Note: Exam time is 10:00AM-12:00PM, 2018/6/15. The total is 120 points.

1. (**20 pts**) For the differential amplifier, the parameters are $V^+=5V$, $V^-=-5V$, $R_1 = 80$ kΩ and $R_D = 40$ kΩ. The transistor parameters are: $K_{n1} = K_{n2} = 50$ μ A/V^2, $K_{n3} = K_{n4} = 100$ μ A/V^2, $\lambda = 0$, and $V_{TN} = 0.8$ V. Determine the maximum and minimum values of the common-mode input voltage?
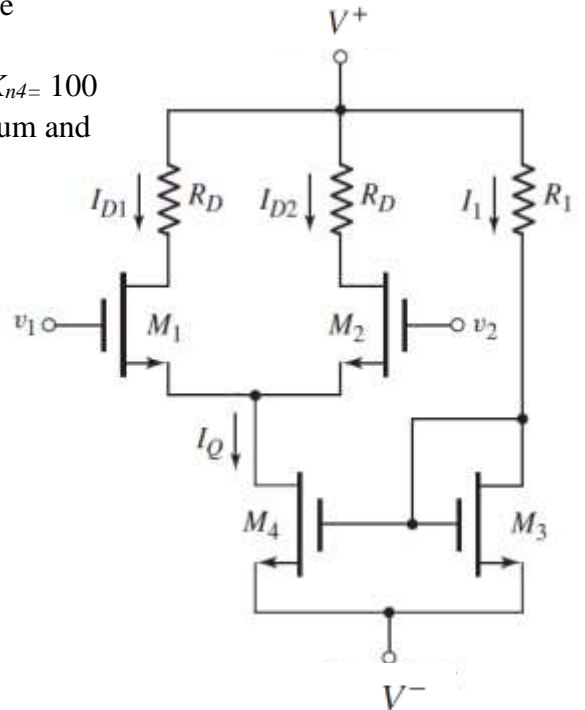
2. (**30 pts**) Assume $\beta = 120$ for all npn transistors and $\beta = 90$ for all pnp transistors. Let $V_{A7} = 60V$ for Q_7, $V_{A11} = 120V$ for Q_{11}, and $V_A = \infty$ for all other transistors. Determine the output resistance R_o.
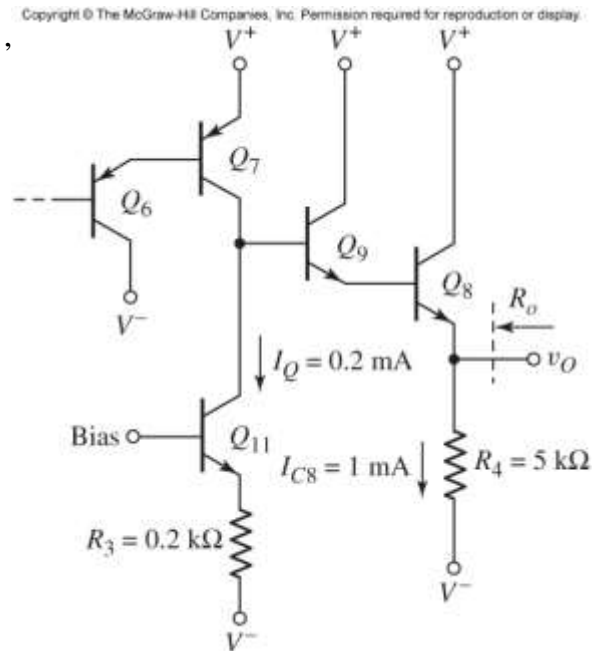
3. (**30 pts**) The circuit and transistor parameters are
$V^+ = 3V, V^- = -3V, R_D = 360k\Omega, I_Q = 12\mu A$,
$V_{TP} = -0.4V, K_p = 30\mu A/V^2$, and $\lambda = 0$. The
output resistance of the current source is
$R_o = 4M\Omega$. (a) Determine V_{SD} of the transistors
for $v_1 = v_2 = 0$ (b) Determine the differential-mode
and common-mode voltage gains for $v_O = v_{D2}$.
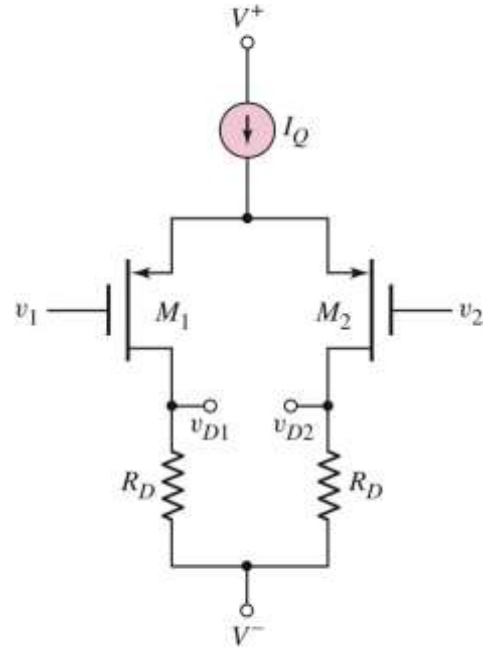
4. (**40 pts**) Given that $V_{BE(on)} = 0.7V, \beta = 150, V_A = \infty$, and $R_2 = R_3$. If $I_Q = 0.4mA$, determine
   (a) R_2 (10 pts)
   (b) I_{R4}, I_{R6}, and I_{R7} (10 pts)
   (c) R_{i2} and R_{i3} (10 pts)
   (d) $A_{d1} = v_{O2}/(v_1 - v_2)$ and $A_2 = v_{O3}/v_{O2}$. (10 pts)