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UC Berkeley
Physics 89 - Introduction to Mathematical Physics, Spring 2020
Course Information

Instructor Information	Lecture Information	Office Hours
Austin Hedeman 258 LeConte Hall aphysicist28@berkeley.edu	MWF, 10:00am – 11:00am 2 LeConte	TBA 258 LeConte Hall

Enrollment: This course is **Physics 89 - Lecture 001 - Introduction to Mathematical Physics.**

Course Description: Math is the natural language of physics. Of central importance to nearly all areas of physics are the fields of linear algebra and differential equations. A solid understanding of the structure and techniques of these fields will allow you to dig deeper into all of your physics courses and (I hope!) give you a greater appreciation of the beauty of physical theory. In this course we will develop and explore a collection of tools including complex numbers, linear algebra, differential equations, Fourier series and transform methods, and tensors. Along the way this course will explore many example systems you were exposed to in your introductory physics classes including waves, circuits, rotations, and oscillations.

Prerequisites: Math 53 is a prerequisite for this course. Note that Physics 89 is meant to *replace* Math 54. We will be exploring many physical systems throughout the semester that I assume you are already at least somewhat familiar with such as the harmonic oscillator, waves, rotations, circuits, and diffraction.

Course Website: https://bcourses.berkeley.edu/

The course website will be hosted through the bCourses system. If you having trouble accessing the website, please e-mail me at aphysicist28@berkeley.edu so we can get you set up!

Texts:

- Altland, Alexander and von Delft, Jan, *Mathematics for Physicists*, *1st Edition*.
  https://www.cambridge.org/core/books/mathematics-for-physicists/2D3A8F34FA57B4FEB55439B4DD33DAF2
  This is a newer book that I am trying out for the first time this semester. It was also used last semester, so you may be able to borrow it from a friend! It has a great range of topics and tends to follow the approach that I will take in class.

On the syllabus you will find a tentative outline of topics and dates for this course. In italics listed next to most of the topics are the relevant sections of Boas. You should read these sections **before** coming to lecture. There will be more specific reading assignments listed in the "Homework Assignments" folder on bCourses.

It is important to get many different perspectives on the subject, since you never know which one may 'click' for you. Different authors have different writing styles, emphases, and organizational schemes. Listed below are other Mathematical Physics texts that you may find useful! They are on reserve at the Physics Library and available online:

- Boas, Mary, *Mathematical Methods in the Physical Sciences, 3rd Edition*. This is a popular mathematical physics textbook that covers a wide range of topics. Many of my peers used this book in their math methods course and we have used it in previous semesters of Physics 89.

- Kreyszig, Erwin, *Advanced Engineering Mathematics*.
  http://www.polo.ufsc.br/fmanager/polo2016/materiais/arquivo38_1.pdf
  This comes recommended from previous Physics 89 professors for a more in-depth look at linear algebra.

- Jeevanjee, Nadir, *An Introduction to Tensors and Group Theory for Physicists.*
  Available as an electronic resource at http://oskicat.berkeley.edu/record=b18553146?.
  This is a really well written and clearly presented introduction to vector spaces and tensors and comes highly recommended by me! It also has a lot of great introduction to group theory, though we unfortunately won't get to explore this topic in class.

- Arfken, George, *Mathematical Methods for Physicists*.
  Available as an electronic resource at http://oskicat.berkeley.edu/record=b20381069?.
  This is a slightly higher-level and more rigorous text than Boas but should still be accessible to you.

Content: This course is roughly broken up into two parts, though we will see that there is plenty of overlap!

- **Part I: Linear Algebra**: One of the most powerful tools in the physicist's toolbox is the field of linear algebra. Very roughly, we may define linear algebra as the branch of math dealing with **vectors** and linear operators. You have already been introduced to vectors in your introductory physics courses but this is the time for us to really appreciate their usefulness. We will see that we can invoke vectors whenever we have a linear system of equations. First we will learn what vectors *are* and apply the vector concept beyond the simple "it's an arrow" presentation you are already familiar with. Then we will introduce matrices, which we can interpret as machines that eat vectors and spit out different vectors in a linear fashion. We will spend some time exploring how to use matrices and ultimately how matrices describe transformations of physical systems. This leads us to the concepts of eigenvalues and eigenvectors, which will allow us to disentangle complicated systems!

- **Part II: Tensors and Differential Equations**: We will start the second half of the course talking about tensors, which are essentially machines that eat a *set* of vectors and spit out a number in a linear fashion! Physical applications we will explore during this section will include the wave on a string, circuits, moments of inertia, and rotations. We will see how tensors allow us to deal with systems in special relativity effectively and how we can use them to transform vectors and matrices to non-Cartesian coordinate systems.

