Course Code	Course Name	Credits
26CH508	MATERIAL SCIENCE AND NANO-MATERIAL	04

Course Objectives

- To understand the structure and properties of crystalline and amorphous solids, including lattice systems and crystal binding.
- To explain dielectric behavior, polarization, and fundamental concepts of superconductivity.
- To analyze the properties, synthesis, and applications of nanomaterials and size-dependent phenomena.

Learning Outcomes

Upon successful completion of this course it is intended that a student will be able to:

- Comprehend crystal structures and diffraction methods used for analyzing solids.
- Understand different types of crystal bonding and their characteristics.
- Learn the fundamentals of superconductivity and dielectric materials.
- Study the synthesis, properties, and applications of nanomaterials, including their size-dependent optical and electrical behaviors.

Unit 1 - Crystalline and amorphous solids (12 Hrs.)

Lattice and Basis; Unit Cell and Primitive Cell; Crystal Systems; Translation Vectors; Number of Atoms per Unit Cell in Cubic Crystals; Bravais Lattices (Simple, Body-Centered, Face-Centered); Hexagonal Close Packing and Diamond Structure; Miller Indices; Interplanar Spacing; Crystal Diffraction; Bragg's Law; Experimental Diffraction Methods (Laue Method, Powder Diffraction Method); Reciprocal Lattice

Unit 2- Crystal binding (12 Hrs.)

Crystal Binding; Inert Gas Crystals; Van der Waals Forces; Cohesive Energy; Compressibility and Bulk Modulus; Ionic Crystals; Madelung Energy; Evaluation of Madelung Constant; Covalent Crystals; Energy of Single Covalent Bonds; Metallic Crystals; Hydrogen Bonding; Atomic Radii; Tetrahedral Covalent Radii; Ionic Crystal Radii

Unit 3 - Dielectrics- Dielectric constant and displacement vector (12 Hrs.)

Dielectrics; Dielectric Constant and Displacement Vector; Clausius–Mossotti Relation; Atomic or Molecular Polarizability; Types of Polarizability; Superconductivity; Occurrence of Superconductivity; Destruction by Magnetic Fields; Meissner Effect; London Equation; Josephson Effect; Energy Gap; Elements of BCS Theory; Classification of Superconductors; Applications

Unit 4 – Nanomaterials (12 Hrs.)

Introduction to Nanomaterials; Types and Properties; Zero-, One- and Two-Dimensional Nanostructures; Size-Dependent Properties; Quantum Confinement; Optical Properties; Specific Heat and Melting Point; Mechanical Properties; Superplasticity; Plastic Deformation of Ceramics; Nanoceramics; Catalytic Properties; Synthesis Techniques; Applications of Nanomaterials

Unit 5 - Synthesis (12 Hrs.)

Size-Dependent Physical Properties; Band Gap and Applications; Optical Luminescence and Fluorescence in Direct Band Gap Nanoparticles; Surface Trap Passivation in Core–Shell Nanoparticles; Carrier Injection; Polymer–Nanoparticle Systems; LEDs and Solar Cells; Electroluminescence; Barriers to Nanoparticle Lasers; Doping of Nanoparticles; Mn–Zn–Se Phosphors; Light Emission from Indirect Semiconductors; Light Emission from Si Nanodots

Reference Books:

1. Soild State Physics, Pillai S.O., 6th Edition, New Age Science, 2013.
2. Introduction to Solid State Physics, Charles Kittel,Wiley, 2005.
3. Fundamentals of Nanoscience and Nanotechnology, Pradeep T., Mc Graw Hill, 2012.
4. Introduction to Nanoscience and Nanotechnology, Chris Binns,1st Edition, Willey- Publication, 2010.
5. Solid State Physics, Ashcroft W.and Mermin N.D.,Holt-Rinehart-Winston, 1976.
6. Solid State Physics, Blakemore J. S., 2nd Edition, Cambridge University Press, Cambridge, 1974.
7. Solid State Physics, Dekker A. J.,Mac Millan, 1971.
8. Solid State Physics, Giuseppe Grosso, Giuseppe Pastori Parravicini, Academic Press, Second Edition, 2014.

Websites and eLearning Sources:

1. https://www.youtube.com/watch?v=iKmzdkvsVW4
2. https://www.youtube.com/watch?v=qUEbxTkPIWI
3. https://www.youtube.com/watch?v=jY2p7LpXAao

COs and Bloom's Taxonomy Mapping – 26CH508		
Course Outcomes	**On completing P.G. program the students will be able to**	**BTL**
CO1	Understand crystal structures and symmetry including lattice systems, unit cells, Miller indices, and diffraction techniques such as Bragg's law and powder methods.	K1, K2,
CO2	Explain bonding in solids by analyzing ionic, covalent, metallic, and van der Waals interactions along with concepts like cohesive energy and atomic radii.	K3
CO3	Apply concepts of dielectric materials and superconductivity, including polarization mechanisms, Meissner effect, and basic theoretical models.	K4
CO4	Analyze nanomaterials and their properties, including classification (0D, 1D, 2D), synthesis techniques, and size-dependent physical, optical, and mechanical behavior.	K5
CO5	Evaluate applications of nanomaterials in modern technologies such as LEDs, solar cells, optoelectronic devices, and semiconductor-based nanostructures.	K6

BTL K1 and K2 – remembering and understanding, K3- Applying, K4 – Analyse, K5- Evaluate and K6-Create

Relationship Matrix – 26CH508												
Course Outcomes	**Programme Outcomes (POs)**						**Programme Specific Outcomes (PSOs)**					**Mean Score of Cos**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	3	3	2	1	1	2	3	2	3	1	2	2.1
CO2	3	3	3	2	1	3	3	3	3	2	1	2.5
CO3	3	3	3	3	1	3	3	3	3	2	1	2.5
CO4	3	3	3	3	2	2	3	3	3	2	1	2.5
CO5	2	3	3	1	2	3	3	3	3	3	3	2.6
											Total	2.4

Mean Score: 3- High, 2- Medium/Moderate, 1-Low