PHYSICS FOR SUSTAINABLE STRUCTURAL SYSTEMS		Semester	I/II
Course Code	**1BPHYC102/202**	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. Discuss the role of waves propagation for structural applications, Earthquakes and Tsunami.
3. Illustrate the concepts of acoustics and radiation parameters for civil engineering construction.
4. Describe non-destructive testing of structural materials for their technological applications.
5. Analyze the role of smart materials and sensors for sustainable structures.

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, Resonance, Sharpness of resonance. Resonance in LCR Circuits (Qualitative), Numerical Problems.

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

Module-2

Waves and their role in structural behavior:

Types of waves, Wave propagation in beams, rods, and slabs, Boundary effects, Wave dispersion, Damping in structures, Energy dissipation techniques in structures, Introduction to earthquakes, General characteristics, P-waves, S-waves, Love waves, and Rayleigh waves, Ground motion and structural response, Site effects and soil-structure interaction, Physics of earthquakes, Richter scale of measurement and earthquake-resistant measures, Tsunami (causes for tsunami, characteristics, adverse effects, risk reduction measures, engineeringstructures to withstand tsunami), Seismometer and Seismograph, Accelerometer

Text Book : 3, Reference Book : 4 Number of Hours:08

Module-3

Acoustics, Radiometry and Photometry:

Acoustics: Introduction to Acoustics, Types of Acoustics, Reverberation and reverberation time, Absorption power and Absorption coefficient, Requisites for acoustics in auditorium, Sabine's formula (derivation), Measurement of absorption coefficient, Factors affecting the acoustics and remedial measures, Sound insulation and its measurements. Noise and its measurements, Impact of noise in multi-storied buildings.

Radiometry and Photometry: Radiation quantities, Spectral quantities, Relation between luminance and Radiant quantities, Reflectance and Transmittance, Photometry (cosine law and inverse square law).

Text Books :1,2, Reference Books :5, 7 Number of Hours:08

Module-4

Non-Destructive Testing:

Introduction to NDT, Need for inspection, Types of inspection system, Benefits of NDT. Visual inspection, Liquid penetration test: Principles surface preparation, Penetrant application and development, Eddy present testing: Inspection probes, Display methods, Ultrasonic testing: Principle, Generation of Ultrasonic, Probes, Radiography: Radiation sources, Attenuation of radiation, Shadow formation and distortion, Identification Markers, Numerical Problems.

Text Book : 4, Reference Book : 6 Number of Hours:08

Module-5

Smart Materials for Sustainable Structures:

Types of smart materials, Piezo, Magnetostrictive, Electrostrictive, Electro-rheological, Magneto-rheological, Shape memory alloys, Phase transformation in shape memory alloys, Overview of sensor technology, uses of sensors in intelligent structures, Classification of sensors, Temperature sensor, Vibration Sensor, Strain Gauge sensors, Basic concepts of structural health monitoring.

Text Book : 5, Reference Books :8,9 Number of Hours:08

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Study of Forced Mechanical Oscillations and Resonance.
2. Study of the frequency response of Series & Parallel LCR circuits.
3. Determination of effective spring constant of the given springs in series and parallell combinations.
4. Kundt's Dust Tube – Determination of Velocity of Sound.
5. Verification of Inverse Square Law of Intensity of Light.
6. Study on types of damping (Pendulum and Damper)
7. Determination of wavelength of ultrasonic using Ultrasonic Interferometer
8. Determination of Young's Modulus of the material of the given bar using Single Cantilever
9. Determination of Rigidity modulus of the Material of the wire using Torsional Pendulum.
10. STEP Interactive Physical Simulations. (Relevant to Theory part)
11. PHET Interactive Simulations (Relevant to Theory part)
12. Interpretation of graphs and images using XRD and SEM
13. Simple case study on acoustics (Auditorium, Cinema Hall, Etc)
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, First Edition, 2025
2. Engineering Physics, Satyendra Sharma and Jyotsna Sharma, Pearson, 2018.
3. Dynamics of Structures - Theory and Applications to Earthquake Engineering Anil K. Chopra, University of California at Berkeley, Fourth Edition. Prentice Hall
4. Non Destructive Testing - Hull, J. B., & John, V. (2015). Macmillan International Higher Education.
5. Smart Materials in Structural Health Monitoring, Control and Biomechanics, Suresh Bhalla (IIT Delhi), C. K. Soh, Yaowen Yang, Springer.

