Fall 2016

# EE201/MSE207: Applied Quantum Mechanics

**Instructor:** Prof. Alexander Korotkov, 827-2345, korotkov@ee.ucr.edu
**Office Hours:** Tuesday, 3 pm – 4 pm, CHUNG 434

**Time:** Tuesday, Thursday, 12:40 p.m. – 2:00 p.m., CHUNG 139

## Description

This one-quarter graduate-level course for EE students covers the topics, which are traditionally spread over several quarters in similar Physics courses. The course provides the basic formalism of quantum mechanics, while the emphasis is on the subjects related to the applications in modern solid-state devices.

## Course includes:

Schroedinger equation, operator formalism, harmonic oscillator, quantum wells, spin, bosons and fermions, solids, perturbation theory, WKB approximation, tunneling.

## Text

D. J. Griffiths, *Introduction to quantum mechanics*, Second edition, Prentice Hall.
The book covers most (but not all) of the material.

## Background

Students are expected to be familiar with basics of classical physics, calculus, partial differential equations, complex numbers, linear algebra, Fourier analysis, and probability concept.

## Course Grading (approximate)

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|---|---|
| Homework: | 20% |
| Midterm Exam: | 30% |
| Final: | 50% |

## Homework

There will be 3 homework assignments during the course. Although studying in a group is encouraged, a homework that is turned in should be a completely independent effort. Understanding of homework solutions is checked in a personal discussion, which contributes to the grading.

## Quizzes

Short tests may be occasionally given during the course; the grades are included into the homework grading.

## Exams

Both the midterm and the final exams are open-book exams. The midterm exam in Fall 2016 will most likely be on November 4th.

## Covered topics

- Wave function and Schrödinger equation (Ch. 1 in the Griffiths' book)
- Time-independent Schrödinger equation (Ch. 2)
  - Stationary states
  - Infinite square well
  - Harmonic oscillator
  - Free particle, wave packets
  - Finite square well
  - 1D scattering matrix
- Operator formalism (Ch. 3)
  - Linear algebra
  - Quantum mechanics in the operator language
  - Uncertainty principle, *x* and *p* representations
- Quantum mechanics in three dimensions (Ch. 4)
  - Separation of variables (Cartesian and spherical coordinates)
  - Quantum wells, quantum wires, quantum dots
  - Hydrogen atom
  - Angular momentum and spin
  - Spin 1/2, Pauli matrices
  - Electron spin in magnetic field
  - Addition of spins
- Identical particles (Ch. 5)
  - Two-particle system
  - Bosons and fermions
- Solids (Ch. 5)
  - Free electron gas, Density of states, Fermi energy (1D, 2D, 3D)
  - Band structure
- Effect of finite temperature (Ch. 5)
  - Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distributions
- Approximations and perturbation theory (Part II in the Griffiths' book)
  - Time-independent perturbation theory (Ch. 6)
  - Variational principle (Ch. 7)
  - WKB approximation (Ch. 8)
  - Fermi Golden rule
- Tight-binding model and elements of the second quantization
  - Second quantization
  - Two-level system
  - 1D array of quantum wells
- Briefly about more advanced subjects
  - Density matrix
  - Schrödinger, Heisenberg, and interaction representations
  - Methods for interacting electrons