

# PHILOS 126 – PHILOSOPHY OF PHYSICS

Ezra Rubenstein

UC Berkeley, Spring 2023

Office hours: Wednesday 3-5pm, Moses Hall 243

Classes: MWF 1-2pm, Dwinelle 88 and one section per/week

GSI: Daniel Villalon

## DESCRIPTION

This course is an introduction to various philosophical issues which arise in physics, concerning the nature of motion, laws, forces, space, time and probability. The first half of the course will be concerned with classical mechanics; the second half will introduce special relativity and quantum mechanics.

Questions to be discussed include: Are there instantaneous velocities? Are the laws of physics true, or are they just predictively useful approximations? Are forces like gravity real, or are they just mathematically convenient fictions? Is space a thing (and what would that even mean)? In what sense does time have a direction? Is the present special? Does time ‘flow’? Does quantum mechanics teach us that the world is fundamentally probabilistic? Or that there are many parallel worlds? Or that space and time are an illusion?

## PREREQUISITES

No formal requirements; solid high-school physics and at least one philosophy class are recommended.

## READINGS

Readings will be drawn from both physics and philosophy. Required texts:

B. Greene, *The Fabric of the Cosmos*

R. Geroch, *General Relativity from A to B*

D. Albert, *Quantum Mechanics and Experience*

(Optional: Feynman, Leighton, Sands, *The Feynman Lectures on Physics, Volume I*)

All other readings will be available in pdf format on through the bCourses site. On average, there will be around two readings per week. You are expected to complete all readings assigned to each class by the time that class begins. If you find some readings difficult, that’s fine—in fact, that is expected! But please try to get through the reading before class. Try to formulate what you don’t understand as a succinct question. We will discuss the readings in class and there will be opportunities to ask questions.

## ASSESSMENT

1. Participation (10%): attendance and participation in discussion sections; regular posting on discussion threads (see below)
2. Homeworks (30%): 3 homeworks, due in weeks 4, 8, 13. Mainly short essay questions.
3. Midterm Exam (25%): similar in style to homeworks; in class on Wed Mar 22.
4. Final paper (35%): 4 pages, open choice of topic, due Mon May 8 (in final exam week).

You will receive a letter grade for each component. Your final grade is calculated by converting each letter grade into a number, taking the average of those numbers (weighted by the percentages above), and converting the resulting number back into a letter grade, using the following schemes:

Letter-to-number conversion    Number-to-letter conversion (boundaries rounded upwards)

A = 95	$> 93.5 = A$
A- = 92	$90 - 93.5 = A-$
B+ = 88	$86.5 - 90 = B+$
B = 85	$83.5 - 86.5 = B$
B- = 82	$80 - 83.5 = B-$
C+ = 78	$76.5 - 80 = C+$
C = 75	$73.5 - 76.5 = C$
C- = 72	$70 - 73.5 = C-$
Etc...	Etc...
F = 60	$< 60 = F$

## COURSE POLICIES

Failure to turn in a take-home assignment on time will result in the lowering of your grade. For each day late, the grade will be lowered one letter grade (e.g., from a B to a B-). Extensions will be granted only in serious circumstances. Please do not hesitate to talk with me about these policies. I understand that people get sick, have family situations, etc. and I am willing to be quite accommodating. But you should make every effort to let me know ahead of time.

I discourage you from missing classes, not only because it will affect your participation grade but also because many topics discussed will be presupposed later on. If you need to miss a class, it is your responsibility to catch up on the material missed. Handouts are not intended to be substitutes for lectures and discussions. For recommendations about handling scheduling conflicts, see: [teaching.berkeley.edu/checklist-scheduling-conflicts-academic-requirements](https://teaching.berkeley.edu/checklist-scheduling-conflicts-academic-requirements)

## CLASSROOM CLIMATE

Discussion is essential to doing philosophy. It can take many forms: ideas can be proposed, developed, supported, clarified, and criticized. Criticism is important, but all discussion should be collaborative, not competitive. Listen carefully to what others have to say, and do not interrupt. If you're not following the

discussion, please speak up — the chances are that others will be grateful for some clarification too. It is everyone’s responsibility to maintain a fun, welcoming and inclusive class environment. There will be no tolerance for bullying, harassment, or disrespectful behavior. In addition, all students are expected to comply with the Student Code of Conduct: <https://sa.berkeley.edu/code-of-conduct>.

