EE 471: Applied Quantum Mechanics for Engineers Fall 2013

Prof. M. Gundersen, SSC 421, mag@usc.edu, Office hours MW 10:30 a.m. or arrange a time
Teaching Assistant: tbd

Schedule:

LECTURE: 8:30 MW, VHE 217 As needed: 8:30 Friday for discussions, reporting

FINAL EXAM: Wednesday, December 11, 8:00-10:00 a.m. location tbd

The purpose of Applied Quantum Mechanics is to develop an understanding of the principles of quantum mechanics (QM), and to learn how these are applied in practical devices. The course includes an introduction to quantum mechanics, an understanding of basic quantum mechanics, and linkage between quantum theory and the devices that are based on quantum mechanics. This subject is generally very challenging on first encounter, however, based on experience with this course, an understanding of the basics can definitely be achieved. QM, which has a very strong theoretical component, also has many experimental aspects, foundations, and applications. QM has become a basis for practical and important devices–and QM has very interesting intellectual elements as well!

Textbook: The textbook is **C. Cohen-Tannoudji, B. Diu and F. Laloe: Quantum Mechanics.**

Handout materials from Instructor will also be used.

EE 471 will primarily follow the lectures of the instructor, with assignments from the text.

Other Recommended Quantum Mechanics Texts:

R.P. Feynman: The Feynman Lectures in Physics Vol. III, Addison Wesley**.** This text is something of an alternative approach to teaching quantum mechanics at an introductory level, and in my experience is most useful when read in parallel with the required material. Feynman loved to develop his own approach to any subject, and one of the great things about this book is that he gives you different insights throughout.

E. Fermi: Notes on Quantum Mechanics. U. Chicago Press. Inexpensive reproduction of handwritten notes by Fermi from the course he taught in 1954. Although concise, the notes are very well reasoned, wonderful exposition, and a useful source for reference as well as study.

French, A.R. and E.F. Taylor: "An Introduction to Quantum Physics", The MIT Introductory Physics Series, Norton **(F&T). F&T** particularly has introductory presentations of material normally covered in an undergraduate modern physics course, and is very helpful for developing familiarity with concepts and ideas. It is strongly recommended for students who have not had previous modern physics or advanced Electricity and Magnetism courses.

A. Levi: Applied Quantum Mechanics, Cambridge Press 2003. Text has excellent examples for applied quantum mechanics, and includes MATLAB code on a CD for working problems.

L. Pauling and E.B. Wilson: Introduction to Quantum Mechanics. An early quantum mechanics textbook, extremely well written, and available as an inexpensive paperback from Dover. Pauling made seminal contributions to the understanding of valence bonding and its quantum mechanical origin, for which he won one of his two Nobel prizes.

Introductory Solid State, Semiconductors:

R.H. Bube: Electrons in Solids: An Introductory Survey, third edition, Academic Press. This text is oriented towards solid state, and will be useful for materials science students in future courses as well as this one. The presentation is clear, direct, and incisive, and essentially any book by Bube is helpful for students. The discussion of wave equations in chapter 2 is especially valuable at the start of the class, and again later, as the concepts become more familiar. Other books by Richard Bube are also useful and readable, including "**Electronic Properties of Crystalline Solids**" (Academic Press).

Background in Electricity and Magnetism (E&M), Waves and Wave Equations: What was your undergraduate preparation in E&M? Are you familiar with the wave equation for electromagnetic waves, or perhaps other waves? What text(s) have you used for this subject? As a recommendation, EE330 and EE470, or the equivalent courses in the physics department, have appropriate textbooks in this area that can be used for review and as references.

Waves and Wave Physics:

French, A.R., "Vibrations and Waves" Norton Press

Georgi, H. "Physics of Waves", Prentice Hall.

Grading

- **2 Midterms 20% each Reports will require oral problem solving and additional quantum mechanics materials.**
- Homework and Extra Credit 20%
- Final Exam 40%

Some Rules:

Homework is to reflect your own work and study. It is permissible and appropriate to discuss homework with others, but homework assignments are to be your work, not the work of others. Homework assignments that are duplicates or indistinguishable may be returned without credit, or in other ways graded off, such as splitting the score.

Homework problems may at times be assigned during lectures. A typical homework assignment will have from 1 to 5 problems.

If you have an idea for a problem that is different from the assigned problem, you are encouraged to turn it in for extra credit.

Late homework will not be graded.

Exams will be closed book, closed notes, no computers.

Expect to take any exams at the scheduled times! If you are absent during an examination, you will receive a grade of zero unless you have a written medical excuse or you have a valid reason for your absence that you have discussed with Professor Gundersen prior to the exam. If a make up exam is allowed, the exam will usually be given to the individual requesting it with both written **and oral** questions.

Academic Integrity Academic standards in the SCampus will be strictly adhered to. All students are responsible for familiarity with USC academic standards covered in the SCampus and elsewhere. Cheating is not only discouraged—it is not tolerated where found to occur.

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Schedule and Topics (Tentative)	
Topic 1 1 week	**Wave nature of electron** Waves in classical physics: Light string, Electromagnetic wave Electrons wave properties, diffracting as waves Description of electron waves moving freely A basic wave equation for electrons – **the Schroedinger equation**
2 weeks	**The Infinite Well – a basic, simple, yet very useful example** **Spatial** dependence of an electron in an Infinite Square Well Wave functions, energy levels The solution of the infinite well and the Fourier sine series, math properties
2 weeks	**More Basic Examples** **The Rigid Rotor** **The Harmonic Oscillator**, Motivation for harmonic oscillator **Vibrations and rotations**: simple diatomic molecules **Barriers**: contacts, tunneling, emission
2 weeks	**QM Math**: Operators, eigenfunctions and eigenvalues Amplitude and probability Hermitian operators The uncertainty principle
1 week	**Solutions in Time** **Time** dependence of amplitudes, or eigenstates **Time** dependence of **transitions between states** Wave functions and energy levels for the coupled states Examples: Ammonia, elementary model for electronic band structure
≈ 3 weeks 1 2 2 2	**More Basic Examples:** **The Harmonic Oscillator**, Ladder operator solutions **Orbital Angular Momentum**, wave eq. and operator **Spin** angular momentum and the Pauli Principle **Hydrogen Atom** Periodic Table of the Elements
2 weeks	**Applications: Light**: Emission of light from an atom. Einstein A and B coefficients Lasers
2 weeks	**Applications: Solid State Introduction** Bands and broadening Introductory band structure in solids Effective mass, mobility, conductivity Density of states, Fermi distribution, Carrier concentration
tbd	**Time independent perturbation theory**, introductory examples.
Week 15	To be determined. Review for final exam.