

SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU-3

(An Autonomous Institution affiliated to Visvesvaraya Technological University, Belagavi,
Approved by AICTE, New Delhi)

PHYSICS FOR SUSTAINABLE STRUCTURAL SYSTEMS (For Civil Stream)

Course Type: Integrated

Contact Hours/ Week:	3(L) + 2(P)	Credits:	4
Total Lecture Hours:	40 + 28	CIE Marks:	50
Course Code:	APC	SEE Marks:	50

Course objectives:

This course will enable students to:

1.	Understand the principles of elasticity for designing structures with a solid materials and their mechanical behavior under stress.
2.	Comprehend different oscillatory systems and to acquire knowledge about interaction between waves and structures.
3.	Study the acoustics of buildings and the essentials of radiometry and photometry.
4.	Understand the principles and techniques used in various non-destructive testing (NDT) methods and to understand shock waves, generation, and applications.
5.	Understand the various relevant material characterization techniques.

UNIT I

ELASTICITY

Introduction, Elastic materials (qualitative), Hooke's law, Stress-strain curve, Strain hardening and softening. Elastic Moduli, Poisson's ratio and its limiting values. Relations between Young's modulus (Y), rigidity modulus (n), bulk modulus (K) and Poisson's ratio (σ) (derivation – Y, n and σ relation & Y, K and σ relation), Beams, Bending moment and expression for bending moment (qualitative). Cantilever, Derivation of expression of Young's modulus of a beam, I section girder and their engineering applications, Failures of engineering materials – Ductile fracture, Brittle fracture, Stress concentration, Fatigue and factors affecting fatigue (only qualitative explanation). Numerical problems.

Prerequisites: Basics of Elasticity.

Self-learning: Stress-Strain Curve, Elastic moduli

8 Hours

UNIT II

OSCILLATIONS & WAVES

Oscillations: Simple Harmonic motion (SHM), Characteristics of 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 (Qualitative), Resonance, Sharpness of resonance, Numerical Problems.

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.

Pre-requisites: Basics of oscillations

Self-learning: Differences between harmonic and un-harmonic oscillations

8 Hours

UNIT III

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, Numerical Problems.

Radiometry and Photometry: Radiation quantities, Spectral Quantities, Relation between luminescence and Radiant quantities, Reflectance and Transmittance, Photometry (cosine law and inverse square law - Qualitative), Numerical Problems

Prerequisites: Basics of Sound, Waves & light properties

Self-learning: Types of acoustics

8 Hours

UNIT IV

NON-DESTRUCTIVE TESTING AND SHOCK WAVES

Introduction to NDT, Needs for inspection, Methods of NDT, Benefits of NDT. Visual inspection, Liquid penetration test: Principle, Basic processing steps of inspection, materials used, advantages and limitations, Eddy current testing: Inspection probes, Display methods, Ultrasonic testing- Ultrasonic flaw detector, - Normal beam pulse-echo, normal beam through transmission, Numerical Problems.

Shock waves: Mach number and Mach Angle, Mach Regimes, definition and Characteristics of Shock waves, Construction and working of Reddy shock tube, Role of Shock waves in NDT methods. Numerical problems.

Prerequisites: Basics of Ultrasonic.

Self-learning: Fundamentals of NDT. Common examination methods.

8 Hours

UNIT V

MATERIAL CHARACTERISATION AND INSTRUMENTATION TECHNIQUES

Introduction to nanomaterials and nanocomposites, surface area to volume ratio, quantum confinement, Optical properties due to quantum confinement, characteristics of composites, metal matrix, ceramic matrix, polymer matrix nanocomposites. Bragg's law, principle, construction and working of X-ray Diffractometer, crystallite size determination by Scherrer equation, Principle, construction, working and applications of Atomic Force Microscope (AFM) and Scanning electron microscope (SEM), Numerical Problems

Prerequisites: Fundamental principles of Quantum Mechanics,

Self-learning: Nanomaterials, Principles of XRD, AFM, and SEM

8 Hours

TEXT BOOKS

1	H M Agarwal and R M Agarwal	Physics, Oscillations and Waves, Optics and Quantum Mechanics, Pearson, 2025
2	Satyendra Sharma and Jyotsna Sharma	Engineering Physics, Pearson, 2018.

REFERENCE BOOKS

1	S L Kakani, Shubra Kakani	Engineering Physics, 3rd Edition, CBS Publishers Pvt. Ltd. 2020
2	R K Gaur and S L Gupta	Engineering Physics, edition, Dhanpat Rai Publications Ltd., New Delhi, 2016
3	Chintoo S Kumar, K. Takayama and K P J Reddy	Shockwaves Made Simple, Wiley India Pvt. Ltd. New Delhi, 2014.
4	Sam Zhang, Lin Li, Ashok Kumar	Material Characterization Techniques, CRC Press, First Edition, 2008

E-Resources:

Simple Harmonic motion: <https://www.youtube.com/watch?v=k2FvSzWeVxQ>

Waves and Oscillations:

https://www.youtube.com/watch?v=xoJWoMQwTAw&list=PLyqSpQzTE6M9X7oRXliYM8t0aaR_NOCsd

Shock waves: <https://physics.info/shock/>

Shock waves and its applications: https://www.youtube.com/watch?v=tz_3M3v3kxk

Oscillations and waves :[https://openstax.org > books > collegephysics 2e](https://openstax.org/books/collegephysics-2e)

Acoustics: <https://www.youtube.com/watch?v=fHBPvMDFyO8>

Material characterization :https://onlinecourses.nptel.ac.in/noc20_mm14/preview

Virtual lab:<https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham>

LIST OF EXPERIMENTS

1. Rigidity modulus by Torsional Pendulum
2. Determination of Young's modulus using Single Cantilever
3. Series & Parallel Resonance using LCR circuit
4. Spring Constant
5. Wavelength of laser using grating,
6. Verification of Stefan's law
7. Frequency of AC source using Sonometer
8. Moment of Inertia of the given irregular body by setting Torsional Oscillations
9. Reddy shock tube
10. Resistivity of a wire by four probe method
11. Verification on Inverse Square Law of Intensity of Light
12. Determination of wavelength of Ultrasonic using Ultrasonic Interferometer
13. Determination of Plank's Constant using LEDs.
14. Data Analysis using Spread Sheets
15. STEP Interactive Physical Simulations (Springs, Simple Pendulum) / PHET Interactive Simulation.

Note: Any ten experiments to be conducted from the above list by covering one a) Open Ended with spreadsheet activity and b) Simulation

Manual/Observation book:

1.	Engineering Physics Lab Manual prepared by Faculty, Department of Physics, SIT.
----	---

Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Apply the theory of elasticity to design and evaluate elastic moduli and bending moments of structural beams.
CO2	Analyze the behavior of simple harmonic, damped, and forced oscillatory systems in mechanical contexts and be able to find effective spring constant, frequency of oscillations, damping coefficient and amplitude of oscillation.
CO3	Apply the principles of acoustics, radiometry and photometry to design and evaluate systems of sound, light and radiation measurements.
CO4	Demonstrate knowledge of non-destructive testing (NDT) techniques and select suitable methods for assessing material and structural integrity.
CO5	Elucidate the importance of XRD, AFM and SEM in the area of engineering for structural characterizations of nanomaterials and be able to evaluate surface-to-volume ratio, crystallite size and interplanar spacing of crystal.

