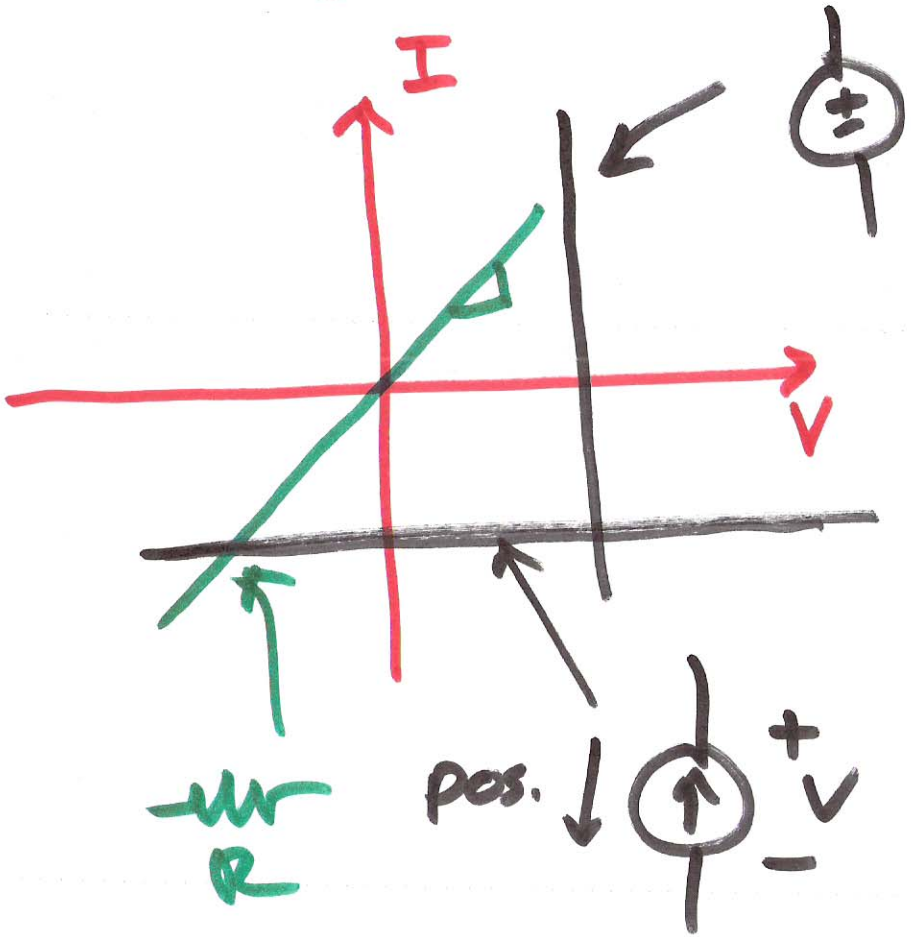
ECE 5/411 CMOS Analog IC Design

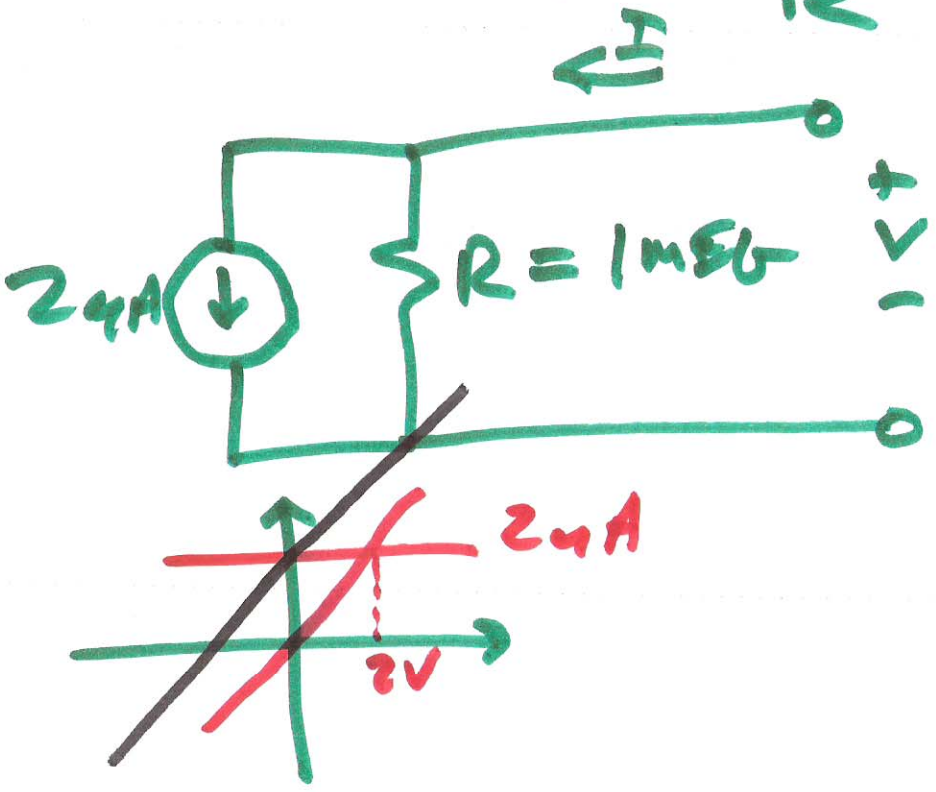
BOISE STATE UNIVERSITY

Lecture 1 JAN. 18, 2012

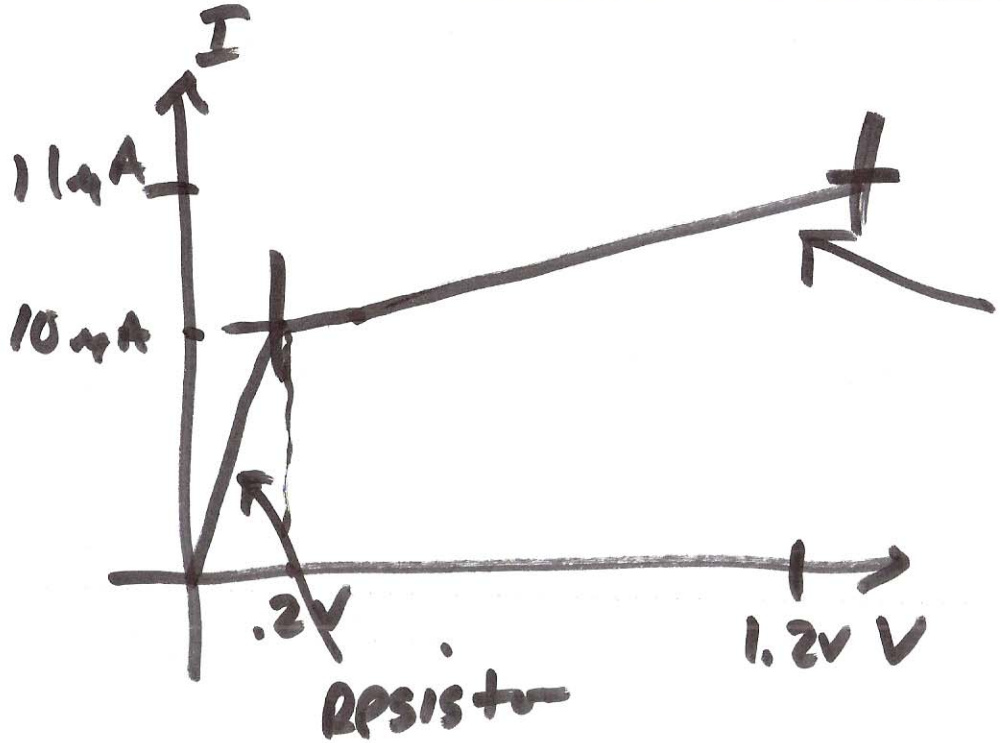
Start Ch. 9 H.W. due Monday



