## PHYS 302 – Intermediate Electrodynamics – Spring 2024

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Office Hours: Tuesday 10:45 am - 12:00 pm (tentative)
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Office Hours: TBD
Grader: TBD
Lecture: Tuesday & Thursday 9:25 - 10:40 am – W211 George R. Brown Hall (GRB)
Recitation: Tuesday 4:00 - 5:15 pm – 103 Brockman Hall (BH)

### Course Objectives and Learning Outcomes

This course is a technical introduction to classical electrodynamics. We live in a universe composed of electrically-charged particles – these include the quarks that make up nucleons (protons and neutrons), the nucleons that make up nuclei (atomic cores), the electrons and nuclei that make up atoms, the atoms that make up molecules, and the molecules that make up materials that we interact with in our day-to-day lives. Charged particles push and pull on one another via the electromagnetic field. For instance, it is this electromagnetic attraction that keeps electrons bound to nuclei allowing for stable atoms. On the other hand, it is the same electromagnetic repulsion that prevents my feet from slipping through the ground and my body from plummeting toward the center of the Earth. Electrodynamics is the theory we use to describe how charged particles source the electromagnetic field, and how the electromagnetic field exerts force on the charged particles.

The key goals of this course are as follows.

- To expose students to the ways in which electrodynamics impacts their everyday life. This includes radio transmission, antennas, lightning, conductivity, circuits, light, and optics.
- To introduce students to various mathematical techniques that are frequently employed in the study of electrodynamics and more broadly in physics, engineering, and finance. These include Fourier series, Fourier transform, complex analysis, differential equations, multivariable calculus, tensors, and special functions.
- To strength students' problem solving skills.
- To clarify the intimate relationship between electrodynamics and Einstein's special relativity.
- To lay the foundations for a deeper study of relativistic field theories, which play a central role in elementary particle physics.

Note that PHYS 302 is a 4 credit hour course, which includes two lectures and one recitation session each week. The material covered here is foundational to the undergraduate physics curriculum, and many areas of modern study draw heavily upon these topics; *e.g.*, elementary particle physics, quantum field theory, cosmology, astrophysics, astronomy, quantum optics, fluid mechanics, and magnetohydrodynamics. It is essential and expected that students will invest time each week to working at PHYS 302 outside of the classroom by reading the textbook and working problems.

## Required Texts and Materials

We will use "Introduction to Electrodynamics" by David J. Griffiths. My copy is the $5^{\text{th}}$ edition, which has a purple cover with $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$. It's okay if you have an older edition, but note that some of the equation numbers may be different. Errata for the older editions are available at Griffths's webpage: https://www.reed.edu/physics/faculty/griffiths/.

## Prerequisites

Students should have taken PHYS 201 - WAVES, LIGHT, AND HEAT and be familiar with concepts such as: electrically charged particles, electric field, magnetic field, electromagnetic waves, wave equation, and special relativity. Additionally, students will benefit from a familiarity with ordinary differential equations (ODEs), partial differential equations (PDEs), rotations and tensors, multivariable calculus (*a.k.a.*, vector calculus), linear algebra, and complex analysis. Some of these topics are covered in MATH 211 and MATH 212.

## Grade Policies

Student performance will be evaluated based on the following:

**20%** Homework assignments (weekly).

**20%** Midterm exam (mid-Feb, take home).

**20%** Midterm exam (late-Mar, take home).

**40%** Final exam (late-Apr, in person).

## Homework Assignments

Working through a calculation carefully gives us the opportunity to develop a deeper understanding of the underlying physics. When our understanding doesn't match the calculation, observation, or measurement, then it's time to learn something new about physics. This is how research gets done!

- There will be 12 homework assignments in total – one due each week except during the week of a midterm.
- Homework assignments will be posted at the end of Tuesday's lecture (Tuesdays 10:40 am), and they will be due the following week before Tuesday's lecture (Tuesdays 9:25 am).
- The two lowest scores will be discarded. This policy provides flexibility for life exigencies, such as illness, social and family issues, travel to conferences, and the like. However, the material is cumulative. If you completely skip an assignment, you will struggle to follow and your exam scores will suffer. Please make every possible effort to complete all the assignments.

