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SEMESTER V (B.TECH.) ACADEMIC YEAR: 2022-23

JAYPEE UNIVERSITY OF ENGINEERING & TECHNOLOGY GUNA

Test-I (Odd Semester 2022)

18B14PH541 INTRODUCTION TO QUANTUM COMPUTING

MAXIMUM DURATION: 1 HOUR MAXIMUM MARKS: 15

IMPORTANT: All the questions are compulsory. The total marks for each question have been indicated next to it.

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1. Calculate values of the following commutators: **[3]**

   (*a*) $[\hat{x}, \hat{p_x}]$ (*b*) $[\hat{L_x}, \hat{L_z}]$

2. The Consider normalised wavefunctions of a particle confined in a one dimensional box of length L,

$$\psi_n(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right) \text{ with } E_n = \frac{n^2\pi^2\hbar^2}{2mL^2}.$$

   Calculate expectation value of position x for $n = 5$, and further calculate probability of finding the particle in the region $x = 0$ to $x = L/2$ for an arbitrary value of n. **[3]**

3. Consider normalised eigenfunctions of particle in a box as given in **QU:2**. Calculate expectation vale of momentum in an arbitrary eigenstate labeled by n. Further verify this by expressing $\psi_n(x)$ as a linear superposition of momentum eigenstates. **[3]**

4. The state of a certain particle is given by

$$\Psi(x) = \frac{1}{2}\Psi_1(x) + \frac{i}{2}\Psi_2(x) + \frac{1}{\sqrt{2}}\Psi_3(x),$$

   here Ψ_1, Ψ_2, Ψ_3 are normalised and mutually orthogonal eigenfunctions. What are the probabilities that the particle be found respectively in states Ψ_1, Ψ_2 and Ψ_3? **[3]**

5. Which of the following wave functions can be solutions of Schrödinger's equation for all values of x? Give your comments. **[3]**

   (*a*) $\Psi(x) = \exp(-x^2)$ (*b*) $\Psi(x) = \exp(x^2)$

   (*c*) $\Psi(x) = x\exp(-x^2)$
