Electrodynamics (PHYS 480) Course Syllabus

Fall 2023 v2.0

> "I have also a paper afloat, with a electromagnetic theory of light which, till I am convinced of the contrary, I hold to be great guns." - James Clerk Maxwell (1864)

1. Introduction to Phys 480:

The form of electrodynamics created by Maxwell in the 19th century is one of the most profoundly influential formulations in physics. It was a turning point in the history of science. For the first time, theoretical work unified distinct disciplines, electricity, magnetism, galvanism (basic circuits) and optics. It led to an understanding of light, gave us both new eyes and new ways of communicating in the form of new technologies (e.g. cell phones). The theory's form and success were largely responsible for many of the developments in 20th century physics, including special relativity and the search for (elusive) unified theories. So Maxwell was right, the theory is "great guns". There are few subjects we could choose to study which are as theoretically satisfying and full of practical application.

It is also a vast subject.

Fortunately we have a master to guide us through the material. Griffiths writes a clear and interesting text. He uses a classical presentation: Mathematical background is presented first, followed by kinematics, dynamics, and applications. We will begin with Maxwell's equations in modern form.

2. Text:

David Griffiths, **Introduction to Electrodynamics** 4th edition.

3. Seminars:

Electrodynamics (Phys 480) will be taught in seminar format. Perhaps this format is new to you all so let me explain a bit about it. The typical seminar consists of a series of 15 $\pm$ 10 minute student presentations at the boards, punctuated by discussion. You take an active role in teaching yourselves. It is your class! There is but one rule: No Keynote, PowerPoint, or similar presentations. We'll take a 15 minute break in the middle of the 3+ hours to share and enjoy some treats.

Your presentations will roughly follow the textbook. I'll assign presentations in the "Guides." Some of the presentations will not involve challenging material but, in addition to being absolutely clear on the material, think carefully on how is best to present the material. If you have a presentation on a section of the textbook, write up your own notes and present from these. You'll gain insight and it will make your presentation much more fluid. Do not present directly from the book!

I encourage you to view your presentations as opportunities to explore the subject - bring in other resources, mention articles, tell us something new. If you don't like Giffith's presentation, then tell us about some other author's presentation of the material. Make use of our wonderful library! Some presentations will be challenging, perhaps by explicitly referring you to journal articles, but most will not be beyond textbook material. You will get a flavor for what I have in mind for presentations from my own examples.

As with usual problem sets it is best to look over the material early to determine whether you will need to spend extra time preparing, asking questions, and researching the topic. This is even more critical in a seminar as the success of the seminar depends on all of us. Your presentations should be - above all - *clear* and well-prepared and thoughtful. Poorly prepared presentations are not acceptable. You may use any method of presentation that is the most effective. (No sitting and pointing at a piece of paper, please.) I have noticed that it is possible, although not easy, to match the effectiveness of

the blackboard. These will be "informal presentations" in that you should feel free to ask a question at any time - or even launch a discussion.

During the week leading up to the seminar you will have a problem set to work on. These problems should help you explore and master the material. With this preparation the discussions in seminar will be interesting, thoughtful, and may very well go beyond the basic material.

I realize that this is a challenging classroom environment! But (IMHO) it is, hands down, the best environment for learning physics. One of my major goals for the semester is for you to become proficient in teaching yourself. You will take a little time getting used to it. That is fine. I've listed some useful points below to help you along. I will also send you feedback via email during the semester.

3.1. **The Ideal, Suggestions, and Slogans:** My Platonic Ideal of The Seminar: The professor provides a detailed syllabus of a subject which, if followed carefully, will build a solid foundation of the subject. The students, working together with the professor, explore, learn, and present the material in class in a way that is clear to everyone. Discussion is active, intellectually challenging, non-threatening, and pushes the envelope of understanding. In preparation every member has no problem asking others about a solution, an integral, or definition whether it is in class, in the common room, or in the dining halls. In seminar any remaining questions are discussed in depth resulting in new insights which, naturally, arrive with a blinding flash of light.

Here are a few suggestions to help you along. Slogans lead the more detailed descriptions.

