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PH XXX Advanced Condensed Matter Physics

Objectives: To introduce various theoretical methods to solve problems in condensed matter systems.

Unit - I Correlated Electron Physics: Second quantization review, Hubbard model, Heisenberg model; Materials phenomenology, magnetic phases, CDW states; Quantum magnetism, Stoner criterion, double exchange; Superconductivity, Cooper argument, BCS, gap equation, Bogoliubov-de Gennes equations, strong coupling theory, RVB and modern approaches to superconductivity in correlated systems.

Unit - II Quantum Hall effect: Quantum Hall effect, integer and fractional, edge states, Laughlin and Jain wave functions, topological defects; Luttinger liquids, Bethe ansatz; Mesoscopic physics; Disordered electronic systems and metal insulator transitions.

Unit - III Soft Condensed Matter Physics: Interactions in soft matter, entropic interactions, fluctuation- induced interactions, hard sphere statistical mechanics and crystallization; Self-assembly of amphiphiles, phases, theoretical approaches; Colloids, self-assembly, the freezing transition; Polymers, polymer structure, self-avoidance, Edwards model, osmotic pressure, Flory-Huggins theory, screening, semi-flexibility, persistence length;

Unit - IV Models for Biological systems: Membranes, biological membranes, lipid bilayers, physical properties, de Gennes-Taupin length, tethered membranes; Liquid crystals, nematic, cholesteric and smectic, order parameters, Frank free energy, Landau-de Gennes model defects, defect phases;

Unit - V Hydrodynamics: Survey of hydrodynamics, hydrodynamic approaches to soft matter physics, dynamical properties of polymers, membranes, colloids; Soft matter away from equilibrium, shear-induced phases; Optional: Granular media and Glasses;

Evaluation Method: Two tests – 40 Marks, Assignment – 10 Marks and Final Semester Exam – 50 Marks.

Outcome: Basic theoretical foundations and understanding will be enriched upon completion of this course.

Text books and References:

1. M. P. Marder, Condensed Matter Physics, Wiley-Interscience, 2000.
2. A. Altland and B. Simons, Condensed Matter Field Theory, Cambridge University Press, 2006.
3. G. D. Mahan, Many-Particle Physics, Springer, 2010.
4. P. M. Chaikin and T. C. Lubensky, Principles of Condensed Matter Physics, 1st Edition, Cambridge University Press, 2000

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95th BoS to be placed before Senate physics for course approval.