# Physics 614

# Quantum Mechanics I (3 credits)

## Fall 2026

**Instructor**: Prof. Michael Eides    rm. 279 CP Bldg.    Phone 257-3997

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**Office hours**: I will follow open door policy. Official office hours are on Wednesdays, 2:00-4:00 pm, or by appointment.

**Class meets** Monday, Wednesday, Friday, 11:00-11:50 am, CP Bldg., rm. 201. There will be no classes on Monday, September 7 (Labor Day), Monday, October 26 (Fall Break), and November 25, 27 (Thanksgiving Break).

**Assignments and Grading**: I will give you home assignments approximately every 10-15 days. Your homework will be graded (35 points). Home assignments will be posted on Canvas. My instructions on home assignments are in the file "advices.pdf" on Canvas. Your solutions to the problems should be uploaded to Canvas as pdf files. As a rule there will be no extensions beyond the due date. If, due to some unforseen extraordinary circumstances, you will need an extension, your request for an extension should be submitted at least 24 hours in advance of the due date.

I encourage you to discuss approaches to homework problems together. However, you should *write up your homework separately.* Identical solutions would not earn any points.

My solutions to the problems will be posted on Canvas after all student solutions are turned in. These solutions are an inseparable part of the course, I advice you to work with them in the same way you work with the class material. If you have any questions about my solutions (as I expect you would), you are welcome in my office for discussion.

**Exam and grading policy**: There will be a midterm exam, tentatively scheduled on Thursday, October 22. The final open books exam is tentatively scheduled on Wednesday, December 16, 10:30 am.

The final grade will be based on homework (35 points), midterm exam (25 points) and the final exam (40 points). For the final grade $A$ you need to earn $\geq 85$ points, $B$ – $[65, 85)$ points, $C$ – $[50, 65)$ points, $E$ – less than 50 points. But you also need to earn more than 50 points out of 100 at the final exam to be assigned a final grade $C$ or higher.

**Student Evaluations**: Course evaluations are an important (and mandatory!) component of our Department's instructional program. The on-line TCE student evaluations system will be open last two weeks of classes. I expect all of you to make your evaluations.

**Intellectual Property**: The University of Kentucky recognizes that a faculty member's class and all pieces of that, lectures, assignments, etc., are the intellectual property of the faculty member. No class materials should be uploaded to the internet. Students may record class lectures, home assignments and their solutions ONLY for his/her personal use. For any other use, including sharing with other students in the class, specific permission of the faculty is required. Recording for any business/commercial purpose is a violation of federal IP (copyright) law as well as a violation of the faculty class policy and, thus, is strictly prohibited.

**AI in this course**: All work submitted by students will be generated by the students themselves. For the purpose of this course, any use of any AI sites or tools will be considered academic misconduct and consequences will follow University policies. If you have any questions or concerns about this policy, contact me before submitting any assignments.

**Academic Policy statements**: A full list of UK academic policies is available at https://provost.uky.edu/proposals/guidance-course-proposals/standard-academic-policy-statements

**Academic Offenses (Cheating, Plagiarism, and Falsification or Misuse of Academic Records)**: UK policies on academic offenses are available at
https://provost.uky.edu/proposals/guidance-course-proposals/academic-offenses

For a thorough description of "plagiarism," see https://ombud.uky.edu/students/what-plagiarism

For a thorough description of "cheating," see https://ombud.uky.edu/students/what-cheating

**Classroom Emergency Preparedness and Response:** Please see the following link for information related to emergency reporting and action: https://provost.uky.edu/curriculumproposals/syllabus-information

**Resources**: The university offers a variety of resources available to students. Visit the Office of Student Success to access the full list at https://studentsuccess.uky.edu/get-help.

**Course Description**: A lecture and problem course dealing with the description of quantum systems in the forms of wave mechanics, matrix mechanics and state vectors. Includes basics of Quantum Mechanics and its mathematics, canonical quantization, Schrödinger euqation, symmetries and conservation laws, angular momentum and its addition, the Coulomb problem. Prereq: PHY 520.

**Learning outcomes**: After completion of this course students should be able to solve quantum mechanical problems using the Schrödinger equation. Students are expected to be fluent with three-dimensional bound state problems and addition of angular momenta.

**Textbook:** Ernest S. Abers, Quantum Mechanics, ISBN 0-13-146100-1, Pearson Education, New Jersey 07458, 2004. There is a list of misprints at http://www.physics.ucla.edu/ abers/QMErrata3.html

**Other useful books.** There are many good books on Quantum Mechanics. To recall what you already know about Quantum Mechanics I recommend to you two good undergraduate texts:

- S. Gasiorowicz, Quantum Physics, ISBN 0-471-85737-8, John Wiley & Sons, 1996.
- D. J. Griffiths, Introduction to Quantum Mechanics, ISBN 0-13-124405-1 Prentice-Hall, New Jersey 07458, 1995.

