UC Berkeley
Physics 89 - Introduction to Mathematical Physics, Spring 2017
Course Information

Instructor Information	**Lecture Information**	**Office Hours**
Austin Hedeman 443 Birge Hall aphysicist28@berkeley.edu	MWF, 10:00am – 11:00am 251 LeConte Hall	M, 11:00am – 12:00pm θ, 2:00pm – 3:00pm F, 11:00am – 12:00pm 429 Birge 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:

- Boas, Mary, *Mathematical Methods in the Physical Sciences, 3rd Edition*. This is a popular mathematical physics textbook that covers a wide range of topics. We won't be able to get to everything, unfortunately, but this book will hopefully serve as a reference for your future studies! Many of my peers used this book in their math methods course. This is a **required** text.

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:

- Kreyszig, Erwin, *Advanced Engineering Mathematics*.
  http://ele.aut.ac.ir/~pdehkhoda/wp-content/uploads/2016/09/Advanced-Engineering-Mathematics-Kreyszig.pdf
  This comes recommended from previous Physics 89 professors for a more in-depth look at linear algebra. I will add the relevant sections from this book to the reading assignments sheet for those who are unsatisfied with Boas. This is a **recommended** text.
- 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! 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.
- Hassani, Sadri, *Mathematical Physics: A Modern Introduction to its Foundations.*
  Available as an electronic resource at http://oskicat.berkeley.edu/record=b20772529?.
  According to the text, "This is a book for physics students interested in the mathematics they use. It is also a book for mathematics students who wish to see some of the abstract ideas with which they are familiar come alive in an applied setting."

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! Finally, we will learn 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.
- **Part II: Differential Equations**: The second part of the course will deal with solving differential equations. 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 then take a quick detour to talk about complex analysis, which will open the door for us to use the Laplace transform to solve differential equations. 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. If there is time at the end, we will discuss "special functions" such as the spherical harmonics, solutions to specific classes of differential equations that commonly occur in physics. 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: Wednesday, 12:00pm - 2:00pm 126 Barrows GSI: [redacted]

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

Office Hours:

My office hours are listed at the top of this document and will be held in 429 Birge 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 weekly problem sets posted on bCourses at least one week prior to the due date of the assignment. Problem sets will typically be due **Fridays at 5pm** (though this may change on a case-by-case basis or by popular demand). You must submit your homework in the designated box in the second floor breezeway between Birge and LeConte Halls.

Late homework will be accepted with a penalty. If you turn the homework in by **2pm** one business day after the due date you will receive a **25% penalty** on the work turned in. If you turn the homework in by **2pm** two business days after the due date you will receive a **50% penalty** on the work turned in. Solutions to the homework will appear on bCourses at this time and late homework will **not** be accepted after that.

Problem sets will constitute 40% of your overall grade. At the end of the semester your lowest homework score will be dropped.

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.

Exams:

There will be three exams for this class - two midterms and a final exam. Since it is impractical to have in-class exams where we only have 50 minutes, the exams will be held in the evening. I am requesting rooms for 6:00pm on **Monday, February 27th** and on **Friday, April 7th**. I will post the rooms once the room reservations are confirmed. If either of these dates conflicts with your schedule, please contact me ASAP, but *no later than Friday, January 27th*. Each of the exams will be worth 18% of your final grade. Watch this space and bCourses for updates. The final exam will be held on **Tuesday, May 9th from 3:00pm - 6:00pm** and will be worth 24% of your final grade.

Midterm 1 will cover the introductory material and the first part of *Part I: Linear Algebra*, up through the middle of Week 5 (the last topic will be the matrix inverse). Midterm 2 will cover the rest of *Part I: Linear Algebra* starting with the eigenvalue problem, and the beginning of *Part II: Differential Equations*, up through the middle of Week 10 (the last topic will be the application of Fourier transform methods to ODEs). The Final Exam will have a focus the rest of *Part II: Differential Equations*, but will be a comprehensive exam.

Piazza:

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. You can sign up to our Piazza page by going to https://piazza.com/berkeley/spring2017/phys89/home.

Grades: The grade breakdown will be as follows:

Homework Assignments	40 %
Midterm 1 (2/27)	18 %
Midterm 2 (4/7)	18 %
Final Exam (Tuesday, 5/9)	24 %

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 staff. Additionally, all members of the campus 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.

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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