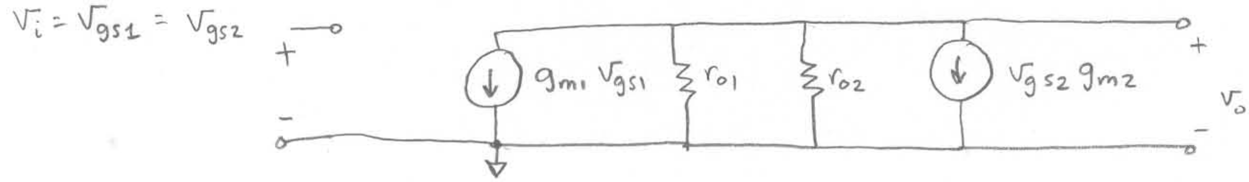
Problem 1.3 (**2 points**) Find the small-signal output resistance R_o assuming the bias conditions in Problem 1.1.

Small Signal model:



$r_{o1} = \frac{1}{\lambda I_D} = \frac{1}{(0.1)(75\,\mu A)} = 133\ k\Omega$ (116 $k\Omega$ for $I_D = 78\,\mu A$)

$r_{o2} = r_{o1}$

$R_{out} = r_{o1} \| r_{o2} = \boxed{66.5\ k\Omega}$
(58.0) $k\Omega$

Problem 1.4 (**3 points**) Find the small-signal gain assuming the bias conditions in Problem 1.1.

$A_v = -G_m R_o = -(g_{m1} + g_{m2})(r_{o1} \| r_{o2})$

$g_{m1} = k_n' \left(\frac{W}{L}\right)_1 (V_{GS1} - V_{tn}) = (300\,\mu A/V^2)(2)(1.5\ V - 1\ V) = 300\,\mu A/V$

$g_{m2} = k_p' \left(\frac{W}{L}\right)_2 (V_{GS2} - V_{tp}) = (100\,\mu A/V^2)(6)(1.5\ V - 1V) = 300\,\mu A/V$

$\boxed{A_v = -39.9 \approx -40}$

Problem 1.5 (**2 points**) Suppose that γ is nonzero and that through source-well biasing, $V_{tn} = 1.25$ V and $V_{tp} = -1.25$ V. How does this affect the small-signal gain (assume the bias conditions in Problem 1.1)?

$A_v = -(g_{m1} + g_{m2})(r_{o1} \| r_{o2}) = \frac{-(g_{m1} r_{o1})\, r_{o2}}{r_{o1} + r_{o2}} + \frac{-r_{o1}\,(g_{m2} r_{o2})}{r_{o1} + r_{o2}}$

$g_{m1} r_{o1} = \frac{1}{\lambda}\left(\frac{2}{V_{GS1} - V_{t1}}\right) = \left(\frac{1}{0.1}\right)\left(\frac{2}{1.5 - 1}\right) = 40$ for $V_{t1} = 1.0$, $g_{m1} r_{o1} = 80$ for $V_{t1} = 1.25$

$\boxed{A_v \text{ doubles}, A_v \approx -80}$