

PHYSICS 438a: Introduction to Quantum Mechanics

COURSE INFORMATION

Spring 2022

Course Description

Physics 438a is the first course in the introductory quantum mechanics series. It covers the foundations of quantum mechanics, including the basic postulates, the Schrödinger equation, the Born rule, Dirac notation and quantum mechanical formalism, exactly-solvable problems in 1 and 3 dimensions, spin, and identical particle statistics.

Learning Objectives

By the end of this course, you should be able to: describe the basic postulates of quantum mechanics; solve the 1D and 3D particle in a box and harmonic oscillator; solve the hydrogen atom in 3D; formally prove the uncertainty principle, Ehrenfest's theorem, and the canonical conjugation relations; and treat spin, angular momentum, and identical/distinguishable particles correctly in quantum systems.

Course Instructor

Prof. Eli Levenson-Falk (he/him)

Email address: elevenso@usc.edu

Office: SSC 222 during normal times, virtual during COVID

Student hours: TBD and by appointment

Textbook

Introduction to Quantum Mechanics 3rd Edition, by David J. Griffiths and Darrell F. Schroeter

(Earlier editions of the same book are acceptable, but you may need a classmate's help to get problems assigned from the 3rd edition)

Course Logistics

This course is taught as a flipped classroom, which may be different from what you're used to. Here's how it works:

- **New concepts will be introduced in short pre-recorded video mini-lectures.** I will post these ahead of time and you can watch them at your convenience, but you must watch the mini-lecture on a topic *before* we cover that topic in class.
- **You must read the textbook sections we're going to cover *before* we cover them.** So please read the textbook and watch the mini-lectures before coming to class. I'll send regular updates about which topics we're about to cover.
- **Class time will be divided into 3 parts: worked examples, Q&A, and group work.**

We'll play around with the ideal order and how much time to give each section, but there will be no traditional lecture. Instead, I will work out an example or two on the topics of the day; we'll have open question & answer time (with open discussion) focused on these topics; and we'll split into smaller groups for group work. The group work may include some work on problem sets. I will be moving between groups to discuss, give advice, and answer questions.

- **Problem sets will be longer and harder than a usual course, but partially done in class and mostly done in group work.** So there will be a lot of work, but you'll have plenty of time to do it and plenty of help to figure things out. The total workload for this course (watching lecture videos, reading the book, and doing the problem sets) will be similar to other classes.

Administrativa

A. Prerequisites

Physics 304 is a prerequisite and Math 445 is a co-requisite for this course. Exceptions can be made in compelling circumstances; please contact the instructor.

B. Disability accommodations

Students who need to request accommodations based on a disability are required to register each semester with the Disability Services and Programs. In addition, a letter of verification to the instructor from the Disability Services and Programs is needed for the semester you are enrolled in this course. If you have any questions concerning this procedure, please contact the course instructor and Disability Services and Programs at (213) 740-0776, STU 301.

C. Academic Integrity

Students who violate university standards of academic integrity are subject to disciplinary sanctions, including failure in the course and suspension from the university. Since dishonesty in any form harms the individual, other students and the university, policies on academic integrity will be strictly enforced. The academic integrity guidelines can be found in

- (i) The Trojan Integrity Guide,
<http://www.usc.edu/student-affairs/SJACS/forms/tio.pdf>
- (ii) The Undergraduate Guide for Avoiding Plagiarism,
<http://www.usc.edu/student-affairs/SJACS/forms/tig.pdf>

In plain language: don't cheat! Don't copy your answers from online, and especially don't post homework or exam problems online. We have ways of determining who posted a problem, and if we catch you doing it then you'll be reported to SJACS—no warnings, no second chances. I promise that you can get an excellent grade in this course if you do the work—just do the work!

D. Classroom Behavior

Masks will be required at all times, just like every other class. If you need to drink some water or something, lower the mask, take a sip, and put the mask right back on.

Any student who wants to learn quantum mechanics belongs in this course. It is the job of the instructor, the TA, and every student to ensure that this welcoming messages is felt by all students. Questions, discussion, and general interaction are strongly encouraged at all times. Hostile or unwelcoming comments or behaviors are always unacceptable and will be addressed appropriately.

E. Faculty Liaison

All courses in the Department of Physics & Astronomy have an assigned Faculty Liaison to serve students as a confidential, neutral, informal, and independent resource when they wish to discuss issues concerning their course without directly confronting their instructor. The Student Ombudsman for this course is Dr. Jack Feinberg, feinberg@usc.edu, 213-740-1134, SSC 327. Please note that the Faculty Liaison is a mandatory reporter for certain topics (e.g. self-harm, sexual assault); if you wish to access truly confidential resources for those subjects, see the listings under “Support Systems”.

F. Statement for observance of religious holidays

USC’s policy grants students excused absences from class to observe religious holidays: <http://orl.usc.edu/life/calendar/absences/>. In this case, please contact me in advance to agree on alternative course requirements.

