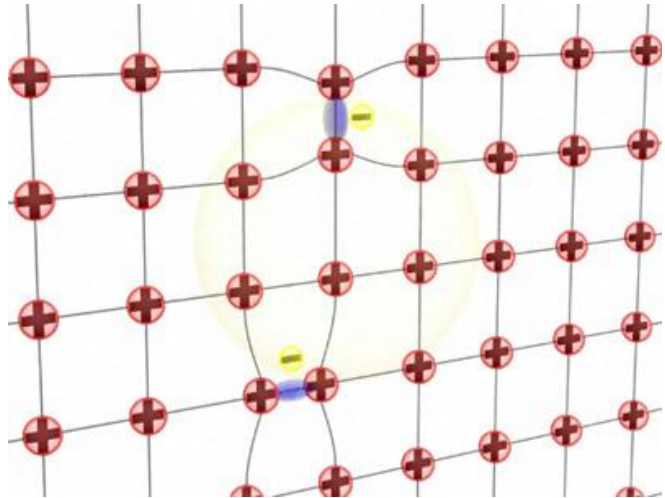


PHY 332: Condensed Matter Physics
PHY 535: Advanced Condensed Matter Physics

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| Instructor: | Muhammad Sabieh Anwar |
| Year: | 2025-2026 |
| Email: | sabieh@gmail.com and sabieh@lums.edu.pk |
| Website | http://www.physlab.org |
| Lecture format: | Two 75 minutes lectures per week |
| Lecture schedule: | Tuesday and Thursday; 11 am to 12:15 pm |

Course Description:

The purpose of the course is to introduce students to the structure of the solid phase of matter and how the properties can be derived from a quantum understanding of electrons, phonons and their interactions, modulated by the periodic arrangement of atoms. Emphasis will be made on the band structure and methods to determine the same. There will be special focus, towards the end, on the burgeoning field of low-dimensional materials as well as the ubiquitous semiconductors. After the course, the students will be familiar with the basics of condensed matter physics, enabling them to take more advanced courses focusing on unique materials properties in the electronic, optical, magnetic, thermal, and acoustic regimes as well as specialized courses on mesoscopic physics and devices.



Pre-requisites:

PHY 312 (Quantum Mechanics-II) and PHY 313 (Statistical Physics)

Text books:

The Oxford Solid State Basics by Steven H. Simon (Oxford University Press)

Selected topics from: *Band Theory and Electronic Properties of Solids* by J. Singleton (Oxford University Press) 2006.

Grading scheme:

Homeworks: 30%

Mid-Term 30%

Final Exam 40%

The instructor has the liberty of varying these grade assignments by 5%.

Tentative Course Schedule & Topics:

| Lectures | Topic | Some Particular Applications |
|----------|--|---|
| 1-6 | Crystal Structure: symmetry, lattice, crystal systems, crystal structures, identifying planes, directions, point and space groups | Correlation between structure and solid properties (ferroelectricity, High- T_c superconductors, graphite and graphene) |
| 7-10 | Reciprocal Lattice: reciprocal lattice, Brillouin zones, Fourier analysis of the basis | Determining crystal structure using X-ray and electron diffraction |
| 11-14 | Free electron Fermi gas: free electron gas in three dimensions, heat capacities due to free electrons, electrical conductivity, thermal conductivity, thermoelectric effect | Liquid He ³ , Fermi gases in astrophysics, classic Hall effect, magneto-resistance and GMR sensors |
| 15 | Review and Mid-Term | |
| 16-20 | Effect of the periodic potential: Bloch's theorem, nearly free electrons, Bloch functions, Kronig-Penney model, | Difference between metals, insulators and semiconductors, |

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|--------------|---|--|
| | effective masses, tight-binding model | band gap engineering, photoconductivity and optical properties |
| 21-24 | Semiconductors: electrons and holes, electrical conductivity, intrinsic and extrinsic behaviors, equilibrium and non-equilibrium carrier densities | Basic semiconducting heterostructures (diodes, junction field-effect transistors, metal-oxide semiconducting FET's), semiconducting heterostructures, molecular beam epitaxy, semiconductor laser action |
| 25-28 | Magnetism: diamagnetism, paramagnetism, exchange interaction, ferromagnetism, anti-ferromagnetism, spin waves | Ferromagnetic domains and Kerr microscopy, superconductors are perfect diamagnets |
| 29 | Final Exam | |