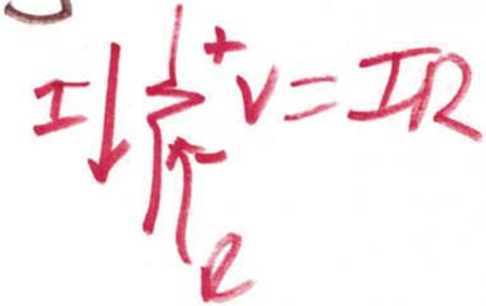
EE 420/ECG 620

Analog IC Design

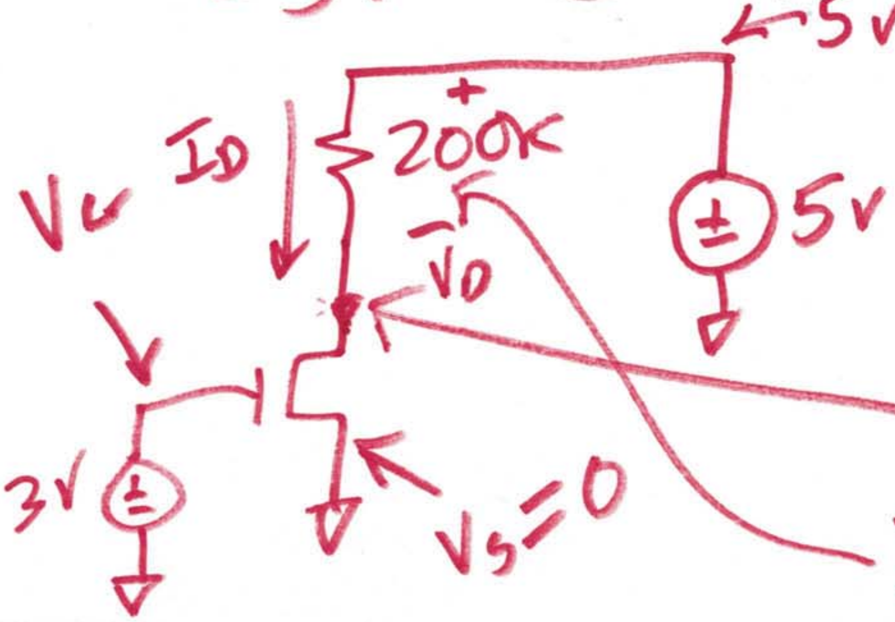
Jan. 26, 2016

Lecture 3



$V_G - V_S = V_{GS}$
$= 3V$

$V_{GS} = 3V$

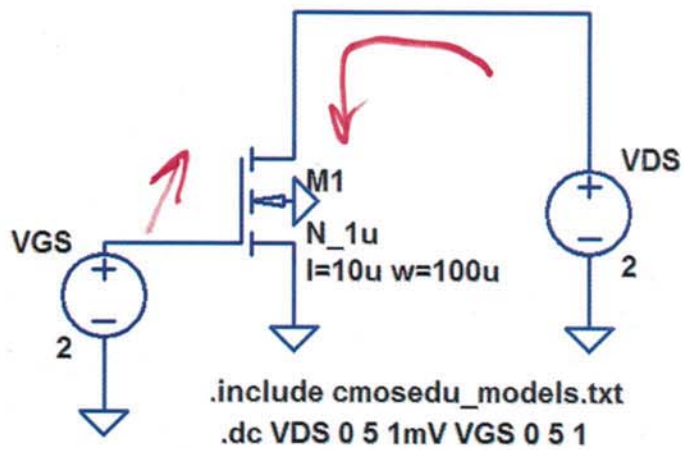


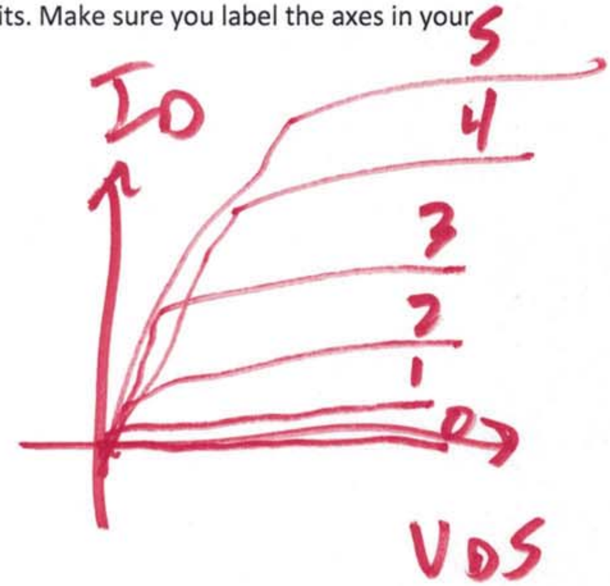
$5 - I_D \cdot 200K = V_{DS} = V_D - V_S$

