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**GIET UNIVERSITY, GUNUPUR - 765022**  
**M. Sc. (First Semester) Regular Examinations, February - 2024**  
**22PHPC104 - Quantum Mechanics-I**  
**(Physics)**

Time: 3 hrs

Maximum: 70 Marks

(The figures in the right hand margin indicate marks.)

**PART – A****(2 x 10 = 20 Marks)**

Q.1. Answer <i>ALL</i> questions	CO #	Blooms Level
a. What is Linear vector space, explain with suitable example?	CO1	K1
b. Define the 'Inner Product' of elements with examples?	CO1	K1
c. Discuss about the 'Closure' & 'Completeness' properties of Basis set?	CO1	K1
d. If <b>A</b> & <b>B</b> are two operators, then show that: $[A, B^{-1}] = -B^{-1} [A, B] B^{-1}$	CO1	K1
e. What are creation and annihilation operator. Explain its action on a Eigen state $ n\rangle$	CO2	K1
f. What do you mean by Time evolution of operators, give some properties?	CO2	K1
g. Show that $L^2$ commute with $L_z$ ?	CO2	K1
h. Find the matrix of $[L_+, L_-]$ ?	CO3	K1
i. Prove that $\mathbf{J} \times \mathbf{J} = i\hbar\mathbf{J}$ ?	CO4	K1
j. Write the Pauli's spin matrices for $S^2$ and $S_z$ for $S=1/2$ .	CO4	K1

**PART – B****(10 x 5=50 Marks)**Answer *ANY FIVE* questions

	Marks	CO #	Blooms Level
2. a. Define Kets, Bras and Bra-ket representations. Discuss their properties with examples.	6	CO1	K1
b. Define Dirac delta function and Kronecker delta function? Discuss the properties of Dirac delta functions?	4	CO1	K1
3.a. What are the different types of operators used in Quantum Mechanics? Discuss all of them with examples?	6	CO1	K1
b. Show that for a Hermitian operator, all of its Eigen values are real and the Eigen Vectors corresponding to different Eigen values are Orthogonal?	4	CO1	K1
4. What are the different types of Quantum Pictures? Derive the equation of motion for all pictures?	10	CO2	K1
5.a. Derive the Eigen value for one dimensional Harmonic oscillator using Matrix method?	6	CO2	K1
b. Show that $\text{Tr}(\widehat{A}\widehat{B}) = \text{Tr}(\widehat{B}\widehat{A})$ . Where $A = \begin{pmatrix} 8-2i & 4i & 0 \\ 1 & 1 & 1-i \\ -8 & i & 6i \end{pmatrix}$ , $B = \begin{pmatrix} -i & 2 & 1-i \\ 6 & 1+i & 3i \\ 1 & 5+7i & 0 \end{pmatrix}$	4	CO2	K1

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| 6. | What do you mean by Momentum of Momentum? Express the Cartesian components of angular momentum and find all the commutation relations between the components $L_x, L_y, L_z, L^2, L_+, L_-$ and also with momentum components $P_x, P_y, P_z$ ? | 10 | CO3 | K1 |
| 7. | Mention the matrix representation of Orbital angular momentum components $L_x, L_y, L_z, L^2, L_+, L_-$ ? Find all the matrices for $L_x, L_y, L_z, L^2, L_+, L_-$ for $l = 1$ & 2.   | 10 | CO3 | K1 |
| 8. | Mention the matrix representation of Spin angular momentum components $S_x, S_y, S_z, S^2, S_+, S_-$ ? Find all the matrices for $S_x, S_y, S_z, S^2, S_+, S_-$ , for $s = \frac{1}{2}, \frac{3}{2}$  | 10 | CO4 | K1 |