

PHYSICS 450 – ELECTROMAGNETIC WAVES

Spring Semester 2021 TR 9:00–10:15 Online

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Office: Watanabe Hall, Room 212; *Office hours:* to be announced

Course description Historically, one of the most important consequences of Maxwell’s investigations into electrodynamics was the understanding that light is a purely electromagnetic phenomenon. Having developed Maxwell’s equations and explored various applications of electrodynamics in Phys 350, we focus our attention in Phys 450 on the nature and propagation of electromagnetic waves in vacuum and in media. We also explore general solutions to Maxwell’s equations that reveal the rich physical content of these equations – that electromagnetic fields possess energy, linear momentum and angular momentum – and lastly, how electric and magnetic fields are not separate entities, but instead are fundamentally related through the four dimensional structure of space-time. The course thus concludes with a thorough development of the theory of relativity.

Textbooks David J. Griffiths, *Introduction to Electrodynamics*, 4th ed., Cambridge University Press, 2017
(*recommended:* T.A. Moore, *Six Ideas That Shaped Physics, UNIT R*, 3rd ed., McGraw Hill, 2017)

Course website <https://laulima.hawaii.edu/portal/site/MAN.86037.202130>

Grade distribution Weekly Homework: 50%
Midterms/Quizzes: M1(10%) / M2(10%) / Q(10%)
Final Examination: 20%

Grade assignment

A+	90 >	B+	75–80	C+	60–65	C–	40–50
A	80–90	B	65–75	C	50–60	D/F	< 40

Online-sync format Due to continuing University requirements for mitigating the COVID-9 pandemic, PHYS 450 will be conducted entirely online, not in the classroom. I will hold all lectures at the regularly scheduled times (TR 9:30–10:15 HST) via live Zoom meetings. While you are strongly encouraged to attend every class, all lectures will be recorded and posted on Laulima, and my lecture notes (composed prior to class) will be saved in pdf format and uploaded prior to each lecture, so you needn’t worry if you can’t attend a particular class. (I will continue to use the Notability app for compiling the lecture notes, which will be screen-shared during the Zoom meeting.)

- Zoom meeting details will be posted under the **Announcements** tab on the Laulima website.
- Videos and lecture notes will be available under the **Resources** tab on the Laulima website.

Homework Weekly homework is to be submitted by the specified date and time by uploading solutions to Laulima. You are welcome to write out your homework by hand, in which case you can upload scans or smart-phone photos. Certainly, word-processor or LaTeX formats are also most welcome. Quizzes will either be administered directly on Laulima or relegated to in-class two-minute problems, and all exams (midterms and final) will be at-home.

- Homework assignments will be available under the **Resources** tab on the Laulima website.
- Homework solutions will be submitted under the **Assignments** tab on the Laulima website.

Corrections Up until one week after each problem set is returned to you, you may submit corrections to any problem on that problem set for up to 3 additional points per problem. Corrections must be done on the original problem set (written directly on the original writeup for small corrections) or on a separate page (attached to the original problem set for longer corrections) as needed. If you are not sure where you made your original error, or have trouble understanding anything about a problem for which you lost points, you may consult with me to go over any questions you may have.

Late policy You are encouraged to complete and submit all homework, even if it is late! The purpose of the course is to learn the material, and the problem sets are designed to help with this. But it is also true that it is easy to fall behind, and equally important to keep up. To encourage timely submission of homework:

- I will charge a late fee of 2 points per calendar day, including the due date.
- Late homework will not be accepted after one calendar week past the due date, nor after the last day of instruction.

Office Hours

The schedule for ‘office hours’ will be determined during the first week of class, and they will be held as live Zoom meetings. However, if you can’t make office hours, or if you ever have any questions at any time, I am very responsive via email and am happy to meet with you separately if needed.

COURSE OUTLINE

Dates	Topics	Chapter
Jan 12–Feb 9	the wave equation; properties of waves; electromagnetic plane waves in free space and dielectric media; reflection at surfaces; electromagnetic waves in conductors; guided waves	Griff 9
Feb 11–Feb 23	energy, momentum and angular momentum in electric and magnetic fields; Poynting’s theorem; Maxwell’s stress tensor	Griff 8
Feb 16	<i>Midterm Examination #1 due Friday, Feb 19</i>	
Feb 25–Mar 9	potential theory; scalar and vector potentials; Coulomb and Lorentz gauges; retarded potentials; Lienard-Wiechert potentials; field of a moving charge	Griff 10
Mar 11–Mar 23	nature and origin of electromagnetic radiation; power radiated by a moving charge; charges in arbitrary motion	Griff 11
Mar 25	<i>Midterm Examination #2 due Monday, Mar 29</i>	
Mar 25–Apr 15	principle of relativity; clock synchronization; the nature of time; the metric equation; proper time; the Lorentz transformation; Lorentz contraction; the causal structure of spacetime; four-vectors; energy and momentum	Griff 12 (notes)
Apr 20–Apr 29	electrodynamics and relativity; transformation of electric and magnetic fields; the field tensor and relativistic potentials	Griff 12
May 4	<i>Review Session</i>	
May 10–14	<i>Final Examination</i>	