

**THE CATHOLIC UNIVERSITY OF AMERICA  
SCHOOL OF ARTS AND SCIENCES  
DEPARTMENT OF PHYSICS**

**PHYS 659 ADVANCED QUANTUM THEORY I  
Credit Hours: 4.00**

**Fall 2025**

**COURSE SPECIFICS**

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**COURSE DESCRIPTION**

Theoretical and mathematical formulation of Quantum Mechanics. Transformations of states and observables, equations of motion, symmetries and conservation laws. Coordinate and momentum representations. Basic applications of wave-mechanics, Schrödinger equation and uncertainty principle. Harmonic oscillator. Theory of angular momentum and rotation group. Formation of bound states. Hydrogen atom.

**INSTRUCTOR INFORMATION**

- Dr. Carlos Yero
- **Email:** [yero@cua.edu](mailto:yero@cua.edu)
- **Office Number:** Hannan 210
- **Office Phone:** (202) 319-6617
- **Office Hours:** As needed, on request

**CLASS MEETINGS/WEBPAGE**

- Tu, Th
- 5:40 pm - 7:40 pm
- Hannan Hall, Hannan 103
- Webpage: <https://yero1990.github.io/cuaQM.github.io/>

## **COURSE GOALS**

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### **PURPOSE**

This course is the first semester of a two-semester sequel on quantum theory, stressing principles. Topics covered include: Hilbert spaces, observables, uncertainty relations, eigenvalue problems and methods for solutions thereof, time-evolution in the Schrödinger, Heisenberg, and interaction pictures, connections between classical and quantum mechanics, angular momentum, density operators, and quantum measurement. The first semester focuses on basic theory while the second semester (PHYS 660) reviews more advanced theory applications. The first semester covers in particular wave functions and the Schrödinger equation; the mathematical formalism of quantum mechanics, including Hilbert space, Dirac notation, and operators; the hydrogen atom; angular momentum and spin.

### **OUTCOMES**

At the conclusion of the course, the student should have acquired a good working knowledge of the basic principles of quantum theory and their mathematical application to standard basic problems of quantum mechanics.

## **INSTRUCTIONAL DELIVERY**

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In-person/on-campus

## **CONTINGENCY PLANNING**

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In the event that a student must shift to online attendance for health reasons, either temporarily or for the remainder of the semester, the student must notify the instructor immediately.

In the event that the university as a whole, or this course in particular, must shift to entirely online course delivery, the following adjustments will be made to the mode of instruction, assignments, and assessments in this course:

**Classes will be given at same time, but via Zoom meetings. Link to zoom will be provided if necessary.**

## **INSTRUCTIONAL METHODS AND COURSE REQUIREMENTS**

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### **REQUIRED TEXT**

(RS) – R. Shankar, *Principles of Quantum Mechanics (2nd. Ed)*  
ISBN-13. 978-0306447907

## Additional Requirements:

### CLASS POLICIES

- **Attendance**  
in-person attendance/participation is highly encouraged
- **Homework**  
The homework will be assigned weekly. It may contain mixed problems from different textbooks. The problems will be explicitly written so no need to purchase more than the required text.
- **Extra Credit**  
Optional extra credit opportunities may be given throughout the course and may be added as extra points to the exams. These involved usually longer projects or tasks which involve solving numerical problems with the help of a computer program (C++, python, Mathematica, etc.)
- **Make-Up Exams**  
Make-up exams will **ONLY** be accepted under extraordinarily rare circumstances (must provide proof of absence, e.g. official document like doctor's appointment, contact me *a priori* explaining reason for absence, etc.)

### COURSE GRADE BREAKDOWN

- Class Participation 10 % of final grade
- HW 30 % of final grade
- Mid-term 30 % of final grade
- Final 30 % of final grade

The University grading system is available:

- Undergraduates - <https://policies.catholic.edu/students/academicundergrad/gradesfull.html#II> for undergraduates
- Graduates - <https://policies.catholic.edu/students/academicgrad/gradesfull.html#iii> for graduate students

Reports of grades in courses are available at the end of each term on <https://csprd.cua.edu/psp/csprd/?cmd=login&languageCd=ENG&>.

