

VJTI, Mumbai
Department of PHYSICS

OPEN ELECTIVE for AY EVEN SEM 2025-26

Course Name:- Nanoscience and Nanotechnology for Engineers

Course Code:- R5PH3301T

Course Outcomes (COs)

CO1 To understand the importance of nanoscience and to differentiate between different Types of nanomaterials

CO2 To understand and analyse structure-property relationship at nanoscale.

CO3 To identify and compare nanomaterial synthesis techniques.

CO4 To be able to interpret data from nanomaterial characterization techniques

CO5 To understand the engineering application of Nanomaterials and to learn how to work safely with Nanomaterials and its environmental impact

Course Contents

1.	Introduction: Introduction to Nanoscience & Nanotechnology (Evolution, Feynman's idea, interdisciplinary nature), Scale of Nanomaterials (Atomic/Molecular scale, surface-to-volume ratio), Nucleation theory, surface energy and stabilization, magic numbers, modeling of nanoparticles, Quantum Nature of Nanoworld: dots, wires, well. Classification of Nanomaterials- One, two and three-dimensional Nanomaterials (Quantum dots, nanowires, nanotubes, thin films), Carbon nanostructures: fullerenes, carbon nanotubes. Silicon nanostructures -nanoscale silicon forms nanoparticles, nanowires, quantum dots. Bulk nanostructured materials, solid disordered nanostructures, nanostructured multilayers, metal nanoclusters	8
2.	Properties of Nanomaterials: Structure property relationship at nanoscale, Mechanical properties at nanoscale, Electrical, Optical, Chemical, Thermal and Magnetic properties, Comparison of bulk and nanomaterials.	8
3.	Fabrication and characterization: Synthesis and Fabrication of Nanostructures: Top-Down Approaches Lithography-Patterning, Masks and Photolithography; High energy mechanical milling, melt mixing, Evaporation-condensation method	6

	Bottom-Up Approaches- Ionized cluster beam deposition, Sputter deposition, ALD, PVD, Chemical Vapor Deposition, pulse laser methods, Chemical Reduction Method, microemulsion, sol-gel method Green synthesis of nanomaterials	
4.	Characterization of nanomaterials: Particle size and surface analysis Structural: XRD (X-ray Diffraction), Electron Diffraction. Microscopy: SEM (Scanning Electron Microscopy), TEM (Transmission Electron Microscopy), STM (Scanning Tunneling Microscopy). Spectroscopy: UV-Vis, FTIR, Raman, XPS (X-ray Photoelectron Spectroscopy).	8
5.	Application of Nanotechnology: Existing and emerging applications in electronics and sensors, Energy, medicine and healthcare, automotives, textiles, construction. Nanodevices- Quantum dots and quantum well devices, plasmon waveguides (optical devices) space and defense, sports and cosmetics. Safety: Environmental impact and nanotoxicology of nanomaterials, Safety protocols. Role of nanotechnology in sustainable development	10

Text / Reference Books

1. Cao G., Nanostructures & nanomaterials: synthesis, properties & applications, Imperial college press, 2004
2. Handbook of Nano structured Materials and Nano Technology, Vols 1-5, Academic Press 2000
3. Poole Jr C .P. and Owens F. J., Introduction to nanotechnology, John Wiley & Sons, 2003
4. Pradeep T., Nano: the essentials: understanding nanoscience and nanotechnology, McGraw-Hill Education, 2007
5. Ashby M. F., Ferreira P. J. and Scholdek D. L., Nanomaterials, Nanotechnologies and Design, Butterworth-Heinemann, 2009
6. Murty B. S., Shankar P., Raj B., Rath B.B. and Murday J. Textbook of Nanoscience and Nanotechnology, Springer Science & Business Media, 2013
7. Nanotechnology: Principles and Practices – S. K. Kulkarni, Springer, 2015