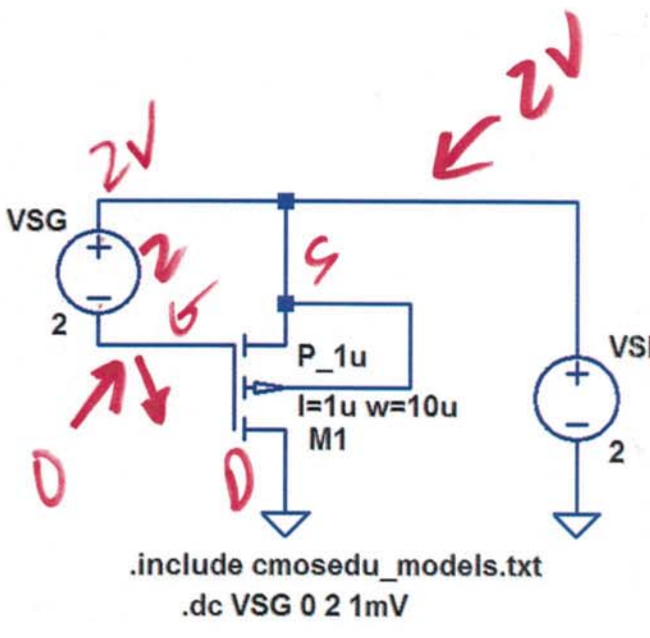
$I_D \cdot 200K$

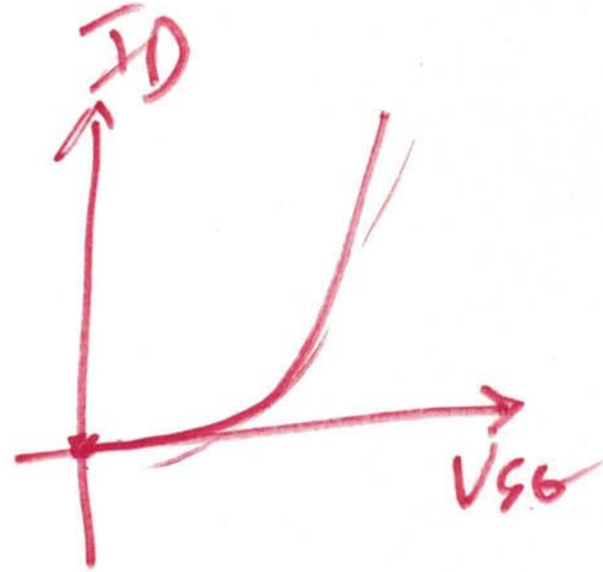
Quiz 2 EE 420/ECG 620 Analog, Spring 2016 Name: ______________________
Closed book and closed notes.
Show your work for credit.

1. Sketch the current that flows in each of the following circuits. Make sure you label the axes in your plot. (6 points)

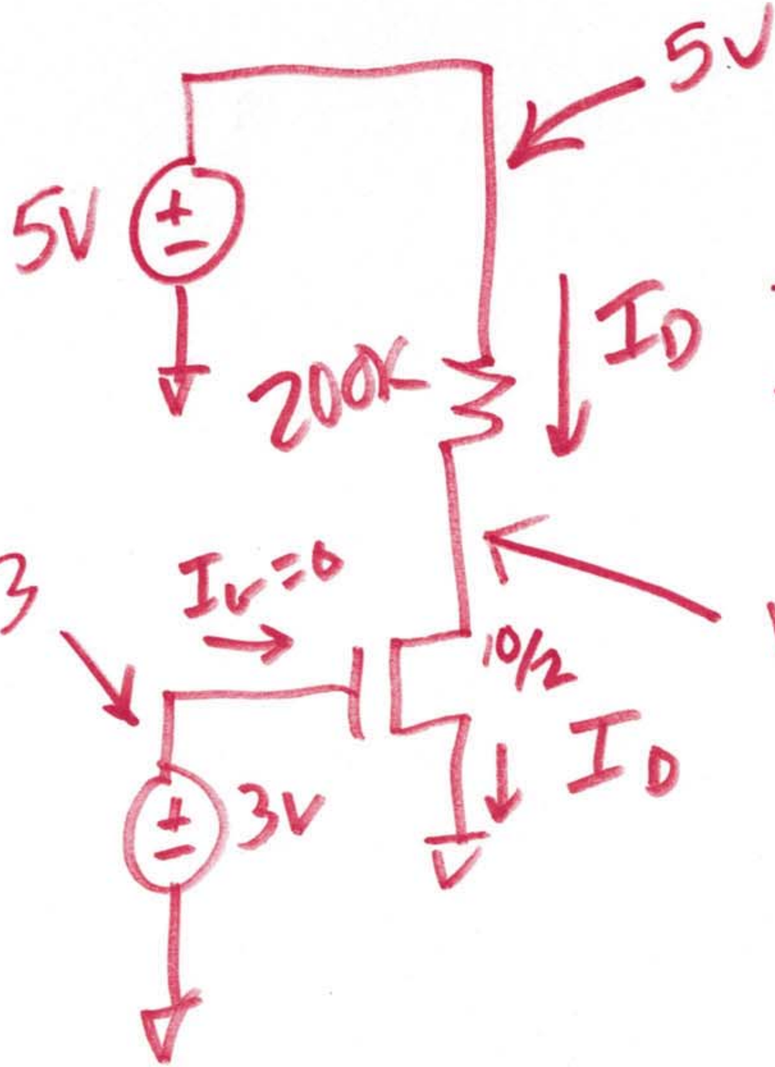








2)



$V_{THN} = 0.8V$

$KP = 120 \frac{\mu A}{V^2}$

$+\ 200k \cdot 1.45mA\ -$

290V!

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

$3 > 0.8$ yes!