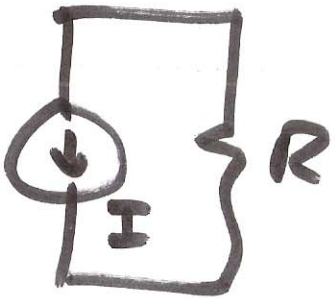
$$\text{slope} = \frac{\Delta I}{\Delta V} = \frac{1}{R}$$

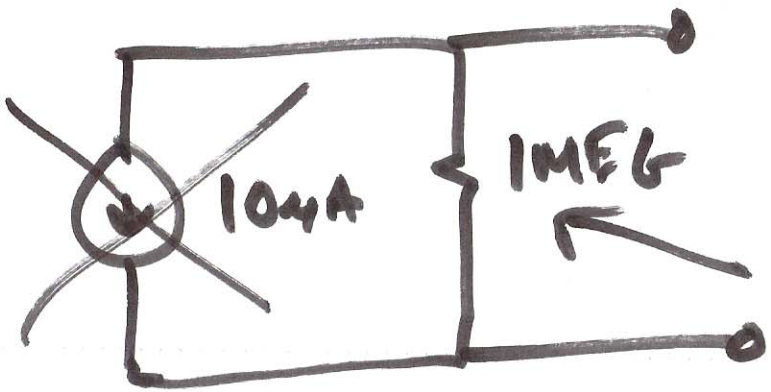


1)



behaves as a current source with output R





Resistor for small-signal analysis.

2)

