62112

Reg. No.

# II Semester M.Sc. Degree Examination, November - 2022

## PHYSICS

## Quantum Machanics - I

## (CBCS Scheme 2019-20)

## Paper : PHY - 202

**Time : 3 Hours** **Maximum Marks : 70**

**Answer All questions.** **(3×15=45)**

1. a) Discuss the various properties to be satisfied for a wavefunction to be physically acceptable. **(5+10)**

   b) Prove that the timerate of change of the expectation value of the momentum operator is the negative gradient of the potential.

**(OR)**

2. a) What is meant by a free particle? Set up and solve the Schrodinger equation for the free particle. **(7+8)**

   b) Solve for the energy eigenvalues and eigenfunctions of particle confined to an infinitely deep square well of length L.

3. a) State and derive the generalized uncertainty principle. **(9+6)**

   b) A system of two particles interact via a time independent potential that depends on their relative position alone. Show how the Schrodinger equation for this system reduces to two one body equations.

**(OR)**

4. a) Show that $[\hat{a}_-, \hat{a}_+] = 1$ **(5+10)**

   b) Prove that the linear momentum operator is the generator of infinitesimal linear translations. Further, prove that when the Hamiltonian is invariant under such translations, linear momentum is conserved.

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5. a) Solve for the eigenfunctions of the $\hat{L}_z$ operator and establish that they form a complete orthonormal set. (7+8)

b) Solve for the energy eigenvalues of a particle that is constrained to move on the surface of a sphere.

(OR)

6. a) Deduce the eigenvalue spectrum for $\hat{J}^2$ and $\hat{J}_z$ using the ladder operator method. (10+5)

b) Prove that the Pauli spin matrices anticommute in pairs.

7. Answer any **Five** of the following. (5×5=25)

a) Show that $[\hat{x}, \hat{p}_x] = i\hbar$

b) plot the energy eigenfunctions and position probability corresponding to the three lowest energy eigenvalues for a one dimensional harmonic oscillator. Compare the probability variation of the ground state with that for a classical harmonic oscillator.

c) Prove that the representation of a wavefunction as a linear combination of eigenfunctions of an observable is unique.

d) Show that the expectation values of an operator remain unchanged under unitary transformations.

e) Prove the following :

i) $[L_x, L_y] = i\hbar L_z$

ii) $[L^2, L_z] = 0$

f) Give matrix representations of the $S^2$ and $S_z$ operators for a spin $\frac{1}{2}$ system using common eigenfunctions of $S^2$ and $S_z$ as the basis set.