**Physics 4200**
**The Physics of Materials**
**MWF 12:30 – 1:20 am**
**Course Syllabus, Spring 2010**

**Instructor:**

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**Office Hours:**

Monday-Friday 10:00-11:00

If these hours don't fit your schedule feel free to drop by my office or call at another time. If I am unavailable, you can make an appointment.

**Texts:**

J. I. Gersten and F. W. Smith, *The Physics and Chemistry of Materials* (Wiley 2001)
R. H. Silsbee and J. Dräger, *Simulations for Solid State Physics* (Cambridge 1997)

I will provide copies of the *Simulations* book for you to use during the semester. These will need to be returned to me at the end of the semester.

The main test for the course (Gersten and Smith) has an ftp site with lots of supplementary material:
ftp://ftp.wiley.com/public/sci_tech_med/materials

**Overview/Comments:**

As you might guess from the title, this course is meant to serve as an introduction to the physics of materials. In this course you will learn the language of materials science, fundamental of the physical properties of solids, some experimental techniques, and some interesting (to me anyway) applications. We will learn about current materials research by delving into the research literature at several points in the semester.

At the end of the course each of you will give a 10-15 minute presentation on an experimental technique (of your choosing) used by researchers to characterize materials. You will be required to work with me in advance of your presentation. You will also each provide a problem/question from your talk and its solution/answer. The combination of these questions will constitute a portion of your take-home final examination.

Some of you are further along in your physics education than others, and may have taken courses (Quantum Mechanics, Electricity and Magnetism, Physical Chemistry) that will help your understanding. As the authors of the text state "To gain the most benefit from courses based on this textbook, students should have had at least on year each of introductory physics, chemistry, and calculus, along with a course in modern physics or physical chemistry. For optimal use of the textbook it would be helpful if the students have had courses in thermodynamics, electricity and magnetism, and an introduction to quantum mechanics." I have compromised and made PHYS 2710, PHYS 3180 and CHEM 1220 prerequisites. I will attempt to design assignments and exams which are as fair as possible to all the students.

The main text (Gersten and Smith) might have given you sticker shock and I apologize for that. There are very few books available at an appropriate level and many of those are out of date. The book is, in my opinion, a good value despite the high price tag. You will notice that there is much more material in the book than we will

cover. With the recent publication date and the ftp site, the book is relatively up-to-date. If you find sections of the book difficult to work through, I can suggest some texts at a slightly lower level including:

*Introduction to Phonons and Electrons* by Lou
*Understanding Solids* by Tilley
*Introductory Solid State Physics* by Myers
*The Solid State: From Superconductors to Superalloys* by Guinier and Jullien.
*Elementary Solid State Physics* by Omar
*The Physics of Solids* by Turton.

As David Goodstein states in *States of Matter*: "The field is not distinguished by imaginative book titles".

**Grading:**

Your grade will be based on homework, exams, and the final as follows:

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|---|---|
| Homework (including simulations) | 20% |
| Exams (3) 3X10% | 30% |
| Journal Articles (5) 5X4% | 20% |
| Presentation | 10% |
| Final | 20% |

The homework assignments should be turned in by 5:00 on the day they are due. Solutions will be made available to you. Late assignments will be considered on a case-by-case basis.

The journal articles are additional reading assignments from research journals intended to relate topics from lecture to current developments in physics. You will be asked to read and summarize the articles and come to class prepared to discuss them. A grading rubric is attached. A rough schedule of articles is included in the schedule.

In general, I will be less strict in grading your homework as compared to your exams. I will let you know the exam format and what material you will be accountable for at least one week in advance.

**Notes:**

Any student requiring accommodations due to a disability must contact Services for Students with Disabilities (SSD) in room 181 of the Student Services Center.

Attendance at lecture is strongly recommended. You will be responsible for material discussed in lecture, which may or may not be in the book.

Please turn cell phones and pagers off before coming to class.

Academic dishonesty will not be tolerated. Cheating on exams may result in your failure of the course.

