1- In the two-stage amplifier shown below, X denotes the W/L ratio of the transistors.

\[ V_{dd}=3V \]

\[ I_{in}=1mA \]

\[ V_{CM}+V_{in}=0 \]

\[ R_{D1} \]

\[ R_{D2} \]

\[ V_{out}^+ \]

\[ V_{out}^- \]

\[ X = \frac{W}{L} = 10 \]

\[ \mu_n C_{ox} = 200 \mu A^2 / V \]

\[ V_{th} = 0.5V \]

\[ \lambda = 0 \]

\[ V_{th}+V_{eff1} \]

\[ M_{1a} \]

\[ M_{1b} \]

\[ M_{2a} \]

\[ M_{2b} \]

\[ M_{b1} \]

\[ M_{b2} \]

\[ V_{th}+V_{eff2} \]

\[ 2X \]

\[ 8X \]

\[ X = \frac{W}{L} = 10 \]

a) Find the differential voltage gain \( \frac{V_{out}^+ - V_{out}^-}{V_{in}^+ - V_{in}^-} \) assuming all transistors are in saturation (20%)

b) Assuming all transistors remain in saturation, if we double the \( I_{in} \), how much will the differential voltage gain change? (20%)

c) What is the minimum input common-mode voltage (Vcm) to guarantee all transistors remain in saturation (20%)

d) If Vcm=2V_{th}+V_{eff1}, find the range of \( R_{D1} \) and \( R_{D2} \) to guarantee all transistors remain in saturation (40%)
2- In circuit shown below, \( X \) denotes the W/L ratio of the transistors, and the Opamp has infinite input impedance

\[
\begin{align*}
V_{dd} & \\
M_2 & \quad \lambda = 0 \\
2X & \quad M_3 \\
\cdots & \\
I_{out} & \\
V_{in} & \\
A_0 & \\
M_1 & \\
X & \\
R_{ref} & \\
\end{align*}
\]

a) Assuming \( A_0 \to \infty \) and all the transistors are in saturation, find \( I_{out} \) (30%)

b) Find \( I_{out} \) if the **Opamp has the limited gain equal to** \( A_0 \) and all the transistors are in saturation (70%)