Basics of Condensed Matter Physics

Upon completion of Basics of Condensed Matter Physics with focus on Basics of Condensed Matter Physics 1, students will be able to:

Knowledge:
1. Define the classical theory of lattice vibrations in 3-dimensions under harmonic approximation.
2. Explain the concept of dispersion relation including acoustical and optical, transverse and longitudinal modes.
3. Describe lattice vibrations in a monatomic simple cubic lattice and the concept of vibrational modes and phonons.
4. Discuss the phonon-phonon interaction and the principles of Inelastic Neutron Scattering.
5. Analyze neutron diffraction by lattice vibrations and the Mossbauer effect.
6. Understand the Boltzmann transport equation and relaxation time in electronic transport properties.
7. Explain the electrical conductivity of metals, impurity scattering, and ideal resistance at high and low temperatures.
8. Discuss electronic properties in a magnetic field including the Hall effect and magnetoresistance in a two-band model.
9. Analyze K-space analysis of electron motion in a uniform magnetic field and thermoelectric effects.
10. Describe energy levels and density of states in a magnetic field, Landau diamagnetism, cyclotron resonance, and the de Haas-van Alphen effect.

Skills:
1. Apply the concepts of lattice dynamics and electronic transport properties to solve theoretical problems.
2. Analyze and interpret experimental data related to lattice vibrations and electronic transport phenomena.
3. Develop computational models for lattice dynamical modeling and electronic transport simulations.
4. Utilize neutron diffraction and Inelastic Neutron Scattering techniques in the study of condensed matter systems.
5. Evaluate the impact of impurity scattering and Umklapp-processes on electronic conductivity in metals.
6. Investigate the behavior of electrons in magnetic fields and analyze the resulting Hall effect and magnetoresistance.
7. Apply the principles of quantum mechanics to understand Landau diamagnetism, cyclotron resonance, and the de Haas-van Alphen effect.
8. Demonstrate critical thinking and problem-solving skills in analyzing complex electronic transport phenomena in condensed matter systems.

Application:
1. Implement theoretical models to analyze and predict the behavior of lattice vibrations and electronic transport in real-world materials.
2. Design experiments or simulations to investigate specific properties of condensed matter systems based on the knowledge gained in the course.
3. Evaluate the implications of different types of phonon-phonon interactions on the thermal and electrical properties of materials.
4. Demonstrate the application of principles of quantum mechanics in understanding electronic properties in magnetic fields.
5. Analyze and interpret experimental data related to electronic transport properties and lattice dynamics in condensed matter systems.
6. Apply computational techniques to simulate and analyze the behavior of electrons in magnetic fields and their impact on material properties.
7. Propose innovative solutions to engineering problems related to electronic transport and lattice vibrations in condensed matter systems.