D2APH2301 **(2 Pages)** **Name.....**
Reg.No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2024
(Regular/Improvement/Supplementary)

PHYSICS
FPHY2C05: QUANTUM MECHANICS-1

Time: 3 Hours **Maximum Weightage: 30**

Part A: Short answer questions. Answer *all* questions. Each carries 1 weightage.

1. Show that eigen values of a Hermitian operator are real and the eigen functions are orthogonal.
2. Distinguish between a pure state and a mixed state.
3. Why are measurements in quantum mechanics termed *selective measurement* or *filtration*?
4. Write the expression for the infinitesimal time evaluation operator and show that it is Hermitian.
5. Obtain the expression for the expectation value of a dynamical quantity in a non-stationary state.
6. Write a note on the Energy-time uncertainty relationship.
7. Differentiate between the Schrodinger and Heisenberg formulations in quantum mechanics.
8. Why is the principle of indistinguishability deeper in quantum mechanics than in classical mechanics?

(8 × 1 = 8 weightage)

Part B: Essay questions. Answer any *two* questions. Each carries 5 weightage.

9. Obtain the expression for reflection and transmission coefficient for a one-dimensional square potential barrier.
10. Derive the general theory of angular momentum and obtain the matrix expression for different angular momentum operators.
11. By solving the Schrodinger equation for the three-dimensional Coulomb potential, obtain the expression for energy and wave function.
12. Discuss about the principle of indistinguishability and obtain the expression for symmetric and antisymmetric wave function for two-particle and N-particle system. Write the wavefunction of helium atom.

(2 × 5 = 10 weightage)

(P.T.O.)

Part C: Problems. Answer any *four* questions. Each carries 3 weightage.

13. The Hamiltonian of a system is $\frac{1}{\sqrt{2}}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$. What are the possible energy values of this system?

14. Prove or illustrate that two anticommuting Hermitian operators have simultaneous eigen kets.

15. Derive the general uncertainty relationship followed by two Hermitian operators which are non-commuting to each other.

16. The Hamiltonian operator for two state system is:
$H = a(|1\rangle\langle 1| - |2\rangle\langle 2| + |1\rangle\langle 2| + |2\rangle\langle 1|)$,
where a is a number with dimension of energy, $|1\rangle$ and $|2\rangle$ are the kets corresponding to two states.
Find the possible energy values and corresponding states.

17. What is the probability to find a spin-half system in $S_{x\pm}$ state at a time t, if it is initially in S_{x-} state?

18. Derive the Ehrenfest theorem.

19. Determine the C-G coefficient matrix for two spin-half systems.

(4 × 3 = 12 weightage)