$V_{DS} = 5 - 200k \cdot I_D$

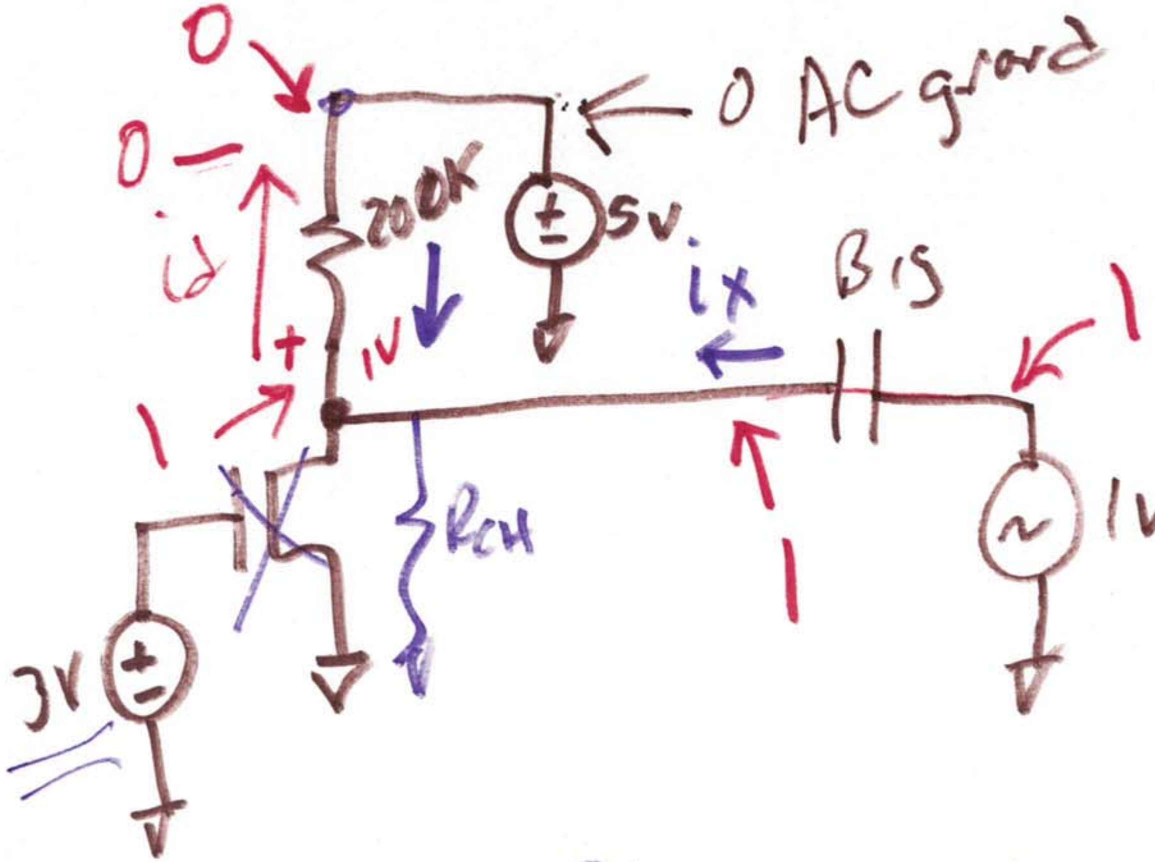
$V_{DS} \geq V_{GS} - V_{THN} =$

$V_{DS} \geq \underline{\underline{2.2V}}$??

