ECE 677/QIC 885, Applied Quantum Mechanics

University of Waterloo, Instructor: A. Hamed Majedi

Winter 2025

General Description

Quantum mechanics serves as a foundational framework for understanding fundamental objects such as electrons and photons, while also unlocking groundbreaking opportunities in information processing, sensing, computation, and communication. The increasing interest among engineering students to explore and master quantum mechanics and its wide-ranging applications underscores its growing relevance.

This course is tailored to cover an array of topics in quantum mechanics, offering accessibility to individuals across disciplines like solid-state electronics, quantum photonics, and quantum information processing. It emphasizes both fundamental principles and practical applications, with carefully designed examples and problem-solving exercises that connect theoretical concepts to real-world challenges in electronic, optoelectronic, photonic, and superconductive devices. No prior knowledge of quantum mechanics is required to participate in the course. The course is open to anyone with a scientific curiosity, a dedication to learning, and an understanding of classical physics and linear algebra.

General Course Contents

1- Brief History of Quantum Physics

2- Schrödinger Wave Mechanics

3- Quantum Confined Structures (quantum well, wire, dot and superlattice)

4- Periodic Structure & Transfer Matrix Method

5- Axiomatic Structure of Quantum Mechanics

6- Electrons in Electromagnetic Field

7- Angular Momentum and Spin

8- Many-Body Systems & Quantum Statistics

9- Electromagnetic Field Quantization

10- Quantum States of EM Field; Introductory Quantum Optics

11- Electron/Photon & Atom-EM Field Interaction

Text

1- Course notes and slides.

Some References

1- D.J. Griffiths, Introduction to Quantum Mechanics, 2nd Edition, Prentice Hall, 1995.

2- H. Kroemer, Quantum Mechanics for Engineering, Material Science and Applied Physics, Prentice Hall, 1994.

3- A.F.J. Levi, Applied Quantum Mechanics, 2nd ed., Cambridge, 2006.

4- Ph. Martin, F. Rothen, Many-Body Problems and Quantum Field Theory, 2nd ed., Springer, 2004.

5- H.A. Bacher, T.C. Ralph, A Guide to Experiments in Quantum Optics, 2nd Edition, Wiley-VCH, 2003.

6- J.C. Garrison, R.Y. Chiao, Quantum Optics, Oxford, 2008..

7- D. Marcuse, Principles of Quantum Electronics, AP, 1980.

8- H. Bruus, K. Flensberg, Many-Body Quantum Theory in Condensed Matter Physics, Oxford, 2004.

Grading Policy: 50% Assignments/mini-project, 50% Final Exam.