ECEN 326 HOMEWORK # 3
(Due date: Tuesday, Feb. 28, 2012)

1. For the below circuit, determine the output current and output resistance of the bipolar current mirror. Find the output current if $V_o = 1\text{V}$, $5\text{V}$ and $30\text{V}$. Ignore the effects of nonzero base currents. Assume $\beta = 200$, and $V_{A,\text{nnp}} = 130\text{V}$. Compare your answer with PSPICE simulations.

![Circuit Diagram]

2. Design a simple MOS current mirror to meet the following constraints:

   (a) Transistor $M_2$ must operate in the active region for the value of $V_o$ to within $0.2\text{V}$ of ground
   (b) The output current must be $50\ \mu\text{A}$.
   (c) The output current must change less than 1% for a change in output voltage of $1\text{V}$.

Make $M_1$ and $M_2$ identical. You need to minimize the total device area ($W\times L$) within the given constraints. Assume $k'_{n} = 100\ \mu\text{A/V}^2$.

![MOS Circuit Diagram]
3. Show that the output resistance of the Wilson’s current source is approximately \( r_{o2}/2 \) if \( r_{o1} = \infty \). What is the percentage change in \( I_{\text{OUT}} \) for a 5V change in \( V_o \)? Assume \( \beta = 200 \), and \( V_{A,\text{nnpn}} = 130V \). Compare your answer with PSPICE simulations.

4. Determine the output current and output resistance of the below circuit. Assume transistors are matches and \( \beta = 200 \), and \( V_{A,\text{nnpn}} = 130V \)

5. Calculate the bias current of the circuit shown below as a function of \( R \), \( k’n \), \( (W/L)_1 \) and \( (W/L)_2 \). Assume \( (W/L)_1 < (W/L)_2 \), \( M_4 \) is identical to \( M_3 \) and ignore the body effect.