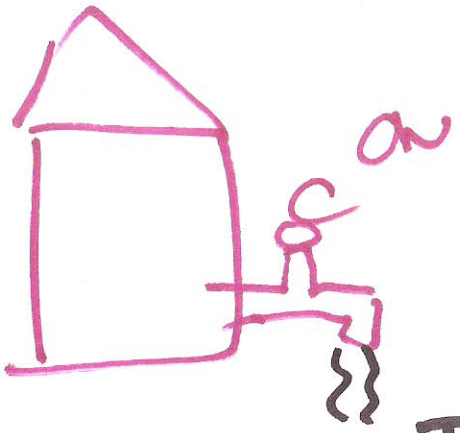
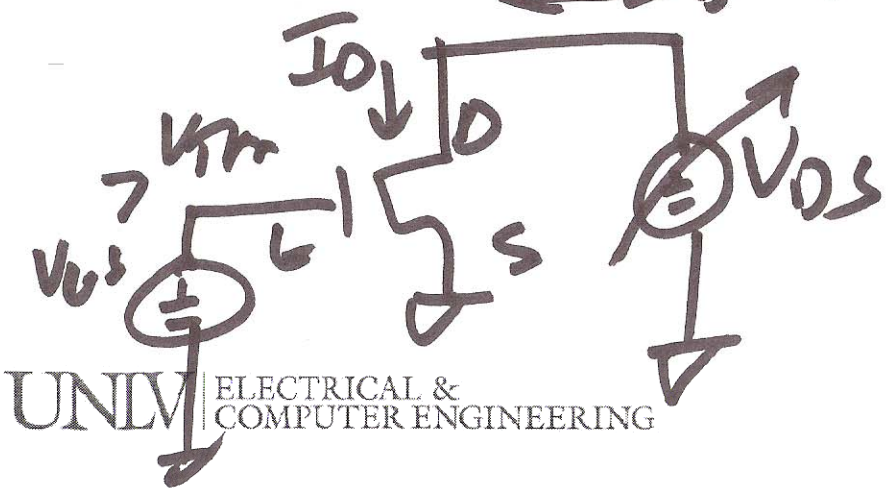
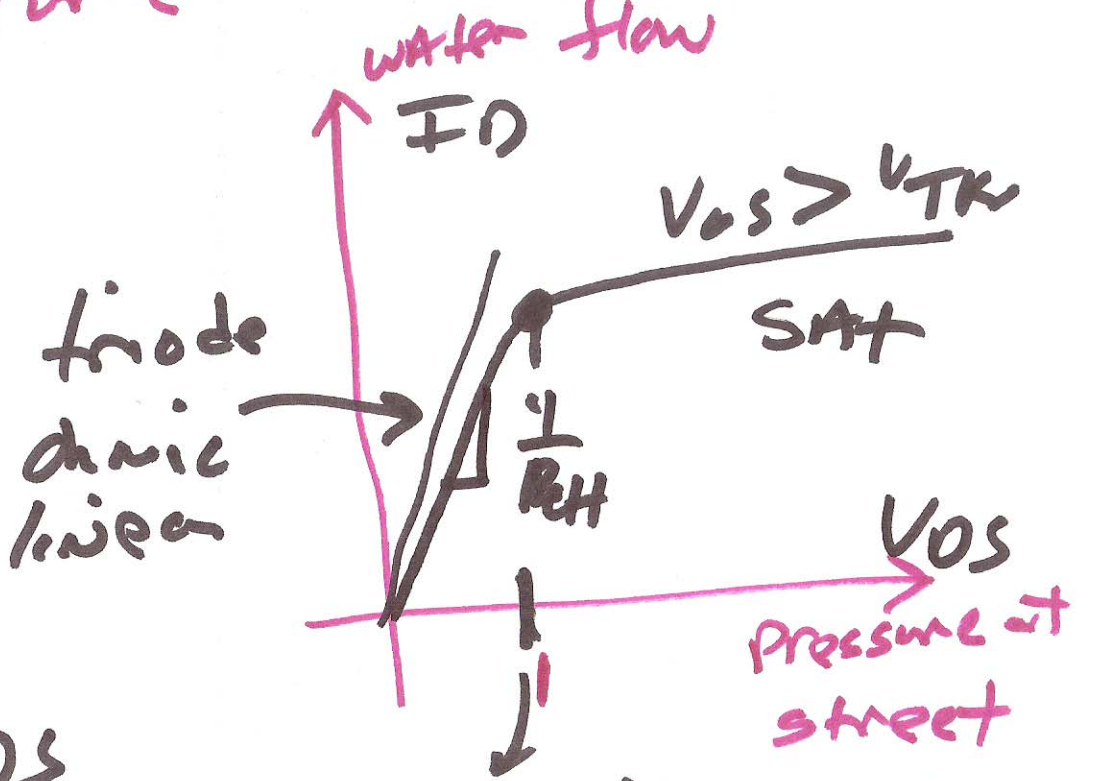
EE 320 Electronics I

