Advanced and Soft Condensed Matter

Course Outcomes:

Upon completion of this course, students will be able to:

1. Remember:
- Recall the basic phenomenology of superfluid helium 4, including the transition to Bose-Einstein condensation and the two-fluid model.
- Explain the concept of vortices in a rotating superfluid, the Roton spectrum, and calculate specific heat.
- Describe the critical velocity and the superfluid phases of Helium-3.

2. Understand:
- Understand the Hubbard Model and its implications in correlated systems.
- Explain the Mott insulator and the Kondo effect in condensed matter physics.
- Analyze disorder in condensed matter, including substitutional, interstitial, and positional disorder, and its effects on short and long-range order.

3. Apply:
- Apply the Anderson model to analyze disorder in condensed matter and understand the concept of mobility edge.
- Apply the Minimum Metallic Conductivity concept to amorphous semiconductors and hopping conduction.
- Analyze percolation phenomena and associated phase transition properties in disordered systems.

4. Analyze:
- Analyze the forces, energies, and time scales in soft condensed matter systems.
- Analyze the dynamics of wetting, surface tension, and droplet spreading on solid and liquid substrates.
- Analyze the viscous, elastic, and viscoelastic behavior of soft condensed matter and understand the mechanical response at a molecular level.

5. Evaluate:
- Evaluate the practical glass forming systems and understand the Zachariasen criteria for glass formation.
- Evaluate the relaxation time, viscosity, and glass transition temperature in glass-forming liquids using the two-state theory.
- Evaluate the behavior of liquids and glasses in terms of rheological properties and understand the concept of viscous fingering.