PHYSICS 125, Fall 2024

WIDELY APPLIED PHYSICS

SYLLABUS

(Preliminary Version, 8/19)

INSTRUCTOR

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TEACHING FELLOWS

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LECTURES

Tuesday and Thursday, 12:00–1:15, Room: TBD

COURSE DESCRIPTION

Physics 125 is an unusual course. Most courses have a specific content-oriented goal in mind, but not so with 125. Instead, the main goals in this course are to develop physical intuition and to become comfortable with order-of-magnitude ("back of the envelope") calculations. However, this doesn't mean we won't also do some rather technical and mathy problems. We will!

We'll learn a little bit about a lot of things, and the topics fall into two basic categories: (1) things from everyday life that are good to know, and (2) cool/nerdy things that every physics student should know, even if they're not terribly useful. The topics include, but are not limited to: dimensional analysis, scaling laws, black-body radiation, fluids, global warming, energy production/use, nuclear power/weapons, health effects of radiation, cosmology, flight, rockets, mechanical design and failure.

On one hand, you might find this course easier than a standard physics course because, although we will cover a very large number of topics, we won't go so deep into any particular one. On the other hand, you might find this course more difficult because real-world physics is rarely clean. The questions are often open-ended and require you to make simplifying assumptions. (Deciding on these is half the battle.) After solving a problem, it's hard to be confident that you did it correctly. Part of the reason for this is that "correctly" isn't even well defined. Is the goal to get the exact answer, or to just be within an order of magnitude? Sometimes it's one, sometimes it's the other. Not having a definite result as a target is often unsettling for students.

OFFICE HOURS

We are eager to help you in any way we can in this course. David Morin's office-hour schedule is posted at: https://davidmorin.physics.fas.harvard.edu/office-hours.

Office hours will generally be in-person, although there might be a few Zoom hours mixed in. The Zoom link is on the Canvas page.

The TFs' office hours will be determined at the start of the semester.

PREREQUISITES
Physics 15a, b, c, and math at the level of Math 21a. If you haven't taken these courses, please see David Morin to discuss things. A few ideas from Physics 143a and 181 will be used, but they will be derived as needed.

TEXTBOOK, LECTURE NOTES
There is no formal textbook for the course, but typed lecture notes will be posted after each lecture. Other resources and papers will be posted as the course progresses.

Handwritten lecture notes ("Lecture N pre") will be posted before each lecture. The solutions to some problems will be removed, so that you can work on them. The solutions will be included in the version ("Lecture N post") that is posted after each lecture.

SECTIONS
Sections meet once each week. The purpose of the sections is to work through examples relevant to the homework problems, and to discuss things in a smaller classroom setting. The three meeting times will be determined via a Canvas poll, but they will be on Monday and/or Tuesday in any case.

The sections are extremely helpful for learning the material and for solving the homework problems. Attendance is required. But aside from being required, it is simply a good idea to attend and to get to know your TF. Sections begin the week of September 9.

PROBLEM SETS
There will be one problem set each week (except during the midterm week), due at the beginning of Thursday's class. Solutions will be available at the end of class. New problem sets will be posted on Thursday evenings. To receive full credit for a problem, it must not only be correct, it must also be written up *neatly*, with clear explanations involving *words*. A good rule of thumb is to ask yourself if a classmate would be able to understand your solution. No credit will be given for a string of equations leading to the correct answer.

We will give one two-day extension, no questions asked. Aside from that, we will not be able to accept late homeworks (except in unusual circumstances). But we will drop your lowest homework score when computing your final grade. Any requests for extensions should be made to David Morin.

WEBPAGE
There is a link from the online course catalog. Problem sets, solutions, lecture notes (handwritten and typed), summaries, announcements, supplementary material, and other useful things will be posted on the webpage. It will be very helpful, so please make good use of it. Most of the material will be in the Pages folder, so look there if you can't find something.

STUDY GROUPS, COLLABORATION
You are encouraged to work together on problem sets, but the work that you hand in must be your own. Be careful not to rely too much on your classmates, because you will need to fully understand the problems for the exams. The best balance between working alone and working with other people is to (1) work on the problem sets alone until you get stuck on things, then (2) work with other students or get hints in office hours, and then (3) finish things up alone where you can collect your thoughts in the peace and quiet of your own brain. If you skimp on the first and third of these, it will definitely show up on the exams.

Note: When working in study groups, please remember to be courteous to the other members. It's great if you get excited about things and shout "Eureka!" every now and then (we encourage this!), but be careful not to dominate the discussion. Remember to regularly take a step back and make sure that everyone else has the opportunity to give their input.

EXAMS
There will be one midterm, one presentation (including a short writeup), and a final exam. The midterm date is Thursday, Oct 10. The final-exam date appears to be Monday, Dec 16.

PRESENTATIONS
Presentations will be in pairs (unless you prefer to do yours on your own), and four pairs will present each day. So there will be $\lceil N/8 \rceil$ class periods of presentations, where N is the number of students in the class. These class periods will be the last few course meeting times of the semester. Since the class size is larger than usual this year, we will need to use the Dec 5 (Thursday) class time during reading period, and possibly also Dec 10 (Tuesday). Your presentation topic can be on anything vaguely related to the course, but you must clear it with David Morin. A list of topics from past years will be provided, so you can get an idea.

GRADING
Homeworks 25%, Midterm 18%, Presentation 20%, Final exam 32%, Lecture attendance 3%, Section attendance 2%.

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES
Students needing academic adjustments or accommodations because of a documented disability must present their Faculty Letter from the Accessible Education Office (AEO) and speak with the professor by the end of the second week of the term. Failure to do so may result in the Course Head's inability to respond in a timely manner. All discussions will remain confidential, although Faculty are invited to contact AEO to discuss appropriate implementation.

WEEKLY SCHEDULE
Your weekly schedule (except for the midterm week) will consist of the following:

- *Lecture*: Attend on Tuesday and Thursday.
- *Section*: Attend your one section per week.
- *Office hours*: Attend as many as you can.
- *Reading*: Do the reading in the typed lecture notes. And look back over the handwritten lecture notes.
- *Homework*: Do the weekly homework (which invariably entails going to office hours), and submit it on Thursday.
- *Study groups*: Work together as much as you can. This is very much encouraged and makes everything more fun. Just be sure to not rely too much on your friends. Give substantial thought to the problems before you meet with your friends, so that you're not playing catch-up. See the three steps above in the Study Groups section.

- *Midterm week*: There will be no homework due during the midterm week. So your main task during that week is to study for the midterm by redoing all the past homework problems and reviewing the lecture notes.

SYLLABUS

A list of the topics covered in the 21 lectures is:

1. Estimation, dimensional analysis
2. Random walks, diffusion, probability
3. Boltzmann distribution, burning hydrocarbons
4. Black-body radiation
5. Fluid drag (no viscosity)
6. Viscosity, flight
7. Flight, rockets, stress/strain
8. General Relativity, GPS
9. Expansion of the universe
10. Cosmology
11. More cosmology, Olber's paradox
12. Water waves
13. Diffraction, resolution
14. Energy consumption
15. Betz's law, energy storage
16. Greenhouse effect
17. Nuclear physics
18. Radiation/health, nuclear power
19. Quantum computing, bomb testing
20. Rainbows, salt, boat wakes
21. Cornu spiral, earliest sunset