M.Sc.(Physics) (NEP Pattern) Semester-II

02MSCPH1 - Paper-I - Fundamentals of Quantum Mechanics

P. Pages : 2 **GUG/W/24/15415**

Time : Three Hours * 6 2 8 8 * Max. Marks : 80

Either:

1. a) State and prove Ehrenfest's theorem. **8**

b) A particle constrained to move along the x-axis in the domain $0 < x < L$ has a wave function $\psi(x) = \sin(n\pi x / L)$, where n is an integer. Normalize the wave function & evaluate the expectation value of its momentum. **8**

OR

c) Derive Schrodinger time dependent & time independent equations. **8**

d) Derive an expression for probability current density. Find the probability current density of wave function $\psi(x) = Ae^{ikx}$, where k is constant. **8**

Either:

2. a) Derive an equations of motion for Schrodinger representation and Heisenberg representation. **8**

b) Define Dirac's bra-ket notations. State mathematical properties of bra and kets vectors. What is the relation between the wave function ψ and corresponding ket notation? **8**

OR

c) What is mean by unitary transformation? Derive an equation for transformation from one orthogonal basis to another. **8**

d) How will you express eigen value equation in matrix representation? **8**

Either:

3. a) What are Clebsch Gordan coefficients? Explain its significance. **8**

b) Derive C. G. coefficients for $j_1 = 1/2,\ j_2 = 1$ **8**

OR

c) What are the Pauli spin matrices? Show that **8**

i) $[\sigma_x, \sigma_y] = 2i\sigma_z$

ii) $[\sigma_y, \sigma_z] = 2i\sigma_x$

iii) $[\sigma_z, \sigma_x] = 2i\sigma_y$

d) Using addition of two angular momenta, Derive the relation between m, m_1, and m_2 where the symbols have their usual meanings. **8**

Either:

4. a) Separate the Schrodinger's equation in to its radial and angular parts. Obtain the solution of radial part of equation for hydrogen atom. **8**

b) Show that the component of angular momentum operator do not commutes among themselves. **4**

c) Prove that the spherical harmonics $Y_{1m}(\theta,\phi)$ has parity of $(-1)^1$. **4**

OR

d) Solve the Schrodinger equation for one dimensional harmonic oscillator and find its energy. **8**

e) Obtain an expression for L^2 operator in spherical Polar coordinates. **8**

5. Attempt all of the following.

a) Discuss the properties of Dirac Delta function. Give representation of Dirac function. **4**

b) Explain the matrix representation of wave function and matrix representation of operator. **4**

c) General angular momentum operator is defined as J_+ and J_- as: **4**

$J_+ = J_x + iJ_y$

$J_- = J_x - iJ_y$

Prove that $[J_+, J_-] = 2\hbar J_z$

d) What is parity operator? How parity is conserved. **4**

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