| Roll No. | | | | | | | | | | | | |
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# PRESIDENCY UNIVERSITY

## BENGALURU

**End - Term Examinations – May/June 2026**

**Date:** 18- 05-2026 **Time:** 09:30am – 12:30pm

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| **School:** SOCSE | **Program:** B.Tech | |
| **Course Code:** PHY2501 | **Course Name:** Optoelectronics and Quantum Physics | |
| **Semester**: II | **Max Marks**: 100 | **Weightage**: 50% |

| CO - Levels | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
|---|---|---|---|---|---|---|
| Marks | 10 | 10 | 20 | 21 | 19 | 20 |

**Instructions:**

*(i) Read all questions carefully and answer accordingly.*

*(ii) Do not write anything on the question paper other than roll number.*

*(iii) Given : Planck's constant $h = 6.625\times10^{-34}$ Js; Boltzmann's constant $k_B = 1.38\times10^{-23}$ J/K , Speed of light $c = 3\times10^{8}$ m/s, Mass of the electron $m = 9.1\times10^{-31}$ kg, Charge of the electron $e = 1.6\times10^{-19}$ C*

## Part A

**Answer ALL the Questions. Each question carries 2marks.** **10Q x 2M=20M**

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| **1.** | Write the truth table of SWAP gate. | **2 Marks** | **L2** | **CO4** |
| **2.** | Write the orthogonality condition for quantum states $\|\psi\rangle$ and $\|\Phi\rangle$. | **2 Marks** | **L2** | **CO3** |
| **3.** | What do you mean by a superposition state in quantum mechanics? | **2 Marks** | **L2** | **CO3** |
| **4.** | $\|\psi\rangle = \begin{pmatrix} 2 \\ 3+i \\ 1-2i \end{pmatrix}$, find the corresponding bra $<\psi\|$. | **2 Marks** | **L2** | **CO3** |
| **5.** | Write any two properties of a wave function. | **2 Marks** | **L2** | **CO3** |
| **6.** | Explain orthonormal wavefunctions. | **2 Marks** | **L2** | **CO3** |
| **7.** | Mention the matrix representation for $\|0\rangle$ and $\|1\rangle$ quantum states. | **2 Marks** | **L2** | **CO4** |
| **8.** | Given $\|\psi\rangle = \alpha \|0\rangle + \beta \|1\rangle$, find the probability of the system being in state $\|0\rangle$. | **2 Marks** | **L2** | **CO4** |

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| **9.** | Write two applications of LASER. | **2 Marks** | **L2** | **CO5** |
| **10.** | What is the lifetime of atom in normal excited state? What kind of emission is obtained from this property? | **2 Marks** | **L2** | **CO5** |

## Part B

**Answer the Questions.** **Total Marks 80M**

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| **11.** | **a.** | Define Critical magnetic field in superconductors. Explain with graph and relevant equation the variation of critical field with temperature. Explain how superconductors can be classified into two categories on the basis of critical field. | **10 Marks** | **L2** | **CO1** |
| | **b.** | Analyze the position of the Fermi level in different types of semiconductors. Explain how Fermi energy can be related to electrical conductivity of the material. | **5 Marks** | **L3** | **CO6** |
| | **c.** | The intrinsic carrier density of a semiconductor is$1.5 \times 10^{16}$ $m^{-3}$. If the mobility of electron and hole are 0.13 $m^2$ $V^{-1}$ $s^{-1}$ and 0.05 $m^2$ $V^{-1}$ $s^{-1}$, Estimate the conductivity. | **5 Marks** | **L3** | **CO6** |
| | | **Or** | | | |
| **12.** | **a.** | Mention the differences between ordinary diode and Zener diode. Explain the breakdown mechanism in Zener diode and draw the V-I characteristics. | **10 Marks** | **L2** | **CO1** |
| | **b.** | The Hall coefficient of certain silicon specimen was found to be $-7.35 \times 10^{-5}$ $m^3$ $C^{-1}$ at 400 K. Calculate the number of charge carriers and determine the nature of the semiconductor. Explain the significance of Hall coefficient on the basis of this problem. | **5 Marks** | **L3** | **CO6** |
| | **c.** | Draw the I-V characteristics graph for solar cell, mark $I_{sc}$=0.65 A, $I_{max}$=0.62 A, $V_{oc}$=11.4 V, $V_{max}$=9.27 V. From this data calculate $P_{max}$, $P_{ideal}$ and fill factor of solar cell. | **5 Marks** | **L3** | **CO6** |

