Paper-14C

Advanced and Soft Condensed Matter Physics

Group A: <u>Advanced Condensed Matter Physics</u> **[36 Lectures]**

Superfluidity: Superfluid Helium 4 : Basic Phenomenology; Transition and Bose-Einstein condensation; Two fluid model; Vortices in a rotating superfluid, Roton spectrum and specific heat calculation, critical velocity, Superfluid Helium 3: Basic Phenomenology; Pair condensation in a Fermi liquid, Superfluid phases of Helium-3

[12L]

Correlated Systems: Hubbard Model, Mott insulator, Kondo effect.

[6L]

Disordered systems: Disorder in condensed matter: substitutional, interstitial and positional or topographical disorder; Short and long-range order; Anderson model; mobility edge; Minimum Metallic Conductivity, Qualitative application of the idea to amorphous semiconductors and hopping conduction. Percolation phenomena and the associated phase transition properties.

[18L]

Reference Books:

1. Solid State Physics by N. W. Ashcroft & N. D. Mermin
2. Solid State Physics by H. Ibach & H. Löth

3. Introduction to Solids by L. V. Azaroff

4. Introduction to Superconductivity by M. Tinkham

5. Principles of the Theory of Solids by J. M. Ziman

Group B: <u>Soft Condensed Matter Physics</u> **[36 Lectures]**

Soft condensed matter: Introduction and Overview, Forces, energies and time scales in condensed matter, Forces and Energy scales: Atomic and molecular forces, van der Waals forces, Casimir forces, Hard core repulsion, Entropy.

[3L]

Rheology: Capillarity and wetting: Surface and interfacial tension, dynamics of wetting, shapes of droplets – solid substrates and liquid substrates, droplet spreading dynamics; Viscous, elastic and viscoelastic behaviour - response of matter to a shear stress, mechanical response of matter at a molecular level; Viscous fingering. Liquids and Glasses - practical glass forming systems, Zachariasen criteria, relaxation time and viscosity in glass forming liquids, glass transition temperature, two state theory.

[9L]

Liquid crystals: Classification, Nematic liquid crystals order, singularity, elasticity, display application, lamellar properties, Cholesterics, Lamellar systems– structures and properties, chiral systems, Smectics and Columnar
systems – structures and properties, phase transitions, preparation of liquid crystals and application to liquid crystal displays.

[8L]

Macromolecules: Polymers: random walks and dimension of polymer chains, viscoelasticity in polymers and the repetition model; Biological polymers: stretching single macromolecules, Protein folding.

[8L]

Supra-molecular self assembly in soft condensed matter: Introduction, Self assembly in polymers. Fractals in polymers – disorder and scale invariance, random aggregation, diffusion limited aggregation , self assembled phases in solutions of ampiphilic molecules; Applications – soaps and detergents, thin films, foams and biological cells.

[8L]

Reference Books:

1. Soft Condensed Matter, Richard A. L. Jones (Oxford University Press, 2002)
2. Structured Fluids: Polymers, Colloids, Surfactants, Thomas A. Witten (Oxford University Press, 2004)
3. Scaling concepts in Polymers, P. G. De Gennes (Cornell University Press,
1979)
4. Principles of condensed matter, Sections 1,2 and 6, P M Chaikin, T C Lubensky (Cambridge University Press, 1995)
5. Soft Matter Physics: An Introduction, Maurice Kleman, Oleg D Laverntovich, J. Firedel, (Springer, 2000)