

**Physics 33-756**  
**Quantum Mechanics II**  
**Spring 2021**  
**Carnegie Mellon University**

**Meeting Times and Places**

<b>Classes:</b>	MWF	12:50pm to 1:40pm	DH A301D
<b>Modality:</b>	IRR	In-Person (Rotation)	+ Remote

**Instructor:** Prof. Colin Morningstar

Office: Wean Hall 8420  
Phone: (412) 268-2728  
e-mail: [cmorning@andrew.cmu.edu](mailto:cmorning@andrew.cmu.edu)

Course web site: <http://www.cmu.edu/canvas>

Office Hours: Due to current pandemic, questions should be submitted using Piazza on the course Canvas site, or via email

**Course Overview:**

This course is the second semester of a two-semester sequence in advanced quantum mechanics for graduate students. First, a brief review of underlying classical mechanics, with emphasis on constraints and Dirac brackets, is presented and Grassmann classical mechanics is introduced. Next, the basics of quantum mechanics, including the postulates and path integral formulation, are summarized. Then topics include spin and orbital angular momentum, addition of angular momentum, stationary perturbation theory, time-dependent perturbation theory, scattering theory, systems of identical particles, and symmetry in quantum mechanics. If time permits, an introduction to the Dirac equation will be given.

**Prerequisites:**

- 33-755 Quantum Mechanics I

**Textbooks:**

- Claude Cohen-Tannoudji, Bernard Diu, and Frank Laloë, *Quantum Mechanics*, Volume II, 2nd Edition, Wiley, 2020.
- J.J. Sakurai and Jim Napolitano, *Modern Quantum Mechanics*, Third Edition, Cambridge University Press, 2021.

**Course Objectives**

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

- solve problems involving multiple angular momentum operators,
- utilize Clebsch-Gordan coefficients to write total angular momentum eigenstates in terms of the component system eigenstates,
- use the Wigner-Eckart theorem to simplify problems involving vector operators,
- derive and utilize stationary perturbation theory expansions,
- derive the fine and hyperfine features of the spectrum of the hydrogen atom,

- solve transition rate problems involving sinusoidal perturbations and other time-dependent perturbations,
- perform scattering cross section calculations including simple partial wave analysis,
- demonstrate an understanding of identical-particle indistinguishability, including its effect on two-particle scattering cross sections.

**Assignment Grader:** Can Onur Akyuz

e-mail: cakyuz@andrew.cmu.edu

### Grading Overview:

Your grade will be based on weekly assignments, an in-semester test, and a final examination, weighted as follows:

Weekly Assignments	34%
In-semester Test 1	18%
In-semester Test 2	18%
Final examination	30%

The letter grade cutoffs are A+ 90, A 86, A- 82, B+ 78, B 74, B- 70, subject to small adjustments. **Lecture attendance is mandatory.** If you miss more than 3 lectures, your assignment grade weighting will be zero and your final examination will count for 70%. If you do not fully complete all assignments, you will receive an R grade.

### Weekly Assignments:

Problem sets will be assigned each week which will appear on the course Canvas web site. You will have about one week to complete each problem set and hand it in for credit. The due date for each assignment will be indicated on the assignment and in Canvas. If you do not fully complete all assignments, you will receive an R grade. In determining the assignment portion of your final grade, all assignments will be included, weighted according to their total points.

Although you may discuss solution approaches with other students, the work you hand in should represent your own efforts. Solutions will be posted on Canvas. If you have not fully understood an exercise, consult the solutions to rectify this. Ask questions until your understanding of each exercise is complete.

### In-semester Test and the Final Examination:

Details concerning the mid-semester test and final examination will be given in the weeks before each occurs.

### Special Dates:

Monday, February 1	First day of classes
Friday, March 5	Test 1
Friday, March 19	Mid-semester Break (no class)
Monday, April 5	Break day (no class)
Friday, April 9	Test 2
Friday, April 16	Spring Carnival (no class)
Friday, May 7	Last day of classes
May TBA	Final examination

### **Accommodations for Students with Disabilities:**

If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at [access@andrew.cmu.edu](mailto:access@andrew.cmu.edu).

### **Student Wellness:**

As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, increased anxiety, substance use, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. CMU services are available, and treatment does work. You can learn more about confidential mental health services available on campus at: <http://www.cmu.edu/counseling/>. Support is always available (24/7) from Counseling and Psychological Services: 412-268-2922.

### **Class Recordings:**

All synchronous classes will be recorded via Zoom so that students in this course (and only students in this course) can watch or re-watch past class sessions. Please note that breakout rooms will not be recorded. I will make the recordings available on Canvas as soon as possible after each class session (usually within 3 hours of the class meeting). Recordings will live in our Canvas site. Please note that you are not allowed to share these recordings. This is to protect your FERPA rights and those of your fellow students.

### **Transferring to fully remote in the middle of the semester:**

If the class needs to go fully remote, you will receive an email from me and an announcement will be published on our course website on Canvas. During the semester, we will use the same Zoom link available on Canvas. At any point during the semester, you may choose to participate in the class remotely. If you decide to switch to remote for one or more classes, please try to let me know by email.

### **Use of technology:**

This semester involves regular use of technology during class – both for in-person and remote students. Research has shown that divided attention is detrimental to learning, so I encourage you to close any windows not directly related to what we are doing while you are in class. Please turn off your phone notifications and limit other likely sources of technology disruption, so you can fully engage with the material, each other, and me. This will create a better learning environment for everyone.

### **Diversity Statement:**

It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age,

socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.