# Savitribai Phule Pune University
# First Year of Engineering (2024 Pattern)
# Course Code: BSC-102-BES Course Name: Engineering Physics

| Teaching Scheme | Credit | Examination Scheme |
|---|---|---|
| **Theory : 03 Hours/Week**<br>**Practical : 02 Hours/Week** | **03**<br>**01** | **CCE : 30 Marks**<br>**End-Semester : 70 Marks**<br>**Term Work : 25 Marks** |

**Prerequisite Courses, if any:**

Bohr's atomic theory, properties of mechanical and electromagnetic waves, Huygens' principle and wavefront, interference and polarization of light, wave particle duality, intrinsic and extrinsic semiconductors, basics of magnetism, trigonometry and calculus.

**Course Objectives:**

The objective of the course is to impart the knowledge of fundamentals of physics through hands-on experiments and extend it to relevant engineering applications.

**Course Outcomes:**

After successful completion of the course, learner will be able to:

**CO1: Develop** the understanding of working principle of lasers, optical fibers and extend it to holography and fiber optic communication.

**CO2: Deduce** Schrödinger's wave equations and apply it to problems on the bound states by summarizing fundamentals of quantum physics.

**CO3: Explain** phenomena of interference in thin films, polarization, double refraction and connect to the Anti-Reflection Coating, LCD.

**CO4: Develop** understanding of Fermi level and Fermi energy in semiconductors on the basis of results of Fermi Dirac statistics and relate them with the working of semiconducting devices. Extend the **understanding** of Ultrasonic to thickness measurement, flaw detection.

**CO5: Explain** properties of nanoparticles and estimate engineering applications; Explain phenomenon of Superconductivity and estimate engineering applications.

## Course Contents

| Unit I | Fundamentals of Photonics | (08 Hours) |
|---|---|---|

**Laser:** Spontaneous and stimulated emission, population inversion, pumping, active medium & active center, resonant cavity; Characteristics of lasers, CO2 laser: construction and working, Engineering applications of laser (IT, medical, industry), Holography (recording, reconstruction, applications); Optical

**Optical fibers:** Critical angle, acceptance angle, acceptance cone, numerical aperture, total internal reflection and propagation of laser; Classification of optical fibers: Single mode & multimode, step index & graded index, Attenuation: attenuation coefficient, causes of attenuation; Advantages of optical fiber communication, numerical problems on parameters of optical fiber.

| Unit II | Quantum Physics | (08 Hours) |
|---|---|---|

de Broglie hypothesis of matter waves, de Broglie wavelength for a particle accelerated by KE "E" and a charged particle accelerated by PD "V", properties of matter waves; Wave function and probability density, mathematical conditions for wave function, problems on de Broglie wavelength; Need and significance of Schrödinger's equations, Schrödinger's time independent and time dependent equations; Energy of a particle enclosed in a rigid box and related numerical problems; Quantum mechanical tunneling, alpha particle decay, principle and applications of STM; Principles of quantum computing: concept of qbit, superposition and entanglement, comparison of classical & quantum computing, potential applications of quantum computing.

| Unit III | Wave optics | (08 Hours) |
|---|---|---|

Interference in thin film of uniform thickness, conditions of maxima and minima for reflected system; Conditions for maxima and minima for wedge shaped film (qualitative), engineering applications – ARC, determination of optical flatness; Numerical problems on thin film and wedge shaped film; Types of polarization: Unpolarized, Polarized, PPL, CPL and EPL, Malu's law and related numerical problems; Double refraction: geometry of calcite crystal, Huygens' theory; Engineering applications of polarization: LCD, communication & radar, 3D movies (recording, projection).

| Unit IV | Semiconductor Physics and Ultrasonics | (08 Hours) |
|---|---|---|

**Semiconductor Physics:** Valence band, conduction band, band gap energy, classification of solids on the basis of band theory; Fermi level and Fermi energy for metal, FD distribution function and its temperature dependence, position of Fermi level in intrinsic semiconductors (derivation); Fermi level for extrinsic semiconductors, working of PN junction diode on the basis of Fermi energy; Solar cell: principle, working, IV-characteristics, efficiency and fill factor, measures to improve efficiency of solar cell, advantages and applications in environmental sustainability; Hall effect: derivation for Hall voltage and Hall coefficient and related numerical problems.