$$I_D = \frac{KP}{2} \cdot \frac{W}{L} \left(V_{GS} - V_{THN}\right)^2$$

NOT in SAT! $= 60\mu \cdot 5 \cdot (2.2)^2$

$= \underline{\underline{1.45mA}}$



$$i_d = \frac{1V}{200K} = 5\mu A$$

AC

i_x

$+ I_x$

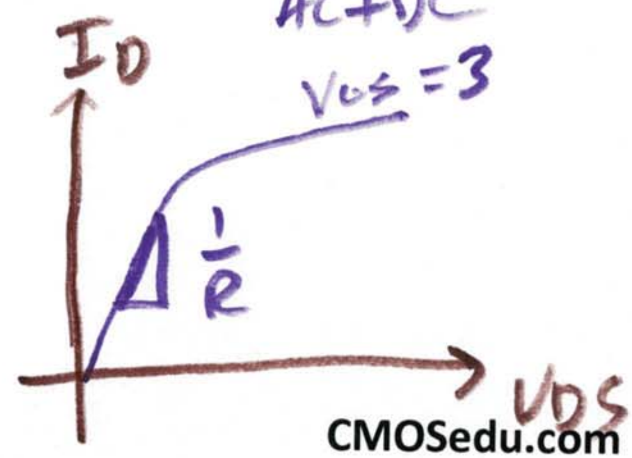
DC

$$\frac{v}{R} = \frac{0-1}{R} = i = -5\mu$$

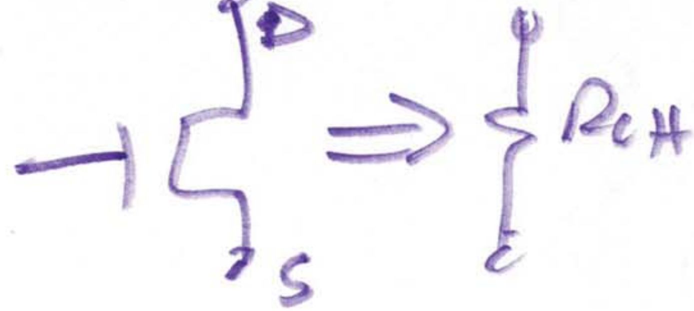
200k

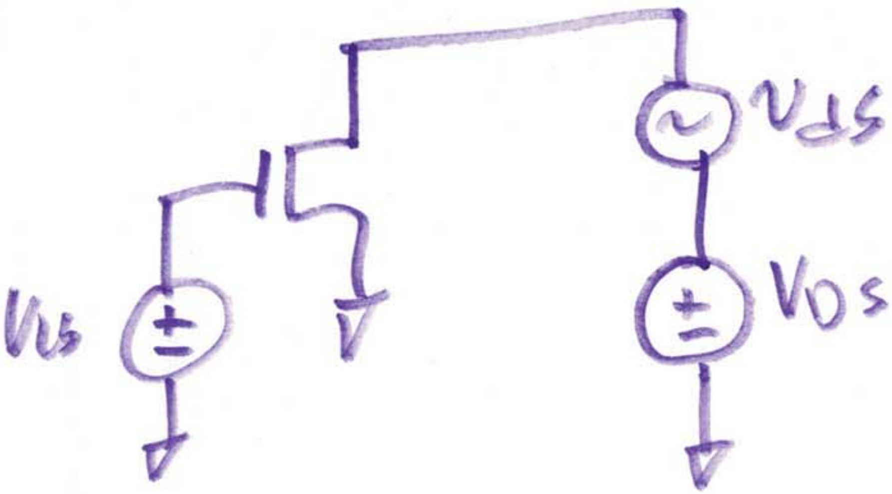
$$i_X = I_x + i_x$$

AC+DC

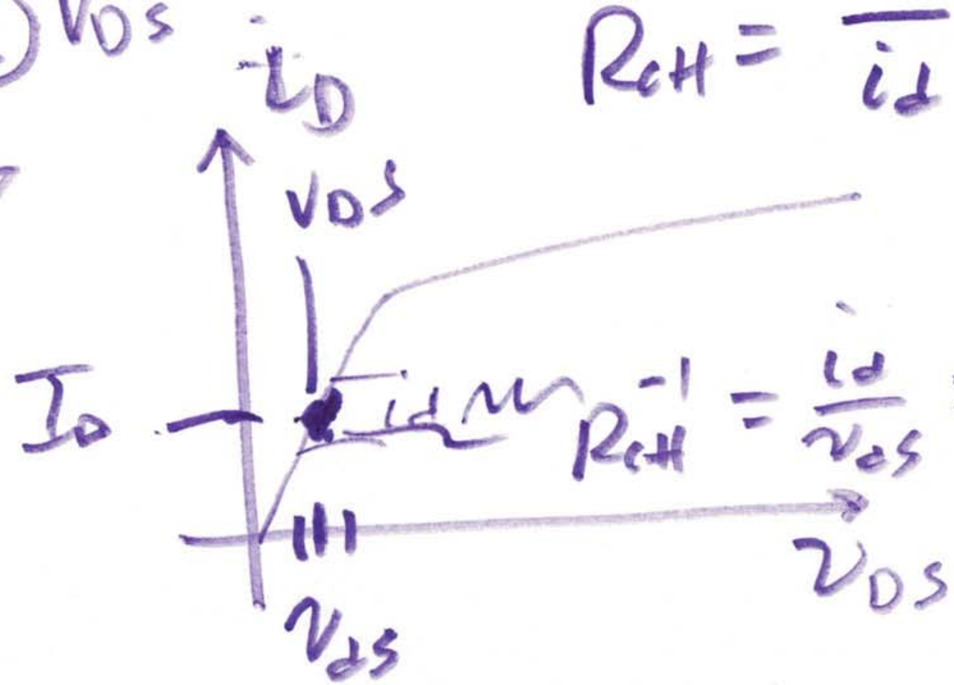


R_{CH} = Resistance between D & S when in triode





$$R_{CH} = \frac{v_{ds}}{i_d}$$



$$R_{CH}^{-1} = \frac{i_d}{v_{ds}} = \text{slope}$$

$$i_D = I_D + i_d = KP_n \cdot \frac{W}{L}\left((V_{GS} - V_{THN}) \cdot (V_{DS} + v_{ds}) - \frac{(V_{DS} + v_{ds})^2}{2}\right)$$

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

$$R_{CH}^{-1} = \frac{\delta i_D}{\delta v_{DS}}\Bigg|_{\substack{I_D = \text{const} \\ V_{DS} = \text{const}}}$$

$$\frac{\delta}{\delta x} K \cdot X = K \frac{\delta y}{\delta y}$$

$$R_{CH}^{-1} = KP \cdot \frac{W}{L}\left((V_{GS} - V_{THN}) - \overbrace{V_{DS} + v_{ds}}^{\approx V_{DS}}\right)$$