MARCH 23, 2015

Lecture 18



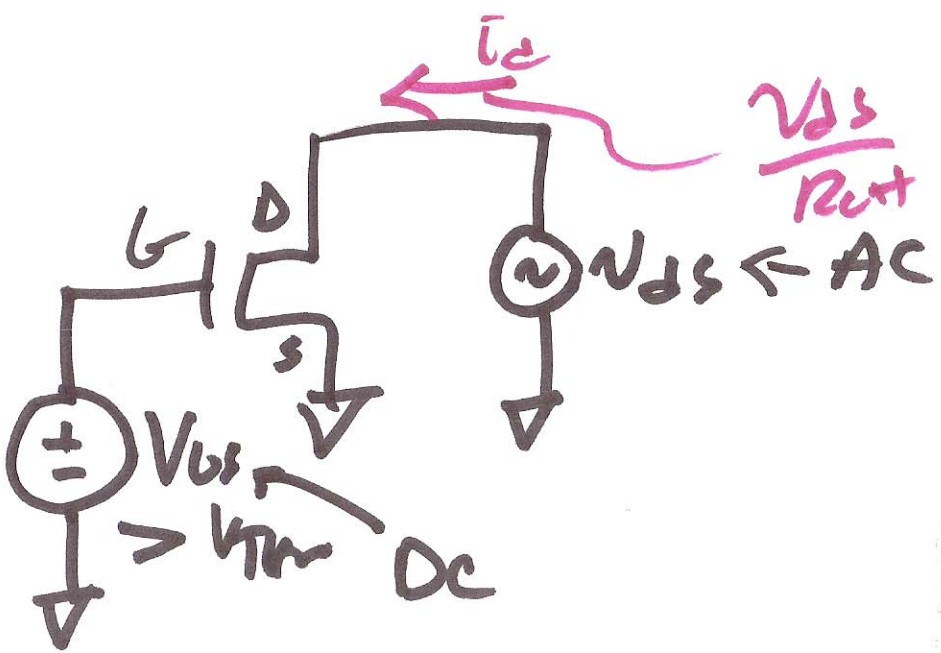


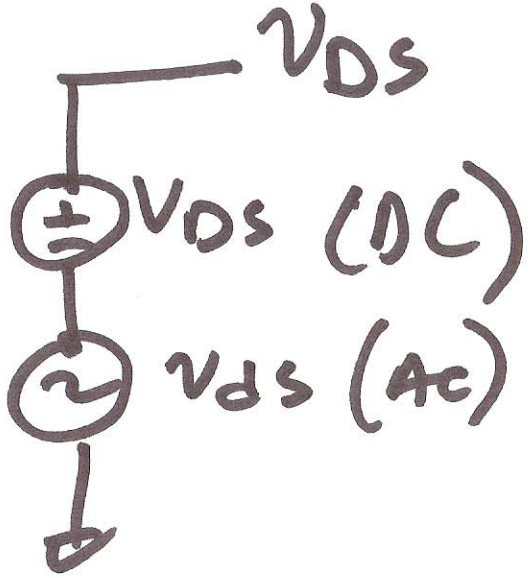


$V_{DS} - V_{THN} = V_{DS,SAT}$

2 1 $= V_{OV,N}$

1)





