5.79 (a) assuming $I_D = 1\ mA$, $V_S = (1\ mA)(3K\Omega) = 3V$

$V_{GS} = 2V \Rightarrow V_G = 5V$

$V_G = \left(\frac{5}{5+10}\right) 15 = 5V$ consistent

if $V_D = 7.5V$, $I_D = \frac{15 - 7.5}{7.5} = 1\ mA$ consistent

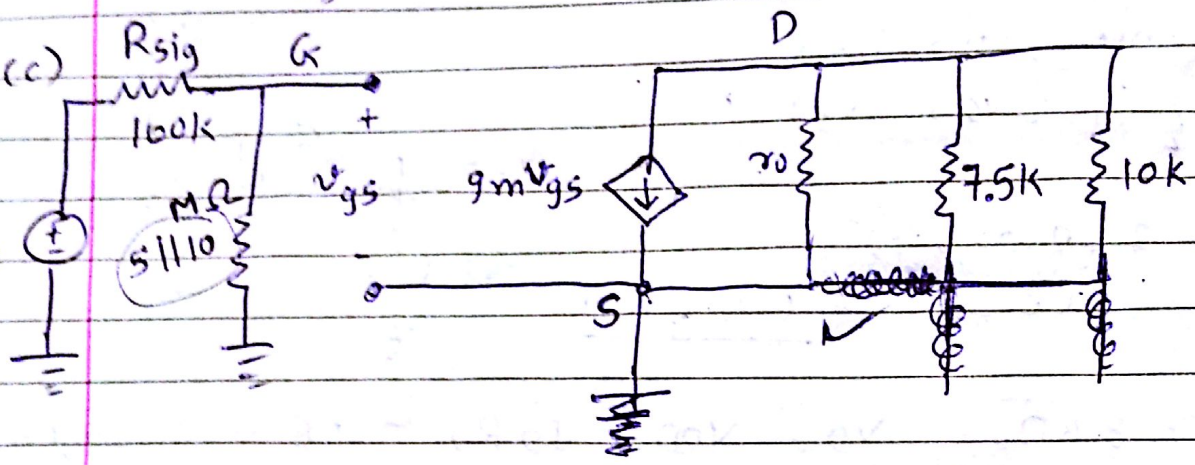
$V_{GS} > V_t$ and $V_{DS} > V_{GS} - V_t \Rightarrow$ sat^n

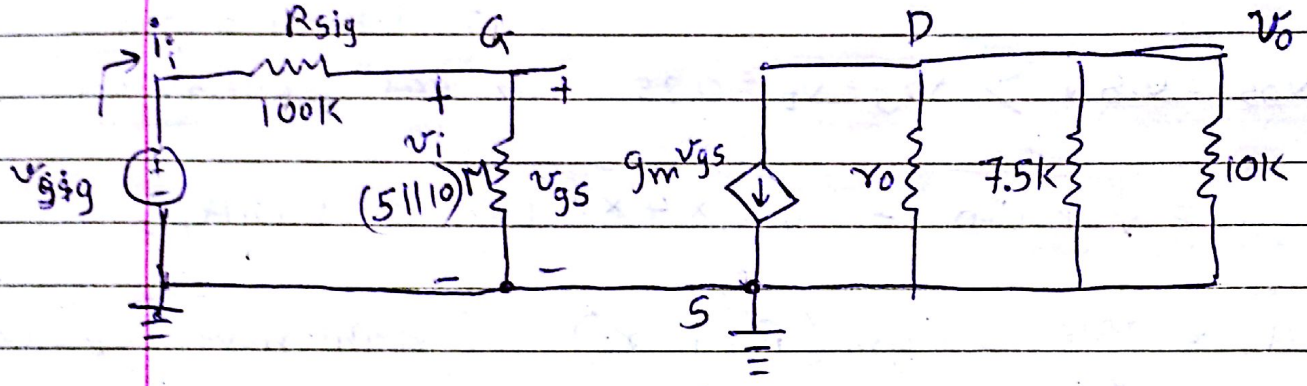
DATE:

(b) $g_m = \sqrt{2K_n I_D} = \sqrt{2(2)(1)} = 2\ mA/V$

$r_o = \frac{|VA|}{I_D} = \frac{100}{1} = \underline{100\ K\Omega}$

(c)





(d) $v_o = -g_m v_{gs} (r_o \,||\, 7.5k \,||\, 10k)$

$\frac{v_o}{v_{gs}} = -g_m (100k \,||\, 7.5k \,||\, 10k) = -2\ mA/V \quad 4.291K\Omega$

(can be ignored)

$= \underline{-8.57}$

$v_{gs} = \left[\frac{(5||10)\,M}{(5||10)M + 100k}\right] v_{sig} \Rightarrow \frac{v_{gs}}{v_{sig}} = \frac{3.33\,M}{3433\,K} = \underline{0.97}$

