D2APH2101 **(2 Pages)** **Name.....**
Reg.No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2022
(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. Explain associative axiom of multiplication.
2. Discuss the inference of sequential Stern-Gerlach experiment.
3. Differentiate between inner product and outer product.
4. What is Ehrenfest theorem?
5. Write down the properties of infinitesimal time evolution operator.
6. Distinguish between Heisenberg and Schrodinger pictures.
7. Write commutation relations between ladder operators and z-component of angular momentum.
8. Explain the effect of parity operators on the observables r, p and L.

(8 × 1 = 8 weightage)

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

9. What are compatible and incompatible observables? Using commutator algebra derive general relation of uncertainty product of two operators.
10. Find the energy eigenvalues and eigenstates of one-dimensional harmonic oscillator.
11. Find the eigenvalues for angular momentum operator J^2 and J_z. Hence obtain matrices for J^2 and J_z for spin 1 system.
12. Using the symmetries of the wavefunctions discuss the ground state of helium atom.

(2 × 5 = 10 weightage)

(P.T.O.)

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

13. Find eigenvalues and eigenvectors of S_x and S_z and evaluate transformation matrix from eigen basis of $S_x$to eigen basis of S_z.

14. Show that eigenvalues of Hermitian operator are real and eigenvectors of Hermitian operator corresponding to distinct eigenvalues are orthogonal.

15. A particle of mass m confined to move in a potential V(x)= 0 for 0 < x < L and V(x)=∞ otherwise. If wave function of the particle at a time t= 0 is given by $\Psi(x,0)$= A sin(6πx/L) cos(4πx/L). Evaluate Ψ (x,t), the wave function at a later time t.

16. A beam of 10 eV electrons is incident on a potential barrier of height 20 eV and width 0.1 nm. Calculate the transmission coefficient.

17. Obtain the Clebsh-Gordan coefficients for a system of two spin ½ particles.

18. A particle of mass m is placed in a finite square well V(r)= $-V_0$ if r ≤ a and V(r)=0 if r > a. Find the ground state by solving the radial equation with ℓ=0.

19. At time t=0, the wave function for the hydrogen atom is given by $\Psi(r,0)=\frac{1}{\sqrt{10}}$ ($\Psi_{100}+2\Psi_{210}+\sqrt{2}\Psi_{211}+\sqrt{2}\ \Psi_{21\text{-}1}+\Psi_{311}$), where subscripts are values of the quantum numbers n, ℓ, m. Find expectation value for energy and L_z of the system.

(4 × 3 = 12 weightage)