COEP TECHNOLOGICAL UNIVERSITY (COEP Tech)
A Unitary Public University of Government of Maharashtra
(Formerly College of Engineering Pune (COEP))

END Semester Examination

Programme: B. Tech.
Course Code: PH23002
Branch: Computer Engg (FY Div8,9)
Duration: 3Hrs

Semester: II
Course Name: Quantum Physics
Academic Year: 2023-24
Max Marks: 60

6	1	2	3	0	3	0	4	3

Student PRN No. Instructions:

1. Figures to the right indicate the full marks.
2. Mobile phones and programmable calculators are strictly prohibited.
3. Writing anything on question paper is not allowed.
4. Exchange/Sharing of stationery, calculator etc. not allowed.
5. Write your PRN Number on Question Paper.

			Marks	CO	PO
Q 1	A	Using the concept of wavepacket, derive the expression for Heisenberg's uncertainty principle.	4	I	
	B	Show that, for a "non-relativistic particle", group velocity is equal to particle velocity.	4	I	
	C	If the kinetic energy of electron is measured to be 1eV with an accuracy of 0.0001eV, what is the uncertainty in it's position? Given that, $(h/2\pi) = 1.054\times10^{-34}$ J sec, mass of electron = 9.1×10^{-31}Kg.(Use the uncertainty product of the order of $\hbar = h/2\pi$)	4	I	
Q 2	A	Using the wavefunction of the particle derive Schrodinger's time dependent wave equation.	4	II	
	B	Apply the Schrodinger's wave equation to the harmonic oscillator problem and show that energy levels are quantized. Also sketch the energy levels.	4	II	
	C	Calculate the probability of transmission of alpha particle through the barrier of height 2eV. Given that, energy of particle is 1eV, mass of alpha particle is 6.4×10^{-27}Kg and width of the barrier is 1 A.U., the value of $(h/2\pi) = 1.054\times10^{-34}$ J sec.	4	II	
Q 3	A	Show that for a Hermitian operator, all of its eigenvalues are real and the eigenvectors corresponding to different eigenvalues are orthogonal.	4	III	

	B	Show that the commutator of two Hermitian operators is anti-Hermitian.	2	III
	C	A state $\|\Psi\rangle$ is define as $\|\Psi\rangle = (1/\sqrt{2})\ \|\phi_1\rangle + (-i/\sqrt{2})\ \|\phi_2\rangle$ where $\{\|\phi_i\rangle\}$ are orthonormal bases. Check if this state $\|\Psi\rangle$ forms the projection operator? Determine the closure condition for the given state $\|\Psi\rangle$	4	III
	D	Determine the eigen value of the operator $\hat{O}$ having eigen function g(x). The operator $\hat{O}$ and the eigen function are as given below: $\hat{O} = \left(-\frac{\partial^2}{\partial x^2} + x^2\right) \qquad g(x) = Axe^{\frac{-x^2}{2}}$	4	III
	E	For the given operators A and B, $A = \begin{pmatrix} 8-2i & 4i & 0 \\ 1 & 0 & 1-i \\ -8 & i & 6i \end{pmatrix}, \quad B = \begin{pmatrix} -i & 2 & 1-i \\ 6 & 1+i & 3i \\ 1 & 5+7i & 0 \end{pmatrix}$ Calculate Trace [A,B]. **OR** Calculate A^{-1}, B^{-1} and check that $(A B)^{-1} = B^{-1} A^{-1}$ for operators A, B as above.	4 4	III
Q 4	A	Consider a state $\|\Psi\rangle$, which is given in terms of three orthonormal vectors $\|\phi_1\rangle$, $\|\phi_2\rangle$, and $\|\phi_3\rangle$ as follows: $\|\psi\rangle = \frac{1}{\sqrt{15}}\|\phi_1\rangle + \frac{1}{\sqrt{3}}\|\phi_2\rangle + \frac{1}{\sqrt{5}}\|\phi_3\rangle,$ where $\|\phi_n\rangle$ are eigenstates to an operator B such that: $\hat{B}\|\phi_n\rangle = (3n^2 - 1)\|\phi_n\rangle$ with n =1, 2, 3. Calculate the norm of the state $\|\Psi\rangle$ and find the expectation value of B for the eigen state $\|\Psi\rangle$. **OR** Determine the expectation value of B^2 for the state $\|\Psi\rangle$. Operator B is defined as above.	4 4	IV

	B	Consider an unpolarised electron beam: 25% spin up state $\|0\rangle$ and 75% spin down state $\|1\rangle$. Calculate the density matrix for the given system. Determine the expectation value of the operator Â which is given by $\hat{A} = \begin{bmatrix} 7 & -3i \\ 3i & 5 \end{bmatrix}$	6	IV	
	C	State the following properties of commutators for the operators A, B and C (1) Linearity and (2) Distributive	2	IV	
	D	Consider a particle whose Hamiltonian matrix is $H = \begin{pmatrix} 2 & i & 0 \\ -i & 1 & 1 \\ 0 & 1 & 0 \end{pmatrix}.$ Calculate the eigen values of H and normalized energy eigenvectors for the corresponding eigen values of H.	6	IV	