BPHE102C/BPHE202C	APPLIED PHYSICS FOR ELECTRICAL AND ELECTRONICS ENGINEERING STREAM (EE, EC & UE Branches) (Integrated)	Credits - 04
Hours/Week:(3:0:2)		CIE Marks: 50
Total Hours:60Hrs(40L+20P)		SEE Marks: 50

Course Objectives:

1. To study the principles of quantum mechanics
2. To study the properties of conductors, dielectrics and superconductors
3. To study the basics of lasers and optical fibers
4. To study the fundamentals of electromagnetism
5. To study the properties of semiconductors and semiconductor devices

MODULE – I — 08 Hrs

Quantum mechanics:

Introduction, quantization of energy levels, de-Broglie hypothesis, matter waves and its properties, de-Broglie wavelength and its derivation. Phase velocity, group velocity, wave packet, relation between group velocity and particle velocity. Heisenberg's uncertainty principle and its physical significance (no derivation), application of uncertainty principle – non existence of electron in the nucleus. Principle of complementarity, wave function, properties and physical significance of a wave function and Born's interpretation.. Derivation of one dimensional time independent Schrodinger's wave equation. Expectation value, normalization of a wave function, eigen functions and eigen values. Applications of Schrodinger's wave equation- eigen functions and energy eigen values of a particle in a one dimensional potential well of infinite height, wave forms and probability densities. Numerical problems.

Pre-requisite: Wave - particle dualism

Self learning: Franck – Hertz experiment, Davisson-Germer experiment

MODULE – II — 08 Hrs

Electrical properties of materials:

Conductors:

Introduction, quantum free electron theory of metals: Assumptions, Bose-Einstein and Fermi-Dirac distribution (qualitative), Fermi energy, Fermi factor, variation of Fermi factor with temperature and energy, mention of expression for electrical conductivity. Numerical problems.

Dielectric properties:

Introduction, polar and non-polar dielectrics, electrical polarization mechanisms, internal fields in solids in one dimension (derivation), Clausius - Mossotti equation (derivation). Application of dielectrics in transformers, capacitors, electrical insulation. Numerical problems.

Superconductivity:

Introduction to superconductors, temperature dependence of resistivity in conductors and superconductors, Meissner's effect, critical magnetic field, temperature dependence of critical magnetic field, Silsbee effect, Type-I and Type-II superconductors, BCS theory (qualitative), Josephson junction, high temperature superconductors. Applications of superconductors – SQUID and MAGLEV. Numerical problems.

Pre-requisites: Classical free electron theory

Self-learning: Basics of dielectrics

MODULE – III — 08 Hrs

Lasers and optical fibers:

Laser:

Introduction, interaction of radiation with matter (absorption, spontaneous emission and stimulated emission), Einstein's coefficients (derivation for energy density), conditions for laser action, requisites of a laser system, working mechanism, characteristics of a laser. Construction and working of carbon dioxide laser. Applications of lasers- defense (laser range finder) and laser printing. Numerical problems.

Optical fibers:

Introduction, total internal reflection, propagation mechanism in optical fibers, angle of acceptance, numerical aperture and its derivation, fractional index change, modes of propagation (qualitative), V number and number of modes, types of optical fibers, attenuation and mention of expression for attenuation coefficient, attenuation spectrum of an optical fiber with optical windows. Applications-optical fiber communication system, merits and demerits, intensity based fiber optic displacement sensor. Numerical problems.

Pre-requisite: Properties of light

Self learning: He-Ne laser and Snell's law

MODULE – IV	**08 Hrs**

Maxwell's equations and EM waves:

Maxwell's equations:

Introduction, fundamentals of vector calculus. Divergence and curl of electric and magnetic fields (static), Gauss divergence theorem, Stoke's theorem. Description of laws of electrostatics. Magnetism, Faraday's laws of EMI, current density, equation of continuity, displacement current (with derivation), Maxwell's equations in vacuum. Numerical problems.

EM waves:

The wave equation in differential form in free space (derivation of the equation using Maxwell's equations), plane electromagnetic waves in vacuum, their transverse nature.

Pre-requisite: Basics of electricity and magnetism

Self-learning: Fundamentals of vector calculus.