G. Support Systems

Counseling and Mental Health - (213) 740-9355 – 24/7 on call

studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention and Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call

studenthealth.usc.edu/sexual-assault

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)- (213) 740-5086 / Title IX – (213) 821-8298

equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual

misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298

usc-advocate.symlicity.com/care_report

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710

uscsa.usc.edu

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call

dps.usc.edu

Non-emergency assistance or information.

Grading

A. Grading Breakdown

Your final course grade will be based upon three major components: problem sets (35% of grade), midterm exam (25% of grade), and final exam (40% of grade).

All students in this course will be given the same problem sets, the same midterm, and the same final exam.

B. Minimum Requirements for Passing the Course

In order to receive a passing grade in the course (D or above), you must contribute to solving at least 10 problems in class. In addition, you must turn in at least 75% of your problem sets.

C. Problem Sets

There will be a problem set assigned every week. I expect that it will take you, in total, approximately 6 hours to complete the weekly assignment (don't worry, some of this time will occur in class). These problem sets are the central way you will learn physics. Understanding physics does not mean knowing the words, having read the book. Instead, understanding implies having developed the ability to solve physics problems you have not seen before.

Problems will range from the trivial to the difficult. Experience shows a strong positive correlation between effort on problem sets and success as a student and as a physicist. **So do the assignments and do them honestly.**

The counsel to do your own work does not mean that you cannot work with other students in the class. On the contrary, **I encourage students to work together** in deciding how to solve problems. Of course, working together does not mean simply copying solutions from each other. That action is a violation of academic integrity standards. There is, however, a large difference between simply copying and learning by cooperating. Take advantage of this opportunity. Work in groups to figure out a problem, and then **write up your own solution.**

I also understand that many solutions can be found online. However, apart from being an academic integrity violation, copying pre-existing solutions denies you an essential learning experience and this will typically result in a poor performance on exams.

Problem sets will be due by Blackboard submission at 11:59pm on Sundays. Handwritten solutions must be scanned or photographed and uploaded as a *single* file, preferably a PDF. Many free apps exist to do this on a smartphone; I recommend CamScanner for those that use Android phones.

Solutions to the assignments will be posted on Blackboard shortly after the deadline. As such, **late work will NOT be accepted.** However...

I know that a student may find it impossible to complete a specific assignment owing to illness or other outside commitments. In order to address this issue, before computing your problem set grade **I will automatically discard your two lowest problem set scores.** This will happen without any special permission and no documentation will be required. This is intended to cover things like, but not limited to, illness, intercollegiate competitions (both academic and non-academic), intramural competitions, conflicts with other courses scheduling required activities outside of their declared times, and family emergencies. The only exceptions are: (i) Religious observances when documented on the web site of the Office of Religious Life, <http://orl.usc.edu>, in which case any affected student must inform his/her instructor of the situation no later than the day before the religious observance; (ii) Extended and well-documented medical issues.

Warning: You should view the fact that the lowest two grades will be dropped as a safety-net, and not as an excuse to goof-off on early assignments. A student who misses an early assignment for inadequate reasons, and then misses later work for completely legitimate reasons will receive little sympathy. **You do not need to request that specific problem set grades be dropped,** I will just drop the lowest two automatically.

It is very important that your written solutions are written legibly with enough details so that anybody, not just you, can understand what is going on. Specifically, be sure to show

intermediate steps and **use words, not just equations, to explain the solution.** Essentially, the solution should make sense to someone who knows the material but has never seen this particular problem before. A solution consisting of a string of equations with no comments, a figure if required, or some minimal explanation will be considered unsatisfactory and graded accordingly.

The minimum threshold 75% submission rate cited in the grading criteria above applies to the assignment as a whole, not to the individual problem count. A partially completed assignment will satisfy the requirement of submission but, for it to count, there must be some evidence of attempts at the assigned problems.

D. Examinations

There will be one Midterm Examination (sometime in March, date TBD, in class). The midterm exam will last 100 minutes and will be given during the normal class period.

The exam will be open-book and open-notes. Don't worry about memorizing equations; focus your efforts on understanding concepts.

Students with special examination requirements as documented by the Office of Disability Services must present their documentation to their instructor as soon after the start of classes as is possible, and certainly no later than seven calendar days prior to the first midterm, or as soon as the accommodation is granted.

The final exam for this course will be 2 hours and will be held on Tuesday, May 10 from 11 am – 1 pm. It will be cumulative and cover all topics in the course, but will focus more on the second half of the course. It will be open-book and open-notes like the midterm.

Assistance

You have a variety of opportunities for assistance available to you. Here are just some of them:

A. Classroom time

Don't underestimate the value of questions during the scheduled class period. Many students are reluctant to pose questions that they fear may seem silly to either their cohorts or the instructor. This probably includes you. Almost always, if one student asks a question, there are several others who have been bothered by the same thing. Often such questions tell me what is not clear to the students. Stopping and getting everyone together on the issue is much more useful than simply letting an explanation continue without clarification.

Classroom hours will consist mainly of group problem solving work, Q&A sessions, demos, and illustrative examples. Introduction of new material will mainly be done through pre-recorded videos and in the textbook.

