

PHY662 - Quantum Mechanics II - Spring 2004

Instructor:

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Office hour: Mondays 3:30-5:00 PM or by Appt.

Textbook:

Principles of Quantum Mechanics, R. Shankar, 2nd Edition
Also see:
Feynman Lectures, Vol. III, Feynman, Leighton, and Sands
Introduction to Quantum Mechanics, D. J. Griffiths

Overview:

Over the last 80 years, the quantum mechanical description of microscopic phenomena has been extremely successful. In order to understand what is happening in physics and many other sciences, one needs to understand quantum mechanics. This course continues from where Quantum Mechanics I left off last semester. These courses are intended to bring you up to speed on fundamental concepts from non-relativistic quantum mechanics. Though the techniques we study have been known for most of the last 80 years, this base knowledge is crucial to understanding extensions of quantum mechanics, such as quantum field theory, and application areas, including condensed matter physics, biological physics, and astrophysics.

The tools of quantum mechanics are abstract and can be studied independently of their immediate application. This is the approach of much of Shankar's text, which develops the mathematical techniques for solving problems in quantum mechanics. This approach has the benefit that one can study a large number of problems using general tools, which include perturbation theory and symmetry principals. These deep ideas are also useful in realms outside of quantum mechanics.

In addition to the abstract techniques, we will study in more detail the physics of some applications, some of which are quite recent. Though the ideas of quantum mechanics have been with us for some time, experimentalists can use modern technology both to study and to use quantum mechanics in a very direct manner. These technological advances include extremely low temperature preparation of gases, scanning probe microscopy, mesoscopic electronic devices, and photonics. With these technologies, one can study collections of coherent atoms, the electronic wave function at the surfaces of solids, the quantum behavior of single electrons, and the statistics of single photons, respectively. I hope we will have the time to review some of these realms as they are used for quantum cryptography, magnetic resonance imaging, Bose-Einstein condensates, lasers, and single-electron electronics.

This semester, we will be learning as much as possible from the remainder of Shankar's text. Given that this is a lot of material and that we will apply some of

these ideas, we will not cover all of each chapter. We will be sacrificing some depth for breadth.

Course Mechanics

We will have class meetings in Room 105, Physics, at 11:30-12:50, each Tuesday and Thursday.

Homework: A full homework will be due each Tuesday *at the beginning of class*. *Late homework will be graded for feedback, but will not receive credit*. In addition to “full homeworks”, I may occasionally assign reading that will require short written feedback; when given, these will be due on Thursdays.

The purpose of the homework will be to give you practice in handling the apparatus of quantum mechanics and in applying it to physical problems. Different instructors may have different expectations for how you solve homework, so let me be clear about what is expected for this course. Practice is the only way to learn a subject fully, so I hope you will use the homework to develop your understanding of the concepts and gain practice with the relevant mathematical techniques. Physicists do work together and sharing ideas can be a good way to learn. You may work with your peers in developing a *general approach* to solve a problem. I encourage you to see me for help when you are stuck on homework questions. I suggest, however, that you first spend some time studying the problems on your own. If you then consult with others, you may try to jointly develop a general approach to a solution. ***Once you have developed a general approach, I require that you work out your own detailed solution and that you write up the solution in your own words.*** The goal of this requirement is to help you learn the material as well as possible. *In addition, you must list the names of all people that you spoke with about the problem and all written or Web sources that you consulted.* Failure to properly cite your sources will result in a grade penalty. This procedure reflects an extremely important principal in science: properly referencing your collaborators and sources. Using sources and consulting is *not* bad in physics (it is the norm). Reading and consultation are not forbidden in this particular course. However, ***not citing your collaborators or sources is very poor practice.***

Examples:

- You think a bit about a homework problem. Though you may know how to apply some of the needed concepts, you are missing an idea or are stuck on a technicality. You then consult with another student. You each understand how to do the problem better by sharing your ideas. *You write up the solution in your own words, separately.* You also include the name of the peer that you consulted with, clearly, in your homework submission.
- You work for a while on a homework problem. You find you can't solve it on your own in a reasonable amount of time. You decide to look on the web for posted solutions from a class at another university and, with great luck, you find a similar problem described. You model your solution on a posted solution from the other university. You must note that you were inspired by a particular website and you include the relevant URL, precisely described, in your written

homework submission. You should also demonstrate that you truly understand the solution yourself, by using your own words in your write-up and maybe extending the question to an extra case. *If you had just copied the solution, that would not be evidence that you yourself had understood the assigned problem, and you would not receive credit.*

- You read the text, think about the problem, review your lecture notes, and then think about the problem some more. You realize you know how to solve it. You write up the solution. In your solution, you might use a phrase like “Following Shankar’s example in deriving equation 5.3.1, ...” to give context to your solution.

This is a graduate course, so you are expected to be able to learn the material by working on your own and with your instructor and peers, without excessive external feedback or overly rigid homework schemes. The homework however, is intended to help you learn the material well, and for this to be effective, some procedures are useful. The guidelines stated here are intended to help you learn the material and to practice scientific *practice*.

To encourage you to attempt homework on your own, I will use a nonlinear grading scheme for the homework (something like $2/3$ completion of assignments during the semester resulting in full homework credit). So you don’t need to be perfect to get full credit on the homework. I expect most students will receive nearly the full homework grade.

Note that I will *decrease* your homework grade some (up to 5%) if I judge that you do not understand your homework solutions by class discussion or if you do not participate in class discussions.

Exams: There are two midterm exams and a final exam (see the course calendar for dates). These exams will be closed book, but you will have a set of formulas and definitions available for consultation.

Determining the course grade: Your course grade will be based upon homework (25%, with 5% being a “participation” evaluation as described above), exams (20% each for the two midterm exams and 35% for the final). I do not know where the final grade cuts will be at this time. I will indicate after each exam what an “A” or “B” type of score is, roughly.

[My views on course grades: The primary purpose of a course grade in a graduate course is for internal use by the department. For example, your precise course grades are not directly relevant for your first job. (They might, however, weigh some in a decision to transfer or for University-wide fellowships.) The course grade indicates my judgement of how well you learned the material; this grade might be used by a potential research advisor or to indicate to you (and possibly your academic advisor, who might have ideas for improvement, if needed) how well you have learned this subject. The main purpose of this course is for you to learn quantum mechanics, not to earn a particular grade. According to current practice, however, I am asked to assign a grade. Course grades may help motivate some people to learn the material better. If your exams, homework, and class discussion indicate you have a good grasp of the fundamentals and know how to use the basic ideas well, your course grade will be an “A”.]