ECE 607 – Quantum Theory for ECEs*

Department of Electrical and Computer Engineering
University of Massachusetts at Amherst

Fall 2019

Day & Time: MWF, 11:15-12:05
Place: 325 ELAB
Instructor: Prof. Neal G. Anderson (210E Marcus, anderson@ecs.umass.edu)
Office Hours: MW, 2:30-3:30 and by appointment

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 (e.g. quantum computing).

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

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* Formally "Introduction to Solid-State Electronics I"

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

    Semiconductor nanostructures; qubits and quantum gates; quantum entanglement.

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.

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 - 30%
Midterm Exam - 35%
Final Exam - 35%

Inclusivity

We are all members of an academic community with a shared responsibility to cultivate a climate where all students/individuals are valued and where both they and their ideas are treated with respect. If you feel that your contribution is not being valued or respected for any reason, please speak with me privately. If you wish to communicate anonymously, you may do so in writing, speak with Assistant Dean Dr. Paula Rees (rees@umass.edu, 413.545.6324, or in person in 128b Marcus Hall, within the Engineering Community, Equity and Inclusion Hub across from the coffee shop). You may also submit any concerns or comments through the College of Engineering Climate Concerns and Suggestions on-line form (https://tinyurl.com/UMassEngineerClimate) and/or the Positive and Negative Classroom Experience online form (https://tinyurl.com/UMassEngineerClassroom).

Accommodation

The University of Massachusetts Amherst is committed to providing an equal educational opportunity for all students. If you have a documented physical, psychological, or learning disability on file with Disability Services (DS), you may be eligible for reasonable academic accommodations to help you succeed in this course. If you have a documented disability that requires an accommodation, please notify me within the first two weeks of the semester so that we may make appropriate arrangements.

Academic Honesty

Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst. Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Instructors should take reasonable steps to address academic misconduct. Any person who has reason to believe that a student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent (http://www.umass.edu/dean_students/academic_policy).