$\frac{v_o}{v_{sig}} = \frac{v_o}{v_{gs}} \frac{v_{gs}}{v_{sig}} = -(8.57) * (0.97) = \underline{-8.3}$

$R_{in} = \frac{v_{sig}}{i_i} = R_{sig} + (5||10)\,M = 100K + 3.33M$

$= \underline{3.433\ M\Omega}$

$R_{in} = \frac{v_i}{i_i} = (5||10)\,M\Omega = \underline{3.33\ M\Omega}$

5.113

$V_{tp} = -0.7\,V$, very large $|V_A| \Rightarrow r_o = \infty$

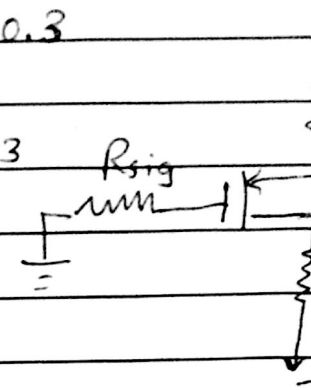
(a) $|V_{ov}| = 0.3 = |V_{GS} - V_{tp}| = 0.3$

$V_G = 0\,V \quad I_D = I_S = 0.3\,mA$

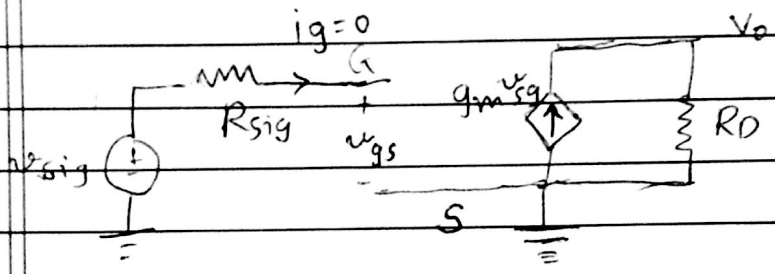
$V_S + V_{tp} = 0.3 \Rightarrow V_S - 0.7 = 0.3$

$\Rightarrow V_S = 1\,V$

$R_S = \frac{2.5 - 1}{0.3} = \frac{1.5}{0.3} = 5\,k\Omega$



(b)



$v_o = g_m v_{sg} R_D$

$v_{gs} = v_{sig}$

$v_o = -g_m v_{sig} R_D$

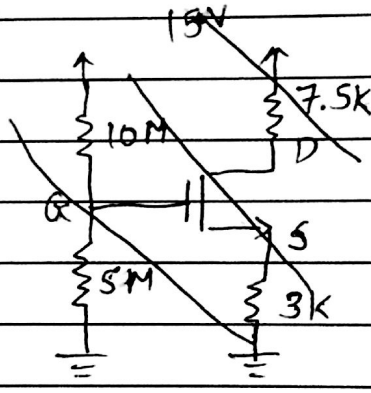
$g_m = \frac{2I_D}{V_{ov}} = \frac{2(0.3)}{0.3} = 2\,mA/V \qquad G_v = \frac{v_o}{v_{sig}} = -g_m R_D = -10\,V/V$

$2\,mA/V \; R_D = 10 \Rightarrow R_D = 5\,k\Omega$

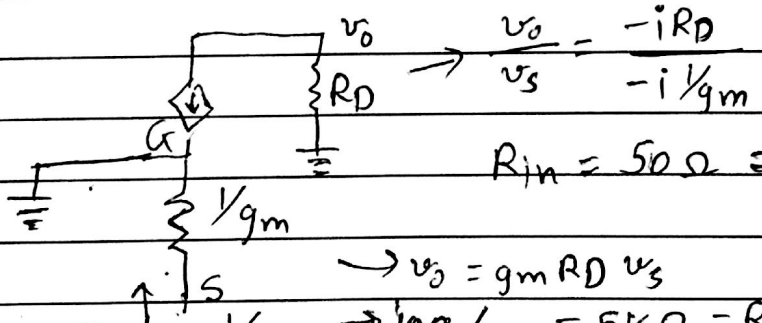
5.79

(a) $V_t = 1\,V, \; K_n = 2\,mA/V^2$

$V_G = \frac{5}{5+10}(15) = 5\,V$



5.114



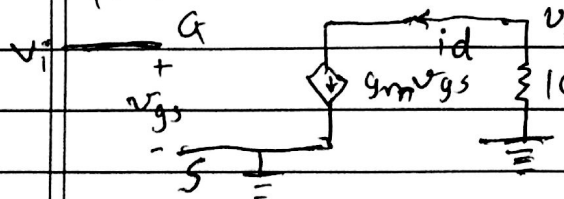
$\frac{v_o}{v_s} = \frac{-iR_D}{-i\,1/g_m}$

