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B. Sc. (Hons. Physics) (Semester – 3rd)

QUANTUM MECHANICS AND APPLICATIONS

Subject Code: BPHYS1303

Paper ID: [19131517]

Time: 03 Hours **Maximum Marks: 60**

Instruction for candidates:

1. Section A is compulsory. It consists of 10 parts of two marks each.
2. Section B consist of 5 questions of 5 marks each. The student has to attempt any 4 questions out of it.
3. Section C consist of 3 questions of 10 marks each. The student has to attempt any 2 questions.

Section – A **(2 marks each)**

Q1. Attempt the following:

a. A particle limited to the *x*-axis has the wave function $\Psi = ax$ between *x=0* and *x=1*; Ψ =0 else where. Calculate the probability that the particle can be found between *x=0.45* and *x=0.55*.

b. In part (a), find the expectation value $\langle x \rangle$ of the particle's position.

c. Writing the wave function for a free particle, obtain its total energy.

d. What do we mean by a physically acceptable wave function?

e. What is the need of quantum mechanics?

f. Prove that $[x, p_x] = i\hbar$.

g. An electron has a speed *1.05X10^4 m/s* within the accuracy of *0.01%*. Calculate the uncertainty in the position of the electron.

h. Describe two physical processes where quantum mechanical tunneling takes place?

i. List the quantum numbers required to specify the state of an electron in the hydrogen atom. What are their allowed values?

j. What is magnetic quantum number? Explain its significance.

Section – B **(5 marks each)**

Q2. Prove the following commutator relation:

$$[[A, B], C] + [[B, C], A] + [[C, A], B] = 0$$

Q3. What is the ratio of the kinetic energy of an electron to that of a proton if their wavelengths are equal?

Q4. Show that the zero point energy $\frac{1}{2}\hbar\omega$ of a linear harmonic oscillator is a manifestation of the uncertainty principle?

Q5. What are spherical harmonics? Are they mutually orthogonal?

Q6. What are p and d-orbitals? Give polar representations of their angular part.

Section – C **(10 marks each)**

Q7. Derive Schrodinger's (i) time-independent and (ii) time-dependent equations for matter waves. What is the physical interpretation of wave function in these equations?

Q8. Write down Schrodinger wave equation for a particle in a box. Solve it to obtain its eigen functions and show that the eigen values are discrete.

Q9. Expressing the Schrodinger equation in spherical polar coordinates, separate it into three parts and solve it for the radial part.