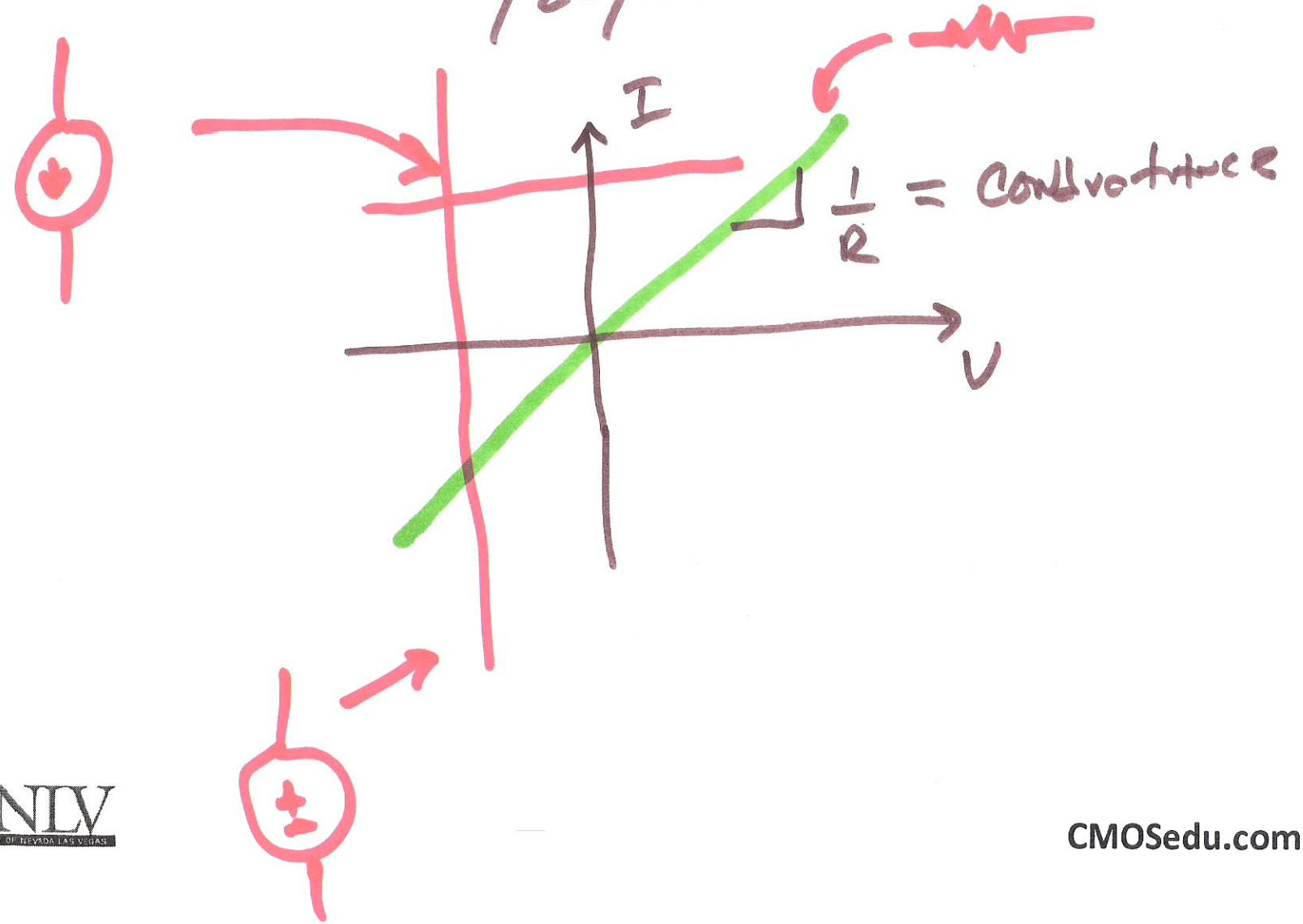
EE 420 / ECE 620

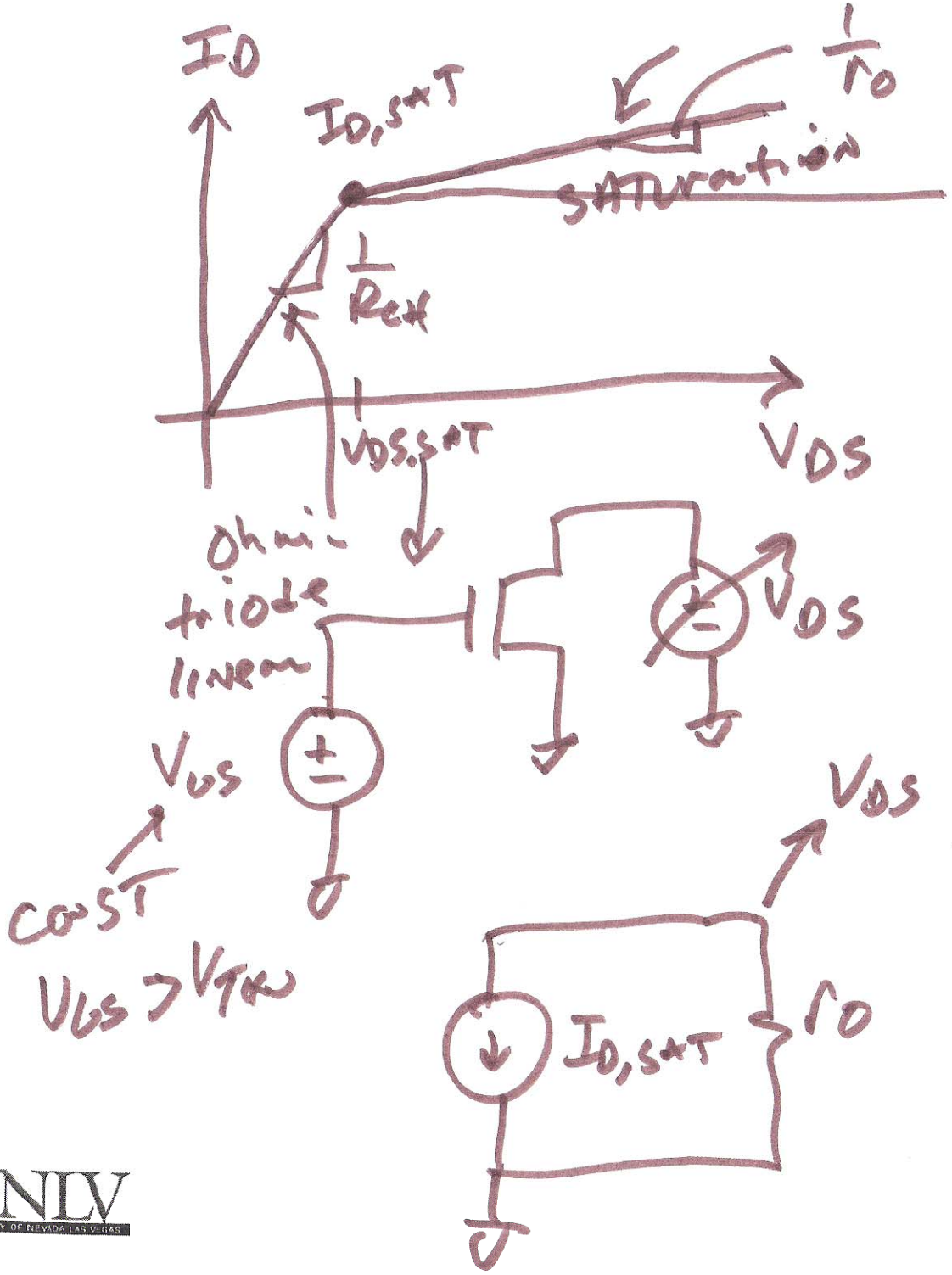
