SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU-3

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

PHYSICS OF MATERIALS

(For ME/IEM/CH Branches)

Course Type: Integrated

Contact Hours/ Week:	3(L) + 2(P)	Credits:	4
Total Lecture Hours:	40 + 28	CIE Marks:	50
Course Code:	APM	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 the theoretical background of lasers, the working of He-Ne laser and the applications of laser. Also, study the nature of light propagation in optical fiber, reasons for the fiber loss and applications of optical fiber.
3	Elucidate the types of oscillation, shock waves & its generation, and applications.
4	Understand the principles, materials, design and operation of thermoelectric devices for energy conversion and temperature control.
5	Comprehensive understanding of materials characterization techniques, analyze and interpret properties and structure of materials.

UNIT I

ELASTICITY

Introduction, Hooke's law, Review of Stress-Strain curve, Strain hardening and softening, Elastic Moduli, Poisson's ratio, Relation between Young's modulus (Y), rigidity modulus (n), and Poisson's ratio (σ) and relation between Y, bulk modulus (K) and σ (with derivation), Limiting values of Poisson's ratio, Static and dynamic loading, Beams, Bending moment and its expression (qualitative), Cantilever – Derivation of expression of Young's modulus of a beam, Torsion and Expression for couple per unit twist (qualitative), Elastic materials (qualitative). Failures of engineering materials - Ductile fracture, Brittle fracture, Stress concentration, Fatigue and factors affecting fatigue (only qualitative explanation), S-N Curve, Numerical problems.

Prerequisites: Basics of Elasticity.

Self-learning: Stress-Strain Curve, Elastic moduli

8 Hours

UNIT II

Laser and Optical Fiber

Lasers: Introduction, characteristics of LASER, and difference between laser light and ordinary light. Concept of induced absorption, spontaneous emission and stimulated emission. Expression for energy density in terms of Einstein's coefficients and discussion of results. Requisites of lasers. Condition for laser action. Construction and working of He-Ne laser, Material processing with laser beam: Surface modification, surface hardening, drilling, welding, cutting. Numerical Problems.

Optical fibers: Structure of optical fiber, working principle, Light propagation mechanism - angle of acceptance, numerical aperture, Expression for numerical aperture, Attenuation, and mechanisms for fiber loss (qualitative). Applications of Optical Fibers - Fiber Optic displacement sensor and Pressure sensor, Numerical Problems.

Prerequisite: Properties of light,

Self-learning: Difference between laser and ordinary light, Principle of optical fiber

8 Hours

UNIT III

OSCILLATIONS and SHOCK WAVES

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.

Shock waves: Mach number and Mach Angle, Mach Regimes, definition and Characteristics of Shock waves, Construction and working of Reddy shock tube, Applications of Shock Waves, Numerical problems.

Pre-requisites: Basics of oscillations

Self-learning: Differences between harmonic and un-harmonic oscillations, Basics of SHM

8 Hours

UNIT IV

THERMOELECTRIC MATERIALS AND DEVICES

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

Prerequisites: Basics of thermoelectricity

Self-learning: Thermo emf and thermo current

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, XPS 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	Chintoo S Kumar, K. Takayama and K P J Reddy	Shockwaves Made Simple, Wiley India Pvt. Ltd. New Delhi, 2014.
3	Sam Zhang, Lin Li, Ashok Kumar	Material Characterization Techniques, CRC Press, First Edition, 2008
4	Hitendra K. Singh and A. K. Singh,	Engineering Physics, Tata McGraw Hill, New Delhi, 2010

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 Shock waves and its applications: https://www.youtube.com/watch?v=tz_3M3v3kxk
6 6.Thermoelecticity:https://www.youtube.com/watch?v=2w7NBuu5w9c&list=PLtkeUZItwHK5y6qy1GFxa4Z4RcmzU aaz6
7. Thermoelectric generator and coolers: https://www.youtube.com/watch?v=NruYdb31xk8
8. Virtual lab:https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham
9. Material characterization :https://onlinecourses.nptel.ac.in/noc20_mm14/preview

LIST OF EXPERIMENTS

1. Rigidity modulus of the material of the wire using Torsional Pendulum
2. Young's modulus of the material of the given bar using Single Cantilever
3. Series & Parallel Resonance using LCR circuit
4. Spring Constant
5. Wavelength of laser using grating,
6. Numerical aperture and fiber loss
7. Study the working of Peltier Modules
8. Verification of Stefan's law
9. Determination of Plank's Constant using LEDs.
10. Frequency of AC source using Sonometer
11. Moment of Inertia of the given irregular body by setting Torsional Oscillations
12. Reddy shock tube
13. Resistivity of a wire by four probe method
14. STEP Interactive Physical Simulations. (Springs, Simple Pendulum) / PHET Interactive Simulation
15. Data analysis using spread sheet

Note: Any ten experiments to be conducted from the above list by covering one a) open ended experiment 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	Apply the theory of LASERs and optical fiber to solve the problems on condition of laser action, power of laser, numerical aperture and attenuation coefficient of optical fiber
CO3	Analyze the behavior of 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.
CO4	Analyze thermoelectric phenomena, device construction, and identify suitable materials and applications for energy conversion.
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.

Course Articulation Matrix

		POs											**PSOs**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
COs	**CO1**	**3**	**2**	-	-	-	-	-	-	-	-	-	-	-
	CO2	**3**	**3**	-	-	-	-	-	-	-	-	-	-	-
	CO3	**3**	**2**	-	-	-	-	-	-	-	-	-	-	-
	CO4	**2**	**2**	-	-	-	-	-	-	-	-	-	-	-
	CO5	**3**	**3**	-	-	-	-	-	-	-	-	-	-	-