PHYS 3122 Electro and Magnetostatics Fall 2026 – Tentative Syllabus 4/16/26

Course Content

This is an advanced undergraduate course in electromagnetism, one of the most beautiful and successful theories in Physics. In this course, we will work within the realm of classical mechanics to construct a theory of electromagnetism applicable to vacuum and matter. The fundamental problem we hope to solve can be formulated simply: *"I hold up a bunch of electric charges here (and maybe shake them around); what happens to some other charge, over there*?" As we will see, the solution is best formulated in terms of a field theory which is the study of Maxwell's equations using the powerful mathematical tool of vector analysis. This semester, we will be primarily concerned with physical situations in which charges are static or traveling at constant velocity, namely electro and magnetostatics. Next semester, you may choose to study the case of accelerating charges in electrodynamics. Electromagnetism is a gateway to advanced theoretical physics but also a ubiquitous tool for applied sciences with deep ramifications in electrical & computer engineering, materials science, atmospheric sciences, aerospace engineering, and more. I hope you will find the course enjoyable, fun and useful for your future career as scientist or engineer. The course is organized into six units covering Chapters 1 to 6 from the legendary Griffiths textbook:

Unit 1: Vector Analysis -- Differential and integral calculus, curvilinear coordinates, delta function.
Unit 2: Electrostatics -- Electric field, electric potential, work and energy.
Unit 3: Potentials -- Laplace's equation, method of images, multipole expansions.
Unit 4: Electric Fields in Matter -- Polarization, dielectrics, electric displacement, linear media.
Unit 5: Magnetostatics -- Magnetic field, magnetic force, vector potential.
Unit 6: Magnetic Fields in Matter -- Magnetization, auxiliary field, susceptibility, ferromagnetism.

Learning Objectives

By the end of this course, you will be able to apply vector calculus in multiple coordinate systems and use integral theorems to analyze physical fields; understand and compute electric fields and potentials from various charge distributions using Coulomb's law, Gauss's law, and boundary-value techniques; solve Poisson's and Laplace's equations with appropriate boundary conditions; analyze the behavior of electric fields in dielectric materials using polarization and the displacement field; calculate magnetic fields from steady currents using the Biot–Savart law and Ampère's law; and understand the role of magnetization and the auxiliary field in magnetic materials. You will learn to develop physical intuition, mathematical rigor, and problem-solving strategies in electrostatics and magnetostatics.

Instructional Team

Instructor: Prof. Martin Mourigal, Dunn Family Professor in the School of Physics

Contact: mourigal@gatech.edu (for regular business)

Mobile: Will be distributed to class (only in case of emergency)

Office: Howey C202

Research: Quantum Materials, Condensed Matter Physics

Course Organization

This course will be deliberately in a deliberately "low-tech" approach, with minimal use of technology and emphasis on white-board derivations and discussions, pen-and-paper assignments, and interaction between participants.

📅 **Schedule:** We will be using the Canvas calendar for **homework** due dates and uploads.

💬 **Communication:** All individual or student-specific communication will take place by email or by appointment.

📚**Materials:**

- The official textbook for this course is the legendary ***Introduction to Electrodynamics*** by David J. Griffiths.
- I teach by closely following the book and using my own handwritten lecture notes**,** which are adapted from the book and the notes of Prof. Steven Pollock (Colorado).
- You must come to class and take notes during lectures.
- A copy of my current and past year lecture notes is available by my office door.
- If you have a disability that requires class materials to be adapted to your needs, please contact me. Machine readable versions of Griffiths exist.

👩🏾‍🏫 **Lectures**: Ford Building L1175

- Every Monday, 11:00 a.m.- 12:15 p.m.
- Every Wednesday, 11:00 a.m.- 12:15 p.m.
- Use of electronic devices is not allowed in class, except tablets in airplane mode for note taking.
- I prohibit the recording of lectures by students (video, voice, AI transcript) except if discussed in advance. Take notes instead.

⏳ **Tests:** held in-person during class time,

- Test 1: Date TBD. (80 minutes)
- Test 2: Date TBD. (80 minutes)
- Final Exam: Date TBD (160 minutes)

📝 **Homeworks**: Twelve assignments,

- Due every Monday at 11:00 a.m. except on exam weeks when no homework is due.
- Grace period of 4 days until the next Friday at 11:00am.
- 💡You can skip two assignments and still get all the homework points (not recommended).

🙋🏼‍♂️ **Office Hours**: except otherwise communicated to class,

- Every Wednesday 4-5:15 p.m. in Howey C202-C204
- Every Thursday 4-5:15 p.m. in Howey C202-C204
- Office hours are group discussions about class concepts and homework assignments. Everybody gets something out of it!

Grading

💻 **Your class performance will be determined out of a total of 100 points by:**

- Three **in-class exams** (80 points)
  - Test 1: 25 points
  - Test 2: 25 points
  - Final: 30 points
- Twelve **weekly homework sets** (20 points)
  - Each homework set: 2 points
  - 12 homework sets to complete for a maximum of 20 points
  - 💡**Possible but not recommended:** You can decide to skip up to 2 out of 12 assignments and still receive all the points.