Analog IC Design

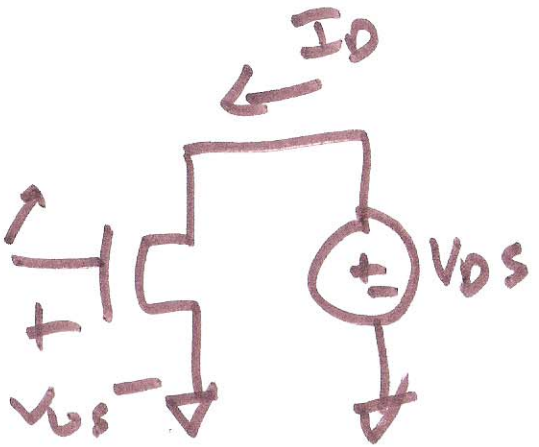
1/22/14 Lecture 1

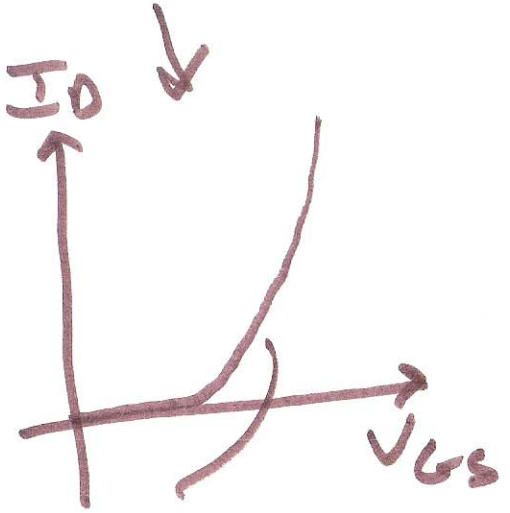


UNLV
UNIVERSITY OF NEVADA LAS VEGAS

CMOSedu.com



