

ECE 607 - Fundamentals of Solid State Electronics I

Department of Electrical and Computer Engineering
University of Massachusetts at Amherst

Fall 2009

Day & Time: TuTh, 2:30-3:45
Place: Room 106, Hasbrouk Lab Addition
Instructor: Prof. Neal G. Anderson (201B Marcus, anderson@ecs.umass.edu)
Office Hours: TBD

Course Goals

To understand critical distinctions between classical and quantum mechanics.

To understand the formal structure of quantum mechanics and apply it to the solution of problems.

To provide a foundation for further study in solid-state and optical electronics, as well as other areas relevant to electrical and computer engineering that make use of quantum mechanics (e.g. quantum information processing).

Preliminary Course Outline

1. Introduction
 - 1.1 Context: Quantum Theory and ECE
 - 1.2 Introductory Example
 - 1.3 Physical Description: What makes a theory “right”?
 - 1.4 Preview of Quantum Theory
2. Mathematical Preliminaries
 - 2.1 Hilbert Spaces
 - 2.2 Linear Operators
3. Quantum Theory
 - 3.1 Classical Backdrop
 - 3.2 The Quantum Postulates
 - 3.3 Formal Development
 - 3.4 Summary: Comparison Classical and Quantum Mechanics
 - 3.5 Wave Mechanics
4. Canonical Applications
 - 4.1 The Free Particle
 - 4.2 Potential Wells

- 4.3 The Harmonic Oscillator
- 4.4 Potential Steps and Tunnel Barriers
- 4.5 The Periodic Potential and Energy Bands
- 4.6 Angular Momentum and Spin

- 5. Perturbation Theory and Applications
 - 5.1 Time-Independent Perturbation Theory (TIPT)
 - 5.2 Time-Dependent Perturbation Theory (TDPT)
 - 5.3 Applications of TDPT: Radiation and Scattering

- 6. The Density Matrix Formalism
 - 6.1 Recasting the Postulates
 - 6.2 Application: Thermal Mixtures

- 7. Advanced Topics

Potential topics include intro to the quantum theory of semiconductors; quantum wells, wires, and dots; composite systems and quantum entanglement; decoherence.

Course Materials

The course is based on lecture notes, to be provided in class, parts of which draw heavily from Isham and Liboff (see below). Isham is strongly recommended but not required.

Useful Reference Texts

- L. Ballentine, *Quantum Mechanics: A Modern Development*, World Scientific, 1998.
 - C. Cohen-Tannoudji, B. Diu, and F. Laloe, *Quantum Mechanics; Vol. 1&2*, Wiley, 1977.
 - C.J. Isham, *Lectures on Quantum Theory*, Imperial College Press, 1995.
 - M. LeBellac, *Quantum Physics*, Cambridge, 2006.
 - R.L. Liboff, *Introductory Quantum Mechanics*, Addison Wesley.
 - R. Shankar, *Principles of Quantum Mechanics*, Plenum Press, 1994.
 - C.L. Tang, *Fundamentals of Quantum Mechanics: For Solid State Electronics and Optics*, Cambridge, 2005.
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Grading

- Homework - 20%
 - Exam I - 25%
 - Exam II - 25%
 - Final Exam - 30%
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