Problem 4.2 (6 points) One can model the thermal noise of resistor R as a small-signal current source i_n in parallel with R. Quantify the impact of the noise current source on the total output current $I_O + i_o$, assuming the bias point you found in Problem 4.1 and $|i_n| = 1\mu\text{A}$.

Small-signal model:

Current gain for common-gate: $\frac{i_o}{i_i} = 1$

$R_{i3} \equiv$ common-gate input resistance $= \frac{1}{g_{m3}}$ $(\lambda = 0)$

$$\frac{i_i}{i_n} = \frac{R}{R + R_{i3}} \quad \text{(current divider)} \qquad \Rightarrow \frac{i_o}{i_n} = (1)\frac{R}{R + 1/g_{m3}}$$

$$g_{m3} = \sqrt{2 I_O K_n' \left(\frac{W}{L}\right)_3} = \sqrt{2(200\mu\text{A})\frac{(300\mu\text{A})}{V^2}(2)} = 4.90 \times 10^{-4}\ \text{S}$$

$$\frac{i_o}{i_n} = \frac{10\ \text{k}\Omega}{10\ \text{k}\Omega + 2.04\ \text{k}\Omega} = 0.83 \Rightarrow |i_o| = 0.83\,\mu\text{A}$$

$$\frac{|i_o|}{|I_o|} = 0.415\ \%$$