  Then, we will learn some techniques for solving the types of differential equations that occur everywhere in physics. First, motivated by our study of linear algebra, we will introduce a powerful tool for solving differential equations known as the Fourier transform. Then we will apply our knowledge of linear algebra to tackle first and second order ordinary linear differential equations, with the simple harmonic oscillator and time-dependent circuits as our main examples. We will explore other solution techniques including Green's functions, the use of ansatz, and the use of series solutions to derive recursion relations. We will also discuss partial differential equations and separation of variables. Physical applications we will explore during this section will include diffraction, the wave and heat equations, AC circuits, and the driven harmonic oscillator.

Discussion Sections:

Section 101:	M 2:00pm - 3:00pm	222 Wheeler	GSI: TBA
Section 102:	W 12:00pm - 2:00pm	155 Kroeber	GSI: TBA

Sections will be devoted to working through examples. You are highly encouraged to attend! There will be no discussion sections the first week.

Office Hours: My office hours will be posted and listed at the top of this document and will be held in 258 LeConte Hall. The GSI will also hold office hours and the schedule will be posted on the course site. These office hours may change based on student availability. I am also available by appointment.

Homework Assignments: There will be problem sets posted on bCourses at least one week prior to the due date of the assignment. You are encouraged to work together on these assignments, but each student must submit their own work. Problem sets will typically be due **Fridays at 6:00pm** (though the dates may move around slightly during exam season so you don't get too slammed with work).

You must submit your homework in the designated box in the second floor breezeway between Birge and LeConte Halls. Problem sets submitted within 24 hours or **one business day** after the deadline (Monday if the problem set is due on a Friday) will be accepted with a **30% penalty**. Late homework assignments *must* be turned in to the folder outside my office door (258 LeConte) rather than the homework box. Late homework will *not* be accepted after the late deadline.

In each problem you do over the semester it is important to not only *show* your work, but also to *explain the steps you are taking*. As with any physics problem set, the answers are not typically as important as knowing *how* to get the answers. Think of these as opportunities to show off what you know. If you can explain what you are doing and why you are doing it, you are well on your way to understanding what is going on!

You are encouraged to work with your peers on these problem sets. Discussing problems, explaining your thought processes to other people, and hearing how others approach the problems are excellent ways of expanding your understanding of the material. That being said, students must turn in their *own* work.

Since we all have bad weeks and I know you all have lots of competing obligations, at the end of the semester your lowest homework score will be dropped. There will also be a homework set due on the last day of summer session that covers the last week's material and is optional. If you turn this set it, it will be used to replace a previous homework.

Exams: We will have a single midterm on **Wednesday, March 18th** which will cover the first half of the class (Taylor series, complex numbers, and linear algebra).

The final exam will be held on **Tuesday, May 12th** and will cover the last half of the class (tensors, ordinary differential equations, and partial differential equations). These topics *use* linear algebra (so I can't say the final is non-cumulative), but the final will be essentially a second midterm on these topics.

Piazza: https://piazza.com/berkeley/spring2020/phys89/home
Piazza is a service that lets students ask questions (either publicly or anonymously) that the instructor, GSI, or other students can then answer. This is great for asking questions about the homework and I highly recommend you use it!

Grades: The grade breakdown will be as follows:

Category	**Percent**
Homework Assignments	40 %
Midterm (F, 7/19)	30 %
Final Exam (F, 8/16)	30 %

Disabled Students' Program: http://www.dsp.berkeley.edu/
All students who have special needs can receive appropriate accommodations. The DSP office must determine or verify these accommodations before they can be offered. Students who are requesting academic accommodations are responsible for contacting the DSP Coordinator *immediately*. Please contact the instructor when a request for accommodation has been filed.

Student Code of Conduct: http://sa.berkeley.edu/code-of-conduct
The instructor and students are expected to behave with the utmost of integrity, responsibility, and civility towards all members of the classroom as well as Extension staff. Additionally, all members of the Extension community are expected to comply with all laws, University policies, and campus regulations, conducting themselves in ways that support a thriving learning environment. For more information, see the linked document. Violation of the code of conduct can result in disciplinary steps as outlined in the code.

Use of Course Materials: The materials provided by the instructor in this course including, but not limited to, lecture notes, homework assignments, solution sets, exams, exam solutions, and study materials (collectively "course materials") are for the use of the students current enrolled in the course only. Distribution or public display of the course materials by students for non-enrolled students is not permitted, and may constitute academic misconduct under Sections 102.01, 102.05, and 102.23 of the student code of conduct. The course materials are also subject to copyright protection, with copyright held by the instructor. As such, the course materials may not be duplicated, distributed, publicly displayed, or modified in a manner contrary to law.

Administrative Issues: Please do not hesitate to e-mail me at aphysicist28@berkeley.com with any questions, feedback, or administrative issues!

Changes and Updates: Any changes, corrections, modifications, amendments, or updates to these policies will be announced in lecture and posted on the course website.

If you are in trouble for whatever reason, please let me know! I'll try to help!

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