# Phsx 4200 Spring Semester Schedule

| | Monday | Wednesday | Friday | Notes |
|---|---|---|---|---|
| **Jan 4-8** | Introduction<br>Solids<br>Materials Science<br>1.1 | Crystal Lattices<br>1.2-1.4 | Crystals: Directions<br>Positions & Planes<br>1.5 | |
| **Jan 11-15** | Crystal Basis<br>1.6-1.7 | Packing Fraction<br>Density<br>Radial Dist. Fn.<br>1.8 | Elastic Scattering<br>of Waves | Article Topic:<br>Quasicrystals |
| **Jan 18-22** | **MLK Day**<br>**Holiday** | Reciprocal Lattice<br>3.1-3.2 | Diffraction<br>Conditions<br>3.3-3.4 | |
| **Jan 25-29** | Diffraction from<br>Caystals<br>Structure& Form Factor<br>3.5 | Diffraction from<br>Amorphous Solids<br>3.6 | **EXAM I** | |
| **Feb 1-5** | Bonding<br>General<br>2.1 | Covalent and Metallic<br>Bonding<br>2.2-2.3 | Van der Waals and<br>Ionic Bonding<br>2.4-2.5 | |
| **Feb 8-12** | Mixed Bonding<br>Hydrogen Bonding<br>2.6-2.7 | Order and Disorder<br>4.1-4.2 | Amorphous Solids<br>Defects<br>4.3-4.4 | Article Topic:<br>Defect Studies |
| **Feb 15-19** | **Pres. Day**<br>**Holiday** | Defects,<br>Thermodynamics<br>4.5-4.6 | Stress and Strain<br>10.1-10.4 | |
| **Feb 22-26** | Elastic Properties<br>10.5-10.7 | **EXAM II** | Atomic Vibrations<br>1D Monatomic Lattice<br>5.1 | Article Topic:<br>Rigidity<br>Percolation |
| **Mar 1-5** | 1D Diatomic Lattice<br>5.2 | Phonons<br>5.3-5.4 | Specific Heat<br>5.5-5.6 | |
| **Mar 8-12** | Specific Heat<br>5.7 | Thermal Expansion<br>5.9 | Electrical Properties<br>Drude Model<br>7.1-7.2 | Article Topic:<br>Heat Capacity<br>Models |
| **Mar 15-19** | **Spring Break** | **Spring Break** | **Spring Break** | |
| **Mar 22-26** | Hall Effect<br>Sommerfield Model<br>7.3-7.4 | Bloch Theorem<br>Bloch Functions<br>7.6 | Nearly Free<br>Electrons<br>7.8 | |
| **Mar 29- Apr 2** | Tight Binding<br>Models<br>7.9 | Metals, Insulators<br>Semiconductors,<br>Semimetals<br>7.10 | Quantum Effects<br>Effective Mass<br>7.12 | |
| **Apr 5-9** | **EXAM III** | Semiconductors<br>Band-Structure<br>11.1-11.2 | Semiconductors<br>Doping<br>11.5 | Article Topic:<br>Nanotechnology |
| **Apr 12-16** | Semiconductor<br>Statistics, Confinement<br>Quantum Wells<br>11.6 | Applications<br>Technology, Moore's<br>Law<br>11.12 | **Student Presentations** | |
| **Apr 19-23** | **Student Presentations** | | | |

Article Summaries Grading Rubric

The point of the article summary is to present the important points of the article in compact form and demonstrate to me that you have read and understand the article.

A summary should contain:

1) What type of study this is (experimental, theoretical, review).
2) The motivation of the study including important previous work
3) The methods used (experimental or theoretical) including definitions of important terms.
4) The results, conclusions, and implications of the work.
5) Your evaluation of the quality and importance of the work.

I will grade using the following guidelines out of a possible 20 points:

| | |
|---|---|
| 20/20 | A summary that not only contains the above elements and is clearly written but shows additional insight from reading the included references or additional sources etc. |
| 18/20 | A summary that includes all the above elements and is clearly written. |
| 16/20 | A summary that includes all the above elements with some errors or omissions. |
| 14/20 | A summary thatincludes most of the elements above but misses some important points or is poorly written. |
| 10/20 | A minimal indication that you have read the article |