PHYS 4702/6702: Quantum Mechanics II
Syllabus

University of Georgia, Fall 2018
MWF Period 2 (9:05 am–9:55 pm), Room 303

Introduction
Quantum mechanics is one of the pillars of modern physics. It’s the foundation for chemistry, condensed matter physics, atomic and molecular physics, nuclear and particle physics, and even optics. Quantum mechanics can be thought of as a generalization of Newtonian mechanics to systems where the wave-like properties of matter can’t be ignored. It has proved to be an enormously successful and practical physical theory.

From the beginning, quantum mechanics has been the source of difficult and often philosophical questions about the nature of reality, the role of measurement, and the interpretation of calculations. The mathematical foundations of quantum theory are still not fully established. As far as we know, the quantum principles apply universally, and yet the transition between “clearly” quantum and “clearly” classical systems is murky. You will probably find the central ideas in quantum mechanics to be abstract, unintuitive, or weird. But you’ll also find that won’t stop you from successfully mastering the techniques of quantum mechanics.

Course Description
This course is the second half of an upper-level sequence on modern quantum mechanics. In this semester, we’ll apply the fundamental principles from the first semester, and some new mathematical tools, to a variety of important topics including angular momentum, the hydrogen atom, identical particles, and perturbation theory.
Basic Information

Instructor: Dr. Craig Wiegert    Phone: 706-542-4023
215 Physics Building    Email: wiegert@physast.uga.edu

Office hours: TBA

Note there are errata for the textbook on eLC.

*The Feynman Lectures on Physics, Vol. 3*, by Feynman, Leighton, and Sands. This wonderful volume, on which our main textbook is loosely based, is freely available online.

Web site: eLearning Commons.
Check this daily for announcements.

Prerequisite: PHYS 4701/6701 (Quantum Mechanics I)

Overall Learning Goals

By the end of this course, you should be able to

- fully analyze the hydrogen atom as a model of atomic systems;
- solve problems involving addition of angular momentum;
- compute corrections to exact solutions of quantum systems using perturbation theory, and understand the connections with spectroscopy;
- apply symmetry principles to analyze the behavior of multiple-particle systems and periodic systems;
- explain the qualitative behavior of your solution to any problem;
- evaluate the reasonableness of solutions through such methods as dimensional analysis, limiting/special cases, order of magnitude estimates, and verifying boundary conditions.

Grading Policies

We will be using a very different assessment approach this semester. It goes by various names ("Standards-Based Grading" or "Learning Outcomes-Based Assessment") and it addresses some issues that can occur in a more traditional homework/exam-based physics course:

- students will cram for an exam, but then don’t retain the understanding even though it’s important for later material;
- students can focus more on points than on learning;
- students learn at different rates, and can develop mastery long after a homework or exam is due.
Each major course topic (textbook chapter) will comprise several standards that you will endeavor to demonstrate mastery in. For each standard you may be assessed multiple times. An assessment might cover 2 or 3 standards, or it might cover just one. Every time a standard is assessed, I will update the score for that standard in the gradebook, and provide you with feedback on the assessment. Your score might go up and it might go down. You can reassess any standard often (within reason!), and I will occasionally require you to reassess on some standards.

Assessments will look like the following:

- Screencasts: you talk me through a calculation or derivation. For example, you can narrate a derivation as you write it on a touchscreen (or type it in a Mathematica notebook) and record the screen. Or you can write out a derivation, scan or photograph it, and record a screencast of you walking through the derivation with the mouse pointer.

- In class: once or twice during the semester we’ll set aside class time for review and oral assessment in class. Prior to these days, you’ll be told the standard(s) that will be assessed. You’ll be able to bring a page of notes/work to the assessment, and you’ll have a 5 minute period in class to present your assessment.

- Office visits: you come to my office to work out a problem. The visit should be scheduled in advance, including mentioning the standard(s) you want assessed.

We will use the final exam period as a final opportunity for oral assessments on standards, as well as a final reflective exercise on the standards themselves.

Brevity is one sign of deeper understanding. It shows that you know the priority of the important concepts, as you don’t spend too much time on less important ones. You will usually not receive highest marks for a technically correct assessment, even one whose content is “brag-worthy,” if it’s too long. A good rule of thumb for the length of a typical assessment is ten minutes.

Scoring

Each standard will be scored on a 0–4 scale:

0. No evidence (not assessed)
1. Beginning (doesn’t meet expectations)
2. Developing (approaches expectations)
3. Proficient (meets expectations)
4. Expert (exceeds expectations)

A more detailed description of each level will be posted to eLC.

The bulk (90%) of your letter grade will be determined by your proficiency on the standards. I will simply average your most recent scores for each standard. The remaining 10% of the grade will come from the final reflective exercise.
Letter grade cutoffs will be no higher than the following percentages:

\[
\begin{align*}
A^- &= [85, 89) & A &= [89, 100] \\
B^- &= [70, 74) & B &= [74, 81) & B+ &= [81, 85) \\
C^- &= [55, 59) & C &= [59, 66) & C+ &= [66, 70) \\
D &= [40, 55) \\
F &= [0, 40)
\end{align*}
\]

Actual grade ranges may end up having lower cutoffs.

At the end of the semester, provided that you complete a course evaluation, I will drop your lowest two assessment scores when calculating your course grade. If you don’t submit a course evaluation during the allotted time, then all scores will count. This policy compensates for the unavoidable circumstances that may prevent you from developing the level of proficiency you want on every standard (e.g., illness, emergency, etc.).

“One Week” Rule

Once a standard has been “activated” (meaning that we’ve covered the relevant material in class), you will have one week to turn in your first assessment for it. If you don’t, you must take a zero for that standard for the course. This policy of having an initial deadline prevents chronic procrastination from becoming a problem, and ensures that you get early feedback on assessments.

