ECE/Mat 162 A, Fall 2008

Assignment 3

Due Tuesday, Oct 21 at 2 pm in Room 2221C ESB

1. Consider a **Particle in a Box** :

   $V(x) = 0, -L/2 \le x \le L/2$

   $= \text{Infinity, elsewhere}$

   a. Sketch the potential
   b. Write down the boundary condition at ± L/2 and determine the wave function in different regions.
   c. Use the b.c to show that 'k' is discrete.
   d. Write down the expressions and plot the wave functions for the first three eigen states
   e. Normalize the first eigen function
   f. Show that energy is also quantized and give an expression for it.

      Where does this quantization come from as opposed the continuous variation in energy of a free electron?

   g. From the plot of first eigen function, we see that the condition for continuity of ψ' (derivative of ψ) is violated. Can you explain why this violation in acceptable?
   h. Consider

      $V(x) = V_o , -L \le x \le L$

      $= \text{Infinity, elsewhere}$

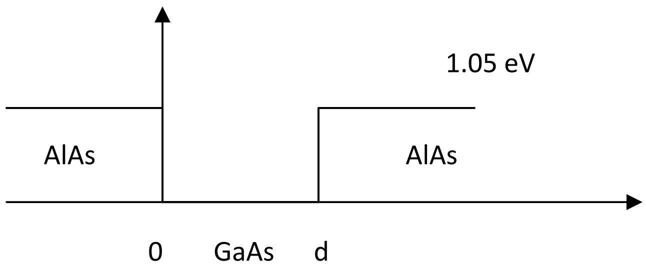
   Determine the allowed values of k, the first three wave-functions and the first three energy eigen values (without redoing steps a-f)

2. AlAs-GaAs-AlAs Hetero junction quantum well

It can be shown that the conduction band-edge of a AlAs-GaAs-AlAs quantum well can be modeled as a potential well of depth 1.05eV, with the only difference of a replacement of the electronic mass m_e with the 'effective mass' of the electron in the conduction band

$m_{eff} = 0.067\ m_e$

a. Looking at the problem as that of a finite-square well, derive the general expression for the wave function an electron of energy 'E' inside the quantum well using boundary conditions. (E < 1.05 eV).



b. Plot qualitatively the wave function of the first three eigen states.

c. Assuming a well of width 5 nm, (and assuming you have not been given the well depth, which in this case was 1.05 eV) calculate the **maximum possible** value of the first energy state possible in such a quantum well .

Use the effective mass for all answers.

3. Calculate the phase difference between incident and reflected waves for a step barrier,

   a. E < V
   b. E > V
   c. V = infinity for a finite E