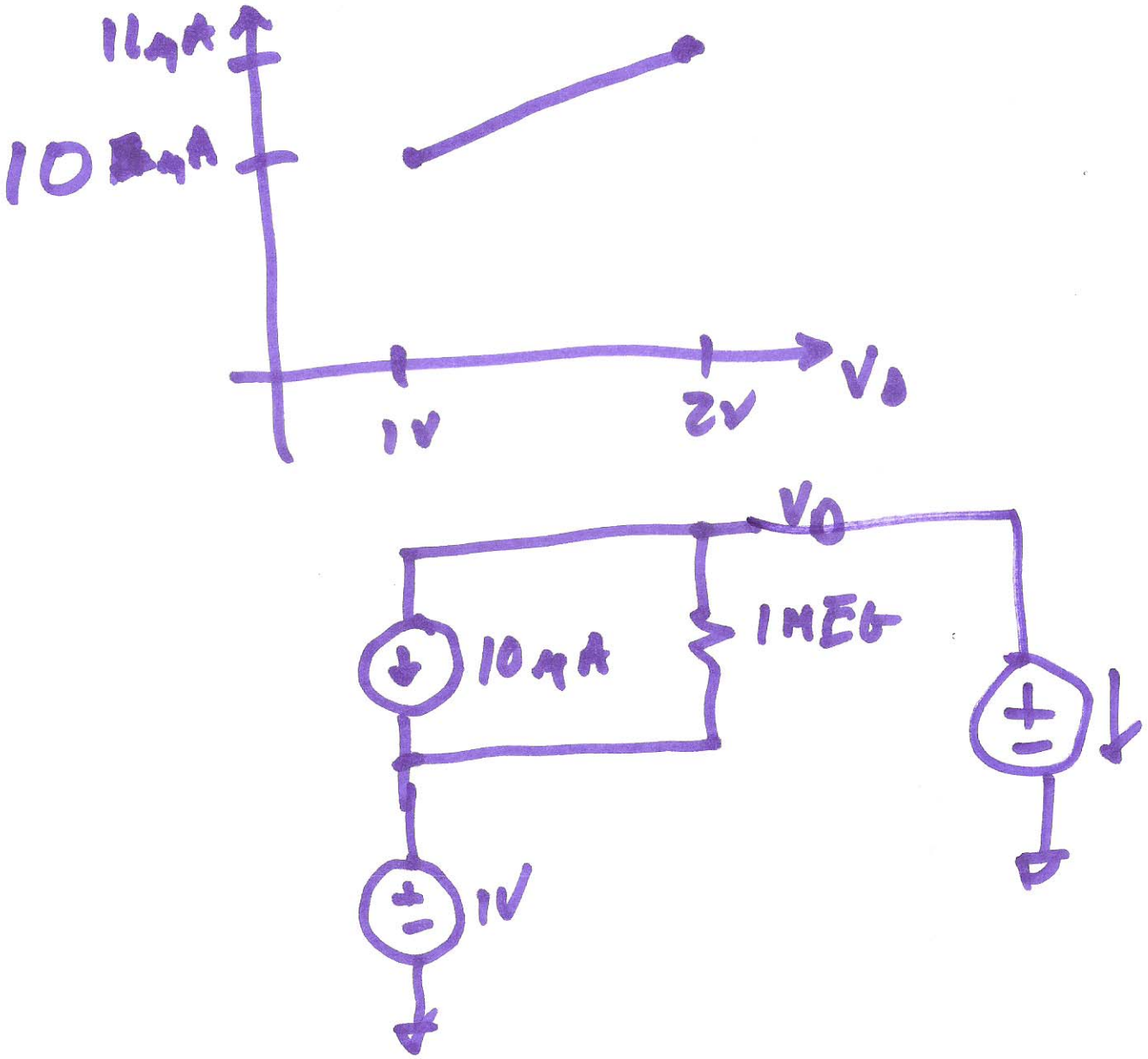


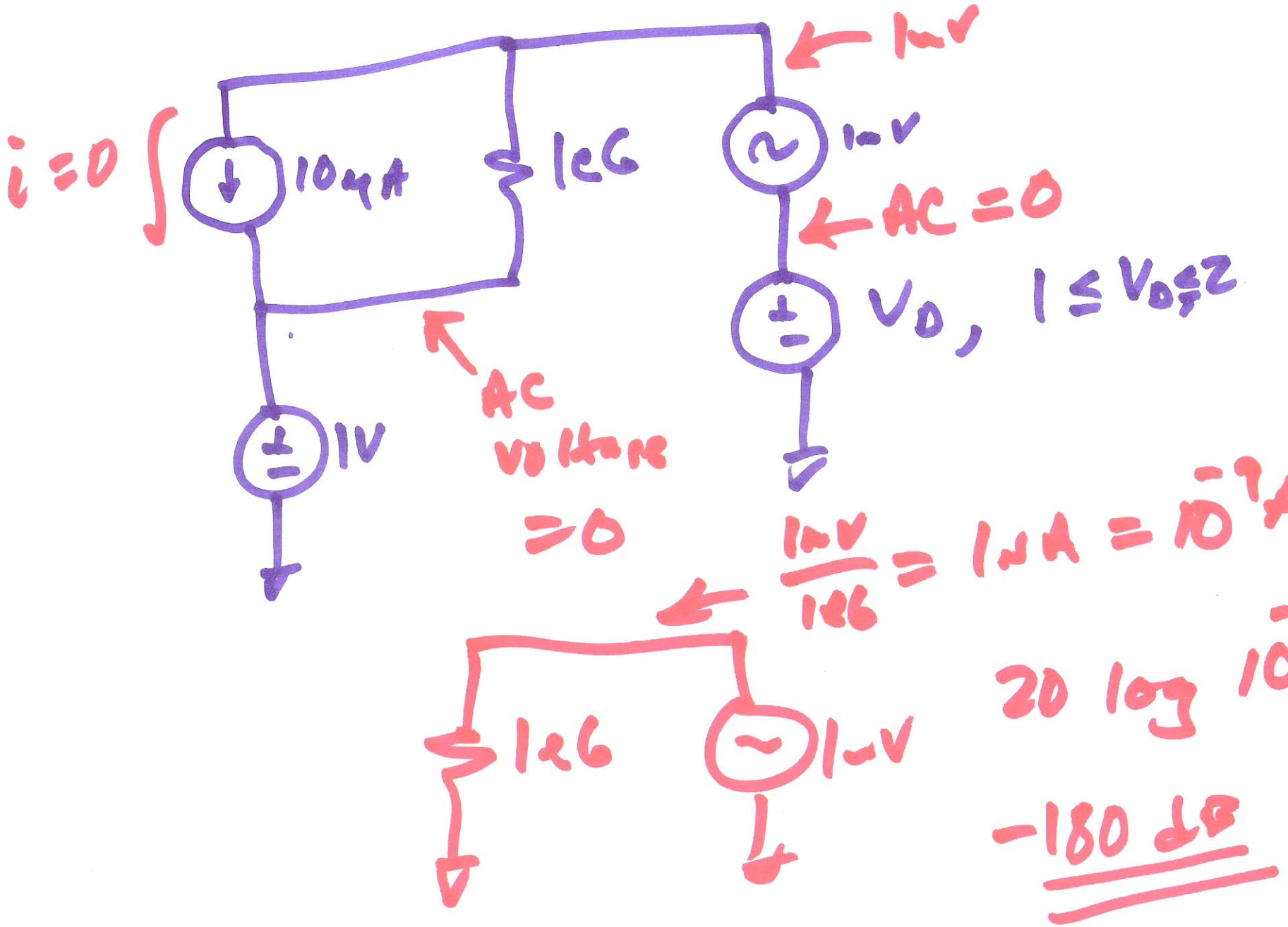


