Solid State Physics

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Required Text: Charles Kittel, *Introduction to Solid State Physics*, Eighth Edition, John Wiley & Sons

Class meetings: MWF 11:10

Prerequisites: Quantum Mechanics (Physics 310) required, Thermal Physics (Physics 320) recommended.

Introduction

Condensed matter physics consists of the study of all phases of matter that are not gaseous, that is, phases of matter where mutual interactions between atoms change cause matter to assume a condensed form. In this course we will primarily look at the properties of crystalline solids with occasional extensions to the properties of non-crystalline matter. The first segment of the course will involve exploration of the fundamental properties of crystalline solids; crystal structures and the reciprocal lattice, phonons, quantum theory of electronic band structure, and some properties of semiconductors. The latter part of the course will focus on surface and interface physics as well as nanostructures. During the course you will independently investigate one topic of interest to you that will result in a four to eight page paper and a presentation. The final two class sessions will be devoted to twenty-minute presentations of the results of your investigations.   Below is a list of possible topics for advanced papers.

- Scattering measurements: phonon spectra by neutrons and light
- Superconductivity
- Ferromagnetism
- Giant, colossal, and ballistic magnetoresistance
- Magnetic resonance measurements
- Semiconductor devices (LED’s, lasers, photovoltaic cells)
- Properties of amorphous semiconductors
- Quasicrystals
- Liquid crystalline phases and their properties
- Tight binding model band structure calculations
- Nanostructures
- Photonic Crystals

Course Elements

- **Problems** are assigned with each reading assignment and are identified on the lecture schedule. Unless you are instructed otherwise, problems are due at the beginning of the class period when we start the next chapter in the text. Problems should be neatly written with compete explanations of your work. Generally, you should outline your approach at the beginning of the solution and offer interpretation and or observations concerning the result of the calculation.

- There will be **one in-class midterm exam** during the course

- The **final examination** will be a take home final that will be due at the end of the regularly scheduled exam period (4:30 PM on Wednesday, June 6). You may use your text, notes, and mathematical references, but no other physics textbooks.

- During weeks eight through ten you will pursue an advanced topic of your choice. You will make a **20 minute oral presentation** to the class on your advanced topic during week ten. **A four to eight page paper** on your topic will be due at the final class meeting.

Grade Determination

• Homework problems	20%
• Midterm exam	25%
• Paper	10%
• Oral Presentation	10%
• Final examination	35%

Honor Code

Each student is expected to present only her or his own work on the hour examination and the final examination. In contrast, you are encouraged to work together on the assignments. You should write up your own assignments, but working with classmates to solve the problems can be a valuable learning aid. I establish only two ground rules. First, working together is most effective if all individuals contribute more or less equally to the group effort. You should be very wary if you are always on the receiving end in such effort, for ultimately you must perform on your own. At the very least, once you have finished solving an exercise in a group, make sure that you could solve a similar exercise yourself. Second, when you receive significant assistance through conversation with a colleague, I ask that you follow common scientific courtesy and acknowledge that help briefly in your submitted work.

Physics 530: Solid State Physics Spring, 2007

LECTURE PLAN

MONDAY	WEDNESDAY	FRIDAY
March 26 1 Crystal Lattices Ch. 1:3-22: Prob: 3	March 28 2 X-ray Diffraction & Reciprocal Lattices Ch. 2: 29-50	March 30 3 Reciprocal Lattices & Structure Factors Prob: 1,2,4,5,6,7
April 2 4 Crystal Binding Ch.3: 48-73 Problem 5	April 4 5 Phonons I Ch. 4: 91-95. Prob: 1,2	April 6 6 Phonons II Ch. 4: 95-102. Prob: 3,5,6
April 9 7 Phonons III: Do phonons destroy crystalline order?	April 11 8 **LAB: Diffraction from powders and single crystals**	April 13 9 **LAB: Diffraction from a crystal with a basis**
April 16 10 Phonons IV Heat Capacity, Thermal Conductivity Ch. 5: 107-126, Prob: 1,3,4	April 18 11 Free Electron Gas Ch. 6: 134-157	April 20 12 Electrical & Thermal Conduction of free electrons Prob.:6,9,10
April 23 13 **Hour Exam**	April 25 14 Band Structure: Bloch's Thm. Ch.7:164-168	April 27 15 Band Structure Ch.7: 169-182 Prob: 1,2,3,4,6
April 30 16 Problems	May 2 17 Semi-Classical Electron Transport: Ch. 8: 187-202 **Choose Paper Topics**	**Reading Period**
May 7 18 Carrier Density: Ch. 8:205-218	May 9 19 Doping Prob: 1,2,3,	May 11 20 De Haas-van Alphen effect & Landau levels. Ch. 9: 242-249, Appendix G Prob. 11
May 14 21 Surface electronic structure Ch. 17: 494-497	May 16 22 Integral Quantum Hall Effect Ch. 17: 498-503 Prob 3	May 18 23 p-n Junctions Ch. 17:503-513 Prob 2
May 21 **LAB: Imaging with STM and AFM**	May 23 24 1D nanostructures Chapter 18: 528-540 Prob. 1	May 25 25 Quantum Dots Ch. 18: 545-549 Prob 5
May 28 26 **Memorial Day**	May 30 27 Presentations	June 1 28 Presentations **Final Exam Distributed**

Final exam due Wednesday, June 6, 4:30 PM