Physics 671 – Advanced Solid State Physics I – Fall 2015

Instructor: Prof. Steven Johnston
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Meeting Time: Tuesday & Thursday, 9:40 AM – 10:55 AM.
Meeting Place: Nielsen Physics Building, Room 512.

Overview - This course covers topics in solid-state physics, with the aim of providing you with the tools and foundation needed for conducting research in solid-state/condensed matter physics.

Prerequisites - Physics 555 or equivalent from your undergraduate institution is encouraged but is not required. We will be reviewing many topics from Phys. 555, but we will do so at a more rapid pace and in more depth. We will also call heavily on your undergraduate courses in quantum mechanics.

List of Topics – This semester we will cover several foundational concepts in solid state physics. Each concept will be introduced progressively as we work towards building more detailed and sophisticated description of solids. The tentative list of topics is as follows:

1. The Sommerfeld theory of Metals (Free electron gas): Fermi statistics and the Fermi surface, electronic heat capacity, inadequacy of the free electron model.
2. Basic concepts of the static crystal lattice: Bravis lattice, the reciprocal lattice, Brillouin zones, diffraction, and cohesive energy of solids.
3. Lattice dynamics: The harmonic approximation, specific heat of a classical crystal, and normal modes.
4. Quantum theory of the harmonic crystal: second quantization of the normal modes, the concept of phonons, high- and low-temperature specific heat, density modes.
5. Electrons in a weak periodic potential: Bloch's theorem, energy bands and classification of materials, crystal momentum, mean velocity, and the Fermi surface.
6. Electrons in a strong periodic potential: the tight binding method.
7. Semiclassical model of electron dynamics: equations of motion, the concept of holes, electrons in electric and magnetic fields, effective mass, De Hass-van Alphen effect.
8. Dielectric properties of Solids.
9. Magnetism in solids.

Course Text and Materials – I am going to be handing out photocopies and/or typed notes throughout the semester. These will serve as the primary source for materials. I will also be borrowing heavily from *A quantum approach to Condensed Matter Physics* by P. L. Taylor and O. Heinonen. (ISBN-13: 978-0521778275) and *Solid State Physics* by Ashcroft and Mermin (ISBN-13: 978-0030839931).

Other recommended books – I recognize that no one book is ideal for every student and that no book covers all topics to the same level. If you would like to refer to other textbooks, I recommend any of the following as a good starting point:

- *Solid state physics: principles and modern applications*, J. Quinn and K.-S. Yi.

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- *Introduction to Solid State Physics*, C. Kittel.
- *Quantum theory of solids,* C. Kittel.
- *Theoretical Solid State Physics,* Jones and March.
- *Principles of condensed matter physics*, P. M. Chaikin and T. C. Lubensky.
- *Condensed matter field theory*, Alexander Altland and Ben Simons.
- *Magnetism in condensed matter*, S. Blundell.
- *Quantum theory of the solid state*, Callaway.
- *Condensed matter in a nutshell*, G. D. Mahan.
- *Many-particle physics*, G. D. Mahan (This is a very advanced book but highly recommended if you plan on pursuing research in this field).

Grading & Evaluation: Your mark will be determined based on your performance on the homework assignments, a mid-term test, and a comprehensive final exam. The relative weighting of these components are: homework sets, 50%; mid-term exam, 10%; and final Exam, 40%.

Homework: I plan on giving out a total of five to six homework sets at regular intervals through the semester. These will contain a mix of conceptual questions and more detailed calculation-based problems. You are not required to show all steps of your solutions, but you must show sufficient work and provide enough explanation that I can reconstruct/follow your logic. You should also take the time to make presentable solutions. (One of goals of graduate school is to learn how to present science.

I encourage you to discuss these problems with your classmates; however, you are expected to turn in your own work. All homework will be due at the beginning of class on the day it is due (see the late policy below).

The homework portion of your grade will be determined from a sum total of the available points: I will total the number of points earned and divide by the total number of points available across all assignments.

Mid-term exam: The mid-term be given in-class and will be closed book. I will not ask you to solve difficult problems, but instead focus on conceptual questions and definitions. You may also be asked to solve simpler problems, drawn from examples in class or from the homework.

Final exam: The final exam will be comprehensive and will be assigned to you during the exam period. It will be divided into two components. The first component will be an in-class test similar in style to the mid-term. This is where I will test for your basic understanding of the core concepts discussed in class. The second component will be a take home problem set of about three to four longer calculations. You will be allowed to use of some specified reference material. You will also be expected to work independently on the exam without discussing the problems with your classmates.

Late Policy

No extensions will be given on material without extenuating circumstances (e.g. a note from a doctor etc.) or prior arrangements with me. I will generally grant extensions if you have a good reason and you see me early enough. Without an extension, I will reduce the grade on any

overdue material by 25% each day that it is late. The only exception to this rule is the final exam, which must be handed in on time or it will receive a grade of zero.
Office hours - I will hold drop-in office hours on Thursday from 11:00 AM - 12:30 PM, immediately after class. If you would like to see me outside of office hours, please email me to make an appointment.

For Students with disabilities
If you need course adaptations or accommodations because of a documented disability, please contact the Office of Disability Services at 2227 Dunford Hall (telephone/TTY 865-974-6087; e-mail ods@utk.edu). This will ensure that you are properly registered for services.

Academic Honesty
I will not tolerate academic dishonesty of any form. All work submitted by a student is expected to represent his/her own work. Students are expected to complete all work in conformance with the University policies regarding Academic Honesty.

Plagiarism of any kind will not be tolerated. Working together on homework does not count as plagiarism, however, a line-by-line copy of another student's work or other source material without proper citation does. If you use a source (book, articles, internet materials, etc.), you must cite it. If you are in doubt as to whether you should cite a source, err on the side of caution and cite it. Treat your assignments and take home exam as you would treat any professional research project.

Cheating and/or plagiarism cases found to be in violation of the Academic Honestly policies will result in disciplinary actions, without exception.