Physical Science 12b: Electromagnetism & Quantum Physics from an Analytic, Numerical and Experimental Perspective

Fall 2022 Syllabus

Course Description

This is the second term of a two-semester course sequence of introductory physical science and engineering. The focus is on quantitative scientific reasoning, with the second term exploring classical electricity and magnetism. Topics include electrostatics and magnetostatics, analog circuits, electromagnetic fields, optics, and a brief introduction to quantum physics and its applications. Examples are drawn from across the physical sciences and engineering.

The course assumes familiarity with calculus-based mechanics and statistical physics covered in Physical Sciences 12a, offered in spring, using both analytical and numerical methods (see course description). Students will further develop competence in both analytic (using pencil, paper, and multi-variable calculus) and numerical methods (using the Python programming language) to model simple physical systems and to analyze experimental data collected in the laboratory component of the course.

The course is aimed at second year students who have an interest in pursuing a concentration in the sciences or engineering. The course includes lecture, laboratory, and discussion components.

Prerequisite

Physical Sciences 12a

Without Physical Sciences 12a, students can request Instructor permission to enroll if they have taken a calculus-based course in classical mechanics and either: a) have taken Applied Mathematics 10 or a higher-level scientific computing course (e.g., AM 111), b) will concurrently enroll in Applied Mathematics 10, or c) will concurrently audit the first module of Applied Mathematics 10.

Books & Resources

We provide lecture notes, lab resources, and reading material to you. A supplemental reading list will cover material from the online textbook, *University Physics, Vol. 2*, published by OpenStax and available here.

Equity & Inclusion

Cooperation, diversity, and accessibility strengthen our academic community. We therefore prioritize collaboration and aim to provide a welcoming and inclusive environment for *all* students.

Students should *always* feel free to reach out to the Instructors about any concerns that they may have. The Accessibility Office offers a variety of accommodations and services to students with documented disabilities. Please visit `https://accessibility.harvard.edu` for more information. In the event that students feel unhappy about their general circumstances this semester, they can always speak confidentially with a health care professional through the Counseling and Mental Health Services (CAMHS). Please visit `https://camhs.huhs.harvard.edu` for more information.

Course Schedule

A detailed week-by-week schedule is attached on the last page of this document. Lab and Help Room times may change; see the course website on Canvas for the latest schedule.

Component	Day	Time	Place
Lectures	Monday & Wednesday	9:00 – 10:15 a.m.	Science Center Hall A
Laboratory	Wednesday & Thursday	3 – 5 p.m. & 6 – 8 p.m.	Science Center 106
Help Room	Sunday	1:30 – 3 p.m.	Science Center 106
	Monday	6– 7:30 p.m.	Science Center 106
	Tuesday	1:30 – 3 p.m.	Science Center 106
	Thursday	1:30 – 3 p.m.	Science Center 106
	Friday	3 – 4:30 p.m.	Science Center 106
Projects	Due Tuesday	11:59 p.m.	
Final Project	Due Friday, December 9	11:59 p.m.	

Teaching Staff

Course Head

Prof. Susanne Yelin
Office: Lyman Lab 322
Office Hours: See Canvas Help Room Schedule & by appointment
Email: syelin@g.harvard.edu

Lab-Instructor (Preceptor)

Dr. Gregorio Ponti gponti@g.harvard.edu

Teaching Fellows

Shivam Raval (lab)	sraval@fas.harvard.edu
Elise Koskelo (lecture)	ekoskelo@g.harvard.edu
Ananya Bansal (lecture)	ananya.bansal525@gmail.com

Course Assistants

Shayna Grossman	shaynagrossman@college.harvard.edu
Neo Guerrero	neoguerrero@college.harvard.edu
Sebastian Millien	smillien@college.harvard.edu
Ismail Ajjawi	iajjawi@college.harvard.edu
Qijia Zhou	qijiazhou@college.harvard.edu

Lectures

Lectures will be given weekly on Monday and Wednesday from 9:00 to 10:15 a.m. Lectures will be structured around in-class activities. Some activities will be done in small groups, and others will be done with the Instructor leading the entire class. In-class activities are a proven learning catalyst, so you are strongly encouraged to participate fully in each of them. We will also observe and discuss physics demonstrations performed in the Science Center.

