

Name of the Programme: B. Tech. (Common to all)	Year: III	Semester: V
Course Name: Introduction to Nanotechnology	Course Code: PHUL560	Credit: 3
Max Marks: 100	CIE: 40	SEE: 60
End Term Exam Time: 3 Hrs.	Teaching Scheme: CI (45) + TW & SL(45) = 90 hrs. per semester	

Module No.	Contents	Classroom Instruction (CI) Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite.	1
2	Unit-1: Fundamentals of Nanoscience and Nanotechnology: Introduction to nanoscience and nanotechnology, Historical background and scientific revolutions leading to nanotechnology, Size scale and classification of nanomaterials, Surface-to-volume ratio and its significance, atomic structure, molecules, and phases at nanoscale, Energy considerations at atomic and molecular scale, Quantum effects in nanomaterials, Dimensionality (0D, 1D, 2D, 3D nanostructures), Size and shape dependent properties: Electronic, electrical, Magnetic, dielectric, Optical, ferroelectric and Mechanical properties	8
3	Unit-2: Basic Synthesis Techniques for Fabrication of Nanomaterials Top-down Approaches: Ball milling, Physical vapor deposition (PVD), Sputtering techniques: DC, RF, Magnetron sputtering, Pulsed laser deposition (PLD), Ion sputtering, E-beam lithography. Bottom-up Approaches: Sol-gel method, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Chemical reduction methods (metal nanocrystals)	8
4	Unit-3: Basic Characterization Techniques of Nanomaterials Structural Characterization: X-ray diffraction (XRD), Electron diffraction, Neutron diffraction, Microscopy Techniques: Optical microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Spectroscopic Techniques: UV-Visible spectroscopy, Infrared (IR) and Fourier Transform Infrared (FTIR) spectroscopy, Raman spectroscopy, Photoluminescence (PL) spectroscopy.	9

5	Unit-4: Functional Nanomaterials and Nanostructures Hybrid nanomaterials: core-shells, nanoshells, Self-assembled nanostructures and superlattices, Nanocomposites: polymeric and ceramic, Nanoporous materials and nanofluids, Nanolayers and thin films Carbon-based Nanomaterials: Fullerene: structure, properties, applications, Carbon nanotubes (CNTs): types, properties, applications, Graphene: structure, properties, applications Bio-inspired Nanomaterials: Biomimetic and bioinspired nanomaterials, Self-assembly in biological systems	10
6	Unit-5: Nanomaterials, Devices, and Applications Nanomaterials in healthcare and drug delivery, Biosensors and nanosensors, Coatings and surface engineering, Environmental applications (water purification, pollution control), Catalysis and green chemistry, Applications in agriculture, Automotive and aerospace applications, Nanoelectronics and photonics, Information technology and quantum computing, Energy applications (solar cells, batteries, supercapacitors)	9
Total		45

Text Books:

1. W. D. Callister Jr. and D. G. Rethwisch, *Materials Science and Engineering: An Introduction*, 9th ed. New York, NY, USA: John Wiley & Sons, 2014.
2. C. P. Poole Jr. and F. J. Owens, *Introduction to Nanotechnology*. New York, NY, USA: John Wiley & Sons, 2003.
3. L. M. Liz-Marzán and P. V. Kamat, *Nanoscale Materials*. Boston, MA, USA: Springer/Academic Press, 2003.
4. C. N. R. Rao, A. Müller, and A. K. Cheetham, Eds., *The Chemistry of Nanomaterials: Synthesis, Properties and Applications*. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA, 2004.
5. L. L. Shaw, Ed., *Processing and Properties of Structural Nanomaterials*. Hoboken, NJ, USA: Wiley/Elsevier, 2008.
6. G. Cao, *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*. London, U.K.: Imperial College Press, 2004.
7. V. V. Novikov and V. L. Novikov, *Grain Growth and Control of Microstructure: Lectures in Polycrystalline Materials*. Boca Raton, FL, USA: CRC Press, 1997.
8. G. Cao, *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*. London, U.K.: Imperial College Press, 2004.
9. P. Sheng, Ed., *Nanoscience and Technology: Novel Structures and Phenomena*. Berlin, Germany: Springer, 2003.
10. M. Rieth, *Nano-Engineering in Science and Technology: An Introduction to the World of Nano Design*. Singapore: World Scientific Publishing, 2003.
11. B. D. Cullity and S. R. Stock, *Elements of X-ray Diffraction*, 3rd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2001.
12. H. H. Willard, L. L. Merritt Jr., J. A. Dean, and F. A. Settle Jr., *Instrumental Methods of Analysis*, 7th ed. Belmont, CA, USA: Wadsworth Publishing, 1986.
13. C. R. Brundle, C. A. Evans Jr., and S. Wilson, Eds., *Encyclopedia of Materials Characterization*. Boston, MA, USA: Butterworth-Heinemann, 1992.

Prerequisite:

1. Basic knowledge of materials' physical properties