

Dr. Ambedkar Institute of Technology, Bengaluru - 56
Department of Physics
Scheme and Syllabus – 2026 – 2027

Open elective subject

	Subject Title: Materials Science and Engineering (For all branches)		
	Subject Code: PHE01	No. of Credits: 03	Contact hours/week: 03
	Exam duration: 3 hrs.	Exam Marks: 100	Total No. of lecture hours: 45

Course Learning Objectives:

CLO1	To introduce the classification of engineering materials and the relationship between structure, bonding and properties in crystalline and non-crystalline solids, including polymers.
CLO2	To explain crystal geometry, unit cells, Miller indices and the use of Bragg's law, Laue and powder XRD methods for determination of crystal structure.
CLO3	To describe the composition, processing, properties and applications of modern engineering materials such as composites, ceramics, metallic glasses and biomaterials.
CLO4	To introduce the synthesis, properties and engineering, agricultural and medical applications of nanomaterials, including carbon nanotubes.
CLO5	To familiarize students with material characterization techniques such as XRD, optical/electron microscopy (SEM, TEM, AFM, STM) and spectroscopy.

Syllabus for the Academic year 2026-27

Sl. No.	Syllabus content	No. of hours
1	UNIT I: Introduction to Material Science Classification of materials, levels of structure, structure-Property relationships in materials, crystalline and non-crystalline states, inorganic solids: Covalent solids, metals, alloys and ionic solids. Polymers: Classification of polymers, structure of long-chain polymers, ethylene –based long-chain polymers and their applications.	8

2	UNIT II: Crystal Geometry And Structure Determination Space lattice, Bravais lattice, basis, crystal structure, unit cell and lattice parameters, primitive and non-primitive unit cells. Crystal systems: explanation of 7 crystal systems. Miller Indices. Expression for inter planar spacing in terms of Miller Indices, coordination number. atomic packing factor for simple cubic, BCC and FCC structure. Bragg's Law, Bragg's X-Ray Spectrometer, determination of crystal structure by Laue's method, powder method. numerical problems.	8
3	UNIT III: Modern Engineering Materials Composites: Classification of composite materials, particle and fiber reinforced composites, processing techniques and applications. Ceramics: Classification of ceramic materials, structure of ceramics, processing techniques and applications. Metallic Glasses: Origin of metallic glasses, principle, preparation, properties and applications. Bio materials: Development and Classification of biomaterials, processing, properties and applications.	8
4	UNIT IV: Nanomaterials Introduction, surface to volume ratio of nanomaterials, types of nanomaterials: 0-D, 1-D and 2-D nanomaterials with examples. Synthesis of nanomaterials: top down and bottom up approach: High Energy Ball Milling, Sol-Gel method. Properties of nanomaterials: mechanical, electrical, magnetic and optical properties. Carbon nanotubes (qualitative): types and properties of Carbon nanotubes. Applications of nanomaterials: engineering, agriculture and medical applications.	8
5	UNIT V: Material Characterization Techniques X-ray Diffraction - Scherrer Equation (derivation). Microscopy techniques: Fundamentals of optical microscopy – resolving power, limitations of optical microscopes, principle of electron microscope, Principle and working of Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) and applications. Spectroscopy Techniques: UV-Visible, and Atomic force microscope (AFM), Scanning tunneling microscope (STM). Numerical Problems.	8

Text Books:

1. Thiruvadigal, J.D., Ponnusamy, S.Sudha.D. and Krishnamohan M.,“Materials Sciences”, Vibrant Publication, Chennai, 2013.
2. Rajendran.V, “Materials Science”, Tata McGraw- Hill, New Delhi, 2011.
3. V. Raghavan, Material Science and Engineering, A First Course, Sixth Edition, PHI- New Delhi, 2015.
4. Sulabha K. Kulakarni, Nanotechnology: Principles and Practices, 3rd Edition Capital Publishing ,Company, New Delhi, 2007.
5. M. A. Wahab, Solid State Physics, 5th Edition, Narosa Publishing House, New Delhi, 2011.

References:

1. William D. Calister, Jr. David G. Rethwisch, Materials Science and Engineering, An Introduction, 9th Edition, John Wiley & Sons, Inc., 2014.
2. Cao G., “Nanostructures and Nanomaterials: Synthesis, Properties and Applications”, 1st Edition, Imperial College Press,London, 2004.
3. Lawrence H. Van Vlack, Elements of Material Science and Engineering, 10th Edition, AWL
4. Pradeep, “A Text Book of Nanoscience and Nanotechnology”, 1st Edition, Tata McGraw Hill, New Delhi, 2012.
5. Sam Zhang, “Materials Characterization Techniques”, 1st Edition, CRC Press, 2008.
6. C.M. Srivastava & C. Srinivasan, Science of Engineering Materials and Carbon Nanotubes, 1st Edition, New Age International (P) Limited, Publishers, Bangalore,2010.

Scheme for Examinations

1. Two full questions to be set from each unit with internal choice
 - Minimum number of sub-questions: 2.
 - Maximum number of sub-questions: 3.
2. Each full question shall be for a maximum of 20 marks

Answer any five full questions choosing at least one full question from each unit.

