ECE 607 - Fundamentals of Solid State Electronics I

Department of Electrical and Computer Engineering
University of Massachusetts at Amherst

Fall 2017

Day & Time: MWF, 11:15-12:05
Place: 305 ELAB
Instructor: Prof. Neal G. Anderson (210E Marcus, anderson@ecs.umass.edu)
Office Hours: MW, 2:00-3:30

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 work and study in solid-state electronics, nanoelectronics, optical and quantum electronics, and other current and future areas relevant to ECE that require background in quantum mechanics.

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 Applications: (Thermal Mixtures, System-Environment Interactions)

7. Advanced Topics

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

Course Materials

The course is based on lecture notes, provided by the instructor, parts of which draw heavily from Isham and Liboff (see below). Isham is recommended but not required.

Useful Reference Texts

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.

B. Schumacher and M. Westmoreland, *Quantum Processes, Systems, & Information*, Cambridge, 2010.

C.L. Tang, *Fundamentals of Quantum Mechanics: For Solid State Electronics and Optics*, Cambridge, 2005.

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

Updated 8•27•17