Physics 2555: Advanced Classical Electricity and Magnetism

Spring 2023

- Recommended textbooks:
  F. Melia: "Electrodynamics,"
  J. Jackson: "Classical Electrodynamics," 3rd edition
- Prerequisites: Mathematical foundation similar to Physics 2373
- Lectures: MF 10:00-10:50am, W 9:00-10:50am (106 Allen Hall)

Course description

This course is a graduate level core course. It discusses the static and dynamic properties of classical electrodynamics at the graduate level. Among the topics emphasized are solutions to problems in electrostatics, magnetostatics and electrodynamics, wave equations, effects of boundaries, propagation of electromagnetic radiation, response of dielectrics to electromagnetic fields, and special relativity.

This course will be taught in a "flipped" format. Students are expected to do weekly assigned readings (see below for more details). This will free up time for exercises and group work during class.

There is no official required textbook for this class. The "standard" text by Jackson is very comprehensive and detailed and serves as a good reference. However, the essential concepts might be learned better from the more compact (although not fully comprehensive) book by Melia. The lecture will be based on several sources, including but not limited to these two books. Therefore it is essential that you consult the lecture notes and attend class times throughout the semester.

I will provide lecture notes on Canvas. Each week a section from the lecture notes is assigned as required reading. I will occasionally go through some of the material during class, but this is not a replacement for reading the lecture notes. This will free up time for exercises and group work during class. For each week's reading, the Canvas page will contain a few conceptual questions ("quizzes") that you are expected to answer. This will help you reflect on the material of the lecture notes, and will assist me in identifying things that I should focus on in class. The "quizzes" will not be individually graded, but there will be participation points assigned for them.

On the other hand, much of the class time will be used for exercises and discussions. These are not contained in the lecture notes, so you are still expected to attend the class times. One possible strategy is to print the notes ahead of time and then make your own annotations during class time.

Furthermore, the lecture notes are intended to provide a concise summary of the course material. They are self-contained, but they do not have the same level of detail and extended explanations as the textbooks. Therefore you are expected to consult one of the recommended textbook whenever you might need additional information.

Learning goals

After completing this course, students are expected to be able to

- analyze the symmetries of a problem, choose appropriate coordinates, and systematically construct a solution approach;
- solve boundary value problems of partial differential equations, as they are commonly encountered in electricity and magnetism, using Green's functions and/or decomposition into orthogonal functions;
- construct solutions for electric and/or magnetic fields generated by compact sources using multipole expansion;
- compute the propagation of waves in free space, dielectric media, wave guides and resonant cavities, as well as understand the transport of energy and momentum by these waves;
- describe applications in special relativity using 4-vector Miskowski formalism;
- analyze the emission and scattering of electromagnetic radiation off a point charge moving at relativistic speeds.

Homework

Homework is an essential part of learning the material of this course. Homework will be assigned each week on Friday and collected next week on Friday. You are encouraged to discuss the homework problems with each other after you have tried them to the best of your ability, but you cannot copy the solutions from each other. The homework assignments and solutions will be available for download on Canvas.

Some of the homework problems will be discussed in class (after they have been graded and returned). For this purpose I will occiasionally pick one student at random to present her/his solution on the board. In this way, you can learn from each other's solutions, and also practice your presentation skills.

Grading scheme

There will be one mid-term exam and a comprehensive final exam. The dates for the exams will be announced several weeks in advance. The

final grade will be determined by the homework submissions (30%), and mid-term (25%) and final exam (40%), and course & lecture quiz participation (5%).

Academic policies

Academic integrity

Students in this course will be expected to comply with the University of Pittsburgh's Policy on Academic Integrity. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators.

Disability resources

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 140 William Pitt Union, (412) 648-7890 as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Copyright and recording

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To ensure the free and open discussion of ideas, students may not record classroom lectures, discussion and/or activities without the advance written permission of the instructor, and any such recording properly approved in advance can be used solely for the student's own private use.