

Dr. Ambedkar Institute of Technology, Bengaluru-56
Department of Physics
Scheme and Syllabus - 2026-27

Course Title	Quantum Physics and Applications						
Course Code	1BPHU102B (CSE stream)						
Category	Applied Science Course (ASC) (Integrated Course)						
Scheme and Credits	No. of Hours / Week					Total Teaching Hours	Credits
	L	T	P	SS	Total		
	3	0	2	4	5	42 + 28 +50= 120	4
CIE Marks: 50	SEE Marks: 50		Total Max. Marks =100		Duration of SEE: 03 Hours		
Course Learning Objectives:							
CLO1	To understand quantum mechanical concepts such as the de Broglie hypothesis, Heisenberg's uncertainty principle, and the Schrödinger wave equation, and apply them to potential wells and quantum tunnelling.						
CLO2	To analyse the electrical properties of metals and semiconductors using quantum free electron theory, Fermi-Dirac statistics and the Hall effect.						
CLO3	To explain the phenomenon of superconductivity, its critical parameters, the Meissner effect, BCS theory and Josephson junctions.						
CLO4	To describe the interaction of radiation with matter and laser action, and analyse light propagation and attenuation in optical fibres for photonic applications.						
CLO5	To introduce the principles of quantum computing, including qubits, the Bloch sphere, and single- and two-qubit quantum gates.						
Unit No.	Syllabus Content						No. of Teaching Hours
1	Quantum Mechanics: 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						8

	significance of a wave function and Born Interpretation, expectation value and its physical significance. Probability density and normalization of wave function. Eigen functions and Eigen values, Particle inside one dimensional infinite potential well, role of higher dimensions (qualitative), Wave function and probability densities for $n=1, 2$ and 3. Quantum tunneling, numerical problems. Self-Study: Group velocity, Application of uncertainty principle – non-existence of electron in the nucleus, operators, Quantum dot.	
2	Electrical Properties of Metals and Semiconductors: Assumptions and failures of classical free electron theory, mechanisms of electron scattering in solids, Matheissen's rule, assumptions of Quantum Free Electron Theory, density of states (qualitative), Fermi Dirac statistics, Fermi Energy (no derivation), variation of Fermi factor with temperature and energy, Semiconductors: expression for carrier concentration: derivation of electron and hole concentrations in an intrinsic semiconductor, Fermi level for intrinsic (derivation) and extrinsic semiconductor (no derivation), Hall effect, expressions for Hall voltage and Hall coefficient and its applications. numerical problems. Self-Study: Success of QFET, Band Theory of Solids.	8
3	Superconductivity: Zero resistance state, persistent current, three critical parameters: critical temperature, critical magnetic field, critical current: Silsbee Effect. Meissner Effect, Type-I and Type-II superconductors, Formation of Vortices, Formation of Cooper pairs - BCS Theory (qualitative) and its limitations, high temperature superconductors, Explanation for upper critical field, Cooper pair Tunneling (Andreev reflection), Josephson junction (AC and DC), Flux quantization, SQUID (DC), numerical problems.	8

	Self-Study: Two fluid model, MAGLEV vehicle, Superconductors in MRI.	
4	Photonics: Interaction of radiation with matter– Einstein’s A and B coefficients, conditions for Laser action. Requisites of a laser system, types of LASER– semiconductor diode LASER, applications of laser in detecting pollutants. use of attenuators for single photon sources, optical modulators Pockel’s effect, Kerr effect, photo detectors – single photon Avalanche diode, Superconducting Nanowire single photon detector, optical fiber, derivation of numerical aperture, V-number, Number of modes, Attenuation: causes for attenuation (Scattering, absorption and bending), numerical problems. Self-Study: Applications of LASERs: Mach-Zehnder interferometer, Propagation mechanism of light in optical fiber, types of optical fibers.	8
5	Quantum Computing: Moore’s law - limitation of VLSI, Classical vs Quantum Computation, bit, qubit and its properties, Bloch Sphere, Dirac notation, Brief discussion on types of qubit, superconducting qubits, Harmonic oscillator (qualitative) – Need for anharmonicity, Charge qubit, Quantum Gates – Pauli Gates, Phase gate (S, T), Hadamard Gate, Two qubit gates – CNOT gate, Predicting the outputs of various combinations of single and two-qubit gates, Numerical Problems. Self-Study: Interference, superposition, entanglement, quantum computers.	8
Experimental Components: Any Ten Experiments have to be completed from the list of experiments 1. Series & Parallel LCR Circuits 2. Determination of Fermi energy of a copper. 3. Wavelength of LASER using Grating 4. Numerical Aperture using optical fiber 5. Charging and Discharging of a Capacitor 6. Energy Gap of the given Semiconductor 7. Planck’s constant using LEDs.		

8. Transistor Characteristics
9. Zener Diode Characteristics
10. Radius of curvature of Plano convex lens using Newton's rings
11. GNU Step Interactive Simulations
12. Study of Electrical quantities using spreadsheet
13. Online Circuit Simulator Online Circuit Simulator (<https://www.partsim.com/simulator>)
14. PHET Interactive Simulations
(<https://phet.colorado.edu/en/simulations/filter?subjects=physics&type=html,prototype>)

Teaching and Learning Process: Chalk and Talk, Power Point presentation and Lab Experiment Videos

Suggested Learning Resources:

1. S. P. Basavaraju, A Detailed Text Book of Engineering Physics, Subhas Stores, Bangalore, CBCS Edition, 2018..
2. Engineering Physics, Satyendra Sharma and Jyotsna Sharma, Pearson, 2018.
3. Engineering Physics-Gaur and Gupta Dhanpat Rai Publications - 2017.
4. Concepts of Modern Physics-Arthur Beiser: 6th Ed; Tata Mc Graw Hill Edu Pvt Ltd - New Delhi 2006.
5. Fundamentals of Fibre Optics in Telecommunication & Sensor Systems, B.P.Pal, New Age International Publishers, 1st edition 2005.
6. Lasers and Non Linear Optics-B. B. Laud, 3rd Ed, New Age International Publishers 2011.
7. LASERS Principles, Types and Applications by K. R. Nambiar New Age International Publishers, 2004.
8. Solid State Physics- S O Pillai, 8th Ed-New Age International Publishers-2022.
9. Quantum Physics and Applications, Dr. Geethanjali H. S., Dr. Nagaraja D., Jeevith Publications, 2025.

Web links and Video Lectures (e-Resources):

1. Laser: <https://Laser:https://nptel.ac.in/courses/115/102115102124/>
2. Quantum mechanics: <https://nptel.ac.in/courses/115/104/115104096/>
3. Physics: <http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html>

4. Numerical Aperture of fiber: <https://bop-iitk.vlabs.ac.in/exp/numerical-aperture-measurement>
5. NPTEL Superconductivity: <https://archive.nptel.ac.in/courses/115/103/115103108/>

Activity-Based Learning (Suggested Activities in Class) /Practical Based Learning

1. <http://nptel.ac.in>
2. <https://swayam.gov.in>
3. <https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham>
4. <https://vlab.amrita.edu/index.php?sub=1&brch=189&sim=343&cnt=1>
5. https://virtuallabs.merlot.org/vl_physics.html
6. <https://phet.colorado.edu>
7. <https://www.mypysicslab.com>

Scheme for Examinations

1. Two full questions to be set from each unit with internal choice
 - Minimum number of sub-questions: 2.
 - Maximum number of sub-question: 3.
2. Each full question shall be for a maximum of 20 marks

Answer any five full questions choosing at least one full question from each unit

Note: 1. Questions from Experiments shall be included in the SEE question paper.

2. Questions from the self-study component will be included only in the CIE, carrying up to 10% of the total marks.

Course Outcomes (COs) and CO-PO Mapping

This document lists the Course Outcomes (COs) framed for the syllabus covering Quantum Mechanics, Electrical Properties of Metals and Semiconductors, Superconductivity, Photonics and Quantum Computing (theory), along with the associated Experimental Component, and maps them to the eleven Program Outcomes (POs) as per the latest NBA (Washington Accord aligned) guidelines, using a correlation scale of 1 (Slight), 2 (Moderate) and 3 (Substantial). In line with current NBA guidance, the total number of COs has been consolidated from six to five (CO6, the experimental component, is retained unchanged as CO5) and the total number of POs has been consolidated from twelve to eleven by merging the erstwhile PO6 ('The engineer and society') and PO7 ('Environment and sustainability') into a single Program Outcome.

1. Course Outcomes (COs)

CO No.	Course Outcome — At the end of the course, the student will be able to:	Bloom's Level
CO1	Apply quantum-mechanical principles such as de Broglie's hypothesis, Heisenberg's uncertainty principle, and the Schrödinger equation to microscopic particles, potential wells, and quantum tunnelling; and explain qubits, the Bloch sphere, and quantum gates to predict single- and two-qubit states.	Apply (L3)
CO2	Analyse the electrical properties of metals and semiconductors using quantum free electron theory, Fermi–Dirac statistics and the Hall effect, and estimate carrier concentration in intrinsic and extrinsic semiconductors.	Analyze (L4)
CO3	Explain the phenomenon of superconductivity, its critical parameters, the Meissner effect and BCS theory, and describe Josephson junctions, flux quantization and SQUIDS as applications of superconductivity.	Understand (L2)
CO4	Describe the interaction of radiation with matter and the requisites of laser action, and analyse light propagation and attenuation mechanisms in optical fibres for photonic applications.	Analyze (L4)
CO5	Conduct experiments to verify physical laws and characterise electronic and optical devices (LCR circuits, semiconductors, LASER, optical fibre, LEDs, transistors, diodes), and interpret the experimental data obtained.	Apply (L3)

2. Program Outcomes (POs) — as per NBA Graduate Attributes (11 POs)

As per the latest NBA (Washington Accord aligned) guidelines, PO6 (“The engineer and society”) and PO7 (“Environment and sustainability”) have been merged into a single graduate attribute, reducing the total number of Program Outcomes from twelve to eleven.

PO No.	Program Outcome	Description
PO1	Engineering knowledge	Apply knowledge of mathematics, science and engineering fundamentals to the solution of complex engineering problems.
PO2	Problem analysis	Identify, formulate, review research literature and analyse complex engineering problems using first principles.

PO3	Design/development of solutions	Design solutions for complex engineering problems and design system components or processes to meet specified needs.
PO4	Conduct investigations of complex problems	Use research-based knowledge and methods including design of experiments, analysis and interpretation of data to provide valid conclusions.
PO5	Modern tool usage	Create, select and apply appropriate techniques, resources and modern engineering/IT tools, including prediction and modelling.
PO6	The engineer, society and environment	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues; understand the impact of engineering solutions in societal and environmental contexts; and recognise the need for sustainable development. (This is a merged attribute, combining the former PO6 ‘Engineer and Society’ and PO7 ‘Environment and Sustainability’, as per the latest NBA guidelines.)
PO7	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO8	Individual and team work	Function effectively as an individual and as a member/leader in diverse and multidisciplinary teams.
PO9	Communication	Communicate effectively on complex engineering activities with the engineering community and society at large.
PO10	Project management and finance	Demonstrate knowledge and understanding of engineering/management principles in multidisciplinary environments.
PO11	Life-long learning	Recognise the need for, and engage in independent and life-long learning in the broadest context of technological change.

3. CO-PO Mapping Matrix

Scale: 1 – Slight (Low) correlation 2 – Moderate correlation 3 – Substantial (High) correlation '-' – No correlation

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	-	1	1	-	-	-	-	-	2
CO2	3	3	-	2	1	-	-	-	-	-	1
CO3	3	2	-	-	-	1	-	-	-	-	2
CO4	3	2	1	-	1	-	-	-	-	-	1
CO5	2	2	1	3	3	-	-	2	1	-	1
Avg.	2.80	2.20	0.40	1.20	1.20	0.20	-	0.40	0.20	-	1.40

Mapping of CO's with Knowledge and Attitude Profile (WK)									
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0									
CO	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CO1	3	3	2	-	-	-	-	2	-
CO2	2	3	3	2	-	-	-	-	-
CO3	3	-	-	2	-	2	1	2	-
CO4	2	-	-	3	2	2	-	-	-
CO5	-	3	-	-	-	3	-	2	-

Mapping of CO's with Sustainable Development Goals (SDG)																	
Strength of correlation: Strongly related-3, Moderately related-2, Weakly related-1, Not related-0																	
CO/SDG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CO1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO3	-	-	2	-	-	-	1	-	3	-	-	-	-	-	-	-	-
CO4	-	-	1	-	-	-	-	-	3	-	-	-	1	-	-	-	-
CO5	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-

4. Justification for CO-PO Mapping

CO1 (Quantum Mechanics & Quantum Computing): Formed by merging the former quantum-mechanics CO with the quantum-computing CO, since both require applying core mathematics/science fundamentals (Schrödinger's equation, qubit/gate formalism) to analyse quantum systems — justifying a strong link to PO1 (3) and PO2 (2), with slight links to PO4/PO5 through problem-solving and simulation of gate outputs, and to PO11 (Life-long learning) as quantum technologies are a rapidly evolving field.

CO2 (Electrical Properties): Requires quantitative analysis of carrier statistics and the Hall effect, giving a strong link to PO1 (3) and PO2 (3), with slight links to PO4/PO5 (derivation and measurement-based reasoning) and PO11.

CO3 (Superconductivity): Conceptually explains BCS theory and device applications (SQUIDS, Josephson junctions), linking strongly to PO1/PO2 and touching PO6 (engineer, society and environment) through technologies such as MAGLEV and MRI, and PO11 through continued learning in an evolving field.

CO4 (Photonics): Involves laser action and optical-fibre analysis, linking to PO1/PO2 (3, 2) and slightly to PO3/PO5 through design and tool-based estimation of fibre parameters.

CO5 (Experimental Component — unchanged): Directly linked to PO4 (Conduct investigations — substantial, 3) and PO5 (Modern tool usage — substantial, 3), since students design/perform experiments and use instruments, circuit simulators and PhET simulations. Group experiments support PO8 (Individual & team work) and recording/interpreting readings supports PO9 (Communication). No CO is mapped to PO3, PO7 or PO10 as the syllabus content does not directly address design, ethics or project-management dimensions; these are addressed by other courses in the curriculum.