I assume that you know Quantum Mechanics at the level of these courses, and advise you to consult these books if you find our textbook too difficult.

There are many superb books on Quantum Mechanics at the graduate and advanced level. I list below, in no particular order, a few of my favorites:

- Lev Landau and Evgeny Lifshitz, Quantum Mechanics (Nonrelativistic Theory), ISBN 0-08-029140-6, Butterworth-Heineman, Oxford OX2 8DP, 1999.
- Gordon Baym, Lectures on Quantum Mechanics, ISBN 0-805-30667-6, Westview Press, 1990.
- Kurt Gottfried and Tung-Mow Yan, Quantum Mechanics, ISBN 0-387-22823-2, Springer-Verlag, New York, 2004.

- Steven Weinberg, Lectures on Quantum Mechanics, ISBN 978-1-107-11166-0, Cambridge University Press, 2015.
- Gerald D. Mahan, Quantum Mechanics in a Nutshell, Princeton University Press, Princeton, 2009.

**Prerequisites.** As I already mentioned I assume that you have had an undergraduate course on Quantum Mechanics. I also expect you to have some knowledge of Classical Mechanics and Classical Electrodynamics. I ask you to recall the Lagrangian and Hamiltonian formalisms of Classical Mechanics, to this end you can consult

- H. Goldstein, Classical Mechanics, 3d ed., ISBN-10-0201657023, Addison Wesley, 2001,

or any other text on Classical Mechanics, where the Lagrangian and Hamiltonian formalisms are discussed.

In our course we will use the $CGS$ (and/or $MKS$) system of units for mechanics, and the Gauss system of units in discussion od electricity and magnetism. From the physical point of view these systems of units are more natural than the International Units that are mainly used in undergraduate education. You may wish to consult

- J. D. Jackson, Classical Electrodynamics, 3d ed., ISBN-10-47130932X, John Wiley & Sons, New York, 1998,

where the Gauss system of units is discussed in detail.

# The Syllabus

1. **Physical Foundations of Quantum Mechanics. Basics of Quantum Mechanics Mathematics**

   Quantum Mechanics and Classical Theories. Black-body radiation, photoelectric effect, Compton effect, Bohr atom, double-slit and Stern-Gerlach experiments. de Broglie Hypothesis. The superposition principle. States in Quantum Mechanics. Linear vector spaces, linear operators. Scalar product, Hilbert spaces. Hermitian and Unitary Operators. Observables. Discrete and continuous spectra. Dirac notation, Dirac $\delta$-function. Probability Amplitudes, and Expectation Values. The Copenhagen Interpretation.

2. **Canonical Quantization**

   Action, the action principle, Euler-Lagrange equations. Canonical momenta and the Hamiltonian, canonical equations of motion. Poisson brackets. The Heisenberg and Schrödinger Pictures. Complete sets of commuting observables. The uncertainty principle.

3. **The Schrödinger Equation**

   Coordinate and Momentum Space Wave Functions. Derivation of the Schrödinger equation in coordinate space. Schrödinger equation in momentum space. Local conservation of probability. Phase and group velocity. Spreading of wave packets. Stationary States. Discrete and continuous spectrum. Properties of wave function. Degeneracy of the Hamiltonian. Simplest One-Dimensional Problems

4. **Symmetries and Conservation Laws. Angular Momentum**

   Space-Time Symmetries. Symmetries and Groups. Lie groups and algebras. The rotation group. Symmetries and conservation Laws. The Noëther theorem. Conservation of Energy and Momentum.

Hamiltonian and Momentum Operator as Generators of Time and Space Translations in Hilbert Space. Rotations and Conservation of Angular Momentum. Integer and Half Integer Angular Momenta, orbital angular momentum.

5. **Two-Particle Systems with Central Potential**

   Reduction of a Two-Particle problem to an Equivalent One-Particle Problem. Algebraic solution of the Coulomb Problem. Schrödinger Equation in Spherical Coordinates with a Central Potential, degeneracy, wave Functions and boundary conditions. Solutions of the free Schrödinger equation, spherical Bessel functions. The Coulomb Problem, properties of the Coulomb spectrum and wave functions.

6. **Addition of Angular Momenta. The Wigner-Eckart Theorem**

   Direct Products of Hilbert Spaces, Bases and Operators in the Product Space. Different Complete Sets of Mutually Commuting Operators. Eigenvalues of Product of Angular Momentum Operators. Addition of Angular Momenta. The Clebsch-Gordan Coefficients. Wave functions of particles with any spin. Rotation Group and Selection Rules. Spherical Components of Vectors, selection rules. Wigner-Eckart Theorem for Vector and tensor operators.