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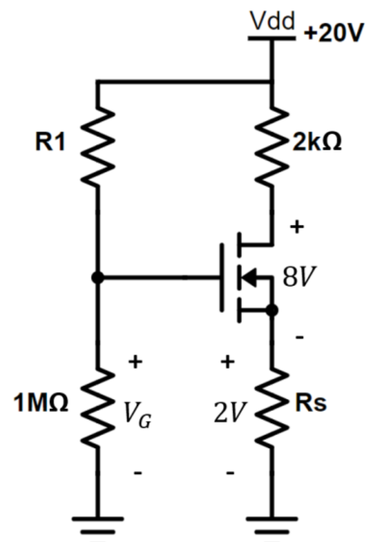
HW6

Due Thursday 6/2 at 3:00PM on Gradescope

Part 2 (Graded):

Q1. Problem 11.29

The transistor in the figure below has $KP = 50\mu A/V^2$, $W = 600\mu m$, $L = 20\mu m$, and $V_{t0} = 1V$. Determine the values of R_1 and R_s.



$$K = \frac{W}{L}\frac{KP}{2} = 0.75mA/V^2$$

$$I_D = \frac{20 - 8 - 2}{2K} = 5mA$$

$$R_S = \frac{V_S}{I_D} = \frac{2}{5mA} = 400\Omega$$

$$I_D = K(V_{GS} - V_t)^2$$

$$5 = 0.75 * (V_{GS} - 1)^2$$

$$V_{GS} = 3.58V$$

$$V_G = V_S + V_{GS} = 5.58V$$

$$V_G = 5.58 = 20 * (\frac{1M}{1M + R_1})$$

$$R_1 = 2.584M\Omega$$

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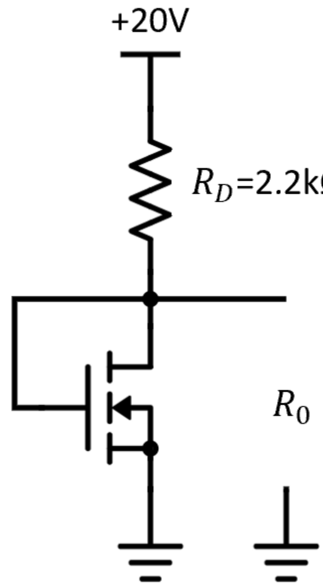
Q2. Problem 11.53

Find V_{DSQ} and I_{DQ} for the FET shown in the figure below, given $V_{t0} = 3V$ and $K = 0.5mA/V^2$. Find the value of g_m at the operating point. Draw the small-signal equivalent circuit, assuming that $r_d = \infty$ (r_d is the resistance in the small signal model due to channel length modulation, not the same as the R_D marked in the circuit). Derive an expression for the resistance R_0 in terms of R_D and g_m. Evaluate the expression for the values given.



Assume the operation point is saturation and we know $V_{GS} = V_{DS}$

$$I_D = \frac{20 - V_{GS}}{R_D} = K(V_{GS} - V_t)^2$$

$$\frac{20 - V_{GS}}{2.2K} = 0.5m(V_{GS} - 3)^2$$

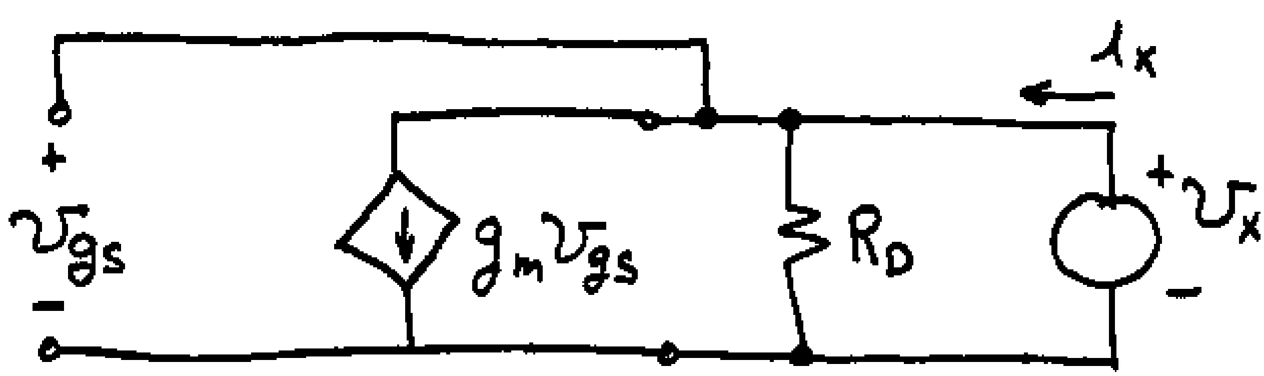
$$20 - V_{GS} = 1.1({V_{GS}}^2 - 6V_{GS} + 9)$$

