[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 1380 **F-7** **Your Roll No.....**

Unique Paper Code : 2221501

Name of the Paper : Quantum Mechanics and its Applications I

Name of the Course : **B.Sc. (H) Physics (Erstwhile FYUP)**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. **1** is compulsory.

1. Attempt any **five** questions of the following : (3×5=15)

   (a) Prove the following commutation relations.

   $[x, p_z] = 0$

   $[x, y] = 0$

   $[z, p_z] = i\hbar$

   (b) Prove Heisenberg's uncertainty relation using the concept of wave packet.

   (c) On the basis of energy bands differentiate among insulator, semi-conductor and conductor.

   (d) Discuss the significance of the quantum numbers 1, m_l and m_s.

   (e) Draw the wave function and corresponding probability density for the first three states of a simple harmonic oscillator.

   (f) Prove $\sigma_x\sigma_y = 2i\,\sigma_z$, where the symbols have their usual memory.

   (g) The wave function for hydrogen atom in 1s state is

$$R_{1s}(r) = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{3/2} e^{-r/a_0}$$

where a_0 = Bohr radius.

Calculate the expectation value of position of the electron in this state.

(h) Why is an inhomogeneous magnetic field required for Stern-Gerlach Experiment ?

2. (a) Derive time dependent Schrodinger equation. Using this equation obtain time independent Schrodinger equation. (10)

(b) Express the most general solution of the time dependent Schrodinger equation in terms of linear combination of stationary states. (5)

3. (a) Solve the Schrodinger equation for an electron moving in a one dimensional periodic potential and discuss how does it lead to the energy band formation in a solid. (10)

(b) Discuss the concept of effective mass of an electron in a metal. Give its physical significance. (5)

4. Solve the Schrodinger equation for a particle having energy $E < V_0$ for a square well potential of finite depth V_0. Discuss the graphical representation of the transcendental equations. (15)

5. (a) Using Schrodinger equation derive an expression of eigen energy for a particle moving in a simple harmonic potential. (10)

(b) What is zero point energy of a simple harmonic oscillator ? Give its physical significance. (5)

6. Starting from Schrodinger equation for hydrogen atom in spherical polar coordinates, split the equation into three parts. Obtain the solution for radial wave equation. (15)

7. (a) Describe and discuss the significance of Stern-Gerlach experiment. How does it lead to the space quantization due to spin ? (10)

(b) A beam of silver atoms with a velocity of 10^6 cm/s passes through a magnetic field of gradient 100 W/m /cm for a distance of 5 cm. What is the separation between the two components of the beam as it comes out of the magnetic field ? (5)

(100)