Syllabus for Electrodynamics I – Fall 2020

1 Technical Details

Course: PHYS 3600  
Credits: 3 credit hours  
Instructor: D. Mark Riffe  
Phone: 797-3896  
Email: mark.riffe@usu.edu  
Office Hours: Mondays, via Zoom appointment  
Prerequisites: PHYS 2710, MATH 2210, 2250  
Textual Material (required)  
   Book: Introduction to Electrodynamics (Fourth Edition) by David J. Griffiths.  
   Notes: PHYS 3600 – Lecture Notes by D. Mark Riffe (on Canvas)  
Class Meetings: 10:30 - 11:45, Thursdays via Zoom  
Recitation: 10:30 - 11:45, Tuesdays in SER 244 and via Zoom  
Course Website: on canvas.usu.edu

2 Subject Matter

The theory of classical electrodynamics is a general framework for describing and explaining the interactions of charged particles and objects composed of charged particles via electric and magnetic fields. Generally, this means our overall goal is to solve the Maxwell equations,

\[
\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}, \quad \nabla \cdot \mathbf{B} = 0, \\
\n\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0, \quad \nabla \times \mathbf{B} - \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} = \mu_0 \mathbf{J},
\]

for the electric field \( \mathbf{E}(\mathbf{r}, t) \) and magnetic field \( \mathbf{B}(\mathbf{r}, t) \) under a wide variety of physical situations. As Newton’s second law is the starting point of solving dynamical problems in classical mechanics, these equations are the starting point for finding the fields \( \mathbf{E} \) and \( \mathbf{B} \). In these equations the terms \( \rho(\mathbf{r}, t) \) and \( \mathbf{J}(\mathbf{r}, t) \) (respectively, the charge density and current density) are the sources of \( \mathbf{E} \) and \( \mathbf{B} \).

In this course we shall cover two basic situations, which come under the headings electrostatics and magnetostatics. Electrostatics is the study of static electric fields produced by static charge distributions \( \rho(\mathbf{r}) \). Electrostatics also includes the interaction of matter with such electric fields. Analogously, magnetostatics is the study of static magnetic fields produced by steady-state current distributions \( \mathbf{J}(\mathbf{r}) \). Magnetostatics also includes the interaction of matter with such
magnetic fields. As we shall see, these two topics parallel each other quite closely. Importantly, the ideas introduced in describing static fields lay the foundation for the study of dynamic electromagnetic fields, the general subject of the follow-on course, Electromagnetism II (PHYS 4600).

While you have already been exposed to electromagnetism in your introductory physics sequence, we shall now discuss this material at much higher conceptual and mathematical levels than you have previously encountered. At times, the word abstract may be an appropriate term to use. In many ways you are at the beginning of your foray into modern theoretical physics. Although it will likely take a lot of work to master this subject, I hope it will be fun!

3 Course Goals (Students should ...)

The goals for this course, while all intertwined to some extent, can be divided into three categories: (i) application of math techniques, (ii) development of physics ability, and (iii) practice of efficient study habits. Let’s discuss each of these. All of the goals listed below are critical to developing the ability to utilize physics in a professional setting.

Application of Math Techniques

Vector calculus. Students should become competent at applying the mathematics of vector calculus – divergence, curl, gradient, Laplacian, various 3D integrals, Stoke’s theorem, and the divergence theorem – in Cartesian, cylindrical, and spherical-polar coordinates.

Limiting cases. Student should become proficient at simplifying expressions in the limit where a particular parameter is either small or large, which often means utilizing Taylor-series expansion. This ability is essential for checking the validity (or at least the plausibility) of complicated mathematical expressions.

Development of Physics Ability

Overview of Time Independent E&M. Students should develop a working overview of the subjects of electrostatics and magnetostatics, including cases involving material response to the fields.