## ACADEMIC INTEGRITY

I will not tolerate acts of academic dishonesty, including plagiarism or the use of unauthorized materials during exams. Any such act may result in a failing grade on the assignment or in the class, depending upon the severity of the case. Examples of academic dishonesty include copying material from a website or classmate and handing it in as your own, copying another student’s work on an exam, quoting from or paraphrasing someone’s work without proper citation.

## DISABLED STUDENTS’ PROGRAM

UC Berkeley is committed to creating a learning environment that meets the needs of its diverse student body including students with disabilities. If you anticipate or experience any barriers to learning in this course, you are encouraged to discuss your concerns with me. If you have a disability or think you may have a disability, you can work with the Disabled Students’ Program (DSP) to request an official accommodation letter. If I have a letter on file for you from the DSP office, you may assume that you have been granted the requested accommodations. You can find more information about DSP, including contact information and the application process, here: <https://dsp.berkeley.edu>.

## GRADUATE STUDENT INSTRUCTORS

Graduate Student Instructors (GSIs) assist in various aspects of teaching here at Berkeley. Your GSI runs your weekly section and is available to talk during their office hours each week. Please note that your GSI is *not* expected to be available to talk outside their office-hour times, respond to involved philosophical questions by email (they will respond to administrative questions within 2 business days), or read and comment on drafts of your work prior to submission.

## POLICY ON SEXUAL VIOLENCE AND HARRASSMENT

Sexual violence and sexual harassment have no place in a learning environment. Therefore, in alignment with Title IX of the Education Amendments of 1972, it is the policy of the University of California (Sexual Harassment and Sexual Violence Policy) to prohibit sexual harassment, sexual assault, domestic/dating violence, and stalking. The UC Sexual Violence and Sexual Harassment Policy requires that the University immediately implement interim remedies and permanent support measures, when necessary, for victims/survivors. If you or someone you know experiences sexual violence or harassment, there are options, rights, and resources, including assistance with academics, reporting, and medical care. Visit [survivorsupport.berkeley.edu](http://survivorsupport.berkeley.edu) or call the 24/7 Care Line at 510-643-2005.

## OVERVIEW OF SCHEDULE

A detailed schedule (including the readings for each week) is posted on the bCourses site. This schedule is provisional and may be updated during the semester. I plan to set aside most Fridays for discussion of the material. There will be twelve discussion/catch-up sessions in total: as part of your participation credit, you are required to post questions/comments on the bCourses site discussion thread by 11.59pm the day before for *at least five* of these sessions. On Mondays and Wednesdays I will mainly be presenting the material but I encourage you to ask questions then too (though some of these may have to be postponed to the discussion session).

Here is an overview of the topics I plan to cover:

### Unit I: Classical Mechanics

Weeks 1 & 2: Intro, Motion (Zeno's paradox, the "at-at" theory, Markovianism, instantaneous velocities, time-reversal invariance)

Week 3: Laws & Forces (realism vs anti-realism)

Week 4: Time (the arrow of time, the Second Law of Thermodynamics, the reversibility objection, the Past Hypothesis)

Weeks 5 & 6: Space (substantivalism vs relationalism, Newton's bucket, Leibniz's shifts, Kant's glove)

### Unit II: Special Relativity

Week 7: Galilean spacetime (events, spacetime structure, inertial frames of reference)

Week 8: The spacetime interval (the relativity of simultaneity, time dilation, the twin paradox)

Week 9: The metaphysics of time (presentism vs eternalism, the flow of time, manifest vs scientific image)

--- Week 10: Midterm Exam ---

### Unit III: Quantum Mechanics

Week 11: Intro to QM (two-slit experiments, interference, spin boxes)

Week 12: The measurement problem (entanglement, superposition, the wave-function, the Born rule, collapse)

Week 13: Interpretations of QM (GRW, Many Worlds, Bohmian Mechanics)

Week 14: Wave-function realism (configuration space vs ordinary space, primitive ontology)

--- Final paper---