PHY 103N: PHYSICS 2, (2007-2008, Semester -II) *(SAR/HW)*

Department of Physics, I.I.T. Kanpur

Assignment - 11 **Quantum Mechanics**

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1. Find the de Broglie wavelength λ_b of the following
   a) An electron whose speed is 10^8 m/s
   b) A grain of sand of mass 0.1mg blown in a wind storm at speeds of 100 km/hr. How would the λ_b compare with the size of the grain.

2. An experiment was performed to determine the x-coordinate of an electron with a given wavefunction ψ_0, by preparing a large assembly of electrons in the same state. This is, all of them have the same wavefunction ψ_0. In all forty measurements were made, each on a different electron. The results obtained are given below with the number of times the respective values were measured is shown in parenthesis.
   -0.08 nm (8), 0.10 nm (4), 0.06 nm (8), 0.08 nm (5), -0.21 nm (1),
   -0.12 nm (9), 0.30 nm (2), -0.01 nm (1), 0.35 nm (1), and 0.00 nm (1).
   Determine $\langle x \rangle$, $\langle x^2 \rangle$ and hence Δx for the electron. What can be said of the momentum observable?

3. A hydrogen atom is 0.5 Angstrom in radius. Use the uncertainty principle to estimate the minimum energy an electron can have in this atom.

4. The human eye can detect 5×10^{-18} W of electromagnetic power at the visible wavelengths. How many photons per second does it represent?

5. *Compton Scattering*
   a) Find the change in the wavelength of 80 pm x-rays that are scattered 120^o by a target electron. ($1\ pm = 10^{-12} m$)
   b) Find the angle between the directions of the recoil electron and the incident photon.
   c) Find the energy of the recoil electron

6. An electron of mass $m = 10^{-30} kg$ is confined to move along x axis within a distance of $100nm$. Determine the energy eigenvalues.

7. A particle of mass m is trapped in an infinitely deep square well potential of length L. If it is in the lowest energy state, calculate the probability of being found in
   (a) $0 < x < L/3$ and (b) $L/3 < x < 2L/3$.

8. The potential energy for a particle of mass m is given by $V(x) = \frac{1}{2} m\omega^2 x^2$.
   a) Write the time-independent Schroedinger equation for this case.
   b) Check if $\psi(x) = Ae^{-x/\alpha}$ can be a wavefunction for the particle with *definite* energy. If yes, find the value of α and the energy.
   c) Check if $\psi(x) = Ae^{-x^2/\alpha^2}$ can be a wavefunction for the particle with *definite* energy. If yes, find the value of α and the energy.