University of CINCINNATI

Syllabus

MTEN6110-5010, Physical Properties of Solids

Instructor Name: Prof. Donglu Shi
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Office Location: 493 Rhodes Hall
Office Hours and Location:
Zoom: https://ucincinnati.zoom.us/s/9377684662#success

Course Overview, Description, Purpose

Overview: The conventional classification of materials defines and divides materials into metals, ceramics, polymers, and composites mainly based on their lattice structures, bonding mechanisms, and mechanical behaviors. Materials can also be categorized into electronic materials in terms of their band structures, physical properties, and special functions such as conductors, semiconductors, dielectrics, magnetic materials, optical materials, and smart materials. It is essential for material science students to have the basic knowledge of physical properties for them to conduct dissertation research in electronic materials.

Course description: This course is intended to provide the background relating to the major physical properties of solids including electrical conductivity, semiconductivity, dielectricity, piezoelectricity, magnetism, fluorescence, photonics, particularly those of emerging advanced nanomaterials in energy and biomedical applications. It is also intended to prepare both undergraduate and graduate students for the most active research in today's high-tech industry such as energy materials, nanomedicine, semiconducting devices, sensors, photovoltaic, transducers, energy storage and generation, optical devices, and telecommunications. This course will provide the basic knowledge that enables students to work in a highly interdisciplinary environment.

Purpose: In the recent decade, materials research has rapidly advanced in many areas of science and technology such as renewable energy, biomedicine, environmental sustainability. A new paradigm of material classification has emerged with fundamentally different views in materials science and engineering. The purpose of this course is to intellectually challenge students to explore new materials and properties in applications of green energy, well-being of humans, and safe built environment. This course is designed not only to inspire innovative and creative ideas in materials science but also to cultivate awareness of ethics and global issues.

Course Learning Outcomes

Upon successful completion, students will have the knowledge and skills to:

1. Think critically and creatively about the design of new materials and structures that offer unique properties required for energy and medical applications.
2. Understand the fundamental physical properties and their applications in novel energy and medical applications.
3. Understand the key issues in global energy, healthcare, and environment, and the current strategies to address them via advanced materials science and engineering.

4. Demonstrate an ability to work effectively in highly interdisciplinary research and working environment.
5. Articulate the basic principles of new technologies that are currently used in energy and nano medicine.
6. Aware of societal and environmental impacts of the nano technologies.

Pre-requisites

Any 2000-3000 level physics courses such as PHYS 2005, 2006, 3020, 3021

Academic Program Prerequisites

This dual-level course is available to both undergraduate and graduate students from all engineering programs

Academic Level Prerequisites

Any fundamental physics courses required in the undergraduate engineering programs

Course Format

Single activity format.

Course Materials

Required readings/equipment/technology

Reference Books:

The Science and Engineering of Materials (6th edition)

Donald R. Askeland

The Solid-State Electronic Devices (6th edition), Ben Streetman

Understanding Solids, Richard Tilley

Introduction to Solid State Physics, Charles Kittel (6th edition)

Assessments/Activities and Grading Policy

Grading standard for a class average of 75% or above

90% to 100% - A, 80% to 89% - B, 70% to 79% - C, 60% to 69% - D, 59% or below – F

Grading policy

1. Midterm1.....30%
2. Midterm 2.....30%
3. Final..... 40%

Classroom Procedures/Policies

Communication

Students can reach the instructor via email (donglu.shi@uc.edu) or work telephone (513 556 3100) for any class related issues. Help sessions on homework and exams can be arranged in person in 493 Rhodes Hall or online via Zoom (https://ucincinnati.zoom.us/s/9377684662#success) at pre-scheduled times and office hours.

Technology use during/for class
All course materials including lecture notes, videos, homework, and solution keys are all uploaded on Canvas. The lectures will be given in person in the designated classroom with all electronic technologies, unless otherwise notified. To learn more about accessibility at the University of Cincinnati, visit https://www.uc.edu/about/accessibility-network.html

Attendance Policy
The instructor must be notified of any absence in advance.

Faculty attendance
In case the instructor does not arrive within the first 15 minutes of class, students may assume that the class is no longer offered in person on that day and they may leave without any consequences. The recorded lecture is available on Canvas.

Class Cancellation Policy
In case a class is cancelled for unexpected reasons, the recorded lecture for that class will be made available on Canvas with detailed instructions and assignments.

Diversity, Equity, and Inclusion Statement
We highly value the participation and contributions of those from diverse backgrounds and perspectives.

Notice of Non-Discrimination
This class will be built and conducted in a welcoming and inclusive environment where discrimination, harassment, and retaliation are not tolerated.

Accessibility Policy
We highly value accessibility and work to create an inclusive and equitable environment to provide universal access. Information regarding the Accessibility Policy can be found at https://uc.instructure.com/courses/1456074

Trigger Warning
Our classroom provides an open space for the critical and civil exchange of ideas. The instructor will aim to forewarn students about potentially disturbing content and ask all students to help to create an atmosphere of mutual respect and sensitivity.

Academic Integrity
Academic integrity is critically important as a core university value for academic success of students. Therefore, we expect that students will conduct themselves in an honest and ethical manner and respect the intellectual work of others.

Specific instructions for academic integrity will be provided before each assignment such as homework and exams.

Student Resources
The following websites provide the university resources to address students' academic success as well as their health and wellness. https://online.uc.edu/student-resources/ https://uc.instructure.com/courses/1456074

Course Calendar

Week	*Lecture Topics*	*In-Class Activities*	*After class Reading*
1	Introduction to Physical Properties of Solids	Lecture in class	Read notes and watch class video
2	Electrical conductivity of metals, Power transmission, AC vs DC	Lecture in class	Read notes and watch class video
3	Microscopic Ohm's law, Origin of resistivity	Lecture in class	Read notes and watch class video
4	Conductivity of semiconductors, Conductivity of ionic conductors, Hall Effect	Lecture in class	Read notes and watch class video
5	Insulators and dielectric properties, Polarization in dielectrics	Lecture in class	Read notes and watch class video
6	Quantum mechanics, Wave-Particle duality, The Uncertainty Principle	Lecture in class	Read notes and watch class video
7	Schrodinger equation, Electron in free space, The Infinite potential well	Lecture in class	Read notes and watch class video
8	Electronic structures, Energy band theory, Density of states, Fermi-Dirac distribution,	Lecture in class	Read notes and watch class video
9	p-n Junctions, Equilibrium conditions Field-Effect Transistors, Semiconducting materials, and devices	Lecture in class	Read notes and watch class video
10	Dielectricity, Piezoelectricity, Pyroelectricity, Ferroelectricity	Lecture in class	Read notes and watch class video
11	Magnetic dipoles and magnetic moments, magnetization, permeability, and magnetic field	Lecture in class	Read notes and watch class video
12	Ferromagnetic, ferrimagnetic, diamagnetic, and paramagnetic	Lecture in class	Read notes and watch class video
13	Domain structure and the hysteresis loop, The Curie temperature, Applications of magnetic materials	Lecture in class	Read notes and watch class video
14	The Electromagnetic spectrum, Refraction, reflection, absorption, and transmission	Lecture in class	Read notes and watch class video
15	Optical properties and materials, Light scatting, LASER, Fluorescence and Phosphorescence	Lecture in class	Read notes and watch class video

I reserve the right to update this syllabus as class needs arise. Be assured that I will communicate to you any changes to our schedule, syllabus, or policies quickly and efficiently through Canvas.