for SAT $K_N = K_N' \cdot \frac{W}{L}$

$$I_D = \frac{K_N}{2}(V_{GS} - V_{THN})^2$$

$$V_{GS} > V_{THN}$$

$$V_{DS} \geq V_{GS} - V_{THN} \quad \text{(SAT)}$$

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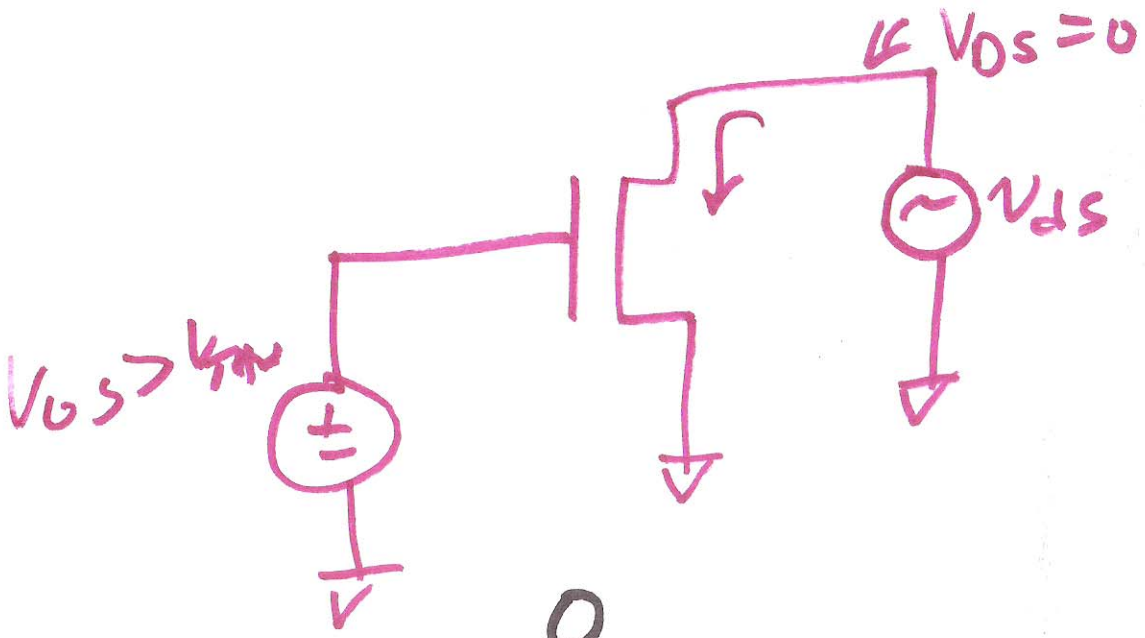
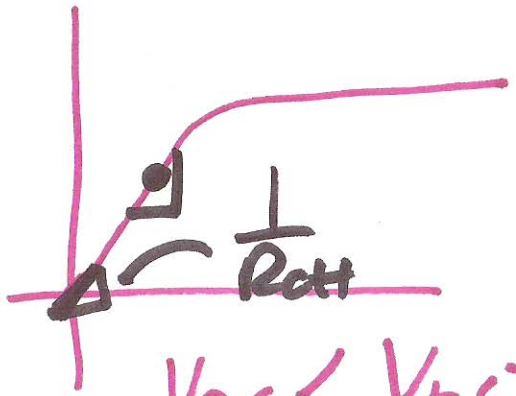
for triode

$$I_D = K_N\left((V_{GS} - V_{THN})V_{DS} - \frac{V_{DS}^2}{2}\right)$$

$$V_{GS} > V_{THN}$$

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





$V_{DS} < V_{GS} - V_{THN}$

$$I_D + i_d = k_N\left((V_{GS}-V_{THN})\left(V_{DS}+v_{ds}\right) - \frac{\left(V_{DS}+v_{ds}\right)^2}{2}\right)$$

$$\frac{1}{R_{ch}} = \frac{\delta i_d}{\delta v_{ds}}\Bigg|_{\substack{I_D=\text{const} \\ V_{GS}=\text{const}}} = \frac{\delta}{\delta v_{ds}}\left(k_N\left((V_{GS}-V_{THN})v_{ds} - \frac{v_{ds}^2}{2}\right)\right)$$

