Quantum Physics (PHY 201)
Home assignment 1 (05-08-2010)

1. You throw a ball up in the air against gravity. It comes back to your hand. Do you think quantum physics is applicable in this phenomenon? Would you like to apply quantum physics to understand this phenomenon?

2. Consider Young's double slits interference experiment. Draw a schematic diagram for it. The amplitudes of the incident light waves from slits 1 and 2 at a point P on the screen are respectively $A_1 \sin(kx_1 - \omega t)$ and $A_2 \sin(kx_2 - \omega t)$. Assume that x_1 and x_2 are respectively distances of point P from slit 1 and 2, k denotes wavenumber and ω= angular frequency of the light.

   a) Find the time varying intensity on the screen.

   b) Derive the time averaged (over a time $\gg T$) intensity pattern on the screen. Here T is the time period of the incident light.

   c) Draw the time averaged intensity pattern on the screen. Would you think the intensity pattern on the screen could be explained by assuming particle nature of light?

3. Consider the photoelectric effect. The work function of silver is 4.3 eV. Find the minimum frequency of the incident photon which can just emit an electron from the surface of silver metal.

4. The relativistic energy of a particle of rest mass m_0 is given by $E = \sqrt{(m_0c^2)^2 + p^2c^2}$, where p is the momentum of the particle and c denotes velocity of light in vacum. Using this relation show that the momentum of a photon is h/λ, where λ is its wavelength.

5. A Compton scattering is one in which X-ray is scattered off a stationary electron by an angle θ with the initial direction of X-ray. Using the concept of energy and momentum conservation derive the shift in wavelength of X-ray due to Compton scattering. Assuming the rest mass of the electron, $m_0 = 9.1 \times 10^{-31}$ kg and that $\theta = 30^\circ$ find the shift in wavelength of X-ray.