D2APH2001 **(2 Pages)** **Name.....**
Reg.No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2021

PHYSICS

FPHY2C05: QUANTUM MECHANICS-1

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

Part A: Short answer questions. *All* questions can be answered. Each carries *one* weightage (Ceiling 6 weightage).

1. What is *Selective* measurement? How can it be represented mathematically for a state?
2. State general uncertainty relation. When does the equality happen in that expression?
3. Distinguish between the stationary and non-stationary state. What is the expectation value of dynamical quantity in stationary and non-stationary states?
4. Prove the quantum mechanical analog of Newton's second law of motion.
5. Show that spin precession frequency is twice that of spin state vector flipping frequency for a spin ½ charged particle in an external magnetic field.
6. What are C-G coefficients? Discuss two properties of C-G coefficient.
7. Write the expression for radial part of the Schrödinger equation for spherically symmetric potential.
8. Show that the wave function of a system identical particles is either totally symmetric or totally antisymmetric.

Part B: Essay questions. *All* questions can be answered. Each carries *six* weightage (Ceiling 12 weightage).

9. With the support of Stern-Gerlach experiment prove the necessity of a complex space in quantum mechanics to represent a system.
10. Determine the sub barrier and over barrier transition probability across a square barrier.
11. Obtain the angular momentum matrix corresponding to the operators J^2, J_z , $J_{+/-}$ with the derivation of sufficient equations.
12. Solve the problem of isotropic harmonic oscillator. Determine the expression of degeneracy of states.

(PTO)

Part C: Problems. *All* questions can be answered. Each carries *four* weightage (Ceiling 12 weightage).

13. A particle of mass m moves freely inside an infinite potential well of length 'a' has following wave function $\Psi(x,0) = \frac{A}{\sqrt{a}} sin\left(\frac{\pi x}{a}\right) + \sqrt{\frac{3}{5a}} sin\left(\frac{3\pi x}{a}\right) + \frac{1}{\sqrt{5a}} sin\left(\frac{5\pi x}{a}\right)$. If measurements of energy carried out, what are the values and what are the probabilities? And also determine the probability to determine the system in the state $\phi(x,t) = \sqrt{\frac{2}{a}} \sin(\frac{2\pi x}{a}) \exp(\frac{-iE_2 t}{\hbar})$

14. Show that the Schrödinger equation follows the equation of continuity. And also write the physical meaning of continuity equation.

15. By using uncertainty principle, prove that the minimum energy of harmonic oscillator is $\frac{\hbar\omega}{2}$

16. Find the energy of a particle of mass m in one dimensional short range potential V(x) = $-V_0\delta(x)$, where $V_0 > 0$ and $\delta(x)$ is Dirac delta function.

17. Components of arbitrary vector ***A*** and ***B*** commute with two component spin operator **σ.** Show that $(\sigma \cdot A)(\sigma \cdot B) = A \cdot B + i\sigma \cdot (AXB)$

18. If $\Psi_+(r)$ and $\Psi_-(r)$ are eigenfunctions of parity operator belonging to even and odd eigen states, show that they are orthogonal.

19. Give the zeroth-order wave function for helium atom (i) in ground state (ii) in excited state. Also express them in Slater determinant form.