$\rightarrow v_o = g_m R_D v_s$

$R_{in} = 50\,\Omega = \frac{1}{g_m} \Rightarrow g_m = \frac{1}{50} = 0.02$

$R_{in} = 1/g_m \Rightarrow 100/20 = 5k\Omega = R_D \qquad g_{m2} = 20\,mA/V$

Q_1 is biased at same point as $Q_2 \Rightarrow g_{m1} = 20\,mA/V$



$id = g_m v_{gs} = g_m v_i$

$id = 20(5) = 100\,mA$

$v_{d1} = -100(id) = -10\,mV$

5.115 $I_D = 0.1\,mA = \frac{1}{2} K_n (V_{OV})^2 = \frac{1}{2}(0.8)(V_{OV})^2$

$\frac{1}{2} = 0.5 = V_{OV} = V_{GS} - V_t = V_{GS} - 1 \Rightarrow V_{GS} = 1.5\,V$

$V_G = 0 \Rightarrow V_S = -1.5\,V$

$\frac{V_S + 5}{I_S} = R_S = \frac{-1.5 + 5}{0.1} = 35\,k\Omega$

$R_{in} = R_G = 10\,M\Omega$

$v_{DS} \geq V_{OV} = 0.5$ ±1 Swing at V_D so $V_{DS} \geq 1.5$

$\frac{5 - V_D}{I_D} = R_D = \frac{5 - 1.5}{0.1} = 35\,k\Omega$

$v_{DS_{min}} = V_{DS} \pm v_{ds} = V_{DS} - v_{d_{max}} \geq 0.5$

$$V_{DS} = V_D - V_S = 5 - I_D R_D - (I_D R_S - 5)$$
$$= 10 - I_D (R_D + R_S)$$

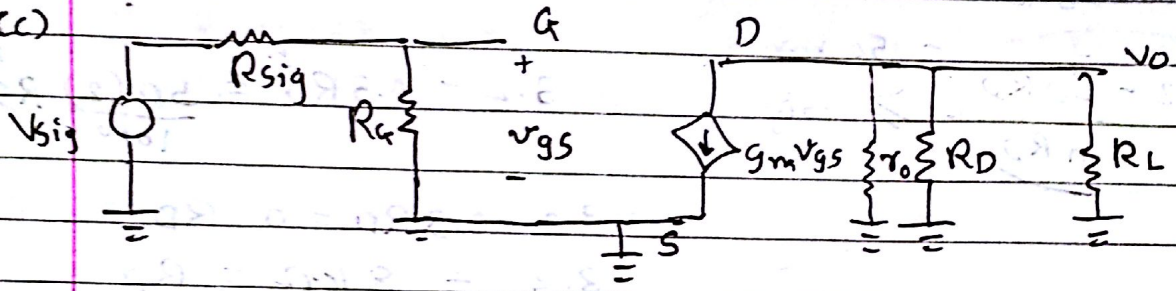
$$10 - I_D (R_D + R_S) - \frac{1}{2} v_{d\,max} \geq 0.5$$

$$8.5 \geq I_D (R_D + R_S) \Rightarrow 85\,K - R_S \geq R_D$$
$$\Rightarrow \underline{R_D \leq 50\,K\Omega}$$

(b) $g_m = \sqrt{2 K_n I_D} = \sqrt{2(0.8)(0.1)} = \underline{0.4\ mA/V}$

$$r_o = \frac{V_A}{I_D} = \frac{40}{0.1} = \underline{400\,K\Omega}$$

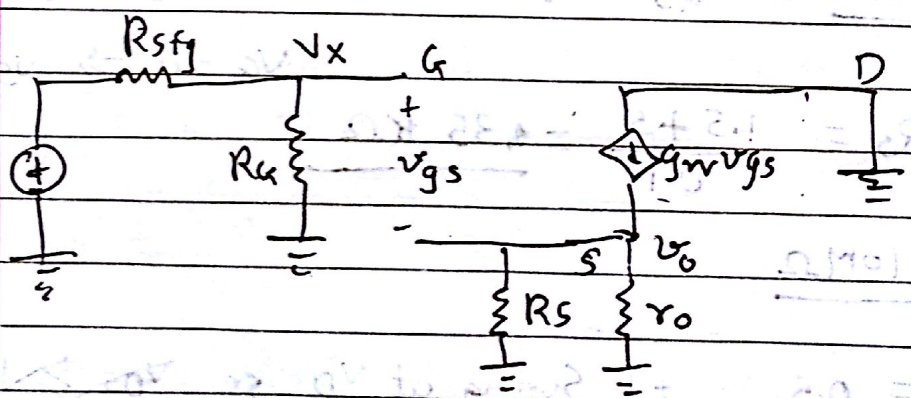
(c)



$$v_o = -g_m v_{gs} (R_D \,||\, R_L) \qquad v_{gs} = \frac{R_G}{R_G + R_{sig}} v_{sig}$$

$$\frac{v_o}{v_{sig}} = \frac{-g_m (R_D \,||\, R_L \,||\, r_o) R_G}{R_G + R_{sig}} = \frac{-0.4\,(40K \,||\, 50K \,||\, 400K)(10\,M)}{1M + 10M}$$
$$= \underline{-8.08} \quad \underline{-7.66}$$

