First Course Handout

PHY 312 Quantum Processes in Low Dimensional Semiconductors
(2026-2027, Semester I)
Department of Physics, IIT Kanpur

Low-dimensional semiconductors lie at the heart of modern science and technologies, from nanoscale transistors to quantum computing and single-photon devices. This course provides a foundational understanding of quantum processes in low-dimensional systems, bridging fundamental physics with cutting-edge technology.

Instructor: Subhomoy Haldar
Office: SL 217D
Email: shaldar@iitk.ac.in, **Phone**: 2593

Prerequisite: The course requires prior knowledge of basic quantum mechanics (at the level of PHY114/PHY201), electrostatics-electrodynamics and electronics.

Course Contents: Introduction to low-dimensional semiconductors, highlighting the scientific and technological significance of semiconductors and quantum devices. Characteristic length scales for quantum phenomena. Basic crystallography and low-dimensional semiconductor material growth using molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD). Electronic properties of low-dimensional systems, including quantum wells, quantum wires, quantum dots, and strained layers. Optical properties of semiconductors such as absorption and luminescence of electron-hole pairs. Transport phenomena in mesoscopic and quantum structures, covering tunnelling, Coulomb blockade, charging effects, ballistic transport, and conductance quantization in nanostructures with an emphasis on the Landauer-Büttiker formalism. Transport in the presence of a magnetic field: Aharonov-Bohm effect and an introduction to the quantum Hall effect. Decoherence and dephasing in semiconductor quantum systems with brief discussions on spin qubit, single-electron sensing & single-photon detectors.

Recommended Books:

1. “The Physics of Low-dimensional Semiconductors” by John H. Davies
2. “Solid State Electronic Devices” by Ben G. Streetman and Sanjay K. Banerjee
3. “Semiconductor Nanostructures: Quantum states and electronic transport” by Thomas Ihn
4. “Introduction to Solid State Physics” by Charles Kittel
5. “Electronic Transport in Mesoscopic Systems” by Supriyo Datta

Classes: Wednesday and Friday 10:30 – 12:00 hrs. Venue: To be declared

Office Hours: Monday from 17:00 to 19:00 hrs.

Division of Marks

- Assignments (2) + Quiz (2): 30 % weighted
- Mid-Sem Exam: 60 Marks (30 % weighted)
- End-Sem Exam: 80 Marks (40 % weighted)

Attendance: Attendance is mandatory and should, in any case, must be greater than 75% (excluding approved leaves). Attendance will determine whether students can make it to the next upper grade if their performance is at the borderline of two grades.