SCHEME: 2025 DATE: 25-08-2025

|| Jai Sri Gurudev ||
Sri Adichunchanagiri Shikshana Trust (R)
SJB Institute of Technology
BGS Health and Education City, Dr. Vishnuvardhana Road, Kengeri, Bengaluru-560060
Approved by AICTE, New Delhi.
Autonomous Institute affiliated to Visvesvaraya Technological University, Belagavi
Accredited by NAAC with 'A+'grade, Certified by ISO 9001 - 2015
Recognized by UGC, New Delhi with 2(f) & 12 (B)

Semester:	I/II	**Course Type:**	IASC		
Course Title: Applied Physics of Quantum Systems and Applications.					
Course Code:	25PHI12A/22A			**Credits:**	4
Teaching Hours/Week (L: T: P:S)			3:0:2:1	**Total Hours:**	40+12 lab slots
CIE Marks:	50	**SEE Marks:**	50	**Total Marks:**	100
SEE Type:	Theory			**Exam Hours:**	3

I. Course Objectives:

- To study the principles of quantum mechanics and its applications in quantum computing
- To study the electrical properties of materials.
- To study the essentials of photonics for engineering applications.
- To understand the operations of different instruments and to analyse the experimental results.

II. Teaching-Learning Process (General Instructions):

Some of the adapted methods in teaching learning methods are

1. Chalk and Talk
2. Blended Mode of Learning
3. Simulations, Interactive Simulations and Animations
4. Smart Classroom
5. Self-learning using AI tools
6. Activity based and experiential learning
7. Models and working model
8. Lab Experiment videos

III. COURSE CONTENT

III (a). Theory part

Module-1: Quantum Mechanics — 8 Hours

de Broglie Hypothesis, Heisenberg's Uncertainty Principle and its application (Qualitative: 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, Particle inside a finite potential well and quantum tunnelling, Numerical Problems (de Broglie wavelength, HUP, Probability of finding the particle and Energy Eigen values).

Text Books: 1, 2 & 3 Reference Books: 1, 2 & 3

Pre-requisites /Self Learning: Dual nature of light and matter waves

RBT Levels: L1 – Remembering, L2 – Understanding, L3 – Applying.

Module-2: Electrical Properties of Materials	8 Hours

Introduction to classical free electron theory, Failures of classical free electron theory, Mechanisms of electron scattering in solids, Mathiesen's rule, Assumptions of Quantum free electron theory, Density of states, Fermi energy, Fermi velocity, Fermi temperature, Fermi factor, Variation of Fermi factor with temperature and energy, Expression for carrier concentration (Only expression), Mention the expression for electron and hole concentration in extrinsic semiconductor, Fermi level for intrinsic (with derivation) and extrinsic semiconductor (no derivation), Hall effect, Numerical Problems (Fermi factor, Fermi temperature, Fermi velocity and Hall co-efficient).

Text Books: 1, 2 & 4 Reference Books: 1, 3

Pre-requisites /Self Learning: Free electron theory

RBT Levels: L1 – Remembering, L2 – Understanding, L3 – Applying,

Module-3: Superconductivity	8 Hours

Zero resistance state, Persistent current, Meissner effect, Critical temperature, Critical current (Silsbee Effect), 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, Josephson junction, Flux quantization, DC and AC SQUID, Charge Qubit, Numerical Problems (Critical field).

Text Books: 1, 2 & 4 Reference Books: 1, 3

Pre-requisites/Self Learning: Temperature dependency of resistivity

RBT Levels: L1 – Remembering, L2 – Understanding, L3 – Applying,

Module-4: Photonics	8 Hours

Interaction of radiation with matter – Einstein's A and B coefficients, Prerequisites for lasing actions, Types of LASER – CO_2 LASER, Use of attenuators for single photon sources, Optical modulators – Pockel's effect, Kerr effect, Photo detectors – Photomultiplier tube, Single Photon Avalanche Diode, Optical fiber, Derivation of Numerical aperture, V–number, Number of modes, losses in optical fiber, Mach-Zehnder interferometer, Numerical problems (Ratio of population, Number of Photons (N), Numerical aperture, V–number and attenuation co-efficient).

Text Books: 1, 2 Reference Books: 4, 5

Pre-requisites /Self Learning: TIR, Properties and applications of LASERs and Optical fibers

RBT Levels: L1 – Remembering, L2 – Understanding, L3 – Applying.

Module-5: Quantum Computing	8 Hours

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, Charge qubit, Pauli matrices and its operation on 0 and 1 states, 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 (Gates)

Text Books: 5 Reference Books : 6

Pre-requisites/Self Learning: Matrix operations

RBT Levels: L1 – Remembering, L2 – Understanding, L3 – Applying.

III (b). Practical part

Sl. No.	Experiments
1	Determination of wavelength of LASER using Diffraction Grating.
2	Determination of acceptance angle and numerical aperture of the given Optical Fiber.
3	Resonance in LCR circuit.
4	Study the Characteristics of a Photodiode and to determine the power responsivity /Verification of inverse square law of light.
5	Determination of Plank's Constant using LEDs.
6	Determination of Fermi Energy of Copper.
7	Black-Box Experiment.
8	I-V Characteristics of a Bipolar Junction Transistor.
9	Predicting the outputs of various combinations of single and two-qubit gates using QUIRK Quantum Simulator.
10	Data Analysis using Spread Sheet.
11	Predicting the outputs of various combinations of single and two-qubit gates using QUISKIT
12	Determination of resistivity of a semiconductor by Four Probe Method.

