230A (FA10) Solution:

(a) The Schordinger equation is:

$$[-\frac{\hbar^2}{2m}\nabla^2 + V(x)]\varphi = E\varphi$$

So in region I, V(x)=0

The Schordinger equation is:

$$-\frac{\hbar^2}{2m_1}\frac{d^2\varphi}{dx^2} = E\varphi$$

The general solution is:

$$\varphi_1(x) = Ae^{i\beta x} + Be^{-i\beta x}, \text{ where } \beta = \frac{\sqrt{2m_1 E}}{\hbar}$$

And in the region II, V(x)=V_0,

$$[-\frac{\hbar^2}{2m_2}\frac{d^2\varphi}{dx^2} + V_0]\varphi = E\varphi$$

The general solution is:

$$\varphi_2(x) = Ce^{\alpha x} + De^{-\alpha x}, \text{ where } \alpha = \frac{\sqrt{2m_2(V_0 - E)}}{\hbar}, \; V_0 \geq E$$

(b) Boundary conditions:

1. $\varphi(0)$ continues in region I and II:

A+B=C+D

2. Continuity of probability flux in regions I and II:

$$\frac{1}{m_1}\frac{d\varphi_1(x)}{dx} = \frac{1}{m_2}\frac{d\varphi_2(x)}{dx}$$

So $$\frac{i\beta(A-B)}{m_1} = \frac{\alpha(C-D)}{m_2}$$

3. Bloch Theroem:

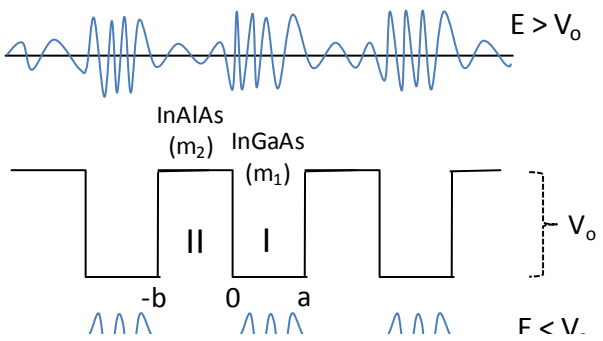
$$\varphi_1(x=a) = \varphi_2(x=-b)e^{ikc}, \text{ where } c = a + b$$

$$Ae^{i\beta a} + Be^{-i\beta a} = (Ce^{-b\alpha} + De^{b\alpha})e^{ikc}$$

4. Continuity of probability flux in a and –b,

$$\frac{i\beta(Ae^{i\beta a} - Be^{-i\beta a})}{m_1} = \frac{\alpha(Ce^{-b\alpha} - De^{b\alpha})}{m_2}e^{ikc}$$

(c,d) Typical solutions of the wavefunction with E < Vo and E > V_o.



230B (FA10) Solution:

(a) The collector current does not change.
I_B decreases to half.
Therefore, the current gain doubles.

(b) The collector current I_C doubles.
The base current does not change.
Therefore, the current gain doubles.

(c) The collector current increases by $\exp(q/kT)$=46.8.
The base current increases by the same amount.
Therefore, the current gain does not change.

(d) n_{ieB} is strongly dependent on the energy band gap, i.e.,

$$n_{ieB}^2(SiGe) = n_{ieB}^2(SiGe)\exp(\frac{\Delta E_{g,SiGe}}{kT}).$$

Therefore, the collector current increases by the factor of 46.8.
The base current does not change.
The current gain, therefore, increases by same amount as the collector current.