PHYSICS 438b: Introduction to Quantum Mechanics

COURSE INFORMATION

Fall 2020

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: 1 hour per week TBA 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)

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

D. Classroom Behavior

This will be an all-online semester, so classroom rules will be a bit different. Please keep your microphone muted when not speaking so that you do not add background noise. Please use headphones if possible to prevent echoes. If you feel comfortable doing so, please keep your video on. Interaction is more difficult than in person, so please be assertive in asking questions!

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. Student Ombudsman

All courses in the Department of Physics & Astronomy have an assigned Student Ombudsman 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 Chris Gould, gould@usc.edu, 213-740-1101, SSC 204.

Grading

A. Grading Breakdown

Your final course grade will be based upon three major components: homework (35% of grade), midterm exam (25% of grade), 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 homework assignment every week. We expect that it will take you, in total, approximately 5 hours to complete the weekly homework. These homework 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.

Homework problems will range from the trivial to the difficult. Experience shows a strong positive correlation between effort on homework and success as a student and as a physicist. So **do the homework and do it honestly.**

The counsel to do your own homework does not mean that you cannot work with other students in the class. On the contrary, **I recommend students work together**, where feasible, 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.

Homework will be due by Blackboard submission at 11:59pm on Tuesdays. Handwritten homework 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 homework assignments will be posted on Blackboard shortly after the deadline. As such, **late work will NOT be accepted**. However…

I know that from time to time students find it impossible to complete a specific homework assignment owing to illness or other outside commitments. In order to address this issue, before computing your homework grade **I will automatically discard your two lowest homework scores**. This will happen without any special permission and so 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 homeworks will be dropped as a safety-net, and not as an excuse to goof-off on early homework. A student who misses an early homework for inadequate reasons, and then misses later homework for completely legitimate reasons will receive little sympathy. **You do not need to request that specific homework 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 homework assignment, not to the individual problem count. A partially completed written homework 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 (Sep 24 in class). The midterm exam will last 90 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.

Once your exam is done, you will need to take a quick photo with a smartphone and upload it to Blackboard. You will then have a period of 1 hour to get a nice scan of your exam and upload it. **Please notify me ASAP if you do not have a smartphone or other camera capable of doing this**.

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 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%).

Alternately, you may take an advanced topic in quantum mechanics (such as a topic from upper-level graduate quantum or a recent research result) 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%).

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 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. 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, homework assignments, important news and announcements, and solutions to examinations in this and previous semesters. Another useful tool is the discussion board within the lecture's Blackboard site. If you are working on a homework problem, or preparing for an exam, and you can't figure out how to proceed, ask your question on the discussion board. It's not "live chat," so you won't get an answer back within seconds, but your question will be saved so that others can respond when they visit the discussion boards. I will sometimes join these discussions.

Important Netiquette: When you start a new discussion thread, give your post a useful subject line. Don't title your question, "Question," "Need help," or "I'm having trouble." Instead, describe the topic succinctly, such as "Problem 10.28," or "The Precarious Lunch Problem." If you're starting a new discussion thread, others will recognize that you're asking for help.

SCHEDULE

WEEK	TOPICS	READING	NOTES
1 (Aug 17)	Review: formalism, ladder operators, angular momentum	Griffiths Ch. 2-4	Quick review through topics covered in 438a, plus

	Addition of angular momentum		one topic that was skipped
2 (Aug 24)	Identical particles; free electron gas, electrons in solids, molecules, exchange statistics	Griffiths Ch. 5	This will make stat mech, solid state, and chemistry all make sense!
3 (Aug 31)	Symmetry and conservation laws; rotational symmetry	Griffiths Ch. 6-6.5	The *deep physics* for all you budding theorists
4 (Sep 7)	Time evolution, degeneracies, selection rules	Griffiths Ch. 6 (remainder)	The "what now" after the "why" and the "what"
5 (Sep 14)	Time-independent perturbation theory	Griffiths Ch. 7	What to do when you can't solve it
6 (Sep 21)	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
Midterm Exam, September 24, in class			
7 (Sep 28)	Fermi's Golden Rule, adiabatic and sudden approximations	Griffiths Ch. 11 (reminader)	Some useful tricks!
8 (Oct 5)	Variational methods	Griffiths Ch. 8	How to be less wrong when you guess
9 (Oct 12)	The WKB Approximation	Griffiths Ch. 9	What to do when you have NO idea
10 (Oct 19)	Scattering	Griffiths Ch. 10	Waves don't really bounce, they diffract
11 (Oct 26)	Density matrix formalism; measurement, the WKB approximation, and decoherence	Griffiths Ch. 12 and notes TBA	The fun stuff! Preview of advanced quantum physics and current research topics
12 (Nov 2)	Buffer		Let's be honest, there's no way we'll actually be on schedule
13 (Nov 9)	Review		
Final Projects Due: Tuesday, Nov 24, 10 am			