

PHYSICS 438b: Introduction to Quantum Mechanics

COURSE INFORMATION

Fall 2022

Note: the most up-to-date version of the syllabus can always be found on the Blackboard site by [clicking here](#). Please check to make sure you are referring to the most up-to-date version. This version was updated 8/7/22.

Course Description

Physics 438b is the second course in the introductory quantum mechanics series. In 438a you learned the basics of quantum mechanics, gained experience with the formalism, and learned how to exactly solve some relevant physical problems. Now it's time to go beyond exact solutions, to learn the current limitations of quantum theory, and to lay the foundations for advanced quantum mechanics.

Learning Objectives

By the end of this course, you should be able to: to use a variety of approximate methods to solve arbitrary physical systems; derive conservation laws and degeneracies based on the symmetries of a system and vice versa; model time-varying quantum systems; and explain the limits of quantum theory and how it contradicts classical realism.

Course Instructor

Prof. Eli Levenson-Falk

Email address: elevenso@usc.edu

Office: SSC 222

Office hours: Tentatively scheduled for Tuesdays 4-5 pm, 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 homework problems assigned from the 3rd edition, and the chapter numbers will be different)

Course Logistics

This class is done mostly as a flipped classroom, similar to 438a. That means:

- **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 main lecture.

- **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 post regular updates about which topics we're about to cover.
- **Class 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 homework problems. I will be moving between groups to discuss, give advice, and answer questions.
- **Homework 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.
- **Instead of a final exam, there will be a final project.** More info on that below.

Administrativia

A. Prerequisites

Physics 438a or equivalent is a prerequisite for this course.

B. Disabilities

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 are currently not required by the university, but I will always wear one and I am *begging* you to wear one too. People in my household are immunocompromised and I really don't want to get them sick. 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.symplicity.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: homework (30% of grade), midterm exams (30% of grade split across 2 exams), and final project (40% of grade).

All students in this course will be given the same homework assignments, the same midterm,

and the same final project.

B. Minimum Requirements for Passing the Course

In order to receive a passing grade in the course (D or above) you must receive a passing grade on the final project. In addition, you must turn in at least 75% of your homework assignments.

C. Homework Assignments

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: 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; OR 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 two Midterm Examinations (Oct 4 and Nov 1 in class). The midterm exam will last 100 minutes and will be given during the normal class period.

You'll be allowed 3 pages of notes for these exams. Don't worry about memorizing equations—make sure you know how to solve the problems!

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.

E. Final Project

Instead of a final exam, a final project will be due at the end of the scheduled final exam period. For your final project you will be asked to choose one of three options:

- (1) Write a number of *original* quantum mechanics problems appropriate for the level of 438b, along with detailed solutions. Half of the problems should be appropriate for a homework assignment, the other half for a midterm exam. Each problem must cover a different topic. You will be graded on the accuracy of your solutions (50%), the appropriateness of the problem to the level of the course (25%), and the pedagogical utility of the problem (25%). **Note:** by picking this option, you are giving me permission to use your problems in future classes.
- (2) Take an advanced topic in quantum mechanics (such as a topic from upper-level graduate quantum) and write an undergraduate-level summary of the topic appropriate for teaching your classmates. Summaries will be graded on accuracy (50%), appropriateness to the level of the course (25%), and clarity of presentation (25%).
- (3) Take a recent scholarly journal article that is heavily focused on quantum mechanics,

quantum information, and/or applications thereof. Write a “lay-physicist”-level summary of this article: this should be appropriate for someone who has some familiarity with quantum mechanics, but is not an expert. Think of yourself and your classmates after the first few weeks of 438a, that’s the level we’re going for. Articles must be no more than 2 years old and must be from a reputable journal (e.g. Physical Review journals, Science, Nature journals, AIP journals--ask me if you’re not sure!) For examples of how to write such a summary, go to QuBytes.org—your task is to write a QuByte just like the ones on the site. Summaries will be graded on accuracy (50%), appropriateness to the level of the reader (25%), and clarity of presentation (25%). **Note:** if your summary is good, I’ll want to publish it on QuBytes. By picking this option for your final project, you are giving me permission to publish your summary.

