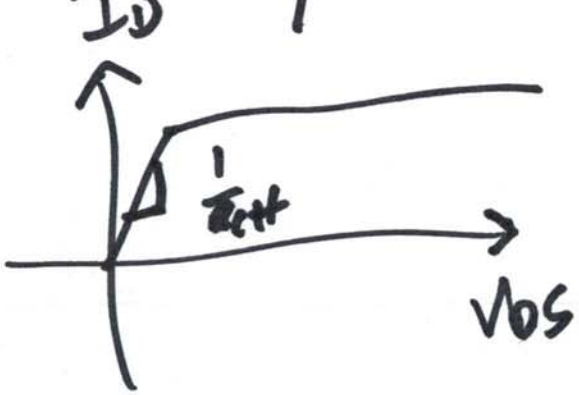
EE 420 / ECG 620

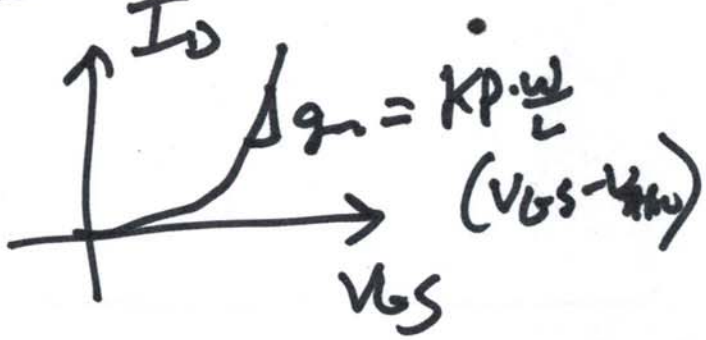
Analog IC Design

Lecture 4

JAN. 28, 2016

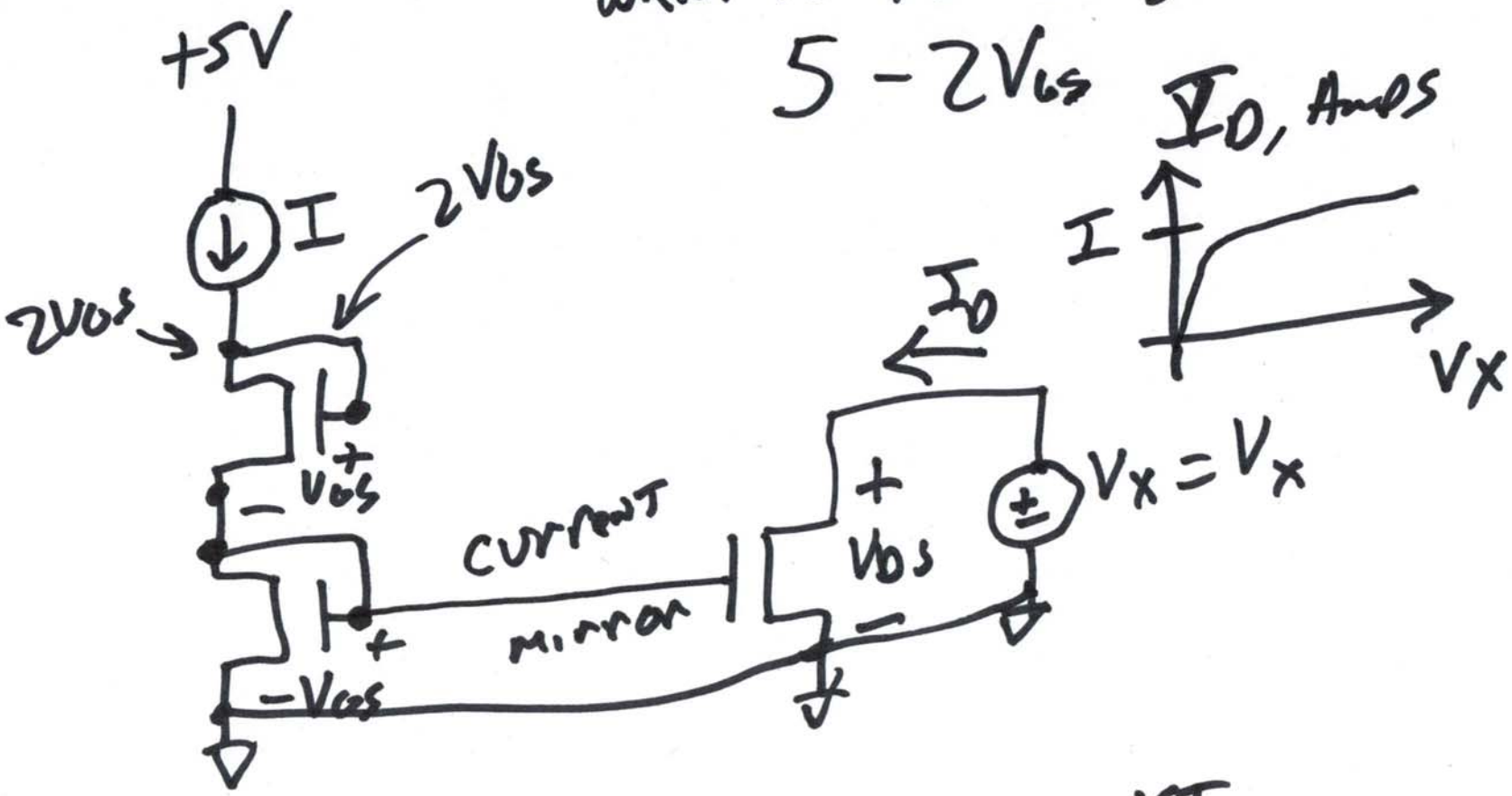
triode $\Big\}$ $R_{CH} = \dfrac{1}{K_P \cdot \frac{W}{L}\left[(V_{GS} - V_{THN}) - V_{DS}\right]}$





