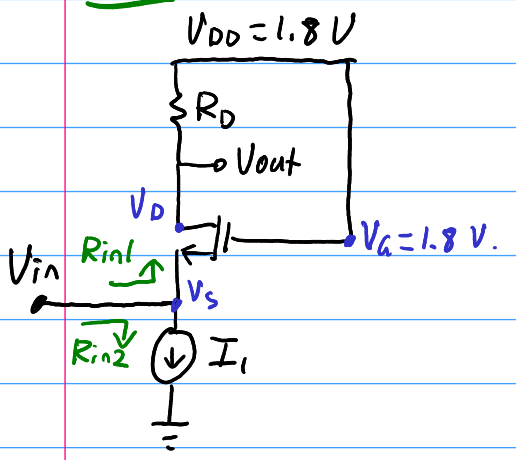
7.67



Design CG stage for $A_v = 5$, $R_{in} = 50\Omega$, power budget $= 3$ mW.

$$I_1 = \frac{P}{V_{DD}} = \frac{0.003}{1.8} = 1.67\ mA.$$
$$\therefore I_D = 1.67\ mA.$$

$$R_{in} = R_{in1} \parallel R_{in2}$$

Since I_1 is treated as an ideal current source, neglect its input impedance. $\therefore R_{in2} = \infty$

$$R_{in} = R_{in1} = \frac{1}{g_m} \quad \text{(from impedance rules).}$$
$$\therefore g_m = \frac{1}{50}\ S = \sqrt{2\mu_n C_{ox} \frac{W}{L} I_D}$$
$$\therefore \frac{W}{L} = 598.8$$

$$\text{Gain} = A_v = 5 = g_m R_D = \frac{R_D}{50}$$
$$\therefore R_D = 250\ \Omega.$$

Check saturation. V_{DS} can be at most $V_{TH} = 0.4$ below V_{GS}.

$$V_D = 1.8 - I_D R_D = 1.8 - 1.67 \times 10^{-3} \times 250$$
$$= 1.38\ V.$$
$$V_G = 1.8\ V$$
$$\therefore \text{Critical } V_D = V_G - V_{TH} = 1.4\ V.$$

V_D is just below the limit! Recommend a smaller I_D, which will require a larger $\frac{W}{L}$ to achieve the same g_m.