PHYS422/822 (ELEC422/822) Introduction to Physics and Chemistry of Solids

Spring 2023

Lecture: Tues/Thurs: 11:00 am - 12:15 pm, Jorgensen Hall 245
Instructor: Xia Hong (Jorgensen Hall 310J, 472-2779, xhong2@unl.edu)
Office Hours: drop-in or by appointment

Course Goals and Objectives:

This course aims at introducing the basic structural, thermal, electrical, and magnetic properties of solids, and the materials design and operation principles for solid-state devices. The topics covered include the concepts of atomic structure, chemical bonding, and electron states in solids, thermal and electrical transport theory, and the physics of semiconductor devices.

The overall learning objectives are to have you gain the ability to apply basic quantum mechanics, mechanics, electricity and magnetism concepts and techniques to solve for issues related to solid state systems. We will emphasize developing both conceptual understanding and problem-solving skills for these topics and understanding how they fit into the broader picture of science and technology.

Pre-requisites:

PHYS 213 or CHEM 481/881, MATH 221/821, or permission. The course assumes knowledge of basic quantum mechanics, electricity and magnetism, wave motion, and thermodynamics.

Textbook:

Charles Kittel, "Introduction to Solid State Physics" 8th Edition (Wiley)

Lectures:

Class meetings are held in-person. Some classes may be conducted via Zoom or other modes depending on the specific situation. The Inclement Weather Policy can be found at the end of the syllabus. The lecture notes will be posted on Canvas weekly.

Homework:

Homework assignments are posted on Canvas. The solutions should clearly explain all the important steps. You may discuss ideas and approaches with other students after you have spent some time thinking about these problems. However, you are required to complete all the technical steps yourself. Copying homework (either from an external source or from fellow students) is considered cheating. (http://stuafs.unl.edu/ja/code/three.shtml) Please note that the quizzes and exams will assume that the HW problems have been worked on, digested, and understood.

Homework is to be graded by the graders. Late homework will be accepted only if the grader agrees. If you believe your grade is incorrect or unfair, please first approach the grader before you appeal it to me.

Quizzes:

There are in-class quizzes. For 422 students, the lowest quiz score will be dropped.

Exams:

There are two midterm exams and one final exam. Below is a tentative schedule and the midterm dates may change depending on the class progress.

First Midterm Exam: Tues. Mar. 7, in class
Second Midterm Exam: Tues. Apr. 11, in class
Final Exam (exam week): Thurs. May 18, 3:30 to 5:30 pm

Grade:

Homework	20%
Midterms (2)	20%×2
Quizzes	10%
Final Exam	30%

Course grades will be assigned according to the following point scale (total: 100 points):

100-95	A^+
94.9-90	A
89.9-86	A^-
85.9-82	B^+
81.9-78	B
77.9-74	B^-
73.9-70	C^+
69.9-66	C
65.9-62	C^-
61.9-58	D^+
57.9-54	D
53.9-50	D^-
less than 50 points	F

Course outline:

1. Crystal structure (Kittel Chs. 1 and 2)

Crystal lattice, Basis vectors, Unit cell, Types of lattices, Index system for directions and planes, Simple crystal structures, X-ray diffraction, Reciprocal lattice, Brillouin zones

2. Crystal Binding (Kittel Ch. 3)

Interatomic forces, Cohesive energy, Ionic bonds, Covalent bonds, Metallic bonds, van de Waals bonds

3. Crystal Vibrations and thermal properties (Kittel Chs. 4 and 5)

Vibrations in a continuous media; Vibrations in monoatomic and diatomic lattices, Density of States, Acoustic and optical modes, Phonons, Heat capacity, Thermal conductivity

4. Free electron theory and electron transport (Kittel Ch. 6)

Conduction electrons, Energy levels of free electrons, Density of states, Fermi energy, Electrical conductivity, Heat capacity, Thermal conductivity, Motion in magnetic fields

5. Band structure of solids (Kittel Chs. 7 and 9)

Crystal potential, Bloch theorem, Crystal momentum, Electronic bands, Nearly-free-electron model, Classification of solids, Fermi surface, Methods for calculating band structure. Band structure of selected metals, Fermi velocity, Electron dynamics, Motion in magnetic fields

6. Semiconductors and Semiconductor devices (Kittel Ch. 8)

Crystal structure and bonding, Electronic structure, Electrons and holes, Effective mass, Mobility, Impurity states, Motion in magnetic fields, P-n junctions, Diodes, Field-effect transistors, Optoelectronic devices

Services for Students with Disabilities: The University strives to make all learning experiences as accessible as possible. If you anticipate or experience barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can discuss options privately. To establish reasonable accommodations, I may request that you register with Services for Students with Disabilities (SSD). If you are eligible for services and register with their office, make arrangements with me as soon as possible to discuss your accommodations so they can be implemented in a timely manner. SSD contact information: 117 Louise Pound Hall; 402-472-3787.

Academic Integrity: Academic honesty is essential to the existence and integrity of an academic institution. The responsibility for maintaining that integrity is shared by all members of the academic community. The University's Student Code of Conduct addresses academic dishonesty. Students who commit acts of academic dishonesty are subject to disciplinary action and are granted due process and the right to appeal any decision.

Intellectual Property and Privacy Issues: Any material related to this course should be treated as the intellectual property of the instructor or creator of the material, and is not to be shared outside the context of this course. Students may not make or distribute files, screen captures, audio/video recordings of, or livestream, any class-related activity, including lectures and presentations, without express prior written consent from the instructor. Failure to follow this policy on recording or distributing class-related activities may subject you to discipline under the Student Code of Conduct.

Inclement Weather Policy:

If in-person classes are cancelled, you will be notified of the instructional continuity plan for this class by announcements on Canvas.

See http://go.unl.edu/coursepolicies for information on University-Wide Course Policies and Resources.