Reference books / Manuals:

1. Vibrations and Waves, A P French, MIT introductory Physics, 2003.
2. Engineering Physics by R. K. Gaur and S. L. Gupta, 2010 edition, Dhanpat Rai Publications Ltd., New Delhi-110002,
3. Engineering Physics, S L Kakani, Shubra Kakani, 3rd Edition, 2020, CBS Publishers and Distributers Pvt. Ltd., 2018.
4. Introduction to Seismology, Earthquakes, and Earth Structure, Stein, Seth, and Michael Wysession. Blackwell Publishing, 2003.
5. Photometry Radiometry and Measurements of Optical Losses, Micheal Bukshtab, Springer, 2nd edition.
6. Engineering Physics, S Mani Naidu, Pearson,2025
7. Building Science: Lighting and Accoustics, B. P. Singh and Devaraj Singh, Dhanpat Rai Publications (P) Ltc.,
8. Lagoudas, D. C. Shape Memory Alloys: Modeling and Engineering Applications. Springer, 2008. ISBN: 978-0-387-47684-1.
9. Holnicki-Szulc, J., & Rodellar, J. (Eds.). Smart Structures: Requirements and Potential Applications in Mechanical and Civil Engineering. Springer, 1999. ISBN: 978-0-7923-5612-7.

Web links and Video Lectures (e-Resources):

1. Simple Harmonic Motion (SHM) – NPTEL Lecture: https://www.youtube.com/watch?v=gnD8Se92hfk
2. Waves and Oscillations Playlist (SHM, damping, resonance, etc.)– NPTEL https://www.youtube.com/playlist?list=PLyqSpQzTE6M9X7oRXliYM8t0aaR_N0Csd
3. Simple Harmonic motion: https://www.youtube.com/watch?v=k2FvSzWeVxQ
4. Stress- strain curves :https://web.mit.edu/course/3/3.11/www/modules/ss.pdf
5. Stress curves: https://www.youtube.com/watch?v=f08Y39UiC-o
6. Acoustics: https://www.youtube.com/watch?v=fHBPvMDFyO8
7. INTRO – Fundamentals of Acoustics" (Lecture 1, NPTEL-NOC, IIT Madras) https://www.youtube.com/watch?pp=0gcJCfwAo7VqN5tD&v=rT9B44Q4Rko
8. Fundamentals of Acoustics playlist (multiple lectures on acoustic wave behavior, sound propagation, etc.) https://www.youtube.com/playlist?list=PLgMDNELGJ1CYWnDbcbVET5zCbN4aLEbZQ
9. Structural Health Monitoring of Composites (IIT Kanpur) – Full NPTEL Course: https://nptel.ac.in/courses/112104160
10. Course Introduction – Structural Health Monitoring (IITM – NPTEL): https://www.youtube.com/watch?v=It4aogUfQis
11. Smart Structures (IIT Kharagpur) – Covers smart materials, actuators, SHM: https://onlinecourses.nptel.ac.in/noc23_ae19/preview

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**.

