Department of Physics
Indian Institute of Technology Kanpur

Course Title: Quantum Phenomena in Materials

[also known as: Quantum Processes in low dimensional semiconductors]

Course Number: PHY312

Course Units: 3-0-0-0 (9)

Course Instructor: Adhip Agarwala

Course Timings: Monday and Wednesdays (5.15pm to 6.30pm, Lecture time: 75mins)

Total Lectures: ~26 Lectures

Course Objective:

The course, targeted towards undergraduates, will open a window to the materials around us and show that even to understand the most basic of their properties we need intricate quantum mechanics. The course will introduce students to a variety of ideas in understanding phases of matter – free fermions as in for metals, band theory for semiconductors, and will provide a basic introduction to magnetism. Furthermore the course will discuss the origin of various properties of such systems - their mechanical properties, origin of color, optical properties, electrical and thermal transport and role of magnetic field. The course will end with an overview of the new generation of materials, nano-structures and some experimental/theoretical overview of methods.

Prerequisite: Quantum Mechanics [PHY204/PSO201A]

Syllabus:

Lectures	Topics
2	Materials around us , Scales and symmetries (1), Condensed matter physics, Why is quantum mechanics necessary? (1)
10	Free Electron Gas (fermi surface, density of states, metals and alloys), Band theory (3), Insulators around us (crystalline, amorphous, polymers) (2), Origin of Spin (1), Magnetism, Magnets around us (ferro, antiferro, ferrofluids) (2), Superconductivity and Superfluidity (2)
10	Origin of color (metals, organic compounds, insulators, glass) (2), electrical properties of metals, (Drude theory) (2), Semiconductors (concept of holes, non-linear effects, device physics) (2), thermal transport (phonons, anharmonic effects) (2), effect of magnetic field (Ahranov Bohm, Shuvnikov-de Haas, quantum Hall) (2)

3	Low dimensional systems, what changes? Quantum wires, quantum dots, nanowires, excitons (2), Overview of State of the Art Experimental Methods (1)
1	A tour of new ideas (topological phases, correlated phenomena, driven matter)

References: [No textbook]
Suggested readings:
(i) Solid State Physics, by Charles Kittel
(ii) DJ Griffiths, Introduction to Quantum Mechanics

Evaluation Scheme:
Quiz (20%), Mid-Sem Examination (20%), Final Examination (30%), Assignments (20%), Readings (10%)