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363 Solid State Physics

(appears in catalog as *Physics of solids*)

Syllabus Fall 2005

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Class Schedule:

MWF between 9:10 pm and 10:00 am.

Description:

This course gives an introduction to the basic concepts and tools of solid state physics, highlighting the most important physical phenomena and effects that are central to the physics of condensed matter. This will give you the essential understanding and necessary preparation to efficiently use advanced textbooks and current papers in the literature to further increase your knowledge in any current or new research field that has to do with solids or periodic, regular arrangements of atoms, from nanotechnology to electronics to optics.

We will discuss what holds matter together, how atoms arrange in regular assemblies with beautiful symmetries, and the properties of the resulting crystal. These include how it stores energy in the form of atomic vibrations, how electrons can move inside it, how light can travel through it, what happens when a magnetic field is applied to it, and how electrons can travel through it forever without any effort when the temperature is low enough. In other words, we will discuss binding energies, crystal symmetries, phonons and specific heat, charge transport, electronic states and bands, what distinguishes an insulator from a semiconductor and a metal, the optical and magnetic properties of matter, and superconductivity.

The material will be introduced and discussed with a strong stress on basic understanding, often favoring a simple model over a more complicated one, or jumping over the detailed derivation of a mathematical result in order to dedicate more time to the description of the physics of what is going on.

Topics:

The topics that will be discussed in this course, in non-chronological order, are: (1) The fundamental structure of matter, i.e. how individual atoms and molecules arrange themselves into a macroscopic structure. The most perfect such structure is the crystal, and the methodologies for describing the crystal structure and its effects will be described. (2) The available energy levels for an electron in a crystal. Allowed and forbidden energy bands. How the energetic structure determines if a material is a metal, semiconductor, or insulator. (3) Free electrons in a crystal, their response to applied electric and magnetic fields, and related properties like conductivity, optical properties, etc. (4) Atoms and molecules in a crystal. How they vibrate around their equilibrium position (phonons) and how this affects the heat capacity, the average speed of an electron pulled by an electric field (mobility), the optical properties of a crystal, etc. (5) Other special topics, such as semiconductors in electronics, the effects of static and modulated electric fields (dielectric and optical properties), magnetism, and superconductivity.

Textbooks:

C. Kittel, *Introduction to Solid State Physics*.
(Useful as a summary of the concepts)

N. Ashcroft, and N. D. Mermin, *Solid State Physics*
(Useful for understanding the concepts and for another, deeper look at the material)

Required coursework and grading distribution:

30%: Short Quizzes and Class Participation
30% Homeworks
40% Exams

Quizzes are short, 10-minute questions that you will answer in writing in class, approximately once a week. There will be several quizzes, graded from 0 (if you are not there or do not write anything) to 4 (if everything is perfect). Only the best 70% will contribute to the grades. Class participation and answers to oral questions will also be taken into account for this partial grade.

Homeworks are due approximately every week. I will give 1 point for an attempt to solve a problem, 2 points for a correct solution. Solutions to the homeworks will be discussed in class after the problems have been turned in. As a result, I cannot accept late homeworks. Hand in whatever you have done! Homework problems are a very important part of the course. It is the same as athletics, without exercise you cannot be good.

Exams. There will be a mid-term exam and a comprehensive final exam. The mid-term exam is only counted for the final grade if its grade was better than the grade in the final exam. If both exams are counted, the total grade will be given by $(m + 2f)/3$, where m is the grade of the mid-term, and f the grade of the final.