Course Code		:	1BPHE102C/202C	QUANTUM PHYSICS & ENGINEERING MATERIALS (Integrated)	Semester	:	I/II
L : T : P		:	3:0 :2		Course Type	:	IPCC
Hours / Sem	Teaching	:	42+28Hrs		CIE Marks	:	50
	Learning (TW+SL)	:	42Hrs		SEE Marks	:	50
	Exam	:	08Hrs		Total Marks	:	100
	Total Hrs	:	120Hrs		Credits	:	04

Professional Competency:
Apply appropriate properties of materials for engineering systems.
Course Outcomes:
At the end of the course the student will be able to: CO1: Apply the quantum mechanics principles and properties of conductors for engineering applications. CO2: Apply appropriate properties of superconductors and semiconductors for engineering applications CO3: Apply appropriate properties of laser and type of optical fiber for engineering applications CO4: Apply appropriate dielectric, magnetic and thermoelectric materials for engineering applications

Unit – I	11 Hrs

Quantum mechanics:
Introduction, de Broglie hypothesis and its derivation, matter waves and its properties, quantization of energy levels, phase velocity and group velocity, relation between group velocity and particle velocity. Heisenberg's uncertainty principle and its physical significance (no derivation), Application of uncertainty principle (nonexistence of electron in the nucleus-relativistic), Principle of complementarity, Wave function and its properties, Derivation of one dimensional time independent Schrodinger's wave equation. Physical significance of a wave function and Born interpretation, Expectation value and its physical significance. 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, role of higher dimensions, waveforms and probabilities. Numerical problems.

Electrical properties of metals :
Introduction, failures of classical free electron theory, Matthiessen's rule, assumptions of quantum free electron theory, Fermi energy, Fermi-Dirac statistics, density of states (qualitative), Fermi factor, variation of Fermi factor with temperature and energy, success of quantum free electron theory. Numerical problems.

Unit – II	10 Hrs

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. Formation of cooper pairs, BCS theory and its limitations, Type-I and Type-II superconductors, high temperature superconductors, quantum tunneling, Josephson junction, DC and AC (RF) SQUIDs. Applications of superconductors: charge qubit, superconducting magnets and Maglev vehicle. Numerical problems.

Semiconductors :
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 voltage and Hall coefficient (derivation) and its applications. Numerical problems.

Unit – III	10 Hrs

Photonics :

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, classification of lasers. Construction and working of Nd:YAG laser, CO_2 laser and semiconductor diode laser. Applications of lasers- laser bar code scanner, laser printer and laser range finder. Numerical problems.

Optical fibers:

Introduction, principle and structure, propagation mechanism in optical fibers, angle of acceptance, numerical aperture and its derivation. Modes of propagation (qualitative), V number and number of modes, types of optical fibers, attenuation and fiber losses. Applications-optical fiber communication system and fiber optic networking. Numerical problems.

Unit – IV	11 Hrs

Dielectric, Magnetic and Thermoelectric Materials:

Dielectrics:

Introduction, types of dielectrics, electrical polarization mechanisms, dielectric constant and relation between dielectric constant and polarization, Internal field and derivation of internal field in solids and liquids (one dimensional), Lorentz field, Clausius-Mossotti relation (derivation) and its implications, dielectric loss (qualitative). Application of solid, liquid and gaseous dielectrics. Numerical problems.

Magnetic materials:

Classification of magnetic materials, Weiss molecular field theory of ferromagnetism(qualitative), importance of Curie temperature, ferromagnetic hysteresis and explanation using domain theory, energy loss, hard and soft ferromagnetic materials. Applications-transformer cores, armature and permanent magnets. Numerical problems.

Thermoelectric Materials:

Thermo emf and thermo current, Seebeck effect, Peltier effect, Seebeck and Peltier coefficients, figure of merit (mention expression) and its importance, laws of thermoelectricity. Expression for thermo emf in terms of T_1 and T_2 (derivation), thermo couples, thermopile. Numerical problems.

