Physics 422
Electrodynamics

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Fall 2009
Course Meets: MWR 10:00-11:15 am
Office Hours: Frank 234B (x2162), TF 11:30-12:30, T 15:30-17:30, R 14:30-16:30
http://www.guilford.edu/physics/422

1 Course Outline and Philosophy

Electrodynamics is a remarkably complete and comprehensive theory that describes a staggering number of distinct phenomena in a very small number of equations. In fact, the vast majority of material covered by this course can be expressed in one single equation. The course first examines electricity and magnetism as distinct entities, starting from the simplest examples and working our way toward the most generally applicable descriptions. The emphasis will be on understanding general principles and mathematical tools rather than on practical calculations in specific cases. In the end, we will show not only how electricity and magnetism can be expressed in unified terms, but how they turn into each other in different frames of reference, showing that whether we think of a force as electric or magnetic is merely a convention of perspective. Both phenomena are manifestations of the same underlying principle.

Completion of this course will give the student experience with advanced mathematical tools such as vector calculus and tensor manipulation. These tools will give the student the means to appreciate the power of unification and reductionism in physical theory. Although the emphasis will be on the mathematical framework underlying the theory of electrodynamics, we will also treat along the way how the electromagnetic force interacts with matter, which yields some practical knowledge that can be applied to electronic circuitry and power systems.

2 Textbooks

The primary textbook for this course will be David Griffith's *Introduction to Electrodynamics, 3rd Edition* (Benjamin Cummings, 1999, ISBN 013805326X). This text will be available in the bookstore. We will also be leaning heavily on Volume II of Feynman, Leightman, & Sands, *The Feynman Lectures in Physics* (Addison Wesley, 2005, ISBN 0805390472). This textbook is not required for purchase, but you should have access to a copy.

There are three further books I can recommend as optional supplementary material. For help with the vector calculus, H. M. Schey's *Div, Grad, Curl and All That* is a brief, lucid

summary. My college course in this subject used *Electromagnetic Fields* by R. Wangsness, which I think now works better as a reference than an introduction. Last but not least, if you really want to dive into the deep end, *Classical Electrodynamics* by J. Jackson is widely considered to be *the* standard textbook on the subject. It is also widely considered to be the most difficult (graduate level) book on the subject. Take a look at it if you want to be really ambitious.

3 Homework

There will be twelve homework sets assigned during the semester. These will consist of about eight problems each. The problems may consist of short answer questions or essay questions; they may require you to perform calculations or derivations. They may also require you to write Matlab (you may use other, equivalent, software, should you wish, but the department supports Matlab) programs to solve problems numerically. If you need to use code, you should include printouts of clearly commented code with your solutions.

You are encouraged to work together to find solutions to these assignments, but only if you (a) attempt to solve the problems on your own before you meet with peers or instructors, and (b) write up the solutions you submit for your grades by yourself, after your collaborative work is over. It is too easy to copy others' work, even inadvertently, if you see the problem for the first time while in a group and if you write your final solution with your helpers around you.

I expect homework solutions to be written up in clear, succinct, coherent English, with equations and derivations as necessary. I should be able to read the solutions sets without having to look up the problems set to remember what the questions were. You may use LaTeX to write up your solutions, should you wish, and submit them either electronically via email or as hardcopy printouts. I will not accept other forms of electronic submission.

Each homework problem will be graded on a ten-point scale, according to the rubric given in Table 1. The assignment as a whole will be assigned a value that is the average of the individual scores. This value will count toward your total grade in the class. See section 8 for a description of how the grades will be assigned.

4 Pre-flight Quizzes

To help you stay current with the reading, as well as to help me plan our time together in class to be most effective, each week's readings will be accompanied by "preflight quizzes." These quizzes will be made available by links from the 422 home page. One will be due every Monday morning at 1 am (that is, Sunday night), but all quizzes may be completed any time in advance of that date. Correct answers are not required; your grade will only consist of "completed" or "not completed", not correct or incorrect. Completion of each quiz will contribute one point to your overall score for the course (see section 8).