	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO4)	Accurately analyzes SHM, damping, and forced oscillations with real-world applications	Good conceptual understanding with minor errors	Basic understanding with limited application	Incomplete or partially correct responses	No meaningful understanding or application

Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO4, PO5, PO11)	Thorough analysis of wave propagation and mitigation strategies	Good interpretation of dynamic responses and tools	Partial understanding of wave effects and materials	Weak analysis with limited justification	No application of wave dynamics or strategies
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO5, PO11)	Applies principles to design and evaluate acoustic, photometric, and radiometric systems accurately	Reasonable application with some inaccuracies	Limited design and evaluation with basic understanding	Minimal application with vague reasoning	No correct application of measurement principles
Performance Indicator 4 (CO4 - PO1, PO2, PO4, PO8, PO9)	Selects and justifies appropriate NDT techniques with clear reporting	Correct selection with minor interpretation issues	Basic understanding with partial justification	Poor method selection and unclear reporting	Incorrect or no NDT technique applied
Performance Indicator 5 (CO5 - PO1, PO4, PO5, PO7, PO11)	Effectively evaluates smart materials for sustainability and performance	Appropriate assessment with some technical gaps	General awareness without critical evaluation	Limited connection between material properties and applications	Fails to evaluate or identify smart material relevance

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

Rubrics for CIE – Continuous assessment:

	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO4)	Accurately analyzes SHM, damping, and forced oscillations with real-world applications	Good conceptual understanding with minor errors	Basic understanding with limited application	Incomplete or partially correct responses	No meaningful understanding or application
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO4, PO5, PO11)	Thorough analysis of wave propagation and mitigation strategies	Good interpretation of dynamic responses and tools	Partial understanding of wave effects and materials	Weak analysis with limited justification	No application of wave dynamics or strategies
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO5, PO11)	Applies principles to design and evaluate acoustic, photometric, and radiometric systems accurately	Reasonable application with some inaccuracies	Limited design and evaluation with basic understanding	Minimal application with vague reasoning	No correct application of measurement principles
Performance Indicator 4 (CO4 - PO1, PO2, PO4, PO11, PO10)	Selects and justifies appropriate NDT techniques with clear reporting	Correct selection with minor interpretation issues	Basic understanding with partial justification	Poor method selection and unclear reporting	Incorrect or no NDT technique applied
Performance Indicator 5	Effectively evaluates smart materials for	Appropriate assessment with	General awareness without	Limited connection between material	Fails to evaluate or identify smart

(CO5 - PO1, PO4, PO5, PO7, PO11)	sustainability and performance	some technical gaps	critical evaluation	properties and applications	material relevance

Rubrics for SEE / CIE Test:

	Superior	Good	Fair	Needs Improvement	Unacceptable
Performance Indicator 1 (CO1 - PO1, PO2, PO4)	Accurately analyzes SHM, damping, and forced oscillations with real-world applications	Good conceptual understanding with minor errors	Basic understanding with limited application	Incomplete or partially correct responses	No meaningful understanding or application
Performance Indicator 2 (CO2 - PO1, PO2, PO3, PO4, PO5, PO11)	Thorough analysis of wave propagation and mitigation strategies	Good interpretation of dynamic responses and tools	Partial understanding of wave effects and materials	Weak analysis with limited justification	No application of wave dynamics or strategies
Performance Indicator 3 (CO3 - PO1, PO2, PO3, PO5, PO11)	Applies principles to design and evaluate acoustic, photometric, and radiometric systems accurately	Reasonable application with some inaccuracies	Limited design and evaluation with basic understanding	Minimal application with vague reasoning	No correct application of measurement principles
Performance Indicator 4 (CO4 - PO1, PO2, PO4, PO11)	Selects and justifies appropriate NDT techniques with clear reporting	Correct selection with minor interpretation issues	Basic understanding with partial justification	Poor method selection and unclear reporting	Incorrect or no NDT technique applied
Performance Indicator 5 (CO5 - PO1, PO4, PO5, PO7, PO11)	Effectively evaluates smart materials for sustainability and performance	Appropriate assessment with some technical gaps	General awareness without critical evaluation	Limited connection between material properties and applications	Fails to evaluate or identify smart material relevance

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
- se of MOOCs and Online Platforms