Semester: I/II			
Course Title	Applied Physics for Computer Science Stream	**CIE Marks**	50
Course Code	BCSPHY112/212	**SEE Marks**	50
Course Type	Integrated	**Total Marks**	100
Course Category	ASC	**SEE Duration**	03 hrs
Hours Per Week	2L: 2 T: 2P	**SEE Type**	Written
Total Hours	40 hrs of theory + 18-20 hrs of practical sessions	**Credits**	04

Course Learning Objectives: This course will enable the students to
● Explain the core concepts of quantum mechanics, such as matter waves, the uncertainty principle, wave functions, and quantisation of energy, with relevance to computational applications.
● Analyze the behaviour of electrons in metals and semiconductors using classical and quantum models to derive key material properties such as conductivity and carrier concentration.
● Evaluate the principles and characteristics of superconductivity, including Meissner's effect, critical parameters, and Cooper pair formation, and their relevance in quantum systems.
● Interpret the interaction of radiation with matter and the operational principles of photonic devices such as lasers, optical fibres, modulators, and photodetectors.
● Summarize the basic concepts of quantum computing, including qubits, quantum gates, and quantum logic, and predict simple outcomes using theoretical circuit models.
Pre-Requisites
● Students must have the knowledge of Dual nature of light, Basics of Electrical conductivity
● Properties of light, Energy levels, Basics of Semiconductors.

Module-1: Quantum Mechanics	**(8 hrs)**
Introduction, de-Broglie Hypothesis, Heisenberg's Uncertainty Principle and its application (Broadening of Spectral Lines), Principle of Complementarity, Wave Function, Time independent Schrödinger wave equation (Derivation), Physical significance of a wave function and Born Interpretation, Expectation value and its physical significance, Eigen functions and Eigen values, Particle inside one dimensional infinite potential well, Role of higher dimensions (Qualitative), Waveforms and Probabilities, Numerical Problems.	
Module -2: Electrical Properties of Metals and Semiconductors	**(8 hrs)**
Concept of Phonon, Mechanisms of electron scattering in solids-Phonon Scattering and impurity scattering. Mathiesen's rule, Assumptions of Quantum Free Electron Theory, Density of states (Qualitative), Fermi Energy, Variation of Fermi Factor with Temperature and Energy. Fermi Dirac Statistics and distribution. Expression for electron concentration and hole concentration, Significance of Fermi level for intrinsic (derivation) and extrinsic semiconductor (no derivation). Expression for electrical conductivity in an intrinsic semiconductor (Derivation), Hall effect and Hall Coefficient (Derivation), Numerical Problems.	
Module-3: Superconductivity	**(8 hrs)**
Zero resistance state, Persistent current, Meissner effect, Critical temperature, Critical current (Silsbee Effect) – Derivation for a cylindrical wire using ampere's law, Critical field, Formation of Cooper pairs - Mediation of phonons, Two-fluid model, BCS Theory - Phase coherent state, Limitations of BCS theory, Examples of systems with low and high electron-phonon coupling, Type-I and Type-II superconductors, Formation of Vortices, Explanation for upper critical field, Cooper pair Tunneling, Josephson junction, Flux quantization, DC SQUID (Qualitative), Numerical Problems.	

Module-4: Photonics	(8 hrs)
Interaction of radiation with matter – Einstein's A and B coefficients, Prerequisites for lasing actions, Types of LASERS – Semiconductor diode LASER, Use of attenuators for single photon sources, Optical modulators – Pockel's effect & Kerr effect (Qualitative), Photodetectors – Single Photon Avalanche Diode, Optical fiber, Derivation of Numerical aperture, V-number, Number of modes, Types of optical fiber, losses in optical fiber, Mach-Zehnder interferometer, Numerical problems.	
Module- 5: Quantum Computing	**(8 hrs)**
Moore's law - limitation of VLSI, Classical vs Quantum Computation, bit, Qubit and its properties, Bloch Sphere, Dirac notation, Brief discussion on types of qubits, Charge qubit, Linear algebra tools-unitary and Hermitian operators, inner products, orthogonality and orthonormality. Quantum Gates – Pauli Gates, Phase gate (S, T), Hadamard Gate, Two qubit gates – CNOT gate, Controlled Z-gate. Predicting the outputs of various combinations of single and two-qubit gates, **Numerical Problems.**	

Practical Components of IPCC

List of Experiments (Any 10 to be conducted)

1. Determination of wavelength of LASER using Diffraction Grating.
2. Determination of acceptance angle and numerical aperture of the given Optical Fiber.
3. Study the Characteristics of a Photo-Diode and to determine the power responsivity / Verification of Inverse Square Law of Light
4. Determination of Planck's Constant using LEDs.
5. Determination of Fermi Energy of Copper.
6. Determination of Energy gap of the given Semiconductor.
7. Black-Box Experiment (Identification of basic Electronic Components)
8. Resonance in LCR circuit.
9. Characteristics of a Bipolar Junction Transistor.
10. Determination of resistivity of a semiconductor by Four Probe Method.
11. Predicting the outputs of various combinations of single and two-qubit gates using QUIRK Quantum Simulator.
12. Predicting the outputs of various combinations of single and two-qubit gates using QUISKIT.
13. Air-wedge / Newtons to study the interference by the division of amplitude.
14. Data Analysis using Spread Sheet.

***One Simulation Experiment is compulsory**

Text Books

1.	"Engineering Physics" by Satyendra Sharma and Jyotsna Sharma, Pearson, 2018.
2.	"Engineering Physics" by S L Kakani, Shubra Kakani, 3rd Edition, 2020, CBS Publishers and Distributers Pvt. Ltd., 2018.
3.	"Solid State Physics" by S O Pillai, New Age International Private Limited
4.	"Quantum Computing" by Parag K Lala, McGraw Hill, 2020.
5.	"Engineering Physics" by R. K. Gaur and S. L. Gupta Dhanpath Rai and Sons, New Delhi
6.	"A textbook of Engineering Physics" by M. N. Avadhanulu, P. G. Kshirsagar and T V S Arun Murthy S, Chand and Company Ltd,11th Edition, New Delhi
7.	"Quantum Computing" by Vishal Sahani McGraw Hill Education

Reference Books & e- Resources	
1.	"Concepts of Modern Physics" by Beiser, A. 6th ed, McGraw-Hill Education, 2002.
2.	"Introduction to Quantum Mechanics" by Griffiths, D. J, (2nd or 3rd ed.). Pearson, 2018.
3.	"Introduction to Superconductivity" Tinkham, M, (2nd ed.). Dover Publications, 2004.
4.	"Superconductivity – Basics and Applications" by Mishra, P. K. Ane Books, 2009.
5.	"LASERS and Non-Linear Optics" by B B Loud, New Age International.
6.	"Fundamentals of Photonics" by Saleh, B. E. A., & Teich, M. C. (3rd ed.). Wiley 2019.
7.	"Quantum Computation and Quantum Information" by Nielsen, M. A., & Chuang, I. L. (10th Anniversary ed.). Cambridge University Press, 2010.
8.	"Quantum Computing" by Vishal Sahani, McGraw Hill Education, 2007.
9.	Quantum Mechanics: https://www.youtube.com/watch?v=p7bzE1E5PMY&t=136s NPTEL – I (IIT Madras): https://nptel.ac.in/courses/115106066 NPTEL–Physics:Introductory Quantum Mechanics (NOC): https://archive.nptel.ac.in/courses/115/104/115104096
10.	Superconductivity: https://www.youtube.com/watch?v=MT5Xl5ppn48 Concepts in Magnetism and Superconductivity – NOC (IIT Kharagpur) Series start (Lecture https://digimat.in/nptel/courses/video/115105131/L01.html
11.	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 LASER: https://www.youtube.com/watch?v=WgzynezPiyc Optical Fiber https://www.youtube.com/watch?v=N_kA8EpCUQo
12.	Quantum Computing: https://www.youtube.com/watch?v=jHoEjvuPoB8 Lecture 04 – Quantum Computing Basics: https://www.youtube.com/watch?v=-fttE1SzpD8 Lecture 08 – Quantum Gates and Circuits Part 1: https://www.youtube.com/watch?v=nGPr1QM_XrY
13.	Virtual LAB:https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham
14.	Virtual LAB: https://vlab.amrita.edu/index.php?sub=1&brch=189&sim=343&cnt=1

Course Outcome Statements: After the successful completion of the course, the student will be able to	
CO1	Describe the concepts of Quantum Mechanics, Quantum Computing, Electrical Properties of Metals, Semiconductors, Superconductors and Photonics.
CO2	Discuss the role of Quantum Mechanical aspects in Computing, Electrical Properties of Metals, Semiconductors' Superconductors and Photonics pertaining to the Engineering problems.
CO3	Apply the Concepts of Quantum Mechanics in Computing, Electrical Properties of Metals, Semiconductors, Superconductors and Photonics by Solving Numerical.
CO4	Determine the electrical properties of materials by conducting experiments and perform simulations, analyse data for practical applications.

Course Articulation Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO2	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO3	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO4	**-**	**2**	**1**	**-**	**1**	**-**	**-**	**1**	**1**	-	**1**
Avg.	**2.5**	**2**	**1**		**1**			**1**	**1**		**1**

3: High, 2: Medium, 1: Low