EEE434/591: Quantum Mechanics

Homework set #4

1. (5 pts) A beam of electrons with number density of 1×10^{15} electrons/m is incident from the left on the step potential energy

$$V(x)=\begin{cases}0 & x<0\\ -V_0 & x\geq 0\end{cases}$$

(The constant V_0 is positive, so this is a "down-step" rather than an "up-step" potential)

(a) Write down the form of the spatial function $\psi_E(x)$ in each region of this potential, defining all wavenumbers and/or decay constants. Don't forget to impose asymptotic conditions for $x\to\pm\infty$.

(b) Obtain expression for the transmission and reflection coefficients for this potential, expressing your results in terms of the quantities you introduced in part (a).

(c) Evaluate $T(E)$ and $R(E)$ for an incident beam of kinetic energy 100 eV and a step of magnitude $V_0=50eV$.

(d) Evaluate the incident and transmitted fluxes for the conditions of part c. Be sure to show units.

(e) Sketch $\psi_E(x)$, being careful to clearly show any differences in the nature of the spatial function or in its amplitude or wavelength between the regions.

2. (5 pts) Suppose that electrons are confined in an infinite potential well of width 0.5 nm. What spectral frequencies will results from transitions between the lowest four energy levels? Use free electron mass in your computations.

3. (5 pts) MATLAB: Consider a potential well with $V=-0.3eV$ for $|x|<a/2$ and $V=0$ for $|x|>a/2$, with a=7.5 nm. Write a computer program that computes the energy levels for $E<0$. Use a mass appropriate for GaAs ($m=6\times10^{-32}$ kg).

(a) How many levels are bound in the well and what are their energy eigenvalues?

(b) Plot the wavefunctions for each bound state.

(c) Plot the transmission coefficient for E>0.