

Dr. Ambedkar Institute of Technology, Bengaluru - 56

Department of Physics

Scheme and Syllabus – 2026 - 2027

Course Title	Physics of Materials						
Course Code	1BPHU202C (ME Stream)						
Category	Applied Science Course (ASC) (Integrated Course)						
Scheme and Credits	No. of Hours / Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	3	0	2	4	5	42 + 28 +50= 120	4
CIE Marks: 50	SEE Marks: 50		Total Max. Marks =100		Duration of SEE: 03 Hours		
Course Learning Objectives:							
CLO1	Understand simple harmonic motion, free/damped/forced vibrations and resonance, and analyze the elastic behaviour of materials (stress-strain, elastic moduli, torsion and beam bending) for engineering design problems.						
CLO2	Explain the Seebeck, Peltier and Thomson thermoelectric effects and evaluate the working of thermoelectric generators (TEG) and coolers (TEC) for energy-recovery applications.						
CLO3	Apply the de Broglie hypothesis, Heisenberg's uncertainty principle and the time-independent Schrodinger wave equation to analyze the quantum-mechanical behaviour of particles in confined potentials.						
CLO4	Describe the synthesis routes and size-dependent properties of nanomaterials, and interpret data from XRD, AFM, TEM and SEM characterization techniques.						
CLO5	Conduct physics experiments to determine material and electrical constants, analyze experimental data, and demonstrate proficiency with simulation-based engineering tools.						
Unit No.	Syllabus Content						No. of Teaching hours
1	Oscillations: Simple harmonic motion (SHM), Differential equation for SHM, Theory of free vibrations, theory of damped vibration types of damping (Graphical Approach). Engineering applications of damped oscillations, theory of forced vibrations, Resonance: condition for resonance, sharpness of						8

	resonance. Resonance in LCR Circuits (qualitative), numerical problems. Self-Study: Types of motion, Musical Instruments, ESR and NMR.	
2	Elasticity: Review of Stress-Strain Curve, Hooke's law and its limits. Elastic Moduli, Poisson's ratio, Relation between Y, n and σ (derivation), mention relation between K, Y and σ, limiting values of Poisson's ratio. Torsion: Expression for couple per unit twist of Cylindrical wire (derivation). Torsional Pendulum: Expression for time period of oscillation and Rigidity modulus (derivation), Beam: Bending of beams, neutral surface and neutral axis, expression for bending moment beam (derivation). Cantilever: expression for depression in loaded cantilever (derivation), applications of beams in engineering. Numerical problems. Self-Study: Types of pendulums, various types of bridges and structures, types of beams.	8
3	Thermoelectric materials and devices: Thermo emf and thermo current, Seebeck effect, Peltier effect, Seebeck and Peltier coefficients, variation of thermoelectric EMF with temperature, relation between T_i and T_N, thermoelectric power, figure of merit (Mention Expression), laws of thermoelectricity. Expression for thermo emf in terms of T_1 and T_2, Thermo couples, thermopile, Construction and working of thermoelectric generators (TEG) and Thermoelectric coolers (TEC), low, mid and high temperature thermoelectric materials, Applications: Exhaust of automobiles, Refrigerator, Space program (Radioisotope Thermoelectric Generator- RTG), numerical problems. Self-Study: Laws of thermodynamics, Thomson's effect.	8
4	Quantum Mechanics: de-Broglie hypothesis, Heisenberg's uncertainty principle and its application (Broadening of Spectral Lines), principle of complementarity, wave function, time independent Schrödinger wave equation (derivation),	8

