Quantum Mechanics 2026

This course presents an introduction to quantum mechanics. The formal structure of the theory is developed systematically, with applications to atomic and radiation phenomena.

Course content

1. Review of classical mechanics: Lagrangian and Hamiltonian formalisms; continuous symmetries and conserved quantities; canonical transformations; Hamilton–Jacobi theory.
2. Quantum states and observables: Superposition principle; bra–ket notation; geometry of Hilbert space; linear operators, adjoints, eigenvalues, and eigenstates; compatible observables; spectral theorem.
3. Representation theory: Dirac delta function; basic kets and bras, resolution of the identity; wave functions and matrix operators, transformation functions.
4. Quantization: Quantum Poisson Brackets; position and momentum representations; uncertainty principle; displacement operators and unitary transformations.
5. Equations of motion: Schrödinger and Heisenberg pictures; stationary states; free-particle dynamics; wave packets; density operators and their time evolution.
6. Harmonic oscillator: Exact solution; ladder operators; position and momentum representation; standard coherent states.
7. Measurement process and interpretations of quantum mechanics..
8. Angular momentum: Rotations; angular momentum algebra; spherical harmonics; addition of angular momenta; electron spin.
9. Central potentials: General theory with application to the hydrogen atom.
10. Perturbation theory: Time-independent and time-dependent perturbation methods.
11. Atoms and radiation: Transition probabilities; selection rules; interaction of atoms with electromagnetic radiation.
12. Identical particles: Symmetric and antisymmetric states; bosons and fermions; connection between bosonic systems and oscillators; applications to photons.
13. Quantized electromagnetic field: Quantization in the Coulomb gauge; emission, absorption, and scattering processes.

References:

Primary reference:
P. A. M. Dirac, The Principles of Quantum Mechanics (4th edition)
Additional reference:
S. Weinberg, Lectures on Quantum Mechanics

Assessment:

Optional written test-out examination offered during the first weeks of the course.
Final assessment:
Final examination (written problem-solving component and oral examination): 85%
Homework assignments: 15%