🔠 **Your letter grade will be calculated as follows:**

- A: 90 points or more, B: 80–89, C: 70–79, D: 60–69, F: 59 or less
- Your final score rounded to the next integer, for instance 89.58 → 90(A), 79.42 →79(C)

📆 **Missed lectures, homework, and exams:**

- Unless in exceptional circumstances, I do not accept or keep track of excuses for missed classes or homework assignments. There is sufficient flexibility built in the course (10/12 assignments turned in → full points *possible*), so I will not waste your and my time on entertaining such requests.
- No makeup exams. If you miss a particular in-class exam, you will be assigned 0 points. However, if you have an official GT absence letter, communicated to me at least 24 hours in advance, and you miss one in-class exam, your score will be replaced by your average on the

other two in-class exams. If you miss two or more in-class exams, you will be assigned 0 points for these. I also understand that emergencies occur, in which case, contact me immediately (mourigal@gatech.edu or Cell Phone).

In-class Tests and Final

The exams are **closed books, closed notes** and taking place during class times. You will only be allowed pencils and an eraser. You instructor will distribute blue books and will include a formula sheet with the test.

Homework

- Homework sets are **assigned weekly** and are due the following **Monday at 11:00 a.m.** by electronic upload of **your handwritten solution** as a single file through Canvas. No homework assignments are due the week of an in-class exam.
- 💡Possible but not recommended: Late homework will be accepted for 4 days after the deadline.
- 🆘 Office hours and Ed discissions are designed to help you the homework. Don't hesitate to reach out!

How to succeed in this class

- **Respect**: I abide by GT's Student-Faculty ExpectationsLinks to an external site. My goal is for every student in the class to rise to their full potential.
- **Be organized**: Time management and regular, steady work are essential. If you are stalling or falling behind, contact me sooner rather than later for help and a motivational speech.
- **Classes are hard work**: Come to class and take your own handwritten notes. After class, rewrite your notes more cleanly, comparing them with my notes. When preparing for in-class exams, prepare a cheat sheet from your notes. This process enables you to assimilate the material thoroughly.
- **Attempt the homework in time**: Homework is critical to use your knowledge in practice. It is better to drop a homework than to be perpetually behind.
- **You are part of a community:** Coming to office hours allows you to meet other students, get help from the instructor about homework and concepts from class. If you cannot attend office hours, ED discussions can provide quick help and feedback.
- **Rest and have fun:** GT can be very stressful. Prioritizing rest over late-night homework usually pays off. Always seek the enjoyable aspects of your education instead of a competition focused on grades.

Academic Integrity, Collaboration, and use of AI

- **Academic integrity:** Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. See the Georgia Tech Honor Code.
- **Collaboration policy:** You are allowed to discuss homework assignments with each other, but the solutions have to be executed and submitted individually. It is forbidden to copy a solution directly from a classmate’s written solution, but it is allowed to explain solutions to each other. The same applies to the use of AI tools to solve homework problems. You can use it as a resource to get guidance (I can't stop you but don't melt your brain) but you are not allowed to directly copy a solution from it.
- **Cheating and Plagiarizing:** Any student suspected of cheating or caught plagiarizing a classmate, the internet or an AI chatbot (without proper citation) on a homework assignment or in-class exam, will be reported to the Office of Student Integrity, who will investigate the incident.

Learning Accommodations

- I will make accommodations for students with documented disabilities. These accommodations must be arranged in advance and in accordance with the Office of Disability Services.

Tentative Lecture Plan (subject to change during the semester)

- Lecture 1: Syllabus, role of electromagnetism, postulates, vector algebra, coordinate systems
- Lecture 2: Coulomb's law and superposition (discrete and continuous charge distributions)
- Lecture 3: Applications of Coulomb's law
- Lecture 4: Gauss's law (integral form), multivariable calculus
- Lecture 5: Gauss's law (local form), applications
- Lecture 6: Dirac delta function, curl of E, Helmholtz theorem
- Lecture 7: Electric potential, Poisson's and Laplace's equations
- Lecture 8: Boundary conditions, electrostatic energy, conductors and capacitance
- Lecture 9: Solving Laplace's equation, method of images

Test #1 will cover content of Lectures 1-9

- Lecture 10: Separation of variables (Cartesian coordinates)
- Lecture 11: Separation of variables (Spherical coordinates)
- Lecture 12: Multipole expansion (general principle, discrete and continuous multipoles)
- Lecture 13: Properties of dipoles and quadrupoles
- Lecture 14: Electrostatic fields in matter, bound charges, polarization
- Lecture 15: Electric displacement, linear dielectrics, dielectric sphere in uniform field
- Lecture 16: Introduction to magnetostatics, Lorentz force
- Lecture 17: Currents and continuity equation
- Lecture 18: Biot–Savart law (theory and application)

Test #2 will cover content of Lectures 10-18

- Lecture 19: Ampère's law (theory)
- Lecture 20: Applications of Ampère's law
- Lecture 21: Magnetic vector potential (theory and gauge transformation)
- Lecture 22: Applications of magnetic vector potential
- Lecture 23: Boundary conditions, Aharonov–Bohm effect
- Lecture 24: Multipole expansion and vector potential of a pure magnetic dipole
- Lecture 25: Microscopic theory of magnetism, bound and free currents
- Lecture 26: Linear and non-linear magnetic media

The final will cover the content of Lectures 19-26 (2/3) and a review of previous topics (1/3)