# PHYS 542 Electromagnetic Theory, Spring 2019

**Instructor:** M. M. Hedman mhedman@uidaho.edu (E/P 323)
**Class Time/Location:** 9:30 AM MWF in BEL 205
**Office Hours:** 10:30-11:30 MWF and by appointment
**Course Website:** http://webpages.uidaho.edu/mhedman/courses/PHYS542/

**Required Text:** Modern Electrodynamics by A. Zangwill (ISBN 978-0-251-89697-9)
**Secondary Text:** Classical Electrodynamics by J.D. Jackson (This is the classic text on Electrodynamics. We will not be using it as the primary work for this course, and so it is not required. However, it can serve as a useful reference.)

**Learning Outcomes:** Students taking this course will become familiar with the tools and techniques required to solve a wide variety of problems involving electric and magnetic fields. In doing so, they will gain a deeper understanding of classic electromagnetic theory and its applications. This course focuses upon electrodynamic phenomena, including electromagnetic waves and scattering theory, as covered in Chapters 14-23 in Zangwill. It is assumed that all the students are familiar with the topics in electrostatics and magnetostatics covered in PHYS 541.

**Accommodations:** Reasonable accommodations are available for students who have documented temporary or permanent disabilities. Accommodations should be made through the Center for Disability Access and Resources, located in the Bruce M. Pitman Center, Suite 127. Contact the Center for Disability Access and Resources (CDAR) at 208-885-6307, email cdar@uidaho.edu or go to www.uidaho.edu/current-students.cdar as soon as possible so that they may inform the instructor regarding such accomodations.

**Grading:** Grades will be based on homework problems (40%), two midterm exams (40%) and a final project (20%) The nominal grade scale is the standard >90%=A, 80-90%=B, 70-80%=C, 60-70%=D, <60%=F

**Homework: (40% of grade):** In general, homework problems will be due once a week at the start of class. You should feel free to talk with me and work with other students on any problems. However, the final answers you submit should be written in your own words. Late homework will be accepted, but there will be a 20% deduction for each school day after the deadline.

**Exams (40% of grade):** Two exams will occur during the semester. The mid-term will occur in the middle of the semester and counts for 20% of your grade and the final will be worth 20% of your grade. These tests may be take-home exams, which will be open-book and open notebook, but no internet resources can be used and you must not talk with anyone besides me about the exam outside of class.

**Project (20% of grade)**: There is a rich diversity of electromagnetic phenomena, and we cannot cover every single one in this class. Each student will therefore do a short research project on a specific electromagnetic phenomenon they find particularly interesting. This project **must** involve (1) a nontrivial derivation of a theoretical result, and (2) a specific application of that derivation to a particular system, either via an analytical calculation or numerical codes. Both these portions can be based upon published works, but you must cite

those properly and demonstrate that you understand the relevant calculations by presenting them in your own words and applying them to a unique case.

Your grade on the project will be based on:

- A paper (worth 50% of project grade) This must be a pdf document that is e-mailed to me no later than the last day of class (5/3). No late papers will be accepted. This paper must have 5 pages of text with a single-spaced, 12 point font (not counting space for equations, references and figures). Since this document will include equations, I strongly suggest using LaTeX, but this is not required.

- A presentation (worth 50% of project grade). This presentation will be delivered to the class around the week of 4/22. Projectors will be available to show powerpoint or pdf slides.

You **must** discuss your topic with me during the first 4 weeks of class to ensure that it is appropriate for this class. Also, guidelines and rubrics for these components of the project will be provided on the class website.

**Possible project ideas:**

**Magnetohydrodynamics**: Examine dynamo theory using induction equation. Understand Cowling's Anti-Dynamo Theorem and how it can be avoided.

**Magnetic Reconnection**: Determine what conditions are needed for reconnection to occur and their implications for plasma transportation.

**Optics of metamaterials and other nonstandard materials**: Examine how materials can have negative indices of refraction, and how this can be used to produce cloaking devices, superlenses, etc.

**Wave propagation/trapping in spherical geometries**: Determine frequencies and propagation properties of plasma waves around planets (e.g. determine frequencies of Schumann resonances).

**Waveguide transitions and Antenna Theory**: Examine how radiation passes between different types of waveguides, and how these waveguides can be coupled efficiently to each other or to free space.

**Rainbows and Parahelia**: Examine how these phenomena arise from scattering theory, compute what they might look like under exotic circumstances (i.e. unusual materials or shapes)

**Academic Honesty:** Students can work together on assignments and talk about the problems and thier solutions. However, be sure to do each problem and enter your own solution, since all work turned in for grading must represent the student's own work. The exams must be done by each student on their own, using only approved resources. The paper turned in for the final project must be in the student's own words and must cite all material appropriately. Any violations will result in a score of zero on the relevant assignment and will be referred to the appropriate administrative authorities. Repeated violations could result in a failing grade for the course. See article II of `http://www.webpages.uidaho.edu/fsh/2300.html`.

**Tentative Calendar**

Nominally, I plan to cover about 1 chapter in Zangwill each week of class. This schedule may shift as the class proceeds:

| Week | Dates | Reading | Note |
|---|---|---|---|
| 1 | Jan 7/Jan 9/Jan 11 | Chapter 14 | First Day of Class Jan 9 |
| 2 | Jan 14/Jan 16/Jan 18 | Chapter 14 | |
| 3 | Jan 21/Jan 23/Jan 25 | Chapter 15 | No class Jan 21 |
| 4 | Jan 28/Jan 30/Feb 1 | Chapter 16 | |
| 5 | Feb 4/Feb 6/Feb 8 | Chapter 17 | |
| 6 | Feb 11/Feb 13/Feb 15 | Chapter 17 | |
| 7 | Feb 18/Feb 20/Feb 22 | Chapter 18 | No class Feb 18 |
| 8 | Feb 25/Feb 27/Mar 1 | Chapter 18 | |
| 9 | Mar 4/Mar 6/Mar 8 | | Midterm Exams |
| | Mar 11/Mar 13/Mar 15 | | Spring Break, No Class |
| 10 | Mar 18/Mar 20/Mar 22 | Chapter 19 | |
| 11 | Mar 25/Mar 27/Mar 29 | Chapter 20 | |
| 12 | Apr 1/Apr 3/Apr 5 | Chapter 21 | |
| 13 | Apr 8/Apr 10/Apr 12 | Chapter 22 | |
| 14 | Apr 15/Apr 17/Apr 19 | Chapter 23 | |
| 15 | Apr 22/Apr 24/Apr 26 | | Project Presentations |
| 16 | Apr 29/May 1/May 3 | | No exam week, Project Papers Due |
| | May 6 | | Final |