Reg. No .... Name **26P221**

M. Sc. DEGREE END SEMESTER EXAMINATION - APRIL 2026

SEMESTER 2 : PHYSICS

COURSE : **24P2PHYT06 : QUANTUM MECHANICS - I**

(For Regular 2025 Admission and Improvement/Supplementary 2024 Admission)

Time : Three Hours Max. Weights: 30

PART A

Answer any 8 questions **Weight: 1**

1. Prove $[A, B]^\dagger = -[A, B]$ (A)
2. Prove $[\Delta A, \Delta B] = [A, B]$ (A)
3. Write the transition amplitude in Schrödinger picture and the Heisenberg picture. Comment. (U)
4. Write the closure relation for a finite dimentional discrete vector space and an infinite dimentional vector space. (R)
5. Evaluate the commutation relation $[L_z, [L_y, L_z]]$. (E)
6. Sketch graphs of $\psi(x)$ and $|\psi(x)|^2$ for the first excited state of the one-dimensional simple harmonic oscillator. (A)
7. Find $[J_+, J_-]$ and $[J_z, J_-]$ where J represents total angular momentum operator. (R)
8. On which quantum numbers do the energy of the elecron in hydrogen atom depend on. (A)
9. Give the relation between the rotation operator and the angular momentum operator. (R)
10. Why should the time evolution operator be unitary? (U)

(1 x 8 = 8)

PART B

Answer any 6 questions **Weights: 2**

11. Prove $a^\dagger|n\rangle = \sqrt{n+1}|n+1\rangle$ (A)
12. Draw the radial wavefunction and the probability density w.r.t $\frac{r}{a_0}$ for $n = 3$ and $l = 0$ in the case of hydrogen atom. (A)
13. Is $|-\rangle$ is represented by $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ find the matrix representation for (a) $|-\rangle$ (b)$|S_x; +\rangle$ (c) $|S_x; -\rangle$ (d) $|S_y; -\rangle$ (e) $|S_y; +\rangle$ (A)
14. Show that the expectation value in the Schrodinger picture is same as the expectation value in the Heisenberg picture. (A)
15. For the S_z+ state ($|+\rangle$) of a spin half system, find the dispersion of S_x (A)
16. Prove $[p_i, p_j] = 0$ using the commutation property of the translation operators. (A)
17. Obtain the commutation relation $[J^2, J_x]$. (A)
18. Evaluate the following commutaion relation (a) $[J_+, J_-]$ (b) $[J_z, J_+]$ (c) $[J^2, J_+]$ (E)

(2 x 6 = 12)

PART C

Answer any 2 questions **Weights: 5**

19. Discuss the uncertainity principle and show that the minimum uncertainity wave function is a Gaussian. Given (A)

$$\langle x'|\alpha\rangle = \frac{1}{\sqrt{d}\pi^{1/4}} e^{\left[ikx' - \frac{x'^2}{2d^2}\right]}$$

20. Using the commutation algebra of angular momentum operators, find the eigen values of J^2 and J_z. (A)

21. Obtain the eigen kets and eigenvalues of a simple harmonic oscillator. (A)

22. Calculate the expectation value of x, x^2 and p for a Gaussian wave packet given by (A)

$$\langle x'|\alpha\rangle = \frac{1}{\sqrt{d}\pi^{1/4}} e^{\left[ikx' - \frac{x'^2}{2d^2}\right]}$$

(5 x 2 = 10)

OBE: Questions to Course Outcome Mapping

CO	Course Outcome Description	CL	Questions	Total Wt.

Cognitive Level (CL): Cr - CREATE; E - EVALUATE; An - ANALYZE; A - APPLY; U - UNDERSTAND; R - REMEMBER;