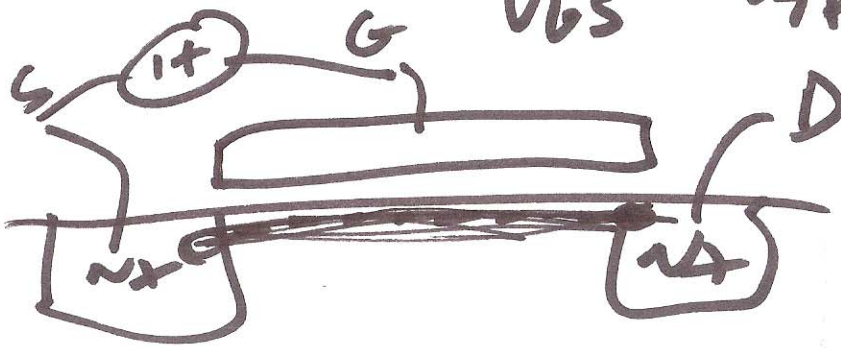
$$= k_N\left(V_{GS}-V_{THN}-v_{ds}\right)$$

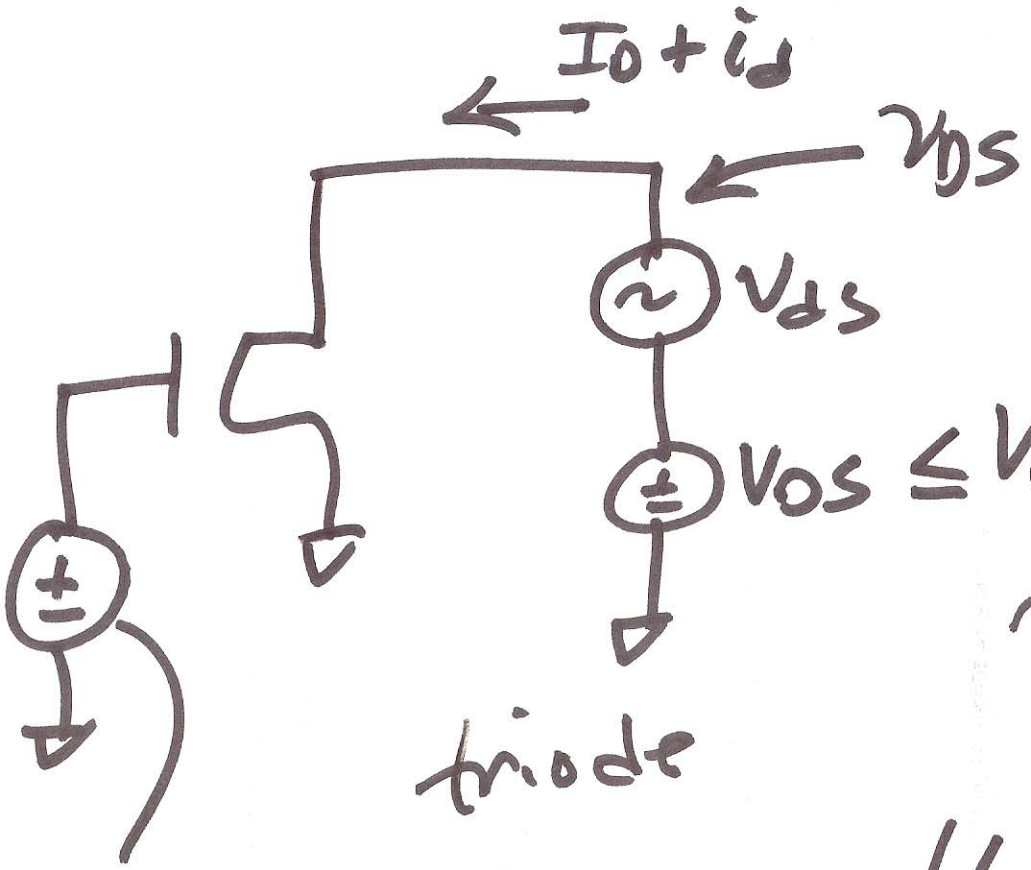
$$\rightarrow R_{CH} = \frac{1}{V_{GS} - V_{THN} - V_{DS}} \simeq \frac{1}{k_n (V_{GS} - V_{THN})}$$