- While working on the assignments, students are free to consult: the textbook, other textbooks, journal articles, online lecture notes, Wikipedia, YouTube videos, and the course instructors.
- Students are free to collaborate with one another while working on the homework assignments. However, each student must submit a separate write-up of the solutions. If students do collaborate, please include a note such as "I worked with so-and-so on problems #1 and #3."
- While working on the assignments, students **may not** consult an online repository of problem solutions, nor may then acquire solutions from students who took the class in previous years.
- Please lay out your solutions clearly and write legibly. If the grader is unable to read what you have written, they have been advised to award zero points (even if the solution is correct).
- All assignments will be submitted electronically. Assignments must be submitted as a single pdf file using Canvas.
- Late submissions will be penalized by 20% per day. For example, if an assignment is out of 20 points, then an on-time submission will be graded out of 20. A submission that is received between 0 and 24 hours after the deadline will be graded as usual, and then a $20 \times 20\% = 4$ point penalty will be removed. A submission that's received between 24 and 48 hours after the deadline will be graded as usual and then a $20 \times 40\% = 8$ point penalty will be removed.

### Midterm exams

There will be two take-home midterm exams. Midterm #1 will occur around the middle of February, and it will cover Chapters 1-4 of Griffths. Midterm #2 will occur around the end of March, and it will cover Chapters 5-8 of Griffths.

### Final Exam

There will be a final exam at the end of April after classes are over. The exam will be cumulative, covering topics from the entire semester, but with a slight emphasis on Chapters 9-12 of Griffths.

### Absence & Attendance Policies

Students are encouraged to bring their own unique perspective on the material to lectures and share their viewpoint with the class through questions and comments. Attendance at lecture is required.

### Rice Honor Code

In this course, all students will be held to the standards of the Rice Honor Code, a code that you pledged to honor when you matriculated at this institution. If you are unfamiliar with the details of this code and how it is administered, you should consult the Honor System Handbook at http://honor.rice.edu/honor-system-handbook/. This handbook outlines the University's expectations for the integrity of your academic work, the procedures for resolving alleged violations of

those expectations, and the rights and responsibilities of students and faculty members throughout the process.

Submitting AI-generated solutions to the homework problems and passing them off as your own will be considered plagiarism akin to simply copying another student's solutions. Such behavior will harm your own understanding of this foundational material and cause difficulties in this and other courses, which rely heavily and build on the topics covered here. AI-assistance may be used to generate hints when you are stuck (with appropriate acknowledgement), but the preferred approaches are to consult the course textbook, other textbooks that provide alternative explanations you find easier to understand, and to discuss problems with fellow students and the course instructors

If you have any questions about whether a particular course of action (*e.g.*, collaborating on an assignment) is in violation of the Rice Honor Code, please consult with the instructor.

### Disability Resource Center

If you have a documented disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with the Disability Resource Center (Allen Center, Room 111 / adarice@rice.edu / x5841) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

### Title IX Responsible Employee Notification

Rice University cares about your wellbeing and safety. Rice encourages any student who has experienced an incident of harassment, pregnancy discrimination or gender discrimination or relationship, sexual, or other forms interpersonal violence to seek support through The SAFE Office. Students should be aware when seeking support on campus that most employees, including myself, as the instructor/TA, are required by Title IX to disclose all incidents of non-consensual interpersonal behaviors to Title IX professionals on campus who can act to support that student and meet their needs. For more information, please visit safe.rice.edu or email titleixsupport@rice.edu.

### Course Schedule

We'll have a total of 27 lectures and 14 recitations over 14 weeks (not counting the week of spring break). This syllabus is not final and may be changed. Please note that we will be moving through topics very quickly, and therefore it is important that you are following along by reading the appropriate chapters in Griffiths. There is roughly 15-20 pages of assigned reading per lecture.

