K25P 1903

Reg. No. : .....

Name : .....

Second Semester M.Sc. Degree (C.B.C.S.S. – OBE – Reg./Supple./Imp.) Examination, April 2025
(2023 and 2024 Admissions)
PHYSICS/PHYSICS WITH COMPUTATIONAL AND NANO SCIENCE SPECIALIZATION PROGRAMME
MSPHY02C08/MSPHN02C08 : Quantum Mechanics – I

Time : 3 Hours

Max. Marks : 60

SECTION – A

Answer **any five** questions, **each** carry **3** marks.

1. Derive the relation between $v_{classical}$ and $v_{quantum}$ speeds of a free particle.
2. Write down any three properties of kets and bras notations.
3. Compare and contrast the Schrödinger picture and the Heisenberg picture in quantum mechanics.
4. Using Cartesian coordinates, write the commutation relations for angular momentum.
5. What are the selection rules governing CGS coefficients ? How do they influence the outcome of quantum mechanical process ?
6. Show that the momentum operator is referred to as the Generator of translations.

SECTION – B

Answer **any three** questions, **each** carry **6** marks.

7. Suppose a particle starts out in a linear combination of just two stationary states : $\psi(x, 0) = c_1\psi_1(x) + c_2\psi_2(x)$
   What is the wavefunction $\psi(x, t)$ at subsequent times ? Find the probability density and describe its motion.

P.T.O.

8. Check whether the following sets of functions are linearly independent or dependent on the real x-axis.
   a) $f(x) = 4$, $g(x) = x^2$, $h(x) = e^{2x}$
   b) $f(x) = x$, $g(x) = x^2$, $h(x) = x^3$
   c) $f(x) = 2 + x^2$, $g(x) = 3 - x + 4x^3$, $h(x) = 2x + 3x^2 - 8x^3$.
9. Write and explain any two conservation laws and their corresponding symmetries.
10. Explain fundamental postulates of quantum mechanics.
11. Prove that
    a) $J_+J_- = J^2 - J_z^2 + \hbar J_z$
    b) $[J_z, J_+] = \hbar J_+$
    c) $[J^2, J_x] = 0$.

SECTION – C

Answer **any three** questions, **each** carry **9** marks.

12. Explain the concept of stationary states. Derive the time-independent Schrödinger equation and discuss its significance in quantum mechanics.
13. What is the importance of eigenvalues and eigenfunctions in the operator formalism of quantum mechanics ? Discuss useful theorems pertaining to eigenvalue problems.
14. Consider the case where $j = 1$,
    a) Find the matrices representing the operators J^2, J_z, J_+, J_-, and J_x.
    b) Find the joint eigenstates of J^2 and J_z and verify that they form an orthonormal and complete basis.
15. Describe the concepts of conservation laws with specific reference to rotations in space and displacement in time.
16. Provide a detailed discussion of the infinite square well problem, including the derivation of energy eigenvalues and the normalization of wave functions.