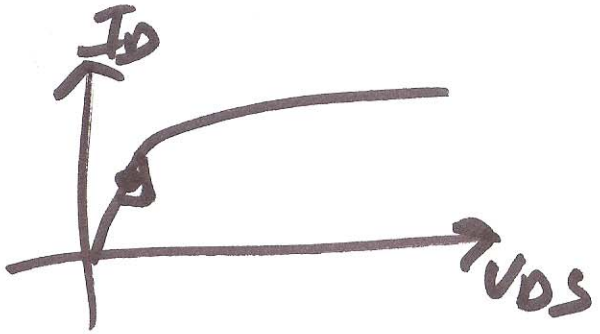
$V_{GS} - V_{THN} \gg V_{DS}$

$= V_{DS,SAT}$

Small-Signal Approx.







$$v_{DS} = v_{ds} + V_{DS}$$

$$V_{DS} > V_{THN} \quad I_D + i_d = K_N\left((V_{GS} - V_{THN})\, v_{DS} - \frac{v_{DS}^2}{2}\right)$$

$$i_D = DC + AC$$

$$\frac{1}{R_{ch}} = \frac{\delta i_D}{\delta v_{DS}}\Bigg|_{\substack{I_D = CONST \\ V_{DS} = CONST}} = K_N\left((V_{GS} - V_{THN}) - v_{DS}\right)$$

$$R_{cH} = \frac{1}{K_N\left((V_{GS}-V_{THN}) - \underbrace{(V_{DS}+V_{dS})}_{V_{DS}}\right)}$$

