3.17 Figure P3.17 shows the parabolic E versus k relationship in the valence band for a hole in two particular semiconductor materials. Determine the effective mass (in units of the free electron mass) of the two holes.

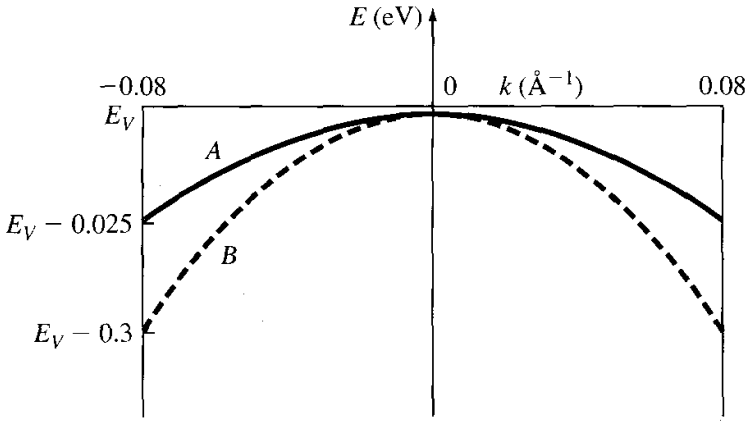

Figure P3.17 | Figure for Problem 3.17.

Parabola A Per (3.53), $E - E_v \approx -C_A k^2$. From graph, $E = E_v - 0.025$ (eV) at $k = 0.08$ Å^{-1}.

$$(E_v - 0.025) - E_v = -0.025 \text{ eV } (1.602176634\times10^{-19} \text{ J/1 eV}) \approx -C_A (0.08 \text{ Å}^{-1})^2$$

$$-4.0054416\times10^{-21} \text{ J} \approx -C_A (0.08\times10^{10} \text{ m}^{-1})^2$$

So, $C_A \approx +4.0054416\times10^{-21} \text{ J}/(0.08\times10^{10} \text{ m}^{-1})^2 = 6.2585025\times10^{-39} \text{ J-m}^2$.

From (3.56) and (3.58), the effective mass of the hole associated with parabola A is

$$m^* = \left|\frac{\hbar^2}{-2C_A}\right| = \frac{(1.0545718\times10^{-34})^2}{2(6.2585025\times10^{-39})}$$

$m^* = 8.8848865\times10^{-31} \text{ kg}/(m_0/9.1093837015\times10^{-31} \text{ kg}) \Rightarrow \underline{\boldsymbol{m_A^* = 0.975355 m_0}}$.

Parabola B Per (3.53), $E - E_v \approx -C_B k^2$. From graph, $E = E_v - 0.3$ (eV) at $k = 0.08$ Å^{-1}.

$$(E_v - 0.025) - E_v = -0.3 \text{ eV } (1.602176634\times10^{-19} \text{ J/1 eV}) \approx -C_B (0.08 \text{ Å}^{-1})^2$$

$$-4.8065299\times10^{-20} \text{ J} \approx -C_B (0.08\times10^{10} \text{ m}^{-1})^2$$

So, $C_B \approx +4.8065299\times10^{-20} \text{ J}/(0.08\times10^{10} \text{ m}^{-1})^2 = 7.510203\times10^{-38} \text{ J-m}^2$.

From (3.56) and (3.58), the effective mass of the hole associated with parabola B is

$$m^* = \left|\frac{\hbar^2}{-2C_B}\right| = \frac{(1.0545718\times10^{-34})^2}{2(7.510203\times10^{-38})}$$

$m^* = 7.4040721\times10^{-32} \text{ kg}/(m_0/9.1093837015\times10^{-31} \text{ kg}) \Rightarrow \underline{\boldsymbol{m_B^* = 0.08128 m_0}}$.