Problem Analysis and Solution. Students should develop the ability to assess what techniques are appropriate for a particular problem, and then be able to apply those techniques to the problem to find the solution.
**Extracting Meaning from Equations.** Students should become proficient at gaining insight from the mathematical equations involved in any particular problem. *What are the equations telling you?*

**Think as a Physicist.** Overall, students should develop the ability to approach, analyze, and solve problems in the manner that an expert (i.e., a professional physicist) does.

*Practice of Efficient Study Habits*

**Assimilate Textual Material.** Students should develop the ability to internalize physics ideas and concepts from written material. The practices of (i) prereading and (ii) efficient note taking are two techniques for achieving this goal.

**Timely Completion of Assignments.** To enable the most proficient assimilation of the material, students should develop the practice of completing assignments in a timely fashion. In this course this involves completing homework assignments shortly after the material has been introduced through the associated reading assignment and class meeting.

4. **Course Structure**

*This course shall be taught via a blended format.** Much of the course content can be found in Canvas, but there are also two synchronous components: class meetings and recitations. **Class Meetings** take place on Thursdays from 10:30 to 11:45 AM, while **recitations** happen on Tuesdays, also from 10:30 to 11:45 AM.

The course is broken down into weekly learning modules, each with the same internal structure. In chronological order this structure can be summarized as follows.

1. Reading assignment(s) from Griffiths text
2. Quiz(zes)
3. Class meeting
4. Reading assignment(s) from the Lecture Notes
5. Homework (with help available via Canvas Discussion board, office hours, or recitation)

Briefly, the textbook reading assignment(s) and quiz(zes) prepare you for the class meeting, which is designed to prepare you for reading the Lecture Notes, which are designed to prepare you to do the homework, which is where you will do the majority of your learning.
of the material. Engaging in each of these steps each week prepares you for subsequent material the following week.

The next several subsections delineate important aspects of the course’s components. The timeline associated with these components is outlined in the class schedule, which can be found in the table on the next page.

Reading Quizzes

In order to encourage you to keep up with the material (and to make class time more profitable), online reading quizzes are assigned each week. Generally, there are two quizzes assigned each week. Each quiz contains on the order of 5 questions, which are readily answerable after reading the assigned material in the textbook by Griffiths. The primary deadline for each quiz is the 1:00 AM the night before the associated class meeting. For full credit, each quiz must be completed before the primary deadline. A secondary deadline occurs 24 hours after the primary deadline. The scores on quizzes completed between these two deadlines are worth 50% of their full value. No quizzes may be completed after the secondary deadline.

Homework

At the end of each Lecture in the Lecture Notes is a set of associated homework problems. You are responsible for doing all of these problems. In order to prepare for the exams, it is strongly suggested you keep your solutions for all the problems together in one place, such as a three-ring binder.

Homework (associated with material covered the previous week) is due each Tuesday night at 1:00 AM. Assignments must be submitted via Canvas as a pdf file. No late homework will be accepted. Approximately 1/3 of the assigned problems will be graded.

For full credit the homework must be written up in complete sentences that clearly indicate your thinking and your process of working out the problem. Neatness counts, as the grader will not be inclined to assess sloppy work. Assessment will mostly be based on your completion of each problem.

