Mechanics and Relativity

PHYS 103 with David — Summer Session A, 2022

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1 Important Information

Instructor: David Grabovsky (`davidgrabovsky@ucsb.edu`). **Office:** Broida 6118.

TA: Ziyue Wang (`zi-yue@ucsb.edu`). **Office hours:** Fridays 3:30 – 5:30 PM (Physics Help Room).

LAs: Henry Yuan (`hengyuan@ucsb.edu`); Nicole Efstathiu (`nefstathiu@umail.ucsb.edu`).

Grader: Jianjie Xu (`jianjiexu@ucsb.edu`).

Lectures: Mondays, Wednesdays, and Fridays at 11:00 AM – 12:20 PM in Girvetz 1115.

Discussions: Fridays at 12:30 PM – 1:50 PM and 2:00 PM – 3:20 PM in Life Sciences Building 1101.

Office hours: Mondays at 2:00 PM – 4:00 PM in the Broida 6th floor lounge, or by appointment.

Weekly problem sets: Due on Tuesdays at 5:00 PM via Gradescope.

Midterm: Friday, 08 July, at 11:00 AM – 1:30 PM in Girvetz 1115.

Final exam: Friday, 29 July, at 11:00 PM – 2:00 PM in Girvetz 1119.

Course websites: We will use Gauchospace for course documents and Gradescope for assignments.

Textbooks: The main textbook is John Taylor, *Classical Mechanics*, University Science Books (2005). ISBN: 189138922X. However, I will sometimes more closely follow Kleppner and Kolenkow, *An Introduction to Mechanics*, Cambridge University Press (2014). ISBN: 9780521198110.

Readings: Sections from Taylor corresponding to each lecture will be posted on Gauchospace. The readings are required! Weekly lecture notes will also be posted for the first 2 weeks.

2 About the Course

Course outline: Newtonian mechanics in 3D. Conservation laws. Complex numbers. Oscillations. Inertial reference frames, Lorentz transformations, relativistic momentum and energy, four-vectors.

Week	Dates	Topics and Themes
1	06/20 – 06/24	Introduction, vectors, kinematics, Newton's laws, inertial frames
2	06/27 – 07/01	Momentum, center of mass, constraints, and angular momentum
3	07/04 – 07/08	Work, energy, potentials, energy conservation, first integrals
4	07/11 – 07/15	Analysis of potentials, complex numbers, the harmonic oscillator
5	07/18 – 07/22	Relativity: the interval, worldlines, Lorentz transformations
6	07/25 – 07/29	4-vectors, relativistic energy and momentum; final exam review

Components of the course: Grades will be determined from the following four components.

- **Homework:** Problem sets (∼4–6 problems each) will be posted to Gradescope on Mondays at 10:00 AM and due the next Tuesday at 5:00 PM. You are welcome to work together, but you must write up your own solutions. List all of your collaborators at the top of your write-up. If you feel that your work has been misgraded, use Gradescope's regrade request feature.
- **Midterm:** The midterm will be a closed-book two-stage exam held in person. The first stage (11:00 AM – 12:20 PM) consists of a standard midterm exam that you will complete on your own. In the second stage (12:30 PM – 1:30 PM), you will discuss the exam in groups of 3–4 and submit corrections to your Stage I work. Stage I will count for 75% of your midterm grade; Stage II will contribute the remaining 25%. The idea here is to turn the exam into a more forgiving, collaborative learning experience that lets you make up some of the points.
- **Sections:** In sections, you will get a chance to practice solving problems and to discuss them with your peers. The problems will be posted to Gradescope on Mondays at 10:00 AM, and you should work through the problems before sections. Participation will count towards your grade in the class; to receive credit, you need to (i) attend the section, and (ii) turn in your notes before 10:00 AM the day of sections. Your scratch work does not have to be correct or complete; as long as you make an honest effort on every problem, you will get full credit.
- **Final exam:** The final will be a standard 3-hour exam held in person. It will be open-notes: you may bring any printed materials you want, but no electronic devices. If you have a scheduling conflict for the midterm or the final, you must email David by 11:59 PM on Friday, 24 June.

Extensions: Late work will not be accepted. However, extensions may be granted in extenuating circumstances. To request an extension, email David or Ziyue at least 24 hours before the assignment in question is due. To make up a missed discussion section, you can set up a brief meeting with either David or Ziyue to talk about that week's section problems.

