PHYS 631: Quantum Mechanics I (Fall 2020)

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Course home page: https://atomoptics-nas.uoregon.edu/~dsteck/teaching/20fall/phys631

Schedule: MT 5-6:30p, 100 Willamette meetings on Zoom (see course notes and exercises page for meeting link)  
Course reference number: 15564  
Credits: 4  
Prerequisites: none

Links: news, course notes, homework sets and keys.

Course overview

This course is a more-or-less standard introduction to quantum mechanics at the graduate level, one of the core components of your Ph.D. studies. This is the first of a 3-quarter sequence. This course will also assume you have studied quantum mechanics for at least one term at the undergraduate level.

Recommended Texts:

There is no required textbook to purchase for this course. The main reference for this course will be online notes posted here.

Much of this material is also covered well in many excellent texts. A few of the more widely used and/or interesting ones that you may want to have in your collection are:
- Sakurai, *Modern Quantum Mechanics*
- Merzbacher, *Quantum Mechanics*
- Landau and Lifshitz, *Quantum Mechanics: Non-relativistic Theory*
- Peres, *Quantum Theory: Concepts and Methods*
- Dirac, *The Principles of Quantum Mechanics*

**Philosophy of This Course:**

This is one of the core courses of your graduate physics training. This first course in the QM sequence covers mostly material that you should have already studied as an undergraduate. However, this course will cover this basic material at a higher, more rigorous level, building up the structure of QM from its basic axioms. In doing so you will likely uncover misconceptions and strengthen your understanding of the subject, while mastering the associated mathematical techniques (linear algebra, differential equations and boundary-value problems, approximation methods, regularization).

**COVID-19 considerations:**

This would normally be a relatively traditional lecture course, but due to the ongoing COVID-19 pandemic, online meetings are required by the UO. Lecture courses are not optimal by Zoom, to say the least. There are alternatives to lectures that work well, but since this is the first course in a year-long sequence, it's good for me to get to know you, and having at least some lecture time helps me to do this. This is especially true if you all ask lots of questions in class. I'll (try to) keep lectures down to around 1 hour during each meeting, after which I'll have you work on exercises related to the material for the day (probably in small breakout groups, but details may evolve).

One of the main challenges of a remote course is that it's more difficult to have a sense of community as a class, which is particularly important for the first-year Ph.D. students among you to develop a support network that will last throughout your graduate career. So when you're attending class meetings on Zoom it's particularly important for you to keep your video feed on so people can see your smiling face. It's okay to disable video for a bit if your cat is jumping on your head, but please try to be maximally present as much as you can.

Of course, you will have questions on the material, homework problems, and exercises outside of the class meeting times. I highly encourage you to contact me to set up a Zoom meeting outside of regular class hours; generally I'll advertise these to the class on the news page so anyone can listen in, unless you request otherwise (we'll use the same Zoom meeting that we use for regular class meetings). These meetings will replace in-person office hours (where the disadvantages of being masked and only one person allowed in my office would seem to outweigh the advantages of meeting in person).

**Study groups:**

As mentioned above, because this class is remote, it's particularly important for you to develop some form of community as a class. I highly encourage you to join/form a study group (whether a zoom group or a study bubble, just stay safe). If you need help in finding a study group, or you have
already formed a group and you can take on more people, just let me know and I'll be happy to facilitate this.

While I encourage study groups, you must still work through problems on your own and turn in your own solutions. These groups work brilliantly for brainstorming, getting unstuck, clarifying, etc., but ultimately you have to **work** or you won't learn anything.

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**Grades**

Grades for the course will be based on homework, a midterm exam, and a final exam. The relative weights will be as follows:

- Homework: 25%
- Exercises: 10%
- Midterm exam: 30%
- Final exam: 35%

**COVID-19 considerations:** you'll submit all documents electronically (via a web submission system). This includes solutions for homework, exercises, and exams. This will mean you will either need to type out solutions (preferably in LaTeX), or scan your handwritten solutions. In the case of the dead-tree method, **please make legible, data-efficient scans.** You may or may not have access to department scanners, so if you have a scanner at home use that; otherwise, use a scanner app for your phone or tablet (I've used Scanner Pro on iOS, which is cheap and works well, but there are many other options available). Having this capability will serve you well beyond this class and the pandemic.

**Homework:** about 6-8 problem sets will be assigned during the term. You'll submit these online, see the [homework page](#) for the upload link.

**Exercises:** These are relatively simple (compared to homework problems) related to the lecture material. These will be assigned during each lecture, when you'll start working on them, and they'll be posted on the [notes page](#). You should turn in (online, see the notes page) your exercise solutions for each week all together, by the following Monday. I'll grade these on completion (i.e., if you do a reasonable job, you'll get full credit).

**Midterm exam:** The midterm exam will be an at-home exam, held during the sixth week of class (2-6 October), details to be finalized.

**Final exam:** The final exam is scheduled for 19:15 Monday, December 7, 7:15-9:15p. Since the exam is remote, the time is flexible (details to be finalized).

**Pass/fail grading option:** Since this is a core graduate course, you should take the graded option.
Syllabus

This is a tentative list of topics we will cover during this term. (I may change things up and substitute other topics.)

1. Overview of mechanics in Hilbert space
2. Operators and expectation values; uncertainty principle
3. Matrix mechanics, unitary transformations, time evolution
4. Free particle
5. Square-well potentials
6. Probability currents and tunneling
7. Delta-function potential
8. Double-well potentials, two-state dynamics, quantum Zeno effect
9. Harmonic oscillator
10.