Arvind Kumar Physics (67)

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B..Tech. (Engg. Physics) 3rd semester **Roll No.:----------**

Subject: Quantum Physics **Subject Code: PH-211**

Max Time: Three Hours **Max marks: 50**

Note: Attempt all questions.

Q1: (a) What is Hamiltonian Operator? What do its eigenvalues represents? (3)

(b) Show that $e^{i\phi}$ is an eigenfunction of the z-component of the angular momentum operator. Find eigen value. (3)

(c) Can the wave associated with a free particle be represented by a wave function: $\psi(x,t) = A\sin(kx - \omega t)$. Explain. (4)

Q2: (a) Consider a system whose state is expressed in terms of a complete and orthogonal set of vectors $I\phi_1\rangle, I\phi_2\rangle, I\phi_3\rangle, I\phi_4\rangle, I\phi_5\rangle$ as follows:

$I\psi\rangle = \frac{1}{\sqrt{19}} I\phi_1\rangle + \frac{2}{\sqrt{19}} I\phi_2\rangle + \sqrt{\frac{2}{19}}\, I\phi_3\rangle + \sqrt{\frac{3}{19}}\, I\phi_4\rangle + \sqrt{\frac{5}{19}}\, I\phi_5\rangle$, where $I\phi_n\rangle$ are the eigenstates to system's Hamiltonian, $\hat{H} I\phi_n\rangle = n\varepsilon_o I\phi_n\rangle$ with n = 1, 2, 3, 4, 5 and ε_o has the dimensions of energy. If the energy is measured on a large number of identical systems that are all initially in the same state $I\psi\rangle$, what values would one obtain and with what probabilities? (5)

(b) Discuss the postulates of Quantum Mechanics. (5)

Q3: Solve the Schrödinger equation for 1-D Harmonic Oscillator to obtain its energy levels. (10)

Q4: (a) Consider the following two kets: $I\psi\rangle = \begin{pmatrix} 5i \\ 2 \\ -i \end{pmatrix}$, and $I\phi\rangle = \begin{pmatrix} 3 \\ 8i \\ -9i \end{pmatrix}$. Are $I\psi\rangle$ and $I\phi\rangle$ orthogonal? (3)

(b) Discuss the conditions for the given operator $\frac{(1+i\hat{A})}{(1-i\hat{A})}$ to be unitary. (3)

(c) Is the operator $I\psi\rangle\langle\psi I$, a projection operator? Write the condition if any to prove the statement. (4)

Q5: (a) Discuss the space quantization of the z-component of the angular moment by considering the Rigid rotor problem. (7)

(b) Consider a rectangle function: $f(x) = \begin{cases} 1 & |x| < \frac{a}{2} \\ 0 & |x| > \frac{a}{2} \end{cases}$. Find its Fourier transform. (3)