Physics 405T: Electromagnetic Theory

Fall 2009

Location: TPL 114
Time: F 1:10-2:25pm
Office Hours: by appointment

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Required Text: *Introduction to Electrodynamics* by David J. Griffiths

Recommended: Computer with *Mathematica*, www.mathworld.com
Electricity and Magnetism by Edward M. Purcell (on reserve in Schow),

Course Overview

Electromagnetic Theory is a tutorial study of advanced theoretical approaches to Maxwell's equations for charges interacting with the electromagnetic field. Electromagnetism plays a key role in physics, bridging the study of particles, atoms, and molecules with the concept of a field, the central insight behind general relativity and quantum field theory. Indeed, electromagnetism is the simplest example of a theory with both Lorentz and gauge symmetry, properties expected to be found in any fundamental theory of everything. Finally, one might say that all of the physics we know depends on electromagnetism through our own optics.

There are four main topics that form the outline of this course. First, we will review the methods to calculate electric fields and potentials, familiar from previous courses, but now using full three-dimensional systems. Special attention will be given to the formal structure of Maxwell's equations, and their solution through expansion in a complete series of functions. The second part will focus on magnetic fields and matter. In the third part of the course we will study time-dependent fields and the physics of radiation. Finally, we will explore advanced topics from both the text and beyond.

Course Goals

At the end of this course, you will be able to identify multiple paths to solve Maxwell's equations in various coordinate systems and using a variety of methods, including integral, differential, and series solutions. As a tutorial, you will gain experience in mastering and presenting material learned independently (and in collaboration), in and outside of the textbook.

Course Structure

Lectures: The scheduled lectures will not necessarily cover all topics to be discussed in tutorial sessions or studied in the problem sets. This time will usually consist of a general outline, to be followed by alternatives to the textbook material, special techniques for certain problems, or new approaches discovered in the preceding week's tutorial sessions.
Tutorials: During the tutorial meeting you will be asked to present (on the blackboard) solutions to one (or more) of the assigned homework problems. You should attempt the

solution of the majority of the problem set (>75%) before the session, so that the time after tutorial is spent writing up your work. Meetings may not cover all of the problems, so feel free to pose questions about the material, even if it is not directly related to the problem set. These sessions will be graded, however, so be prepared to discuss some of the problem set.

Grading

Much of your final assessment will be based on performance during the tutorial sessions. Attendance at these sessions is mandatory---if you anticipate being unable to attend a session (for a good reason), please contact me well in advance. Here are some rough guidelines on the tutorial grades.

A: You have worked through all of the problems, have presented them clearly, and are ready to discuss the implications of these results (or methods) in a broader context.
B: You have worked through most problems, have some ideas how to proceed, but may be stuck on some others.
C: You have started the problems.
D: You show up.
E: You don't show up.

The other components of the course are written work to be turned in every week, and a final take-home exam. The written work will be assessed both for correctness and clarity, so be prepared to spend some time writing things up from your notes.

Graded Work	Grading Weight
Tutorial Session	30 %
Homework	35 %
Final Exam	35 %

Late policy: Problem sets will be due each Friday at the lecture. In general, and due to the pace of this course, late homework will not be accepted.

Course Outline and Schedule

Week	Dates	Topic / Chapter
1	Sept. 11	Vector Analysis and Coulomb's Law (Chapters 1 and 2)
2	Sept. 18	Electrostatics (Chapter 2)
3	Sept. 25	Special Techniques (Chapter 3)
4	Oct. 2	Electric Fields in Matter (Chapter 4)
5	Oct. 9	Magnetostatics (Chapter 5)
6	Oct. 16	Magnetic Fields in Matter (Chapter 6)
7	Oct. 23	Extra lecture due to reading days / Mountain Day
8	Oct. 30	Maxwell's Equations and beyond (Chapters 7 and 8)
9	Nov. 6	Electromagnetic Waves (Chapter 9)
10	Nov. 13	Potentials and Fields (Chapter 10)
11	Nov. 20	Radiation (Chapter 11)
12	Nov. 27	Independent Topics / Special Relativity (Chapter 12)
13	Dec. 11	Wrap-up
Final	Dec. **15**	Final Exam

The date indicates the initial lecture; the tutorial sessions will be held during the following week. However, two weeks (indicated by the *) will have no tutorial sessions: week 5 (Oct. 13-14, due to the reading days), and week 11 (Nov. 24-25). Note also that Mountain Day will occur in October (not necessarily Oct. 23); expect to be flexible for this and the surrounding lectures.

Honor Code

Every work that is done by you and your fellow students is subject to the honor code. Note that the honor code is not just about cheating: all activities in class are to be undertaken with honesty and integrity. However, this should not be pursued at the expense of learning. Your peers are a great resource, and you are greatly encouraged to discuss this class and all assignments (with the exception of the final exam) with your fellow students. However, all submitted work must be your own. Significant collaboration with others should be acknowledged. If in doubt, contact me with your question.

Final Disclaimers

All contents of this syllabus are subject to revision by the instructor. While physics is not usually a politically charged topic, passionate discussion may occasionally occur. Please do not take any perceived offense personally, and please see me if you have any concerns.