1. Design a simple MOS current mirror to meet the following constraints:
(a) Transistor M2 must operate in the saturation region for a minimum output compliance voltage of 0.2V.
(b) The output current must be 50μA

Make M1 and M2 identical and minimize the total device area (WxL). What is the output resistance of the current mirror?

Use the following transistor parameters
\( K_{PN} = \mu_n C_{ox} = 200 \mu A/V^2, \quad V_{TH_N} = 0.4V, \quad \lambda = 0.1V^{-1} \)

\[
V_0 = V_{DS2} \geq V_{GS2} - V_{TH}
\]

\[
V_G \leq 0.2V + 0.4V = 0.6V
\]

Set \( V_G = 0.6V \) for \( \min \frac{W}{L} \)

\[
I_D = \frac{\mu C_{ox}}{2} \frac{W}{L} \left( V_{GS} - V_{TH} \right)^2
\]

\[
\frac{W}{L_{1,2}} = \frac{ZI_D}{\mu C_{ox} \left( V_{GS} - V_{TH} \right)^2} = \frac{2(50 \mu A)}{(200 \mu A/V^2)(0.6V - 0.4V)^2}
\]

\[
\frac{W}{L_1} = \frac{W}{L_2} = 12.5
\]

\[
I_o = \frac{1}{ZI_D} = \frac{1}{(0.1V^{-1})(50 \mu A)} = 200k\Omega
\]

\[
I_o = 200k\Omega
\]
2. In the following circuit, all transistors are identical with $\beta = 200$, $V_AQ_{11} = 100V$, $V_{A,QI,Q10} = \infty$, and $|V_{BE,ON}| = 0.7V$, $C_{CS} = 20fF$, $C_\mu = 5fF$, $C_a = \frac{20fF}{200} = 0.1fF$

Estimate the 3 main poles of the circuit.

3 poles at nodes 1, 2, and $V_o$.

Node 1: $R_{eff1} = R_{C1} || R_{T2} = 2.5k||5.1k = 1.69k$

$C_{total1} = C_m \left(1 + \frac{1}{5fF(1.69k)} + C_{CS1} + C_{T2} + 2C_m \right) = 5fF \left(1 + \frac{1}{1.89k(1.69k)} \right) + 20f + 20f + 2(5f) = 55.2fF$

Node 2: $R_{eff2} = R_{es} = \frac{V_T}{1mA} = \frac{2.5mV}{1mA} = 2.5 ohm$

$C_{total2} = 2C_m + C_{CS3} + C_T5 = 2(5fF) + 20f + 20f = 50fF$

$|WP_2| = \frac{R_{eff2} C_{total2}}{R_{C5}} = \frac{1}{(2.5mV)(50fF)} = 772 \text{Grd/}s = 12.3 \text{GHz}$

Node $V_o$: $R_{effv0} = R_{C5} = 1k$

$C_{totalv0} = C_{CS5} + C_{es5} = 5fF + 5fF = 10fF$

$|WP_{v0}| = \frac{1}{(R_{effv0})(C_{totalv0})} = \frac{1}{(1k)(10fF)} = 100 \text{Grd/}s = 15.9 \text{GHz}$