	physical significance of a wave function and Born Interpretation, expectation value and its physical significance. Probability density and normalization of wave function. Eigen functions and Eigen values, Particle inside one dimensional infinite potential well, role of higher dimensions (qualitative), Wave function and probability densities for $n=1, 2$ and 3. Quantum tunneling, Numerical Problems. Self-Study: Group velocity, Application of uncertainty principle – non-existence of electron in the nucleus, operators.	
5	Materials Characterization and Instrumentation Techniques: Nanomaterials: Introduction to nanomaterials, surface area to volume ratio, size effects, types of nanomaterials (0D, 1D, 2D, 3D), Synthesis: Top-Down approach - high energy Ball-milling and Bottom-Up approach - sol-gel method. Instrumentation Techniques: Bragg 's law of X-ray diffraction (derivation), X-ray diffractometer (XRD), Scherrer equation (derivation), Atomic Force Microscope (AFM), Transmission electron microscope (TEM), Scanning Electron Microscope (SEM), Numerical Problems. Self-Study: Properties of nanomaterials (optical, electrical and mechanical) and applications of nanomaterials.	8
Experimental Components: Any Ten Experiments have to be completed from the list of experiments 1. Series & Parallel resonance LCR Circuits. 2. Determination of Fermi energy of a copper. 3. Determination of Wavelength of LASER using Grating. 4. Determination of Numerical Aperture using Optical Fiber. 5. Determination of Planck's constant using LEDs. 6. Determination of Radius of curvature of Plano convex lens using Newton's rings. 7. Determination of Young's Modulus of the given Beam by Single Cantilever.		

8. Determination of Rigidity Modulus of the wire using Torsional Pendulum.
9. Determination of Acceleration due to Gravity by Bar Pendulum.
10. Determination of Moment of Inertia of the given regular and irregular bodies using Torsional Pendulum.
11. Energy Gap of the given Semiconductor
12. GNU Step Interactive Simulations
13. Study of Electrical quantities using spreadsheet
14. Online Circuit Simulator (<https://www.partsim.com/simulator>)
15. PHET Interactive Simulations
(<https://phet.colorado.edu/en/simulations/filter?subjects=physics&type=html.prototype>)

Teaching and Learning Process: Chalk and Talk, Power Point presentation and Lab Experiment Videos

Suggested Learning Resources:

1. Physics, Oscillations and Waves, Optics and Quantum Mechanics, H M Agarwal and R M Agarwal, Pearson, 2025.
2. Engineering Physics, Satyendra Sharma and Jyotsna Sharma, Pearson, 2018.
3. Engineering Physics-Gaur and Gupta Dhanpat Rai Publications -2017.
4. Concepts of Modern Physics-Arthur Beiser: 6th Ed; Tata Mc Graw Hill Edu. Pvt. Ltd. New Delhi, 2006.
5. Engineering Physics by R. K. Gaur and S. L. Gupta, 2008 Edition, Dhanpat Rai Publications (P) Ltd., New Delhi.
6. Electrical Engineering Materials, R. K. Shukla, Tata McGraw_Hill Education, India, 2017 reprint edition.
7. Solid State Physics - S O Pillai, 8th Ed-New Age International Publishers-2018.
8. Quantum Physics and Applications, Dr. Geethanjali H. S., Dr. Nagaraja D., Jeevith Publications, 2025. (Unit – IV)

Web links and Video Lectures (e-Resources):

1. Laser: <https://Laser:https://nptel.ac.in/courses/115/102115102124/>
2. Quantum Mechanics: <https://nptel.ac.in/courses/115/104/115104096/>
3. Physics: <http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html>

4. Numerical Aperture of fiber: <https://bop-iitk.vlabs.ac.in/exp/numerical-aperture-measurement>
5. NPTEL Superconductivity: <https://archive.nptel.ac.in/courses/115/103/115103108/>

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

1. <http://nptel.ac.in>
2. <https://swayam.gov.in>
3. <https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham>
4. <https://vlab.amrita.edu/index.php?sub=1&brch=189&sim=343&cnt=1>
5. https://virtuallabs.merlot.org/vl_physics.html
6. <https://phet.colorado.edu>
7. <https://www.mypysicslab.com>

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-question: 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

Note: 1. Questions from Experiments shall be included in the SEE question paper.

2. Questions from the self-study component will be included only in the CIE, carrying up to 10% of the total marks.

Course Outcomes (COs) and CO-PO Mapping

This document lists the Course Outcomes (COs) framed for the syllabus covering Oscillations and Elastic Properties of Materials, Thermoelectric Effects, Quantum Mechanics, and Nanomaterials (theory), along with the associated Experimental Component, and maps

them to the eleven Program Outcomes (POs) as per the latest NBA (Washington Accord aligned) guidelines, using a correlation scale of 1 (Slight), 2 (Moderate) and 3 (Substantial). In line with current NBA guidance, the total number of COs has been consolidated from six to five (CO6, the experimental component, is retained unchanged as CO5) and the total number of POs has been consolidated from twelve to eleven by merging the erstwhile PO6 ('The engineer and society') and PO7 ('Environment and sustainability') into a single Program Outcome.

