

PHYSICS 450 – ELECTROMAGNETIC WAVES

Spring Semester 2023; TR 9:00–10:15; WAT 420

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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, 4th ed., McGraw Hill, 2023)

Course website <https://laulima.hawaii.edu/> → PHYS-450-001 [MAN.80968.SP23]

Grade distribution

Weekly Homework:	50%
Quizzes/ Midterms:	Q(5%) / M1(15%) / M2(15%)
Final Examination:	15%

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

In-class section The primary format of PHYS 450 will be in-class lectures. The complete lecture notes for each class will be made available on Laulima prior to each class, and during the class itself I will discuss selected features of the topics covered.

Periodic quizzes will be administered and submitted in class. All exams will be take-home and submitted online.

- Prior to each class, lecture notes will be made available under the **Resources** tab on the Laulima website.

Online resources As part of the in-class lectures, I will record all PHYS 450 lectures over Zoom. This process will be for recording purposes only – the lectures themselves will not be simulcast over Zoom. However, it will give students an opportunity to review the lecture material at their own pace, and also catch up on any lectures they may miss for any reason.

- After each class, links to the cloud recordings will be distributed under **Announcements** as soon as they are available (usually the next day).

Homework Weekly homework is to be submitted by the specified date and time by uploading solutions to Laulima (pdf format preferred). You are welcome to write out your homework by hand (legibly!), in which case you can upload scans or smart-phone photos. Certainly, word-processor or LaTeX formats are also most welcome and, indeed, encouraged.

- Homework assignments will be posted and submitted through the **Assignments** tab on the Laulima website as soon as they are available.

Corrections Up until one week after any problem set is returned to you, you may submit corrections to any problem on that problem set, together with the original problem set, for up to 3 points per problem (out of 10). Corrections must be done on the original problem set in red ink (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 discuss any questions you may have.

Late fee policy

I encourage you to complete and submit all homework, even if it is late! The goal 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 you to submit your homework on time, I will charge a late fee of 2 points per day. Thus, submission on the due date after start of class is 2 points reduction, submission one day later is 4 points reduction, etc. For modestly late homework, I don't think this is too great, but obviously becomes more serious the later the homework. I will not let any late fees reduce your score to less than 50% of your raw score.

If you submit corrections, then the additional 3 corrections points (per problem) are applied to the original score, not the late fees.

Late homework will not be accepted after one calendar week past the due date.

Office hours

The format for office hours will be determined in class.

COURSE OUTLINE

Dates	Topics	Chapter
Jan 10–Feb 7	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 9–Feb 21	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</i>	
Feb 23–Mar 2	potential theory; scalar and vector potentials; Coulomb and Lorentz gauges; retarded potentials; Lienard-Wiechert potentials; field of a moving charge	Griff 10
Mar 7–Mar 9	nature and origin of electromagnetic radiation; power radiated by a moving charge; charges in arbitrary motion	Griff 11
Mar 23	<i>Midterm Examination #2</i>	
Mar 21–Apr 11	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	Notes (Griff 12)
Apr 13–Apr 25	electrodynamics and relativity; transformation of electric and magnetic fields; the field tensor and relativistic potentials	Notes (Griff 12)
Apr 27–May 2	<i>Review Sessions</i>	
May 8–12	<i>Final Exam Week</i>	