K. S. INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU, Approved by AICTE

Department of Physics

FIRST / SECOND SEMESTER SYLLABUS

Course : Applied Physics for ECE Stream: QUANTUM PHYSICS AND ELECTRONIC SENSORS		Semester	I/II
Course Code	25BPHEC102/202	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
- To understand the electrical properties of materials
- To study the essentials of Lasers and optical fibers
- To study the properties of semiconductors and their applications in electronic devices and sensors.

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 1and Ch 2

Module-2: Electrical Properties of Metals and Semiconductors

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.

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)**

Text 1:Ch 3 and Ch 9

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: Use of attenuators for single photon sources, Optical modulators – Pockel's effect, Kerr effect, Photodetectors – Single Photon Avalanche Diode, 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-Zchnder interferometer, Numerical Problems. **(8 hours)**

Text 1: Ch 6 and Ch 7

Module-4: Superconductivity

Fundamental Concepts of Superconductivity: Zero resistance state, Persitent 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)**

Text 1: Ch 8

Module-5: Semiconductor Devices and Sensors

Semiconductor Devices: Direct and indirect band gap, Band gap engineering, LED, Photo Diode, Light dependent resistor, Resistance temperature detectors (high, medium, low), VLSI basics, Construction and working of Solar Cell.

Sensors: Sensing mechanisms, Piezo electric Sensors, Metal Oxide Semiconductor (MOS) sensors, Superconducting Nanowire Single Photon Detector, Numerical Problems. **(8 hours)**

Text 1:Ch 9

Text 2:Ch 31

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

1. Determination of Planck's Constant using LEDs.
2. Verification of Stefan's Law
3. Determination of Fermi Energy of Copper.
4. Determination of Energy gap of a semiconductor.
5. Determination of resistivity of a semiconductor by Four Probe Method.
6. Determination of dielectric constant of the material of capacitor by Charging and Discharging method.
7. Determination of wavelength of LASER using Diffraction Grating.
8. Determination of acceptance angle and numerical aperture of the given Optical Fiber.
9. Determination of resistivity of a material with increasing temperature.
10. Study the I-V Characteristics of the Given Bipolar Junction Transistor.
11. Study the characteristics of photodiode.
12. Determination of Efficiency of Solar Cell.
13. Simulation Experiment.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

CO1 Apply the fundamental principles of quantum mechanics to understand the behaviour of matter and energy.

CO2 Examine the behavior of electrons in metals and semiconductors using quantum theory to understand and explain the properties of materials.

CO3 Describe the principles of lasers and optical fibers, and explain their relevant applications in Photonic devices.

CO4 Summarize the essential properties of superconductors and its applications

CO5 Illustrate the properties of semiconductors and the working principles of semiconductor devices.

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. An Introduction to Lasers theory and applications by **M. N. Avadhanulu and P.S. Hemne**, revised Edition 2012. S. Chand and Company Ltd -New Delhi.
2. Concepts of Modern Physics-**Arthur Beiser**: 6th Ed;Tata McGraw Hill Edu Pvt Ltd- New Delhi 2006.
3. Fundamentals of Fibre Optics in Telecommunication & Sensor Systems, **B.P. Pal**, New Age International Publishers.
4. Lasers and Non Linear Optics – **B.B. Laud**, 3rd Ed, New Age International Publishers 2011.
5. Solid State Physics, **S O Pillai**, New Age International Private Limited, 8^{th} Edition, 2018.

Weblinks and Video Lectures (e-Resources):

Laser: https://www.britannica.com/technology/laser,k
Laser: https://nptel.ac.in/courses/115/102/115102124/
Quantum mechanics: https://nptel.ac.in/courses/115/104/115104096/
Physics: http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
Numerical Aperture of fiber:https://bop-iitk.vlabs.ac.in/exp/numerical-aperture-measurement

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

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

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