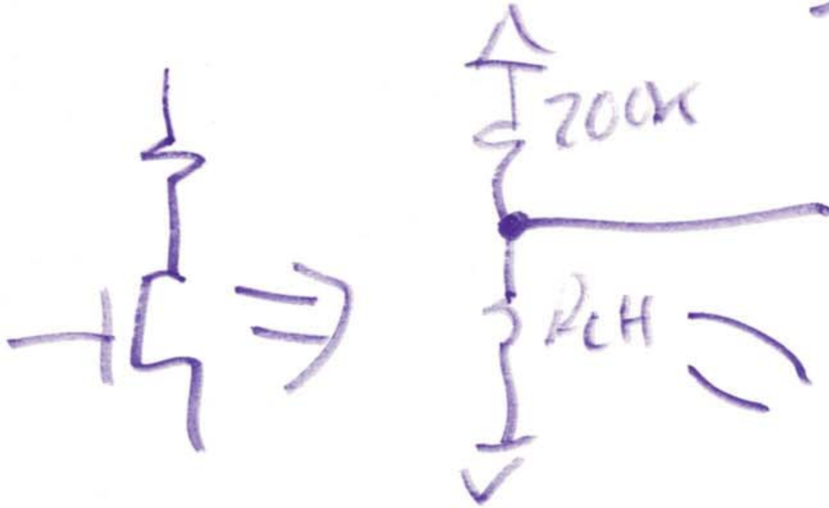
$v_{ds} << V_{DS}$

small-signal app.

$$R_{CH} = \frac{1}{\frac{KPW}{L}\left((V_{GS} - V_{THN}) - V_{DS}\right)}$$

$$R_{CH} = \frac{1}{KP\cdot\frac{W}{L}\left((V_{GS}-V_{THN}) - V_{DS}\right)}$$

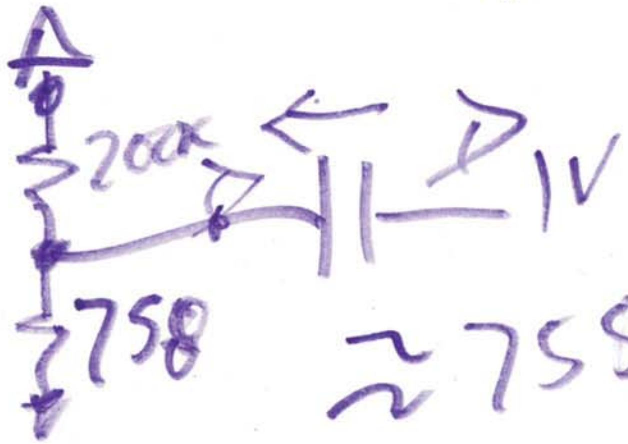
$$\approx \frac{1}{KP\cdot\frac{W}{L}(V_{GS}-V_{THN})}$$



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

$$\frac{1}{120\mu\cdot 5\cdot 2.2}$$

~~84Ω~~



≈ 755 $\qquad \frac{1}{755}$

$$\boxed{i = 1.3\,mA}$$

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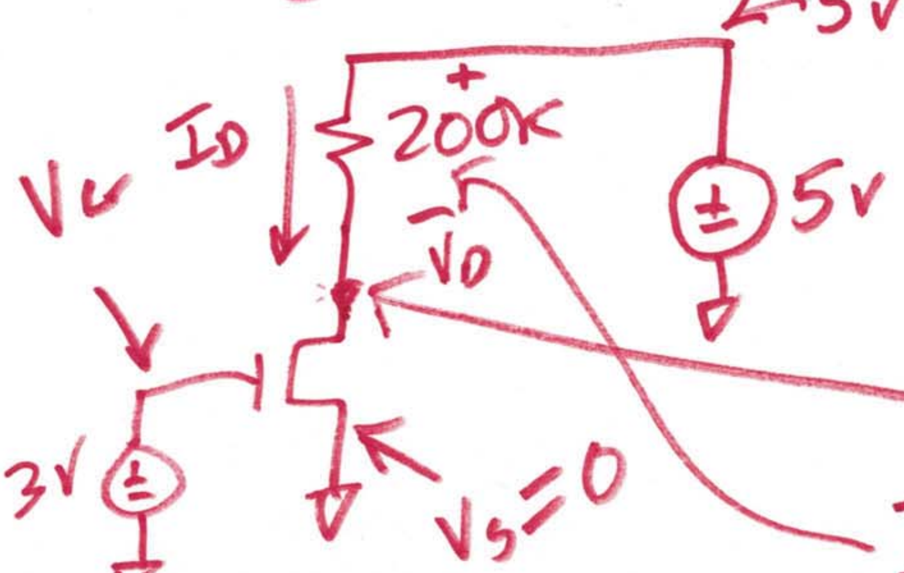
$I \downarrow$ $V = IR$, R