These quizzes serve two purposes: they help you stay on-task in completing the readings on time, and they help me assess where you are in your understanding of the material in the

Table 1: Rubric for Grading Homework Problems

Score	Description
10	Setup and work are clear, answer is correct, with sanity checks and comments
9	Answer is wrong due to minor mistakes, but everything else is present and clear
8	Answer is wrong due to major mistakes, or comments missing
7	Setup is weak or absent, or there are major mistakes, but main ideas are there
6	Adequate understanding but not mastery of the topic. Work is not clear.
5	About half the problem is missing. Partial understanding.
4	Articulation is unclear, work is missing, little thought shown about work.
3	Poor understanding and/or articulation. Set up is adequate, but nothing after.
2	Good faith effort, but flailing wildly about with no idea what to do.
1	A correct answer only
0	Nothing at all

readings. If I can enter class knowing something already about what you understand and what you don't understand, I can shape the in-class activities to more efficiently match what you need.

Because of how IT&S has structured the campus network, the preflight quizzes will only be accessible via the on-campus computer network. If you wish to complete them from off-campus, you will need to install a "Virtual Private Network" (VPN). See the IT&S help facilities for instructions and assistance with this installation. If you do not wish to use a VPN, you will have to use on-campus computers to complete the quizzes, but any computer on-campus will suffice. You will be given a login/password in class.

5 Self-Directed Projects

In addition to the assigned homeworks, which will emphasize the topics we discuss in class, there are six optional self-directed projects that you may complete. These projects give you a chance to explore topics beyond the ones I have chosen to emphasize in the course schedule. Each project is worth a different number of total points, dependent on the difficulty of the project. The project will be graded on the same standards as a homework set, and the number of points earned will be proportionately scaled to the value of the project. To avoid the danger of a massive pile-up of projects at the end of the semester, each project will be assigned a due date. The full list of projects and due dates will be listed on the 422 course web page.

6 Exams

There will be two mid-term examinations as well as a final examination. The examinations will not be cumulative (except in so far as the material is cumulative): the first will cover electrostatics, the second will incorporate magnetism and electrodynamics, and the third will cover the unified relativistic perspective. The first exam will be due on October 13th, and the second exam will be due on November 17th. The final exam must be handed in before 11 am on December 14th, 2009. These examinations will not disrupt the ongoing assignment of homework sets.

All exams will be take-home, and must be completed within a given amount of time, to be determined when the exam is written. Other conditions for each exam, such as use of a "cheat sheet," Matlab code, or internet resources, will be specified as part of the instructions for each exam. Compliance with the instructions for the exams is assumed as part of the Guilford Honor Code, and suspected violations will be referred to the Dean's office.

Each of the three exams will be graded on the same kind of scale as the homework sets. Each exam as a whole contributes a maximum of 30 points toward your total grade (see section 8). You may rewrite the first two exams to earn half of the points you missed on the first effort. These rewrites must be completed by 5 pm on the seventh day after you receive your graded exam handed back to you.

7 Department Seminar

As members of the Physics Department community, it is crucial to be active in the events of the community. Without active participation, the camaraderie and strong connections that the department fosters will dissolve. In particular, it is important to participate in the weekly department seminar. Registration in Physics 422 carries with it the requirement that you attend the seminar. Furthermore, you must give at least one 15-minute oral presentation to the seminar, on a topic of your choosing, related to the material you've learned in Electrodynamics. This presentation should be scheduled with Don Smith at least two weeks in advance, and should be completed before or on 02 December, 2009. There is a limit to how many presentations gan be given in a single day's seminar, so do not leave this until the last minute. Your participation in seminar (including the presentation) will contribute up to 15 points toward your total score.

8 Grading Policy

This is a senior-level course. Your work is expected to be motivated, thorough, and creative. A-level work will show mastery of the topic at hand and clarity in its expression. Work will exceed the minimum satisfactory level and show thought beyond the explicit frame of the assignment, such as addressing an unforeseen implication or making a connection to another class of problem. Mistakes, if any, will be minor. B-level work will have the main idea and answer the assigned question at a functional level, but will lack the initiative and creativity

Table 2: Tentative Schedule for Physics 422, Fall 2009

Week	Griffiths	Feynman	Topics
1	2.1, 1.2-3	II:1-2	Intro, Charge, Vector Calc
2	1.4-6	II:3	More Vector Calc
3	2.2-3	II:4-5	Gauss's Law & Potentials
4	2.3-5	II:8	Energy & Conductors
5	4.1-3	II:10	Electric Fields in Matter
6	4.4, 12.3.1, 5.1-2	II:11, 13-14	Dielectrics, Magnetic fields
7	5.3-4, 6.1	II:15	Ampere's Law, Vector Potential, Magnetization
8	6.2-4	II:34-37	Magnetic Fields in Matter
			Fall Break
9	7.1-3	II:16-18	Electrodynamics
10	8.1-2	II:27	Conservation Laws
11	10.1,12.3	II:25-26	Gauge Transformations, Relativity
12			More relativity
13	3.4	II:6	Multipole expansions
14	9.1-3	II:20	Electromagnetic Waves
15	9.4-5	II:32-33	EM Waves in matter

