SEMESTER S8

NANOMATERIALS AND NANOTECHNOLOGY

Course Code	PECHT833	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3: 0: 0: 0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	Course Type	Theory

Course Objectives:

1. Equip students with fundamental knowledge on the physics, chemistry, synthesis and characterisation of nanomaterials.
2. Enable the students with the understanding of the applications and potential of nanomaterials and nanotechnology for humankind.

SYLLABUS

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Module No.	Syllabus Description	Contact Hours
1	**Introduction to Nanotechnology**: History of nanotechnology, Pioneers in the field of nanotechnology. Classification of nano-materials - Zero-, one-, two- and three-dimensional nanostructured materials, Electromagnetic spectrum, particle size and its significance. Physics of nanomaterials: Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials, surface area and aspect ratio, band gap energy, quantum confinement effect. Chemistry of nanomaterials-Ionic properties of nanomaterials. Electronic phenomenon in nanostructures. **Synthesis methods** - top down and bottom up approaches. Top down approach – size reduction techniques like milling and machining. Bottom up approach - Sol-gel methods, Chemical vapour deposition, Physical vapour deposition, Laser ablation methods.	**9**
2	**Synthesis, properties and applications of nanomaterials**: Nanometals - gold andsilver, different types of nano-oxides - Al_2O_3, TiO_2, ZnO and SiO_2. Special nanomaterials: synthesis, properties and applications –	**9**

	fullerenes,graphite, graphene, carbon nano-tubes, nano wires, nano rods, nanofluids, nanoclusters, quantum dots. Nanocomposites - Matrix materials- Basics of Metal matrix, Ceramic Matrix and Polymer Matrix nanocomposites - Nano-reinforcements, nanofillers and nanoclays.	
3	**Characterisation techniques**: Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM) - Scanning Tunneling Microscopy (STM) UV-visible spectroscopy, Raman spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS), Thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC).	**9**
4	**Nanoelectronics:** Introduction to Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS), Nanomanipulation – STM based atomic manipulations, Nanolithography, softlithography, Scanning Probe Lithography, photolithography, E-beam Lithography, Focused ion beam lithography, Dip-pen Lithography. **Applications in energy and catalysis:** Applications (fundamental concepts only)Nanoscale advances in energy and catalysis - Nanotechnology for sustainable energy, nanotechnology enabled renewable energy technologies. Application of nanomaterials in catalysis. **Applications in biotechnology**: (fundamental concepts only) - Nanomedicine, Drug delivery, Therapeutic applications, biosensors.	**9**

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Course Assessment Method (CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the basic principles of Physics and Chemistry and synthesis methods of in Nanomaterals.	**K2**
CO2	Summarize the synthesis, properties and applications of nanomaterials and nanocomposites.	**K2**
CO3	Outline various characterisation techniques applied to nanomaterials.	**K2**
CO4	Explain the applications of nanotechnology in different fields of science and technology.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**					**2**	**2**					**2**
CO2	**3**					**2**	**2**					**2**
CO3	**3**					**2**	**2**					**2**
CO4	**3**					**2**	**2**					**2**

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Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Physics and Chemistry of Materials	Joel I. Gersten	Wiley	2001
2	Nano: The Essentials	T. Pradeep	McGraw-Hill (India) Pvt Limited	2008
3	Nanostructures & Nanomaterials: Synthesis, Properties & Applications	G. Cao. Y Wang	World Scientific	2011
4	Materials Characterization Techniques	S Zhang, L. Li and Ashok Kumar	CRC Press	2008
5	Nanocomposite science and technology	P. M. Ajayan, L. S. Schadler, P. V. Braun	Wiley-VCH	2005
6	Nanobiotechnology: Concepts, Applications and Perspectives	C. M. Niemeyer, C. A. Mirkin,	Wiley-VCH	2004
7	Nanotechnology and Nanoelectronics–Materials, Devices, Measurement Techniques	W. Fahrner	Springer-Verlag Berlin, Germany	2004
8	Surface Science: Foundations of Catalysis and Nanoscience	K.W. Kolasinski	John Wiley	2012

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Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Nanomaterials: Synthesis, Properties and Applications	S. Edelstein and R. C. Cammarata	Taylor & Francis	1998
2	Physics and Chemistry of Nanostructured Materials	S.Yang and P.Shen	Taylor & Francis	2000
3	Characterization of Nanophase materials	Z L Wang (Ed.)	Wiley-VCH	2000
4	Nanofabrication, Principles, Capabilities and Limits,	Zheng Cui	Springer Science + business media, New York	2008
5	X-rays in Nanoscience - Spectroscopy, Spectromicroscopy, and Scattering Techniques	Guo, Jinghua (Ed.)	John Wiley	2010
6	Handbook of Nanoscience, Engineering and Technology,	William A. Goddard III (Ed), Donald Brenner (Ed), Sergey Edward Lyshevski (Ed), Gerald J Iafrate (Ed)	Kluwer publishers	2007
7	Bionanotechnology: Lessons from nature	David S Goodsell	John Wiley	2004
8	Textbook of Nanoscience and Nanotechnology	B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday	Springer	2013

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Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/113/104/113104102/
2	https://archive.nptel.ac.in/courses/118/102/118102003/ https://archive.nptel.ac.in/courses/118/107/118107015/
3	https://archive.nptel.ac.in/courses/102/104/102104069/
4	https://archive.nptel.ac.in/courses/112/107/112107283/ https://archive.nptel.ac.in/courses/118/107/118107015/