$V_G - V_S = V_{GS}$
$= 3V$



$V_{GS} = 3V$

$5 - I_D \cdot 200K = V_{DS} = V_D - V_S$

$I_D \cdot 200K$

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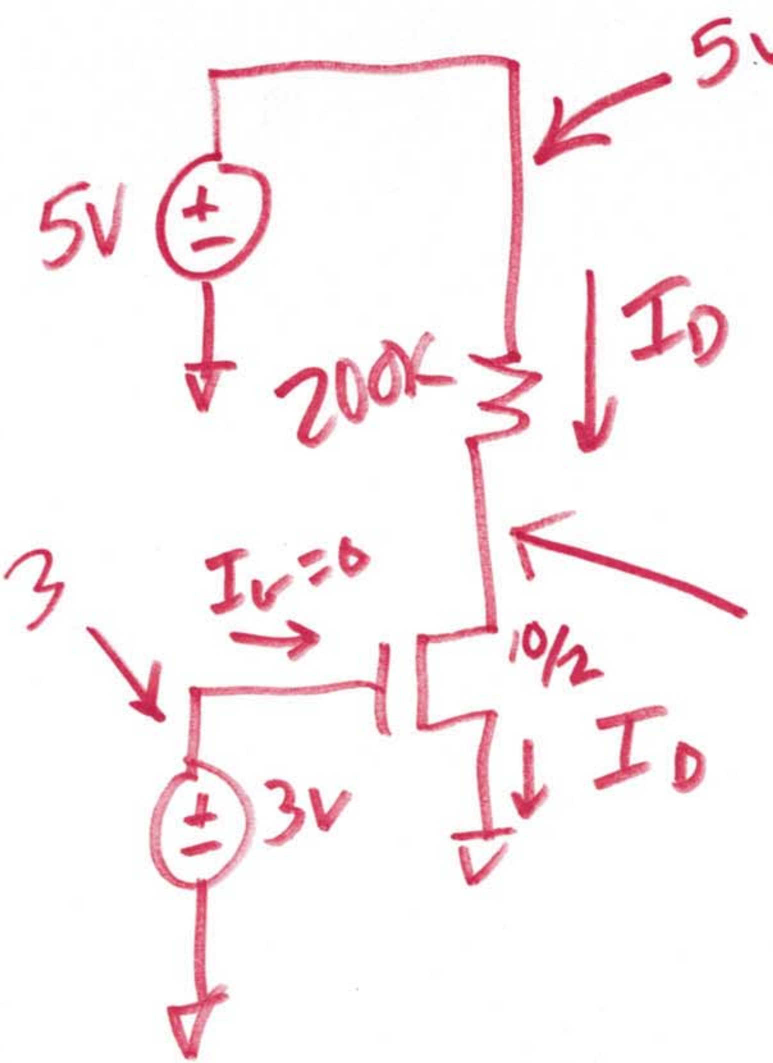

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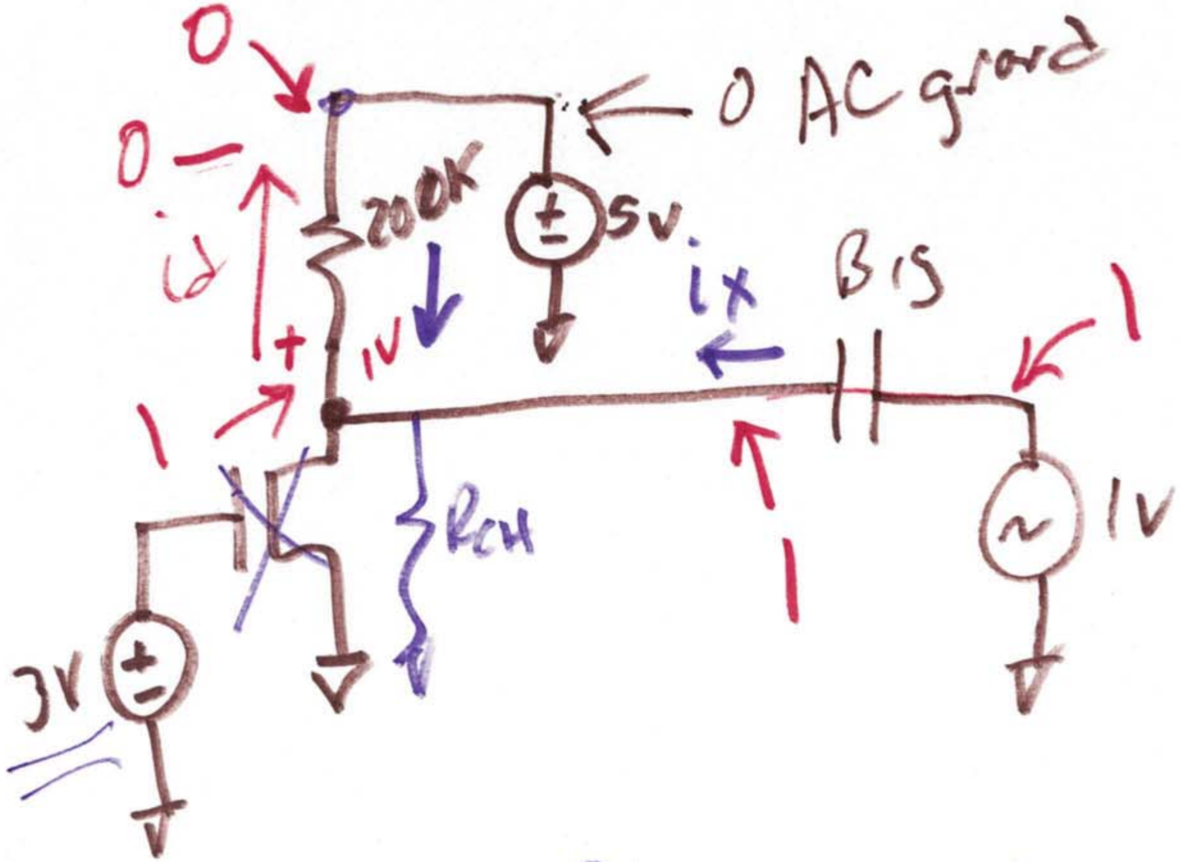
$= \underline{\underline{1.45mA}}$

