PHYSICS OF MATERIALS		Semester	I/II
Course Code	**1BPHYM102/202**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy (Theory and Lab hours)	64	Total Marks	100
Credits	4	Exam Hours	3
Examination type (SEE)	**Descriptive**		

Course outcome (Course Skill Set)

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

1. Apply simple harmonic, damped, and forced oscillations in mechanical and electrical systems.
2. Describe stress, strain, and elastic moduli concepts to evaluate elastic behavior.
3. Explain thermoelectric effects and assess materials/devices for energy conversion and thermal management.
4. Summerize the knowledge of low-temperature physics, cryogen production methods, and cryogenic applications.
5. Discuss material characterization techniques and instrumentation for analyzing macroscopic and microscopic properties of engineering material

Module-1

Oscillations:

Simple harmonic motion (SHM), Differential equation for SHM, Springs: Stiffness factor and its physical significance, Series and Parallel combination of springs (Derivation), Types of springs and their applications. Theory of damped oscillations (Qualitative), Types of damping (Graphical Approach). Engineering applications of damped oscillations, Theory of forced oscillations with derivation, Resonance, Sharpness of resonance, Resonance in LCR circuits (Qualitative), Numerical problems.

Text Book : 1,2, Reference Book : 1(Forced Oscillation) Number of Hours:08

Module-2

Elasticity:

Review Stress-Strain Curve, Strain hardening and softening. Elastic Moduli, Poisson's ratio, Relation between Y, n and σ (with derivation), mention relation between K, Y and σ, limiting values of Poisson's ratio. Static and dynamic loading, Beams, Bending moment and derivation of expression, Cantilever, Torsion and Expression for couple per unit twist, Elastic materials (qualitative). Failures of engineering materials - Ductile fracture, Brittle fracture, Stress concentration, Fatigue and factors affecting fatigue (only qualitative explanation), S-N Curve (Wohler curve), Numerical problems.

Text Book : 2, Reference Book : 2 Number of Hours:08

Module-3

Thermoelectric materials and devices:

Thermo emf and thermo current, Seebeck effect, Peltier effect, Seeback and Peltier coefficients, 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

Text Book : 3 Reference Book : 3 Number of Hours:08

Module-4

Cryogenics:

Introduction to Thermodynamics, Carnot's principle, Efficiency, Production of low temperature - Joule Thomson effect (Derivation with 3 cases), Porous plug experiment with theory, Thermodynamical analysis of Joule Thomson effect, Liquefaction of Oxygen by cascade process, Lindey's air liquefier, Liquefaction of Helium and its properties (superfluidity), Platinum Resistance Thermometer, Applications of Cryogenics: Aerospace, Dewar Flask, Numerical Problems

Text Book : 4 Reference Book : 4,5 Number of Hours:08

Module-5

Material Characterization and Instrumentation Techniques:

Materials Properties:

Wave particle dualism, Schrodinger equation, Interpretation of wave function, Particle in an infinite 1D potential well, Quantum confinement in 0, 1, 2 and 3 Dimension (Qualitative), Density of states expressions and graphical representation, Optical properties due to quantum confinement, blue shift, absorption, florescence, Quantum tunnelling

Instrumentation Techniques: X-Ray Diffractometer (XRD), Schrerrer equation, Atomic Force Microscope (AFM), X-ray Photoelectron Spectroscopy (XPS), Scanning Electron Microscope (SEM), Numerical Problems.

Text Book : 5 Reference Book : 6 Number of Hours:08

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Determination of Young's modulus of the material of the given bar Uniform Bending.
2. Determination of Rigidity modulus of the Material of the wire using Torsional Pendulum.
3. Study of Forced Mechanical Oscillations and Resonance.
4. Study of the frequency response of Series & Parallel LCR circuits.
5. Determination of effective spring constant of the given springs in series and parallel combinations.
6. Verification of Newton's Law of Cooling.
7. Determination of Young's modulus of the material of the given bar using Single Cantilever.
8. Determination of Moment of Inertia of the given irregular body by setting Torsional Oscillations.
9. Determination of Grating constant using LASER Diffraction / Estimation of particle size of lycopodium powder using Laser Diffraction
10. Experiment on Thermo-emf / Peltier Module
11. Determination of Planck's Constant using LEDs.
12. STEP Interactive Physical Simulations. (Springs, Simple Pendulum)
13. PHET Interactive Simulation (Relevant to Theory)
14. Data Analysis using Spread Sheets

Note :

1. At least ten laboratory experiments must be conducted.
2. Minimum one simulation experiment is mandatory and should be conducted either in the computer lab for the entire batch or on dedicated systems in the physics lab.

Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):

Text books:

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. A Text book of Engineering Physics by M.N. Avadhanulu, P G. Kshirsagar, S Chand, 2014, Revised Edition.
4. Heat Thermodynamics and Statistical Physics, Brij Lal , N Subrahmanyam , P S Hemne, S Chand and Company Limited, Multicolour Revised Edition, 2018
5. Characterization of Materials- Mitra P.K. Prentice Hall India Learning Private Limited.

Reference books / Manuals:

1. Vibrations and Waves (MIT introductory Physics Series), A P French, CBS, 2003 Edition
2. Elements of Properties of Matter, D S Mathus, S Chand, Reprint 2016
3. Engineering Physics, S L Kakani, Shubra Kakani, 3rd Edition, 2020, CBS Publishers and Distributers Pvt. Ltd.
4. Cryogenics: A Text Book, S.S. Thipse, Alpha Science International , Limited, 2013.
5. Treatise on Heat, M N Saha and B N Srivastava, 2nd Edition, Indian Press, 1935 ; Original from, the University of California,
6. Materials Characterization Techniques-Sam Zhang, Lin Li, Ashok Kumar, CRC Press, First Edition, 2008.

Web links and Video Lectures (e-Resources):

1. Lecture Series on Physics - I: Oscillations and Waves by Prof.S.Bharadwaj, Department of Physics and Meteorology, IIT Kharagpurn: https://www.youtube.com/watch?v=gnD8Se92hfk
2. Waves and Oscillations : https://www.youtube.com/watch?v=xoJWoMQwTAw&list=PLyqSpQzTE6M9X7oRXliYM8t0aaR_N0Csd
3. Stress- strain curves :https://web.mit.edu/course/3/3.11/www/modules/ss.pdf
4. Stress curves: https://www.youtube.com/watch?v=f08Y39UiC-o
5. Cryogenic Engineering by Prof. M.D. Atrey , Department of Mechanical Engineering, IIT Bombay.: https://www.youtube.com/watch?v=4gGMBNEzeuc
6. Liquefaction of gases: https://www.youtube.com/watch?v=aMelwOsGpIs
7. Non-destructive testing: https://youtu.be/JGQnbwxPiFA
8. Non-destructive testing: https://youtu.be/uzogGRDSmMA
9. Materials Characterisation : https://youtu.be/SXIYzrFGmkU

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Self-Learning using AI Tools
2. Activity Based Learning
3. Gamification of Activities
4. Short Animations and Videos
5. Models and Working Models
6. Simulations and Interactive Simulations
7. Experiential Learning
8. Flipped Class Learning
9. Hybrid Learning
10. ICT Based Learning

Assessment Structure (IPCC): (Circular-Ref.: VTU/BGM/IPCC 2025/3748, DATED: 24TH Oct 2025)

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks**.

The CIE Theory component consists of IA tests for **25 marks**. The CIE Practical component for continuous assessments will be for **15 marks** through rubrics and for lab Internal Assessment will be conducted for **10 marks** through rubrics.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25marks**, i.e., **10marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18**

marks.

A student is deemed to have **completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):

	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO4)	Accurately analyzes SHM, damping, and forced oscillations with applications	Minor gaps in conceptual application	Basic understanding with limited real-world linkage	Misinterprets or inconsistently applies concepts	Unable to analyze or apply oscillatory principles
Performance Indicator 2 (CO2 - PO1, PO3, PO5, PO11)	Evaluates wave propagation with smart mitigation strategies effectively	Uses appropriate models but lacks depth in application	Identifies wave types but struggles with mitigation link	Incorrect application of wave theory	No attempt to connect wave theory to structural response
Performance Indicator 3 (CO3 - PO1, PO2, PO5)	Demonstrates the types of waves Causing earthquakes effectively	Describes the types of waves Causing earthquakes effectively	Identifies the types of waves Causing earthquakes effectively	Partially Identifies the types of waves Causing earthquakes effectively	Unable to identify the types of waves Causing earthquakes effectively
Performance Indicator 4 (CO4 - PO1, PO4, PO11)	Selects and justifies correct NDT methods with clarity	Reasonable selection but minor interpretive issues	Correct method chosen but lacks justification	Incomplete or unclear NDT method application	Incorrect or no method applied
Performance Indicator 5 (CO5 - PO1, PO4, PO5, PO7, PO11)	Evaluates smart materials with relevance to sustainability and performance	Applies smart materials with general insight	Aware of types but unclear on impact	Weak connection to system improvement	Unable to identify or apply smart materials

