Condensed Matter Physics
Physics 575
Winter Quarter 2008

Course web site: http://faculty.washington.edu/seattle

Synopsis: Introduction to the theory of solids: crystal structure in real space and reciprocal space, phonons, free electrons, band structure, Fermi surfaces and metals, semiconductors, semiconductor devices, superfluidity and superconductivity.

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Text Books: **Solid State Physics** by Hook and Hall
The Solid State by Rosenberg
Solid State Physics for Advanced Undergraduate Students*

*Solid State Physics for Advanced Undergraduate Students $19.95
By Harold T. Stokes see http://stokes.byu.edu/textbooks.html
Available from BYU Press. Phone orders 801-422-6231

Tentative Course Timetable

Topic	Week of	Exams
Crystal Structure 1	January 7	
Crystal Structure 2	January 14	
Phonons	January 21	
		Exam 1
The Free Electron Model	January 28	
Band Structure	February 4	
Fermi Surfaces and Metals	February 11	
		Exam 2
Semiconductors	February 18	
Semiconductor Devices	February 25	
Superconductors and Superfluids	March 3	
		Exam 3
Nobel Prizes	March 10	
Nobel Prizes	March 17	

Questions to Ponder...

Introduction

What is solid state physics?
What will you learn in this course?
What do you want to learn in this course?

Feynman: The subject that tries to understand bulk matter in terms of the laws of atomic behavior is called solid state physics.

Kittel: Solid state physics is concerned with the properties, often astonishing and often of great utility, that result from the distribution of electrons in metals, semiconductors, and insulators.

What are the "Newton's Laws", the "Maxwell's equations" or the "Schrodinger's equation" of solid state physics?

Crystal Structure

Why are there crystals? Why isn't everything a liquid or a gas?
How are the atoms arranged in crystals?
What are the 14 crystal classes?
What are the 32 point groups?
What are the 230 space groups?
What are the structures of most of the pure elements?
How do we know these structures?

Why did Rontgen (1901), von Laue (1914), Bragg and Bragg (1915), Davisson and Thompson (1937), Debye (1936), Sumner (1946), Pauling (1954), Perutz, Kendrew, Crick, Watson, and Wilkens (1962), Hodgkin (1964), Lipscomb (1976), Klug (1982), Hauptman and Karle (1985), Siegbahn (1981), Ruska (1986), Deisenhofer, Huber, and Michel (1988), DeGennes and Ernst(1991), Curl, Kroto and Smalley (1996), Boyer, Walker and Skou (1997), Brockhouse and Shull (1994), Kohn (1998) Heeger, MacDiarmid and Shirakawa (2000), Wuthrich (2002), MacKinnon (2003), and Kornberg (2006) receive the Nobel Prize?

Phonons

What is a phonon?
What is an optical phonon?
What is an acoustic phonon?
Why are there phonons?
How do we know there are phonons?
What is the relationship between the energy and the momentum of a phonon?
How much energy does it take to heat up a solid?
Why do solids expand with temperature?
What makes a solid a good heat conductor?
What is the Debye model?
What is the Einstein model?

Why did Raman (1930), Mossbauer (1961), and Brockhouse (1994) receive the Nobel Prize?

Free Electron Models

Why are metals good electrical conductors?
Why are metals good thermal conductors?
How much energy does it take to heat up a metal?
Why are metals shiny?

Band Structure

Why isn't everything a good electrical conductor?
What is a nearly free electron?
What is the band gap?
How can we use the periodicity of the solid to predict its electrical properties?

Fermi Surfaces and Metals

What is a Fermi surface?
What is a metal?
Why must we modify the free electron picture to understand the behavior of real metals?
How do we modify it?

Why did Einstein (1921), Richardson (1928) and Giaver (1973) receive the Nobel Prize?

Semiconductors

What is a semiconductor?
What is an insulator?
What controls their electrical conductivity?
What is the conduction band?
What is the valence band?
What does doping do? What's n-type? What's p-type?
What are holes?
What is the effective mass of an electron in a semiconductor?

Why did Bardeen, Brattain and Shockley (1956), Basov (1964), Esaki (1974), Anderson and Mott (1977), von Klitzing (1985), and Laughlin, Stormer and Tsui (1998), and Kroemer, Alferov and Kilby (2000), Furt and Grunberg (2007) receive the Nobel Prize?

Semiconductor Devices

How does a transistor work? What are bipolar and field effect transistors?
How does a semiconductor diode work?
How does an LED work?
How does a laser diode work?
How does a photodiode work?
What does temperature do?
How are these devices made?

Why did Bardeen, Brattain and Shockley (1956), Basov (1964), Esaki (1974), Anderson and Mott (1977), von Klitzing (1985), and Laughlin, Stormer and Tsui (1998), and Kroemer, Alferov and Kilby (2000), Furt and Grunberg (2007) receive the Nobel Prize?

Superconductors and Superfluids

What is a superconductor?
How does it work?
How can electrons move through many light years of cold dirty lead wire without any loss in their energy?
What is a superfluid?
How can it flow forever without any losses?

Why did Onnes (1913), Landau (1962), Bardeen, Cooper and Schrieffer (1972), Giaver and Josephson (1973), Kapitza (1978), von Klitzing (1985), Bednorz and Muller (1987), Lee, Osherfoff, and Richardson (1996), Laughlin, Stormer and Tsui (1998), and Abrikosov, Ginzburg, Leggett (2003) receive the Nobel Prize?

Conclusion

What was this course about?
What did you learn?
What would have liked to learn?
What should you have learned?

Why did van der Waals (1910), Bridgman (1946), Bloch and Purcell (1952), Zernike (1953), Neel (1970), Anderson, Mott, and van Vleck (1977), and Wilson (1982) receive the Nobel Prize?