I will be “scaffolding” these projects to make sure no one leaves things to the last minute—this has happened in the past, as it’s easy to underestimate how long it will take to write problems or really understand a concept well enough to explain it. **There will be checkpoints in the final weeks of the class to ensure that you’re making progress on your project.** These checkpoints are ungraded, *unless* you miss 2 checkpoints in a row, in which case you will receive a 10% grade penalty on your final project. More details on the checkpoints TBA.

Assistance

You have a variety of opportunities for assistance available to you. Here I list a non-exclusive set of these opportunities.

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 the lecture and getting everyone together on the issue is much more useful than simply letting a lecture 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. Instructor Office Hours

For more personal attention you can come to my office hours (held both in person and virtually on Zoom). If at all possible, come to the regularly scheduled office hours listed there. However, if your schedule conflicts with this and you need to meet with me privately, please e-mail me to set up an appointment. Unfortunately I cannot schedule private meetings for homework 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 homework assignments. If you have friends also enrolled in the course in any section, feel free to discuss homework

problems, approaches to solutions, and even solutions, though you are cautioned not to simply copy solutions.

You might find it useful to use the discussion board within the lecture's Blackboard site to set up and organize discussion groups.

D. Published Solutions

Solutions to all homework sets will become available at any time after you have submitted them for grading. Looking back through the homework 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 438b]” (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 homework problem?” For homework 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 office 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. I'll often help out on the homework problems by answering questions and giving hints *if* the question is posed in a public channel. I will respond to Slack DMs, but there may be a lag of up to 48 hours (usually

much faster).

B. Course Web Site

Everyone registered in PHYS 438b 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, problem sets, solutions to problem sets and exams, mini-lectures, copies of in-class notes, and some other useful materials.

SCHEDULE

WEEK	TOPICS	READING	NOTES
1 (Aug 22)	Review: formalism, ladder operators, angular momentum, spin, addition of angular momentum	Griffiths Ch. 2-4	Quick review through topics covered in 438a
2 (Aug 29)	Review: addition of angular momentum, identical particles; free electron gas and solids	Griffiths Ch. 4-5	Continued lightning-speed review of 438a
3 (Sep 5)	Review: symmetry and conservation laws, degeneracies, selection rules; time evolution	Griffiths Ch 6	Review con't; we'll go into more detail on selection rules, which will be extremely useful for...
4 (Sep 12)	Time- independent perturbation theory	Griffiths Ch. 7	What to do when you can't solve it
5 (Sep 19)	Time-dependent perturbation theory, resonant transitions, emission and absorption of radiation	Griffiths Ch. 11- 11.3	What to do when you can't solve it and also it's moving

6 (Sep 26)	Fermi's Golden Rule, adiabatic and sudden approximations	Griffiths Ch. 11 (remainder)	Some useful tricks!
Midterm 1 in class October 4, covering through Week 6 material			
7 (Oct 3)	Variational methods	Griffiths Ch. 8	How to be less wrong when you guess
8 (Oct 10)	The WKB Approximation	Griffiths Ch. 9	What to do when you have NO idea
Fall break: no class Oct 13			
9 (Oct 17)	Scattering	Griffiths Ch. 10-10.3	Waves don't bounce, they diffract
10 (Oct 24)	Scattering con't	Griffiths Ch. 10 (remainder)	But sometimes they do kinda bounce
Midterm 2 in class Nov 1, covering through Week 9 material			
11 (Oct 31)	Density matrix formalism	Griffiths Ch. 12.3	What happens when things aren't ideal
12 (Nov 7)	Density matrix con't; measurement and decoherence	Notes TBA	The fun stuff!
Final Projects Checkpoint #1 Nov. 11			
13 (Nov 14)	Quantum devices	Notes TBA	You won't escape without me forcing you to learn about my research
14 (Nov 21)	Buffer		If we're on schedule I'll introduce a special topic, otherwise we'll use this time to catch up
Final Projects Checkpoint #2 Nov. 23			
Thanksgiving break, no class Nov 24			
15 (Nov 28)	Review		
Final Projects Checkpoint #3 Dec. 2			
Final Projects Due Monday, Dec. 12, 11:59 pm			