IV curves of a MOSFET

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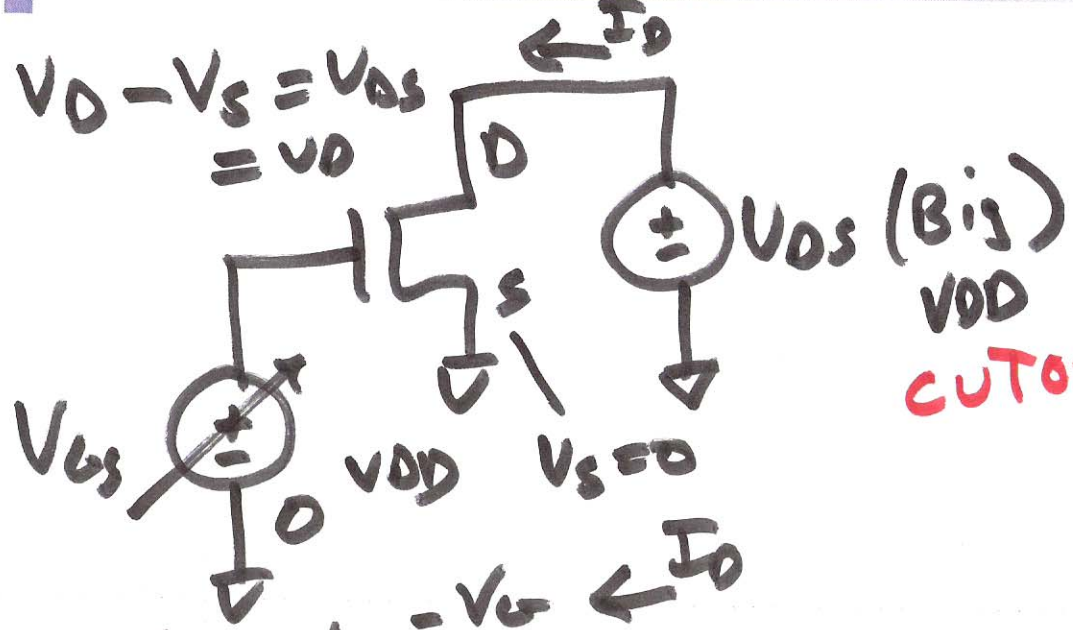
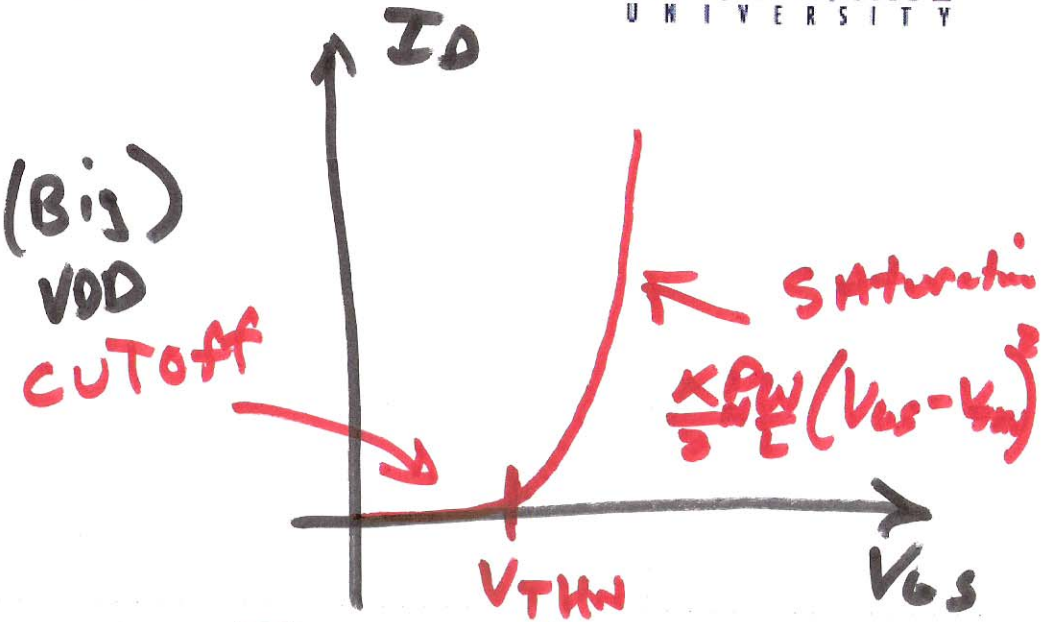
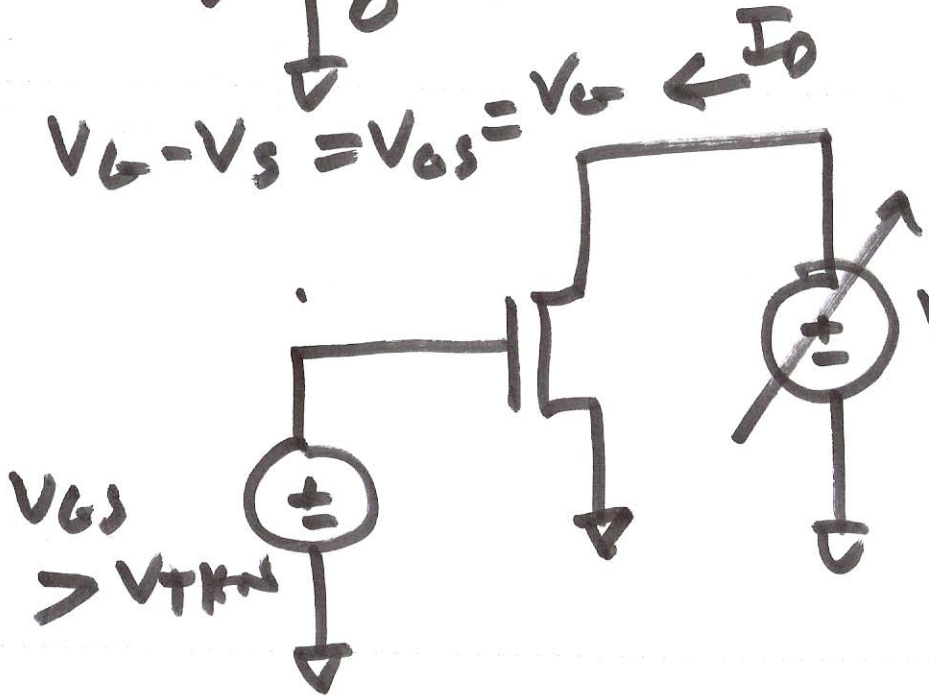
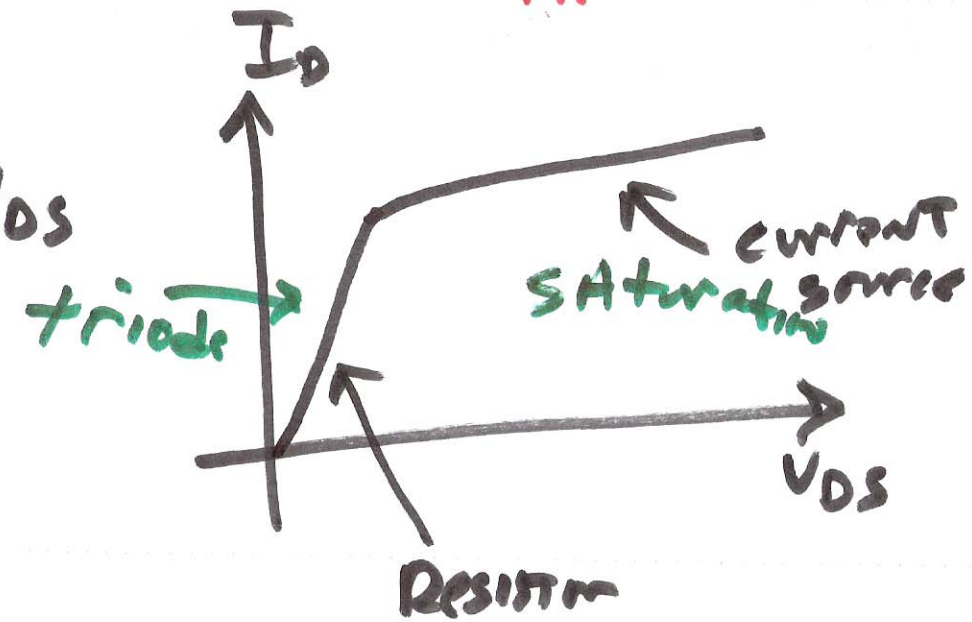


