UC Berkeley
Physics 89 – Introduction to Mathematical Physics, Spring 2021
Course Information

Instructor Information	Lecture Information	Office Hours
Austin Hedeman 258 Physics North aphysicist28@berkeley.edu	TΘ, 12:30pm – 2:00pm Meetings will be held via **Zoom**. Recorded lectures will be hosted on **Box**.	TBA Instructor office hours will be held in **gather.town**

All times are for the Pacific Time Zone.
Standard Time (UTC-8) ends and Daylight Savings Time (UTC-7) begins on March 14, 2021.

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

Lecture: 3 hrs/week **Discussion:** 2 hrs/week **Unit Value:** 4

Prerequisites: Math 53; Physics 5A or 7A (can be taken concurrently) or Instructor's Consent.

Due to the ongoing pandemic, this course will be held remotely.

Lectures:
Zoom Link: https://berkeley.zoom.us/j/98537708554?pwd=WHZOc1RWVWtLSGxFVXRzOFpJMURzZz09
Zoom ID: 985 3770 8554 **Password:** 089121
Box Link: https://berkeley.box.com/s/t2vw69vnu2m18yv1jnvpdkttjxd7lv2o

Discussion Sessions:
Zoom Link: TBA
Zoom ID: **TBA**

Instructor Office Hours:
Gather Link: https://gather.town/app/UUQuJikAXfPRHn3M/berkeley-physics
Gather Room: 258 [2nd floor]

GSI Office Hours:
Zoom Link: TBA
Zoom ID: **TBA**

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.

Related Courses and Sequences: Physics 89 covers much of the same material as Math 54 but from a physics perspective. It may cover material outside the scope of Math 54.

Course Website:

- bCourses: 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!
- Box Link for Lecture Recordings: https://berkeley.box.com/s/t2vw69vnu2m18yv1jnvpdkttjxd7lv2o

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.

On the course schedule 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:

- Hassani, Sadri, *Mathematical Methods: For Students of Physics and Related Fields, 2nd Edition.* This is the **recommended** text and one I am looking into as our official text for future semesters.

- 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.

- 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.

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.

Lectures: Lectures will be recorded live on Zoom. If you have a question during lecture and do not feel comfortable with your voice on the recording, please type your question into the chat. I will then repeat the question aloud and address it.

Lecture recordings and a PDF of the "whiteboards" will be uploaded to **Box**.
Recordings will be posted within **24 hours** of the lecture.

Since our lectures are recorded, you may be tempted to put off the material. We urge you to stay current with the lecture recordings. This is crucial for the problem sets and staying on top of course material. If you find yourself falling behind, please reach out to the course staff!

Due to the nature of remote delivery of lectures we may be unable to cover every topic listed in the course schedule. We will regularly update the schedule and clearly communicate what topics will and won't be covered.

Discussion Sections:

GSI:	Malcolm Lazlow		
	Section 101:	M 2:00pm - 4:00pm	Zoom link above.
	Section 102:	W 12:00pm - 2:00pm	Zoom link above.

Sections will be devoted to working through examples. You are highly encouraged to attend! Discussion sections will start the second week of classes (M 1/25 and W 1/27).

Office Hours: https://gather.town/app/UUQuJikAXfPRHn3M/berkeley-physics

My office hours are be posted and listed at the top of this document and will be held on the platform **gather.town**. You are encouraged to come to these, even if it's just to hang out! You will need a Berkeley e-mail address to access this space. Note that I will *also* be on Zoom in our main room at the same time in case you are unable to access the gather.town site.

The gather.town platform allows you to digitally 'walk up' to other students and work with them at a whiteboard and will allow me to work with groups in a much more informal setting than Zoom. Our Society of Physics Students set up the space modeled after the Physics North building in Berkeley. Note that you may access this platform at any time and use it as a group study space for you and your peers (like the reading rooms and libraries back when we could be in-person).

These office hours may change based on student availability. I am also available by appointment.

Problem Sets: 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 11:59pm**.

You will submit your problem sets via **Gradescope**. You will be responsible for "tagging" which pages go with which parts. Problem sets submitted within 24 hours or **one business day** after the deadline (Monday for any assignments due on Friday) will be accepted with a **25% penalty**. These should also be submitted via Gradescope.

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 (on top of the challenges due to the pandemic), at the end of the semester your lowest homework score will be dropped. There will also be an

optional homework set due on the last day of RRR week 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.

Solution sets for the problem sets will be posted on bCourses no later than one week after the due date. We will strive to have the problem sets graded within two weeks of submission.

