## PHYSICS FOR COMPUTER SCIENCE AND ENGINEERING STREAM

| **Course Code** | **22PHYS12/22** | CIE Marks | 50 |
|---|---|---|---|
| Course Type (Theory/Practical/Integrated) | Integrated | SEE Marks | 50 |
| | | Total Marks | 100 |
| Teaching Hours/Week (L:T:P:S) | 3:0:2:0 | Exam Hours | 03 |
| Total Hours of Pedagogy | 40 Hours Theory + 12 Hrs. Lab slots | Credits | 04 |

**Prerequisite:**
Properties of light, Wave–Particle dualism, Classical Free Electron Theory, Basics of Electrical conductivity, Motion in one dimension, Probability

**Course objectives.**

- To study the essentials of photonics and its application in computer science.
- To study the principles of quantum mechanics and its application in quantum computing.
- To study the electrical properties of materials
- To study the essentials of physics for computational aspects like design and data analysis.

| **Module-1** | **Hours** |
|---|---|
| **Laser and Optical Fibers:**<br>**LASER**: Characteristic properties of a LASER beam, Interaction of Radiation with Matter, Einstein's A and B Coefficients and Expression for Energy Density (Derivation), Laser Action, Population Inversion, Metastable State, Requisites of a laser system, Semiconductor Diode Laser, Applications: Bar code scanner, Laser Printer, Laser Cooling(Qualitative), Numerical Problems.<br>**Optical Fiber**: Principle and Structure, Propagation of Light, Acceptance angle and Numerical Aperture (NA), Derivation of Expression for NA, Modes of Propagation, RI Profile, Classification of Optical Fibers, Attenuation and Fiber Losses, Applications: Fiber Optic networking, Fiber Optic Communication. Numerical Problems<br>**Pre requisite: Properties of light Self-learning: Total Internal Reflection** | **(8 Hours)** |
| **Module-2**<br><br>**Quantum Mechanics:**<br>de Broglie Hypothesis and Matter Waves, de Broglie wavelength and derivation of expression by analogy, Phase Velocity and Group Velocity, Heisenberg's Uncertainty Principle and its application (Non existence of electron inside the nucleus - Non Relativistic), Principle of Complementarity, Wave Function, Time independent Schrödinger wave equation (Derivation), Physical Significance of a wave function and Born Interpretation, Expectation value, Eigen functions and Eigen Values, Particle inside one dimensional infinite potential well, Quantization of Energy States, Waveforms and Probabilities. Numerical Problems.<br>**Pre requisite: Wave–Particle dualism Self-learning: de Broglie Hypothesis** | **(8 Hours)** |

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| **Module-3**<br><br>**Dielectric Properties:**<br>polar and non-polar dielectrics.. Types of polarization mechanism(Electrical Polarization Mechanisms). Equation for internal field in liquids and solids (1D case & 3D solid). Classius-Mossoti equation(Derivation). Frequency dependence of dielectric constant/polarization. Numerical. Ferroelectric materials, Characteristic properties: Hysteresis loop and Curie Temperature. Application of dielectrics in transformers, Capacitors, Electrical Insulation. Numerical Problems.<br>.**Pre-requisites: Classical Free Electron Theory**<br>**Self-learning: Dielectrics Basics** | **(8 Hours)** |
| **Module-4**<br><br>**Electrical Properties of Materials and Applications Electrical Conductivity in metals**<br>Resistivity and Mobility, Concept of Phonon, Matheissen's rule, Failures of Classical Free Electron Theory, Assumptions of Quantum Free Electron Theory, Fermi Energy, Density of States, Fermi Factor, Variation of Fermi Factor With Temperature and Energy. Numerical Problems.<br>**Superconductivity**<br>Introduction to Super Conductors, Temperature dependence of resistivity, Meissner's Effect, Critical Field, Temperature dependence of Critical field, Types of Super Conductors, BCS theory (Qualitative), Quantum Tunnelling, High Temperature superconductivity, Josephson Junctions (Qualitative), DC and RF SQUIDs (Qualitative), Applications in Quantum Computing: Charge, Phase and Flux qubits, Numerical Problems.<br>**Pre requisites: Basics of Electrical conductivity Self-learning: Resistivity and Mobility** | **(8 Hours)** |
| **Module-5**<br><br>**Applications of Physics in computing:**<br>**Physics of Animation**:<br>Taxonomy of physics based animation methods, Frames, Frames per Second, Size and Scale, Weight and Strength, Motion and Timing in Animations, Constant Force and Acceleration, The Odd rule, Odd-rule Scenarios, Motion Graphs, Examples of Character Animation: Jumping, Parts of Jump, Jump Magnification, Stop Time, Walking: Strides and Steps, Walk Timing. Numerical Problems<br>**Statistical Physics for Computing**: Descriptive statistics and inferential statistics, Poisson distribution and modeling the probability of proton decay, Normal Distributions (Bell Curves), Monte Carlo Method: Determination of Value of ð. Numerical Problems.<br>**Pre requisites: Motion in one dimension, Probability Self-learning: Frames, Frames per Second** | **(8 Hours)** |