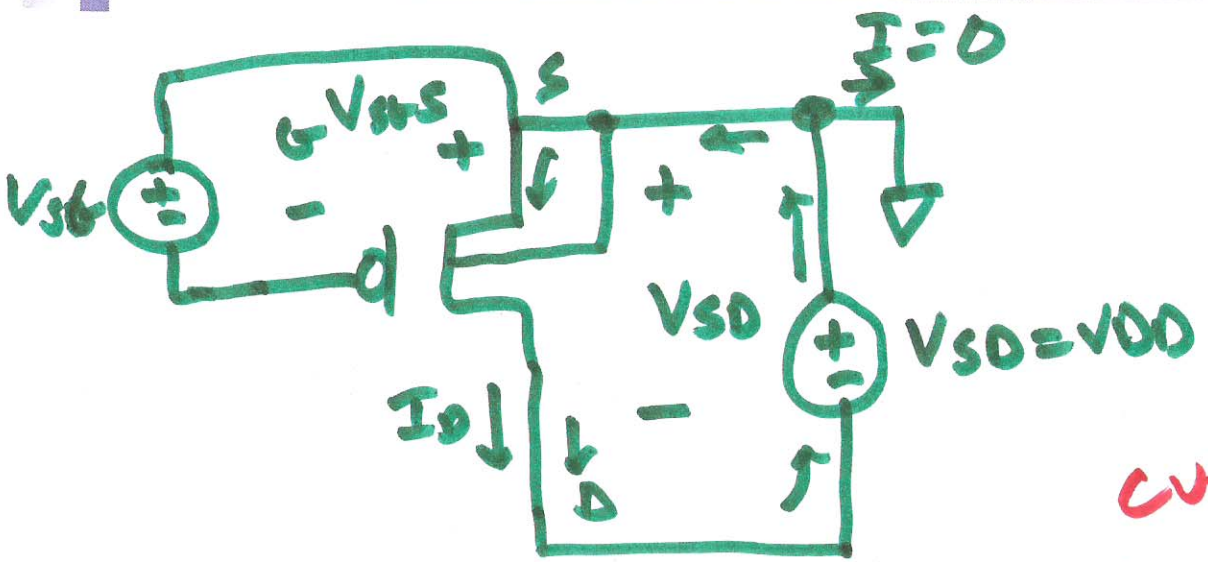


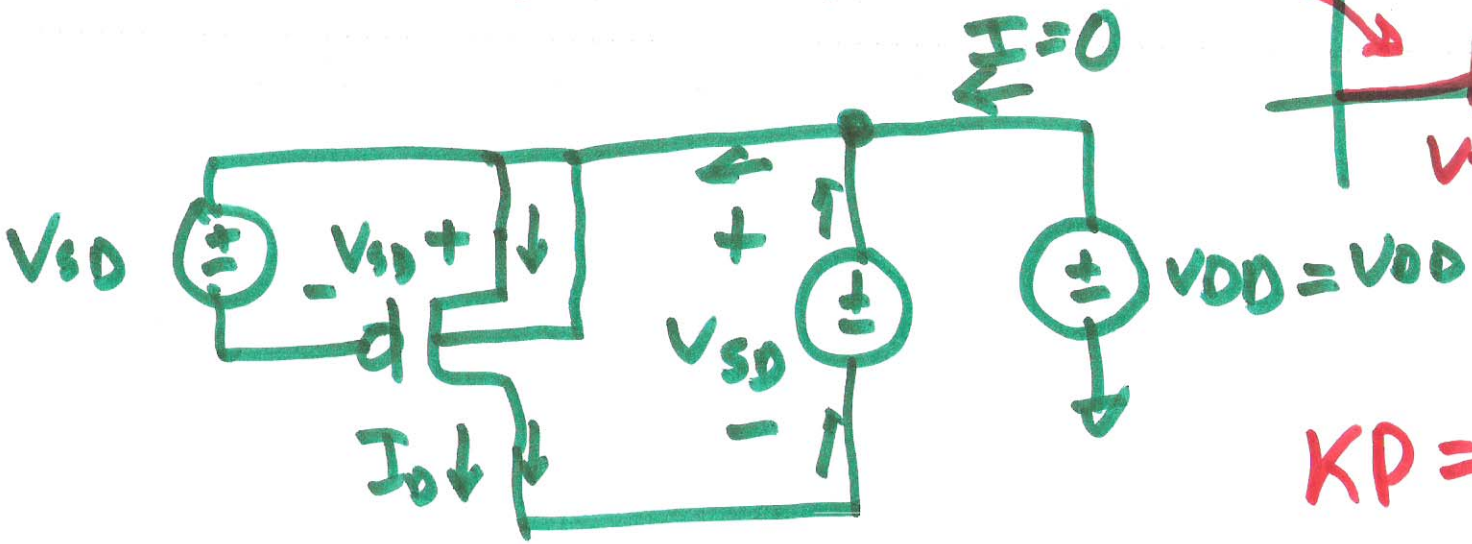


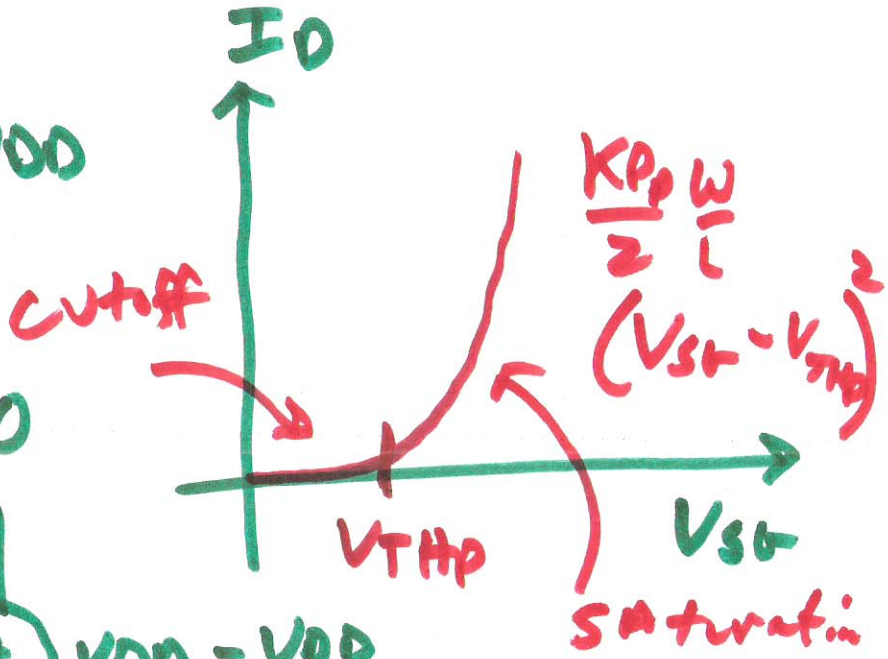


3)

