

Department of Physics

Indian Institute of Technology Kanpur

Course Title: Introduction to Quantum Materials

Course Number: PHY406

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

Course Instructor: Adhip Agarwala

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

Venue: TBA

Total Lectures: ~26 Lectures

Prerequisite: Knowledge of Quantum Mechanics [PHY204/PSO201A]

Office hours: (Please send an email to: adhip@iitk.ac.in)

First lecture: TBA

Course Objective:

The course, targeted towards undergraduates, will open a window to understanding materials around us that are important for science and technology. The course will introduce students to a variety of ideas in understanding different phases of matter – free electrons as in for metals, band theory for semiconductors, and will provide a basic understanding of their electrical and magnetic properties. This will prepare the students well for advanced courses in multiple departments and as well provide them a new appreciation for the quantum world around us.

Syllabus:

Lectures	Topics
5	Overview: Scales and symmetries in physics, Bird's eye view of materials around us (2), Brief Review of Quantum Mechanics and Thermal Physics (Equipartition Theorem, Quantum and Classical Distribution Functions) (3)
8	Metals, Alloys, Semiconductors and Insulators: Free Electron Gas (Metals, fermi surface, density of states) (2), Thermal and Mechanical Properties of metals and alloys, Lattices and Brillouin Zone, Brief Introduction to XRD (3), Electrons in Periodic Potentials, Bloch Theorem and Energy Bands in One Dimension, Insulators/semiconductors around us and their band structures, Concept of holes (3)
5	Magnetic Properties of Materials: Electron Spin and its Magnetic Moment, Exchange Energy and Hund's Rules (2), Dia and Paramagnetism (Larmor, Curie, Pauli) and magnetic response of everyday materials. Introduction to Ferromagnetism (3)

4	Transport: Drude theory, Lorenz Number, Wiederman-Franz, Characteristic Length Scales in Different type of transport mechanism in materials (4)
2	Crystal Vibrations: Introduction to Normal Modes, Acoustic Phonons and Specific Heat (2)
2	Exotic Phenomena in Materials: Introduction to phenomena such as superconductors, electronics and spintronics.

References: [No textbook]

Suggested readings:

- (i) Solid State Basics, by Steven H. Simons
- (ii) Solid State Physics, by Charles Kittel
- (iii) DJ Griffiths, Introduction to Quantum Mechanics

Grading scheme:

Quiz (20%), Mid-Sem Examination (20%),
 Final Examination (30%), Assignments (20%),
 Readings and discussions (10%).
 Grading will be relative.

Assignment Submission Policy:

Will be in hard-copy. Please respect deadlines.

Assignment/Exam Policy:

In Assignments: Participants are welcome to discuss among each other and refer to literature. Due credit should be provided in terms of references/people discussed with, when submitting the assignment.

Copying an assignment from a colleague – will be penalized. Students may be asked to present their answers to assignment questions to the rest of the class, therefore please ensure you stand by your submitted scripts.

In exams, any kind of mal-practice will be severely penalized. Present examiner's discretion will be final in such instances.

Attendance policy: An attendance record will be maintained. Exams/surprise quizzes (if any) will *not be repeated* for absentees. Frequent casual absences/vegetative participation may be penalized, and/or sustained attendance with active participation may be rewarded. Instructor discretion will be final.

Absence due to medical/emergencies will be duly considered, even for re-examination, if informed with necessary documents and in time.