EEE 352A, Properties of Electronic Materials, Spring 2007

Homework 4

Due: Wednesday, February 14, in class

1. Problem 3.12 in Kasap (15 points).
2. Problem 3.13 in Kasap (10 points)
3. (25 points) A quantum-mechanical particle is represented by a one-dimensional wave packet that contains approximately 100 wavelengths in space.
   - What is Δx?
   - Say one wishes to measure the wavelength λ. What is $\Delta\lambda$, the accuracy of the measurement?
   - What is the product $\Delta x \cdot \Delta\lambda$?
   - Now use the de Broglie relation to show that the Heisenbert's uncertainty principle $\Delta x \cdot \Delta p \sim \hbar$ can be obtained from the product obtained above.
4. (25 points) The uncertainty principle can be used to *estimate* the size of an atom. Take, for example, the hydrogen atom. Let a be the size of the atom. This means that $\Delta x \approx a$ and $\Delta p \approx h/a$, where h is the Planck constant.
   - Since Δp specifies the range of momemtum fluctuation, for a rough estimate we can write $p \approx \Delta p$. What is the kinetic energy of the electron?
   - Now write down the total energy $E(a)$ of the electron as a function of a, which is the sum of the kinetic and the Coulomn potential energy.
   - Find a_0 where $dE/da|_{a=a_0} = 0$.
   - Find $E(a_0)$ and compare it with the value -13.6eV.
5. (25 points) The wave function in the one-dimensional infinite potential well system that we discussed in class can be written as

   $$\psi(x) = \sqrt{\frac{2}{L}} \sin\frac{n\pi x}{L}, \quad n = 1, 2, \ldots,$$

   where L is the width of the potential well.
   - What is the expected (or the average) value of x?
   - What is the probability $P(L/4)$ of finding the particle in the small interval $[L/4 - \delta/2, L/4 + \delta/2]$ about $L/4$, where δ is much much smaller than L?
   - What values of n maximize $P(L/4)$?