$V_S - V_G = V_{SG}$



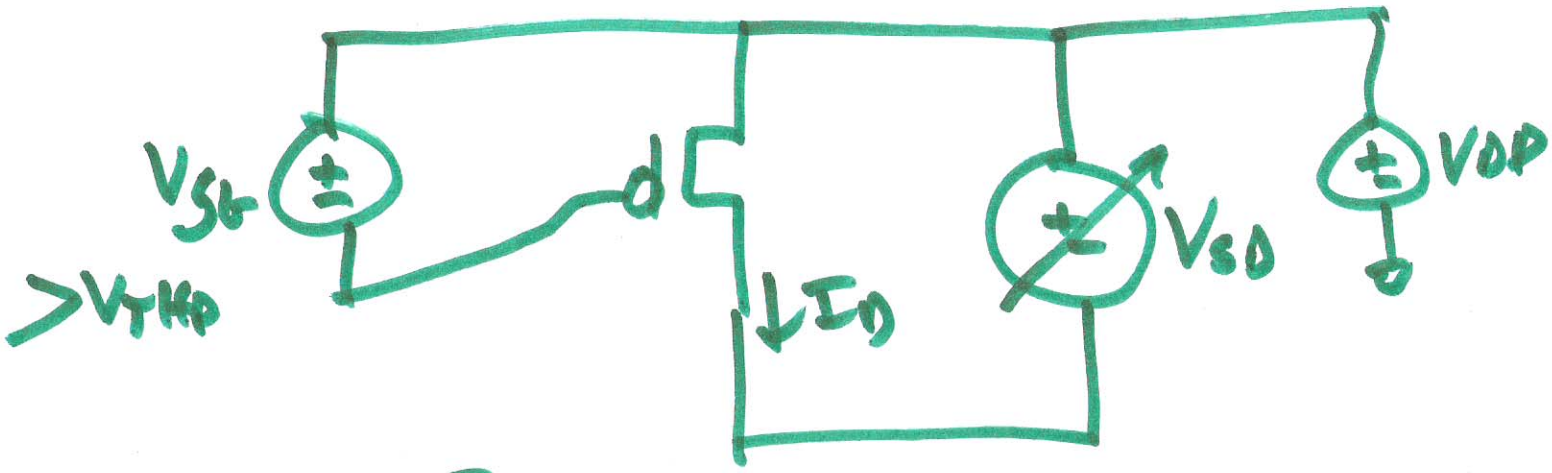


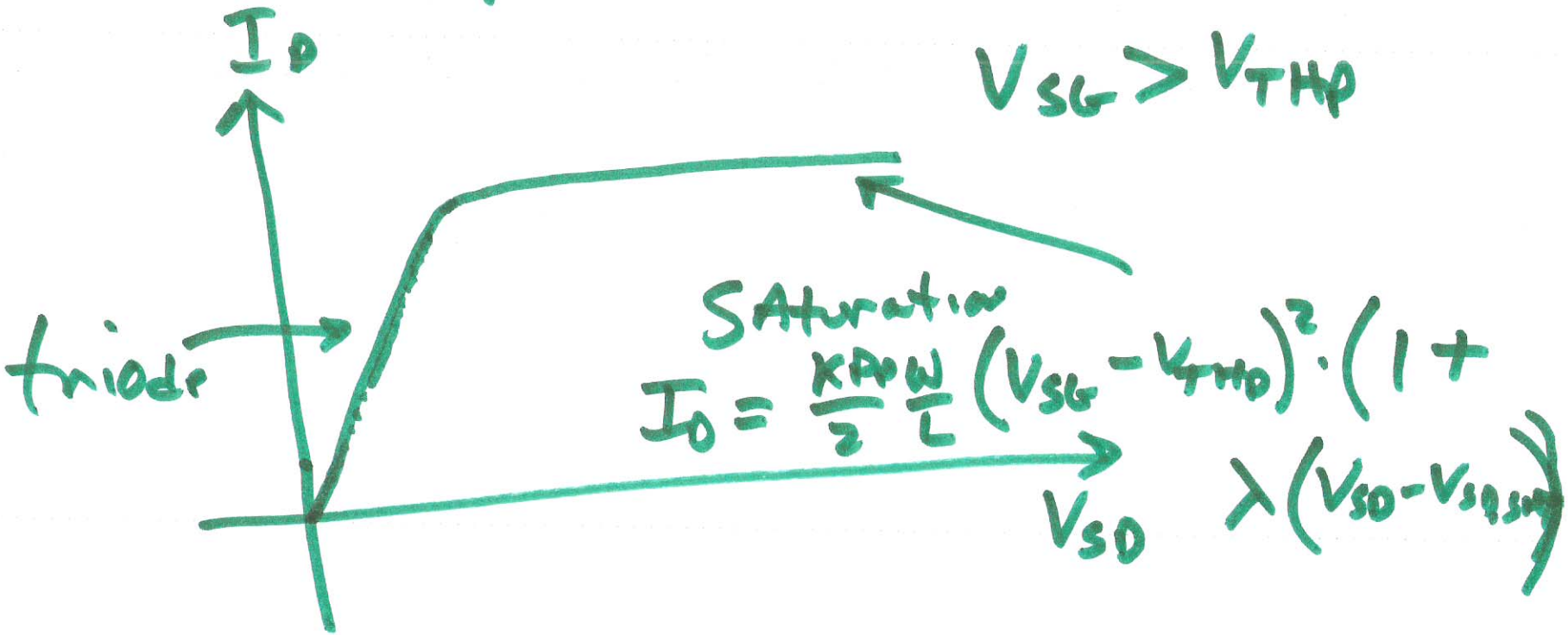


KP = transconductance parameter

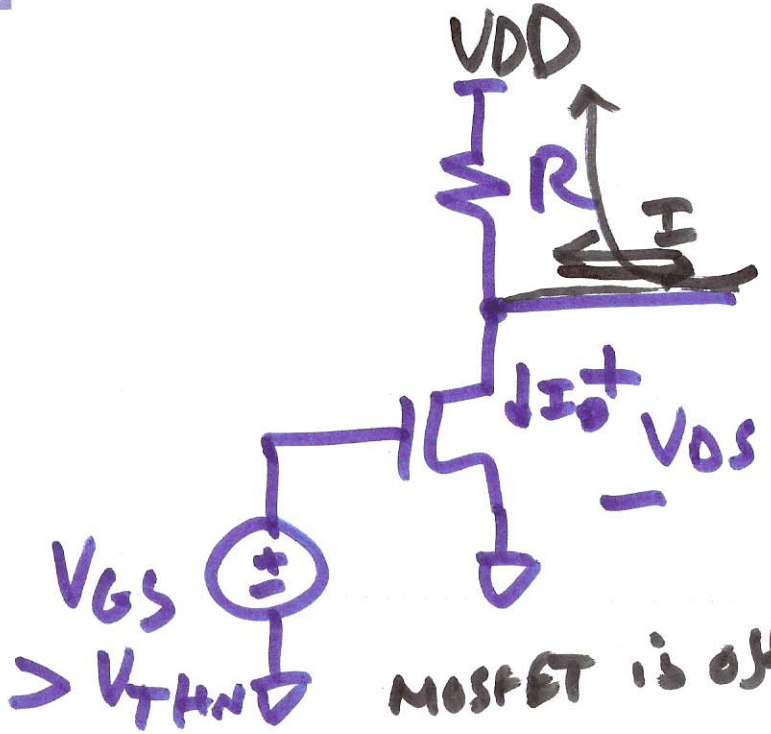
KP_p
KP_n

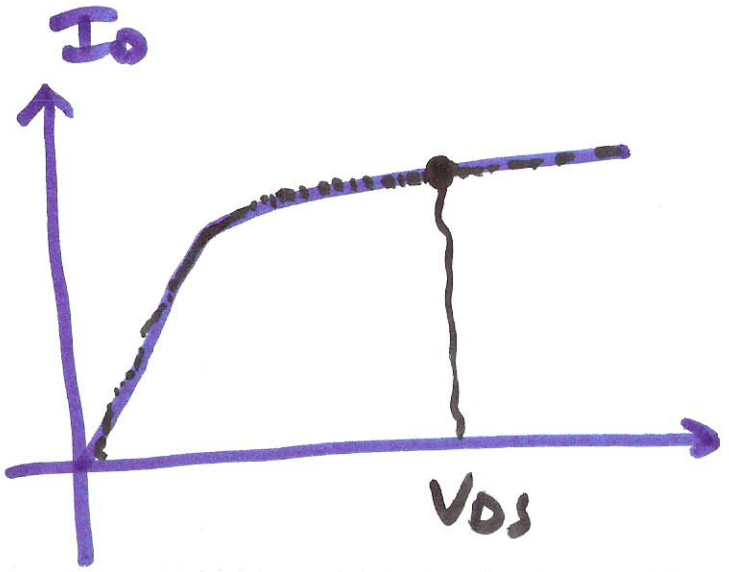
4)


V_{SG}
$> V_{THP}$
I_D
V_{SD}
V_{DD}


I_D
$V_{SG} > V_{THP}$
triode
saturation
$I_D = \frac{K_P W}{2 L} (V_{SG} - V_{THP})^2 \cdot (1 + \lambda (V_{SD} - V_{SD,sat}))$
V_{SD}

