UNIVERSITY OF MISSISSIPPI
Department of Physics and Astronomy
Grad Electromagnetism II (Phys. 722) — Prof. Leo C. Stein — Fall 2025

Grad Electromagnetism II Syllabus

Class schedule:	TTh 0800–0920, Lewis 109
Office hours:	TBD, Lewis 205
Course website:	https://duetosymmetry.com/teaching
Professor:	Leo C. Stein (he/him; you can call me "Leo" or "Dr. Stein")
Email:	⟨lcstein@go.olemiss.edu⟩
Office:	205 Lewis Hall

Accessing homeworks/exams will be through Blackboard. If you are in this course and do not have access to the virtual classroom, email Leo ASAP!

Course goals and learning outcome

This is the second half of a standard course on electromagnetism in the graduate curriculum for physics.

Key concepts (time permitting): • cavities and waveguides, • magnetohydrodynamics, • special relativity and index gymnastics, • covariant and potential formulation of electromagnetism, • Lagrangian formulation of electromagnetism, • Noether's theorem and conservation laws, • partial wave decomposition, • diffraction and scattering theory .

Goals: Understanding of electro- and magneto- statics and dynamics; relevance to physical systems; strengthen tools of vector/tensor calculus; applying multivariate/tensor calculus and special mathematical tools (e.g. Green's functions and the multipole expansion). These goals are to enhance students' mathematical reasoning, critical thinking, and analytical reasoning.

Texts

There is no required textbook for this course. However, for your own studies and reference, I recommend getting a standard text. There are lots of options, e.g.

- Schwinger et al., *Classical Electrodynamics*.
- Jackson, *Classical Electrodynamics*.

I list some additional references:

- Wald, *Advanced Classical Electromagnetism*. Better treatment of point particles, the self-force, and some other topics than most texts.
- Griffiths, *Introduction to Electrodynamics*. An undergraduate textbook but very easy to follow.
- Thorne and Blandford, *Modern Classical Physics*. Very comprehensive (∼1500 pages) covering much more than electrodynamics. Includes intro to magnetohydrodynamics and plasma physics. PDFs of pre-publication notes currently available at http://www.pmaweb.caltech.edu/Courses/ph136/yr2012/.
- Sturrock, *Plasma Physics*. Specialist text, but starts from scratch and I found it easy to follow.
- PDFs available online from Russell Herman (UNC Wilmington); David Tong (Cambridge); Philip Nelson (UPenn); Richard Fitzpatrick (UT Austin); Alan Guth (MIT)

Evaluation

Grade type:	Letter grade A–F
Grade ranges:	(subject to change) • A: 88% and up • B: 75–87% • C: 65–74% • D: 55–64% • F: <55%
Grade breakdown:	(subject to change) • 50% Homework • 20% Midterm • 30% Final

Homework, tests, and final exam

Homework assignments will be announced via the course web site, and they must be turned in by midnight on the due date. Late homework will be penalized 20% per day (exceptions and extensions permitted with good cause). Homeworks and exams may be physically handed in, or submitted as PDFs or JPGs via the course web site. Homework must be easy to read: please clearly write down your name and the problem set number, do not use a red pen. The midterm and final exam will be open-book and open-notes, and a calculator will be permitted.

Attendance

There is no strict attendance requirement, but you are strongly advised to attend class. Attendance has a strong correlation with performance. I recommend that you read the book sections in advance and come ready to participate. If you miss an exam or cannot turn in homework, please inform me beforehand and get a doctor's note if applicable. Absences from tests count as zeros, unless they are justified. If you must be absent during a test for a University sponsored event, you must discuss this with me before the test date.

Disability Access and Inclusion

The University of Mississippi is committed to the creation of inclusive learning environments for all students. If there are aspects of the instruction or design of this course that result in barriers to your full inclusion and participation, or to accurate assessment of your achievement, please contact the course instructor as soon as possible. Barriers may include, but are not necessarily limited to, timed exams and in-class assignments, difficulty with the acquisition of lecture content, inaccessible web content, and the use of non-captioned or non-transcribed video and audio files. If you are approved through SDS, you must log in to your Rebel Access portal at https://sds.olemiss.edu to request approved accommodations. If you are NOT approved through SDS, you must contact Student Disability Services at 662-915-7128 so the office can: 1) determine your eligibility for accommodations, 2) disseminate to your instructors a Faculty Notification Letter, 3) facilitate the removal of barriers, and 4) ensure you have equal access to the same opportunities for success that are available to all students.

