1. The schematic diagram for the uA741 operational amplifier is shown below. The supply voltages are $V_{CC} = V_{EE} = 5V$. The relevant resistor values are: $R_5 = 39k\Omega$ and $R_4 = 5k\Omega$. Assume that $Q_8$, $Q_9$, $Q_{10}$, $Q_{11}$, $Q_{12}$ have equal areas, and that the areas of $Q_{13B}$ and $Q_{13A}$ are 25% and 75% of the area of $Q_{12}$, respectively. Neglect the base current of transistors $Q_3$ and $Q_4$ in your analysis. Determine

a) the bias currents $I_{O1}$, $I_{O2}$ and $I_{O3}$.

b) the input resistance $R_d = 4r_x$ of the amplifier looking from the base of $Q_1$ to the base of $Q_2$.

c) the overall voltage gain.

d) the bandwidth and slew rate if $C_C = 30pF$

2. The following diagram shows a multistage amplifier biased by current mirrors. The transistor parameters are: $k_n' = 80\mu A/V^2$, $k_p' = 40\mu A/V^2$, $V_{tn} = -V_{tp} = 0.7V$, $\lambda_n = \lambda_p = 1/100V$, $(W/L)_{1,2,4,5,7,10} = 2/1$ and $(W/L)_{3,6,8,9} = 8/1$. Determine the following quantities:

a) bias currents for all transistors.

b) overall voltage gain if no load is present.

c) voltage gain and power dissipated if $R_L = 1k\Omega$ is attached to the output.
3. For the following differential amplifier,

\[ A_d = \frac{v_{C1} - v_{C2}}{v_d} \]

when \( v_1 = +v_d/2 \) and \( v_2 = -v_d/2 \), \( R_{C1} = R_{C2} = 20\,k\Omega \), \( R_E = 0 \), \( R_{CS} = \infty \) and \( I_{CS} = 200\mu A \).

b) The differential gain \( A_d = \frac{v_{C1} - v_{C2}}{v_d} \) when \( v_1 = +v_d/2 \) and \( v_2 = -v_d/2 \), \( R_{C1} = R_{C2} = 20\,k\Omega \), \( R_E = 500\Omega \), \( R_{CS} = \infty \) and \( I_{CS} = 200\mu A \).

c) The common-mode rejection ratio if \( v_O = v_{C1}, R_{C1} = R_{C2} = 20\,k\Omega, R_E = 0, R_{CS} = 500k\Omega \) and \( I_{CS} = 200\mu A \).

d) The common-mode rejection ratio \( A_{cm}/A_d \) if \( v_O = v_{C1} - v_{C2}, R_{C1} = 20.5k\Omega, R_{C2} = 19.5k\Omega, R_E = 0, R_{CS} = 500k\Omega \) and \( I_{CS} = 200\mu A \).