16:332:581: Introduction to Solid State Electronics
Fall 2023

Instructor Information

Name: Demetrios Lambropoulos
Office: EE-216
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Office Hours: Thursday 4:00 PM

Class Information

Time: Wednesday 7:30PM–10 :30PM
Classroom: ARC-207

Additional individual meetings to discuss course material or any other concerns can be scheduled by contacting me via email, after class, or during office hours. On occasion, if I am on campus with free time available, I will post where I can be located along with the times I will be there on my 'Office Hours' tab on my webpage.

Course Goals

The goals for each student of the course is:

- 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 a background in quantum mechanics (e.g., quantum computing)

Course Outline

The course outline is as follows:

- Mathematics of Quantum Mechanics
  - Hilbert Spaces
  - Linear Operators
- Quantum Theory
  - Classical Backdrop
  - The Quantum Postulates
  - Formal Development
  - Comparison of Classical and Quantum Mechanics

  - Wave Mechanics
- Quantum Mechanical Models
  - Free Particle
  - Step Potential
  - Potential Barrier
  - Infinite Well
  - Finite Well
  - Simple Harmonic Oscillator (SHO)
  - Delta Function Potential
  - Airy Function Potential
  - Three-dimensional "Particle-In-A-Box"
- Perturbation Theory and Applications
  - Time-Independent Perturbation Theory (TIPT)
    - Non-denerate
    - Degenerate (time-permitting)
  - Time-Dependent Perturbation Theory (TDPT)
  - Applications of TDPT: Radiation and Scattering
- Band Theory of Solids: The Kronig-Penney Model
- The Density Matrix Formalism
  - Recasting the Postulates
  - Applications
    - Thermal Mixtures
    - System-Environment Interactions
- Advanced Topics
  - Semiconductor nanostructures
  - Qubits and quantum gates
  - Quantum Entanglement

Texts

The main readings for this course will be papers assigned and course decks provided. The majority of the material will be adapted from Isham, Razeghi, and Liboff.

Selected Reference on Solid State:

- M. Razeghi, *Fundamentals of Solid State Engineering*, Springer Nature

Selected References in Quantum Mechanics:

- C. J. Isham, *Lectures on Quantum Theory*, Imperial College Press
- G. Baym. *Lectures in Quantum Mechanics*, John Wiley & Sons
- C. Cohen-Tannoudji, B. Dui & F. Laloe, *Quantum Mechanics*, Vol. I and Vol. II, John Wiley & Sons
- S. Gasiorowicz, *Quantum Physics*, John Wiley & Sons
- A. Goswani, *Quantum Mechanics*, Win. C. Brown Publ.
- D. Bohm, *Quantum Physics*, Prentice-Hall, Inc.
- R. B Leighton, *Principles of Modern Physics*, McGraw-Hill, Inc.
- R. N. Liboff, *Introductory Quantum Mechanics*, Holden-Day
- E. Merzbacher, *Quantum Mechanics*, John Wiley & Sons
- D. A. Park, *Introduction to Quantum Theory*, McGraw-Hill, Inc.
- L. Pauling & E. B. Wilson, *Introduction to Quantum Mechanics*, McGraw-Hill, Inc.
- R. W. Robinett, *Quantum Mechanics*, Oxford University Press
- J. J. Sakurai, *Modern Quantum Mechanics*, Addison-Wesley Publ. Co.
- L. I. Schiff, *Quantum Mechanics*, McGraw-Hill, Inc.
- A. Yariv, *An Introduction to Theory and Application of Quantum Mechanics*, John Wiley & Sons

Course Grading

The course grade will be broken down as follows:

- Homework 10%
- Presentation 10%
- Term Paper 30%
- Midterm 20%
- Final Exam 30%

Class Attendance Policy

Lectures will be given in person and will not be recorded. Attendance of lectures is strongly recommended to achieve the objectives of the course. You are responsible for learning all the materials covered in class (written or orally transmitted), which can appear in examinations.

General Policies

Attendance at tests is mandatory. Absence from an examination will not be excused except in cases of an illness or other emergency. Unexcused absence from an examination will result in a grade of zero. It is the student's responsibility to see the instructor as soon as possible regarding an excused

absence. All approved make-up work must be scheduled no later than the last day of classes in the semester. Students are responsible for all materials covered in lectures and announcements for homework assignments, assignment due dates, and test dates.

Academic Integrity at Rutgers

The principles of academic integrity require that a student:

- Make sure that all work submitted in a course, academic research, or other activity is the student's own and created without the aid of impermissible technologies, materials, or collaborations.
- Treat all other students ethically, respecting their integrity and right to pursue their educational goals without interference. This principle requires that a student neither facilitate academic dishonesty by others nor obstruct their academic progress.
- Uphold the ethical standards and professional code of conduct in the field for which the student is preparing.
- http://newbrunswick.rutgers.edu/chancellor-provost/academic-itegrity-students
- Please also read over the IEEE code of ethics https://www.ieee.org/about/corporate/governance/p7-8.html