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Office Hours: TBD

Textbook: *Condensed Matter Physics* by Michael Marder.

Prerequisites: PHYS 435; PHYS 485 or PHYS 486. Quantum mechanics is a required pre-requisite for a reason and will be used. If you don't have this pre-requisite make sure you are comfortable enough with the material before the drop date.

Grade Structure: Homework will be 40% of the total grade, and exams is other 60%. There will be one midterm worth 15% and a final exam worth 45%.

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 superconductivity. A more detailed outline is given on the following pages.

Grading: Partial credit will be given on homework and exams if and only if the work is coherent. A random scattering of thoughts will not be awarded points. 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) checking your answer for consistency e.g. are units correct, does the solution behave correctly in known limits. When writing solutions on homework or exams, it is best to act as though you are explaining your method to a fellow class mate at your same level. That will require that you show your steps logically and lead the grader/reader through your solutions. Expect the exams to be challenging but grounded in lecture and homework material.

Homework: There will be roughly one problem set every two weeks, consisting of a combination of textbook questions and original problems. Homework will be posted on the course webpage and at 5:00 PM two weeks after first posted. Assignments will be penalized 25% for every day the homework is late. If one misses the 5:00PM deadline on Friday, the penalty for handing assignments on Monday is 50%. After 4 days (or 2 plus a weekend), absolutely no credit will be awarded. Academic dishonesty is a very serious matter. Any indications that homework solutions were derived from online internet sources will be acted upon accordingly.

Topics Covered: Lectures will be structured to follow the chapters from Marder, supplemented with material from outside sources. The course will include the topics listed below, roughly in the order given. Students should be aware, however, that both topics and order are subject to change without notice. Several topics will take more than one lecture. Lectures will cover:

1. Electrons in metals, and the Drude model (Chapter 16.1)
 - Base model and underlying assumptions
 - Conductivity, plasma frequency, Hall effect, thermal conductivity, Wiedemann-Franz law
 - Comparison to data: successes and failures
2. Sommerfeld theory and the effects of quantum mechanics (Chapter 6)
 - The free electron ground state and the Fermi surface
 - Fermi distribution
 - Density of states, energy and heat capacity
3. Lattices and the description of periodic structures (Chapters 1, 2 and 3)
 - Bravais lattices and lattice bases
 - Lattice types and symmetries
 - Reciprocal lattices and Fourier transforms
 - Indexing lattice planes and X-ray diffraction
4. Phonons (Chapter 13)
 - Toy models and calculations in 1D
 - Monatomic and diatomic lattices
 - Acoustic and optical modes
 - Phonons in 3D and polarization vectors
 - Inelastic neutron scattering
5. Electrons in a periodic potential (Chapter 7)
 - Consequences of discrete translational symmetry

- Describing periodic potentials and the Schrodinger equation
 - Bloch's theorem
 - Brillouin zones and crystal momentum
6. Electron models in a periodic potential (Chapters 7 and 8)
- Nearly free electron model
 - Tight binding model
 - Kronig-Penney model
 - Band theory: metals versus insulators
 - Effective mass, Fermi surfaces and measurement with ARPES
7. Semiconductors physics and devices (Chapter 19)
- Intrinsic semiconductors, electrons and holes
 - Semiclassical equations of motion and effective mass
 - Extrinsic semiconductors
 - Interfaces and diodes
 - Transistors
 - 2DEGs
8. Magnetism (portions of Chapters 24, 25 and 26)
- Introduction to magnetism: Pauli paramagnetism, local spins and Hund's rules
 - Curie paramagnetism and Larmor diamagnetism
 - Exchange and the origin of interactions
 - Spontaneous symmetry breaking and magnetic order