3)



$$i_s = \frac{1V}{200K} = 5\mu A$$

AC

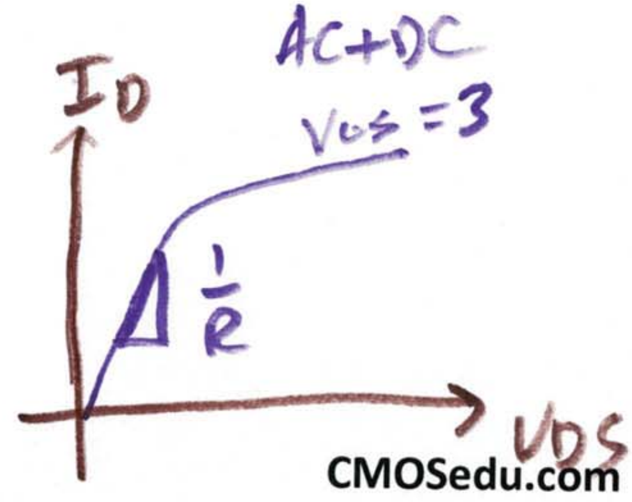
i_x

$+ I_x$

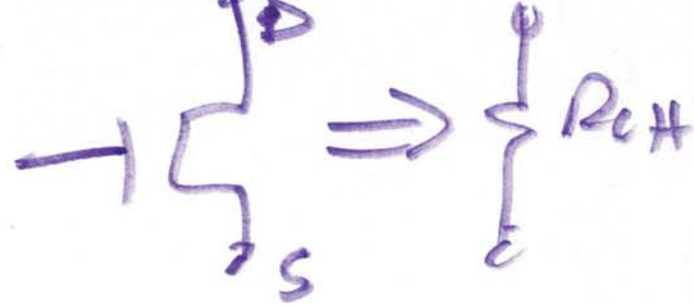
DC

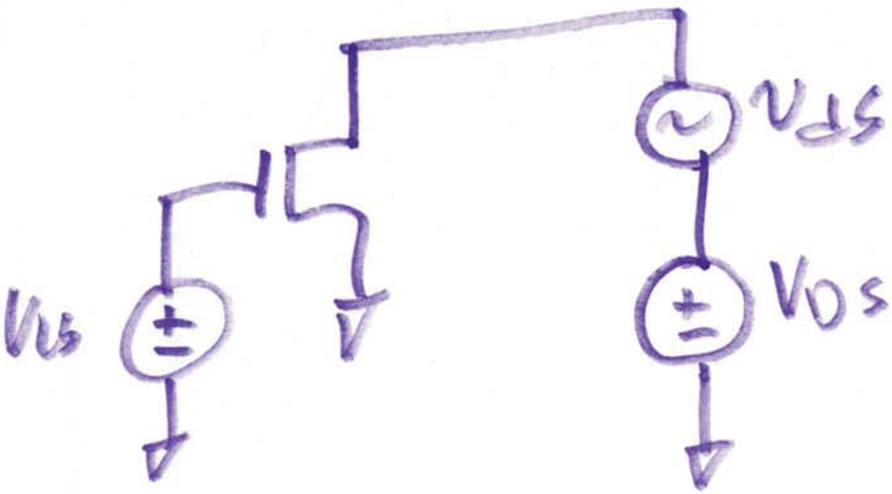
$$\frac{v}{R} = \frac{0-1}{200K} = i = -5\mu$$

$$i_X = I_x + i_x$$

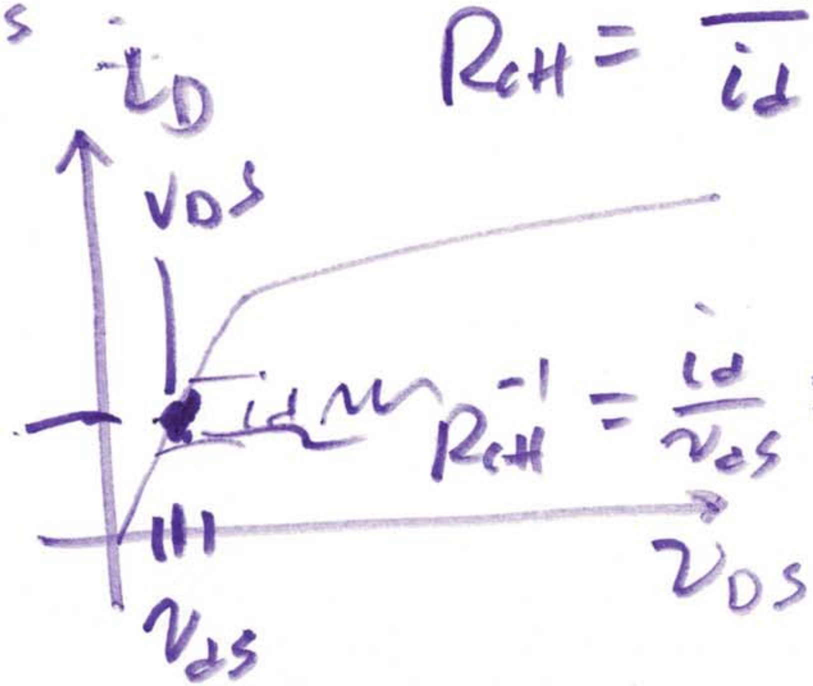


R_{CH} = Resistance between D & S when in triode





$$R_{CH} = \frac{v_{ds}}{i_d}$$



$$R_{CH}^{-1} = \frac{i_d}{v_{ds}} = \text{slope}$$

$$i_D = I_D + i_d = KP_N \cdot \frac{W}{L}\left(\left(V_{GS} - V_{THN}\right) \cdot \left(V_{DS} + v_{ds}\right) - \frac{\left(V_{DS} + v_{ds}\right)^2}{2}\right)$$

