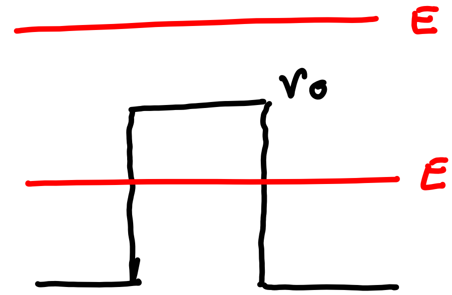
$$\left\{\begin{aligned} \text{Trans}(E<V_0) &= \frac{1}{1+\left(\frac{k_1^2+k_2^2}{2k_1k_2}\right)^2 \sinh^2(k_2L)} \\ \text{Trans}(E\geq V_0) &= \frac{1}{1+\left(\frac{k_1^2-k_2^2}{2k_1k_2}\right)^2 \sin^2 k_2L} \end{aligned}\right.$$



<u>T versus energy</u>: $E = \frac{\hbar^2 k_1^2}{2m} \rightarrow k_1^2 = \frac{2mE}{\hbar^2}$

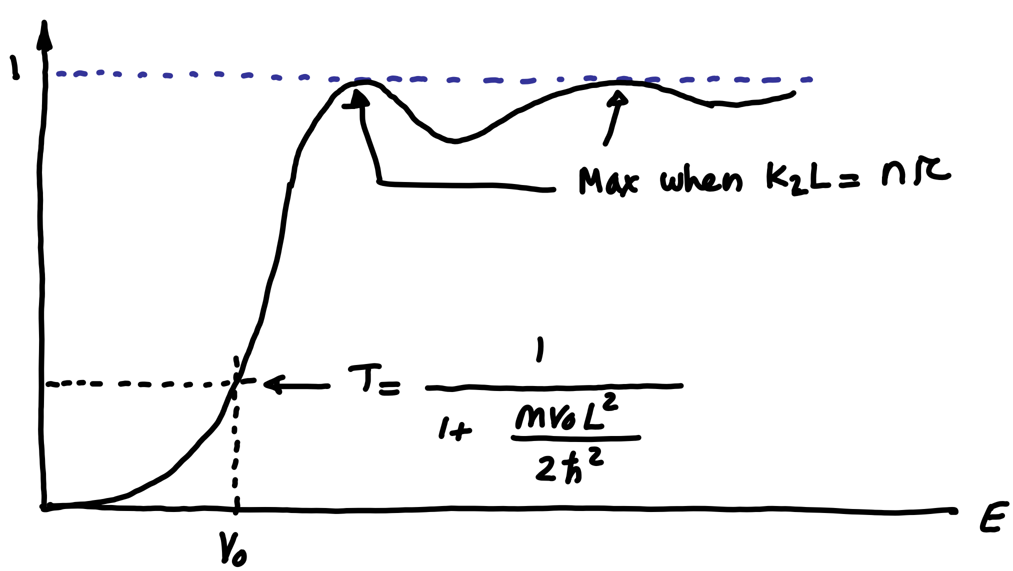
when $E<V_0$: $-E+V_0 = \frac{\hbar^2 k_2^2}{2m} \rightarrow k_2^2 = \frac{2m(V_0-E)}{\hbar^2}$

when $E>V_0$: $E-V_0 = \frac{\hbar^2 k_2^2}{2m} \rightarrow k_2^2 = \frac{2m(E-V_0)}{\hbar^2}$

