Q1 (a)
1.) (59 points total)

![Circuit Diagram]

Figure 1

a.) (10 points)
Suppose $v_{i_1} = v_{i_2} = v_{i_{CM}}$ is set so that transistors $M_1$-$M_6$ are in saturation. What region does transistor $M_7$ operate in?
What is the nominal drain current $I_D$ in $M_7$?

Q1 (b)
Draw a small signal half-circuit model corresponding to differential mode operation.

Q1 (c)
Determine the differential mode gain $A_{DM}$. You may express your solution in terms of $g_m$, $r_o$, etc.

Q1 (d)
Draw a small signal half-circuit model for common mode operation.

Q1 (e)
Determine the common mode gain $A_{CM}$. You may express your solution in terms of $g_m$, $r_o$, etc.
Q2 (a)

2.) (30 points total)

Determine the minimum supply voltage $V_{DD}$ that keeps all transistors in saturation. Express your answer in terms of $V_{T8}$, $V_{Tp}$, $\Delta V_1$, $\Delta V_2$, $\Delta V_3$, $\Delta V_4$, $\Delta V_5$, etc.

Q2 (b)

Determine $R_{out}$, the small signal output resistance looking into the drain of $M_6$. 

Q2 (c)

Determine the minimum supply voltage $V_{DD}$ that keeps all transistors in saturation. Express your answer in terms of $V_{T8}$, $V_{Tp}$, $\Delta V_1$, $\Delta V_2$, $\Delta V_3$, $\Delta V_4$, $\Delta V_5$, etc.