Reg. No.									

MANIPAL
ACADEMY of HIGHER EDUCATION
(Deemed to be University under Section 3 of the UGC Act, 1956)

DEPARTMENT OF SCIENCES, I SEMESTER M.Sc. (PHYSICS)
END SEMESTER EXAMINATIONS, FEBRUARY 2021

QUANTUM MECHANICS - I [PHY 5153]

(Choice Based Credit System (CBCS) - 2020)

Time: 3 Hours Date: 12/02/2021 MAX. MARKS: 50

Note: Answer **ALL** questions

1.
   a) Define a linear vector space.
   b) Show that the commutator of two Hermitian operators is anti-Hermitian.
   c) Prove that the momentum operator is Hermitian.

(5 + 2 + 2 = 09 Marks)

2.
   a) Reduce the time dependent Schrodinger equation to the time independent form and discuss stationary states.
   b) Suppose the state a quantum system at $t = 0$ is given by a linear combination of just two stationary states
   $$\Psi(x,0) = c_1\psi_1(x) + c_2\psi_2(x)$$
   What is the wave function at some future time t? Is this wave function stationary?
   c) Prove the Ehrenfest theorem. Given:
   $$\frac{d}{dt}\langle\hat{A}\rangle = \frac{1}{i\hbar}\langle[\hat{A},\hat{H}]\rangle + \langle\frac{\partial\hat{A}}{\partial t}\rangle$$

(5 + 2 + 3 = 10 Marks)

3.
   a) Discuss the finite potential well problem for bound states.
   b) The ground state wave function for a 1D harmonic oscillator is given by
   $$\psi_0(x) = A\exp\left(-\frac{m\omega}{2\hbar}x^2\right)$$
   Find the normalization constant A. Also find the first excited state of the harmonic oscillator.

(7 + 3 = 10 Marks)

P.T.O.

4.

a) Solve the angular Schrodinger equation:

$$\sin\theta \frac{\partial}{\partial\theta}\left(\sin\theta \frac{\partial Y}{\partial\theta}\right) + \frac{\partial^2 Y}{\partial\phi^2} = -l(l+1)\sin^2\theta \; Y$$

b) Obtain the normalized radial wave functions $R_{10}(r)$, $R_{20}(r)$ and $R_{21}(r)$ of the Hydrogen atom. Given, the recursion formula

$$c_{j+1} = \frac{2\,(j+l+1-n)}{(j+1)(j+2l+2)} c_j$$

(5 + 5 = 10 Marks)

5.

a) Show that: $L^2 = L_+L_- + L_z^2 - \hbar L_z$.

b) Derive the matrix representations of the spin operators (S^2, S_x, S_y and S_z) for a spin-1/2 particle.

c) Suppose a spin-1/2 particle is in the state

$$\chi = A\begin{pmatrix} 1+i \\ 2 \end{pmatrix}$$

where A is a normalization constant. What are the probabilities of getting $+\hbar/2$ and $-\hbar/2$, if you measure S_z and S_x?.

(2 + 6 + 3 = 11 Marks)

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