Graduate/Honors Credit

Graduate students in this course enroll in PHYS 6702. Undergraduates wishing to receive Honors credit for the course must complete the necessary paperwork with the Honors Program and then transfer into PHYS 6702.

Students taking the course at the 6000 level will be assessed on a few “graduate/challenge standards” in addition to the regular standards. Assessments for these standards are mandatory for graduate and Honors-option students; other students can complete them for extra credit.

A graduate term project will be assigned separately and will be of longer duration. Students taking the course at the 4000 level will not have a chance to complete the term project for extra credit.

The purpose of these 6000-level tasks is to merit the distinction of graduate/Honors credit. This is not designed to give PHYS 6702 students an opportunity that PHYS 4702 students don’t have. As a result, in most cases satisfactory work on these tasks will not change the letter grade of 6000-level students. However, truly exceptional work will be rewarded with a one-step increase in letter grade (e.g., B+ to A–). If the work is unsatisfactory but at least attempted, the final letter grade will be one step lower (e.g., B+ to B). If the work is missing or late, the final letter grade will be lowered by two steps (e.g., B+ to B–).
Course and University Policies

Academic Honesty

UGA has a comprehensive academic honesty policy, *A Culture of Honesty*, which is available from the Office of Academic Honesty at [https://honesty.uga.edu/](https://honesty.uga.edu/). This policy covers all academic work, and all students are responsible for fully understanding and abiding by this policy. If you have *any* questions about the appropriateness of your actions or your work, you are obligated to ask me for clarification.

I take issues of academic honesty very seriously, and it is my responsibility to uphold the University’s policy. This means, among other things, that I won’t hesitate to report evidence of dishonesty to the Office of Academic Honesty. Typical consequences of academic dishonesty can range from receiving a zero for that grade, to failing the course, to being suspended.

Collaboration

Science is inherently collaborative; therefore, I strongly encourage and even expect you to interact with classmates, more advanced students, and me as you work to learn the material.

Nevertheless, you’re ultimately responsible for your own learning. I expect each student to turn in assessments that have been independently written up. *Under no circumstances* is it acceptable to copy or paraphrase from someone else’s work, or allow your work to be copied.

Here’s a good model for how to prepare an assessment:

1. First try to make progress on your own.
2. If you find that you’ve worked for a half-hour or so without making any forward progress, that’s a good sign to seek help to overcome a specific hurdle. Then try to make further headway on your own.
3. Don’t allow your helper to guide you all the way through.
4. Once you’ve worked out a problem on scratch paper, rewrite your solution, making sure you can explain the steps as you go. This will form the basis of your screencast. The less you refer to previous notes, the better.
5. The end product should be a unique explanation that teaches you something about what you really understand.

Be conscious of your role in a collaboration. If you’ve mastered a problem and a collaborator is still stuck, limit your help to getting them back on track. If you’re working with someone at a comparable level of understanding, keep mutually challenging each other. There may or may not be a cat reference here.

Assessments can from a variety of sources: textbooks, colleagues, and my own deranged imagination. It’s likely that many of these problems have solutions on the Internet or elsewhere. **These solutions are off limits.** Copying existing solutions is plagiarism, and even “just peeking at them for hints” is sketchy. Limit yourself to in-person, verbal help and you’ll be better off.

Likewise, any solutions or examples I provide are for your use only. Sharing them with other students sabotages their learning and could jeopardize your school career.
Disability Accommodations

I will make every reasonable effort to accommodate students with documented disabilities. Students requesting accommodations must provide documentation from the Disability Resource Center during the first two weeks of class (or within two weeks of DRC certification).

Withdrawals/Incompletes

The Undergraduate Bulletin and the Registrar’s Office website describe the University policies regarding withdrawals and incompletes. If you are considering withdrawing from the course, you should discuss your choice with me beforehand. Often, students are doing better in a physics course than they think they are.

A grade of Incomplete is not appropriate for a student who has missed a large portion of the course assessments, for whatever reason.

Student Distress

If your course performance is significantly affected by issues beyond your control, I urge you to let me know and to seek assistance promptly from Student Care and Outreach. It is always easier to address exceptional circumstances when you raise these concerns as early as possible. Waiting until the end of the semester to take action may limit my ability to provide you with appropriate support.

Student Responsibilities

• Above all, you have the responsibility to act courteously toward your classmates and the right to expect the same from others. Courtesy includes coming to class on time, ready and willing to learn and interact for the full period. It means asking questions, and helping the class with your own responses. It also means being supportive of others’ mistakes, and comfortable making your own.

• It’s your responsibility to show me what you do and don’t understand through your questions, so that I can help you learn. You help influence the pace of the course. Silent confusion benefits no one.

• Ask for clarification on anything you find unclear, ambiguous, or unspecified. This includes both course policies and physics topics. Ignorance is never a valid excuse.
Course Topics and Schedule

The following schedule of topics is tentative and subject to change.

2 weeks  Angular momentum: spinning and tumbling into 3-D (Chapter 7/11)
2 weeks  The hydrogen atom (Chapter 8)
2 weeks  Time-independent perturbation theory: beyond exact solutions (Chapter 10)
2 weeks  Angular momentum addition; hyperfine structure (Chapter 11)
1 week   Yes, more hydrogen (Chapter 12)
2 weeks  Identical particles and spin statistics (Chapter 13)
2 weeks  Time-dependent perturbation theory (Chapter 14)
1 week   Periodic systems: introduction to condensed matter physics (Chapter 15)

According to the Registrar, the final exam time slot for this course is Monday, 10 December, from 8–11 am. Yes, another 8 am time.