1.  (25%) Assume all transistors are matched. Let $I_{REF} = 0.2mA$, $K_n = 0.2mA/V^2$, $V_{TN} = 1V$, and $\lambda = 0.02V^{-1}$. Determine the output resistance looking into the drain of $M_6$.
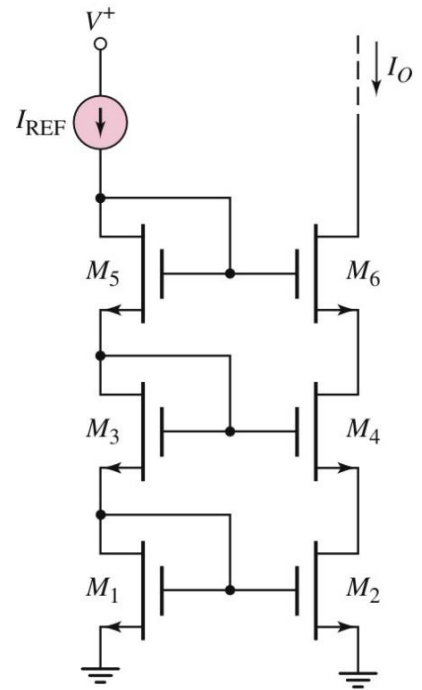
2.  (25%) The transistor parameters are
    $V_{TP} = -0.4$ V, $k'_p = 60\mu A/V^2$, and $\lambda = 0$.
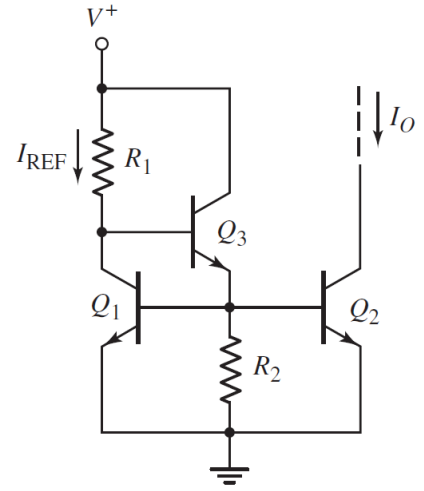    The width-to-length ratios are $(W/L)_1 = 25$, $(W/L)_2 = 15$, and $(W/L)_3 = 5$.
    (a) Determine $I_O$, $I_{REF}$, $V_{SG1}$, and $V_{SG3}$. (20%)
    (b) What is the largest value of $R$ such that $M_2$ remains biased in the saturation region? (5%)
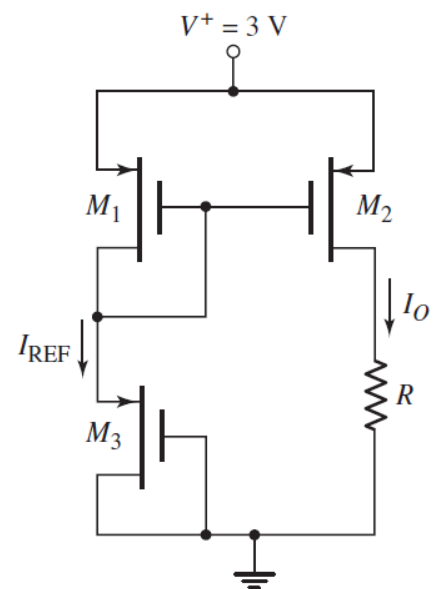
3. (25%) The transistor parameters are $\beta = 80$, $V_{BE}(\text{on}) = 0.7V$, and $V_A = \infty$.

(a) Derive the expression for $I_O$ in terms of $I_{REF}$, $\beta$, and $R_2$. (15%)

(b) For $R_2 = 10k\Omega$, $I_O = 0.7mA$ and $V^+ = 10V$, find $R_1$. (10%)



4. (25%) The transistor $M_2$ sources a bias current to a load circuit. Assume the circuit is biased at $V^+ = +5$ V and $V^- = -5$ V, and assume the transistor parameters are $V_{TP} = -0.5$ V, $k'_p = 50$ $\mu A/V^2$, $(W/L)_1 = (W/L)_2 = 15$, $(W/L)_3 = 3$, and $\lambda = 0$. Determine $I_{REF}$, $I_O$, and $V_{SD2}(\text{sat})$.