UC Berkeley
Physics 137B - Quantum Mechanics 2, Fall 2019
Course Information

Instructor Information	Lecture Information	Office Hours
Austin Hedeman 443 Birge Hall aphysicist28@berkeley.edu	MWF, 5:00pm – 6:00pm 102 Moffitt	M, 2:00pm – 3:00pm F, 1:00pm – 2:00pm 429 Birge Hall

Enrollment: This course is **Physics 137B - Lecture 002 - Quantum Mechanics.**

Course Description: Quantum Mechanics is the startling theory of the microscopic world that was forced on science near the beginning of the 20th century. This theory is of fundamental importance for physics and most modern devices rely on the strange-seeming rules of Quantum Mechanics to function properly. In this course we will continue our development of quantum mechanics, looking at multi-particle systems, identical particles, perturbation theory and approximation methods, scattering theory, and some selected advanced topics.

Prerequisites: The introductory physics sequence (7ABC or 5ABC) and Physics 137A are prerequisites for this course.

Course Website: https://bcourses.berkeley.edu/
The course website will be hosted through the bCourses system. If you having trouble accessing the website, please e-mail me at aphysicist28@berkeley.edu so we can get you set up!

Texts:

- Townsend, John, *A Modern Approach to Quantum Mechanics, 2nd Edition*. This is the introductory text you may have used in 137A and it is a good overview that starts from the beginning with the spin system. This is our **required** text, though Griffiths (see below) is an acceptable alternative! This semester will primarily cover Chapters 5 and 11 through 14 of this text.
- Griffiths, David, *Introduction to Quantum Mechanics, 3rd Edition*. This has become a standard introductory text for Quantum Mechanics. This is a **recommended** text. This semester we will primarily cover Chapter 5 and 7 through 11.

On the syllabus you will find a tentative outline of topics and dates for this course. In italics listed next to most of the topics is the relevant section of the books. These sections are to be read **before** coming to lecture. There will be more specific reading assignments listed in the Homework Assignments folder on bCourses.

It is important to get many different perspectives and takes on the subject, since you never know which one may 'click' for you. Different authors have different writing styles and organizations of the subject. Listed below are other Quantum Mechanics texts that you may find useful! They are on reserve at the Physics Library:

- Shankar, Ramamurti, *Principles of Quantum Mechanics*. This book is very useful for learning Dirac notation. This book is available as an electronic resource through the Berkeley Library at: http://link.springer.com/book/10.1007%2F978-1-4757-0576-8.
- Bransden & Joachain, *Quantum Mechanics*. This is the textbook that is preferred by some other professors in the department (notably Professor Siddiqi). This is also a very good text. The material for this class will cover up through Chapter 7 of this book.
- Liboff, *Introductory Quantum Mechanics*. This is another standard introductory text.
- Feynman, *The Feynman Lectures on Physics, Vol. 3*. Volume 3 of the Feynman Lectures covers Quantum Mechanics. Like all of Feynman's stuff it is very well written and worth looking at!

Content: This course is roughly up into three parts:

- **Part I: Combining Degrees of Freedom**: After a review of 137A, we will dive in by analyzing what happens when we have two or more different angular momenta in a system. This includes the orbital and spin angular momentum of an electron in hydrogen and the two spins in a two-electron system (combining qubits into larger quantum information structures). Then we will study multi-particle systems and collections of identical particles (hydrogen as a two-body system, the two electrons in helium, multi-electron atoms, solids, etc.). Finally, we will introduce the density operator, which allows us to effectively analyze subsystems of a larger multi-degree of freedom system.
- **Part II: Perturbation Theory and Approximation Methods**: By this time we have pretty much exhausted the list of systems that we can exactly solve. In practice, complicated systems are analyzed using various approximation methods. We will begin by exploring perturbation theory (what happens if we add a small change to a system whose solution we know). Using this will allow us to study the fine structure of hydrogen. We will look at the variational principle (a way of estimating ground-state energies), WKB theory (a way of approximating the energy spectrum, tunneling probabilities, and wave functions when the relevant quantum numbers are large), and time-dependent perturbation theory (which will allow us to study the interaction between our systems and an electromagnetic field, including the emission and absorption of photons).
- **Part III: Scattering Theory and Advanced Topics**: Finally, we will explore scattering theory in three-dimensions, including scattering cross-sections and resonances (the bread and butter of high-energy particle physics). We will introduce partial wave analysis and the Born approximation as approximation methods of analyzing scattering problems. The remainder of the course (if there is *any* time at all left!) will be devoted to special topics! I hope to cover the path-integral formulation of quantum mechanics and the semiclassical phase space approach to quantum mechanics, though other possible topics include quantum information theory, relativistic quantum machanics and the Dirac equation, the POVM formalism as a way of interpreting quantum measurement, etc.