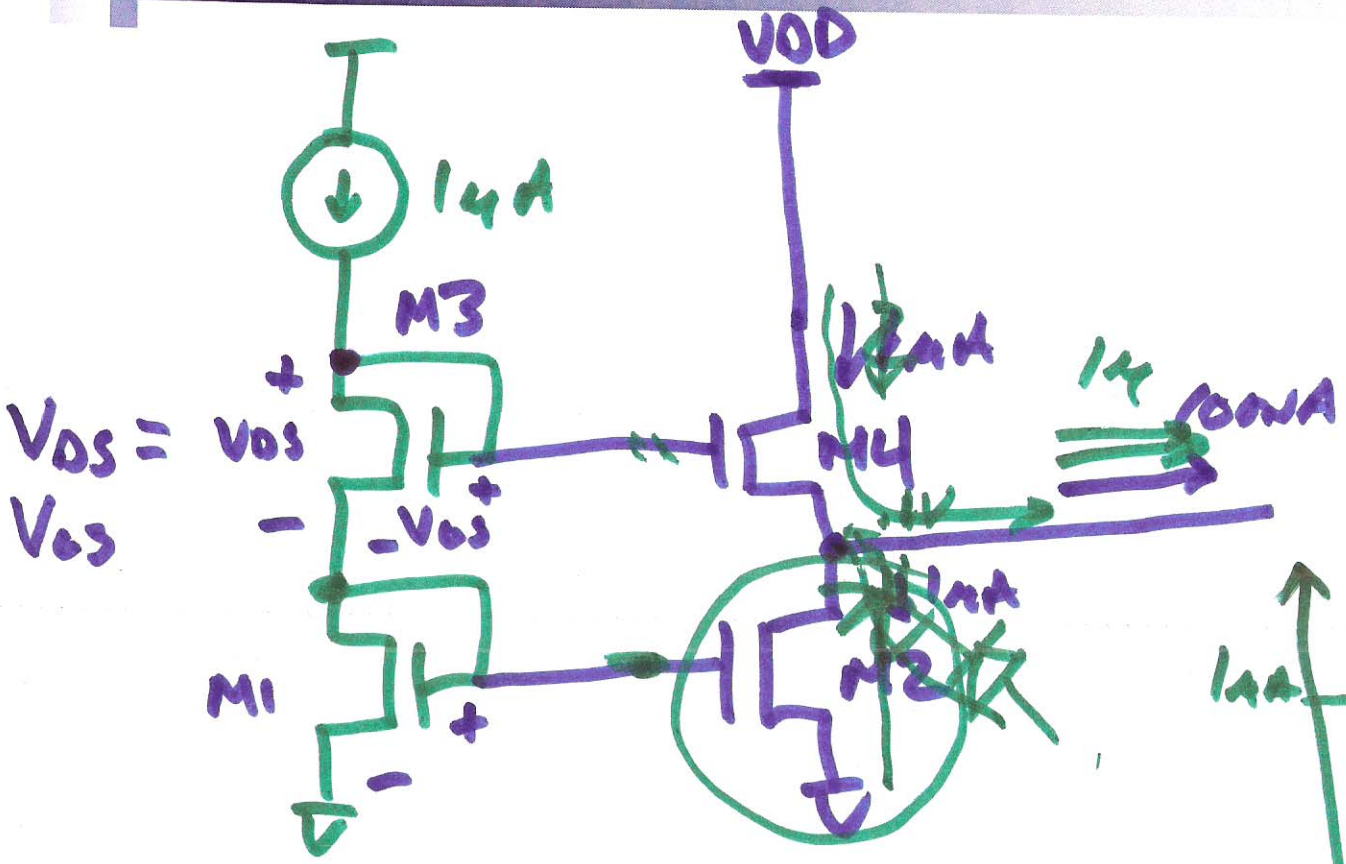
5)

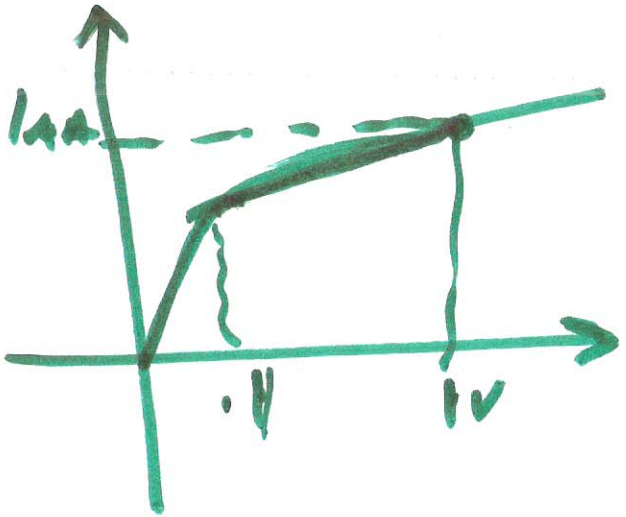




$$V_{DD} - IR = V_{DS}$$

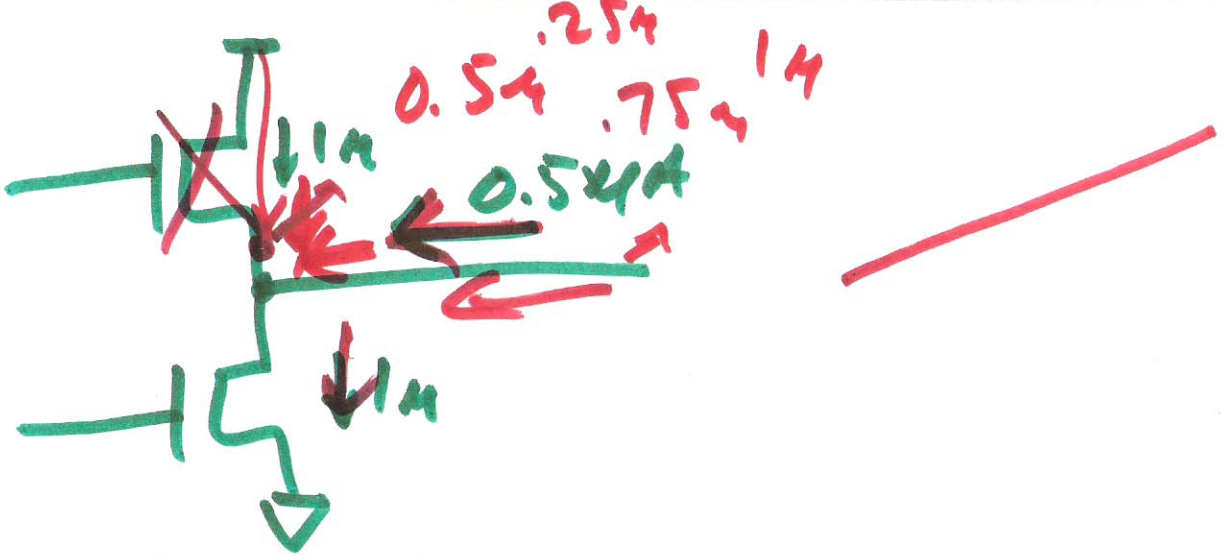
6)