Rubrics for CIE – Continuous assessment:

	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO4)	Precise problem solving with theoretical and applied clarity	Good solution with slight errors in modeling	Correct steps but unclear interpretation	Incomplete or partially correct attempts	Incorrect approach and solution
Performance Indicator 2 (CO2 - PO1, PO3, PO5, PO11)	Comprehensive analysis of structural dynamics using smart strategies	Competent in identifying wave patterns and responses	Recognizes concepts but lacks analytical depth	Misunderstands effects or techniques	Fails to identify dynamic wave response
Performance Indicator 3 (CO3 - PO1, PO2, PO5)	Designs effective experiments for radiation and sound measurement	Understands tools but misapplies some aspects	Limited design ability with reliance on templates	Minimal connection to performance parameters	No functional understanding shown
Performance Indicator 4 (CO4 - PO1, PO4, PO11)	Correct selection and explanation of NDT tool, procedure, and result	Method chosen but results partially analyzed	Superficial NDT knowledge shown	Major flaws in method and analysis	No demonstration of NDT skills
Performance Indicator 5 (CO5 - PO1, PO4, PO5, PO7, PO11)	Connects material properties to real-world engineering applications	Describes material use with moderate clarity	Recognizes functions but lacks system integration	Limited awareness of usage contexts	Cannot relate smart materials to performance

Rubrics for SEE / CIE Test:

	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO4)	Accurately applies equations of SHM, damping, and forced oscillations	Mostly correct usage with minor formula or interpretation errors	Basic formulation without clear physical understanding	Incomplete calculations or irrelevant application	No use or wrong application of principles
Performance Indicator 2 (CO2 - PO1, PO3, PO5, PO11)	Integrates seismic and blast response theory into structural solutions	Applies theory but lacks specificity in dynamic contexts	General understanding but gaps in reasoning	Misapplies dynamic concepts	No relevant content provided
Performance Indicator 3 (CO3 - PO1, PO2, PO5)	Solves photometric and acoustic problems using precise methods	Approaches problems logically but with procedural gaps	Answers lack theoretical depth	Attempts are partially incorrect	No valid method or solution shown
Performance Indicator 4 (CO4 - PO1, PO4, PO11)	Describes and evaluates appropriate NDT tools accurately	Correctly identifies tools but interpretation is weak	Partially applies theory, misses steps	Misidentifies or misapplies method	No or incorrect description provided
Performance Indicator 5 (CO5 - PO1, PO4, PO5, PO7, PO11)	Explains smart material selection with function-structure relation	Describes usage but limited technical justification	Identifies material type but vague on use-case	Weak or confused explanation	Cannot define or explain use of smart materials

Suggested rubrics for Practical continuous assessment:

Performance Indicators	Excellent	Very Good	Good	Satisfactory
Fundamental Knowledge (4) (PO1)	The student has well depth knowledge of the topics related to the course (4)	Student has good knowledge of some of the topics related to course (3)	Student is capable of narrating the answer but not capable to show in depth knowledge (2)	Student has not understood the concepts clearly (1)
Design Of Experiment (5) (PO2 & PO3)	Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5)	Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4)	Student is capable of discussing single design with its merits and de-merits (3)	Student is capable of explaining the design (1-2)
Implementation (8) (PO3 & PO8)	Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8)	Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6)	Student is capable of implementing the design with proper explanation. (3-4)	Student is capable of implementing the design. (1-2)
Result &Analysis (5) (PO4)	Student is able to run the program on various cases and compare the result with proper analysis. (5)	Student will be able to run the program for all the cases. (4)	Student will be able to run the code for few cases and analyze the output (3)	Student will be able to run the program but not able to analyze the output (1-2)
Demonstration (8) (PO9)	The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8)	The lab record is organized, with clear sections, but some sections are not well-defined. (5-6)	The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4)	The lab record is poorly organized, with missing or unclear sections. (1-2)

Note: Can add Engineering & IT tool usage based on the nature of the course

Suggested Learning Activities may include (but are not limited to):

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms