



K. S. INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU, Approved by AICTE

Department of Physics

FIRST/SECOND SEMESTER SYLLABUS

Course : Applied Physics for CSE Stream: QUANTUM PHYSICS AND APPLICATIONS		Semester	I/II
Course Code	25BPHCS102/202	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	04	Exam Hours	03
Examination type (SEE)	Theory		

Course Objectives (Course Skill Set): The students will be able

- To study the principles of quantum mechanics and its application in quantum computing
- To study the essentials of photonics and its application in Computer Science
- To study the electrical properties of materials

Module-1: Quantum Mechanics

Introduction to Quantum Mechanics : de Broglie Hypothesis and Matter Waves, de Broglie wavelength and derivation of expression by analogy, Heisenberg's Uncertainty Principle and its application (Non-existence of electron inside the nucleus - Non Relativistic), Principle of Complementarity.

Mathematical Formulation : Wave Function, Time independent Schrödinger wave equation (Derivation), Physical Significance of a wave function and Born Interpretation, Eigen functions and Eigen Values, Particle inside one dimensional infinite potential well, Role of higher dimensions (Qualitative), Waveforms and Probabilities, Particle inside a finite potential well and quantum tunneling, Linear superposition, Numerical Problems. **(8 hours)**

Text1: Ch 1 and Ch 2

Module-2: Quantum Computing

Principles of Quantum Information & Quantum Computing: Introduction to Quantum Computing, Moore's law & its end, limitations of VLSI, Differences between Classical & Quantum computing. Concept of bit, qubit and its properties. Representation of qubit by Bloch sphere. Single and Two qubits. Extension to N qubits, Dirac notation, Matrix representation of 0 and 1 States, Superconducting qubits, Harmonic oscillator (qualitative) – Need for anharmonicity, Charge qubit.

Quantum Gates: Single Qubit Gates: Quantum Not Gate, Pauli – X, Y and Z Gates, Hadamard Gate, Phase Gate (or S Gate), T Gate. **Multiple Qubit Gates:** Controlled gate, CNOT Gate, (Discussion for 4 different input states), Numerical Problems. **(8 hours)**

Ref3: Ch 1-1.1-1.3 , Ch 4-4.2-4.5

Module-3: Photonics

Lasers: Interaction of Radiation with Matter, Einstein's A and B Coefficients and Expression for Energy Density (Derivation), Laser Action, Population Inversion, Meta stable State, Requisites of a laser system, Characteristic properties of LASER, Semiconductor Diode Laser Applications: Laser range finder, Use of attenuators for single photon sources, Optical modulators – Pockel's effect, Kerr effect, Numerical Problems.

Optical Fiber: Principle and Structure, Propagation of Light, Acceptance angle and Numerical Aperture (NA), Derivation of Expression for NA, Modes of Propagation, V-number, Attenuation and Fiber Losses, Mach-Zehnder interferometer. Numerical Problems. **(8 hours)**

Text 1: Ch 6 and Ch 7

Module-4: Electrical Properties of Metals and Semiconductors
<p>Electrical Conductivity in metals: Mechanisms of electron scattering in solids, Matheissen's rule, Failures of Classical Free Electron Theory, Assumptions of Quantum Free Electron Theory (QFET), Density of States (Qualitative), Fermi Dirac Statistics, Fermi Energy, Fermi Factor, Variation of Fermi Factor with Temperature and Energy, Numerical Problems.</p> <p>Semiconductors: Fermi level in Intrinsic & Extrinsic Semiconductor, Expression for concentration of electrons in conduction band & holes concentration in valance band (only mention the expression), Fermi level for intrinsic(with derivation) and extrinsic semiconductor (no derivation), Derivation of electron concentration in an intrinsic semiconductor, Hall effect, Expressions for Hall voltage and Hall coefficient, Numerical Problems. (8 hours)</p> <p>Text 1:Ch 3 and Ch 9</p>
Module-5: Superconductivity
<p>Fundamental Concepts of Superconductivity: 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, Josephson junction, Flux quantization, DC and AC SQUID, Maglev vehicles, Numerical Problems. (8 hours)</p> <p>Text 1: Ch 8</p>
List of Laboratory experiments (2 hours/week per batch/batch strength 15) 10 lab sessions + 1 repetition class + 1 Lab Assessment.
Title of the experiment
<ol style="list-style-type: none"> 1. Determination of Planck's Constant using LEDs. 2. Verification of Stefan's Law 3. Predicting the outputs of various combinations of single and two-qubit gates using QUIRK Quantum Simulator. 4. Predicting the outputs of various combinations of single and two-qubit gates using QUIRKIT. 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 Fermi Energy of Copper. 8. Determination of Energy gap of a semiconductor. 9. Determination of resistivity of a material with increasing temperature. 10. Resonance in LCR circuit. 11. Identification of circuit elements in a Black Box and determination of values of the components. 12. Data analysis using Spread Sheet.
<p>Course outcome (Course Skill Set) At the end of the course, the student will be able to:</p> <p>CO1 Apply the fundamental principles of quantum mechanics to understand the behaviour of matter and energy.</p> <p>CO2 Apply the basic concepts of quantum mechanics to understand their relevance in computational applications.</p> <p>CO3 Describe the principles of lasers and optical fibers, and explain their relevant applications in Photonic devices.</p> <p>CO4 Examine the behavior of electrons in metals and semiconductors using quantum theory to understand and explain the properties of materials.</p>

