

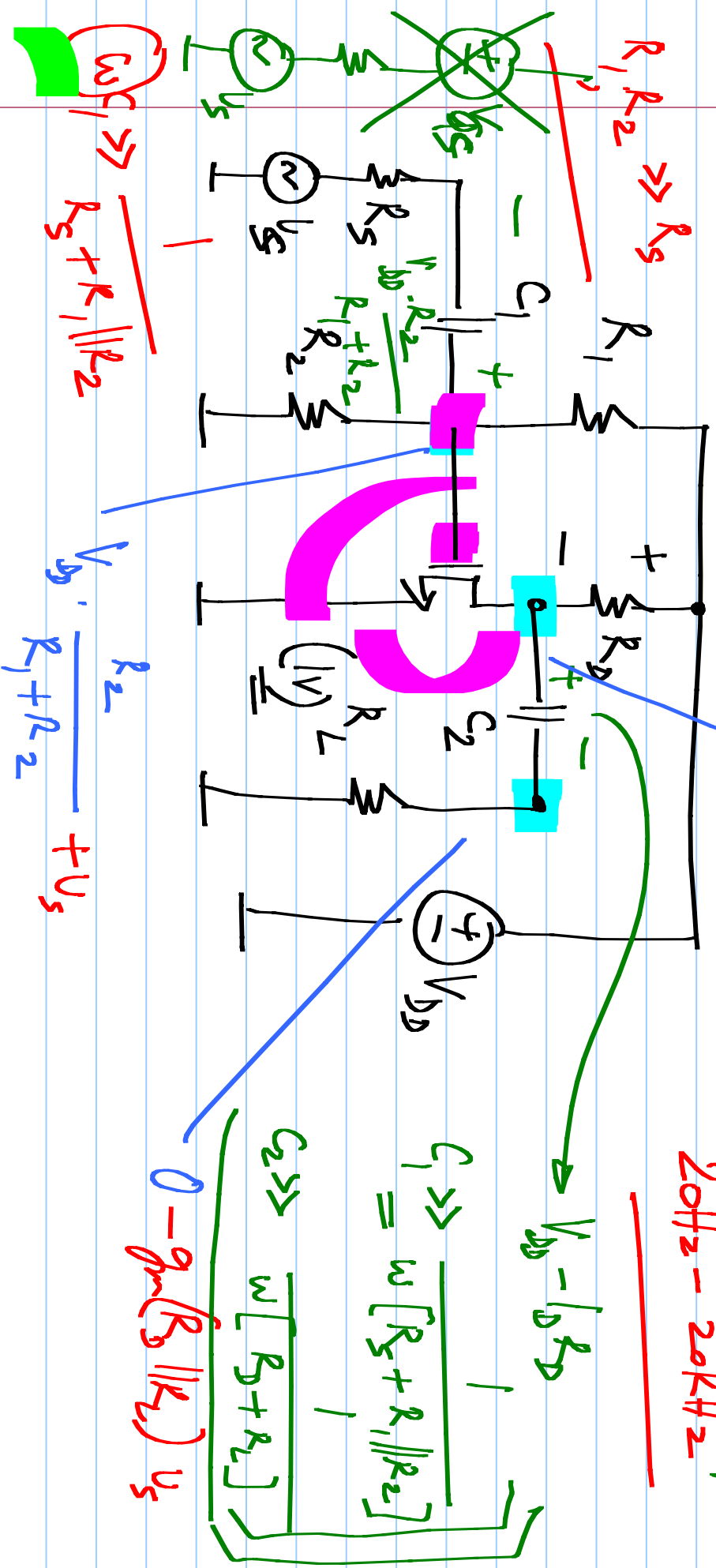
Lecture 6

$\omega C_2 \gg \frac{1}{R_D + R_L}$

$V_{DD} - I_D R_D - g_m (R_D || R_L) v_s$

$\frac{1}{f}$

20Hz - 20kHz



$\omega C_1 \gg \frac{1}{R_S + R_1 || R_2}$

$V_{gs} = \frac{R_2}{R_1 + R_2} + v_s$

$C_1 \gg \frac{1}{\omega [R_S + R_1 || R_2]}$
 $C_2 \gg \frac{1}{\omega [R_D || R_L]}$
 $0 - g_m (R_D || R_L) v_s$

$$(-g_m R_L) \rightarrow \frac{-g_m (R_B \parallel R_L)}{R_D = 20k\Omega, R_L = 20k\Omega} \approx -g_m R_L$$