Instructions for conduction of practical part:

Any Ten Experiments must be completed from the list of experiments.

Each experiment to be evaluated for conduction with observation sheet and record write up. Rubrics for the evaluation of the write-up for experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.

- Record should contain all the specified experiments in the syllabus, and each experiment write-up will be evaluated for 50 marks.
- Average marks scored by the students from all the experiments are considered.
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 test for 50 marks; test shall be conducted after the completion of prescribed experiments.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 80% and the rest 20% for viva-voce.

IV. COURSE OUTCOMES

CO1	Summarize the fundamental principles of Quantum Mechanics and Quantum computing.
CO2	Analyze the behaviour of electrical conductivity in metals, semiconductors and superconductors
CO3	Interpret the interaction of radiation with matter and the operational principle of photonic devices.
CO4	Conduct the experiments and analyze the data to design the solution of engineering problems through critical thinking and collaborations.

V. CO-PO-PSO MAPPING (Mark H = 3; M = 2; L = 1)

PO/PSO	1	2	3	4	5	6	7	8	9	10	11	12	S1	S2	S3	S4
CO1	3	3			2							2				
CO2	3	3	1		2							2				
CO3	3	2		3	2							2				
CO4	3	3	3	3	3	2		1	2	2		2				

VI. Assessment Details (CIE & SEE)

General Rules: Refer Appendix section 2

Continuous Internal Evaluation (CIE): Refer Appendix section 2

Semester End Examination (SEE): Refer Appendix section 2

VII. Learning Resources

VII(a): Textbooks:

Sl. No	Title of the Book	Name of the author	Edition and Year	Name of the publisher
1.	A Textbook of Engineering Physics	M. N. Avadhanulu and P.G. Kshirsagar	10th revised Ed.,	S. Chand. & Company Ltd, New Delhi
2.	Engineering Physics	Satyendra Sharma and Jyotsna Sharma	2018	Pearson
3.	Engineering Physics	S L Kakani and Shubra Kakani	3rd Edition, 2020	CBS Publishers and Distributers Pvt. Ltd.
4.	Solid State Physics	S. O. Pillai	8th Ed; 2018	New Age International
5.	Quantum Computing	Parag K Lala	2020	McGraw Hill

VII(b): Reference Books:

1.	Engineering Physics	S P Basvaraju	CBCS edition	Subhas Publications
2.	Concepts of Modern Physics	Arthur Beiser	6th Ed; 2006	Tata McGraw Hill Edu Pvt Ltd- New Delhi
3.	Engineering physics	G. Aruldhas	1st Ed;2010	Eastern Economy Edition
4.	Engineering Physics	R K Guptha and R K Gaur	8th Revised-2001	Dhanpat Rai Publications
5.	Lasers and Non-Linear Optics	B B Laud	2011 edition	New age international
6.	Quantum Computing.	Vishal Sahani	2007 Edition	McGraw Hill Education
7.	Applied Physics Lab Manual.	Anoop Sing Yadav	1st Ed	Vayu Education of India
8.	Applied Physics for engineers	P K Diwan	2014	Wiley Publications
9.	LASERS Principles, Types and Applications	K.R. Nambiar	1st Ed; 2004	New Age International Publishers

10.	Fundamentals of Fibre Optics in Telecommunication & Sensor Systems	B.P. Pal	2nd Ed; 2015	New Age International Publishers

VII(c): Web links and Video Lectures (e-Resources):

Mention the links of the online resources, video materials, etc.

1. NPTEL – Quantum Mechanics I (IIT Madras): https://nptel.ac.in/courses/115106066
2. NPTEL – Physics: Introductory Quantum Mechanics (NOC): https://archive.nptel.ac.in/courses/115/104/115104096
3. Solid State Physics – NPTEL (IIT Madras) https://nptel.ac.in/courses/115106127
4. A Brief Course on Superconductivity – NPTEL IIT Guwahati (Prof. Saurabh Basu)
5. Playlist Introduction Video: https://www.youtube.com/watch?v=SHoGV-sezNI
6. Full playlist available via the YouTube channel description or archive link.
7. Concepts in Magnetism and Superconductivity – NOC (IIT Kharagpur) Series start (Lecture 1): https://digimat.in/nptel/courses/video/115105131/L01.html
8. 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
9. Semiconductor Optoelectronics – NPTEL (IIT Delhi, Prof. M. R. Shenoy) Direct video link (start relevant lecture): https://nptel.ac.in/courses/108108174/05
10. Lecture 04 – Quantum Computing Basics: https://www.youtube.com/watch?v=-fttE1SzpD8
11. Lecture 08 – Quantum Gates and Circuits Part 1: https://www.youtube.com/watch?v=nGPr1QM_XrY
12. https://phet.colorado.edu
13. https://bop-iitk.vlabs.ac.in/basics-of-physics/List%20of%20experiments.html
14. https://virtuallabs.merlot.org/vl_physics.html
15. https://www.myphysicslab.com

VIII: Activity Based Learning / Practical Based Learning/Experiential learning:

Seminar, assignments, quiz, case studies, self-study activities and group discussions