Department of Physics
IIT Kanpur

PHY623-Course Handout
Semester- I, 2024-25

Condensed Matter Physics-I (PHY623)

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Lectures: Monday, Tuesday and Thursday (10:00 – 11:00)

Tutorial: Friday (14:00-15:00) **Office hour:** Friday (11:30 – 12:30) or *by appointment*

Syllabus (40 lectures in total)

1. **Free electron theory:** Drude and Sommerfeld theory of metals to understand electric and thermal transport, Hall effect and heat capacity. *5 lectures*
2. **Structure and geometry of solids:** Chemical bonding (such as Ionic, Covalent and Van der Waals bonding), Crystal lattices, Neutron and X-Ray diffraction, Crystalline symmetry groups. *3 lectures*
3. **Phonons:** Lattice vibrations, optical and acoustic phonons, Specific heat, Thermal transport, Anharmonic effects, Experiments. *5 lectures*
4. **Band theory:** Bloch's theorem, Kronig-Penney model, Nearly-free electron model, tight-binding model. Metals, semiconductors and insulators. Examples in square and hexagonal lattices, Basic idea of Berry curvature and topology of electronic band structure. *6 lectures*
5. **Semiconductors:** Intrinsic & extrinsic, impurity levels, semiconductor devices. 4 *lectures*
6. **Electronic transport:** Semiclassical electron dynamics, Boltzmann transport theory, Landau levels, Quantum Hall effect, Quantum oscillation and topology of Fermi surface. *6 lectures*
7. **Magnetism:** Pauli paramagnetism, Landau diamagnetism, Exchange interactions, Ferromagnetism and antiferromagnetism, spin waves. *6 lectures*
8. **Superconductivity:** Phenomena of superconductivity and phenomenological understanding, Flux quantization and Josephson effect, BCS theory. *5 lectures*

Evaluation: Two surprise quizzes- 15% each (One before and one after the midsem), Midsem exam- 30%, Final exam- 30% and Attendance (> 85%)- 10%. Fail with marks < 40%. Absolute grading policy will be followed.

Recommended textbooks:

1. *Solid State Physics* by N. W. Ashcroft and N. D. Mermin
2. *Introduction to Solid State Physics* by C. Kittel
3. *Solid State Physics* by H. Ibach and H. Lüth