$R_B = 200k\Omega$

$$[-4] \xrightarrow{200\mu S} \underline{\underline{-2}} \Rightarrow 20k\Omega$$

$$\underline{V_{GS} = 1.5V}$$

$$R_D \uparrow 4k\Omega, V_{DD} \rightarrow 6V$$

$$R_D = 200k\Omega, -V_{GS} \rightarrow 2.2V \approx -g_m R_L$$

$$I_D \cdot R_D = 20V \quad R_D \gg R_L$$

$$100\mu A$$

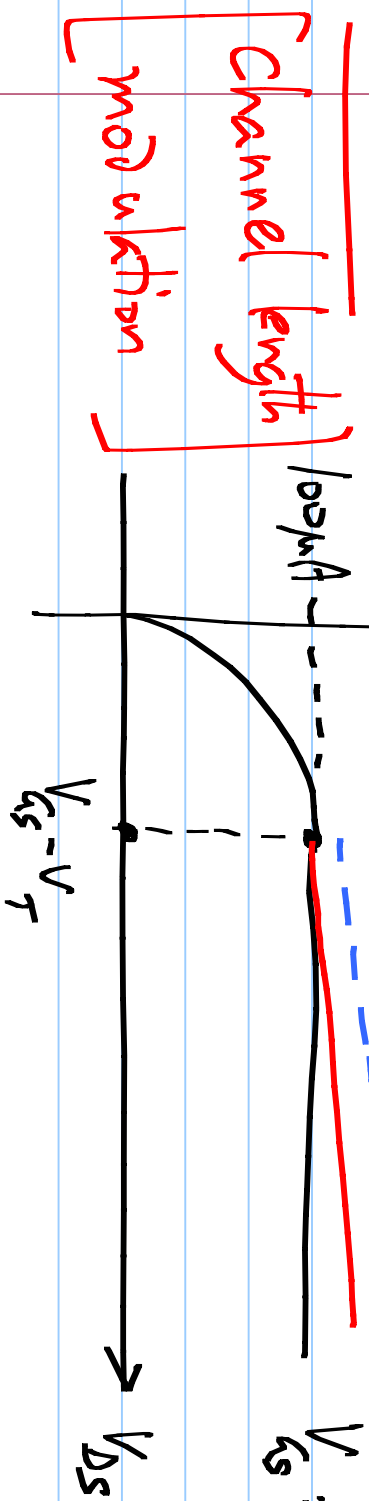
$$R_1 : R_2 = 20.5 : 1.5$$

$$I_D = 0 \quad V_{GS} \leq V_T$$

$$\mu_n C_{ox} \frac{W}{L} \left[(V_{GS} - V_T) V_{DS} - \frac{V_{DS}^2}{2} \right]$$

