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FIFTH SEMESTER (CUFYUGP) DEGREE EXAMINATION, NOVEMBER 2026

PHYSICS /APPLIED PHYSICS

PHY5CJ303/APH5CJ303 : QUANTUM MECHANICS-I

2024 Admission onwards

Maximum Time :2 Hours | **Maximum Marks :70**

Section A

All Questions can be answered. Each Question carries 3 marks (Ceiling : 24 Marks)

1	State the conditions for the physical acceptability of a wave function.
2	How operators are represented in matrix representation?
3	Discuss the conditions under which degeneracy can occur for a three dimensional anisotropic harmonic oscillator.
4	What is the significance of $\| \Psi(x, t) \|^2$?
5	What is the momentum-space interpretation of a wave function? Write the momentum operator in the position representation.
6	Can a particle simultaneously have definite position and momentum? Explain briefly.
7	Show that if $\hat{A}^{-1}$ exists, the eigenvalues of $\hat{A}^{-1}$ are just the inverse of those of $\hat{A}$.
8	What are square-integrable functions? Explain why they are suitable for representing quantum mechanical wave functions.
9	What is a Hilbert space? Give its important properties.
10	What are stationary states?

Section B

All Questions can be answered. Each Question carries 6 marks (Ceiling : 36 Marks)

11	For the normalized wave function , $$\Psi(x) = \sqrt{\frac{2}{L}} \sin \frac{\pi x}{L},\ 0 < x < L,$$ calculate the probability of finding the particle between 0and $L/2$.
12	Obtain the energy eigenvalues of a spinless particle of mass m confined in a three-dimensional rectangular box.
13	(a) Show that the commutator of two Hermitian operators is anti-Hermitian. (b) Evaluate the commutator $\left[\hat{A},\ \left[\hat{B}, \hat{C}\right]\hat{D}\right]$.
14	Discuss the case of a particle incident on a potential step when $E < V_0$. Explain the nature of the wave function in the classically forbidden region.
15	Show that the group velocity of a free-particle wave packet is equal to the classical particle velocity.

16	Show that the eigenvalues of a Hermitian operator are real and the eigenvectors corresponding to different eigenvalues are orthogonal.
17	Consider the following two kets; $\|\psi>=\begin{bmatrix}5i\\2\\-i\end{bmatrix}$ and $\|\phi>=\begin{bmatrix}3\\8i\\-9i\end{bmatrix}$ (a) Find $\|\psi>^*$ and $<\psi\|$ (b) Is $\|\psi>$ normalized? If not normalize it. (c) Are $\|\psi>$ and $\|\phi>$ orthogonal?
18	Explain the concept of a wave packet. Show how a localized particle can be represented by a superposition of plane waves.
Section C	
Answer any ONE. Each Question carries 10 marks (1x10=10 Marks)	
19	Explain the quantum mechanical treatment of a particle incident on a potential barrier. Obtain the reflection and transmission coefficients. Explain the phenomenon of quantum mechanical tunnelling.
20	Discuss the quantum mechanical treatment of the one-dimensional harmonic oscillator using the operator method. Derive the energy eigenvalues and the corresponding energy eigenstates.