1. Consider a traditional BJT current mirror with a nominal current transfer ratio of unity. (e.g. \( I_o/I_{ref}=1 \)) \( I_S=10^{-15} \text{ A}, \beta=100, \text{ and } V_A=100V \). For \( I_{ref}=1\text{mA} \), find \( I_o \) when \( V_o=5V \). Also, find the output resistance.

2. Assuming the availability of BJTs with scale currents \( I_S=10^{-15} \text{ A}, \beta=100, \text{ and } V_A=50V \), design the current-source circuit of the figure below to provide an output current \( I_o=0.5\text{mA} \) at \( V_o=2V \). Use a power supply \( V_{CC}=5V \). Give the values of \( I_{REF}, R, \text{ and } V_{OMIN} \). Also, find the actual value of \( I_o \) at \( V_o=5V \).

3. Find the output resistance of each of the two current sources below. Let \( R_1=942\text{k}\Omega, R_2=9.3\text{k}\Omega, R_3=11.5\text{k}\Omega, V_A=100V \) and \( \beta=100 \).

4. The current-source circuit of the figure to the right utilizes a pair of matched \( pnp \) transistors having \( I_S=10^{-15} \text{ A}, \beta=100, \text{ and } V_A=50V \). It is required to design the circuit to provide an output current \( I_o=1\text{mA} \) at \( V_o=2V \). What values of \( I_{REF} \) and \( R \) are needed? What is the maximum allowed value of \( V_O \) while the current source continues to operate properly? What change occurs in corresponding \( I_o \) to \( V_O \) changing from the maximum positive value to -5V?
5. Find the voltages at all nodes and the currents through all branches in the circuit below. Assume $|V_{BE}|=0.7V$ and $\beta=\infty$.

6. Using the ideas embodied in the figure below, design a multiple-mirror circuit using power supplies of $\pm 5V$ to create source currents of $0.4mA$, $0.8mA$ (currents shown below as $I_{REF}$, $I_1$, and $I_3$) and sink currents of $1mA$, and $2mA$ (currents shown below as $I_2$, and $I_4$). Assume that the BJTs have $|V_{BE}|=0.7$ and large $\beta$. 
7. Find the output resistance of the double-cascode current mirror below by drawing the hybrid pi model and finding the equivalent resistance at the drain of Q3. (Hint: Use a test source and find the Thevenin equivalent resistance).

8. Show that the input resistance (R seen at V3 node) for the Wilson MOS mirror shown at right is given by $2/g_m$. Assume that all three transistors are identical and neglect the Early effect. (Hint: Use a test source and find the Thevenin equivalent resistance)

9. (a) For the circuit below, assume BJTs with high $\beta$ and $v_{BE}=0.8V$ at 1mA. Find the value of $R$ that will result in $I_o=10\mu A$.
(b) For the design in (a), find $R_o$ assuming $\beta=100$ and $V_A=50V$. 

10. If the pnp transistor in the circuit below is characterized by its exponential relationship with a scale current $I_S$, show that the dc current $I$ is determined by $I_\text{R}=V_T\ln(I/I_S)$. Assume $Q_1$ and $Q_2$ to be matched and $Q_3$, $Q_4$, and $Q_5$ to be matched. Find the value of $R$ that yields a current $I=100\text{A}$. For the BJT, $V_{EB}=0.7\text{V}$ at $I_E=1\text{mA}$.