B. Student Hours

For more personal attention you can come to my open student hours (held virtually on Zoom). If at all possible, come to the regularly scheduled student hours listed on the syllabus. However, if your schedule conflicts with this or you need to meet with me privately, please e-mail me to set up an appointment. Unfortunately I cannot schedule private meetings for problem set help—I'd love to, but there are just too many students!

C. Study Groups

One of the most effective ways to learn new material is to teach it to others. To this end, I encourage you to work together in learning the material and in doing problem sets. I encourage you to discuss problems, approaches to solutions, and even solutions, though you are cautioned not to simply copy solutions.

You might find it useful to use the Slack channel to set up and organize discussion groups.

D. Published Solutions

Solutions to all problem sets will become available at any time after you have submitted them for grading. Looking back through the assignments and reminding yourself how to solve the problems is an excellent way to study. I will also work through examples in recorded videos and during live classroom time, and will publish the solutions.

E. Other Books

There is no shortage of alternatives to the assigned textbook. Some of these will be in Leavey Library including:

- Sakurai and Napolitano, Modern Quantum Mechanics
- Shankar, Principles of Quantum Mechanics
- Thayer, Modern Introductory Quantum Mechanics with Interpretation

Electronic Assistance

A. E-mail

E-mail is the most efficient method of contacting me outside of class. You can use e-mail to make appointments to speak privately with me, to find out class logistics, or to just ask more physics questions. Important: Use your USC email account. Non-USC accounts cannot be authenticated and cannot be relied upon for any grade-affecting communication. Email from non-USC accounts may be blocked, deleted, or ignored. **Your email subject *must* include “[Physics 438a]” (including the brackets), followed by the subject of the message.** I receive a lot of spam from textbook companies, so it can be impossible to correctly categorize messages; e-mails which do not include this subject may be ignored.

I will answer e-mail within 48 hours (usually faster), except on weekends, and will answer almost any question *except* “How do I do this problem?” For problem set help, use any of the other resources listed here! General physics questions or clarifications of an assignment are ok; occasionally a question cannot be answered easily in e-mail, in which case you will be asked to come to student hours.

B. Slack Channel

I’ll be conducting most course communication (announcements, Q&A, general discussion) via the course Slack channels. I highly encourage you all to openly discuss concepts, problems, and any general topics you would like. You can even make a students-only channel and shut me out of it so that you can make fun of my terrible jokes in peace.

B. Course Web Site

Everyone registered in PHYS 438a should find a courses already set up within their Blackboard account (<https://blackboard.usc.edu>). In this lecture course you will find a copy of the syllabus, assignments, important news and announcements, and solutions to problem sets and exams.

SCHEDULE

WEEK	TOPICS	READING	NOTES
1 (Jan 11)	History of QM; the basic postulates; Schödinger equation and wave functions;	Griffiths Ch. 1-1.2	Why quantum? How do the basics work?
2 (Jan 18)	Probability; position and momentum; uncertainty principle	Griffiths Ch. 1 (remainder)	The universe <i>does</i> play dice
3 (Jan 25)	The time-independent Schrödinger equation; particle in an infinite square well; quantum harmonic oscillator (part 1)	Griffiths Ch. 2-2.2	Let's start solving things
4 (Feb 1)	Quantum harmonic oscillator (part 2); other exactly-solvable problems in 1D	Griffiths Ch. 2.3-2.5	The simplest problems, which is why we do our best to only ever solve these ones
5 (Feb 8)	Vector spaces; eigenstates and eigenvalues; linear algebra	Griffiths Appendix A	The advanced math that's actually way easier than the "basic" calculus
6 (Feb 15)	Hilbert space; observables; eigenstates	Griffiths Ch. 3-3.3	The FORMALISM (oooooh)
7 (Feb 22)	The uncertainty principle; commutation relations; operators; Dirac notation	Griffiths Ch. 3 (remainder)	Formalism continued; what all the funny arrows mean
Midterm Exam, February 24, in class			
8 (Mar 1)	The Schrödinger equation in 3D	Griffiths Ch. 4.1	We don't live on lines...
9 (Mar 8)	The hydrogen atom, angular momentum	Griffiths Ch. 4.2-4.3	Here's why chemistry works
Spring Break, March 14 - 18			
11 (Mar 22)	Spin, addition of angular momenta, electromagnetic fields	Griffiths Ch. 4 (remainder)	Just wait until you see what the vector potential has been up to while we were distracted

12 (Mar 29)	Identical particles, atoms, and solids	Griffiths Ch. 5	Ever wondered why stars aren't all black holes?
13 (Apr 5)	Translations; conservation laws; parity	Griffiths Ch. 6-6.4	Cool tricks you can play to bring Nöether into the 20 th century
14 (Apr 12)	Rotations; degeneracies; selection rules	Griffiths Ch. 6 (remainder)	Tricks for the future
15 (Apr 19)	Time evolution; unitary operations; quantum computing	TBA	A bit of what I work on
16 (Apr 26)	Review		
Final Exam: Tuesday, May 10, 11 am			