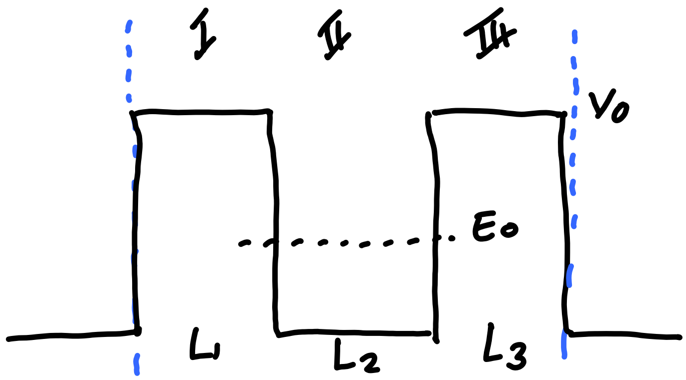
Substitute k_1 & k_2 in T $\Rightarrow$

$$T(E<V_0) = \frac{1}{1+\frac{V_0^2}{4E(E-V_0)}\sin^2(k_2L)}$$

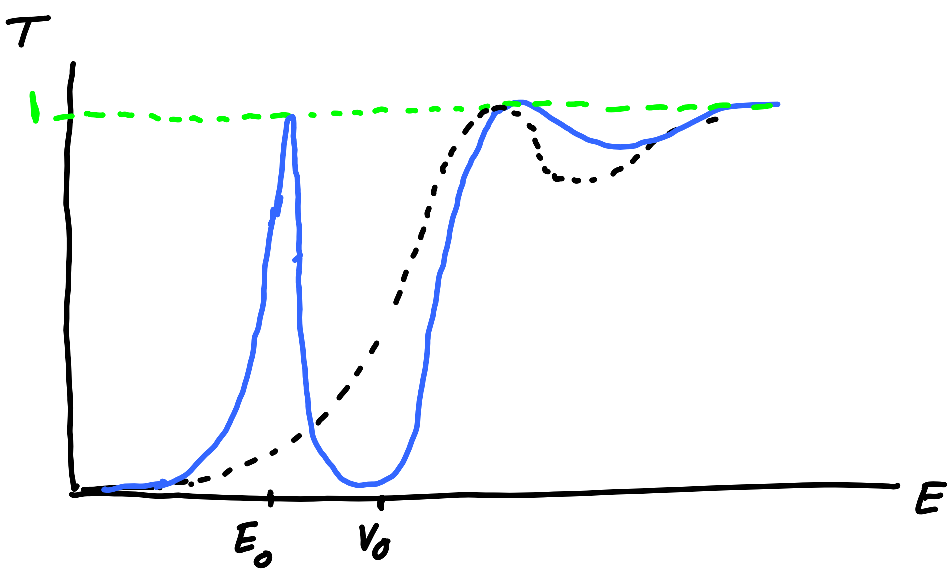
$$T(E>V_0) = \frac{1}{1+\frac{V_0^2}{4E(V_0-E)}\sinh^2(k_2L)}$$



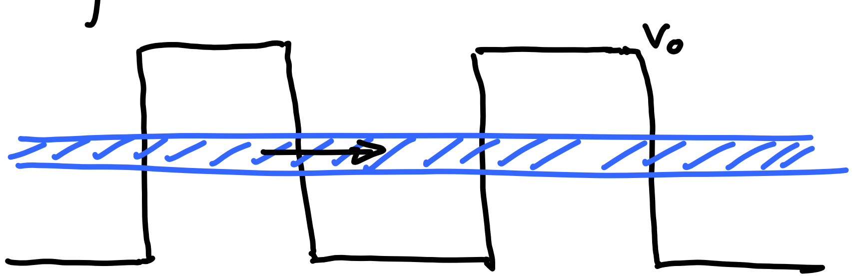
Resonant tunneling



$$P = P_s(V_0)\, P_f(L_1)\, P_s(-V_0)\, P_f(L_2)\, P_s(V_0)\, P_f(L_3)\, P_s(-V_0)$$



Miniband formation in SL's:



Bloch's Theorem

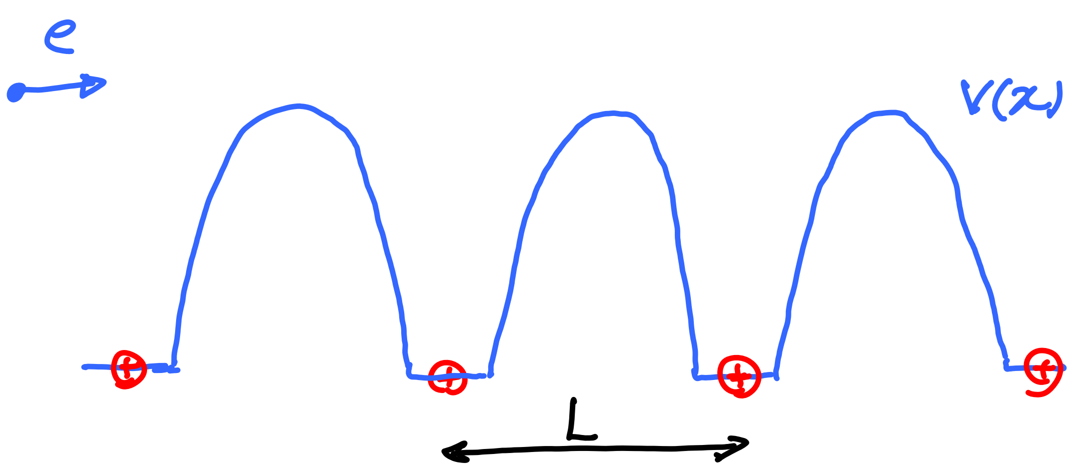
for a free electron in 1D space we have:

$$-\frac{\hbar^2}{2m}\psi'' = E\psi \quad \Rightarrow \quad \psi(x,t) = A\, e^{ikx}\, e^{-i\omega t}$$

$$\Rightarrow \quad |\psi(x,t)|^2 = A^2$$ So the probability

of finding the electron is uniform everywhere.

Now we add a periodic potential $V(x)$:



$V(x) = V(x+nL)$ which means it's periodic

This is the case for an electron moving in a crystal.

To find ψ, solve the schrodinger equ.:

$$\hat{H}\psi = E\psi$$

$$-\frac{\hbar^2}{2m}\psi'' + V(x)\psi = E\psi$$

Since $V(x)$ is periodic, $|\psi|^2$ is periodic:

$$|\psi(x)|^2 = |\psi(x+nL)|^2$$

The Bloch's theorem states that ψ has the following form:

$$\psi(x,t) = U(x)\, e^{ikx}\, e^{-i\omega t}$$

and $U(x)$ is periodic: $U(x) = U(x+nL)$