ECE 350 / 450 - Fall 2010
Applied Quantum Mechanics for Engineers (3)

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Required Reading Textbook:

1. Nelson Tansu, *Applied Quantum Mechanics for Engineers*, Draft Version (2004-2010).
   We will cover approximately 10-11 chapters in the required reading, with approximately 3-4 additional chapters for your own perusal. The required text consists of approximately 14 chapters.
   Coverage for Fall 2007 semester: Chapters 1-9, 12, 13.
   Optional materials: 10, 11, 14.

Other Additional References or Readings:

1. Peter L. Hagelstein, Stephen D. Senturia, and Terry P. Orlando, *Introductory Applied Quantum and Statistical Mechanics*, Wiley (2004).
2. A. F. J. Levi, *Applied Quantum Mechanics* (2nd Edition), Cambridge (2006).
3. D. A. B. Miller, Quantum Mechanics for Scientists and Engineers, Cambridge (2008).
4. Richard Liboff, *Introductory Quantum Mechanics*, 4th edition, Addison Wesley (2003).
5. Jasprit Singh, *Quantum Mechanics: Fundamentals and Applications to Technology*, Wiley (1996).
6. Herbert Kroemer, *Quantum Mechanics: For Engineering, Materials Science, and Applied Physics*, Prentice Hall (1994).

Course Abstract:

This course covers the fundamentals of quantum mechanics, and applications of quantum mechanics to engineering and applied physics problems. Classical physics is an approximation of quantum physics, in the case that the dimensions of interest are many orders magnitude larger than those of atoms. Though classical physics can explain and approximate some of the phenomena quite accurately, in reality, our world is a quantum world and it should only be described with quantum physics. As the technology is rapidly moving toward the nano-scale dimension (so-called nanotechnology), classical physics fails to describe quantum phenomena observed in nanotechnology. Today, quantum mechanics have been the foundations of many applications in the fields of engineering, biology, chemistry, and others. Applications in the fields of engineering have included photonics, semiconductor lasers, semiconductor optoelectronic devices, resonant tunneling diodes, semiconductor transistors, quantum optics, and many other important novel applications that truly utilize quantum phenomena in their operation principles.

Quantum Mechanics have also been commonly thought as a difficult course, which is only intended for physics students. The advancement of nanotechnology has required engineers and applied scientists to fully understand quantum mechanics, and to appreciate and to apply the quantum ideas on engineering problems. The knowledge of quantum mechanics is essential and fundamental to provide engineers with strong foundation for understanding quantum devices based on semiconductor nanostructure, and the ability to utilize this knowledge for exploring new semiconductor nanostructure devices utilizing quantum phenomena.

The purpose of this course for engineers and applied physicists is 1) to provide strong, essential, important methods and foundations of quantum mechanics, and 2) to understand the fundamental principle operations of various applications in semiconductor nanostructure and heterostructure devices. This course will apply quantum mechanics on engineering fields, in particular related to semiconductor electronic-optoelectronic devices, and semiconductor nanostructure & heterostructure devices.

Intended Levels:

The course is intended for upper-level undergraduate (junior/senior, for ECE 350-level) or first-year graduate students (for ECE 450-level) in engineering (Electical and Computer Engineering, Material Science Engineering, and other related engineering) and applied physics areas, who are intending to understand and apply quantum mechanics in the fundamentals underlying the operation principles of modern electronic and optoelectronic semiconductor devices, and semiconductor nanoelectronic and nano-optoelectronic devices.

Prerequisites:

1. Physics 11 and 21: Students should have the knowledge of the Newtonian mechanics, Maxwell's equation in electromagnetic theory, and wave theory.
2. ECE 203, ECE 126
3. Mathematics: Students should have the knowledge of linear algebra, differential equations, statistics, and geometry.
4. Computing: Students should have the knowledge of <u>one</u> of the programming or numerical programs (ie. MatLab, MathCad, Mathematica, C language, Fortran language, or other numerical programs).

The course will cover all the chapters in the textbook with the following topics:

1. Motivation for Quantum Mechanics and Review of Classical Physics (0.5 week)
2. The Advent of Quantum Mechanics and Semiconductor Nanostructure (1 week)
3. The Schrodinger Wave Equations (1 week)
4. Solving the Schrodinger's Equation in Bound Quantum Systems (1.5 week)
5. 1-D Scattering of Particles in Unbound Quantum Systems (1 week)
6. Quantum Tunneling Phenomena (1 week)
7. Matrix Formulation of Schrodinger's Wave Equation (1.5 week)
8. Quantum Mechanics of Harmonic Oscillator (1.5 week)
9. Applications of Simple Harmonic Oscillator (1 week)
10. 2-D Quantum Phenomena (Optional)
11. Many Particle Physics and Quantum Statistics (Optional)
12. Time Independent Perturbation Theory (1 week)
13. Time Dependent Perturbation Theory (1 week)
14. Quantum Computing and Information Processing (Optional)

Structure of the Course Grading:
The structure of the course will consist of weekly homework assignments, a midterm exam, and a final exam with the following proportion toward the final grade:

1. Problems – 50 % (approximately 12 homework sets)
2. Midterm Exam – 20 % (scheduled in the evening)
3. Final Exam – 30 % (scheduled by the Registrar Office)

The purposes of this course:

1. You would be able to understand the device physics and the operating principles of basic semiconductor electronic devices in microelectronic integrated circuits.
2. You would be introduced to the basic device physics of semiconductor optoelectronic devices. The purpose of this course for engineers and applied physicists is 1) to provide strong, essential, important methods and foundations of quantum mechanics, and 2) to understand the fundamental principle operations of various applications in semiconductor nanostructure and heterostructure devices. This course will apply quantum mechanics on engineering fields, in particular related to semiconductor electronic-optoelectronic devices, and semiconductor nanostructure & heterostructure devices.
3. The fundamental knowledge on the quantum mechanics developed here are intended for engineers and applied physicists, and it should serve as a sound foundation for further advance training in the fields of solid state physics, semiconductor device physics, high speed semiconductor electronics devices, semiconductor optoelectronics, semiconductor nanotechnology, quantum electronics, and quantum optics.

Homework and Exam Policy:

1. Homework is given on every Monday, and due on the following Monday before class. (a week later)
2. No late homework is accepted, unless there is a medical emergency or permissions given in advance.
3. Working together in homework is encouraged, but not copying!
4. Academic Dishonesty will be subject to disciplinary action by Lehigh University.

Accommodations for Students with Disabilities:
If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center 212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.