Practical Module	28 Hrs

01	Determination of wavelength of LASER using diffraction grating.
02	Determination of numerical aperture and acceptance angle of the given optical fiber.
03	Study the characteristics of a photo - diode and to determine the power responsivity.
04	Determination of Planck’s constant using LEDs.
05	Determination of Fermi energy of copper.
06	Determination of energy gap of the given semiconductor.
07	Black-box experiment (Identification of basic electronic components).
08	Resonance in LCR circuit.
09	Determination of resistivity of a semiconductor by four probe method.
10	Determination of dielectric constant of the material in a capacitor by charging and discharging method.
11	Verification of Stefan’s law.
12	Characteristics of a bipolar junction transistor.
13	Interference by the division of amplitude (Air wedge/Newton’s rings).
14	Data analysis using spread sheets.
15	Electronic / electrical circuit simulations

Note: i) Introduction lab
ii) Any ten experiments are to be conducted from the above list.
iii) Two Virtual/simulation labs

Text Books:

01	Avadhanulu M.N., Kshirsagar P. G. and Arun Murthy T.V.S, “ A Textbook of Engineering Physics”, S. Chand, New Delhi, 11^{th} edition, 2019.
02	Kakani S.L., Shubra Kakani, “Engineering Physics”, CBS Publishers and Distributers Pvt. Ltd, 3^{rd} edition, 2020.
03	Satyendra Sharma and Jyotsna Sharma, “Engineering Physics”, Pearson, 2018.

Reference Books:

01	Pillai S.O, “Solid state physics”, New Age International Publishers, 8^{th} edition, 2018
02	Griffiths D. J, “Introduction to Quantum Mechanics”, Pearson, 2^{nd} edition, 2018.
03	Tinkham M, “Introduction to Superconductivity”, Dover Publications, 2^{nd} edition, 2004.
04	Mishra P. K, “Superconductivity – Basics and Applications”, Ane Books, 2009.
05	Loud B.B, “LASERS and Non-Linear Optics”, New Age International, 2002.
06	Saleh B. E. A. & Teich M. C, “ Fundamentals of Photonics”, Wiley, 3^{rd} edition, 2019
07	Mathur D.S, “Elements of properties of Matter”, S. Chand, Reprint, 2016.
08	Beiser A, ” Concepts of Modern Physics”, McGraw-Hill Education, 6^{th} edition, 2002.
09	Krane Kenneth S, “ Modern Physics”, John Wiley and sons, 3^{rd} edition, 2012.

Web Links and Video Lectures:

01	NPTEL – Quantum Mechanics I (IIT Madras): https://nptel.ac.in/courses/115106066
02	NPTEL – Physics: Introductory Quantum Mechanics (NOC): https://archive.nptel.ac.in/courses/115/104/115104096
03	Solid State Physics – NPTEL (IIT Madras) https://nptel.ac.in/courses/115106127
04	A Brief Course on Superconductivity – NPTEL IIT Guwahati (Prof. Saurabh Basu) Playlist Introduction Video: https://www.youtube.com/watch?v=SHoGV-sezNI Full playlist available via the YouTube channel description or archive link.
05	Concepts in Magnetism and Superconductivity – NOC (IIT Kharagpur) Series start (Lecture 1): https://digimat.in/nptel/courses/video/115105131/L01.html
06	Introduction to Photonics – NPTEL (IIT Madras, Prof. Balaji Srinivasan) Lecture 03 to Lecture 12 cover: Direct video link (start Lecture 03): https://nptel.ac.in/courses/108106135/03
07	Semiconductor Optoelectronics – NPTEL (IIT Delhi, Prof. M. R. Shenoy), Direct video link (start relevant lecture): https://nptel.ac.in/courses/108108174/05

Course Outcomes (Cos)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	**3** (WK1,WK2 and WK3)	**2** (WK1,WK2 and WK3)						1			1	1	
CO2	**3** (WK1,WK2 and WK3)	**2** (WK1,WK2 and WK3)						1			1	1	
CO3	**3** (WK1,WK2 and WK3)	**2** (WK1,WK2 and WK3)						1			1	1	
CO4	**3** (WK1,WK2 and WK3)	**3** (WK1,WK2 and WK3)						1			1	1	