$$\mu_n C_{ox} \frac{W}{2L} (V_{GS} - V_T)^2 (1 + \lambda V_{DS})$$

$$\lambda = 0.01 \text{ V}^{-1}$$



Channel length

modulation

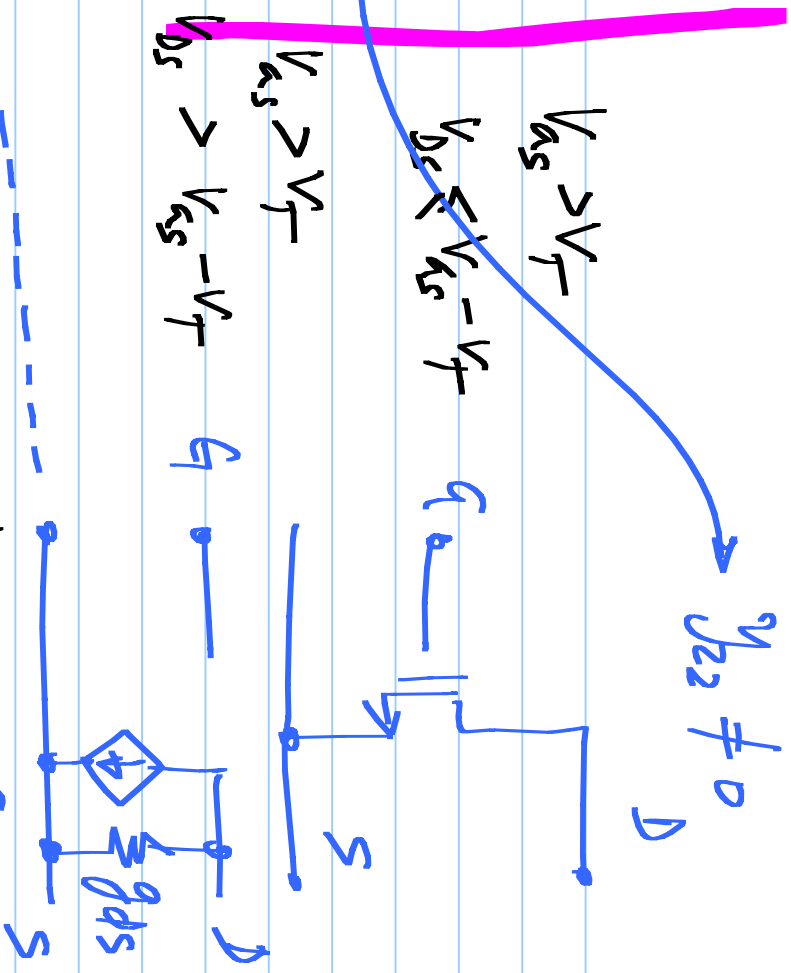
$V_{GS} > V_T$

$V_{DS} \leq V_{GS} - V_T$

$V_{GS} > V_T$

$V_{DS} > V_{GS} - V_T$

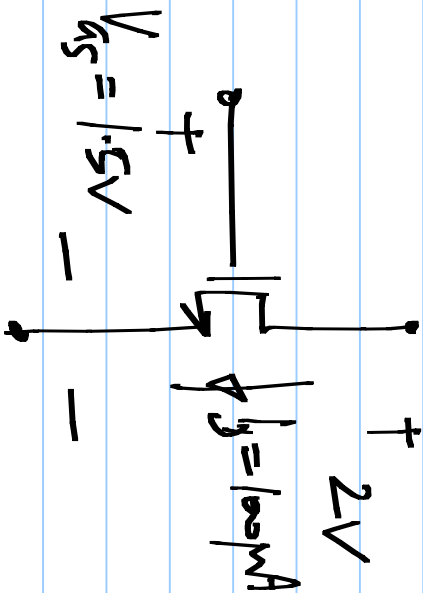
$$g_{m2} \neq 0$$



$$V_{GS} = 1.5 \text{ V} \quad \mu_n C_{ox}$$