CO5 Summarize the essential properties of superconductors and its applications

Suggested Learning Resources:

Books (Name of the author/Title of the Book/Name of the publisher/Edition and Year)

Text Books:

1. Engineering Physics, **S P Basavaraj**, 2018 Edition, Subhash Stores
2. A Textbook of Engineering Physics- **M.N. Avadhanulu and P.G. Kshirsagar**, 10th revised Ed, S. Chand. & Company Ltd, New Delhi.

Reference Books:

1. Concepts of Modern Physics, **Aurthur Beiser, Mc Grawhill**, 6th Edition, 2009.
2. Lasers and Non Linear Optics, **BB Loud**, New age international, 2011 edition.
3. Quantum Computation and Quantum Information, **MichaelA. Nielsen & IsaacL. Chuang**, Cambridge Universities Press, 2010 Edition.
4. Quantum Computation and Logic: How Quantum Computers Have Inspired Logical Investigations, **Maria Luisa Dalla Chiara, Roberto Giuntini, Roberto Leporini, Giuseppe Sergioli**, Trends in Logic, Volume 48, Springer.
5. Introduction to Superconductivity, **Michael Tinkham**, McGraw Hill, INC, II Edition
6. Solid State Physics, **S O Pillai**, New Age International Private Limited, 8th Edition, 2018.

Web links and Video Lectures (e-Resources):

LASER: <https://www.youtube.com/watch?v=WgzynezPiyc>

Superconductivity: <https://www.youtube.com/watch?v=MT5Xl5ppn48>

Optical Fiber : https://www.youtube.com/watch?v=N_kA8EpCUQo

Quantum Mechanics: <https://www.youtube.com/watch?v=p7bzE1E5PMY&t=136s>

Quantum Computing: <https://www.youtube.com/watch?v=jHoEjvuPoB8>

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

Quantum Computing: <https://www.youtube.com/watch?v=ZuvCUU2jD30>

Physics of Animation : https://www.youtube.com/watch?v=kj1kaA_8Fu4

NPTEL Superconductivity: <https://archive.nptel.ac.in/courses/115/103/115103108/>

NPTEL Quantum Computing : <https://archive.nptel.ac.in/courses/115/101/115101092Virtual>

LAB: <https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham>

Virtual LAB: <https://vlab.amrita.edu/index.php?sub=1&brch=189&sim=343&cnt=1>

Teaching-Learning Process Pedagogy

Teaching-Learning Process: These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes and make Teaching –Learning more effective

1. Flipped Class
2. Chalk and Talk
3. Blended Mode of Teaching and Learning
4. Simulations, Interactive Simulations and Animations
5. NPTEL and Other Videos for theory topics
6. Smart Class Room
7. Lab Experiment Videos

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE, minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:**CIE for the theory component of the IC:**

- The internal Assessment Test component of the CIE carries 25 marks.
- Each test shall be conducted for 25 marks. The first test will be administered after 35-40% of the coverage of the syllabus, second test will be administered after 65-70%, and the third test will be administered after 90-100% of the coverage of the syllabus. The average of the three tests shall be considered for 25 marks.
- Three assignments (average is scaled down to 5 marks)/mini project/Quiz/Seminar are conducted for 5 marks.
- To qualify and become eligible to appear for SEE, in the CIE theory component, a student must score at least 40% of 30 marks, i.e., 12 marks.

CIE for the Lab component of the IC:

Every experiment in the laboratory will be evaluated for 15 marks, comprising marks for conducting the experiment and for laboratory record. An additional 05 marks shall be for the test conducted at the end of the semester. To qualify and become eligible to appear for SEE, in the CIE Practical component, a student must secure a minimum of 40% of 20 marks, i.e., 08 marks.

CIE for the theory 30 MARKS + CIE for the practical 20MARKS = Total CIE 50 MARKS
Semester End Exam (SEE):50 marks