(d)



$$v_o = g_m v_{gs} (R_S \,||\, r_o)$$

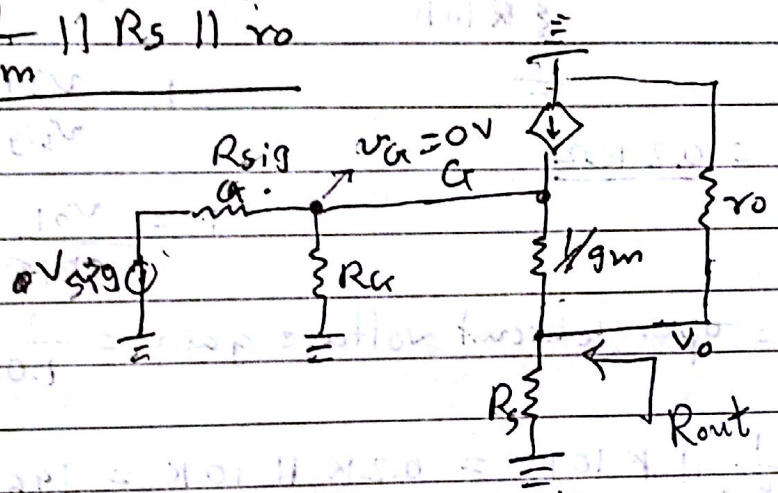
$$\frac{v_o}{v_{sig}} = g_m (R_S \,||\, r_o) \frac{R_G}{R_G + R_{sig}}$$

$$v_{gs} = v_x - v_o = v_x - g_m v_{gs} (R_S \,||\, r_o)$$
$$v_x = v_{gs} \left(1 + g_m (R_S \,||\, r_o)\right)$$

$$\frac{v_o}{v_x} = \frac{g_m(R_S \| r_o)}{1 + g_m(R_S \| r_o)} = 0.4\,\frac{(400K \| 35K)}{1 + 0.4(400K \| 35K)}$$

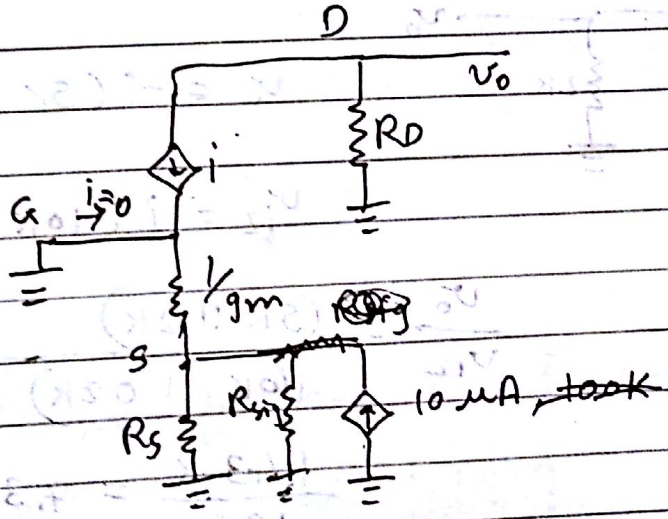
$$= 0.93$$

$$R_o = \frac{1}{g_m} \| R_S \| r_o$$



$$R_o = 35K \| 400K \| 2.5K \approx 2.5K$$

(c)



$v_o = -iR_D$

~~$v_S = i_S R_S = (10)(100K)(\mu)$~~

$= 1V$

$v_S = i \, 1/g_m$

$i = v_S g_m$

$= 0.4$ mA

$v_o = -0.4(50K) = -20$ V

$R_{in} = R_S \| 1/g_m$

$= 35K \| 2.5K \approx 2.5K$

$R_{in} \| R_{sig} = 2.5 \| 100$

$\approx 2.5K$

$v_S = (10\,\mu A)(2.5K) = 25$ mV $\Rightarrow$ $i = v_S g_m$

$= 25(0.4)$

$= 10\,\mu A$

$v_o = -(10\,\mu A)(50K) = -0.5$ V

↑ peak of voltage signal at Y