A teaching assistant (TA) assigned to the course will lead a recitation each Tuesday that homework is due. You may attend the recitation either in person in SER 244 (as long as you follow mandated social-distancing protocols) or via Zoom video conferencing. The TA
<table>
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<tr>
<th>Week</th>
<th>Topics</th>
<th>Monday</th>
<th>Tuesday</th>
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| Aug 31 | 1 E field / Coulomb’s law (Ch. 2: 59-65)  
2 Gauss’ law (Ch. 2: 66-78) | Welcome!  
Introductions  
Course Overview (via Zoom) | Quiz 1 & 2  
due 1000 AM | Class Meeting  
(via Zoom) |
| Sept 7 | 3 Scalar potential V (Ch. 2: 78-83)  
4 Poisson’s Eq. / B.c.’s (Ch. 2: 83-91) | Labor Day Holiday | Recitation  
(SER 244 and Zoom)  
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HW 1 & 2 due 1000 AM | Quiz 3 & 4  
due 1000 AM | Class Meeting  
(via Zoom) |
| Sep 14 | 5 Electrostatic energy (Ch. 2: 91-97)  
6 Conductors / Capacitance (Ch. 2: 97-102, 105-107) | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
——  
HW 3 & 4 due 1000 AM | Quiz 5 & 6  
due 1000 AM | Class Meeting  
(via Zoom) |
| Sep 21 | Review / Exam I | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
——  
HW 5 & 6 due 1000 AM | Class Meeting  
(via Zoom) | Exam I (Th & F) |
| Sep 28 | 7 Laplace’s equation (Ch. 3: 115-124)  
8 V by hook or by crook (Ch. 3: 124-130) | Office Hours  
(by appointment) | Quiz 7 & 8  
due 1000 AM | Class Meeting  
(via Zoom) |
| Oct 5  | 9 SOV: Cartesian (Ch. 3: 130-140)  
10 SOV: Spherical (Ch. 3: 141-149) | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
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HW 7 & 8 due 1000 AM | Quiz 9 & 10  
due 1000 AM | Class Meeting  
(via Zoom) |
| Oct 12 | 11 Multipole expansion of V (Ch. 3: 151-159)  
12 Polarization field P (Ch. 4: 167-179) | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
——  
HW 9 & 10 due 1000 AM | Quiz 11 & 12  
due 1000 AM | Class Meeting  
(via Zoom) |
| Oct 19 | 13 Displacement field D / Linear response (Ch. 4: 185-189) | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
——  
HW 11 & 12 due 1000 AM | Quiz 13  
due 1000 AM | Class Meeting  
(via Zoom) |
| Oct 26 | 14 Capacitance revisited (Ch. 4: 190-196)  
15 Energy / C.M. relation (Ch. 4: 197-202, Prob. 4.41) | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
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HW 13 due 1000 AM | Quiz 14 & 15  
due 1000 AM | Class Meeting  
(via Zoom) |
| Nov 2  | Review / Exam II | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
——  
HW 14 & 15 due 1000 AM | Class Meeting  
(via Zoom) | Exam II (Th & F) |
| Nov 9  | 16 Currents / Magnetic force (Ch. 5: 210-223)  
17 Biot-Savart law (Ch. 5: 223-230) | Office Hours  
(by appointment) | Quiz 16 & 17  
due 1000 AM | Class Meeting  
(via Zoom) |
| Nov 16 | 18 Ampere’s law (Ch. 5: 229-242)  
19 Vector potential A (Ch. 5: 243-248) | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
——  
HW 16 & 17 due 1000 AM | Quiz 18 & 19  
due 1000 AM | Class Meeting  
(via Zoom) |
| Nov 23 | Thanksgiving Week | Office Hours  
(by appointment) | Recitation  
(SER 244 and Zoom)  
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HW 18 & 19 due 1000 AM | Thanksgiving Break | Thanksgiving Break |
| Nov 30 | 20 B.c.’s / Mag. dipole m (Ch. 5: 249-255)  
21 Magnetization field M (Ch. 6: 266-279) | Office Hours  
(by appointment) | Quiz 20 & 21  
due 1000 AM | Class Meeting  
(via Zoom) |
| Dec 7  | 22 Auxiliary field H (Ch. 6: 279-287) | Office Hours  
(by appointment) | Recitation  
(Zoom only)  
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HW 20 & 21 due 1000 AM | Quiz 22  
due 1000 AM | Class Meeting  
(via Zoom) |
| Dec 14 | Exam Week | HW 22  
due 1AM | Final Exam  
9:30 AM - 11:20 AM | | |
will answer any question you have regarding course material, especially assigned homework problems. Take advantage of this resource!

Exams

There will be two midterm exams and a final exam. The final is not comprehensive. The midterm exams shall take place during the fourth and tenth weeks of the semester; see the schedule above. The final exam is scheduled for 9:30 AM - 11:20 AM, Tuesday, December 15, 2020.