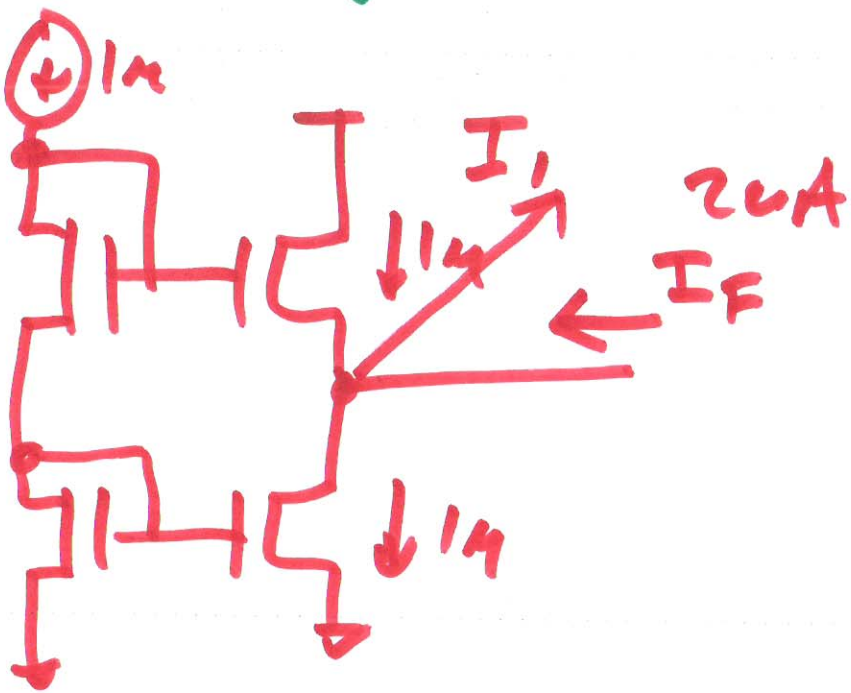




$$I_D = \frac{K_P}{2}\frac{W}{L}(V_{GS} - V_{TH})^2$$

$$V_{GS} = \sqrt{\frac{2I_D}{K_P}\frac{L}{W}} + V_{TH}$$





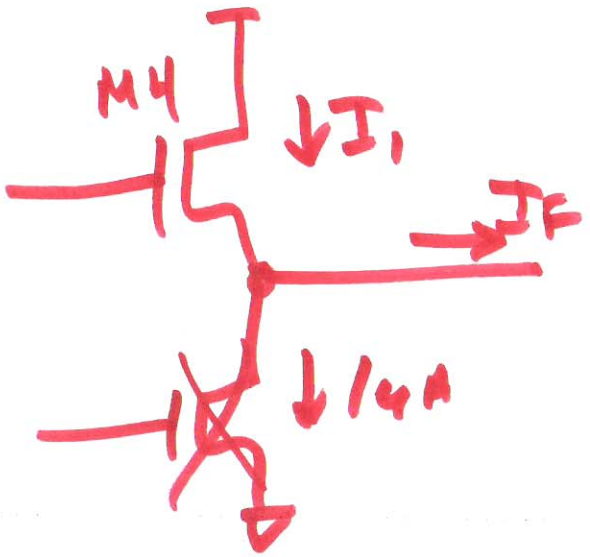
$I_1 + I_F = I_M$

$\frac{1}{2uA} + \frac{1}{2}mA = 1uA$

$0 + 1uA = 1uA$

$+2uA = 1uA$

8)



$$I_1 = I_F + 1\mu A$$

$$I_1 = 1mA + 1\mu A = 2mA$$

$$I_F >> 1\mu A$$

$$I_1 \simeq I_F$$

TRANSCONDUCTANCE

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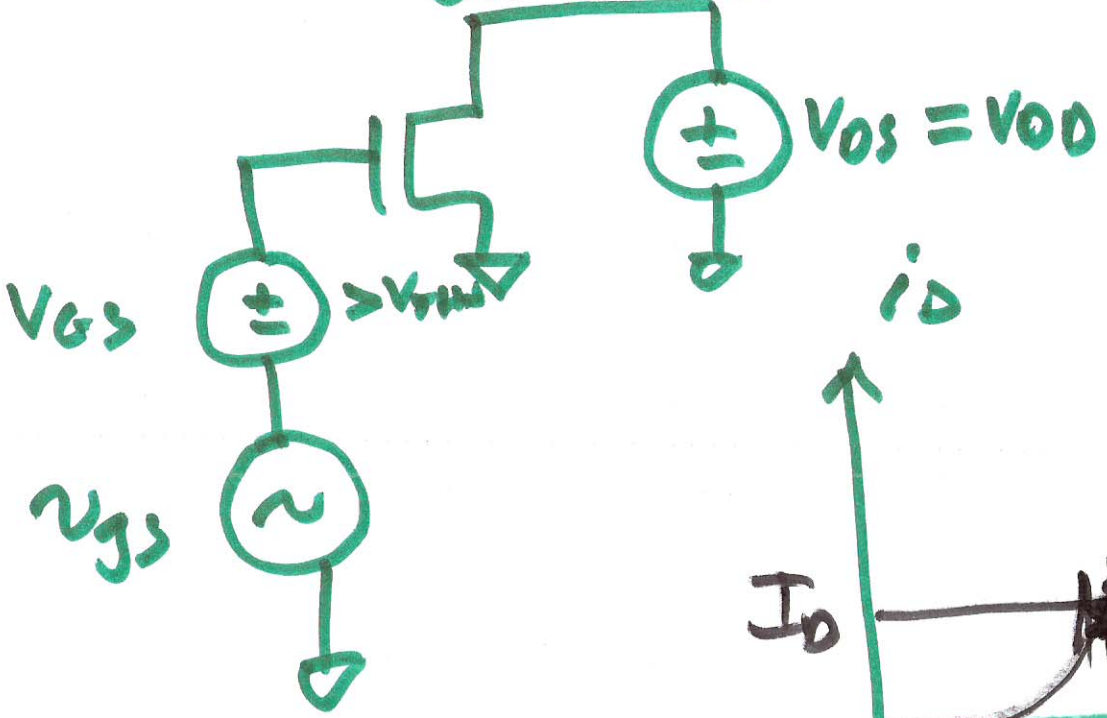
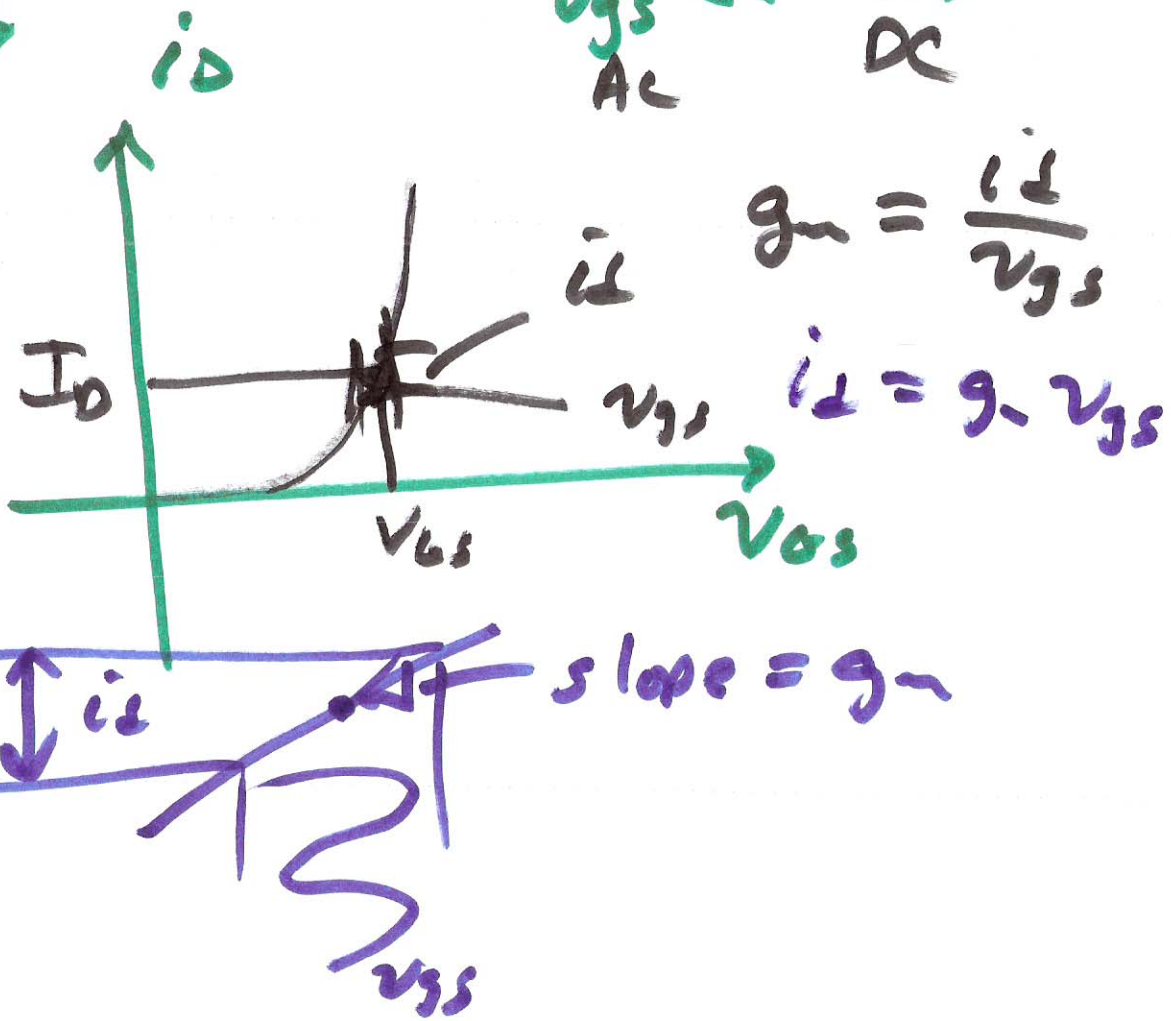
$i_D = \underbrace{I_D}_{DC} + \underbrace{i_d}_{AC}$

