| Course Type | Course Code | Name of Course | L | T | P | Credit |
|---|---|---|---|---|---|---|
| DE | NECD522 | Fundamentals of Nanoelectronic Devices | 3 | 0 | 0 | 3 |

| Course Objective |
|---|
| The objective of the course is to develop an understanding of physical and mathematical background for understanding of the transport phenomena in Nanoelectronic devices. The fundamental concepts are utilized to understand various classical and modern day electronic devices. |
| **Learning Outcomes** |
| Upon successful completion of this course, students will:<br>• acquire a knowledge of the fundamentals required for nanoelectronics.<br>• develop the understanding of the working of some classical and modern day nanoelectronic devices. |

| Unit No. | Topics to be Covered | Lecture Hours | Learning Outcome |
|---|---|---|---|
| 1. | Trends in Nanoelectronics, Mesoscopic systems, Mathematical Foundations of Quantum Mechanics | 6 | Acquire an understanding of the physical and mathematical foundations of Nanoelectronics. |
| 2. | Electrons in Solids - Drude and Sommerfield model, k-space quantization from periodic boundary condition, Density of states, Fermi energy and derivation of Fermi-Dirac distribution | 6 | Get fundamental concepts of the Solid state physics. |
| 3. | Crystal lattice, Reciprocal lattice space, Brillouin zone, Electron levels in periodic potential, Bloch theorem, Bandstructure, Crystal momentum, band velocity, Effective mass, Bandstructure examples in common semiconductors (Si, Ge, III-V) and implications to device physics | 7 | Acquire an understanding of thetransport of electrons in Solid state devices. |
| 4. | Semiclassical theory of electron dynamics in periodic lattice, Bloch electrons and wave packets, conductivity of perfect crystal, conservation of energy, current carrying capability by empty, filled and partially filled bands, introduction to the concept of holes, Ballistic transport through a quantum wire, Landauer formula, quantum resistance and conductance | 7 | Acquire an understanding of the semiclassical and quantum transport in nanodevices. |
| 5. | Principles of operation of MOSFET, top of the barrier concept, Short channel effects, Quantum effects in MOSFET - Coupled Poisson-Schrodinger equations and iterative solutions, quantization in MOSFET channel, quantum capacitance, Tunneling, One Dimensional barrier transmission problem, Gate oxide tunneling, Direct source to drain tunneling, Band-to-band tunneling | 8 | Acquire an understanding of the MOSFET operation in nanoscale dimensions. |
| 6. | Lattice vibrations, one dimensional chain of atoms, acoustic and optical branches, quantum theory of linear harmonic oscillators, phonons, effects in devices due to electron-phonon scattering, Quantization of angular momentum, possible eigenvalues of total angular momentum and its components, Pauli spin matrices, spin-orbit coupling | 8 | Acquire the understanding of the implications of lattice vibration, phonons and electron spin in Nanoelectronic devices. |
| | **Total** | **42** | |

**Text Books:**

1. Fundamentals of Nanoelectronics, George. W. Hanson, Pearson Prentice Hall (2008)
2. Y. Taur and T. H. Ning, Fundamentals of Modern VLSI devices, Cambridge University Press.

**Reference Books:**

1. D. J. Griffiths, Introduction of Quantum Mechanics, Prentice Hall.
2. Solid State Physics, N. W. Ashcroft and N. D. Mermin.
3. S. M. Sze, Physics of Semiconductor devices, Wiley-Interscience.
4. Introduction to Nanoelectronics, V.V. Mitin, V. A. Kochelap and M. A. Stroscio, Cambridge University Press (2007)
5. The Physics of Low-dimensional Semiconductors: An Introduction, John Davies, Cambridge University Press (1997).
6. Quantum Transport: Atom to Transistor, Supriyo Datta, Cambridge University Press (2005).