What is the voltage drop across I?

$5 - 2V_{GS}$

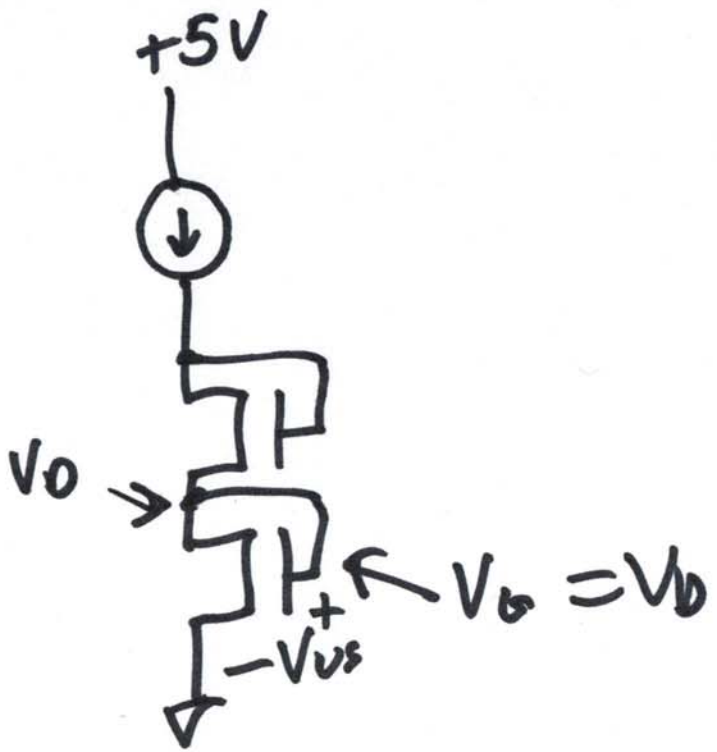


$$V_{GS} = \sqrt{\frac{2I}{KP \cdot \frac{W}{L}}} + V_{THN}$$

$$I = \frac{\beta_N}{2}\left(V_{GS} - V_{THN}\right)^2$$

(I: CONST; V_{GS}: CONST)

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



SAT!