Grading scheme: Course grades will be computed using the weights below. You will notice that the weights add up to 101%: this is intentional. Enjoy your extra credit!

Category	Weight
5 Homeworks	35% (7% each)
5 Sections	12% (2% each)
Midterm	24% (18% + 6%)
Final Exam	30%

Grading scale: Your raw scores (computed using the scheme above) will be converted to letter grades using a table of cutoffs (to be determined). There is no curve, in the sense that the number/fraction of students who earn a given letter grade is not limited or tied to a bell curve.

3 Further Information

How to do well. The only way to succeed in physics is to practice and put in the necessary time. Collaborate with your classmates on the problem sets. Write up careful HW solutions on your own. Participate actively in sections and turn them into lively discussions. Practice explaining the material to yourself and others: physics is not there to be learned, but to be experienced. Go to office hours! Ziyue's hours will focus on problem-solving, while David's hours will focus on conceptual issues. Read Taylor before class, the lecture notes after class, and the solutions after HW is due.

Nectir. Nectir is a UCSB-specific messaging platform that works like Discord or Slack. Use the class Nectir channel to collaborate with your peers on the HW assignments and to talk physics more generally. David and Ziyue will monitor the channel and may occasionally chime in, but for the most part the channel will be your space to help each other out. Keep the atmosphere friendly!

Workload. This course is intense. Every week, you will spend 4 hours in lecture and 1.5 hours in sections. Beyond this, the time you spend reading, thinking about mechanics, working on HW, and in office hours will vary. Please know that this time is not lost or wasted! It takes courage to try hard only to fail, and then—in spite of failure—to keep trying. This courage will be rewarded.

Prerequisite knowledge. Classical mechanics at the level of PHYS 21–22 is required, as well as a working knowledge of integral and differential calculus and Taylor series. Some familiarity with vector calculus, linear algebra, and differential equations will help, but these are not required. We will develop the entire theory of classical Newtonian mechanics, and to some extent also Einstein's special theory of relativity, from the ground up, introducing the necessary math along the way.

Recommended resources. There are many good textbooks on classical mechanics. Here are a few of them: *An Introduction to Mechanics* (Kleppner and Kolenkow); *Introduction to Classical Mechanics* (Morin); *Classical Dynamics of Particles and Systems* (Thornton and Marion); and of course *The Feynman Lectures on Physics, Volume I* (Feynman, Leighton, and Sands). Also, check out MIT OpenCourseWare, which has several great courses on mechanics and relativity.

The word "trivial." Occasionally I will say that something is trivial. This is not because I mean to intimidate you. In physics, the word "trivial" is actually a technical term with two distinct meanings, neither of which is "easy" or "obvious." (Very few things in physics are obvious!) They are:

1. A consequence of a standard but often difficult piece of theory, e.g. "The equations of motion are trivial to solve" or "the motion of the particle is trivial" or "the general theory of relativity follows trivially in the semiclassical limit of quantum gravity."

2. Reducing to an edge case, e.g. "It is trivially false that every vector has positive length."

Academic integrity. It is expected that students attending the University of California understand and subscribe to the ideal of academic integrity, and are willing to bear individual responsibility for their work. In plain language: be good to yourself and to others. Don't cheat.

Inclusivity. Physics is a difficult subject. It is also necessarily somewhat adversarial, if only in the sense that one must struggle to learn it: it sometimes feels as though one must do battle, through sustained and diligent application, to emerge with an understanding of its abstractions and to acquire the use of its tools. There is no need for us to make it any more difficult, or more of an uphill battle, by putting down others or ourselves. On the contrary, let us do our best to create a collaborative, inclusive, accessible, respectful, and friendly environment that inspires everyone.

DSP accommodations. If you need DSP accommodation, you must file with the DSP office by 11:59 PM on Friday, 24 June in order to ensure that you are able to take quizzes and the final exam on DSP protocol. Regardless of whether you are in DSP, you may email David or Ziyue at any time if a disability of any kind prevents you from reliably completing coursework. We will work together to make the class as productive and successful for you as it can be under the circumstances.

N.B. I intend to run this class with generosity, inclusivity, and a friendly spirit at the fore. However, to ensure that the class runs smoothly and is fair to everyone, I will follow the rules laid out in this syllabus to the letter and without exception. To earn a small amount of extra credit, added directly to your final exam score, please email David a picture of a kitten by 11:59 PM on Friday, 24 June.