UNIVERSITY OF MISSISSIPPI
Department of Physics and Astronomy
Graduate Electromagnetism I (Phys. 721) — Prof. Leo C. Stein — Spring 2024

Graduate Electromagnetism I Syllabus

Class schedule:	MWF 0900–0950, Lewis 109
Office hours:	F 1100–1200, 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!

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

Key concepts (time permitting): • vector calculus and index gymnastics, • methods for electro/magnetostatics, • Green's function methods, • static multipole expansion, • radiative multipole expansion, • special functions, • tensor methods, • Liénard-Wiechart potentials .

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 Blackboard, and they must be turned in by the stated time 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 digitally via Blackboard. 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.

Schedule (subject to change)

M	Jan	22	Lecture 01:	(Campus closed from snow)
W	Jan	24	Lecture 02:	(Campus closed from snow)
F	Jan	26	Lecture 03:	Admin. Overview. Maxwell's Eqs.
M	Jan	29	Lecture 04:	Vector spaces/index notation basics
W	Jan	31	Lecture 05:	Transformation of tensor components
F	Feb	02	Lecture 06:	Tensor derivatives
M	Feb	05*	Lecture 07:	(Electro)Statics: Basics
W	Feb	07*	Lecture 08:	Gauss's law and Ampère's law
F	Feb	09	Lecture 09:	(Electro)Statics: Uniqueness
M	Feb	12	Lecture 10:	(Electro)Statics
W	Feb	14	Lecture 11:	Method of images
F	Feb	16	Lecture 12:	Method of images
M	Feb	19	Lecture 13:	Delta functions and Green's functions
W	Feb	21	Lecture 14:	Separation of variables
F	Feb	23	Lecture 15:	Basis expansions
M	Feb	26	Lecture 16:	Legendre polynomials, spherical harmonics, Fourier
W	Feb	28	Lecture 17:	Reduced Green's functions
F	Mar	01*	Lecture 18:	Reduced Green's functions
M	Mar	04	Lecture 19:	Variation of parameters
W	Mar	06	Lecture 20:	Electrostatic multipole expansion (Legendre polynomial version)
F	Mar	08	Lecture 21:	Electrostatic multipole expansion (spherical harmonic version)
				Mar 09–17 Spring Break
M	Mar	18	Lecture 22:	Electrostatic multipole expansion (spherical harmonic version)
W	Mar	20	Lecture 23:	Tensor symmetries
F	Mar	22	Lecture 24:	Electrostatic multipole expansion (tensor version)
M	Mar	25	Lecture 25:	Effective sources and magnetostatic multipole expansion
W	Mar	27	Lecture 26:	Magnetostatic multipole expansion
F	Mar	29		Good Friday – Holiday
M	Apr	01	Lecture 27:	Energy/forces/torques on dipoles
W	Apr	03*	Lecture 28:	Interaction of dipoles and multipoles
F	Apr	05*	Lecture 29:	Magnetostatics and induction
M	Apr	08	Lecture 30:	Displacement current; electrodynamics
W	Apr	10	Lecture 31:	Gauge transformations; radiative Green's function
F	Apr	12	Lecture 32:	Radiative Green's function
M	Apr	15	Lecture 33:	Retarded Green's function; Jefimenko's equations
W	Apr	17	Lecture 34:	Liénard–Wiechert potentials
F	Apr	19	Lecture 35:	E and B fields from L–W potentials; charge in uniform motion
M	Apr	22	Lecture 36:	Energy in radiation and conservation
W	Apr	24	Lecture 37:	Dipole radiation
F	Apr	26	Lecture 38:	Radiative multipole expansion
M	Apr	29	Lecture 39:	Radiative multipole expansion
W	May	01	Lecture 40:	Radiative multipole expansion
F	May	03	Lecture 41:	Vector spherical harmonics
				May 06–10 Final exams

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