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

$V_D \geq V_G - V_{THN}$

$0 \geq -V_{THN}$

YES

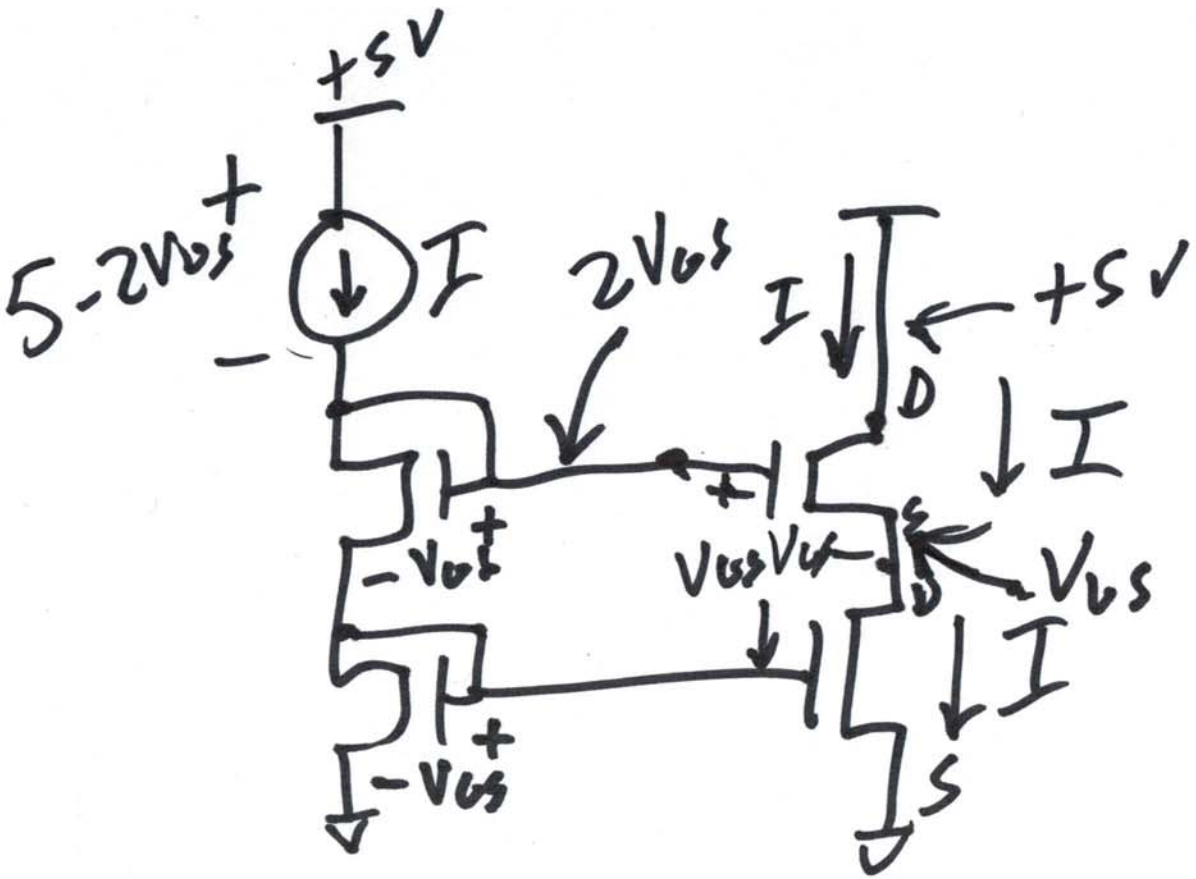
$$V_{GS} = \sqrt{\frac{2I}{\beta_N}} + V_{THN}$$

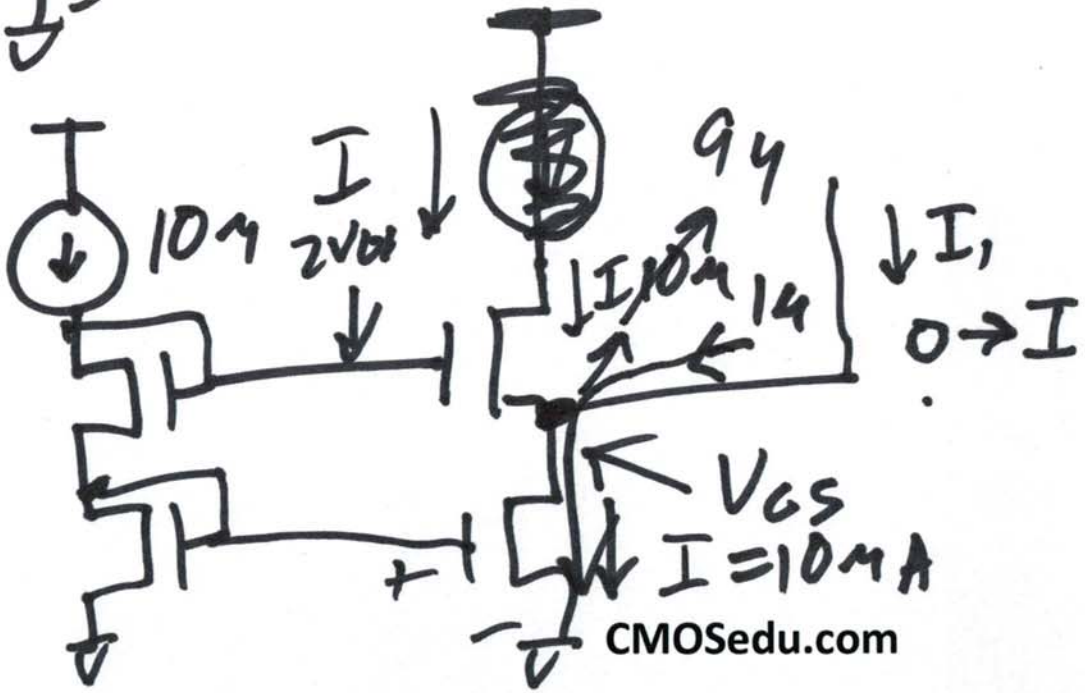
$$I = \frac{\beta_N}{2}\left(V_{GS} - V_{THN}\right)^2$$