(1) *Start early. Work carefully.* Nothing will help you more than to start preparing for seminar early. As good as they are, these chapters are not short stories; it would be unpleasant to read the entire chapter in one sitting. Further, read with a scratch pad and writing utensil; work through the presentation of the text. Schedule in plenty of time. Most of the week's work occurs *before* seminar.

(2) *Do all the problems.* Dance is not learned by only watching a video; physics is not learned by only reading. To learn the subject one must try out the stuff by talking and writing about it and working through problems. For many of us this process has two purposes. One is to gain mathematical fluency. The other is to unravel the physics in the mathematics.

(3) *Minimize frustration!'* One of the aspects of the seminar experience that took me the longest to learn was the utility of asking a question. If you encounter difficulty, carefully formulate a question (sometimes the question answers itself in this process!), then ask someone. If this person is madly preparing a midterm or a French buttercream, or does not know the answer then try someone else. In particular, do not hesitate to ask me (Science G052, x4919, smajor). If all else fails, go on to other problems and return to the question later.

(4) *Write clean and clear solutions* When writing solutions keep in mind that there is also a large difference in sketching a solution on a piece of scrap paper and writing up the solution so that a fellow student can read it easily (and that includes you!) As with much writing, keep your audience in mind. Keep your classmates in mind but also try thinking of yourself in 3 months. The logical argument of your solution should be clear on a first read.

(5) *For presentations: Be clear. To impress, exhibit novelty.* Much of what is true for solutions also applies to presentations. Clearly state the issue or problem, outline the tools needed, and proceed providing information when needed. Learn from your classmates' presentations. Feel free to skip algebraic steps once you have cleared it with the class. Show us (including me) something we don't already know, e.g. a new numerical solution or an experimental manifestation of a problem.

(6) *Preserve class notes.* The best policy is to prepare fully for seminar before we meet and write up summaries and/or complete solutions after the actual seminar. It is not easy to keep up. But your notes will be loads of help for the final, for graduate school classes, for qualifying

exams, and even when you teach this course! Think of this as writing up notes from which you can relearn the subject.

(7) *Be clear about what you understand and what you don't.* It is never too early (or too late) to start being clear about what you understand and what you do not. There is a vast, amorphous plain between familiarity and understanding. Question your own understanding by trying it out on new situations. If your knowledge is not what is required, find the difference and learn from it.

(8) *Make a formula sheet* If you haven't already started, start keeping a sheet of paper with useful formulae so you can quickly answer questions such as, how is the magnetic field found from the vector potential?

We only meet 14 times during the semester, discussing about 1 chapter a week, so each seminar is critical. That being said, if you are really sick, it may be best for you to rest. Please let me know in advance if this is the case. It is also that time of year when you may have interviews and campus visits. Please let me know as soon as you know if there is a conflict.

Any absences that are not arranged ahead of time hurt the learning of your peers. Each such absence will cause you to loose one letter grade in presentations, number (1) in section 7.

3.2. **Timing and scheduling:** Because our seminar time is precious please plan on arriving, along with any copies you need, 5 minutes before the official start of seminar. We may (frequently) run a bit late. Please plan on it. If are unable to attend, please send me an email as soon as you know. Late notification hurts us all as I would not have time to reshuffle the presentations.

4. Course info:

All materials will be available online. You can find them through the Courses tab on my homepage by googling or via direct link http://academics.hamilton.edu/physics/smajor/Courses/480.html. All versions of pdf documents will be labeled by a version number in the top right of the first page. I'll try to keep you posted as versions change.

5. Grades:

There are 3 parts to the grade:

(1) Problem sets and discussion participation (60%): Weekly problem sets will be due once a week on Tuesday. Although I encourage you to work together you must write up your own solutions. The assignments will normally be posted and distributed at least one week prior to the due date. Your in-class contributions will be assessed for clarity and novelty.

(2) Mid-term: (15%) The exam will be sometime in early March. Details to follow.

(3) Final (25%):

6. Problem Sets:

6.1. **Logistics.** These will be due 24 hours after the seminar, although in a typical week you also might have them done by the seminar. The purpose of seminar is, in part, to ensure you have solutions. Please write up your complete solutions with care.

I will closely grade your problem sets a couple of times during the semester, particularly the first one so you know the parameters of good solutions. On most other weeks I will grade a subset of problems. As we discussed in the first seminar, please turn in the full set every week. I will let you know in seminar which ones I am grading that week.