Academic Integrity

Violations of the University's policy of academic integrity will result in a failing grade and other disciplinary actions. A student with a documented case of plagiarism or cheating in this course will receive a failing grade for the course and may face disciplinary action by the University, including expulsion.

In particular, do not turn in problem set solutions copied from online or a solutions manual. Copying solutions does nothing to enhance your learning. If I see this then you will get an automatic 0 for the problem set. It if happens more than once I will report it to the chair of the department.

Use of Generative Artificial Intelligence

Generative AI refers to technologies like ChatGPT or similar tools, that can draw on a large corpus of training data to create new written, visual, or audio content. The point of education is not just to correctly answer problems, but to deeply understand a topic for yourself. If you feel that generative AI helps you think for yourself and more deeply understand the material we are learning, I am not going to stop you from using it. Copying output from generative AI still constitutes plagiarism, and there is no guarantee that the tool is responding correctly (it is just like autocompletion). I therefore discourage you from using tools like OpenAI's ChatGPT, Google's Gemini, Microsoft's Copilot, Anthropic's Claude, etc.

Other

If a change in the syllabus becomes necessary during the semester, it will be discussed in class and then posted on the course website. The course website will also contain up-to-date information on the class schedule, homework assignments, and complementary material.

Schedule (subject to change)

Expressions in parentheses refer to sections of Jackson (marked with J) or other texts that are useful references for these topics.

T	Aug	26	Lecture 01:	Admin. Lightning review of EM I
Th	Aug	28	Lecture 02:	Dispersion relations (J7.5, 7.8)
T	Sep	02	Lecture 03:	Waveguides (J8.2–8.4)
Th	Sep	04	Lecture 04:	Magnetohydrodynamic waves (J7.7/Sturrock)
T	Sep	09	Lecture 05:	Magnetohydrodynamic waves
Th	Sep	11	Lecture 06:	Radiative Green's function (review/reminder)
T	Sep	16	Lecture 07:	Dipole radiation. Radiative multipole expansion (J9.2)
Th	Sep	18	Lecture 08:	Radiation using vector spherical harmonics (J9.6–9.8)
T	Sep	23	Lecture 09:	Special relativity (J11.2–11.4)
Th	Sep	25	Lecture 10:	Lorentz vectors, tensors, velocity, momentum, force (J11.4–11.5)
T	Sep	30	Lecture 11:	Special relativistic kinematics
Th	Oct	02	Lecture 12:	Maxwell's eqs. and Lorentz force law in 4d language (J11.9–11.10)
T	Oct	07	Lecture 13:	Potential formulation, gauge invariance
Th	Oct	09	Lecture 14:	Lagrangian formulation of electrodynamics (J12.7)
T	Oct	14	Lecture 15:	Symmetries and Noether's theorem
Th	Oct	16	Lecture 16:	Energy-momentum-stress tensor
T	Oct	21	Lecture 17:	Radiation from arbitrary relativistic motion (J14.1–14.4)
Th	Oct	23	Lecture 18:	Radiation from arbitrary relativistic motion (J14.4)
T	Oct	28	Lecture 19:	Angular, spectral distribution of energy (J14.5)
Th	Oct	30	Lecture 20:	Radiation spectrum from circular motion (J14.6)
T	Nov	04	Lecture 21:	Synchrotron sources (J14.7)
Th	Nov	06	Lecture 22:	Beginning scattering
T	Nov	11	Lecture 23:	Born approximation (J10.2)
Th	Nov	13	Lecture 24:	Partial wave expansion (J10.3–10.4)
T	Nov	18	Lecture 25:	Diffraction (J10.5–10.7)
Th	Nov	20	Lecture 26:	Optical theorem (J10.11)
				Nov 22–30 Thanksgiving Holidays
T*	Dec	02	Lecture 27:	Thomson scattering (J14.8)
Th*	Dec	04	Lecture 28:	Radiation from collisions (J15.1)
				Dec 08–12 Final exams

*=Leo has another responsibility (e.g. travel). So far, this schedule is just a suggested order. Please let me know about any holidays that I should be aware of (e.g. Eid, Yom Kippur, etc.).