UNIVERSITY OF MISSISSIPPI
Department of Physics and Astronomy
Graduate Electromagnetism I (Phys. 721) — Prof. Leo C. Stein — Spring 2023

Graduate Electromagnetism I Syllabus

Class schedule:	MWF 0900–0950, Lewis 109
Office hours:	W 1730–1900, Lewis 109
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 Google Classroom. If you are in this course and do not have access to the virtual classroom, email Leo ASAP!

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)

Course goals and learning outcome

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

Key concepts (time permitting): • special relativity and index gymnastics, • covariant and potential formulation of electromagnetism, • Lagrangian and Hamiltonian formulations of electromagnetism, • Noether's theorem and conservation laws, • Green's function solutions, • multipole expansion, • radiation, • partial wave decomposition, • scattering, • EM fields in media .

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.

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 (electronic submission is preferred). 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.

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.

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.

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.

Classroom Health Requirements

- Students are expected to comply with the University's protocols when they are in effect. Currently, a mask requirement is in place for vaccinated and unvaccinated people. As a result, proper mask wearing is required indoors and in the classroom. Current protocols can be found at https://coronavirus.olemiss.edu/.
- Students who have a diagnosed health concern that interferes with the wearing of face masks may contact the Student Disabilities Services (SDS) Office to seek a University-approved accommodation. Please contact SDS at https://sds.olemiss.edu/ for more information.
- If students test positive for COVID-19 at any health care facility, they must contact the Student Health Center at 662-915-7274. (Faculty and staff should contact the Employee Health Service at 662-915-6550.) University Health Services will coordinate contact tracing to lessen the likelihood of spread.
- Students with COVID-19 should seek medical attention at the Student Health Center and contact their instructor to let them know that they will be missing class due to a health-related issue.
- If you are exposed to someone with COVID-19, you should contact the Student Health Center to get tested three to five days following exposure and follow the guidance recommended by the Health Center. If you are not fully vaccinated, you should follow quarantine protocols found at https://coronavirus.olemiss.edu/students/.

Non-adherence with Health Requirements

- Currently, COVID-19 guidelines for the Fall 2021 semester include face masks for vaccinated and unvaccinated people inside University buildings; therefore, students should not be in classroom spaces when they are out of compliance with these guidelines unless they have an accommodation approved by Student Disability Services.
- The University's Academic Conduct and Discipline Policy states that "disorderly behavior that disrupts the academic environment violates the standard of fair access to the academic experience." Failure to adhere to health requirements during the COVID-19 emergency will be deemed as disruptive to the classroom and will be enforced following the Academic Conduct and Discipline procedures.
- The University of Mississippi has adopted a tiered disciplinary protocol for non-adherence to COVID-19 health requirements. This disciplinary protocol is maintained by the Office of Conflict Resolution and Student Conduct: https://conflictresolution.olemiss.edu/covidupdates.

Schedule (subject to change)

M	Jan	23	Lecture 01:	Admin. Overview. Maxwell's Eqs.
W	Jan	25	Lecture 02:	Index notation basics
F	Jan	27	Lecture 03:	(Electro)Statics: Basics
M	Jan	30	Lecture 04:	Gauss's law and Ampère's law
W	Feb	01	Lecture 05:	"Ice storm"
F	Feb	03	Lecture 06:	(Electro)Statics: Uniqueness
M	Feb	06	Lecture 07:	(Electro)Statics
W	Feb	08	Lecture 08:	Method of images
F	Feb	10	Lecture 09:	Delta functions and Green's functions
M	Feb	13	Lecture 10:	Separation of variables
W	Feb	15	Lecture 11:	Basis expansions
F	Feb	17	Lecture 12:	Legendre polynomials and spherical harmonics
M	Feb	20	Lecture 13:	Static electric multipole expansion
W	Feb	22	Lecture 14:	Magnetostatics and dipoles
F	Feb	24	Lecture 15:	Static magnetic multipole expansion
M	Feb	27	Lecture 16:	Averaging from microscopic to macroscopic
W	Mar	01	Lecture 17:	Macroscopic media: dielectrics
F	Mar	03*	Lecture 18:	Macroscopic media: magnetized materials
M	Mar	06	Lecture 19:	Electromotive force, induction
W	Mar	08	Lecture 20:	Special relativity, index gymnastics, Minkowski, tensors
F	Mar	10	Lecture 21:	Lorentz vectors, tensors, velocity, momentum, force
				Mar 11–19 Spring Break
M	Mar	20	Lecture 22:	Special relativistic kinematics, causal structure
W	Mar	22	Lecture 23:	Maxwell's eqs. and Lorentz force law in 4d language
F	Mar	24	Lecture 24:	Potential formulation, gauge invariance
M	Mar	27	Lecture 25:	Lagrangian formulation
W	Mar	29	Lecture 26:	Lagrangian formulation of electrodynamics
F	Mar	31	Lecture 27:	Densities, fluxes, conservation laws
M	Apr	03	Lecture 28:	Energy-momentum-stress tensor
W	Apr	05	Lecture 29:	Symmetries and Noether's theorem
F	Apr	07		Good Friday – Holiday
M	Apr	10	Lecture 30:	Wave equation Green's function, adv. and ret. solutions
W	Apr	12	Lecture 31:	Plane waves, general radiation
F	Apr	14	Lecture 32:	Reflection at interfaces
M	Apr	17*	Lecture 33:	Dispersion in media
W	Apr	19	Lecture 34:	Waveguides
F	Apr	21	Lecture 35:	Radiative multipole expansion
M	Apr	24	Lecture 36:	
W	Apr	26	Lecture 37:	
F	Apr	28	Lecture 38:	
M	May	01	Lecture 39:	
W	May	03	Lecture 40:	
F	May	05	Lecture 41:	
				May 08–12 Final exams

*=Leo has another responsibility (e.g. conference). So far, this schedule is just a suggested order.