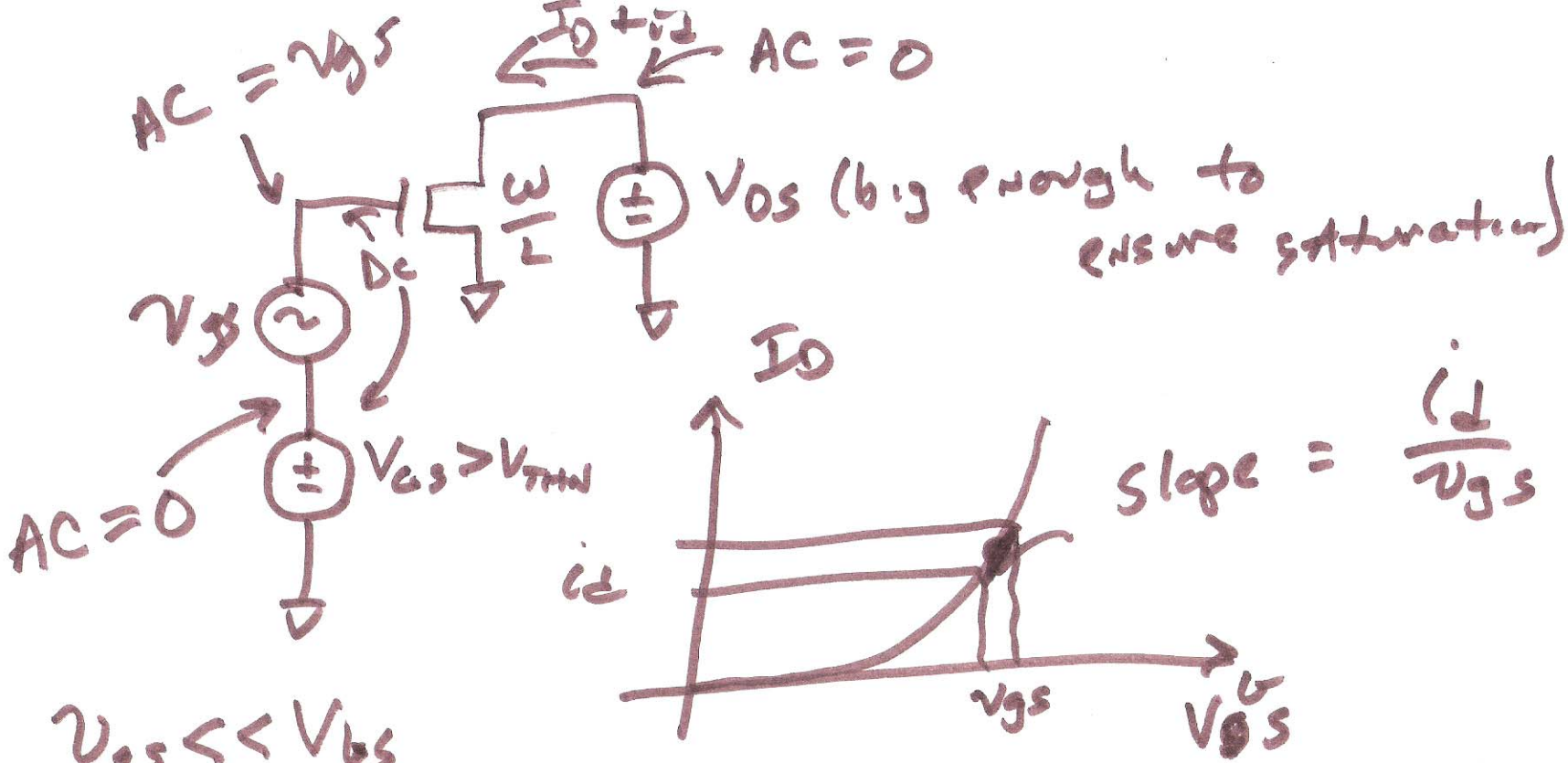
$$I_D = \frac{KP_n}{2}\cdot\frac{W}{L}\left(V_{GS}-V_{THN}\right)^2$$