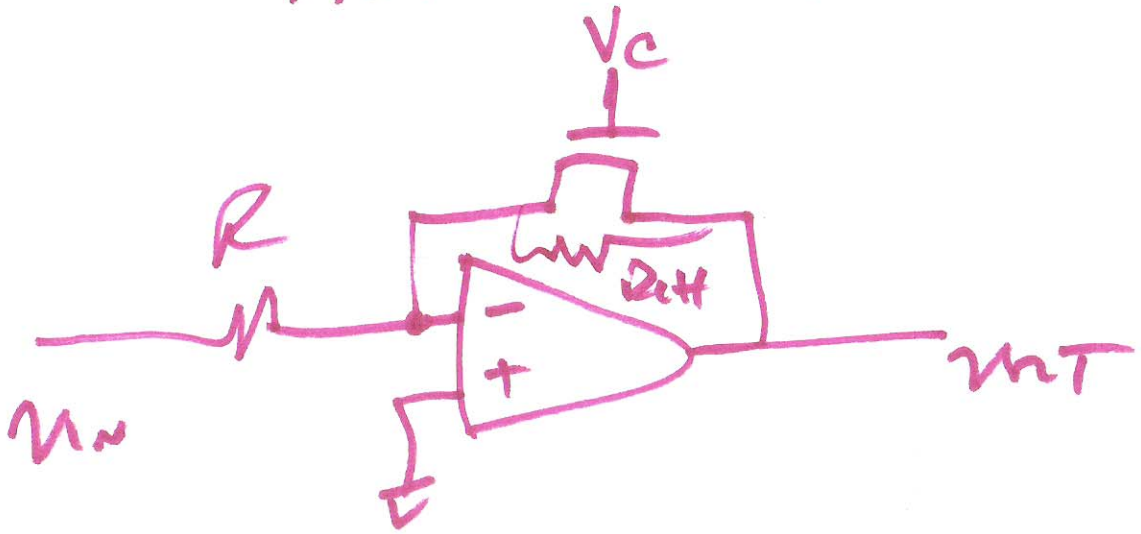
$$V_{DS} \gg V_{dS}$$

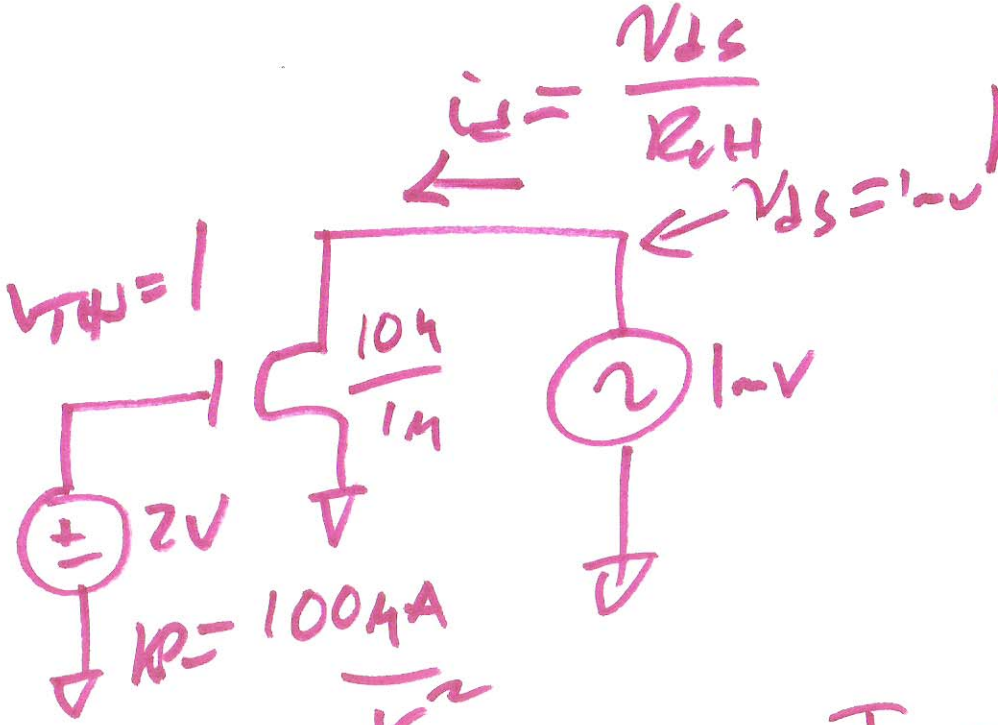
$$R_{cH} = \frac{1}{K_N\left((V_{GS}-V_{THN}) - V_{DS}\right)}$$

if $V_{GS} - V_{THN} \gg V_{DS}$

$$R_{cH} \simeq \frac{1}{K_N(V_{GS}-V_{THN})}$$

Automatic Gain Control





$K_N' = 100\frac{\mu A}{V^2} = K_P$

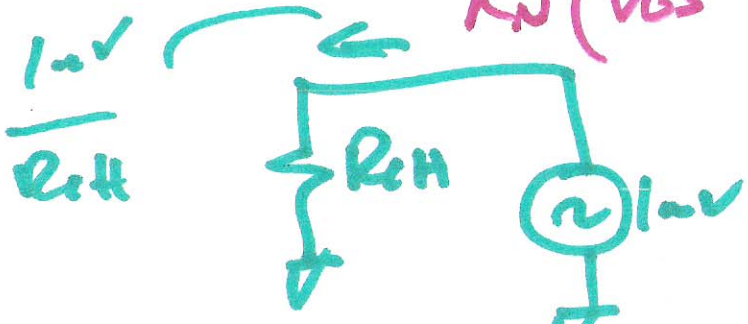
$K_N = K_N' \frac{W}{L} = K_P \cdot \frac{W}{L}$