MODULE – V	**08 Hrs**

Semiconductors and Devices:

Introduction, Fermi level in intrinsic and extrinsic semiconductor, expression for concentration of electrons in conduction band and holes concentration in valance band (no derivation), relation between Fermi energy and energy gap in intrinsic semiconductors (derivation), law of mass action, electrical conductivity of a semiconductor (derivation), Hall effect, expression for Hall coefficient (derivation) and its application. Photodiode and power responsivity, construction and working of semiconducting laser, four probe method to determine resistivity, phototransistor. Numerical problems.

Pre-requisite: Basics of semiconductors

Self-learning: Direct and indirect band gap semiconductors

Reference Books :

1. M. N. Avadhanulu, P. G. Kshirsagar and T. V. S. Arun Murthy, 2019, "A textbook of Engineering Physics" (11th edition), S. Chand, New Delhi,
2. Arthur Beiser, 2006, "Concepts of Modern Physics" (6th edition), TMH, New Delhi
3. Kenneth Krane, 2006, "Modern physics" (2nd edition), John Wiely, New Delhi
4. An introduction to lasers theory and applications by M.N.Avadhanulu and P.S. Hemne revised edition 2012. S.Chand and Company Ltd -New Delhi
5. B.B. Laud, 2002, "Lasers and Non-Linear Optics" (2nd edition), New age international publishers, New Delhi
6. K.R. Nambiar, 2006, "LASERS Principles, Types and Applications", New age international publishers, New Delhi
7. B.P.Pal, 2015, "Fundamentals of Fibre Optics in Telecommunications and sensor systems" (2nd edition), New age international publishers, New Delhi
8. David J. Griffiths, 2020, "Introduction to electrodynamics" (4th edition), Cambridge university press, New Delhi
9. S. O. Piliai, 2010, "Solid State Physics" (6th edition), New age international publishers, New Delhi
10. R. K. Gaur and S. L. Gupta, 2018, "Engineering Physics" (8th edition), Dhanpat Rai publications, New Delhi

Web links and video lectures (e-resources):
Laser: https://www.britannica.com/technology/laser,k
Laser: https://nptel.ac.in/courses/115/102/115102124/
Quantum mechanics :https://nptel.ac.in/courses/115/104/115104096/
Physics :http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
Numerical aperture of fiber :https://bop-iitk.vlabs.ac.in/exp/numerical-aperture-measurement
Activity-based learning (suggested activities in class)/practical-based learning
http://nptel.ac.in
https://swayam.gov.in
https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham
https://vlab.amrita.edu/index.php?sub=1&brch=189 and sim =343&cnt=1
https://virtuallabs.merlot.org/vl_physics.html
https://phet.colorado.edu
https://www.myphysicslab.com

Laboratory component:
Any ten experiments have to be completed from the list of experiments

LIST OF EXPERIMENTS

1. Verification of Stefan's law
2. Determination of Planck's constant using LEDs
3. Determination of Fermi energy for a copper
4. Determination of dielectric constant of a material in a capacitor by charging and discharging method
5. Determination of wavelength of laser using diffraction grating
6. Determination of acceptance angle and numerical aperture of the given optical fiber
7. Determination of magnetic flux density at any point along the axis of a circular coil
8. Determination of energy gap of a given semiconductor
9. The study of characteristics of a photodiode
10. The study of I-V characteristics of a given bipolar junction transistor
11. Determination of energy gap of a semiconductor by four probe method
12. The study of frequency response in series and parallel LCR circuits
13. Identification of passive components and estimation of their values in a given black box
14. Determination of velocity of ultrasonic waves in a given liquid using ultrasonic interferometer
15. Step interactive physical simulations
16. Study of motion using spread sheets
17. Study of application of statistics using spread sheets
18. PHET interactive simulations (https://phet.colorado.edu/en/simulations/filter?subjects=physics&type=html,prototype

Course outcomes:
At the end of the course the student will be able to:

1. Apply Schrodinger's wave equation for computing probability density and energy for one dimensional system.
2. Select appropriate properties of conductors, dielectrics and superconductors for engineering applications.
3. Select appropriate properties of laser and type of optical fiber for engineering applications.
4. Apply concepts of electromagnetism for engineering applications.
5. Select appropriate properties of semiconductors and semiconductor devices for engineering applications.

Course Outcomes	Programme Outcomes											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3	2			1				1			1
CO2	3	2			1				1			1
CO3	3	2			1				1			1
CO4	3	2			1				1			1
CO5	3	2			1				1			1