class average μ, class standard deviation σ, and your score z in units of σ i.e. $z = (x - \mu)/\sigma$, where x is your raw score.

Normal distribution z	Letter Grade
$\geq 1\sigma$	A
0σ – 1σ	B
-1σ – $0\ \sigma$	C
-1.5σ – -1σ	D
$\lesssim -1.5\sigma$	F

Quizzes are a good indicator of exam grades. Another way to gauge how you are doing is to try HRW problems. If you can reliably solve 2-dot level problems without peeking at the solutions, then you are doing fine.

Other Course Information and Policies:

Course policies are developed to support fair and equitable treatment in the classroom and to set performance standards.

Exam Rules: Your responses to exam questions must be the product of your own intellectual effort. Whether in-person or take-home, you may not copy the answers to exam questions from any website, person, or other resource. You may not post a question to an online message board or ask someone else for the answer.

- Calculators are not permitted on exams.
- You may use hardcopy notes for the exams (but not weekly quizzes).
- No textbooks are permitted for any in-person exam.
- Cell phones must be out of sight and inaccessible. It would be best to bring nothing into the exam room other than yourself, your notes, and writing instruments.
- Try not leave the room at any time during an exam. Use the bathroom before you come in.
- Please avoid being absent on exam days. Missing one quiz isn't a big deal, but missing an exam can be difficult to resolve. If it is impossible to attend the exam, contact me to discuss the situation. If needed we can arrange an oral exam.

Errors in Grading: I sometimes make errors in grading. If you believe I have misunderstood your response or made an error, please talk to me and I will review it.

Letter Grades: – Letter grades will not be known until the end of the semester. I will tell you the average and standard deviation on each evaluation. That information is sufficient for you to gauge your performance. If you demonstrate that you have learned physics, then you will do well.

Technology Policy: You may use a tablet or a laptop during class to take notes and may use a computer to complete homework assignments. You may use a calculator during class. You may not use a laptop, tablet, cell phone, or any other electronic device during class for any purpose unrelated to class. No technology is permitted during Exams or Quizzes.

Accommodations: Students with disabilities or who need special accommodations for this class are **required to notify the Dean of Students and meet with me** so that arrangements can be made.

In order to receive accommodations for an exam, you must notify me in writing at least two weeks before the accommodations are needed and you must also be registered with the Dean of Students. Students will not be afforded any special accommodations retroactively, i.e., for academic work completed prior to disclosure of the disability to me and the Dean. Disability support services for students are described here `https://cooper.edu/students/student-affairs/disability`. The Accommodations process is described here
`https://cooper.edu/students/student-affairs/disability/accommodation_process`.

Title IX: While I want you to feel comfortable coming to me with issues you may be struggling with or concerns you have, please be aware that I have reporting requirements that are part of my responsibilities as a member of the faculty. If you inform me of an issue of sexual harassment, sexual assault, or discrimination, I will keep the information as private as I can, but I am required to report the basic facts of the incident to Cooper's Title IX Coordinator. The Cooper Union Title IX policy on sexual misconduct can be found here
`https://cooper.edu/students/student-affairs/sexual-misconduct`.

Counseling and mental health: Counseling Services at The Cooper Union are coordinated through the Office of Student Affairs. The Cooper Union counseling and mental health services website can be found here `https://cooper.edu/students/student-affairs/health/counseling/services`.

Academic standards for engineering: The Cooper Union School of Engineering Policy on Academic Integrity is posted here
`https://cooper.edu/engineering/curriculum/academic-standards-regulations`.
Violations of the Academic Integrity policy (i.e., plagiarism or cheating) will be reported to the Dean and will likely result in significant consequences, up to possible dismissal.

Other policies for students: Just for your reference, most of Cooper's policies that relate to students can be found here `https://cooper.edu/students/student-affairs`

Tentative Schedule:
Exam dates may shift.

Week	**Content**
Week 1 9/2 & 9/4	• Waves on a string • Basic properties of the wave equation • Sound waves
Week 2 9/9 & 9/11	• Review complex exponentials and phasors • Wave reflection and standing modes.
Week 3 9/16 & 9/18	• Interference • Doppler shift
Week 4 9/23 & 9/25	• Fourier Series • Electric charge • Coulomb's law and Electric fields
Week 5 9/30 & 10/2	• More electric fields • Start Gauss's law
Week 6 10/7 & 10/9	• Review and Exam 1 • Gauss's law
Week 7 10/14 & 10/16	• Electric potential
Week 8 10/21 & 10/23	• Properties of conductors • Capacitors • Electric field energy density
Week 9 10/28 & 10/30	• Current and resistance • Magnetic forces
Week 10 11/4 & 11/6	• Review and Exam 2 • Magnetic fields
Week 11 11/11 & 11/13	• Biot-Savart law • Ampere's law
Week 12 11/18 & 11/20	• Faraday's law • Inductance and inductors
Week 13 11/25	• Tuesday 11/25 is a "Cooper Union Thursday" • Ampere-Maxwell law • Maxwell's equations and light waves
Week 14 12/2 & 12/4	• Basic circuits • AC circuits and oscillators
Week 15 12/9 & 12/10	• AC circuits and oscillators • No class 12/10 as it's a study day
Week 16 12/16 & 12/18	• Review and Final Exam