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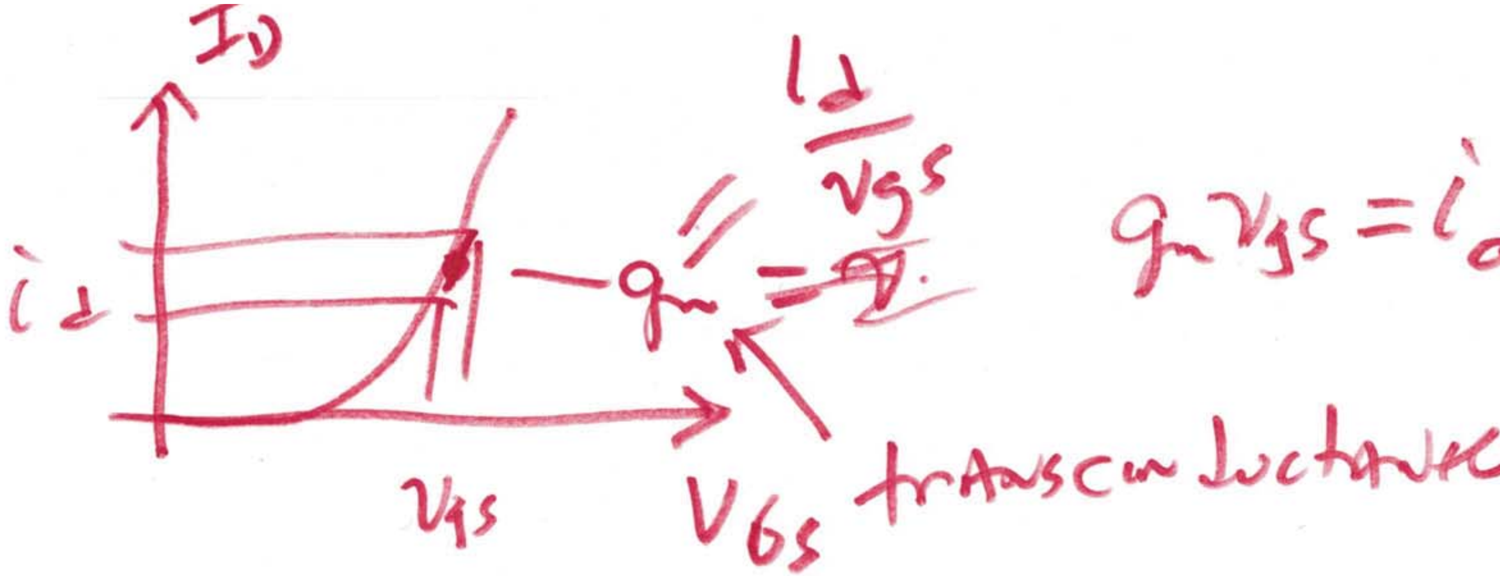
$$R_{CH}^{-1} = KP \cdot \frac{W}{L}\left(\left(V_{GS} - V_{THN}\right) - \underbrace{V_{DS} + v_{ds}}_{\approx V_{DS}}\right)$$

$v_{ds} << V_{DS}$

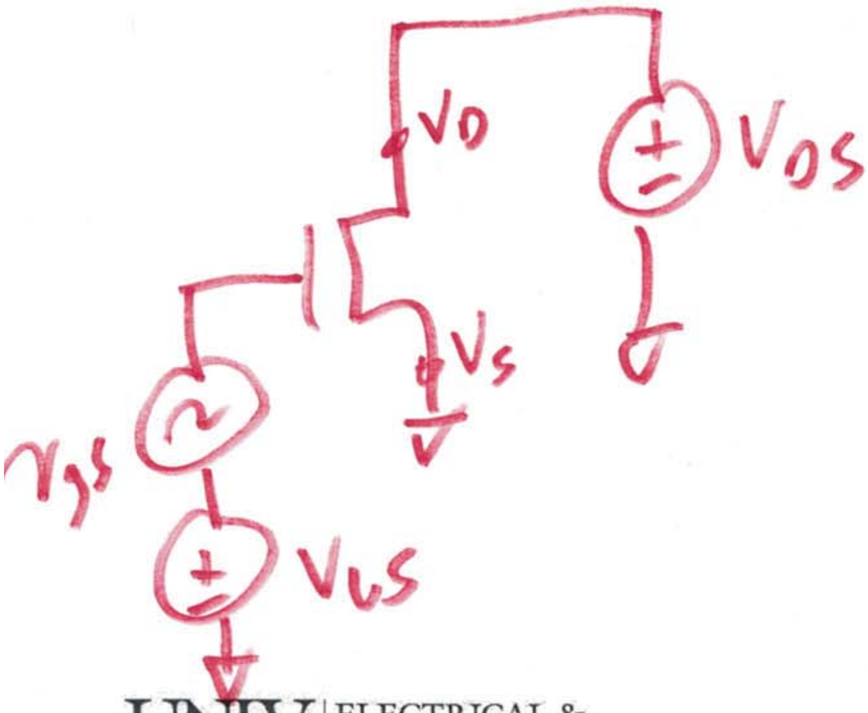
small-signal app.

$$R_{CH} = \frac{1}{KP\frac{W}{L}\left(\left(V_{GS} - V_{THN}\right) - V_{DS}\right)}$$



I_D
i_d
v_{gs}
V_{GS}
$g_m = \frac{i_d}{v_{gs}}$
transconductance

$g_m v_{gs} = i_d$



V_D
V_{DS}
V_S
v_{gs}
V_{GS}