18UPHO876	Nanotechnology	(3-0-0)3 Credits

Contact Hours: 39, CIE: 50 Marks, SEE: 100 Marks, Exam Duration: 3 Hrs.

Course Learning Objectives (CLOs):

The students are expected to learn about the fundamentals and multidisciplinary nature of nanotechnology and to understand the advantages of nanomaterials to bring novelty in the devices. The student learns the size and shape dependent properties, classification of nanomaterials, different methods to prepare nanostructures including hybrid fabrication approaches and characterization techniques. Finally, they are expected to be acquainted with the significance of nanomaterials.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Understand the basics of nanoscience and nanostructures	2	1	
CO-2	Elaborate the various synthesis methods of nanostructures	1	2	
CO-3	Understand to the construction and working principle of a broader range of characterization techniques.	1	2	
CO-4	Realize the carbon clusters and nanocomposites for device applications	1	2	
CO-5	Outline the application of nanomaterials	2	1	

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	2.6	2.4										

Prerequisites: Nil

Contents:

Unit I

Basics of Nanoscale Materials: Wave particle duality, Quantum size effect-Schrödinger wave equation, Particle in box problem, Formation of bands in solids, Density of states. Introduction to nanoscale materials and their classification, Size dependent properties of Nano materials- Physical, electrical optical and magnetic properties. **8 Hrs.**

Unit II

Synthesis of Nanostructured materials: Top-down and Bottom-up approaches of synthesis of nanomaterial, Top down approach – Mechanical attrition, Nanolithography-photo, electron beam and dip pen lithography.

Bottom up approach –Sol gel methods, Chemical vapour deposition (CVD), solvothermal synthesis, Spin coating and spray pyrolysis. Sputtering, laser ablation, molecular beam epitaxy. **8 Hrs.**

Unit III

Characterization techniques: Principle and working of XRD technique, Construction and working principle of Optical spectroscopy (UV-VIS, photoluminescence spectroscopy), Electron microscopy - scanning electron microscopy, Scanning Tunneling Microscopy, transmission electron microscopy (TEM), EDAX, atomic Force Microscopy. **7 Hrs.**

Unit IV

Carbon nano structures and Nanocomposites: Carbon clusters: Fullerenes (Buckminister fullerene), graphene – introduction, properties. Carbon nanotubes – classification, Synthesis, Properties and their applications.

Nanocomposites: Introduction, Ceramic and polymer-based nano-composites, grapheme, carbon nanotube and metal-matrix fillers, Properties and applications of nano-composites. **8 Hrs.**

Unit V

Applications of Nanomaterials: Optoelectronic applications-Hybrid solar cells, LED, nano-sensors. Photo-catalysis, Fuel cells, nanofluids, electrochemical energy storage systems, spintronics, MEMS and NEMS. Applications in medical field (drug delivery), food processing and agriculture. **8 Hrs.**

Reference Books:

1) Sulabha K Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Company, 2007.
2) T. Pradeep, Nano: The Essentials, Tata McGraw Hill Education Pvt Ltd., 2013.
3) James Murday, Textbook of Nano-science and Nanotechnology, University Press-IIM, 2012.

4) Charles. P. Poole and F. J. Owens, Introduction to Nanotechnology, John Wiley & Sons Inc., 2003.
5) P. Mukhopadhyay and R. K. Gupta, Graphite, Graphene and their polymer Nanocomposites. CRC Press, Taylor & Francis Group. 2012.