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| **13.** | **a.** | State de Broglie's hypothesis and derive the expression for de Broglie wavelength in terms of kinetic energy of particle.<br><br>Calculate the de Broglie wavelength of an electron if its kinetic energy is 1 eV. | **10 Marks** | **L2** | **CO2** |
| | **b.** | A cricket ball is having mass 0.15 kg and velocity 30m/s. An electron is having mass $9.1 \times 10^{-31}$ kg and velocity $2.2 \times 10^6$ m/s. Calculate the respective de Broglie wavelengths and explain the physical significance of your observation. | **5 Marks** | **L3** | **CO6** |

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| | **c.** | Vector $\|A\rangle$ is given by $\|A\rangle=\begin{pmatrix}1+3i\\4\\8\end{pmatrix}$, find the norm of this vector and normalize $\|A\rangle$. | **5 Marks** | **L3** | **CO3** |
| | | **Or** | | | |
| **14.** | **a.** | i) $\|A\rangle=\begin{pmatrix}-3i\\2+i\\4\end{pmatrix}$ , $\|B\rangle=\begin{pmatrix}2\\-i\\2-3i\end{pmatrix}$<br>Evaluate the inner products <A\|B> and <B\|A>, verify the relation between them.<br>ii) $\|\psi\rangle=\begin{pmatrix}1+i\\2\end{pmatrix}$, $\|\phi\rangle=\begin{pmatrix}2\\i\end{pmatrix}$, check whether they are orthogonal or not. | **10 Marks** | **L3** | **CO2** |
| | **b.** | Show the vectors are orthonormal.<br>$\|\psi\rangle=\begin{pmatrix}\frac{1}{\sqrt{2}}\\\frac{1}{\sqrt{2}}\end{pmatrix}, \|\phi\rangle=\begin{pmatrix}\frac{1}{\sqrt{2}}\\-\frac{1}{\sqrt{2}}\end{pmatrix}$ | **5 Marks** | **L3** | **CO6** |
| | **c.** | Write the three Pauli spin matrices, mention the properties of Pauli matrices. | **5 Marks** | **L2** | **CO3** |

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| **15.** | **a.** | Explain Pauli-X, Pauli-Y, and Pauli-Z gates with their matrix representation, symbolic form, and truth table. Derive their effect on basis states $\|0\rangle$ , $\|1\rangle$ and $\alpha\|0\rangle+\beta\|1\rangle$. | **10 Marks** | **L3** | **CO4** |
| | **b.** | Explain the working of Hadamard gate on basis states $\|0\rangle$ and $\|1\rangle$. | **5 Marks** | **L2** | **CO4** |
| | **c.** | Write three differences of classical and quantum computers. | **5 Marks** | **L2** | **CO3** |
| | | **Or** | | | |
| **16.** | **a.** | Explain the working of multiple-qubit gates CNOT, and CCNOT (Toffoli gate) in detail. Show their truth tables and matrix representations. | **10 Marks** | **L3** | **CO4** |
| | **b.** | Explain the differences between bit and qubit. Explain the significance of qubits. | **5 Marks** | **L2** | **CO3** |
| | **c.** | Explain the working of Controlled-Z gate with truth table and matrix representation. | **5 Marks** | **L2** | **CO4** |

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| **17.** | **a.** | Derive the relation between Einstein coefficients A21, B12, and B21 under thermal equilibrium. | **10 Marks** | **L2** | **CO5** |
| | **b.** | Explain in detail the conditions for a laser system. | **5 Marks** | **L3** | **CO6** |

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| | **c.** | Find the ratio of population of the two states in a diode Laser that produces a light of wavelength 6500 Å at 30°C. | **5 Marks** | **L2** | **CO5** |
| | | **Or** | | | |
| **18.** | **a.** | Explain point-to-point communication using optical fibers with block diagram. | **10 Marks** | **L2** | **CO5** |
| | **b.** | Explain the principle of optical fiber with neat diagram. | **5 Marks** | **L2** | **CO5** |
| | **c.** | Calculate the numerical aperture, and acceptance angle in an optical fibre. Refractive indices of core and cladding are respectively 1.41 and 1.4. Wavelength of laser used is 820 n m. | **5 Marks** | **L3** | **CO6** |