Thapar Institute of Engineering and Technology

School of Physics and Materials Science

Quantum Mechanics

TUTORIAL #9

1. Kinetic energy of an electron and photon is 4.55 x 10^{-25} J. Calculate the velocity, momentum and wavelength of the electron and photon.
2. Write down the conditions for the acceptable wave function and prove that $\Psi = Ae^{-x^2}$ ($-\infty \leq x \leq \infty$) is an acceptable wave function.
3. The wave function of a free particle in normalized state is represented by

$$\Psi = Ne^{-\left(\frac{x^2}{2a^2}\right)+ik}$$

   Calculate the normalization factor N and the maximum probability of finding the particle.
4. Which of the following are eigenfunctions of the operator $\frac{\partial^2}{\partial x^2}$? Find out the appropriate eigenvalues of the following functions.
   (i) Sin x
   (ii) $\mathrm{Sin}^2 x$

5. A particle limited to the x axis has the wave function Ψ = ax between x = 0 and x =1; Ψ =0 elsewhere. (a) Find the probability that the particle can be found between x= 0.45 and x =0.55. (b) Find the expectation value $\langle x \rangle$ of the particle's position.
6. In a region of space, a particle with zero energy has a wave function $\Psi = Ae^{-\left(\frac{x^2}{L^2}\right)}$. Determine the steady state potential energy as a function of x.

7. A proton is confined in an infinite square well of width 10 fm. Calculate the energy and wavelength of the photon emitted when the proton undergoes a transition from the first excited state (n = 2) to the ground state (n = 1).

8. Electrons with energies of 1.0 eV and 2.0 eV are incident on a barrier 10.0 eV high and 0.50 nm wide. (a) Find their respective transmission probabilities. (b) How are these affected if the barrier is doubled in width?