$V_{GS} > V_{THN}$

UNLV
UNIVERSITY OF NEVADA LAS VEGAS


11mA
10mA
1V
2V
V_0
V_0
10mA
1MEG
1V


i = 0
10μA
1GΩ
1mV
1mV
AC = 0
V_D, 1 ≤ V_D ≤ 2
1V
AC voltage = 0
1mV / 1GΩ = 1nA = 10^-9 A
1GΩ
1mV
20 log 10^-9
-180 dB



$v_{gs} << V_{GS}$

I.C. AC DC

$v_{GS} = v_{gs} + V_{GS}$

↑ ↑

V.C. AC + DC

$i_D = I_D + i_d =$

$\frac{KP}{2} \cdot \frac{W}{L} \cdot \underbrace{\left(V_{GS} + v_{gs} - V_{THN}\right)}_{v_{GS}}^2$

$\mu_N \cdot C_{ox}'$

UNLV UNIVERSITY OF NEVADA LAS VEGAS

$$g_m = \text{slope} = \frac{\delta i_D}{\delta v_{GS}} = \frac{\delta}{\delta v_{GS}} \left(\left(\frac{KP}{2} \frac{W}{L} \left(V_{GS} + v_{gs} - V_{THN} \right)^2 \right) \right)_{\substack{V_{GS} = \text{CONST} \\ I_D = \text{CONST}}}$$

$$\frac{\delta}{\delta v_{GS}} \left(\frac{KP}{2} \cdot \frac{W}{L} \left(\underbrace{V_{GS} + v_{gs}}_{v_{GS}} - V_{THN} \right)^2 \right)$$

(DC: V_{GS}, AC: v_{gs})

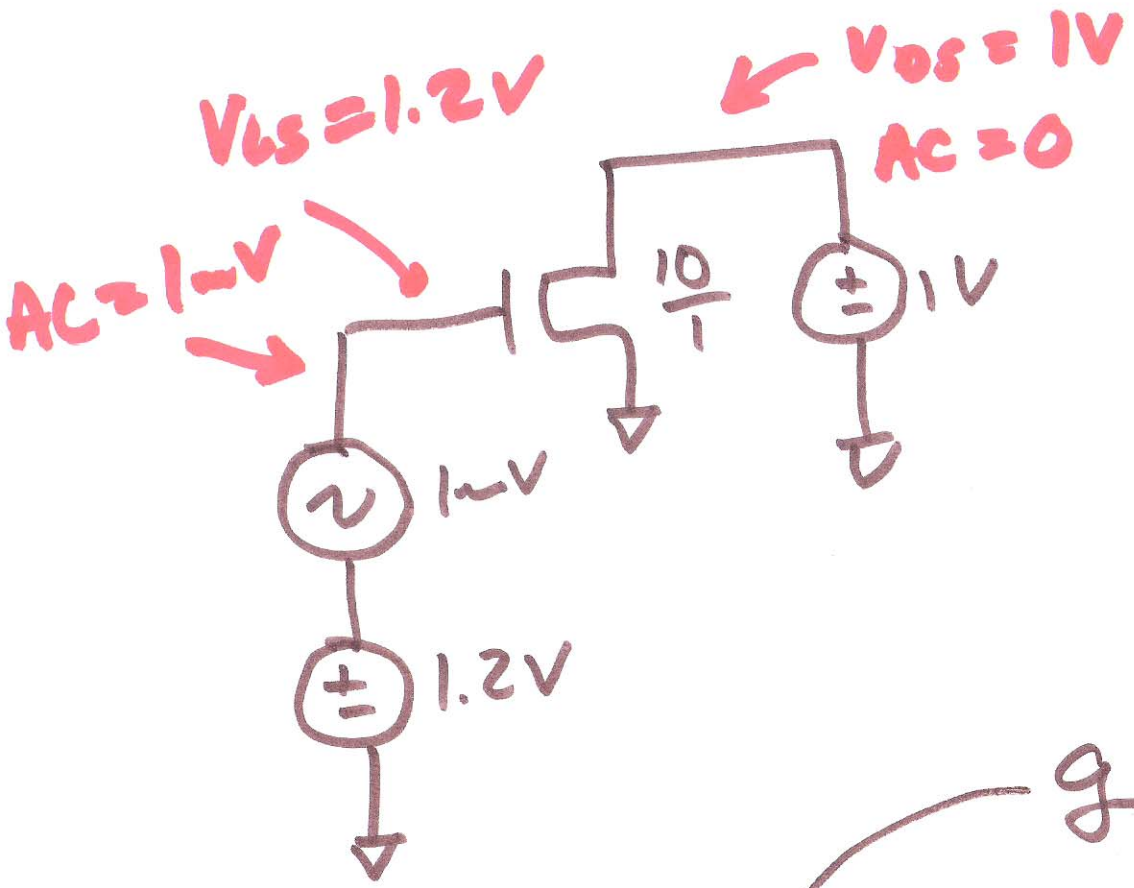
$$g_m = KP \cdot \frac{W}{L} \left(V_{GS} + v_{gs} - V_{THN} \right) \cdot 1$$