Note*:* The purpose of the problem sets is *not* to test you. Rather, they are the exercises you will use to strengthen your understanding of mathematical physics. I try to write the problems to help guide you through. You will see new systems and ways of applying what we learn. You will be walked through some explorations of the theorems and structure of linear algebra, tensors, and differential equations. There are not-for-credit parts to give you extra practice. These problem sets will be bringing you to some new territory and are trying to stretch you. Because of that, it's okay if you don't easily know how to do any given problem or part or have trouble starting a problem. Reach out and talk to us, form study groups, work together (even if you are working together remotely), discuss things!

Exams: There will be one midterm exam and one final exam. These will be **24-hour take-home exams**. The exams will be open-book/open-notes. You may work on the exam for any or all of the 24-hour period but the recommended/designed time to take each exam is three hours. Your work must be submitted to gradescope by the deadline. Each of the two exams will be worth 25% of your final grade, with a small adjustment to enhance the effect of the exam you do better on.

You are not allowed to collaborate on the exams or to upload any part of the exam to an online service. Any violations of this will be brought to the Center for Student Conduct.

The midterm exam will go live at **6:00pm PDT on Tuesday, March 16th** and will be due at **6:00pm PDT on Wednesday, March 17th**. It will cover up through the end of Week 7 of material.

The final exam will go live at **3:00pm PDT on Thursday, May 15th** and will be due at **3:00pm PDT on Friday, May 16th**. It will emphasize the material not originally covered by the midterm (though all of that material *uses* the material from the first half).

Piazza: https://piazza.com/berkeley/spring2021/physics89
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! I will be posting a rundown of the topics to be covered before each lecture and re-posting the Zoom and Box links there.

We consider this forum to be an academic space and you are expected to follow the Berkeley Honor Code and be respectful of each other.

Estimated Total Number of Required Hours of Student Work Per Semester:

- 3 hours/week Lecture
- 2 hours/week Discussion
- 7 hours/week Reading/Problem Sets
- 6 hours/semester Exams (1 midterm and 1 final)

Grades and Grading: The grade breakdown will be as follows:

Category	Percent
Problem Sets	50%
Midterm (Due W, 3/17)	25%
Final (Due F, 5/14)	25%

Since we are in a remote learning semester, there will *not* be a curve for the final grade distribution. We will use the pre-COVID grading bins as an upper-bound guideline for the number grade-to-letter grade conversion. We may choose to expand the bins downward if the situation warrants but we will *not* shift the bins upwards.

In the old/curved grading guidelines with a curve, courses were limited in the number of As and Bs they could assign. By removing this restriction, if a large portion of the class does what we consider A-level work, every one of those students can receive the A they deserve. In a challenging class, a particularly challenging exam, and with the mitigating circumstances of the pandemic, we might decide that a 75% on a test is indeed A-quality work for the semester, for example.

For Physics 89, the *upper-bounds* on grade boundaries (ignoring the +/- subdivisions) will be:

89.0 for the A/B boundary
75.0 for the B/C boundary
55.0 for the C/D boundary
45.0 for the D/F boundary

Again, I want to emphasize that these are *upper bounds* and may be lower in the final tally (giving a more generous grade distribution).

If you choose to take this class Pass/Not Pass, a grade of C- or higher is considered a Pass (P) and a grade of D+ or lower is considered a Not Pass (NP).

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 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.

Honor Code: The UC Berkeley honor code reads "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." The instructor, course staff, and students will be expected to uphold this honor code in all respects of the course.

As in every class at Cal, you are expected to abide by the Berkeley Honor code. You are allowed (and encouraged) to discuss homework and workshop assignments with your peers or instructors, but you are personally responsible for each assignment. Plagiarism (e.g. copying from external sources verbatim without proper acknowledgement) is considered cheating and will not be tolerated. Any student caught cheating will receive academic sanctions in the course and will be referred to the Center for Student Conduct.

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.

Mental Health and Other Resources: Remote learning and the pandemic have introduced a lot more stress and challenges into the student experience. Please take care of yourself and prioritize your physical and mental health. The following links may be of use if you or a friend are in trouble:

CAPS Website: https://uhs.berkeley.edu/caps
CAPS COVID-19 Website: https://uhs.berkeley.edu/coronavirus/student-mental-health

Helping a Distressed Friend: https://uhs.berkeley.edu/sites/default/files/distressed_friend.pdf
Student Advocates Office: https://advocate.berkeley.edu/
Division of Student Affairs COVID-19 Toolkit: https://sa.berkeley.edu/covid19
Student Technology Equity Program: https://technology.berkeley.edu/STEP
UC Berkeley Basic Needs Guide to COVID-19: https://docs.google.com/document/d/1WwPF-Q3Z8EXBfM-Wf_WwBzdTU39hfz85JL2F8Z5IfDE/edit?usp=sharing

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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