

$$w_{fi} = \frac{2\pi}{\hbar} |V_{fi}|^2 \delta(\varepsilon_f - \varepsilon_i - \hbar\omega)$$

Quantum mechanics provides the fundamental framework for modern physics. This course is the second part of the department's two-semester core graduate course on quantum mechanics. Last semester you have learned how the theory of quantum mechanics was built on a handful postulates as well as how to solve some simple systems analytically. However, the vast majority of the problems in the real world do not have an exact solution. In this semester you will learn two sets of important tools to deal with such problems. One is to find and use the symmetries of the system. Much can be learned about the system even without solving the system. The other set of the tools are approximation methods. A good physicist must know when and how to make appropriate approximations. We will also use these tools to treat some realistic systems such as the transition between hydrogen states and scattering.

General Information

- **Instructor:** Dr. Huaiyu "Mike" Duan, <duan@unm.edu>, P&A 1144, 505-277-1508.
- **Instructor's office hour:** You are welcome to drop by and discuss physics with me whenever my door is open. You may also send me a email to make an appointment
- **TA:** Ninnat "Tom" Dangniam <ninnat@unm.edu>.
- **TA's office hour:** 2:00 – 3:00 PM, Thursday, Room 17.
- **Lecture hours:** 9:30 – 10:45 AM on Tuesday and Thursday, Room 184.
- **Problem session (PHYC551.021):** 11:00 AM – 12:15 AM on Friday, Room 184.
- **Main textbook:** Principles of Quantum Mechanics by R. Shankar (2nd edition, published by Springer, ISBN 978-0-306-44790-7).
- **Course homepage/repository:** UNM Learn <<https://learn.unm.edu>>.
- **Communication:** Notices of the class will be sent to your UNM email address, i.e. <your_unm_net_id@unm.edu>. Please check your UNM mailbox regularly during the week.

Prerequisites

- Two semesters of undergraduate Quantum Mechanics (PHYC491/492). If you have taken only one semester of undergraduate QM, you are strongly encouraged to take PHYC492 first.
- One semester of Methods of Theoretical Physics (PHYC466).
- First semester of graduate Quantum Mechanics (PHYC521).
- Passing the preliminary exam on undergraduate QM. If you have not passed this exam, you may encounter a very steep learning curve.

Pedagogy

The goal of our graduate program is to equip students with the skills of a successful physicist who can learn by reading the literature and who can find and work on interesting problems to which no one knows the solutions yet. Therefore, it is very important that you cultivate a good habit of self-studying.

1. **Textbook and supplementary materials.** Study of the textbook and supplementary materials should be the PRIMARY way for you to develop understanding of the course material. The instructor will provide skeleton lecture notes to guide your reading. It is of great importance that you READ the corresponding sections of the textbook and supplemental materials BEFORE you work on homework problems. Here are a few reference books that you may also find useful:

- Quantum Mechanics, vol. I&II, by C. Cohen-Tannoudji, B. Diu, and F. Laloë. A good textbook that requires some time to read.
- Quantum Mechanics, by Eugen Merzbacher. A fairly comprehensive textbook organized in an unconventional order.
- A Modern Approach to Quantum Mechanics by J. S. Townsend. This book or any of your favorite undergraduate textbooks on quantum mechanics can be useful when you find the lectures and/or the main textbook are difficult to understand.

2. **Problems.** The best way to learn a subject is by practicing. You can grasp mathematical skills and achieve deeper understanding of the subject through solving problems: the examples in the textbook, reference books, supplemental materials and lectures, and the problems in problem sessions, homework and textbooks. You are encouraged to discuss these problems with the instructor, TA and your fellow students if you have trouble solving them by yourself. But you must work out the homework problems THOROUGHLY and INDEPENDENTLY after discussing with other people. One of the ways to improve your understanding of the homework is to consult the solutions which the instructor has spent many hours to prepare. You may gain a deeper or alternative understanding of the problems by reading the solutions even if you have solved the problems successfully.

3. **Quizzes.** Many students find their mind completely blank when they encounter a “new” problem, especially during an exam, even though they have worked hard. The way out is not to memorize everything, which is impossible, or to write everything down on the cheatsheet, which has no use if you do not know how to use it. My suggestion is to spend time pondering on and playing with the key equations until you can truly understand the physical concepts behind these equations. These equations and concepts are usually the starting point of solving a problem. You also need to keep some math tricks in you memory which may be used repeatedly in this course. To encourage you along this direction there will be several unannounced 10-minute, in-class quizzes focusing on the basic concepts and frequently used formulas. Some students may fail the course because they have developed an unhealthy habit of spending little time studying except before exams. These quizzes will check if you are on the right track and alert you before it is too late.

4. **Instructor.** The role of the instructor is to give his own perspective on the subject, which is not necessarily the same as that of the textbook, and to provide timely help and to clarify confusions. His job is best achieved when you are not shy to ask questions in and after class. There is NO DUMB QUESTION! There may be times that we have to continue the discussion in small groups after the class if the questions are relevant to only a few students.

Grades and Other Policies

1. **Homework 40% + 5% (bonus)** Please turn in EVERY homework even if you cannot finish it. The solution to each assignment will be posted in UNM Learn after the assignments have been collected. There will be NO MAKEUP HOMEWORK.
2. **Exams 20% + 20% + 20%** Two exams will be held during the **problem sessions on 2/16 and 3/30**. The last exam will be held during the final week. All exams will be closed-book but you may carry a letter-sized double-sided information sheet.
3. **Quizzes 5% (bonus)** There will be NO MAKEUP QUIZ.
4. **Final letter grades** can be: A+ (≥ 100), A (95.0–99.9), A- (90.0–94.9), B+ (85.0–89.9), B (80.0–84.9), B- (75.0–79.9), C+ (70.0–74.9), C (65.0–69.9), C- (60.0–64.9), F (< 60).
5. **Problem session:** You will receive Credit for the problem session as long as you register and show up for more than 60% of the time.