20-3-17

DOON UNIVERSITY, DEHRADUN

Mid Semester Examination, Second Semester, 2016-17

Department of Physics, School of Physical Sciences

M.Sc. Physics 2 Year Programme

Course: PHC-452: Quantum Mechanics

Time Allowed: 2 Hours **Maximum Marks: 30**

Instructions:

1) All questions are compulsory. Read the questions carefully and attempt each part.
2) Number the questions and their sub parts properly.

SECTION: A

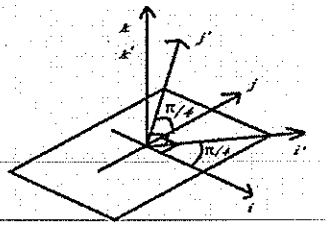
Marks: 4 x 2.5 = 10

1) Show that the raising and lowering operators L_+ and L_- are Hermitian conjugates.
2) There is a bra corresponding to every ket but the converse is not true always. Elaborate with an example.
3) Project an arbitrary three dimensional vector $\vec{r}$ onto two different bases using the Closure relation.
4) The Hamiltonian matrix of a system is $H = \begin{bmatrix} 1 & \epsilon & 0 \\ \epsilon & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$. Find the energy eigenvalues of the perturbation matrix.

SECTION: B

Marks: 4 x 3 = 12

5) Write the relation between the Pauli matrices (σ) and the Spin matrices(S). Prove that the spin matrix S_y has Eigen values $\pm\hbar/2$.
6) Evaluate the most probable distance of the electron in Hydrogen Atom for the 1s state.
7) Derive the expression for the transformation of the matrix elements of an operator from one basis to the other basis. An operator in three dimensional system R $(\hat{i},\hat{j},\hat{k})$ is transformed into the new system R' $(\hat{i}',\hat{j}',\hat{k}')$. Where, the system R' is obtained by rotating R along z axis by angle $\pi/4$. Find out the new matrix elements of the operator in R system.



8) The system consisting of a particle in an infinite square well of bottom **a** is perturbed by raising the well by a constant amount V_0. Calculate the first and second order corrections to the energy of the n^{th} state.

SECTION: C

Marks: 2 x 4 = 8

9) At time t=0, the wave function for the hydrogen atom is

$$\psi(r,0) = \frac{1}{\sqrt{10}}(2\psi_{100} + \psi_{210} + \sqrt{2}\,\psi_{211} + \sqrt{3}\,\psi_{2,1,-1})$$

Where the subscripts are the values of the quantum numbers n, l and m. What is the expectation value for the energy of the system? Also, what is the probability of finding the state with l=1 and m=1?

10) Find the expectation value of the following:
    a. J_+J_- with respect to the state $|j, m>$
    b. r^2 with respect to the ground state of hydrogen atom.