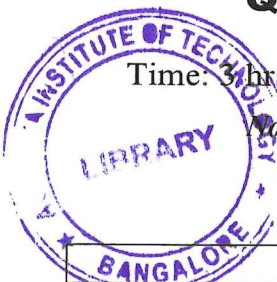


## First/Second Semester B.E./B.Tech. Degree Examination, June/July 2026 Quantum Physics and Applications (CSE stream)

Time: 3 hrs.

Max. Marks: 100

- Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.  
2. M : Marks, L: Bloom's level, C: Course outcomes.  
3. VTU Formula Hand Book is permitted.*



### Module – 1

|     |    |                                                                                                                                                     | M | L  | C   |
|-----|----|-----------------------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.1 | a. | State Heisenberg's uncertainty principle. Mention its physical significance and illustrate broadening of spectral line using uncertainty principle. | 8 | L2 | CO1 |
|     | b. | Set-up Schrodinger's time independent wave equation for a particle in one dimension and mention the same in three dimensions.                       | 8 | L2 | CO1 |
|     | c. | An electron is associated with a de-Broglie wavelength of 1nm. Find the kinetic energy of the electron in eV.                                       | 4 | L3 | CO1 |

### OR

|     |    |                                                                                                                                                                  |   |    |     |
|-----|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.2 | a. | Discuss de-Broglie hypothesis and derive an expression for de-Broglie wavelength. Also discuss the concept of expectation values with its physical significance. | 8 | L2 | CO1 |
|     | b. | Find the Eigen functions and energy Eigen values for particle in a one dimensional potential well of infinite height.                                            | 8 | L2 | CO1 |
|     | c. | In Planck's constant experiment the knee voltage of a blue LED emitting light wavelength 490nm is 2.54V. Calculate Planck's constant.                            | 4 | L3 | CO1 |

### Module – 2

|     |    |                                                                                                                                                        |   |    |     |
|-----|----|--------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.3 | a. | Enumerate the assumptions of Quantum free electron theory of metals and discuss the success of Quantum free electron theory of metals.                 | 8 | L2 | CO2 |
|     | b. | Define Fermi level in semiconductor. Show that it always lies mid-way between conduction band and valence band in the case of intrinsic semiconductor. | 7 | L2 | CO2 |
|     | c. | Find the temperature at which the probability of occupancy is 0.95 at an energy level 0.3eV below Fermi level.                                         | 5 | L3 | CO2 |

### OR

|     |    |                                                                                                                                                                                                                                                                                                                                        |   |    |     |
|-----|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.4 | a. | Describe different electron scattering mechanisms in solids.                                                                                                                                                                                                                                                                           | 8 | L2 | CO2 |
|     | b. | Define Fermi factor and discuss the variation of Fermi factor with temperature and energy.                                                                                                                                                                                                                                             | 7 | L2 | CO2 |
|     | c. | The concentration of electrons at room temperature in an extrinsic semiconductor used in Hall experiment is $1.7 \times 10^{23}/\text{m}^3$ . If a current of 100 mA flows through the semiconducting strip of thickness 1mm and strength of magnetic field is 3.6 Wb/m <sup>2</sup> , estimate the Hall coefficient and Hall voltage. | 5 | L3 | CO2 |

## Module – 3

|     |    |                                                                                                                                                                                 |   |    |     |
|-----|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.5 | a. | Explain Silsbee effect. Derive an expression for critical current for a current carrying superconductor wire.                                                                   | 8 | L2 | CO3 |
|     | b. | Explain in detail BCS theory of superconductor and mention the limitations of BCS theory.                                                                                       | 7 | L2 | CO3 |
|     | c. | Calculate the critical current for a wire of lead having diameter of 1mm at 4.2K. The critical temperature for lead is 7.18K and critical field is $6.5 \times 10^4$ A/m at 0K. | 5 | L3 | CO3 |

## OR

|     |    |                                                                                                                                       |   |    |     |
|-----|----|---------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.6 | a. | What is SQUID? Mention two applications of it. Explain the construction and working of DC SQUID.                                      | 8 | L2 | CO3 |
|     | b. | Explain Meissner effect and two fluid model with suitable diagram.                                                                    | 8 | L2 | CO3 |
|     | c. | The critical field of Niobium is $10^4$ A/m at 8K and $2 \times 10^5$ A/m at 0K. Calculate the transition temperature of the element. | 4 | L3 | CO3 |

## Module – 4

|     |    |                                                                                                                                                                                                                                           |   |    |     |
|-----|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.7 | a. | Describe the construction and working of semiconductor diode laser.                                                                                                                                                                       | 8 | L2 | CO4 |
|     | b. | What is attenuation in an optical fiber? Discuss the attenuation mechanisms in optical fiber communication.                                                                                                                               | 8 | L2 | CO4 |
|     | c. | In a diffraction grating experiment the distance between screen and grating is 20 cm and the average distance of the second order spot is 2.7 cm. Calculate the wavelength of the laser light. (Grating constant = $1 \times 10^{-5}$ m.) | 4 | L3 | CO4 |

## OR

|     |    |                                                                                                                                                                                                            |   |    |     |
|-----|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.8 | a. | Explain the construction and working of Mach-Zehnder interferometer. Mention its applications.                                                                                                             | 8 | L2 | CO4 |
|     | b. | What are optical modulators? Explain Pockels effect and Kerr effect.                                                                                                                                       | 7 | L2 | CO4 |
|     | c. | The sum of refractive indices of core and cladding in a step index optical fiber is 3.12 and their difference is 0.08. The diameter of the core is $50 \mu\text{m}$ . Find V- number at wavelength 594 nm. | 5 | L3 | CO4 |

## Module – 5

|     |    |                                                                                                                     |   |    |     |
|-----|----|---------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.9 | a. | Mention any two properties of a qubit. With a neat diagram explain the representation of qubits using Bloch sphere. | 8 | L2 | CO5 |
|     | b. | Discuss the working of T gate with its matrix representation and action on $ 0\rangle$ and $ 1\rangle$ states.      | 8 | L2 | CO5 |
|     | c. | Show that Hadamard gate is unitary.                                                                                 | 4 | L3 | CO5 |

## OR

|      |    |                                                                                                                                     |   |    |     |
|------|----|-------------------------------------------------------------------------------------------------------------------------------------|---|----|-----|
| Q.10 | a. | Explain anharmonicity along with a relevant diagram and its importance in quantum computing.                                        | 8 | L2 | CO5 |
|      | b. | Explain the operation of CNOT gate on four two qubits. Mention truth table and matrix representation.                               | 8 | L2 | CO5 |
|      | c. | A linear operator 'X' operates such that $X 0\rangle =  1\rangle$ and $X 1\rangle =  0\rangle$ . Find matrix representation of 'X'. | 4 | L3 | CO5 |

\*\*\*\*\*