In the Name of GOD

HW set 3 — SSD - Fall 2016 – EE-SUT

Due date: 1395/08/16 — Prof. M. Fardmanesh

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1. A 0.40kg football is traveling at 40m/s. The uncertainty in its momentum (Δp) is 10^{-6} of its momentum.

   a) What is its uncertainty in position (Δx)?

   b) 2 mL of water is traveling at the same speed and has the same Δp/p. Calculate its Δx.

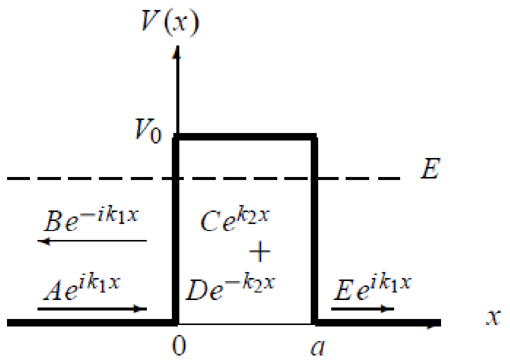
   c) An electron is traveling at the same speed and has the same Δp/p. Calculate its Δx.

   d) Comment on the differences in the uncertainty of momentum and position between the ball, water, and electron. How does the mass affect this value?

2. Consider a beam of particles of mass m that are sent from the left on a potential barrier:

$$V(x) = \begin{cases} 0, & x < 0, \\ V_0, & 0 \le x \le a, \\ 0, & x > a. \end{cases}$$

   a) For $E < V_0$, find the transition-coefficient ($T = \frac{|E|^2}{|A|^2}$) and the reflection-coefficient ($R = \frac{|B|^2}{|A|^2}$).



   b) Simplify your answers for part (a) with the following parameters:

$$\lambda = a\sqrt{2mV_0/\hbar^2} \text{ and } \varepsilon = E/V_0.$$

   c) Consider the special case in which $E \ll V_0$, hence $\varepsilon \ll 1$ or $\lambda\sqrt{1-\varepsilon} \gg 1$. Simplify your answer for part (b).

3. Consider a particle of mass m moving in the following symmetric potential:

$$V(x) = \begin{cases} V_0, & x < -a/2, \\ 0, & -a/2 \le x \le a/2, \\ V_0, & x > a/2. \end{cases}$$

   a) Is there a case for V_0 in which no possible bound state exists for this system?

   b) Find possible V_0 in a way that the system has only one bound state.

   c) Find possible V_0 in a way that the system has exactly n bound states.

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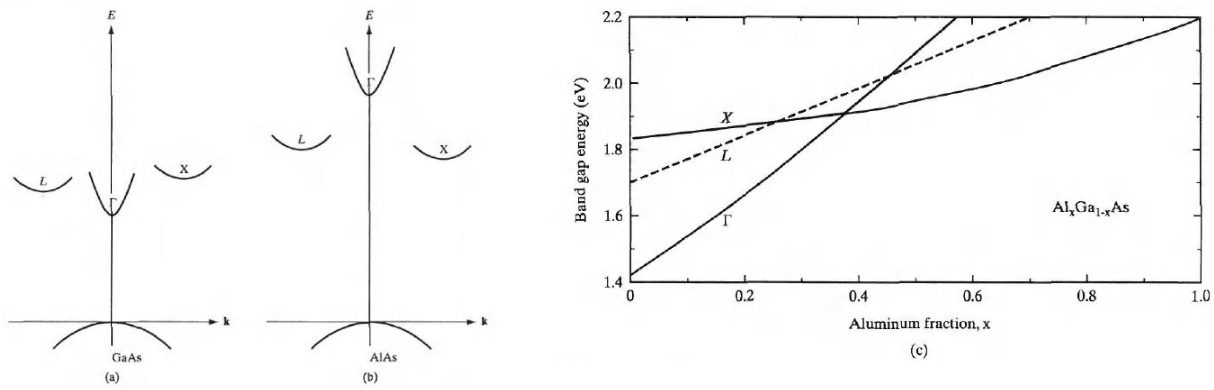
4. Consider the following conduction band energy E vs. wave vector k(x) dispersion relation in GaAs and AlAs.
   a) Define and briefly explain direct band gap and indirect band gap. What kind of band structure do GaAs and AlAs have?
   b) In GaAs, which energy valley has the greater effective mass (Γ or X)? Why? How about in AlAs?
   c) Up to what percentage of Al is the ternary alloy $Al_xGa_{1-x}As$, a direct semiconductor?



5. Using the Bohr model results for Si (m_n^*= 0.26m_0 , ε_r= 11.8):
   a) Calculate the donor binding Energy.
   b) Calculate the radius of the electron orbit around the donor in Si, assuming a ground state hydrogen-like orbit.