$\beta = KP \cdot \frac{W}{L}$

Small-signal approx $V_{GS} \gg v_{gs}$

$$\sqrt{2\beta \cdot I_D} = \boxed{g_m \simeq KP \cdot \frac{W}{L} \left(V_{GS} - V_{THN} \right)}$$

$KP = 120\mu A/V^2$



$V_{THN} = 0.8V$

$V_{DS} \overset{?}{\geq} V_{THN}$

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

$1 \overset{?}{\geq} 1.2 - .8$

yes!

$$g_m = KP \cdot \frac{W}{L}(V_{DS} - V_{THN})$$

$$I_D = \frac{120\mu A/V^2}{2} \cdot \frac{W}{L}(1.2 - .8)^2$$

$\frac{10}{1}$

$\frac{120\mu}{V^2} \cdot \frac{10}{1}(1.2 - .8)$

$1.2 - A \cdot .4$

$600\mu A \cdot 0.4 \cdot 0.4$

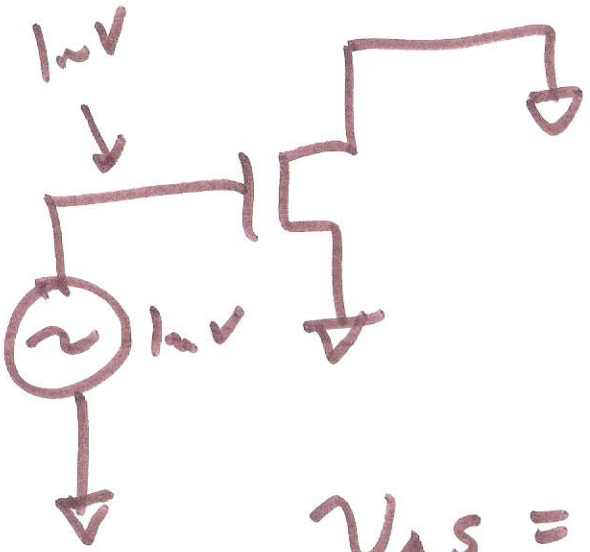
$96\mu A$

$$g_m = 480\frac{\mu A}{V}$$

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

CMOSedu.com

7)



