Course Outline: Physics 476: Solid State Physics
Carl Adams, Fall 2008

- **Summary:** This course provides a description of the experimental techniques and theoretical concepts that we use to describe condensed matter systems. Particular attention is paid to the crystal lattice and properties arising from the electrons (electrical conduction, magnetism, and superconductivity). Classic examples as well as those from current research will be provided. An experimental lab is part of the course.

- **Text:** *Introduction to Solid State Physics*, 8th edition, Charles Kittel

- **Grading scheme:**
  - Assignments (5) 25%
  - Midterm (Oct. 24) 15%
  - Lab 20%
  - Comprehensive Final Exam 40%

  I draw your attention to Section 3.9 of the Academic Calendar **Regulations on Plagiarism, Cheating, and Academic Dishonesty** and online at
  http://www.stfx.ca/ services/registrar/academic-integrity-document.pdf
  I support a safe classroom environment free of harassment or discrimination for all students regardless of race, religion, gender, sexual orientation, gender identity, or disability. Assignments are due by by 4 p.m. The assignment dues dates are Sept. 19, Oct. 6, Oct. 20, Nov. 10, and Dec. 1. Your mark will be penalized by 10% for each teaching day the assignment is late after the due date up to a maximum of one week. After one week or if in special circumstances where I circulate solutions prior to that time (a warning will be given) the assignment will be worth zero. (I may still mark the assignment if you would like to see how well you did.) I will do my best to return the assignments within 10 days or sooner. A considerable portion of the midterm and exam questions will be based on assignment and examples covered in class and in the book so it is very important that you understand these solutions. *All midterms and exams will be closed book with one double sided formula sheet.* The midterm will take place in class on Oct. 24. There are no scheduled tutorials for this class but if the class wishes I will try to arrange for a question and answer doughnut period prior to the midterm.

- **Office Hours:** Rm 1006 Physical Sciences Complex, x5337 or in research lab PS 1063. Email: cadams@stfx.ca. I am usually in my office or lab from 10 to 5 each day with the exception of classes and labs (although since I am Department Chair I may not be as easily available as I was in the past). Formal office hours will be Monday 1:15 to 2:15, Wednesday 11:15 to 12:15, and Friday 10:15 to 11:15. This overlaps with blocks E, F, and L. Let me know if you would like a special appointment.

- **Website:** http://www.stfx.ca/people/cadams/physics476

- **Course Outline:** Follows chapters 1,2,4-13. Topics in *italics* are not very well covered in the text. You will need to depend more on your class notes and other resources.

  1. Crystal Structure (4 lectures)
     (a) Experimental evidence

(b) Definitions
(c) Bravais lattices
(d) *Symmetry operations and space groups*
(e) Review of common crystal structures
(f) Notation for directions and planes

2. Diffraction and Scattering from Crystals (4 lectures)
   (a) Scattering probes
   (b) Review of Bragg scattering
   (c) Laue formulation
   (d) Reciprocal lattice and k-space
   (e) The Brillouin Zone
   (f) Systematic absences and structure factors
3. Thermal Vibrations and Phonons (6 lectures)
   (a) Normal modes of coupled oscillators
   (b) Phonons and dispersion
   (c) *Classical equipartition theory and its failure*
   (d) Lattice specific heat in the Einstein and Debye models
   (e) *Thermal conductivity: a transport property*
   (f) *Measurements of phonons*
4. Electronic Properties (6 lectures)
   (a) Review of free electron Fermi gas
   (b) Low temperature specific heat
   (c) *Descriptions of electrical conduction (Drude, Sommerfeld, Weidemann-Franz Law)*
   (d) Energy bands and gaps (partial review)
   (e) Tight binding versus nearly-free
   (f) The Fermi surface
5. Superconductivity (5 lectures)
   (a) Discovery and prevalence
   (b) Meissner effect
   (c) London equations
   (d) BCS theory
   (e) High temperature superconductivity
6. Magnetism (6 lectures)
   (a) *Atomic magnetism and Hund's rules*
   (b) Pauli paramagnetism
   (c) Ferromagnetism and antiferromagnetism
   (d) *Itinerant magnetism*
   (e) *Relationship between magnetism and transport (Mott insulators)*

- **Texts:** Other than your textbook I will select or enrich topics from other solid state text books. You may find these in the library and I may also have some. Mike Steinitz may also have copies. *I highly recommend reading these other texts.* Solid state physics, perhaps more so than other physics courses, leaves you with an "okay, I understand that" feeling that can really sneak up on you. Specific texts are:

1. H.M. Rosenberg *The Solid State*
2. Christman, *Fundamentals of Solid State Physics*
3. Ashcroft and Mermin, *Solid State Physics*

Some googling is also fun and so is looking at Phys Rev B.

- **Labs:** Labs are in a state of development and there are some labs where I am more interested in you developing your experimental skills. The lab takes place in PS 1026 (the "bright" side of the Modern Physics lab). There will be specific labs on single crystal diffraction, Hall effect, electron resonance, vacuum technology, and magnetic susceptibility. I am also trying to develop labs on electrical and thermal transport. I will determine your lab mark using the following scheme: attendance/interest (15%), record keeping (15%), good experimental practice and skill (25%), data presenation and analysis (25%), and ability to form conclusions (20%). I will take your lab books in at the end of every month and give you an update on your lab mark so far. Your lab book should contain theoretical musings, description of experimental setup, a list of tests you performed and the results, a record of data points if relevant (i.e. if you didn't use a computer to record the data), graphs with analysis, and thoughtful conclusions. There may be times you want to do a full error analysis but other times just mentioning main sources and estimates of their sizes is more useful. The labs will probably take roughly 3 weeks each to complete.