Physics 672 – Advanced Solid State Physics II – Spring 2015

Instructor: Dr. Steven Johnston
Class times: Tuesday &Thursday, 12:40 – 1:55 P.M.
Class location: Nielson 512
Office: Nielson 406-A
Phone: (865) 974-7837
Email: sjohn145@utk.edu

Overview
This course covers advanced topics in solid-state physics. The aim is to provide you with the tools and framework needed for understanding and conducting research in solid-state/condensed matter physics. This course will build directly on the material covered in Physics 555 and 671 and will draw heavily on your knowledge of quantum mechanics. The primary focus of this course will be on describing elementary excitations in solids and their mutual interactions.

List of Topics
- Second quantization in condensed matter with examples: a review of the SHO, normal modes in solids, the non-interacting H_2 molecule, the uniform electron gas, and tight-binding models.
- Magnetism and magnetic order: magnetic interactions, the Heisenberg model, antiferromagnetic and ferromagnetic magnons, linear spin-wave theory, and spin-density-waves.
- Electron-electron interactions: Hartree-Fock theory, electronic screening, density functional theory, Fermi liquid theory, and concepts related to elementary excitations.
- Semi-classical model of electron dynamics and transport. Electrons in electric and magnetic fields.
- Correlated electrons: the Hubbard model, the Emery model, Mott and charge-transfer insulators.
- Electron-lattice interactions: electron-phonon interactions, Kohn Anomalies, charge-density-waves, and the effective attractive interaction mediated between electrons.
- Superconductivity: The Cooper instability, BCS Theory, strong coupling theory, and an introduction to unconventional superconductivity.
- (If time permits) Impurities in solids: the Kondo problem and Anderson impurities.

Grading & Evaluation
Problem sets - 50%
Mid-term exam - 15%
Final Exam – 35%

A total of five to six homework sets will be handed out at regular intervals, consisting of both 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. I encourage you to

discuss these problems with your classmates; however, you are expected to turn in your own work. Homework will be due at the beginning of class on the day it is due.

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

The mid-term exam 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.

The final exam will be comprehensive and will be given during the exam period. It will be divided into two components. The first will be an in-class component similar to the mid-term. The second component will be a take home problem set. You will be allowed to use of some specified reference material. You will also be expected to work independently.

Office hours
I will hold drop-in office hours on Monday from 1:00-3:00 PM. If you want to see me outside of office hours, please email me to make an appointment.

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.

Textbook and other reference materials

Large parts of the course will draw upon "Quantum Theory of Solids" by Charles Kittel. The bookstore carries the second edition, ISBN-13: 978-0471624127. I will also be supplementing the textbook with copies of my notes and material taken from other sources.

I recognize that students may find other books more suited to their learning style, and a number of other books are available. For these reasons the textbook is not mandatory. I recommend the following books if you find that Kittel's book does not meet your needs:

- *Solid state physics: principles and modern applications*, J. Quinn and K.-S. Yi.
- *Principles of condensed matter physics*, P. M. Chaikin and T. C. Lubensky.
- *A quantum approach to condensed matter physics*, P. L. Taylor and O. Heinonen.
- *Condensed matter field theory*, Alexander Altland and Ben Simons.
- *Introduction to superconductivity*, Michael Tinkham.

- *Solid state physics*, Ashcroft and Mermin.
- *Magnetism in condensed matter*, Blundell.
- *Superconductivity and superfluids in condensates*, Annett.
- *Quantum theory of the solid state*, Callaway.
- *Condensed matter in a nutshell*, G. D. Mahan.
- *Quantum field theory for the gifted Amateur*, Blundell.
- *Many-particle physics*, G. D. Mahan (This is a very advanced book but highly recommended if you plan on pursuing research in this field).

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 at the graduate level. 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 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. Treat your assignments as you would treat professional academic research.

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