Syllabus
Quantum Mechanics I
Physics 601
Fall 2022

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Location: Performing Arts and Humanities room 124
Time: Tuesday and Thursday 1:00 – 2:15
Office hours: Wednesday 2:15 – 3:15 Friday 2:30 – 4:30

Course description:

This course is intended to cover most of the basic topics in quantum mechanics, including postulates, one-dimensional and three-dimensional systems, Kronig-Penny model, angular momentum, operator methods, harmonic oscillators, perturbation theory, interaction of charged particles with a classical electromagnetic field, hydrogen and helium atoms, Zeeman effect, and fine and hyper-fine structure. A more complete list of topics is given in the schedule below. Applications to solid-state theory, lasers, and quantum optics will be included as examples of the theory.

Additional topics and more advanced techniques are covered in a second course (Quantum Mechanics II, Phys 701) that is taught in the following semester.

Course learning goals:

This course is intended to provide an enhanced, graduate level understanding of quantum mechanics. The specific topics to be included are outlined in the schedule provided below.

By the end of the course, the students should be able to:

1. Utilize the postulates of quantum mechanics to describe quantum systems and determine their properties, including the results of measurements.
2. Use operator techniques to solve relevant problems.
3. Analyze the time dependence of quantum systems using the Heisenberg picture.
4. Use the properties of angular momentum and spin to describe quantum systems such as the hydrogen atom and an electron in a magnetic field.

5. Understand the interaction of the electromagnetic field with charged quantum-mechanical particles and solve related problems such as the rate of absorption and emission of light.
6. Use perturbation theory to find approximate solutions to more complex quantum-mechanical systems.

Textbooks:

The texts will be *Quantum Physic*s by Stephen Gasiorowicz and *Lectures on Quantum Mechanics* by Gordon Baym. The more basic topics will be covered in the text by Gasiorowicz, while some of the more advanced topics will be taken from Baym's text, which is also used in Quantum Mechanics II.

Class structure:

Students are encouraged to read the corresponding textbook chapters before each lecture. This will allow them to better understand the lectures and ask any relevant questions.

Homework is intended to be a learning tool for the students. The students are expected to make their best effort at solving the homework problems on their own, which will give them feedback on their knowledge of the topic as well as develop problem-solving skills. If questions arise, the homework problems can be discussed with other students, who may work together on the problems. After the homework has been handed in, the solutions will be discussed in class. If there are any remaining questions regarding the homework, the students are encouraged to stop by during office hours for further discussion. The instructor will not explain how to do the homework before it has been handed in.

There will be an in-class midterm and final exam. No books, notes, computers, cell phones, headphones, or other electronic devices are allowed during the exams.

Grading procedure:

The grade in the course will be based on a total score that is determined as follows:

Homework	5%
Midterm	45%
Final exam	50%

The exams and homework are intended to cover all of the topics described in the course schedule. Given the amount of material to be covered, it is expected that the exams and homework will be based on a representative sampling of the material.

The exams will be graded “on the curve”. The goal is to have approximately 50% A and 50% B overall grades. Students whose scores are substantially lower than the class average may receive grades of C or lower.

Learning outcome assessment:

The results of the exams and quizzes for the class as a whole will be used as part of the Physics Department’s student learning outcome assessment plan. These statistical results will be provided to the faculty, graduate program committee, and department chairman for use in assessing the department’s success in achieving its overall goals and in determining the need for any possible improvements to the curriculum or teaching methods. The test results for individual students will not be used for this purpose.

Academic integrity:

Academic integrity is an important part of scientific research. The UMBC academic integrity statement is as follows:

> *"By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC Policies section of the UMBC Directory [or for graduate courses, the Graduate School website]."*

Students who observe cheating on the exams are required to report that to the instructor.

COVID-19:

- Please see the following link for UMBC Policies and Resources during COVID-19.

  https://docs.google.com/document/d/1xWWGAR8qEzKYr7qaVHoEhvO6lyXIyn6M3M7EFZPJQgA/edit

Class schedule:

Lecture 1	Syllabus and introduction; experimental basis
Lecture 2	Photon polarization: example of a state vector

Lecture 3	Postulates of quantum mechanics
Lecture 4	Schrodinger’s equation and wave functions
Lecture 5	Operators, eigenfunctions, and eigenvalues
Lecture 6	One-dimensional potentials
Lecture 7	One-dimensional potentials
Lecture 8	Harmonic oscillator (based on wave functions)
Lecture 9	General structure of wave mechanics
Lecture 10	Time dependence of operators (Heisenberg picture)
Lecture 11	Operator methods
Lecture 12	Harmonic oscillator (based on operator techniques)
Lecture 13	N-particle systems
Lecture 14	Schrodinger Equation in three dimensions
Lecture 15	Spherical symmetry and angular momentum
Lecture 16	Angular momentum
Lecture 17	The radial equation
Lecture 18	Hydrogen atom
Lecture 19	Interaction with classical EM fields
Lecture 20	Interaction with classical EM fields
Lecture 21	Operators and spin
Lecture 22	Spin of the electron
Lecture 23	Addition of angular momenta
Lecture 24	Time-independent perturbation theory
Lecture 25	Corrections to the hydrogen atom
Lecture 26	Structure of atoms and the periodic table
Lecture 27	Time-dependent perturbation theory
Lecture 28	Simplified quantization of the EM field (photons)