HSOE4003 PRINCIPLES AND APPLICATIONS OF NANOTECHNOLOGY (3-0-0)

Course Objectives: The course aims to:

1. Introduce the basic concepts, history, and scope of nanoscience and nanotechnology.
2. Explain the size-dependent properties of nanomaterials and their scientific principles.
3. Familiarize students with synthesis and characterization techniques used in nanotechnology.
4. Highlight important applications of nanomaterials in engineering and technology sectors.
5. Create awareness about societal, environmental, ethical, and safety issues related to nanotechnology.

Module I: Fundamentals of Nanoscience and Nanotechnology (9 Hours)

Classification of nanomaterials: nanoparticles, nanowires, nanotubes, thin films, quantum dots.
Size-dependent properties: surface area-to-volume ratio, quantum confinement effect, Physical and chemical properties at nanoscale.
Types of nanomaterials: carbon-based nanomaterials (fullerenes, carbon nanotubes, graphene), metal and metal oxide nanoparticles, polymeric nanomaterials, Introduction to nanocomposites

Module II: Synthesis and Characterization of Nanomaterials (9 Hours)

Synthesis Techniques: Top-down approaches (Mechanical milling, Lithography, Etching), Bottom-up approaches (Sol-gel method, Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Hydrothermal synthesis, Self-assembly techniques), Green synthesis of nanoparticles (overview)
Characterization Techniques: X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), UV-Visible Spectroscopy, Dynamic Light Scattering (DLS) (Overview)

Module III: Applications of Nanotechnology (9 Hours)

Electronics and IT: Nanoelectronics, Quantum dots, Carbon nanotubes in transistors, Flexible electronics.
Energy Sector: Nanomaterials in solar cells, Hydrogen storage, Lithium-ion batteries and supercapacitors, Fuel cells.
Biomedical Applications: Drug delivery systems, Targeted therapy, Biosensors, Nanotechnology in diagnostics.
Environmental Applications: Water purification using nanomaterials, Air filtration, Nanocatalysts.

Module IV: Emerging Trends, Safety, and Societal Implications (9 Hours)

Nanorobotics (Overview), Smart materials and nanosensors, Nanotechnology in agriculture and food technology, Industrial applications and commercialization, Ethical, legal, and social issues (ELSI), Environmental impact and nanotoxicology, Safety guidelines in handling nanomaterials, Future prospects of nanotechnology in India and globally

Course Outcomes (COs) : After successful completion of the course, students will be able to:

CO-1: Define key concepts, terminology, and classifications related to nanoscience and nanotechnology.
CO-2: Explain size-dependent properties and unique characteristics of nanomaterials.
CO-3: Apply knowledge of synthesis and characterization techniques to select appropriate methods for preparing and analyzing nanomaterials.
CO-4: Analyze the suitability of nanomaterials for various engineering and technological applications.
CO-5: Evaluate the benefits, risks, and societal implications of nanotechnology and propose responsible applications in real-world contexts.

Textbooks

1. C.P. Poole Jr. & F.J. Owens, Introduction to Nanotechnology, Wiley India.
2. K.K. Chattopadhyay & A.N. Banerjee, Introduction to Nanoscience and Nanotechnology, PHI Learning Pvt. Ltd., India.
3. T. Pradeep, Nano: The Essentials – Understanding Nanoscience and Nanotechnology, Tata McGraw-Hill Education.

Reference Books

1. Bharat Bhushan, Springer Handbook of Nanotechnology, Springer India.
2. Charles P. Poole & Frank J. Owens, Nanotechnology, Wiley India.
3. Mark Ratner & Daniel Ratner, Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson Education.
4. Richard Booker & Earl Boysen, Nanotechnology for Dummies, Wiley India.
5. Rakesh Rathi (Ed.), Nanotechnology: Fundamentals and Applications, S. Chand Publishing.