5 How to Succeed in this Course

Collaboration is Encouraged

I strongly encourage collaboration, which is an essential skill in science (and highly valued by employers!) Social interaction (these days at a safe distance – most preferably via video chatting) is critical to the success of all scientists – most good ideas grow out of discussions with colleagues. Essentially all scientists work as part of a research team. Find a partner or two with whom you can discuss the homework. However, it is also important that you own the material. It is best to limit yourself to verbal help; resist the impulse to take written information from others. This practice will ensure that you think things through independently after you get help. If you complete the homework but do poorly on exams, then you may be getting too much help. The point of the homework is not to just find the answer, but more importantly to understand the pathway that leads to the answer.

While collaboration is the rule in technical work, the evaluation of each individual also plays an important role. Exams will be done without help from others. The reading quizzes are to be done by yourself. Your homework solutions should be your own.

Guidelines

I firmly believe anyone can do well in this class if they adhere to the following guidelines.

- Before each class meeting read the assigned sections in the textbook. Many students find it helpful to make an outline of the material as they read, highlighting important concepts and equations;
notes should also include questions about material that is unclear. Follow up your reading by getting answers to your questions.

- Take the quiz immediately after reading the assigned material.
- Attend every class meeting. And ask questions while you are there!
- Study the Lecture Notes in preparation for doing the homework.
- Keep up with the homework. Schedule a regular time each week for doing the assignments.
- Work together and/or get help when necessary. Help is available via the Discussion board on Canvas, the instructor’s office hours, or at the weekly recitation.
- Don’t get behind. It’s very hard to catch up.

These points can be summed up as follows:

do the **textbook readings**, take the **quizzes**, attend the **class meeting**, study the **Lecture Notes**, complete the **homework**...

(lather, rinse, repeat,...)

6 **GRADING**

Scores on reading quizzes, homework, and exams contribute to your final grade. The percentage that each contributes is as follows.

- Reading quizzes 10%
- Homework assignments 20%
- Exam I 20%
- Exam II 25%
- Final Exam 25%

If the Exam I is your lowest scoring exam, then your exams shall be weighted as follows.

- Exam I 10%
- Exam II 30%
- Final Exam 30%
The grading scale is listed below. Expect final grades in the course to adhere to this scheme.

- $A \geq 90\%$, $A- \geq 85\%$
- $B+ \geq 80\%$, $B \geq 75\%$, $B- \geq 70\%$
- $C+ \geq 65\%$, $C \geq 60\%$, $C- \geq 55\%$
- $D \geq 50\%$

Yes, Virginia, there is no possibility for a D+ grade.

7 Final Details

COVID-19 Classroom Protocols

In order to continue to provide a high-standard of instruction at USU, and to limit the spread of COVID-19 during the pandemic, students are asked to follow certain classroom protocols during the Fall 2020 semester. These protocols are in place not only for your safety but also the safety of the rest of the campus community. You will be asked to clean your desk area at the start of each class, sit in designated seats, wear face coverings, and follow instructions for egress from the classroom. If for some medical reason you cannot wear a face covering, then please attend recitations via Zoom conferencing. It is imperative that we each do our part so that on-campus instruction can continue.

Disability Accommodations

USU welcomes students with disabilities. If you have, or suspect you may have, a physical, mental health, or learning disability that may require accommodations in this course, please contact the Disability Resource Center (DRC) as early in the semester as possible (University Inn 101, 435-797-2444, drc@usu.edu). All disability related accommodations must be approved by the DRC. Once approved, the DRC will coordinate with faculty to provide accommodations.

Honor Code

The honor code will be strictly enforced in this course. Any suspected violations of the honor code will be promptly reported to the honor system. For more information please visit http://studentconduct.usu.edu/studentcode/article6.
Disclaimer

The instructor reserves the right to modify – as deemed necessary and/or appropriate – any part of this syllabus.