

Foundations of Quantum Mechanics

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Fall 2008

- Lecture 1:** What is a fundamental physical theory? Reductionism.
- Lecture 2:** Classical mechanics: Newtonian mechanics, conservation of energy, Hamilton's equations
- Lecture 3:** Examples of Hamiltonian systems. Electrodynamics.
- Lecture 4:** The rise of quantum mechanics: The problem of spectral lines, black-body radiation, the photo-electric effect, and the stability of matter
- Lecture 5:** The Bohr atom. De Broglie waves
- Lecture 6:** Wave equations. Schrödinger's equation for one particle
- Lecture 7:** Quantization. Stationary states. The Born rule for a particle on the line.
- Lecture 8:** A free quantum particle in an interval. The Born rule for a particle in space ($d = 3$). Schrödinger's equation for a many-particle system
- Lecture 9:** The Born rule for a many-particle quantum system
- Lecture 10:** Schrödinger's equation and quantum theory. The quantum continuity equation
- Lecture 11:** The Copenhagen interpretation and textbook quantum theory. Hilbert space
- Lecture 12:** The double-slit experiment.
- Lecture 13:** Complementarity. The measurement axioms of quantum theory: operators and observables
- Lecture 14:** Quantum nonlocality
- Lecture 15:** Linear operators. Self-adjoint matrices. The Pauli spin matrices. The momentum operator. Eigenvalues and eigenstates.
- Lecture 16:** Energy eigenstates. Momentum "eigenstates". Position "eigenstates"
- Lecture 17:** Probabilities for the results of quantum measurements: probability amplitudes and the generalized Born rule

Lecture 18: Ideal measurements and the Projection Postulate

Lecture 19: Commuting observables and simultaneous measurability. The Heisenberg commutation relation

Lecture 20: Spin 1/2 commutation relations. The formula for quantum expected value. The uncertainty principle.

Lecture 21: Quantum mechanics and reality. Hidden variables and pre-existing values. Hardy's theorem.

Lecture 22: The issue of the existence of hidden variables

Lecture 23: The strict Copenhagen interpretation. The completeness of the wave-function description

Lecture 24: The measurement problem and the paradox of Schrödinger's cat.

Lecture 25: The measurement problem and the paradox of Wigner's friend. What is the problem with quantum mechanics?

Lecture 26: Many worlds/Everett

Lecture 27: Many worlds and history. Bohmian mechanics