Section 3-7: Bipolar Junction Transistor

Problem 3.73 The two-transistor circuit in Fig. P3.73 is known as a current mirror. It is useful because the current $I_0$ controls the current $I_{REF}$ regardless of external connections to the circuit. In other words, this circuit behaves like a current-controlled current source. Assume both transistors are the same size such that $I_{B_1} = I_{B_2}$. Find the relationship between $I_0$ and $I_{REF}$. (Hint: You do not need to know what is connected above or below the transistors. Nodal analysis will suffice.)

![Figure P3.73: A simple current mirror (Problem 3.73).](image)

Solution: Upon replacing the two transistors with equivalent circuits, per the model given in Fig. 3.28, we get the circuit in Fig. P3.73(b).

At node $C_1$: $I_{REF} = \beta I_{B_1} + I_1$
At node $B$: $I_1 = I_{B_1} + I_{B_2}$
At node $C_2$: $I_0 = \beta I_{B_2}$

Also, problem states that $I_{B_1} = I_{B_2}$.

Solution is:

$$I_0 = \frac{\beta I_{REF}}{\beta + 2}.$$  

Since $\beta$ is typically between 30 and 1000,

$$I_0 \simeq I_{REF}.$$