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**W1a – Tue., Jan. 9, 2024.**

- Lecture – Preface, Advertisement, Ch. 1 Vector Analysis, App. A Vector Calculus in Curvilinear Coordinates, App. B The Helmholtz Theorem, App. C Units
- Recitation – AL covers for SB

**W1b – Thu., Jan. 11, 2024.**

- Lecture – Ch. 2 Electrostatics – Sec. 2.1-2.2

**W1c – Fri., Jan. 12, 2024.**

- Homework #1 due. note the special date

**W2a – Tue., Jan. 16, 2024.**

- Lecture – Ch. 2 Electrostatics – Sec. 2.3-2.4
- Recitation

**W2b – Thu., Jan. 18, 2024.**

- Lecture – Ch. 2 Electrostatics – Sec. 2.5 and Sec. 3.1
- Homework #2 due

**W3a – Tue., Jan. 23, 2024.**

- Lecture – Ch. 3 Potentials – Sec. 3.1-3.3
- Recitation

**W3b – Thu., Jan. 25, 2024.**

- Lecture – Ch. 3 Potentials – Sec. 3.3-3.4
- Homework #3 due

**W4a – Tue., Jan. 30, 2024.**

- Lecture – Ch. 4 Electric Fields in Matter – Sec. 4.1-4.2
- Recitation

**W4b – Thu., Feb. 1, 2024.**

- Lecture – Ch. 4 Electric Fields in Matter – Sec. 4.3-4.4
- Homework #4 due

**W5a – Tue., Feb. 6, 2024.**

- Lecture – Ch. 4 Electric Fields in Matter – Sec. 4.4
- Recitation

**W5b – Thu., Feb. 8, 2024.**

- There is no PHYS 302 Lecture today
- Follow your Monday class schedule instead
- Homework #5 due

**W6a – Tue., Feb. 13, 2024.**

- Lecture – Ch. 5 Magnetostatics
- Recitation

**W6b – Thu., Feb. 15, 2024.**

- Lecture – Ch. 5 Magnetostatics
- Midterm #1 due

**W7a – Tue., Feb. 20, 2024.**

- Lecture – Ch. 5 Magnetostatics
- Recitation

**W7b – Thu., Feb. 22, 2024.**

- Lecture – Ch. 6 Magnetic Fields in Matter
- Homework #6 due

**W8a – Tue., Feb. 27, 2024.**

- Lecture – Ch. 6 Magnetic Fields in Matter
- Recitation

**W8b – Thu., Feb. 29, 2024.**

- Lecture – Ch. 7 Electrodynamics
- Homework #7 due

**W9a – Tue., Mar. 5, 2024.**

- Lecture – Ch. 7 Electrodynamics – SB covers for AL
- Recitation

**W9b – Thu., Mar. 7, 2024.**

- Lecture – Ch. 7 Electrodynamics – SB covers for AL
- Homework #8 due

**SBa – Tue., Mar. 12, 2024.**

- Rice spring break
- No PHYS 302 Lecture / Recitation

**SBb – Thu., Mar. 14, 2024.**

- Rice spring break
- No PHYS 302 Lecture / Recitation

**W10a – Tue., Mar. 19, 2024.**

- Lecture – Ch. 8 Conservation Laws
- Recitation

**W10b – Thu., Mar. 21, 2024.**

- Lecture – Ch. 8 Conservation Laws
- Homework #9 due

**W11a – Tue., Mar. 26, 2024.**

- Lecture – Ch. 9 Electromagnetic Waves – SB covers for AL
- Recitation

**W11b – Thu., Mar. 28, 2024.**

- Lecture – Ch. 9 Electromagnetic Waves

- Midterm #2 due

**W12a – Tue., Apr. 2, 2024.**

- Lecture – Ch. 10 Potentials and Fields
- Recitation

**W12b – Thu., Apr. 4, 2024.**

- Lecture – Ch. 10 Potentials and Fields
- Homework #10 due

**W13a – Tue., Apr. 9, 2024.**

- Lecture – Ch. 11 Radiation
- Recitation – AL covers for SB

**W13b – Thu., Apr. 11, 2024.**

- Lecture – Ch. 11 Radiation
- Homework #11 due

**W14a – Tue., Apr. 16, 2024.**

- Lecture – Ch. 12 Electrodynamics and Relativity
- Recitation

**W14b – Thu., Apr. 18, 2024.**

- Lecture – Ch. 12 Electrodynamics and Relativity
- Homework #12 due

**Wed., Apr. 24, 2024 to Tue., Apr. 30, 2024.**

- Final exam (tentative)