PHYS 412/ELEC 461: SOLID STATE PHYSICS SPRING 2019

Instructors: *Pengcheng Dai*, Professor, Department of Physics & Astronomy, 362 Brockman Hall, pengcheng.dai@rice.edu (phone: 8656078067)

Teaching Assistants: Yaofeng Xie, graduate student, Yaofeng Xie <yx39@rice.edu>

Course location: SST 106, from 10:50 AM till 12:05 PM, TR each week.

Course Objective: This course will provide an introduction to elementary topics in solid state physics, including free electrons in metals, lattice vibrations, crystal structure, reciprocal lattice, electronic band structure, Bloch electron dynamics, and magnetism.

Course Outcomes: At the conclusion of PHYS 412/ELEC 461, students should have gained an understanding of and perform quantitative calculations concerning:

- Thermal, electrical, optical, and magnetic properties of a free-electron Fermi gas
- Phonons and their contributions to thermodynamic properties
- Crystal structure types and reciprocal lattice
- Energy states and dynamics of electrons in a periodic potential
- Types of magnetism, long-range magnetic order, and phase transitions
- Representative experimental methods for determining properties of solids (electrical resistivity, Hall coefficient, absorption coefficient, magnetization, specific heat, thermal expansion)

Required Textbook: Steven H. Simon, The Oxford Solid State Basics (Oxford University Press, 2013)

Recommended Textbooks: Charles Kittel, Introduction to Solid State Physics, 8th Edition (Wiley, 2005), and Neil W. Ashcroft and N. David Mermin, Solid State Physics (Holt, Rinehart and Winston, 1976)

Grading: 40% – Midterm Exams, 30% – Final Exam, 20% – Problem Sets, 5% – Module Quiz, and 5% In-Class Attendance

Exams: There will be two midterm exams and one final exam. They are in-class exams. Exams MUST be an individual effort, and any violations of this will be considered violations of the Rice Honor Code.

Class Format: Professor will give normal lectures but will also reserve classroom time for questions & answers, and discussions. We will also try to solve problems in class. After each class, the students are required to do quiz problems within 24 hours.

Homework: A problem set per week will be given, which students are required to download before each class. Questions concerning the homework problems will be discussed in class. Homework is due at 5:00 pm on Monday in the following week. Late homework will be accepted with a penalty of 10% per week after they are due.

Rice Honor Code: In this course, all students will be held to the standards of the Rice Honor Code, a code that you pledged to honor when you matriculated at this institution. If you are unfamiliar with the details of this code and how it is administered, you should consult the Honor System Handbook at http://honor.rice.edu/honor-systemhandbook/. This handbook outlines the University's expectations for the integrity of your academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process.

Disability Support Services: If you have a documented disability or other condition that may affect academic performance, you should: 1) make sure that this documentation is on file with Disability Support Services (111 Allen Center, adarice@rice.edu, x5841) to determine the accommodations you need; and 2) talk with one of the instructors to discuss your accommodation needs.

Syllabus Change Policy: This syllabus is only a guide for the course and is subject to change with advanced notice.

Course Schedule:

#1: 01/08; Introduction, overview and diverse experimental techniques

#2: 01/10; Solid State Physics and Modern Technology, Nanostructures and Thermopower

#3: 01/15; Early History of Metal Theory:1900-1930, Exact and Approximate Hamiltonians

#4: 01/17; Statistical and Thermal Properties

#5: 01/22; Electrical and Optical Properties

#6: 01/24; Magnetic Properties

#7: 01/29; Emergent Phases in Strongly Correlated Materials, Methods for Generating High Magnetic Fields

#8: 01/31; How Sound and Heat Travel in Air and Solids

#9: 02/05; Vibrations of Monoatomic and Diatomic Chains

#10: 02/14; Quantization of Lattice Vibrations, Phonon Heat Capacity

#11: 02/19; Phonons in Strongly Correlated Materials, Coherent Phonons in Nanostructures

#12: 02/21; Early History of Crystallography, Translational Symmetry and Bravais Lattices

#13: 02/26; Lattice Types and Reciprocal Space

#14: 02/28; X-Ray Diffraction

#15: 03/5; Periodic Potentials and Bloch's Theorem

#16: 03/07; The Kronig-Penney Model, the Tight-Binding Model, and the Reduced Zone Scheme

#17: 03/07; Metals, Insulators, and Semiconductors

#18: 03/21; Dynamics of Bloch Electrons

#19: 03/26; Heterostructures and Nanomaterials, Topological Matter

#20: 03/28; Magnetic Properties of Atoms

#21: 04/02; Paramagnetism and Diamagnetism

#22: 04/04; Ferromagnetism and the Curie-Weiss Law

#23: 04/09; Spin Waves in Ferromagnets

#24: 04/11; Antiferromagnetism: Types of Exchange Coupling

#25: 04/16; Magnetism of Strongly Correlated Materials

#26: 04/18; Summary of the semesters, problem solving session

February 7 – No Class (Spring Recess)

February 12 – 1st Midterm Exam

March 12 – No Class (Spring Break)

March 14 – No Class (Spring Break)

March 19 – 2nd Midterm Exam