$= 1mA/V^2$

$I_D = 0$

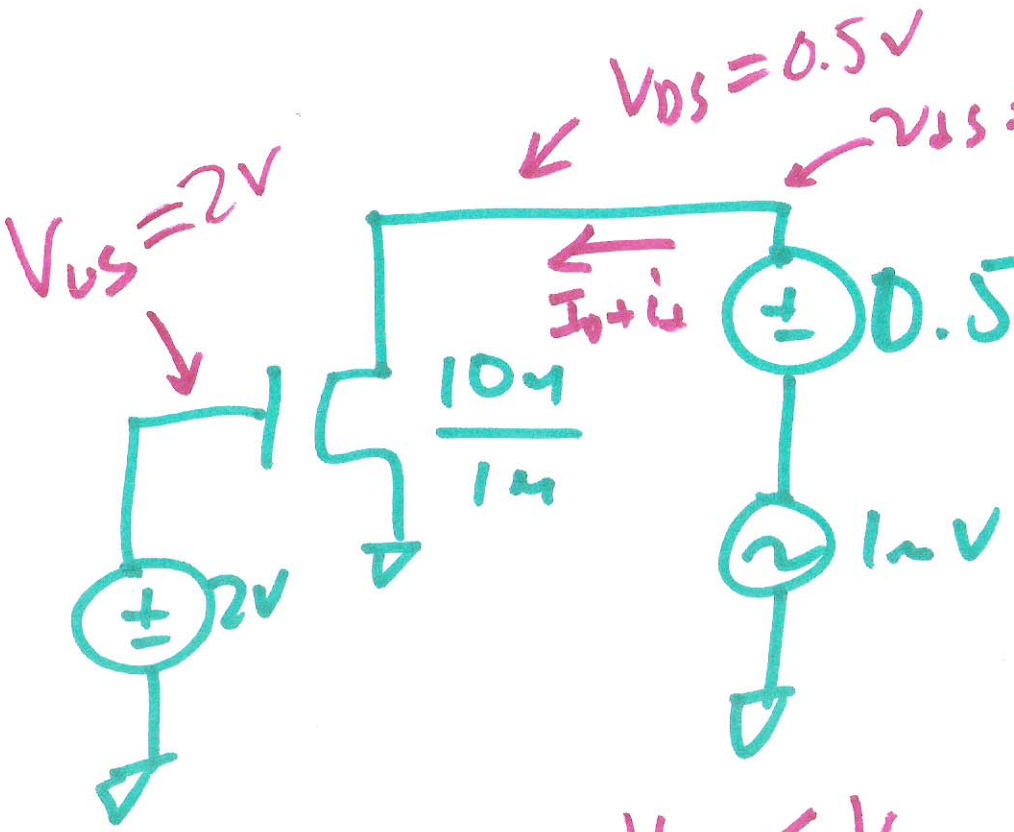
$R_{DH} = \frac{1}{K_N(V_{GS} - V_{TN})} = \frac{1}{1mA} = 1K$

$\frac{10^{-3}}{10^3} \cdot \frac{10^{-3}}{10^{-3}}$



$i_d = \frac{1mV}{1K} = 1\mu A$

8)



Verify in triode

$$I_D = \frac{1mA}{V^2}\left((2-1)\frac{1}{2} - \left(\frac{1}{2}\right)^2\right)$$

$$= 1mA\left(\frac{1}{2} - .125\right)$$

$$= .375mA$$

$$V_{DS} \le V_{GS} - V_{THN}$$

$$\frac{1}{2} \overset{?}{\le} 2-1$$

$$\frac{1}{2} \le 1$$

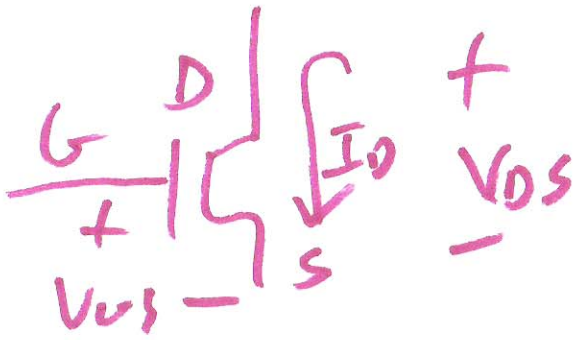
Yes

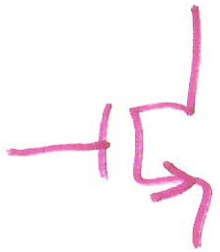
$$R_{eff} = \frac{1}{\frac{1mA}{V^2}\left((2-1) - \frac{1}{2}\right)}$$