**Ultrasonics:** Characteristics and properties of ultrasonic waves, Generation of ultrasonic waves by inverse piezoelectric effect (using transistor); Engineering applications - thickness measurement, flaw detection and related numerical problems.

| Unit V | Physics of Nanoparticles and Superconductivity | (08 Hours) |
|---|---|---|

**Nanoparticles:** Quantum confinement and its effect on properties of nanoparticles, synthesis methods - ball milling and Physical Vapor Deposition; Properties of nanoparticles (optical, electrical, mechanical, magnetic); Applications of nanotechnology: Electronics (GMR effect and its application in read-write head of HDD), automobiles, environmental & energy, medical field (targeted drug delivery).

**Superconductivity:** Temperature dependence of resistivity, critical magnetic field, critical current, Meissner effect and perfect diamagnetism; Type I and Type II Superconductors, Numerical problems on critical magnetic field; Formation of Cooper pairs, DC and AC Josephson effect, SQUID: working principle and applications; Engineering applications: electronics, principle of Maglev train.

## List of Laboratory Experiments/Assignments (Any 8 from the given list)

1. An experiment based on Laser: To determine the divergence of a laser beam or to determine diameter of a thin wire or to perform beam profile analysis of a laser beam.
2. An experiment based on optical fiber: To determine the numerical aperture or attenuation coefficient or critical angle of incidence for given a glass slab or any experiment to calculate parameters of optical fiber.
3. Determination of Planck's constant using available experimental setup.
4. Newton's rings - to understand the interference and determine radius of curvature of a given plano-convex lens or determine wavelength of given monochromatic light.
5. An experiment based on diffraction: determination of number of lines per centimeter on grating surface using normal incidence method or determination of wavelength of laser using transmission grating or to determine wavelength of light using diffraction grating & spectrometer.
6. An experiment based on polarization: To verify cosine square law of Malus Law for plane polarized light or to determine the specific rotation of the given sample with the help of a polarimeter or to determine refractive indices of extraordinary and ordinary rays using double refractive prism.
7. To determine the band gap energy of a semiconductor sample using a PN junction diode.
8. To plot I-V characteristics and determine fill factor and efficiency of a given solar cell.
9. To determine Hall coefficient and charge carrier density of a given semiconductor sample.
10. Determination of velocity of ultrasonic waves and compressibility of given liquid by using Ultrasonic Interferometer
11. An experiment based on physical measurements developed using Arduino interface for Hall effect sensor or Ultrasonic sensor.
12. Study tour / visit to a research laboratory / facility and submit a report.

**Note:** Apart from the above list, any one experiment related to the curriculum available in the institute / developed in-house / performing experiment on Virtual Lab platform may also be considered to be performed out of eight experiments.

## Learning Resources

### Text Books:

- A Textbook of Engineering Physics, M. N. Avadhanulu, P. G. Kshirsagar & TVS Arun Murthy, S. Chand Publications.
- Engineering Physics, R. K. Gaur and S. L. Gupta, Dhanpat Rai Publications.

**Reference Books:**

- Optics, Ajoy Ghatak, Tata Mc Graw Hill
- Introduction to Solid State Physics, C. Kittel, Wiley and Sons.
- Quantum Mechanics, A. K. Ghatak, S. Lokanathan, Laxmi Publications.
- Nanotechnology: Principles and Practices, Dr. S. K. Kulkarni, Capital Publishing.
- Physics for Scientists and Engineers with Modern Physics, Serway and Jewett, Cengage Publications.

**e-Books:**

1. Feynman Lecture series: https://www.feynmanlectures.caltech.edu/
2. Concepts of Modern Physics, Arthur Beiser: https://nitsri.ac.in/Department/PHYSICS/Beiser_Modern_Physics.pdf

**MOOC / NPTEL/YouTube Links:**

1. Lectures by Walter Lewin: https://www.youtube.com/channel/UCiEHVhv0SBMpP75JbzJShqw
2. Quantum Mechanics Lecture Series by Prof. H. C. Verma: https://www.youtube.com/playlist?list=PLWweJWdB_GuISnGkAafMpzzDBvTHg02At