1. Course Outcomes (COs)

After successful completion of this course, the student will be able to:

CO	Course Outcome: At the end of the course, the student will be able to:	Bloom's Level
CO1	Classify engineering materials on the basis of structure, bonding and structure–property relationships, and identify materials suited to a given engineering requirement.	Understand / Apply (L2/L3)
CO2	Determine crystal structure parameters (unit cell, Miller indices, inter-planar spacing, atomic packing factor) and interpret Bragg's law/Laue and powder XRD data to characterise crystalline solids.	Apply (L3)
CO3	Analyse the composition, processing techniques, properties and applications of modern engineering materials — composites, ceramics, metallic glasses and biomaterials.	Analyse (L4)
CO4	Explain the synthesis (top-down and bottom-up), properties and applications of 0-D, 1-D and 2-D nanomaterials, including carbon nanotubes, across engineering, agriculture, defence and medical fields.	Understand / Apply (L2/L3)
CO5	Select and apply appropriate microscopy (optical, SEM, TEM, AFM, STM) and spectroscopy techniques, including XRD (Scherrer equation), for the characterisation of material microstructure and properties.	Apply / Evaluate (L3/L5)

2. Programme Outcomes (POs) — Reference

The 11 Programme Outcomes (graduate attributes) defined by NBA / Washington Accord used for mapping:

PO No.	Program Outcome	Description
PO1	Engineering knowledge	Apply knowledge of mathematics, science and engineering fundamentals to the solution of complex engineering problems.
PO2	Problem analysis	Identify, formulate, review research literature and analyse complex engineering problems using first principles.

PO3	Design/development of solutions	Design solutions for complex engineering problems and design system components or processes to meet specified needs.
PO4	Conduct investigations of complex problems	Use research-based knowledge and methods including design of experiments, analysis and interpretation of data to provide valid conclusions.
PO5	Modern tool usage	Create, select and apply appropriate techniques, resources and modern engineering/IT tools, including prediction and modelling.
PO6	The engineer, society and environment	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues; understand the impact of engineering solutions in societal and environmental contexts; and recognise the need for sustainable development. (This is a merged attribute, combining the former PO6 ‘Engineer and Society’ and PO7 ‘Environment and Sustainability’, as per the latest NBA guidelines.)
PO7	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO8	Individual and team work	Function effectively as an individual and as a member/leader in diverse and multidisciplinary teams.
PO9	Communication	Communicate effectively on complex engineering activities with the engineering community and society at large.
PO10	Project management and finance	Demonstrate knowledge and understanding of engineering/management principles in multidisciplinary environments.
PO11	Life-long learning	Recognise the need for, and engage in independent and life-long learning in the broadest context of technological change.

3. CO–PO Mapping Matrix

Mapping is expressed on a 3-point scale: 3 = Substantially/Highly mapped, 2 = Moderately mapped, 1 = Slightly/Low mapped, – = No correlation. The bottom row shows the course-

level average contribution to each PO (rounded to the nearest integer; averages below 0.5 shown as –), used for CO/PO attainment computation.

CO	PO1		PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3		2	-	-	-	-	-	-	-	-	2
CO2	3		3	-	2	1	-	-	-	-	-	2
CO3	3		2	1	-	-	1	-	-	-	-	2
CO4	3		2	1	-	-	1	-	-	-	-	2
CO5	3		2	-	3	3	-	-	-	-	-	2
Avg.	3		2	-	1	1	-	-	-	-	-	2

Mapping of CO's with Knowledge and Attitude Profile (WK)										
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0										
CO	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	
CO1	3	1	3	-	-	-	-	-	-	-
CO2	2	3	3	-	-	1	-	-	-	-
CO3	2	-	2	3	2	2	1	-	-	-
CO4	2	-	2	3	1	2	2	1	-	-
CO5	1	2	2	2	-	3	-	3	-	-

Mapping of CO's with Sustainable Development Goals (SDG)																	
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0																	
CO/SDG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CO1	-	-	-	2	-	-	-	-	2	-	-	-	-	-	-	-	-
CO2	-	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-
CO3	-	-	2	-	-	-	-	-	3	-	-	1	-	-	-	-	-
CO4	-	2	2	-	-	-	1	-	3	-	-	-	-	-	-	-	-
CO5	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-

4. Justification for CO–PO Mapping

Justification is provided for the principal (Level-2/3) mappings, in line with NBA's requirement that every non-trivial CO–PO correlation be substantiated:

CO	Dominant PO mapping	Justification
CO1	PO1 (3), PO2 (2), PO11 (2)	Classification of materials and structure–property correlation build core engineering-science knowledge (PO1) and require analysing why a given structure yields specific properties (PO2). Exposure to diverse material classes supports continued/independent learning (PO11).
CO2	PO1 (3), PO2 (3), PO4 (2), PO5 (1), PO11 (2)	Deriving lattice geometry, Miller indices and Bragg's law, and solving numericals, strengthens fundamental knowledge (PO1) and analytical problem solving (PO2). Interpreting XRD data to determine structure constitutes a basic investigative activity (PO4) using a standard characterisation tool (PO5).
CO3	PO1 (3), PO2 (2), PO3 (1), PO6 (1), PO11 (2)	Relating processing routes to properties of composites/ceramics/biomaterials touches solution-oriented thinking (PO3) at an introductory level. Biomaterial and ceramic applications have direct societal and sustainability/environmental (PO6) relevance.
CO4	PO1 (3), PO2 (2), PO3 (1), PO6 (1), PO11 (2)	Nanomaterial synthesis routes and property tuning involve basic design thinking (PO3); applications in medicine, agriculture and defence connect to societal impact and sustainable technology (PO6).
CO5	PO1 (3), PO2 (2), PO4 (3), PO5 (3), PO11 (2)	Characterisation techniques (XRD, SEM, TEM, AFM, STM, spectroscopy) are directly investigative in nature (PO4, strongly mapped) and constitute modern engineering/analytical tools (PO5, strongly mapped).