At the end of each lecture, there will be an *Am I getting it?* quiz posted on the Canvas website to test your understanding of the material covered in class that day. The quiz is graded for participation only, and all students are expected to complete the quiz before the next lecture. At the end of each quiz, you may write a *One-Minute Paper* to let us know about any questions, confusions, or comments you may have. You will earn full credit for participation by doing the in-class activities and the quiz for at least 21 of the 24 lectures (see **Grading** below).

Lectures will be in-person by default. There will be no zoom option available, but the lectures are recorded. If necessary (e.g., covid), the link to the lecture recording will be shared upon request.

Laboratory

Science is an empirical process. We make observations and develop theories to make new predictions to be tested experimentally. The theoretical part of this course goes hand-in-hand with the experimental part obtained in the lab.

The Laboratory Teaching Fellows for this course will run lab sections throughout the week (see **Course Schedule** above). Labs will be set up to further explore the lecture material in a stress-free group-oriented environment. Students are required to sign-up for and attend their assigned section weekly.

Half of labs will be of the numerical sort, where we will guide you through writing and using more elaborate `Python` code to simulate complex systems and to analyze experimental measurements. The other half will be hands-on. Students will work in small groups during lab section to setup their experiments to gather and analyze data. Each student is expected to submit their work on Canvas at the end of each lab as evidence of their participation.

In addition, students are expected to prepare a *Lab Write-up* to be submitted as part of each of the three mid-term *Project* assignments (see **Assignments** for details).

Help Room

Help Room is an opportunity to get help from your Teaching Fellows and also from your classmates within the academic integrity policy requirements (see **Academic Integrity & Collaboration** below).

The Lecture Teaching Fellows for this course will run Help Room sessions throughout the week (see **Course Schedule** above). We will offer in-person sessions in the Science Center and remote sessions over Zoom.

Students are welcome to attend as many or as few sessions per week as needed and to bring questions about the homework or any material covered in the course.

Assignments

Weekly assignments will consist of eight *Homework* problem sets, as well as three take-home *Projects* in lieu of mid-term exams, and a take-home *Final Project* in lieu of a final exam. The *Homework* assignments cover weekly material and are designed to help you prepare for the more difficult *Project* assignments, which are designed to measure student performance.

Because this course has no traditional exams, our expectations for correctly solving all problems in the *Project* assignments are very high: comparable to our expectations for writing a perfect exam.

All assignments will be posted on Canvas on Tuesday evenings and will be due before midnight (11:59 p.m.) the following Tuesday. Solutions will be posted on Canvas shortly after the due date.

Each *Homework* problem set has three components:

- *Sub-skills*: Multiple-choice style questions posted on the Canvas home page. Submit by completing the sub-skill section on Canvas.
- *Analytical*: Pencil-and-paper style problems that can be solved by hand. Submit by uploading to Canvas a PDF file of your work (e.g., a scan of your handwritten worksheet, a copy of your tablet file, or your typed file from Word or LaTeX).
- *Numerical*: Simulation problems to be programmed in `Python` on Jupyter Notebook that are too complex to solve on paper. Submit by uploading to Canvas an HTML file exported from your Jupyter Notebook.

Each take-home *Project* touches on all of the material covered since the previous *Project* and has an *Analytical* and a *Numerical* component. In addition, each *Project* has a *Lab Write-up* component where students are expected to write an informal paper about a recent laboratory session and synthesizes analytical and numerical methods covered so far in the course.

The *Final Project* will be posted in lieu of final exam during the last week of classes and will draw from all material in the course.

Late Assignments & Extensions

All assignments must be submitted electronically on Canvas following given formatting instructions.

Every student gets **four** days of extension total. They can be taken at any time and without giving a reason. They need to be communicated **before** the due date/time to any of the instructors, TFs or CAs via email. A full day (24 hours) is the minimum extension that can be taken and late HW will get zero points. Beyond four days, **no** extensions will be given, except for serious cases (long illness or such) which need to be documented to the Course Head (syelin@g.harvard.edu).

