D2APH2401 **(2 Pages)** **Name.............................**
Reg.No..........................

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2025
(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. What do you mean by the *complete representation*? How does it differ from the *maximal representation* of a state?
2. Why energy eigen state is often referred as a *stationary state*? What is meant by *non-stationary state*?
3. Write about time-energy uncertainty principle. Is it keep justice to general uncertainty principle?
4. Define the general angular momentum operator.
5. What is C-G coefficients. Mention two properties of C-G coefficients.
6. Write the equation of continuity and express value of density and current density in terms of wave function.
7. What are the characteristics of symmetry transformation?
8. What is Kramer’s degeneracy?

(8 × 1 = 8 weightage)

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

9. By obtaining the transformation function, derive the form of momentum wavefunction in terms of position wavefunction.
10. Obtain the time evolution operator and derive the Schrodinger equation for time evolution operator. Discuss about the possible solution of corresponding Schrodinger equation.
11. Obtain the eigen value of the angular momentum operators J^2 and J_Z, where J is the total angular momentum and its z-component is J_Z.
12. Solve the Schrodinger equation for any inverse square central force and obtain the solution.

(2 × 5 = 10 weightage)

(P.T.O.)

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

13. Determine the uncertainty in position for a wave function $Aexp(ikx - x^2/2d^2)$, where A is the normalization constant. Given $\int_{-\infty}^{+\infty} exp(-ax^2) = \sqrt{\frac{\pi}{a}}$.

14. A certain observable in quantum mechanics has a 3X3 matrix representation as follows $\frac{1}{\sqrt{2}}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$. Find the normalized eigen vectors of this observable and the eigen values. Is there any degeneracy?

15. Show that expectation value will oscillate if the state of the system is taken as super position of energy eigen states.

16. Prove the Ehernfest theorem for free particles.

17. Show that $(\boldsymbol{\sigma}.\boldsymbol{a})(\boldsymbol{\sigma}.\boldsymbol{b}) = \boldsymbol{a}.\boldsymbol{b} + i\boldsymbol{\sigma}.(\boldsymbol{a} \times \boldsymbol{b})$, where, $\boldsymbol{\sigma}$ is the Pauli's spin and ***a, b*** are ordinary vectors in 3-d space.

18. Show that eigen value of Hermitian operator is real and that of anti-Hermitian is purely imaginary.

19. Write the spin-orbitals of helium atom in ground and first excited state.

(4 × 3 = 12 weightage)