Physics 731

Solid State Physics: Survey

Fall 2010

Instructor:	Dr. J. R. Anderson
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Office Hours:	Wed. after 5 P.M. & Thurs. 4:30 - 6 P.M., banders@umd.edu
Grader:	
	Mon. 4-6

Textbook:	Neil W. Ashcroft & N. David Mermin, "Solid State Physics" 1976
Suppl. Text:	Michael Marder, "Condensed Matter Physics" 2000
Class Time:	Tues. & Thurs. 11:00 A.M.- 12:15 P.M.. Room: Z4208 (0360)

Lecture Schedule*,***

	Tues.	Thurs.	Assignment from Ashcroft & Mermin**	Sections
August	30		Introduction & History of Condensed Matter	
September		2	Chapt. 4, Bravais Lattices	
	7		Chapt. 5, Reciprocal Lattice	
		9	Chapt. 6, X-Ray Diffraction & Crystal Structure	
	14		Chapt. 6, X-Ray Diffraction & Crystal Structure	
		16	Chapt. 7, Symmetric Point Groups & Space Groups	
	21		Chapt. 7, Symmetric Point Groups & Space Groups	
		23	Chapt. 1 Drude Model	
	28		Chapt. 1, Drude Model con	
		30	Chapt. 1, Drude Model con.	
October	5	7	Chapt. 2 & 3, Sommerfeld Model	
	12	14	Chapt. 8, Periodic Potential & Bloch's Theorem.	
	19		Chapt. 8, Bloch's Theorem	
		21	Chapt. 8 & Chapt. 9 Weak Periodic Potential	
	26		Chapt. 9 & Review	
		28	Midterm Exam	
November	2	4	Chapt. 10 Tight-Binding Method of Band Calculations & Chapt. 19 &20, Classification of Solids, Cohesion	
	9	11	Chapt. 23, Harmonic Crystals - Quantum Theory	
	16	18	Chapt. 28, Semiconductors(Diluted Magnetic Semiconductors)	
	23		Semiconductor Electronics (Reading to be assigned)	
November	30		Chapt. 31, Diamagnetic & Paramagnetic Materials	
December		2	Chapt. 34, Superconductivity, Josephson Junctions	
	7	9	Chapt. 34 con. and Review	

*This is a tentative selection of topics to be covered. Changes in assignments will be announced in class.

** Not all sections will be covered. Relevant sections will be announced in class.

*** Presentation about Library resources by Robert Kackley and Nevenka Zdravkovska.

Course Description

This course will be based in part on the textbook by Ashcroft and Mermin, but I would like to cover some more recent topics such as the quantum Hall effect, High T_C superconductors, and field-effect transistors. Reading material for subjects not included in Ashcroft and Mermin will be announced in class. The lectures will concentrate on covering the major topics and providing insight into the material. **Students are also responsible for material that is discussed in class but is not in the textbook, especially if the subject is emphasized during the lecture. If you miss a lecture, get notes from a classmate or see Dr. Anderson. In fact, you are strongly encouraged to come to office hours or schedule a separate meeting if you have questions. You can make arrangements at the end of a lecture, by telephone, or by dropping by Dr. Anderson's office. *You should not expect a timely response to e-mail, however.* To get the most out of the lectures, it is imperative you read the relevant parts of the text before class.**

Other Possible Topics for the Class

I expect that the topics covered in this course will evolve during the semester. This will depend upon your interests. We do not have to follow the syllabus rigidly. I am listing some possible topics below:

1. Diluted Magnetic (Semimagnetic) Semiconductors and their applications
2. III-V Materials such as GaAs and GaN; Growth by different methods such as MBE; quantum well and heterostructures, light detectors
3. Quantum Hall Effect
4. Quantum Computing with Josephson junctions, with impurities in semiconductors, and with trapped atoms or ions
5. Justification for quantum computing: public key encryption, Shor's and Grover's algorithms
6. Fermi surface of metals; de Haas-van Alphen & de Haas-Shubnikov effects
7. Band structure of crystalline materials: pseudopotential method, augmented plane wave method, etc.
8. Carbon nanotubes, graphene
9. Scanning probe microscopy
10. High-temperature superconductors
11. Magnetic Resonance: NMR a.k.a. MRI

Final Exam

Final Exam Mon. 13 Dec. 8:00 – 10:00 A.M. Room 4208 (Tentative)

There will be two exams, Midterm and Final, as indicated in the schedule above. The exams will be cumulative.

Homework

My tentative approach to homework assignments and schedules is as follows: Homework assignments will be announced in class. These will be taken primarily from the homework problems in your text. As this course progresses, the homework assignments may be changed. These changes will be announced in class with handouts. You are also encouraged to ask about this homework during the lectures.

Homework solutions in a ring binder will be on reserve and available for study at the Engineering and Physical Sciences Library. You may make a xerox copy of the solutions at the Library, but, if any solutions are missing from the ring binder, I will no longer provide solutions in the library.

