Course Title:	**Introduction to Nano Science**	Semester	I/II
Course Code:	**BETCK105C /205C**	CIE Marks	50
Course Type (Theory/Practical/Integrated)	Theory	SEE Marks	50
		Total Marks	100
Teaching Hours/Week (L:T:P: S)	3:0:0:0	Exam Hours	03
Total Hours of Pedagogy	40 hours	Credits	03

Course Learning Objectives

CLO 1. To provide a comprehensive overview of synthesis and characterization of nanoparticles, nanocomposites and hierarchical materials with nanoscale features.

CLO 2. To provide the engineering students with necessary background for understanding various nanomaterials characterization techniques

CLO 3. To develop an understanding of the basis of the choice of material for device applications

CLO 4. To give an insight into complete systems where nanotechnology can be used to improve our everyday life

Teaching-Learning Process

1. Chalk and Talk
2. Power point presentation
3. Video Lecturing
4. E-sources
5. Self-learning

Module-1: Introduction to Nanomaterials (8 hours)

Self-study: Density of States

Nanotechnology, Feynman's Vision on Nanoscience, Length Scales, Variation of physical properties from bulk to thin films to nanomaterials, Density of States, Density of states in 0D,1D,2D,3D quantum structures, Surface to Volume Ratio and its correlation to properties. Synthesis of Nanomaterials: **Physical Methods:** Top-Down Approach Ball Milling, Molecular Beam Epitaxy (MBE), Spray Pyrolysis, Electrodeposition technique. **Chemical Methods:** Bottom-Up Approach Chemical Reduction, chemical Vapor depositions, sol-gel technique, SILAR

Applications: Cosmetic industry and Nano drugs

(RBT Levels: L1, L2 and L3)

Module-2: Characterization of Nanomaterials (8 hours)

Self-study: SEM

Basic principles and instrumentations of Electron Microscopy –Transmission Electron Microscope, Scanning Electron Microscope, Scanning Probes- Scanning Tunneling microscope, Atomic Force Microscope –different imaging modes, comparison of SEM and TEM, AFM and STM. Basic principles of working of X-ray diffraction, derivation of Debye-Scherrer equation, numericals on Debye Scherrer equation, Optical Spectroscopy-Instrumentation and application of IR, UV/VIS (Band gap measurement)

Applications: Structure and image of nanomaterials
(RBT Levels: L1, L2 and L3)

Module-3:Carbon Based Materials (8 hours)

Self-study: Graphene sheet to nano tube

From Graphene sheet to Nano tube, Structure of CNTs: Single walled and Multiwall Nanotubes- Arm Chair, Zigzag and Chiral, Synthesis of CNTs by Arc Discharge Method and Pyrolysis. Properties of CNTs (electrical, Electronic and Mechanical), Applications of Graphene, SWCNT, MWCNT, Fullerenes and other Carbon Materials: Carbon nanocomposites, nanofibres, nanodiscs, nanodiamonds.

Applications: Composities
(RBT Levels: L1, L2 and L3)

Module-4: Nanotechnology in Energy storage and conversion (8 hours)

Self-study: Solar cells 1G

Solar cells: First generation, second generation and third generation solar cells: Construction and working of Dye sensitized and Quantum dot sensitized solar cells. Batteries: Nanotechnology in Lithium ion battery- working, Requirements of anodic and cathodic materials, classification based on ion storage mechanisms, limitations of graphite anodes, Advances in Cathodic materials, Anodic materials, Separators Fuel Cells: Introduction, construction, working of fuel cells and nanotechnology in hydrogen storage and proton exchange membranes

Applications: Li- battery, hydrogen energy
(RBT Levels: L1, L2 and L3)

Module-5: Applications of Nanotechnology (8 hours)

Self-study: Impact of Nanotechnology and Nanomaterial

Nanotech Applications and Recent Breakthroughs: Introduction, Significant Impact of Nanotechnology and Nanomaterial, Medicine and Healthcare Applications, Biological and Biochemical Applications (Nano biotechnology), Electronic Applications (Nano electronics), Computing Applications (Nano computers), Chemical Applications (Nano chemistry), Optical Applications (Nano photonics), Agriculture and Food Applications, Recent Major Breakthroughs in Nanotechnology.

Applications: Nano drugs, Nano electronics
(RBT Levels: L1, L2 and L3)

Course outcome

At the end of the course the student will be able to:

1. **Demonstrate** the synthesis of nanoparticles by various techniques.
2. **Understand** working of basic instruments used in characterization of nanoparticles.
3. **Summarize** the role of carbon-based materials in electronics, mechanical and civil domains
4. **Impact** of nanotechnology in energy storage devices
5. **Discuss** the impact of Nanotechnology on biological, chemical and electronics fields

Course Assessment and Evaluation Details (both CIE and SEE)

Continuous Internal Evaluation: 50 marks		
Theory Assessment Tool	**Marks**	**Reduced marks**
IAT-1	25	25
IAT-2	25	
Assessment -1(activity based)	25	25
Assessment-2(activity based)	25	
Semester End Examination (SEE) : 50 marks		
SEE	**Marks**	**Reduced marks**
Course end examination (Answer any one question from each unit – Internal choice)	**100**	**50**

Activity Based Learning (Suggested Activities in Class)/ Practical Based Learning

1. Seminars on Characterization techniques- XRD, AFM, SEM, TEM
2. Learning Characterization techniques through virtual lab
3. Learning synthesis techniques through virtual lab
4. Analysis of IR/Raman/XRD spectra

http://nptel.ac.in https://swayam.gov.in
https://virtuallabs.merlot.org/vl_physics.html

Suggested Learning Resources:

Text Books

1. Nano Materials – A.K. Bandyopadhyay/ New Age Publishers
2. Nanocrystals: Synthesis, Properties and Applications – C.N.R. Rao, P. John Thomas and G. U. Kulkarni, Springer Series in Materials Science
3. Nano Essentials- T. Pradeep/TMH
4. Peter J. F. Harris, Carbon nanotube science: synthesis, properties, and applications. Cambridge University Press, 2011
5. M.A. Shah, K.A. Shah, "Nanotechnology: The Science of Small", Wiley India, ISBN 13: 9788126538683

Reference Books

1. Introduction to Nanotechnology, C. P. Poole and F. J. Owens, Wiley, 2003
2. Understanding Nanotechnology, Scientific American 2002
3. Nanotechnology, M. Ratner and D. Ratner, Prentice Hall 2003
4. Nanotechnology, M. Wildon, K. Kannagara, G. Smith, M. Simmons and B. Raguse, CRC Press Boca Raton 2002
5. Recent reviews on Li-ion batteries, solar cells and fuel cells

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/118104008
- https://www.digimat.in/nptel/courses/video/118104008/L16.html
- https://archive.nptel.ac.in/courses/113/106/113106099/
- https://nptel.ac.in/courses/112107283
- https://onlinecourses.nptel.ac.in/noc22_me131/preview

COs and POs Mapping (CO-PO mappings are only Indicative)

COs	POs											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	3	3	2							2		
CO2	3	3	2							2		
CO3	3	3								2		
CO4	3	3				1				2		2
CO5	3	3				1				2		2

Level 3- Highly Mapped, Level 2-Moderately Mapped, Level 1-Low Mapped, Level 0- Not Mapped