

Syllabus
Quantum Mechanics II
Physics 701
Spring 2022

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Location: Public Policy 206
Time: Tuesday and Thursday 10:00 – 11:15
Office hours: Any afternoon between 2:00 and 4:30 (except as noted)

Course description:

This course is intended to be a follow-on course to Quantum Mechanics I, which covered most of the basic topics in quantum mechanics, including perturbation theory, operator techniques, and the addition of angular momentum. These techniques will be applied to investigate a variety of more advanced subjects, including mixed states, the quantization of the electromagnetic field, the interaction of light with matter, entanglement, second quantization formalism, the Dirac theory, and anti-particles.

In addition to covering these more advanced topics, the course will also review some of the topics covered in Quantum Mechanics I.

Goals and objectives:

The primary goal of this course is to develop an understanding of some of the more advanced topics and techniques used in quantum mechanics. This material will be essential for graduate research in many areas of physics, such as quantum optics, astrophysics, and atmospheric physics. This course will provide the necessary knowledge and skills to apply advanced techniques in quantum mechanics throughout the students' careers.

A secondary goal is to further develop the students' problem solving ability, which will be essential not only on qualifying exams but in the students' future research. As in Quantum Mechanics I, the use of Mathematica to solve problems will be encouraged.

Textbooks:

The text for the course will be *Lectures on Quantum Mechanics* by Gordon Baym.

Additional material will be taken from a number of other textbooks, which are available in the library:

Photons and Atoms: An Introduction to Quantum Electrodynamics, by C. Cohen-Tannoudji, J. Dupont-Roc, and G. Grynberg.

Quantum Physics by Stephen Gasiorowicz.

Quantum Mechanics by L. Schiff.

Classical Electrodynamics by J.D. Jackson.

Class structure:

Students are strongly encouraged to look over the lecture slides and read the corresponding textbook chapters before each lecture. This allows the students to have some familiarity with the material before the lecture so that any questions can be discussed in class.

Copies of the lecture slides will be available on the Blackboard website. Homework solutions will also be posted on the Blackboard website.

No cell phones are allowed in class.

There will be an in-class midterm exam and an in-class final exam. **Both of the exams will be closed book – no textbooks, notes, computers, cell phones, or other electronic devices.** The exams scores will be combined with the scores from the homework to determine the course grade, as described below.

Grading procedure:

The grade will be determined as follows:

Homework	15%
Midterm	40%
Final exam	45%

The homework will be graded on the scale of 0, 1 or 2. This coarse grading reflects the fact that the homework only determines 15% of the grade.

Course requirements:

The students are expected to make their best effort at solving the homework problems on their own without working in groups, since this provides the best learning opportunity. If the students cannot solve a problem on their own, they may discuss the question with other students or the instructor, but they should still try to solve the problem

themselves. The homework solutions will then be discussed in class and posted on Blackboard.

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](#)]."

Class schedule:

The lecture topics are listed below. The schedule will be adjusted as necessary to ensure that enough time is spent on each topic. As a result, some of the more advanced topics may not be covered in detail.

1. Mixed states
2. Density operator
3. Adiabatic theorem and the geometric phase
4. Molecules
5. Quantization of the electromagnetic field
6. Interaction of light with matter
7. Absorption of light
8. Emission of photons and dipole moment
9. Selection rules
10. Scattering of light
11. Entanglement
12. EPR paradox and Bell's inequality
13. Quantum key distribution
14. Second quantization formalism
15. Field operators
16. Wave functions and second-quantized operators
17. Correlation functions
18. Review of special relativity
19. Special relativity continued

20. Relativistic dynamics
21. Klein-Gordon equation
22. Klein-Gordon equation continued
23. Dirac equation
24. Dirac equation continued
25. Second-quantized Dirac equation
26. Relativistic Compton scattering