Laboratory Component

Any Ten Experiments have to be completed from the list of experiments

**Note:** The experiments have to be classified into

(a) Exercise
(b) Demonstration
(c) Structured Inquiry
(d) Open Ended

Based on the convenience classify the following experiments into above categories. Select at least one simulation/spreadsheet activity.

**List of Experiments**

1. Determination of wavelength of LASER using Diffraction Grating.
2. Determination of acceptance angle and numerical aperture of the given Optical Fiber.
3. Determination of Magnetic Flux Density at any point along the axis of a circular coil.
4. Determination of resistivity of a semiconductor by Four Probe Method
5. Study the I-V Characteristics of the Given Bipolar Junction Transistor.
6. Determination of dielectric constant of the material of capacitor by Charging and Discharging method.
7. Study the Characteristics of a Photo-Diode and to determine the power responsivity / Verification of Inverse Square Law of Intensity of Light.
8. Study the frequency response of Series & Parallel LCR circuits.
9. Determination of Planck's Constant using LEDs.
10. Determination of Fermi Energy of Copper.
11. Identification of circuit elements in a Black Box and determination of values of the components.
12. Determination of Energy gap of the given Semiconductor.
13. Step Interactive Physical Simulations.
14. Study of motion using spread Sheets
15. Study of Application of Statistics using spread sheets
16. PHET Interactive
17. Determination od frequency of alternating current using sonometer
18. Interference at an Air wedge
19. Simulations(https://phet.colorado.edu/en/simulations/filter?subjects=physics&type=html,prototype)

**Suggested Learning Resources:**

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


1. Solid State Physics, S O Pillai, New Age International Private Limited, 8th Edition, 2018.
2. Engineering Physics by Gupta and Gour, Dhanpat Rai Publications, 2016 (Reprint).
3. A Textbook of Engineering Physics- M.N. Avadhanulu and P.G. Kshirsagar, 10th revised Ed, S. Chand. & Company Ltd, New Delhi.
4. Concepts of Modern Physics, Aurthur Beiser, McGrawhill, 6th Edition, 2009.
5. Lasers and Non Linear Optics, B B Loud, New age international, 2011 edition.
6. A Textbook of Engineering Physics by M.N. Avadhanulu, P G. Kshirsagar and T V S Arun Murthy, Eleventh edition, S Chand and Company Ltd. New Delhi-110055.
7. Quantum Computation and Quantum Information, Michael A. Nielsen & Isaac L. Chuang, Cambridge Universities Press, 2010 Edition.
8. Quantum Computing, Vishal Sahani, McGraw Hill Education, 2007 Edition.
9. Quantum Computing – A Beginner's Introduction, Parag K Lala, Indian Edition, Mc GrawHill, Reprint 2020.
10. Engineering Physics, S P Basavaraj, 2005 Edition, Subhash Stores.
11. Physics for Animators, Michele Bousquet with Alejandro Garcia, CRC Press, Taylor & Francis, 2016.

12. Quantum Computation and Logic: How Quantum Computers Have Inspired Logical Investigations, Maria Luisa Dalla Chiara, Roberto Giuntini, Roberto Leporini, Giuseppe Sergioli, Trendsin Logic, Volume 48, Springer.
13. Statistical Physics: Berkely Physics Course, Volume 5, F. Reif, McGraw Hill.
Introduction to Superconductivity, Michael Tinkham, McGraw Hill, INC, II Edition

**Course outcome (Course Skill Set)**

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

CO1 **Describe** the principles of LASERS and Optical fibers and their relevant applications.
CO2 **Discuss** the basic principles of the Quantum Mechanics and its application in Quantum Computing.
CO3 **Summarize** the essential properties of Dielectric superconductors and its applications in qubits.
CO4 **Illustrate** the application of physics in material sensing temperature resistance sensing materials.
CO5 **Practice** working in groups to conduct experiments in physics and **perform** precise and honest measurements