Homework Assignments

1. A&M Chapt. 4 – Problems 2, 5, 6
2. A&M Chapt. 5 – Problems 1, 2, 3
3. A&M Chapt. 6 – Problems 2, 3
4. A&M Chapt. 1 – Problems 1, 5
5 A&M Chapt. 2 – Problems 1 (a) – (e), 2 (a) – (d)
6 A&M Chapt. 8 – Problem 1
7. A&M Chapt. 9 – Problem 1
8. A&M Chapt. 10 – Problem 1

Help

Help in understanding concepts and solving problems: Discussions with me after class or in my office. I encourage you to stop by my office and see if I am available or you may telephone to set up a meeting time. I think it is helpful to study with others and you may come as a group to my office to ask questions. My regular office hours will be announced later.

Grade

Your grade will be determined approximately as follows:
Final exam 50% Midterm 30% HW 20%

Active class participation will improve your chances for a higher grade. I expect all of you to get As or Bs.

Academic Integrity: This University has a student-administered Honor Code and Honor Pledge on the web at http//:www.jpo.umd.edu/aca/honorpledge.htm. This code prohibits cheating on exams, plagiarizing papers, etc. All students are expected to follow this Code.

Students with Disabilities: See me after class or in my office.

Goals

1. Science is all around.
2. Science is not so scary; easier than e.g. psychology (my opinion).
3. Solve problems by logical thinking.
4. Develop science intuition.

5. Learn about the mechanisms that are the basis of the working of everyday objects.
6. Learn that an effect has a cause. Not simple. Discus difference between “emergence” and “reductionism” ideas.
7. Historical perspective on science and technology.

Reference Texts and Internet Sites

Scientific Tutorials

1. Carl Hepburn (Essex): Guide to Semiconductor Physics.
2. Introduction to Solid State Physics Eighth Edition – Charles Kittel
3. Solid State Physics – An Introduction to Principles of Materials Science Third Edition – H. Ibach & H. Luth
4. Introduction to Condensed Matter Physics Volume 1 – Feng Duan & Jin Guojin
5. users.telnet.be/educypedia – Gino De Beer: searchable data base for information technology and science.
6. Introduction to Condensed Matter Physics – K. C. Barua
7. Crystal Fire The Birth of the Information Age – Michael Riordan & Lillian Hoddeson
8. Solid State Physics Essential Concepts – David W. Snoke (2009)

Research Developments

R & D August 2005

1. Scanning Electron Microscopy (SEM) with He ions.

2. Intel and new wafer fabrication facility – leading-edge microprocessors in 2007.
3. Nanovalves to trap and release molecules on demand.
4. High performance precision mirrors to focus x-rays and neutron beams.
5. Pittsburgh unveils Big Ben the supercomputer – 2090 processors with peak performance of 10 trillion (10^{10}) calculations/sec.
6. Toyota plans $150 million R&D center near Ann Arbor, Michigan. *(Of course, our Comcast Center cost about the same.)*
7. "Making light from a grain of sand." In other words, using silicon nanocrystals for white-light emitting diodes (LEDs) to replace ordinary incandescent lights.

"First Theorem of Science: It is impossible to convince a person of any true thing that will cost him money." – Robert Laughlin

LASER 50-Year Anniversary
Reference Laser Focus World – May 2010

1954 – Charles Townes, James Gordon, & Herbert Zeigler – first microwave maser.
1957 – Charles Townes – "optical maser. Gordon Gould – Fabry-Perot "laser resonator" as start for patents.
1958 – Charles Townes and Arthur Schawlow – first description of laser.

1960 – Theodore Maiman – Demonstration first laser (Hughes Labs). Al Javan, William Bennett, & Donald Herriott – He-Ne laser (Bell Labs) First both gas & CW laser.

1961 – First Nd-doped solid-state lasers: L. F. Johnson & K. Nassau (Bell Labs) in $CaWO_4$; Elias Snitzer (American Optical) mm-scale glass fibers. Early laser companies: Maiman – Korad (1962); Herb Dwight, Robert Rempel, & Earl Bell – Spectra-Physics for gas lasers. Peter Franken (U. Mich.) frequency conversion of ruby laser pulse.

1962 – Robert Hall – First semiconductor diode laser (GE Labs) Pulsed at liquid N_2 Temps. Alan White & Dane Rigden (Bell Labs) –First visible CW Laser (He-Ne at 632.8 nm) Laser beam bounced off the moon!

1963 – Herbert Kroemer (Varian Labs) proposes Heterostructures for better performance of diode lasers. Zhores I. Alferov & Rudolf Kazarinov (Ioffe Inst.) patent double heterostructure laser. Charles Campbell (New York) and H. Christian Zweng (Palo Alto) use ruby lasers for retinal coagulation on humans. Robert Keyes & Ted Quist (MIT) – first diode-pumped laser, U-pumped CaF_2 4K.

Questionnaire for Physics 731

Name:
Local Address:
Local Phone:
E-mail Address:
Major:

What days and times for office hours would fit your schedule?

If we had weekly review sessions late in the afternoon or in the evening, would you be interested? _____Would you attend?_____ If so, what days and times would be best for you?_____

Although we are expected to cover main topics, I have some flexibility in the material to be covered. Are there any particular things that you hope to get from this course? Examples are given above under “Other Possible Topics for the Class”.

Are there any topics you want stressed, or questions you want answered? (This is your best chance to be sure that they will be covered; therefore, be as explicit as possible. Adjustments can be made during the semester if there is sufficient class interest.)