## **COURSE SCHEDULE & BIBLIOGRAPHY**

### **TENTATIVE COURSE SCHEDULE**

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Refer to the course webpage: <https://yero1990.github.io/cuaQM.github.io/>

## **CATHOLIC UNIVERSITY POLICIES**

### **UNDERGRADUATE LEVEL**

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All members of the Catholic University community have a shared responsibility to know and to abide by the University's policies, especially relating to:

- Academic Integrity
- Accommodations for Students with Disabilities
- Attendance
- Conduct
- Final Exams
- Grades and appeals

All of Catholic University's policies are detailed at <https://policies.catholic.edu/index.html>. Please follow up with the instructor if you have any policy-related questions.

Of particular note are the policies regarding Academic Integrity, Accommodations for Students with Disabilities, and Final Exams, which are described below.

### **ACADEMIC INTEGRITY**

Academic dishonesty at The Catholic University of America is not tolerated (<https://policies.catholic.edu/students/academicundergrad/integrityfull.html> and <https://policies.catholic.edu/students/academicundergrad/integrityprocedures.html>)

As such, academic integrity is not merely avoiding plagiarism or cheating, but it certainly includes those things. Academic integrity means, above all else, taking responsibility for your work, your ideas, and your effort, and giving credit to others for their work, ideas, and effort. If you submit work that is not your own – whether test answers, whole papers, or something in-between – that is considered to be academic dishonesty. University procedures related to academic dishonesty are conducted with respect and dignity, while also preserving accountability, and they presuppose that all participants will treat each other with respect and dignity.

The following sanctions are presented in the University procedures related to Student Academic Dishonesty:

*“The presumed sanction for undergraduate students for academic dishonesty will be failure for the course. There may be circumstances, however, where, perhaps because of an undergraduate student’s past record, a more serious sanction, such as suspension or expulsion, would be appropriate. ...In the more unusual case, mitigating circumstances may exist that would warrant a lesser sanction than the presumed sanction.”*

At times, you may do group work for an in-class presentation or group project. For that *specific* assignment, you are allowed to share material, ideas and information; however, for any related work that is to be submitted on an individual basis, your submission is expected to be your own in its entirety. If there is no group work in the class you should not collaborate with classmates on work that is to be submitted for an individual grade.

For more information about what academic integrity means at CUA, including your responsibilities and rights, visit <https://integrity.catholic.edu/index.html>.

**Accommodations for students with disabilities:** Any student who feels s/he may need a reasonable accommodation based on the impact of a disability should contact the Office of Disability Support Services (<https://dss.catholic.edu/index.html>) by email at [CUA-DSS@cua.edu](mailto:CUA-DSS@cua.edu) or call 202-319-5211 to make an appointment to discuss possible accommodations. DSS recommends that a student with a disability meet with DSS staff during the first week of every semester since accommodations are not retroactive. Please note that instructors will only provide those accommodations included in the DSS accommodation letter. DSS is located in PRYZ 127.

**Final Exam:** The final exam must be given on the day and time assigned by Enrollment Services. Please plan accordingly for travel, work, special events, or appointments.

A student having an exam scheduling conflict as defined in the policy must report to her/his school's Academic Dean's Office no later than fourteen calendar days before the end of classes. The dean will assist the student in rescheduling the exam(s) for the course having the lowest enrollment(s). All make-up exams must be completed at the earliest possible time during the final examination period.

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The following sanctions are presented in the University procedures related to Student Academic Dishonesty:

*“The presumed sanction for undergraduate students for academic dishonesty will be failure for the course. In the context of graduate studies, the expectations for academic honesty are greater, and therefore the presumed sanction for dishonesty is likely to be more severe, e.g., expulsion. ...In the more unusual case, mitigating circumstances may exist that would warrant a lesser sanction than the presumed sanction.”*

At times, you may do group work for an in-class presentation or group project. For that *specific* assignment, you are allowed to share material, ideas and information; however, for any related work that is to be submitted on an individual basis, your submission is expected to be your own in its entirety. If there is no group work in the class you should not collaborate with classmates on work that is to be submitted for an individual grade.

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#### UNIVERSITY RESOURCES

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- **Libraries** <https://libraries.catholic.edu/>
- **Center for Academic and Career Success** <https://success.catholic.edu/>
- **Math Center** <https://success.catholic.edu/academic-support/math-center/index.html>
- **Tutoring Services** <https://success.catholic.edu/academic-support/tutoring-services/index.html>
- **Writing Center** <https://success.catholic.edu/academic-support/writing-center/index.html>
- **Office of Disability Support Services** <https://dss.catholic.edu/index.html>
- **Counseling Center** <https://counseling.catholic.edu/index.html>
- **Student Health Services** <https://health.catholic.edu/index.html>
- **Dean of Students Office** <https://deanofstudents.catholic.edu/index.html>