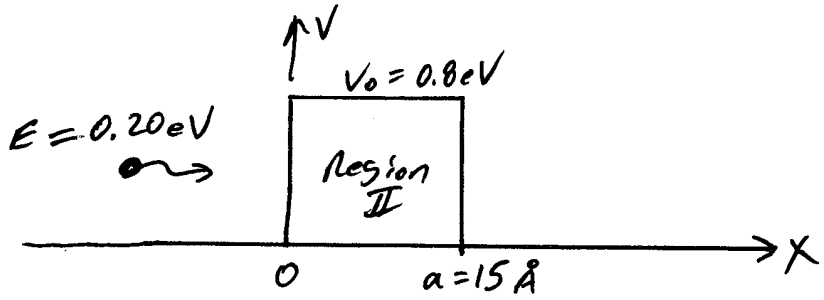
2.36 (*a*) Estimate the tunneling probability of a particle with an effective mass of $0.067m_0$ (an electron in gallium arsenide), where m_0 is the mass of an electron, tunneling through a rectangular potential barrier of height $V_0 = 0.8$ eV and width 15 Å. The particle kinetic energy is 0.20 eV. (*b*) Repeat part (*a*) if the effective mass of the particle is $1.08m_0$ (an electron in silicon).



From notes, $T = \dfrac{1}{1 + \dfrac{V_0^2 \sinh^2(K_2 a)}{4E(V_0 - E)}}$ (exact)

(2.63) $T \simeq 16\left(\frac{E}{V_0}\right)\left(1 - \frac{E}{V_0}\right) e^{-2K_2 a}$ (approx)

where (2.61b) $K_2 = \sqrt{\dfrac{2m(V_0 - E)}{\hbar^2}}$

a) $m = 0.067 m_0$

$$K_2 = \sqrt{\frac{2(0.067)9.1093837\times10^{-31}(0.8-0.2)1.6021766\times10^{-19}}{(1.054571817\times10^{-34})^2}}$$

$$= 1.027192 \times 10^9 \text{ Np/m}$$

$K_2 a = 1.0272 \times 10^9 (15\times10^{-10}) = 1.54079$ ← approx. eqn not going to be great

(exact) $T_a = \dfrac{1}{1 + \dfrac{0.8^2 \sinh^2(1.54079)}{4(0.2)(0.8-0.2)}} \Rightarrow \underline{\underline{T_a = 0.131357}}$

(approx) $T_a \simeq 16\left(\frac{0.2}{0.8}\right)\left(1 - \frac{0.2}{0.8}\right) e^{-2(1.54079)} \Rightarrow \underline{\underline{T_a \simeq 0.137661}}$

$\Rightarrow$ Fair agreement

b) $m = 1.08\, m_0$

Now $k_2 = \sqrt{\dfrac{2(1.08)9.1093837\times10^{-31}(0.8-0.2)1.6021766\times10^{-19}}{(1.054571817\times10^{-34})^2}}$

$= 4.12407\times10^{9}\ N/m$

$k_2 a = 4.124\times10^{9}(15\times10^{-10}) = 6.18611$ ← expect approx. to be good

(exact) $T_b = \dfrac{1}{1+\dfrac{0.8^2\sinh^2(6.18611)}{4(0.2)(0.8-0.2)}} \Rightarrow \underline{\underline{T_b = 1.270389\times10^{-5}}}$

(approx) $T_b \simeq 16\left(\dfrac{0.2}{0.8}\right)\left(1-\dfrac{0.2}{0.8}\right)e^{-2(6.18611)} \Rightarrow \underline{\underline{T_b \simeq 1.270395\times10^{-5}}}$

$\Rightarrow$ Excellent agreement