Syllabus
Physics 358/558, Condensed Matter Physics
Spring 2011

Condensed Matter is a vast subfield of physics that encompasses a large fraction of current physics research. In this course, we are going to explore a few of the core ideas in condensed matter physics with a focus on crystalline solid-state materials. For this we will begin by describing crystals. We will then explore the elastic vibrations of crystals, called phonons, and the electronic states in crystals that will lead us to band structure. We will wrap up the semester looking at semiconductors and possibly some magnetic materials.

Condensed Matter physics provides an excellent opportunity to apply many ideas you have learned in other physics courses. Both the periodic structure of crystals and the wave nature of the phenomena of interest will lead us to heavy use of reciprocal or momentum space, so we will need the tools of Fourier analysis. We will need ideas from quantum mechanics, electromagnetism, classical dynamics, and thermal physics. Electricity and Magnetism (Phys 324) or Quantum II (Phys 315) are listed as pre-requisites, but a full description of condensed matter requires the whole tool box. Each week we will try to point out some of the main background material needed for the next week so that you can review as necessary.

Instructors: Due to unusual staffing constraints this semester, the course will be split between two instructors. For the first half of the semester (up to spring break), Prof. Starr will be the instructor, and after break Prof. Voth will take over. We have carefully coordinated to ensure the continuity of the course material and format. Our contact information is:

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Time and Location: The class will meet Tues./Thurs. morning 10:30 – 11:50 pm in SCIE 72.

Web Site: Moodle. Look in your portfolio under "moodle", or point your browser to https://moodle.wesleyan.edu. If you are registered for the course, you should have access.

Course Structure and Philosophy

We are planning for the format of this course to be a little different than some of the other upper level courses that are almost entirely focused on lecture. Around half of our time will be spent in normal lecture/classroom discussion. The rest will be spent in guided exploration of the material. We will use a series of computer simulations as numerical experiments allowing us to visualize and measure properties of materials that can only be extracted experimentally with expensive and elaborate equipment. You are also encouraged to seek out any other sources that help you to learn the key ideas that are identified in the lectures and assignments.

This style of exploration-based education is often very effective, partly because it puts a little more of the responsibility on you to synthesize the material yourself. However, it can also

be frustrating. Discovering things for yourself involves trying many ideas, and some of them will not work out. Choose carefully which avenues of inquiry to pursue and be persistent down them. But realize that your mistakes can often be more instructive than your successes. We will try to direct you toward avenues that are likely to be fruitful, but don't limit your focus to just the questions on the assignments. This exploratory approach is vital for success in physics research, and indeed for nearly any field where you are trying to chart unknown waters. We hope this course will help you to develop these abilities, and simultaneously master the central ideas of condensed matter physics.

Please provide feedback **during the semester** on how the course is going for you. In the past, different students have responded quite differently to the style of this course. Fortunately, the class is small so that we can sometimes adjust things to match your learning style if you tell us how it is going for you.

Text: *Introduction to Solid State Physics,* by Charles Kittel (Eighth Edition). This text is the standard undergraduate Solid State Physics text. It is at the appropriate level and covers all the main topics. It gives a wealth of data on properties of real materials. Sometimes it can be a challenge to identify the key ideas in the midst of all the details. We will try to point out what we consider to be the key ideas in the assignments each week and during lecture sessions.

Other Texts: With a broad subject like condensed matter physics, there is a vast array of textbooks coming from different angles. When you want to go deeper, there are three recommended graduate level texts. The classic is *Solid State Physics* by Ashcroft and Mermin which is clear and well organized. A recent and more comprehensive text is *Condensed Matter Physics* by Michael Marder. A graduate level text that gives more emphasis to soft condensed matter is *Principles of Condensed Matter Physics* by Chaikin and Lubensky.

Online Resources:
Simulations for Solid State Physics by R.S. Silsbee *et. al.*. This is the project that produced the simulations that we will be using throughout the course. You can download the software via the course Moodle page, if you want a copy to play with at home.

Find more on your own! Given the exploration emphasis of the course, you are encouraged to find online resources that help you learn the material. There is a lot of it out there of varying quality, but that is what it is like doing research: you try to find the answers to the questions you care about using whatever tools you have available. And you often have to sort through some junk before you find the answer you were looking for. If you find some compelling visualizations, tutorials, etc, be sure to let us know so that we can post links on the course Moodle.

Assignments:
There will be weekly assignments that will often include problems drawn from the computer simulations. Sometimes these will also include mathematical exercises to prepare for the next section or simple questions that are drawn from the reading for the next section. You will be allowed to drop one assignment during the semester. Late assignments (up to one week) will receive half credit. Assignments will typically be due Thursdays, although it may change over the semester.

Final Project:

You will choose some issue in condensed matter physics to explore in more depth and write a paper on. A brief summary of your planned project will be due with the assignment for the first week of April. Please consult with us as you develop your topic. You could explore some issue in one of the simulations in more depth, or do a research paper on a topic, or propose something else. Treat this like any scientific research project—work hard to identify an interesting and tractable question and then use any tools available to you to develop as complete an answer as possible.

Grading:

Problem sets	40%
Exam I	20%
Exam II	20%
Final Project	20%

Honor Code Matters:

We value Wesleyan's honor code for the integrity it fosters and the pedagogical flexibility it affords. The important guiding principle of academic honesty is that you must never represent the work of others as your own. It is not always easy to apply this principle to advanced physics coursework since much of the learning in these courses is done collaboratively.

Please work together in doing the assigned exercises and preparing for class discussions. These collaborative problem-solving situations are one of the best preparations for future careers in industry, academia, and almost anywhere else physics is used. For your own good, avoid situations in which you are contributing either too much or too little to such collaborations. Just copying someone else's work without having worked through each step for yourself is clearly a representation of another student's work as your own and is a violation of the code.

You should attribute any problems you worked with others, and any measurements or simulations you performed with others.

Approximate Exam Schedule:

Thurs, March 3:	Exam I
Tues, May 3:	Exam II
Thurs, May 14 at noon:	Final Project Due