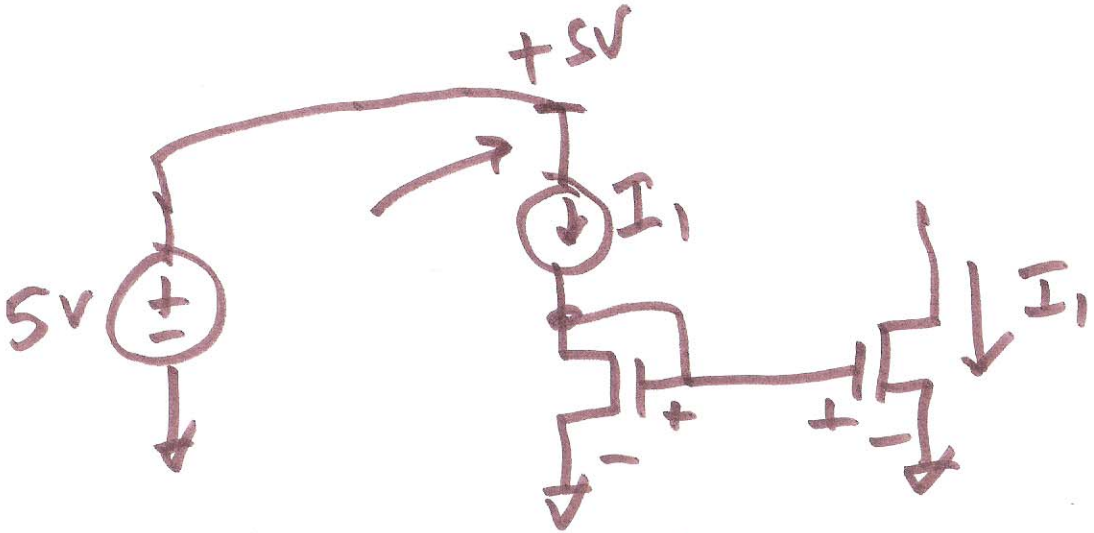
$g_m v_{gs} = i_1$

$v_{gs} = 1mV$

$g_m = 480 \frac{\mu A}{V}$

$i_1 = 480 \mu A$

UNLV
UNIVERSITY OF NEVADA LAS VEGAS



$V_{GS} > V_{THN}$

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

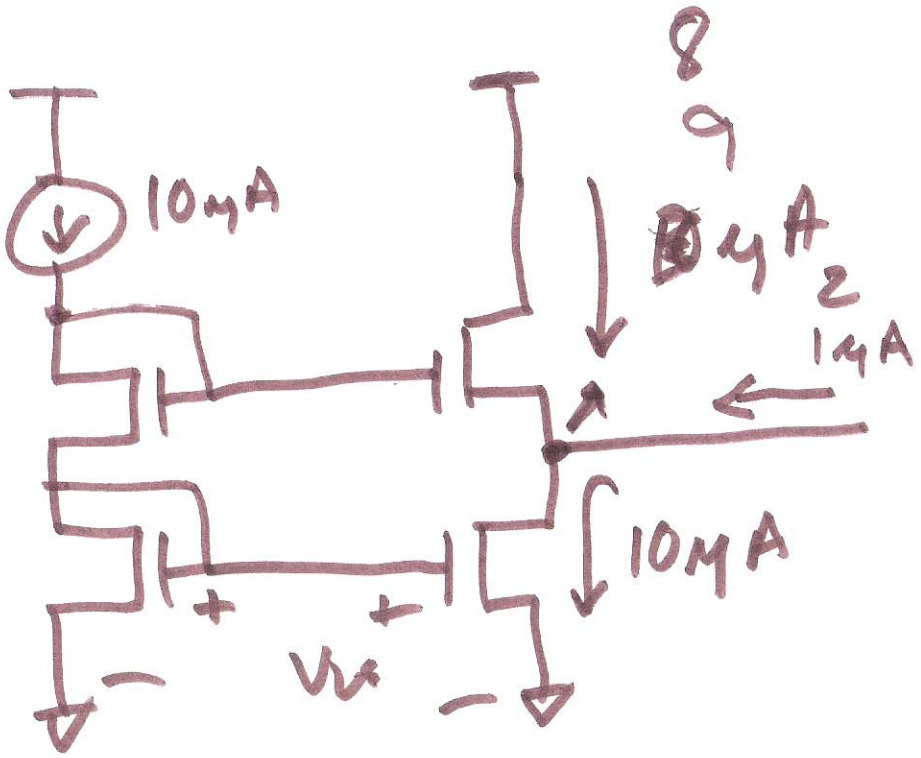
$$V_D - \cancel{V_S} \geq V_G - \cancel{V_S} - V_{THN}$$

Key point: Always in sat. when on!

$$\cancel{V_D} \geq \cancel{V_G} - V_{THN}$$

$$0 \geq -V_{THN} \quad \text{always true}$$

UNLV UNIVERSITY OF NEVADA LAS VEGAS



UNLV
UNIVERSITY OF NEVADA LAS VEGAS