$$g_m = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)$$

$$\lambda = 0.01 \text{ V}^{-1}$$



$$g_{ds} =$$

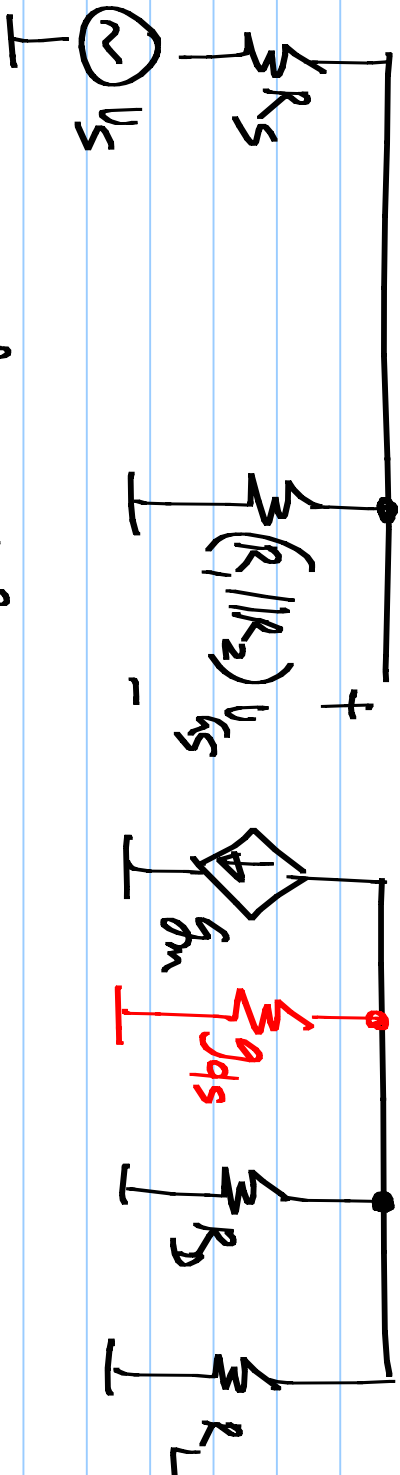
usually ignored
while calculating

$$I_D = \mu_n C_{ox} \frac{W}{2L} (V_{GS} - V_T)^2 (1 + \lambda V_{DS})$$

$$\frac{\partial I_D}{\partial V_{GS}} = \mu_n C_{ox} \frac{W}{2L} (V_{GS} - V_T) \cdot \lambda$$