$$1.1{V_{GS}}^2 - 5.6V_{GS} - 10.1 = 0$$

$$V_{GS} = 6.5V$$

$$g_m = 2K(V_{GS} - V_t) = 1m(6.5 - 3) = 3.5m$$

Draw the small signal circuit,



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$$R_0 = \frac{V_x}{I_x} = \frac{V_x}{g_m V_{GS} + \frac{V_x}{R_D}}$$

Since $V_x = V_{GS}$, $R_0 = \frac{1}{g_m + \frac{1}{R_D}} = 252.87\Omega$

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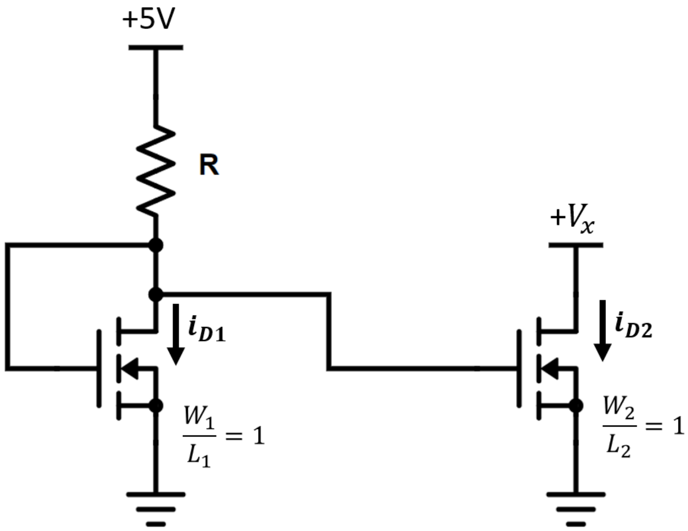
Q3. Problem 11.35

Both transistors shown in the figure below have $KP = 100\mu A/V^2$ and $V_{t0} = 0.5V$. Determine the value of R needed so that $i_{D1} = 0.2mA$. For what range of V_x is the second transistor operating in the saturation region? What is the resulting value of i_{D2}? Provided that V_x is large enough so that the second transistor operates in saturation, to what ideal circuit element is the transistor equivalent?



$$I_D = K(V_{GS} - V_t)^2 = \frac{100u}{2} * 1 * (V_{GS} - 0.5)^2 = 0.2m$$

$$V_{GS} = 2.5V$$

Hence, $R = \frac{5-V_{GS}}{I_D} = 12.5K\Omega$

To let the second transistor operate in the saturation region,

$$V_{DS} = V_X > V_{GS} - V_t = 2V$$

$$i_{D2} = K(V_{GS} - V_t)^2 = 50u * (2.5 - 0.5)^2 = 0.2mA$$

The second transistor is an ideal current source of 0.2mA.

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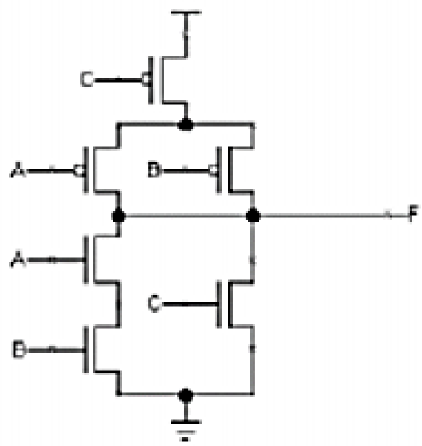
Q4. Analyze the CMOS circuit below (triode region equivalent) and fill out the "truth table" for it.



A	B	C	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0