$$\frac{1mV}{I_D} = 2k$$

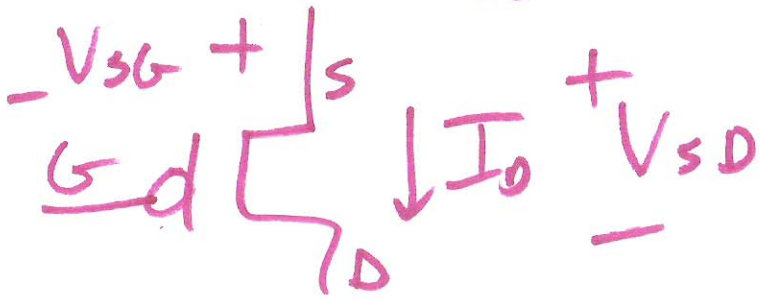
$$I_D = \frac{1mV}{2k} = \frac{1}{2}mA$$

NMOS





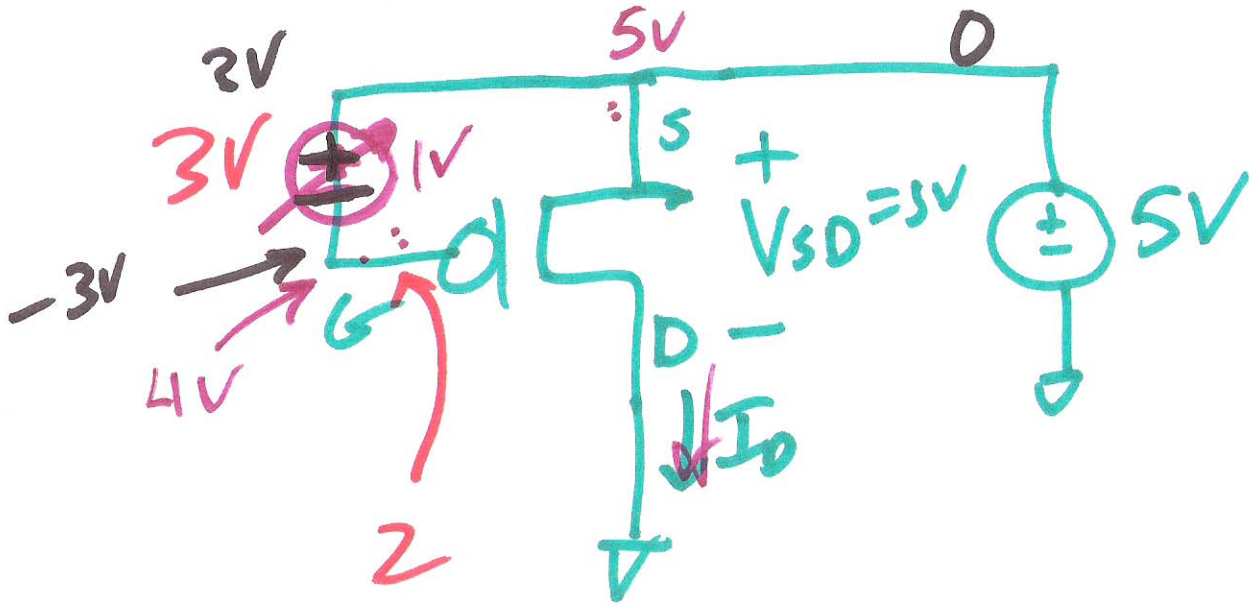
PMOS $V_{TO} = -1$



$$I_D = \frac{K_P}{2}\left(V_{SG} - V_{THP}\right)^2$$

$V_{SG} > V_{THP}$ SAT

$V_{SD} \geq V_{SG} - V_{THP}$



$V_{SG} = V_S - V_G$

$= 1$

$5 - 4$

$I_D = \frac{k_p}{2}(V_{SG} - V_{TH})^2$