MT319 Materials Physics

Course Information

Course Number: **MT319**

Course Name: **Materials Physics**

Course Hours: **64**

Course Credits: **4**

Prerequisites: Calculus, General Physics, Fundamental of Materials Science

Course Outcomes:

On the successful completion of this course, the student will be able to:

1. Have a general understanding in the description of a crystal.
2. Understand how electrons or electromagnetic waves are scattered by crystal lattice.
3. Know how the atoms are bonded to form crystals.
4. Understand how to describe the atom vibrations in crystals and the concept of phonons.
5. Understand how the atomic vibration modes affect the thermal properties of a crystal.
6. Understand the fundamental concepts of quantum mechanics as involved.
7. Understand what the classical description of the electrons states in metals is.
8. Understand the origin of energy bands for crystals.
9. Understand basic concepts of semiconductors.

Course Outline

SOLID-STATE PHYSICS (I)

1. Crystal Structure (4 hours)
1.1 Introduction of the Course
1.2 Periodic Array of Atoms
1.3 Fundamental Types of Lattices
1.4 Simple Crystal Structure

2. Wave Diffraction and the Reciprocal lattice (6 hours)
2.1 Diffraction of Waves by Crystals
2.2 Scattered Wave Amplitude
2.3 Brillouin Zones
2.4 Fourier Analysis of the Basis

3. Crystal Binding (4 hours)
3.1 Crystals of Inert Gases
3.2 Ionic Crystals
3.3 Covalent Crystals
3.4 Metals and Hydrogen Bonds

4. Crystal Vibrations (4 hours)
4.1 Vibrations of Crystals with Monatomic Basis
4.2 Two Atoms Per Primitive Basis
4.3 Quantization of Elastic Waves

QUANTUM MECHANICS

1. The Wave Function (4 hours)
1.1 The Schrodinger Equation
1.2 The Statistical Interpretation
1.3 Probability
1.4 Normalization
1.5 Momentum
1.6 The uncertainty Principle

2. The Time-independent Schrodinger Equation (6 hours)
2.1 Stationary States
2.2 The Infinite Square Well
2.3 The Harmonic Oscillator
2.4 The Free Particle
2.5 The Delta-Function Potential
2.6 The finite Square Well

3. Formalism (8 hours)
3.1 Linear Algebra
3.2 Function Spaces,
3.3 The Generalized Statistical Interpretation
3.4 The Uncertainty Principle

4. Quantum Mechanics in Three Dimensions (2 hours)
4.1 Schrodinger Equation in Spherical Coordinates
4.2 The Hydrogen Atom
4.3 Angular Momentum
4.4 Spin

SOLID-STATE PHYSICS (II)

5. Thermal Properties (6 hours)
5.1 Phonon Heat Capacity
5.2 Anharmonic Crystal Interactions
5.3 Thermal Conductivity

6. Free Electron Fermi Gas (6 hours)
6.1 Energy Levels in One Dimension
6.2 Free Electron Gas in Three Dimensions
6.3 Electrical Conductivity and Ohm's Law

7. Energy Bands (8 hours)
7.1 Nearly Free Electron Model
7.2 Bloch Functions
7.3 Kronig-Penney Model
7.4 Wave Function of Electron in a Periodic Potential

8. Semiconductor Crystals (4 hours)
8.1 Band Gap
8.2 Equation of Motion
8.3 Intrinsic Carrier Concentration
8.4 Impurity Conductivity

Assessment:

1. Lecture Attendance (10%)
2. Homework (20%)
3. Final Examination (70%)

Textbook & References:

1. C. Kittel, *Introduction to Solid State Physics.* 8th edition, John (Wiley & Sons, Inc. 2005).

2. David J. Griffiths, Introduction to Quantum Mechanics, 2nd edition, (Pearson Prentice Hall, 2004).