1. [25 points] In the circuit below, find the transfer function $H(s) = \frac{v_{out}}{v_{in}}$. Assume the op-amp is ideal.
2. [25 points] In the circuit below, find the small signal output voltage $v_{out}$.

Assume:
- The op-amps are ideal.
- M1 and M2 are biased in saturation region.
- The output resistance of M1 and M2, $r_o = \infty$.
- The transconductance of M1 and M2, $g_m = 20 \text{ mA/V}$.
- M1 and M2 have no parasitic capacitance ($C_{gs} = C_{gd} = C_{sb} = C_{db} = 0$).

\[ i_{in} = 10 \cdot \cos(\omega t + 45^\circ) \text{ nA} \]
\[ \omega = 10^7 \text{ rad/sec} \]
3. [25 points] In the circuit below, find the small signal output voltage $v_{out}$.

Assume:
- The current source $I_{Bias}$ is ideal.
- $M1$ is biased in saturation region.
- $M1$ has no parasitic capacitance ($C_{gs} = C_{gd} = C_{sb} = C_{db} = 0$).
- The output resistance of $M1$, $r_0 = \infty$.
- The transconductance of $M1$, $g_m = 20$ mA/V.

\[ v_{in} = 5 \cdot \sin(\omega t) \ \mu V \]
\[ i_{in} = 10 \cdot \sin(\omega t) \ \text{nA} \]
\[ \omega = 10^7 \ \text{rad/sec} \]
4. [25 points] In the circuit below, find the small signal output voltages $v_{o+}$ and $v_{o-}$.
Assume:
- $V_p$ node is an AC ground
- All transistors are biased in saturation region.
- The bias current sources are ideal.
- All transistors have no parasitic capacitance ($C_{gs} = C_{gd} = C_{sb} = C_{db} = 0$).
- For all transistors, the output resistance $r_0 = \infty$.
- For all transistors, the transconductance $g_m = 20 \text{mA/V}$.

\[ v_{in} = 10 \cdot \sin(\omega t) \ \mu V \]
\[ \omega = 10^7 \text{ rad/sec} \]