BACHELORS WITH PHYSICS AS MAJOR
8th SEMESTER
PHY822J3 PHYSICS _ NANO-MATERIALS AND APPLICATIONS

CREDITS: THEORY – 4, PRACTICAL - 2

THEORY (4 CREDITS: 60 HOURS)

LEARNING OUTCOMES:

The learning outcomes help students to gain a comprehensive understanding of nanoscale systems, materials, and structures. Develop knowledge of synthesis methods and characterization techniques for nanomaterials. Analyze the optical and electron transport properties of nanostructures. Explore real-world applications of nanoparticles and nanodevices in various technologies. Enhance problem-solving skills through the application of nanoscale physics concepts.

1. *Understand the concept of length scales in physics and the distinctive characteristics of nanoscale systems.*
2. *Define nanomaterials and differentiate between various nanostructures, including 1D, 2D, and 3D nanostructures (nanodots, thin films, nanowires, nanorods).*
3. *Analyze the band structure and density of states of materials at the nanoscale.*
4. *Compare surface-to-volume ratios for nanostructures and understand the implications of confinement regimes.*
5. *Understand the top-down and bottom-up approaches in the synthesis of nanostructure materials.*
6. *Explain physical vapor deposition (PVD) techniques such as sputtering and pulsed laser deposition.*
7. *Describe chemical vapor deposition (CVD), sol-gel, and hydrothermal synthesis methods.*
8. *Utilize qualitative characterization techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM).*
9. *Examine the optical properties of nanostructures.*
10. *Understand the concept of the dielectric constant for nanostructures.*
11. *Analyze electron transport and carrier transport in nanostructures.*
12. *Explore Coulomb blockade effects, thermionic emission, and conductivity mechanisms such as tunneling and hopping.*
13. *Investigate applications of nanoparticles, quantum dots, nanowires, and thin films in photonic devices, including LEDs and solar cells.*
14. *Understand the qualitative principles of single electron transfer devices.*
15. *Explore carbon nanotube-based transistors and their applications.*
16. *Examine nanomaterial devices such as quantum dot heterostructure lasers, optical switching, and optical data storage.*

UNIT-I (15 HOURS)

Nanoscale Systems, Length scales in physics, Physics based definitions of Nanomaterials Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, surface to volume ratio comparison, Confinement regimes, Examples on nano-materials.

UNIT-II (15 HOURS)

Synthesis of Nanostructure Materials; Top down and Bottom-up approach, Physical vapor deposition (PVD): Sputtering method, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Hydrothermal synthesis. Characterizations Tech (Qualitative): Phase and Crystal structure using X-ray diffraction (XRD), Shape & Morphology, Scanning Electron Micrsocpe (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope.

UNIT-III (15 HOURS)

Optical Properties of nano-structures, Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Electron Transport, Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunnelling and hoping conductivity.

UNIT-IV (15 HOURS)

Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (qualitative). Carbon nano tube-based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage.

PRACTICAL (2 CREDITS: 60 HOURS)

1. Synthesis of nano-particles using hydrothermal method.
2. Synthesis of Carbon nano tube nano-composites.
3. Estimation of particle size of nano-particles using various methods.
4. X-ray diffraction studies of nanoparticles and measuring the crystallite size.
5. To study Optical properties of nanoparticles by using UV-Vis spectroscopy.
6. Characterization of nano-particles using Scanning Electron Microscopy.

BOOKS:

1. Introduction to Nanotechnology, C.P. Poole, Jr. Frank J. Owens, (Wiley India Pvt. Ltd.).
2. Nanotechnology: Principles & Practices S.K. Kulkarni (Capital Publishing Company).
3. Introduction to Nanoscience and Technology K.K. Chattopadhyay and A. N. Banerjee, (PHI Learning Private Limited).
4. Nanotechnology, Richard Booker, Earl Boysen, (John Wiley and Sons).
5. Nanoparticle Technology Handbook, M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, (Elsevier, 2007).
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
7. Springer Handbook of Nanotechnology, Bharat Bhushan, (Springer-Verlag.
8. Nanomaterial Characterization: An Introduction, Ratna Tantra, Willey.