Discussion Sections:

Section 201:	F 12:00pm - 1:00pm	110 Barr	GSI: Chris Olund (colund@berkeley.edu)
Section 202:	W 4:00pm - 5:00pm	200 Wheeler	GSI: Chris Olund (colund@berkeley.edu)

Sections will be devoted to working through examples. You are highly encouraged to attend! There will be no discussion section the first week.

Office Hours: My office hours are listed at the top of this document and will be held in 429 Birge Hall. The GSIs will also hold office hours and their schedule will be posted on the course site. These office hours may change based on student availability. I am also available by appointment.

Homework Assignments: There will be problem sets posted on bCourses at least one week prior to the due date of the assignment. You are encouraged to work together on these assignments, but each student must submit their own work. Problem sets will typically be due **Tuesdays at 9am** (though the dates may move around slightly during exam season so you don't get too slammed with work).[1]

You must submit your homework in the designated box in the second floor breezeway between Birge and LeConte Halls. Problem sets submitted within 24 hours or **one business day** after the deadline will be accepted with a **25% penalty**. Late homework assignments *must* be turned in to the folder outside my office door (443 Birge) rather than the homework box. Late homework will *not* be accepted after solutions appear on bCourses.

In each problem you do over the semester it is important to not only *show* your work, but also to *explain the steps you are taking*. As with any physics problem set, the answers are not typically as important as knowing *how* to get the answers. Think of these as opportunities to show off what you know. If you can explain what you are doing and why you are doing it, you are well on your way to understanding what is going on!

You are encouraged to work with your peers on these problem sets. Discussing problems, explaining your thought processes to other people, and hearing how others approach the problems are excellent ways of expanding your understanding of the material. That being said, students must turn in their *own* work.

[1] The homework should really be due Monday evening, but not all of you may have access to the building and our lecture runs late, so Tuesday morning will be our official deadline.

Since we all have bad weeks and I know you all have lots of competing obligations, at the end of the semester your lowest homework score will be dropped. There will also be a homework set due on the last day of summer session that covers the last week's material and is optional. If you turn this set it, it will be used to replace a previous homework.

Exams: We will have two midterm exams, tentatively planned for **Friday, October 11th** and **Friday, November 15** and will take place *after class*. I am still waiting on confirmation of the rooms and will discuss options with you in lecture! Please let me know if you have any other conflicting exams ASAP. The final exam will be held on **Friday, Dccember 20th** at 3:00pm.

Piazza: http://piazza.com/berkeley/fall2019/physics137b/home
Piazza is a service that lets students ask questions (either publicly or anonymously) that the instructor, GSI, or other students can then answer. This is great for asking questions about the homework and I highly recommend you use it!

Grades: The grade breakdown will be as follows:

Category	**Percent**
Homework Assignments	40%
Midterm 1 (F, 10/11)	18%
Midterm 2 (F, 11/15)	18%
Final Exam (F, 12/20)	24%

Disabled Students' Program: http://www.dsp.berkeley.edu/
All students who have special needs can receive appropriate accommodations. The DSP office must determine or verify these accommodations before they can be offered. Students who are requesting academic accommodations are responsible for contacting the DSP Coordinator *immediately*. Please contact the instructor when a request for accommodation has been filed.

Student Code of Conduct: http://sa.berkeley.edu/code-of-conduct
The instructor and students are expected to behave with the utmost of integrity, responsibility, and civility towards all members of the classroom as well as Extension staff. Additionally, all members of the Extension community are expected to comply with all laws, University policies, and campus regulations, conducting themselves in ways that support a thriving learning environment. For more information, see the linked document. Violation of the code of conduct can result in disciplinary steps as outlined in the code.

Use of Course Materials: The materials provided by the instructor in this course including, but not limited to, lecture notes, homework assignments, solution sets, exams, exam solutions, and study materials (collectively "course materials") are for the use of the students current enrolled in the course only. Distribution or public display of the course materials by students for non-enrolled students is not permitted, and may constitute academic misconduct under Sections 102.01, 102.05, and 102.23 of the student code of conduct. The course materials are also subject to copyright protection, with copyright held by the instructor. As such, the course materials may not be duplicated, distributed, publicly displayed, or modified in a manner contrary to law.

Administrative Issues: Please do not hesitate to e-mail me at aphysicist28@berkeley.com with any questions, feedback, or administrative issues!

Changes and Updates: Any changes, corrections, modifications, amendments, or updates to these policies will be announced in lecture and posted on the course website.

If you are in trouble for whatever reason, please let me know! I'll try to help!

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