$v_{GS} = \underbrace{v_{gs}}_{AC} + \underbrace{V_{GS}}_{DC}$



$v_{gs} \ll V_{GS}$ (AC, DC)



10)

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

$$\beta_N = KP_N\cdot\frac{W}{L}$$

$$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_{\substack{I_D=\text{CONST}\\ V_{DS}=\text{CONST}}} = KP\cdot\frac{W}{L}\left(\underbrace{v_{GS}}_{\approx V_{GS},\ v_{GS}>>v_{gs}}-V_{THN}\right)\cdot 1 = g_m$$

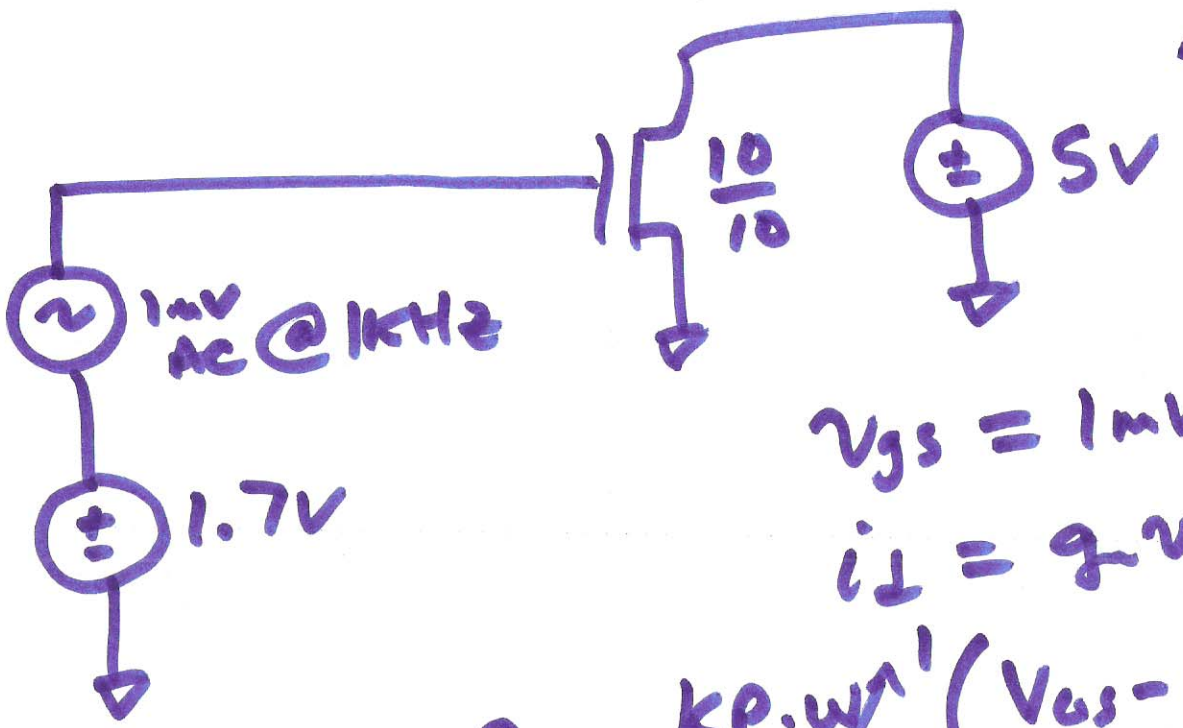
$$I_D = \frac{\beta}{2}(V_{GS}-V_{THN})^2$$

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

$$= \sqrt{\frac{2I_D}{\beta}} = \sqrt{\frac{2I_D}{KP\cdot\frac{W}{L}}}$$

11)

Long channel



$v_{gs} = 1mV$

$i_d = g_m v_{gs} = 108\frac{\mu A}{V} \cdot 1mV = 108\mu A$

$g_m = kp \cdot \frac{W}{L}(V_{GS} - V_{THN})$

$= 120\frac{\mu A}{V}(1.7 - .8)$

$= 108\mu A/V$

12)