

Reg. No. :

Name :

Second Semester M.Sc. Degree (CBCSS – OBE – Reg./Supple./Imp.)
Examination, April 2026
(2023 Admissions Onwards)
PHYSICS/PHYSICS WITH COMPUTATIONAL AND NANO SCIENCE
SPECIALIZATION PROGRAMME
MSPHY02C08/MSPHN02C08 : Quantum Mechanics I

Time : 3 Hours

Max. Marks : 60

SECTION – A

Answer any 5. Each carries 3 marks.

1. Obtain the orthonormality condition in integral form for the one-dimensional infinite square well stationary eigenfunctions $\psi_n(x)$.
2. What is a Hilbert space and what are its four main properties ?
3. Explain the significance of the Stern-Gerlach experiment.
4. What are Clebsch-Gordan coefficients and what is their purpose ?
5. What is an entangled state in quantum mechanics ?
6. State Laporte's rule for electric dipole transitions and explain its physical basis in terms of parity. (5×3=15)

SECTION – B

Answer any 3. Each carries 6 marks.

7. For any stationary state of the harmonic oscillator the average kinetic energy equals the average potential energy. Using this find the expectation value of x^2 for the n^{th} state.
8. Using the time-independent Schrödinger equation, show that the wave function of a free particle with a definite energy E cannot be normalized. Give the physical meaning of this statement.

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9. Consider the following two sets : $|\psi\rangle = \begin{pmatrix} -3i \\ 2+i \\ 4 \end{pmatrix}$ and $|\phi\rangle = \begin{pmatrix} 2 \\ -i \\ 2-3i \end{pmatrix}$.

- a) Find the bra $\langle\phi|$.
 - b) Evaluate the scalar product $\langle\phi|\psi\rangle$.
 - c) Examine why the product $|\psi\rangle|\phi\rangle$ does not make sense.
10. Describe the geometric interpretation of angular momentum in quantum mechanics, including how the total angular momentum vector, its components and the quantization of direction are represented visually.
 11. Discuss the exchange force concept for identical particles. Using the expectation value $\langle(x_1 - x_2)^2\rangle$, show how bosons and fermions differ from distinguishable particles. (3×6=18)

SECTION – C

Answer any 3. Each carries 9 marks.

12. With a suitable diagram, discuss the dynamics of a particle in a finite square well potential, derive the transcendental equation for the allowed energy E and obtain an approximate solution for the case of a wide and deep well.
13. Explain the concept of operators in quantum mechanics, including :
 - a) The definition of a linear operator and the meaning of an expectation value.
 - b) Hermitian, unitary and projection operators, along with their key properties.
 - c) The definitions of the commutator and anticommutator of two operators.
14. Discuss the role of evolution operator in Schrödinger picture. Derive time dependent Schrödinger equation and show that Hamiltonian is the generator of equation of motion of the state vector in the Schrödinger picture.
15. Discuss in detail the general formalism of angular momentum, including the commutation relations, the construction of ladder operators and the derivation of eigenvalue equations.
16. Discuss how the conservation of angular momentum follows from the rotational invariance of a system and how the conservation of energy follows from its time translation invariance ? (3×9=27)