PHYS 460: Condensed Matter Physics

Fall 2019

Prerequisite courses: Phys 435; 485 or 486. Familarity with quantum mechanics will be assumed.

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Office hours: 11am Thursday

Teaching Assistant: Paul (Yubo) Yang, 3137 ESB, yyang173@illinois.edu
Office hours, 10am Monday

Text Book: *The Oxford Solid State Basics* by Steven Simon.

Course website. http://courses.physics.illinois.edu/phys460/fa2019/

Grading: Homework will count 30%, the mid-term exam 25% and the final exam 45% of the total grade. We expect the grade structure to be:

100% ≥ A+ ≥ 96%, 96% > A ≥93% , 93%> A- ≥ 90%
90% > B+ ≥ 86%, 86% > B ≥83% , 83%> B- ≥ 80%
80% > C+ ≥ 76%, 76% > C ≥73% , 73%> C- ≥ 70%
70% > D+ ≥ 66%, 66% > D ≥63% , 63%> D- ≥ 60%
The cutoffs for the grades might be adjusted if needed.

Partial credit will be given on homework and exams if the work is coherent. Simple numerical errors will not be strongly punished, however errors which give incorrect physical results will be. The steps to receiving partial credit are: (i) write your solution neatly and coherently using equations and words to describe what you are doing (ii) check your answer for consistency, e.g. are units correct, does the solution behave correctly in known limits?

Homework: There will be one problem set every two weeks. The homework will consist of problems from the textbook and original problems. The homework problems will be posted on the course website 2 weeks before it is due. Homework is due 5pm on Monday starting on September 16 in the box on the 2nd floor of the Loomis-MRL interpass. If it is 1-day late it will receive only 80% credit, 2 days late 60%, 3 days late 40% and by 5pm on Friday 20%. After that no credit will be awarded. Submitted homework should be your own work and not copied from on-line resources. Graded homework returned 1 week later.

The Midterm Exam will be held on October 17th in class.

The Final Exam will be held during the exam period on Dec 20 from 8-11am in 144 Loomis.

Academic Integrity: See http://studentcode.illinois.edu/article1/part4/1-402/

Disability Accommodations -To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TTY), or e-mail a message to disability@illinois.edu.

Course Objectives: The goal of this course is to set the foundation for future coursework and research in condensed matter physics. We will cover topics such as electronic structure of crystalline systems, metals, semi-conductors, magnetically ordered materials, and touch on more advanced topics such as low-dimensional systems and superconductors. The book will not be strictly followed and extra material will be included in the lectures for which students are responsible.

Tentative weekly listing of topics with readings from the textbook (Simon)

1. Einstein and Debye models of solids (Chpt 2) Recap of quantum mechanics. Periodic boundary conditions.
2. Drude and Sommerfeld models (Chpts 3-4) Free electron model, state counting, Pauli principle, chemical potential. Core and conduction electrons.
3. Chemical bonding (Chpts 5-6) Ionic bonds, covalent bonds, Van der Waals forces.
4. Bravais Lattice (Chpt 12). Crystal lattices in 2 and 3 dimensions, unit cells, lattice vectors, crystal symmetries.
5. Reciprocal Lattice (Chpt 13), fourier transforms.
6. X-ray and neutron diffraction (Chpt 14) Bragg scattering, structure factor.
7. Tight binding models (Chpt 11) Application to one dimensional model.
8. Electrons in periodic potentials, (Chpt 15) Bloch's theorem. Brillouin zone.
9. Band theory of metals and insulators (Chpt 16). Fermi surface, localized electrons, Wannier functions.
10. Semiconductors (Chpts 17-18), electrons and holes, band mass.
11. Graphene. Dirac points.
12. Classical and quantum theory of the harmonic crystal (Chpts 8-10). Optical and acoustic phonons, Lindemann's rule.
13. Diamagnetism and paramagnetism of atoms (Chpt 19)
14. Magnetic Ordering (Chpts 20-22) ferromagnetism, electron exchange, mean field models.

15. Superconductivity, Meissner effect, electron pairing.