1. Course Outcomes (COs)

CO No.	Course Outcome — At the end of the course, the student will be able to:	Bloom's Level
CO1	Explain simple harmonic, free, damped, and forced vibrations, including resonance, and apply them to mechanical and LCR systems. Analyze material elasticity using stress-strain relations and elastic moduli, and apply torsion and beam-bending principles to engineering design problems.	Understand/Apply /Analyze (L2–L4)
CO2	Describe the Seebeck, Peltier, and Thomson thermoelectric effects, and evaluate the working principles of thermoelectric generators (TEG) and coolers (TEC) for real-world applications.	Understand/Evaluate (L2/L5)
CO3	Apply the de Broglie hypothesis, Heisenberg's uncertainty principle, and the Schrodinger wave equation to analyze quantum behavior of particles in confined potentials.	Apply/Analyze (L3/L4)
CO4	Explain the synthesis routes and size-dependent properties of nanomaterials, and interpret data from XRD, AFM, TEM and SEM characterization techniques.	Understand/Analyze (L2/L4)
CO5	Conduct physics experiments to determine material and electrical constants, analyze experimental data, and demonstrate proficiency with simulation-based tools.	Apply/Analyze (L3/L4)

2. Program Outcomes (POs) — as per NBA Graduate Attributes (11 POs)

As per the latest NBA (Washington Accord aligned) guidelines, PO6 ("The engineer and society") and PO7 ("Environment and sustainability") have been merged into a single graduate attribute, reducing the total number of Program Outcomes from twelve to eleven.

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.
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3. CO-PO Mapping Matrix

Scale: 1 – Slight (Low) correlation 2 – Moderate correlation 3 – Substantial (High) correlation '-' – No correlation.

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	1	-	-	-	-	-	1
CO2	3	2	1	-	2	1	-	-	-	-	1
CO3	3	3	-	-	1	-	-	-	-	-	2
CO4	2	2	1	-	3	-	-	-	-	-	2
CO5	2	3	2	3	3	-	1	2	1	-	2
Avg.	2.60	2.60	1.20	0.60	2.00	0.20	0.20	0.40	0.20	-	1.60

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	3	3	3	2	1	0	1	0	
CO2	3	3	3	3	1	2	1	1	0	
CO3	3	3	3	3	0	1	0	2	0	
CO4	2	3	2	2	1	3	0	2	0	
CO5	3	3	3	3	2	3	0	3	1	

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	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0
CO2	0	0	0	0	0	0	3	0	1	0	0	0	2	0	0	0	0
CO3	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0
CO4	0	0	0	1	0	0	0	0	3	0	0	2	0	0	0	0	0
CO5	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0

4. Justification for CO-PO Mapping

CO1 (Oscillations & Elasticity): Formed by merging the vibrations/resonance CO with the elasticity/beam-bending CO, since both are theory-heavy, design-relevant mechanical topics — giving a strong PO1/PO2 link (3, 3) and a moderate PO3 link (2) because elastic behaviour and beam design feed directly into engineering design problems, with a slight PO5 link through circuit-analogy tools.

CO2 (Thermoelectrics): Connects to real devices (RTGs, refrigerators, automotive exhaust recovery), giving PO1/PO2 links plus PO6 (engineer, society and environment) touches for societal and environmental relevance of waste-heat-recovery technology.

CO3 (Quantum Mechanics): Conceptually deep with limited direct design application, so PO1/PO2 dominate; PO11 (Life-long learning) is included as quantum mechanics underlies modern technology literacy.

CO4 (Nanomaterials): Strong PO5 correlation due to reliance on instrumentation (XRD, AFM, TEM, SEM) for characterisation, alongside PO1/PO2 for underlying materials-science principles.

CO5 (Experiments — unchanged): Broadest mapping — PO4 (investigation), PO5 (tools/simulations), PO8 (teamwork in lab), PO9 (recording/reporting results), and a slight PO7 (Ethics) link through adherence to lab safety and reporting integrity.