You have 3 automatic extension tokens during the semester. The policy is as follows: To opt in for one of these, write me an email before the end of the afternoon on Tuesday. The request can be for any reason, illness, busy, travel, etc. You then have 2 more days to complete your solutions. Otherwise

(and after this extension) the score decreases by 20% per day (24 hours): the set is graded then a reduction is computed based on the number of days the work is late. Of course, if you turn on your work within the 2 days of the extension then your solutions have no reduction.

6.2. **On writing up your work for others.** For full credit for your solutions you must find the correct answer **and** present your result clearly. You can receive full credit only when you show clearly what you did. If a problem on the homework is not written up properly, you may lose up to 50%. If your solutions are illegible or otherwise unacceptable, it will be returned without grading or credit.

Some Advice for Problem Sets:

(1) Start preparation early!
(2) Make a clear sketch. A well drawn figure can save a tremendous amount of time.
(3) Work slowly, carefully, and thoughtfully through the problem. It is better to work slowly but get the right answer than to work faster and make unnecessary mistakes. Start your work on white board, blackboard, or scrap paper so you don't freeze trying to get every step the correct.
(4) Work with friends. It is more fun!
(5) To avoid a round-off error, do not round numbers early in the calculations.
(6) Make use of spreadsheets - it will save time, prevent round off error and make it easy to adjust parameters. Start off with building a template with all relevant constants, ϵ_o, μ_o, etc.
(7) Use a reasonable number of significant digits in your answer, usually no more than 3. More digits does not make a result more accurate.
(8) Attend office hours! Attend office hours! Attend office hours!
(9) Collaborate but write up your own solutions *this includes mathematica code*
(10) Celebrate you final answers with a box.
(11) Check your final answers: Do they make sense? A simple dimensional analysis can catch a big mistake.
(12) Write out final copy from your solution notes. If you make a mistake at the end or a problem, don't erase what you did before or rewrite everything. Just cross out or mark what you found to be wrong and continue with a correct solution. (This shows the grader that you checked what you had done.)
(13) Present the answer in the form asked for. For example, if the electric field (which as you know is a vector quantity) is asked for, do not just give the magnitude.
(14) Write down clearly and unambiguously with whom you worked on the problem and any resources you consulted.
(15) Build a top notch, easy to access set of records for the course - notes, problem sets, and corrected solutions. They may turn out to be an invaluable resource for you in the future...

7. Staying healthy

We should all be mindful about the stresses of life on the Hill. There are times that we may feel overwhelmed, anxious, or depressed. The Dean of Students Office and Counseling Center have resources available on campus to help and support:

- Counseling Center (www.hamilton.edu/offices/counselingcenter, 315-859-4340) offers individual and group therapy, peer counselors and psychiatric treatment. If you need immediate assistance, phoning the Counseling Center and selecting option 2 will connect you with a counselor, 24 hours a day, 7 days a week. Campus Safety is available 24/7 for urgent concerns at 315-859-4000.
- Associate Dean of Students for Student Support, Sarah Solomon (315-859-4600; ssolomon@hamilton.edu)
- Associate Dean of Students for Academics, Adam Van Wynsberghe (315-859-4600; avanwyns@hamilton.edu)

- Your faculty advisor, RA and Area Director in your residence hall

8. Weekly Schedule

What follows is preliminary!

Week	Seminar Day	Topic	Reading
1	23 January	Vector Math Review	Ch 1
2	30 January	Electrostatics	Ch 2
3	6 February	Potentials	Ch 3
Seth at Tux Workshop, 11-19 Feb			
4	??	Electric fields and matter	Ch 4
5	20 February	Magnetostatics	Ch 5
6	6 March	B-fields in matter	Ch 6
Spring break			
7	27 March	Electrodynamics	Ch 7
8	3 April	Conservation Laws I	Ch 8
9	10 April	Electromagnetic Waves	Ch 9
10	17 April	Potentials and Fields	Ch 10
11	24 April	Radiation	Ch 11
12	1 May	Electrodynamics and relativity	Ch 12
13	8 May	catch up	
14		rest, study, study, study...	
Final May 12 7 PM			

Enjoy!

Seth Major
Science G052
x4919
smajor@hamilton.edu