# B.E. COMPUTER SCIENCE AND ENGINEERING
Choice Based Credit System (CBCS) applicable for 2024 Scheme
## SEMESTER – I/II

## Quantum computing and Photonics (3:0.5:0.5) 4
(Effective from the academic year 2024-25)

| Course Code | BPHYCS12/22 | CIE Marks | 50 |
|---|---|---|---|
| Teaching Hours/Week (L:T:P) | 3:0:2 | SEE Marks | 50 |
| Total Number of Contact Hours | 40 (Theory) + 12 (Lab sessions) | Exam Hours | 3 |

**Course Objectives:**
This course will enable students to:
1. Identify the fundamental concepts related to the theory of quantum mechanics, Quantum computing, photonics and animations.
2. Elucidate the significance of principles of quantum mechanics in quantum computing.
3. Apply the knowledge in solving the problems of quantum mechanics, photonics and animations.
4. Demonstrate and construct the electrical, optical experiments.
5. Learn the conduction of experiments using simulations/virtual mode.

**Preamble:** Introduction to Quantum Mechanics, Quantum computation, Quantum Gates, Physics of animation, photonics, hands-on and simulation experiments.

## Module – 1
### Quantum Mechanics

Introduction, Heisenberg's Uncertainty Principle and its significance, Application: Non-existence of electron inside the nucleus (Relativistic condition), Principle of Complementarity, Wave Function and its properties, Physical Significance of a wave function and Born's Interpretation, Expectation value. Time independent (derivation) and time-dependent (qualitative) Schrodinger wave equations, Eigen functions and Eigen Values, Applications of Schrodinger wave equation: Eigen Values and Eigen functions of a particle in a one-dimensional potential well of infinite depth, mapping of wave function and probability density, free particle case, Numerical.

**(08Hours)**

## Module – 2
### Quantum computation

Introduction, Moore's law & its end, single particle quantum interference, quantum superposition and entanglement, Qubit: properties of a qubit, representation of qubit by Bloch sphere, Single and Two qubits, Extension to N qubits. Differences between classical & quantum computing. Matrix representation of 0 and 1 States, Identity Operator, Pauli Matrices and its operations on $|0\rangle$ and $|1\rangle$states, Conjugate of a matrix and Transpose of a matrix. Unitary matrix, Inner Product, Probability, normalization rule, Orthogonality, Orthonormality, Numerical.

**(08 Hours)**

## Module – 3
### Quantum Gates and Physics of animation

Introduction, Single Qubit Gates: Quantum Not Gate, Pauli-Z Gate Hadamard Gate, Pauli Matrices, Phase Gate (or S Gate), T Gate. Multiple Qubit Gates: CNOT Gate, Swap gate, Controlled-Z gate, Toffoli gate. Applications of quantum gates: Artificial Intelligence and Machine Learning, Cryptography, Model Realizations.

Introduction, Taxonomy of physics-based animation methods, Frames, Frames per Second, Size and Scale, Motion and timing in animations, Constant Force and Acceleration, Slow in Slow out, The Odd rule, Motion graphs, Numerical Calculations based on Odd Rule, Examples of Character Animation: Jumping, Walking, Numerical.

**(08 Hours)**

## Module – 4
## LASER and Holography

Introduction, Interaction of radiation with matter, expression for the energy density of the radiation in terms of Einstein's Coefficients (derivation), condition for Laser Action: Population Inversion, Metastable State, Stimulated emission, Requisites of a Laser system, construction and working of Semiconductor Diode Laser, Q- switching, Applications of Lasers: Bar code scanner, data storage, Numerical.

Introduction, Principle of holography, construction and reconstruction of hologram, Applications: Holographic data storage and security.

**(08 Hours)**

## Module – 5
## Optical Fiber

Introduction, Propagation mechanism, Acceptance angle, Numerical Aperture (derivation), condition for ray propagation, Modes of propagation and V-number, Classification of Optical Fibers, Attenuation and causes for attenuation: absorption, bending, scattering loss, dispersion losses, distortion losses, expression attenuation coefficient (derivation). Optical wave guides-Types of optical wave guides, guided modes in planar wave guides, guided modes in step-index optical fibers, Attenuation Spectrum of an Optical fiber, Optical Windows. Applications: Fiber Optic networking, Fiber Optic Communication, Fiber optic sensors, optical computers, Numerical.

**(08 Hours)**

## Practical components (10 experiments needed to be completed from the list)

| Sl. No. | Experiments |
|---|---|
| | **Physical lab experiments** |
| 1 | Photo–Diode Characteristics |
| 2 | Wavelength of LASER using Grating |
| 3 | Numerical Aperture using optical fiber |
| 4 | Fermi energy of copper by using Wheatstone's meter bride. |
| 5 | Series & Parallel LCR resonance |
| 6 | Magnetic field along the axis of a circular coil carrying current |
| 7 | Energy gap of a semiconductor by four probe method |
| | **Simulation/Virtual lab experiments** |
| 8 | Study of motion using spread sheets : Study of projectile motion using Excel sheet/PHET. |
| 9 | Interactive simulations: Energy-bandgap of a semiconductor |
| 10 | Interactive Simulations: Numerical-aperture-measurement. |
| 11 | Creating animated videos using software. |
| 12 | Interactive Simulations: Realization of quantum gates using virtual lab software. |
| 13 | Interactive Simulations: Verification and interpretation of truth table for AND, OR, NOT, NAND, NOR, Ex-OR gates. |
| 14 | Interactive Simulations: study of the motion of the simple pendulum |
| | **Demonstration experiments** |
| 1 | Determination of velocity of ultrasound using interferometer. |
| 2 | Determination of spring constant and verification of laws of springs. |

**Course Outcomes:**
The students will be able to:

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|---|---|
| CO1 | Comprehend the principles of the Quantum Mechanics and Quantum Computing. |
| CO2 | Analyse the application of Quantum mechanics, Quantum computation in engineering applications. |
| CO3 | Apply the concepts of physics in Quantum gates and animations. |