to go beyond the letter of the specific assignment. Mistakes may be more serious, but still not impeding the overall sense of understanding. C-level work will contain the bare minimum amount of writing to indicate some understanding of the assigned topic. It may contain several serious mistakes. D-level work will be rife with error and misunderstanding, or it will be so poorly written that the level of understanding cannot be accurately assessed. An F will be given to missing work or work that completely fails to show any understanding of the course material. A detailed rubric for the ten-point scale is given in Table 1.

Your final grade for the course will be based on the number of points you achieve throughout the semester. Each homework contributes ten points, each exam contributes thirty, the preflights contribute fifteen, and you can earn fifteen points by participating in the department seminar. That yields a maximum total of 240 points that can be earned without completing any of the optional projects. Your final grade for the course will be an A if you earn 210 points or more. A score between 200 and 209 will earn an A-. A score between 190 and 199 corresponds to a B+. From 180 to 189 is a B, and 170 to 179 is a B-. Each successive ten point range corresponds to the next grade, and a score below 100 will result in an F.

9 Course Schedule

The primary thread of this course is to develop the basic building blocks of understanding electricity and magnetism as distinct phenomena, and then to use those blocks to construct a

unified understanding of Electromagnetism as a single phenomenon in the context of the Theory of Special Relativity. To that end, we will begin with a review of necessary mathematics. Then we will explore Electrostatics (electric charges at rest). Then we will allow the charges to move, but at constant rates, which leads to the theory of Magnetostatics. Once we allow the currents to change, we have an integrated theory of Electrodynamics, as expressed through Maxwell's Equations. Finally, we bring Maxwell's Equations into the 20th century by exploring how the electric and magnetic phenomena can be described by a single, Lorentz-invarient theory.

This planned sequence is summarized in Table 2. For each week, the assigned readings from Griffiths as well as corresponding optional readings from Feynman are listed, as well as a very brief summary of the topics we will cover. The course may well diverge from this plan. Events in class take precedence over anything written here. The course web page will be kept up-to-date.

The final few weeks of the course have some flexibility. If we stay on-schedule, we will have time to explore an additional topic of relevance. We could delve deeper into specific techniques of finding the electric field in a variety of situations, or we could explore how Maxwell's Equations lead to an understanding of light as electromagnetic waves. On the other hand, we may need that time to slow down and spend more time on the material up to that point.

10 Course Policies

10.1 Credit Hours

This course is worth four credits, although we will only spend about four hours in official class contact per week. For a four-credit course, it is expected that you spend on average twelve hours a week on the course. This expectation is based on the faculty-approved standard that students are awarded one credit for every three hours they spend on course work.

10.2 Attendance Policy

Attendance will not be taken as a daily policy. However, this class is heavily based in the participation in group discussions, and therefore chronic absence will interfere with your ability to learn what the class has to offer. Guilfords policy for classes that meet three times a week is that nine absences are allowed. If you know of an impending situation that will require your absence from class, you must contact me in advance.

10.3 Honor Code

I am a firm believer in acting with integrity and performing at least to the standard of the Guilford Honor code. The work you submit is understood to be claimed by you to be your work. If others helped you, or if you got ideas from other sources, you must credit them appropriately. I have a zero-tolerance policy for plagiarism. If I am convinced you have violated the Guilford Honor Code, you will fail this course, and the case will be referred to the Dean's office for the

possibility of other consequences. According to the college catalog, the statement, "I have been honest and have not observed any dishonesty," gives testament to the honor system and should be pledged in writing on all academic work. Compliance is assumed even if the statement does not appear on college work. The word "pledged" may substitute for the longer statement.

10.4 Accommodations

Guilford complies with the Americans with Disabilities Act by providing a process for disclosing disabilities and arranging for reasonable accommodations. The policy may be found online[1]. Students who require accommodations must complete a disabilities disclosure form and submit it to the Disability Services Coordinator, located in the Learning Commons (x2253), along with the appropriate documentation. It is the students choice to disclose difference/disability information to individual instructors. However, only students who provide their instructors with a 504 Accommodations Agreement may receive accommodations. All disability information is treated confidentially and is not a part of your academic record.

[1] http://www.guilford.edu/about guilford/values/handbook/ada.html