$$\approx \lambda I_D = 1 \mu\text{S}$$

$$r_{ds} = 1/g_{ds}$$



$$R_1, R_2 \gg R_S$$

$$R_D \gg R_L$$

$$-g_m (V_{ds} \parallel R_L)$$

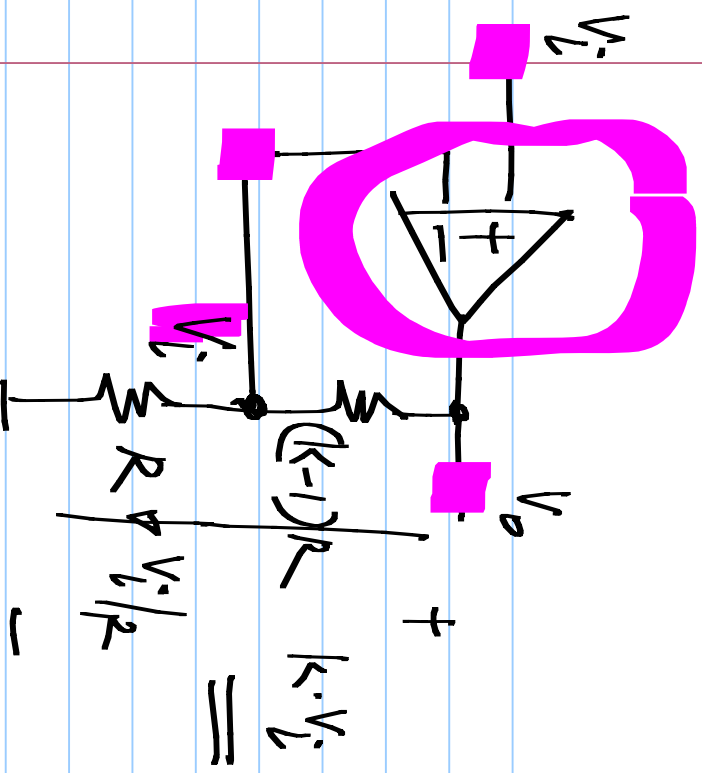
$$R_L \rightarrow \infty$$

$$\underline{-g_m r_{ds}}$$

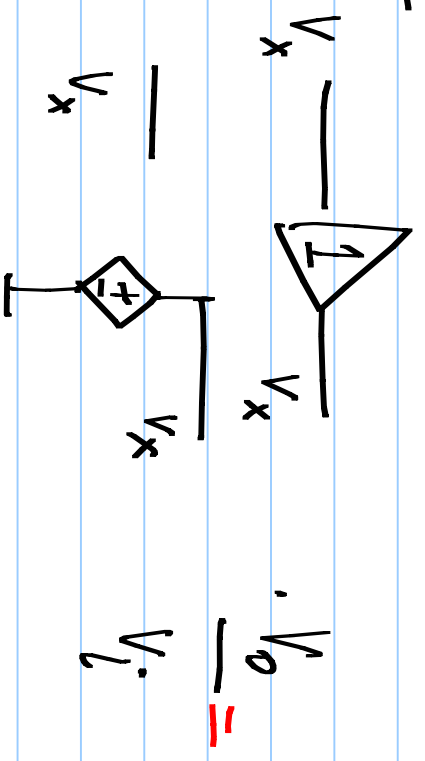
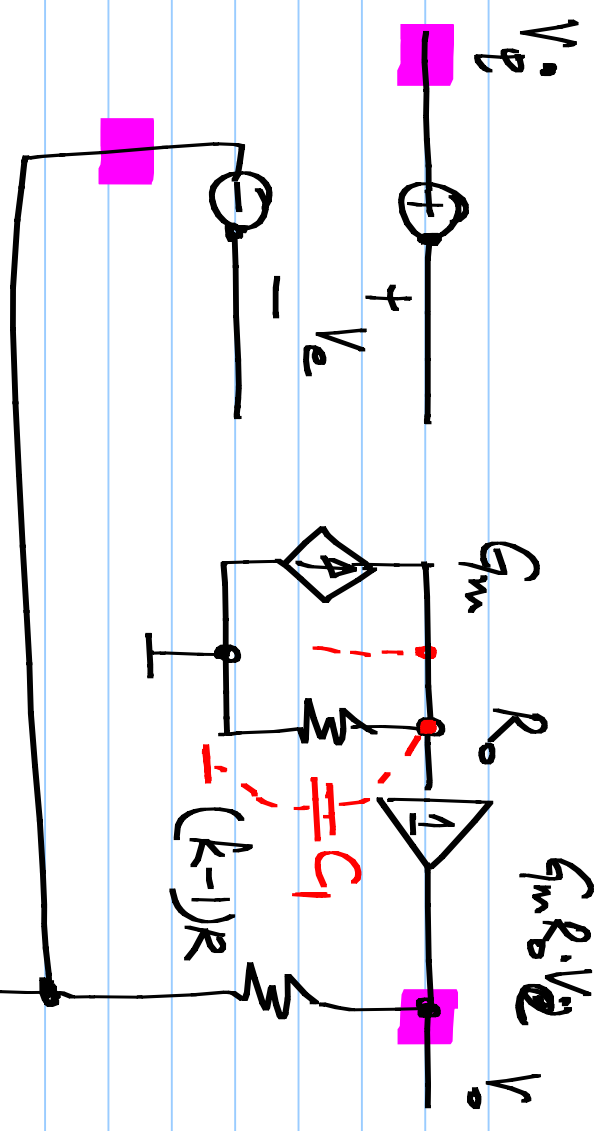
$$\underline{200 \mu S \cdot 1 M \Omega = 200}$$

* Inherent gain of the MOS transistor limited to $g_m r_{ds}$ (~ 10 in modern processes)

* Need to implement large gains (e.g. opamp)



$$\frac{V_o}{V_L} = k$$



$$R_o = \frac{V_o}{V_x}$$