

PHYSICS 450 – ELECTROMAGNETIC WAVES

Spring Semester 2025; TR 9:00–10:15; MSB 307

Instructor: Eric B. Szarmes (szarmes@hawaii.edu)

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

Course description Historically, one of the most important consequences of Maxwell’s investigations into electro-dynamics 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*, 5th ed., Cambridge University Press, 2024
- (*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.80639.SP25]

Grade distribution

Weekly Homework: 40%
Quizzes/ Midterms: Q(15%) / 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 lectures In Spring 2025, the format of PHYS 450 will consist of 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 in class. All exams (midterm exams and the final exam) will be take-home exams and submitted on Laulima.

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

Homework Weekly Homework is to be submitted by the start of class on the specified date by uploading solutions in pdf format to Laulima. You are welcome to write out your homework by hand (legibly!), in which case you can upload scans or smart-phone photos after converting to pdf. Of course, 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.

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 (out of 10) **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 why you may have lost points, please meet 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.

... continued

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.

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 regular office hours will be determined during the first week of class. For convenience, these are typically held over Zoom. However, if you are unable to attend office hours, or if you prefer to meet in person, I am happy to make separate arrangements.

COURSE OUTLINE

Dates	Topics	Chapter
Jan 14–Feb 11	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	<i>Midterm Examination #1</i>	
Feb 13–Feb 25	energy, momentum and angular momentum in electric and magnetic fields; Poynting's theorem; Maxwell's stress tensor	Griff 8
Feb 27–Mar 6	potential theory; scalar and vector potentials; Coulomb and Lorentz gauges; retarded potentials; Lienard-Wiechert potentials; fields of a moving charge	Griff 10
Mar 11–Mar 13	nature and origin of electromagnetic radiation; power radiated by a moving charge; charges in arbitrary motion	Griff 11
Mar 11	<i>Midterm Examination #2</i>	
Mar 17–21	<i>SPRING RECESS</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	Notes (Griff 12)
Apr 17–Apr 29	electrodynamics and relativity; transformation of electric and magnetic fields; the field tensor and relativistic potentials	Notes (Griff 12)
May 1–May 6	<i>Review Sessions</i>	
May 12–16	<i>Final Exam Week</i>	