Academic Integrity & Collaboration

Collaboration is the lifeblood of science, and plagiarism is its bane. For assignments in this course, you are encouraged to consult with your classmates as you work on problem sets. However, after discussions with peers, tutors, or teaching staff, make sure that you can work through the problem yourself and ensure that any answers you submit for evaluation are the result of your own efforts. You must cite any books, articles, websites, etc. that have helped you with your work using appropriate citation practices. You must also list the students with whom you have collaborated on all homework and projects.

For more information, please consult Harvard's policy on academic integrity, in the Undergraduate Handbook. The relevant section is found at https://handbook.fas.harvard.edu/book/academic-integrity

Grading

Your grade will be computed as the sum of following components:

Course work	points
Class participation (21×1 point/each)	21
Homework (8×4 points/ea.)	32
Labs (11×1 point/ea.)	11
Projects (3×8 points/ea.)	24
Final Project	12
Total	100

How to do well in this course

1. **Practice regularly**. This course is for participants not spectators. Like an athlete, you need to work out regularly. Be active in all meetings you attend, and do the reading assignments to reinforce your learning.

2. **Question everything**. Don't just accept a concept without understanding the logic. Ask questions during class and in Help Room. We will be happy to repeat any explanation until it is clear!

3. **Collaborate**. Reach out to us and your classmates to discuss the material and the homework. This will sharpen your mastery of the subject by clearing up misconceptions and by providing different perspectives.

PhySci 12b: Introduction to Electromagnetism and Quantum Physics **Fall 2022**

Week	Mon. Lecture	Homework due Tuesday	Wed. Lecture	Lab *Wed. & Thurs.*
1			8/31 **Lecture 1** Potential Fields Ch. 7	
2	9/5 *NO CLASS* (*Labor Day*)	9/6 Homework 0	9/7 **Lecture 2** Coulomb's Law Ch. 7	**Lab 0** Welcome to lab! (no sections)
3	9/12 **Lecture 3** Conductance Ch. 9	9/13 Homework 1	9/14 **Lecture 4** Capacitance Ch. 8	**Lab 1** Resistor Circuits
4	9/19 **Lecture 5** Circuit Analysis Ch. 10	9/20 Homework 2	9/21 **Lecture 6** RC Circuits Ch. 10	**Lab 2** Microcontrollers
5	9/26 **Lecture 7** Electric Fields Ch. 5	9/25 Project 1	9/30 **Lecture 8** Distributed Charges Ch. 5	**Lab 3** Electronic Piano
6	10/3 **Lecture 9** Gauss's Law Ch. 6	10/4 Homework 3	10/5 **Lecture 10** Magnetic Fields Ch. 11	**Lab 4** Capacitance (part 1)
7	10/10 *NO CLASS* (*Columbus Day*)	10/11 Homework 4	10/12 **Lecture 11** Biot–Savart Law & Ampère's Law Ch. 12	**Lab 5** Capacitance (part 2)
8	10/17 **Lecture 12** Faraday's Law & Induction Ch. 13	10/18 Homework 5	10/19 **Lecture 13** Inductance & RL Circuits Ch. 14	**Lab 6** Magnetic Fields
9	10/24 **Lecture 14** RLC Circuits & Resonance Ch. 14, 15	10/25 Project 2	10/26 **Lecture 15** Maxwell's Equations Ch. 16	**Lab 7** Speaker Lab
10	10/31 **Lecture 16** Electromagnetic Waves Ch. 16	11/1 Homework 6	11/2 **Lecture 17** Interference Ch. 16	**Lab 8** Antenna Lab
11	11/7 **Lecture 18** Diffraction Ch. 16	11/8 Homework 7	11/9 **Lecture 19** Why Quantum Mechanics? (L19 notes)	**Lab 9** Wave Interference
12	11/14 **Lecture 20** Formal Description (L20 notes)	11/15 Homework 8	11/16 **Lecture 21** Physical Potentials (L21 notes)	**Lab 10** Atomic Spectra
13	11/21 **Lecture 22** Many Particles (L22 notes)	11/22 Project 3	11/23 *NO CLASS* (*Thanksgiving Recess*)	
14	11/28 **Lecture 23** Quantum Information (L23 notes)	Final Project due 12/9	11/30 **Lecture 24** Summary & Outlook	