SAT.

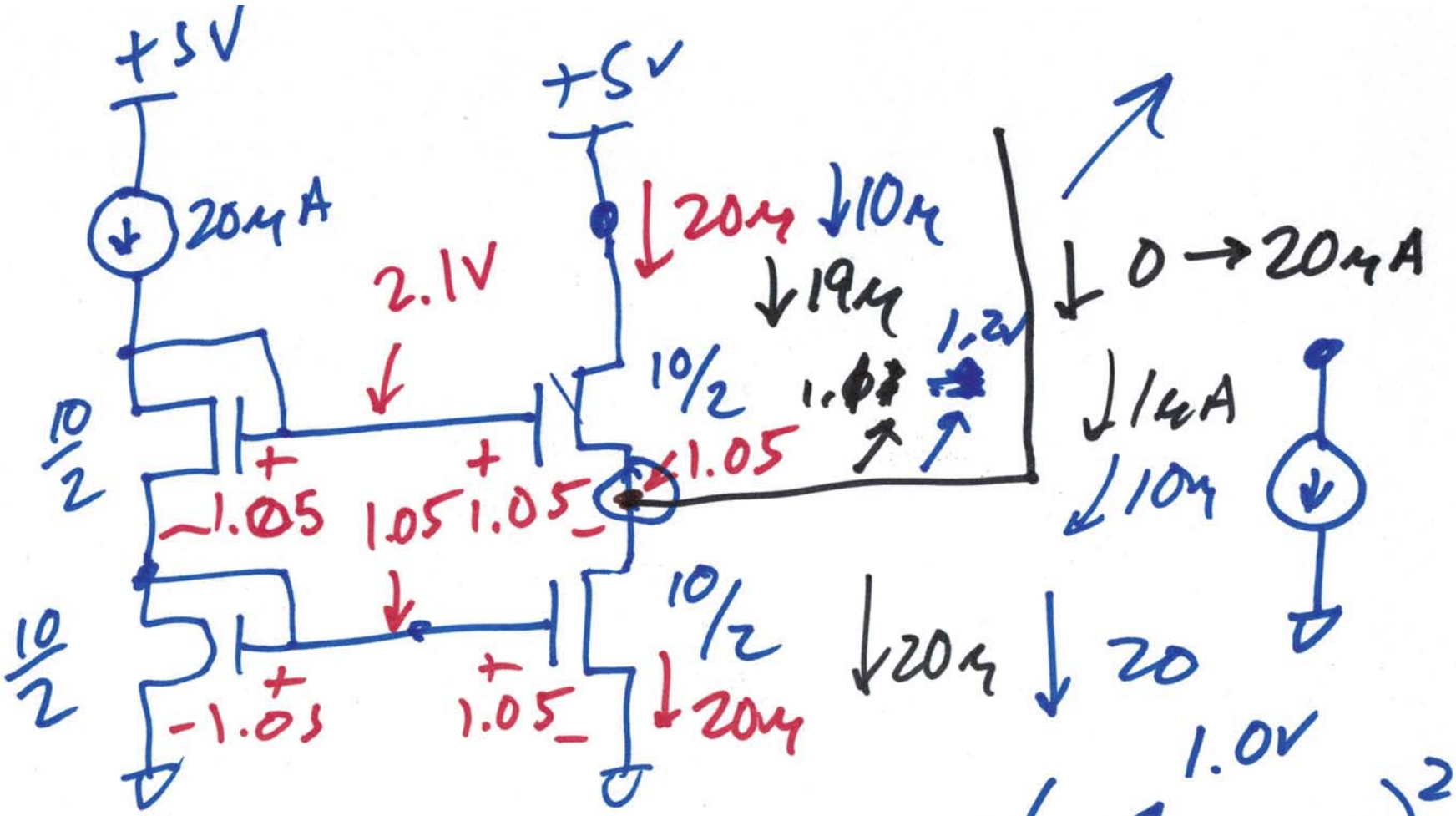
$V_{DS} \geq V_{GS} - V_{THN}$

$V_{GS} > V_{THN}$





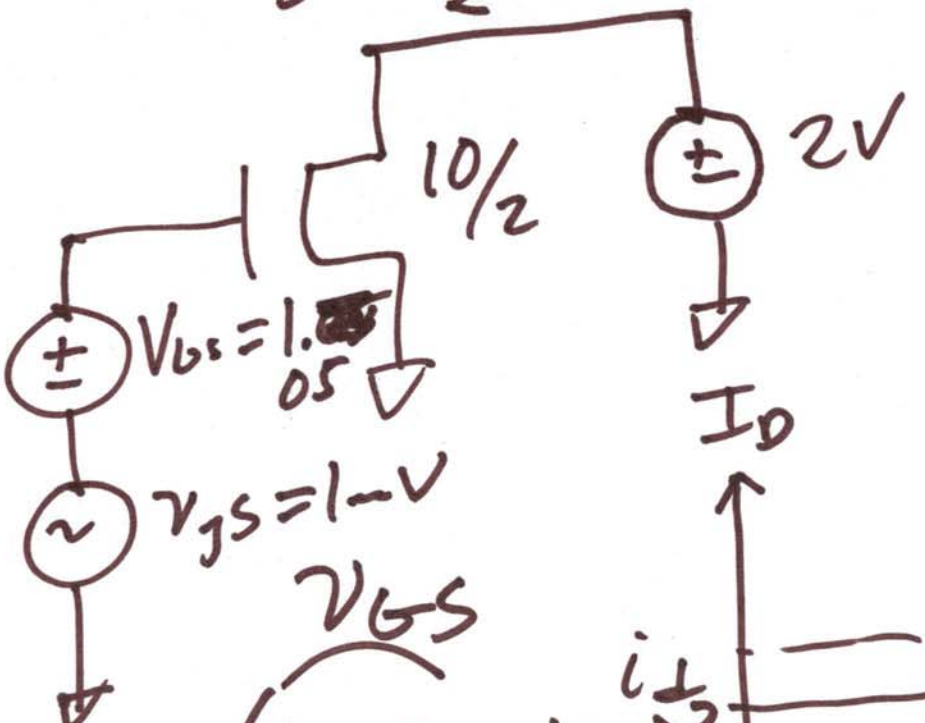
4)



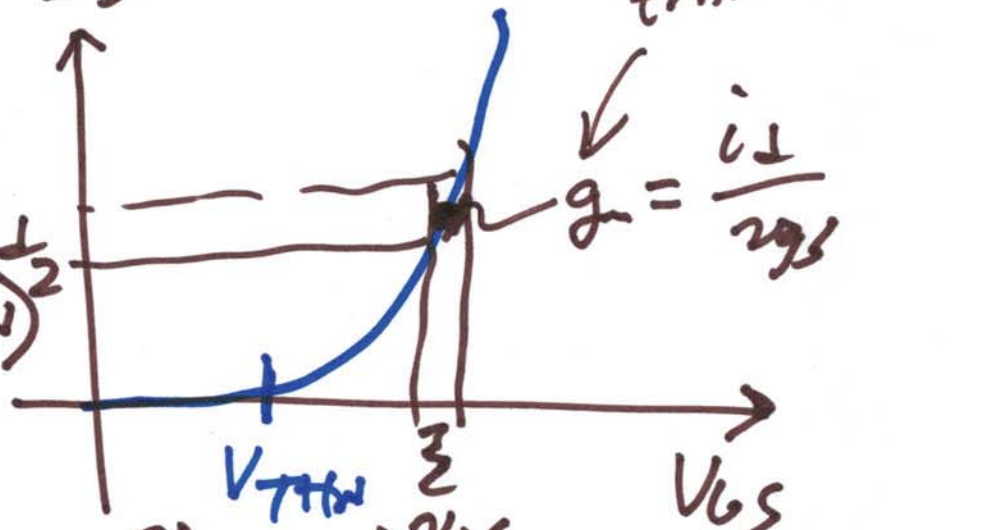
$$10_1 = \frac{K_{D_N}}{2} \cdot \frac{W}{L}\left(V_{GS} - 0.8\right)^2$$

$V_{GS} > V_{THN}$ YES $\quad V_{DS} > V_{GS} - V_{THN}$ YES

$i_D = I_D + i_d$



$$g_m v_{gs} = i_d$$



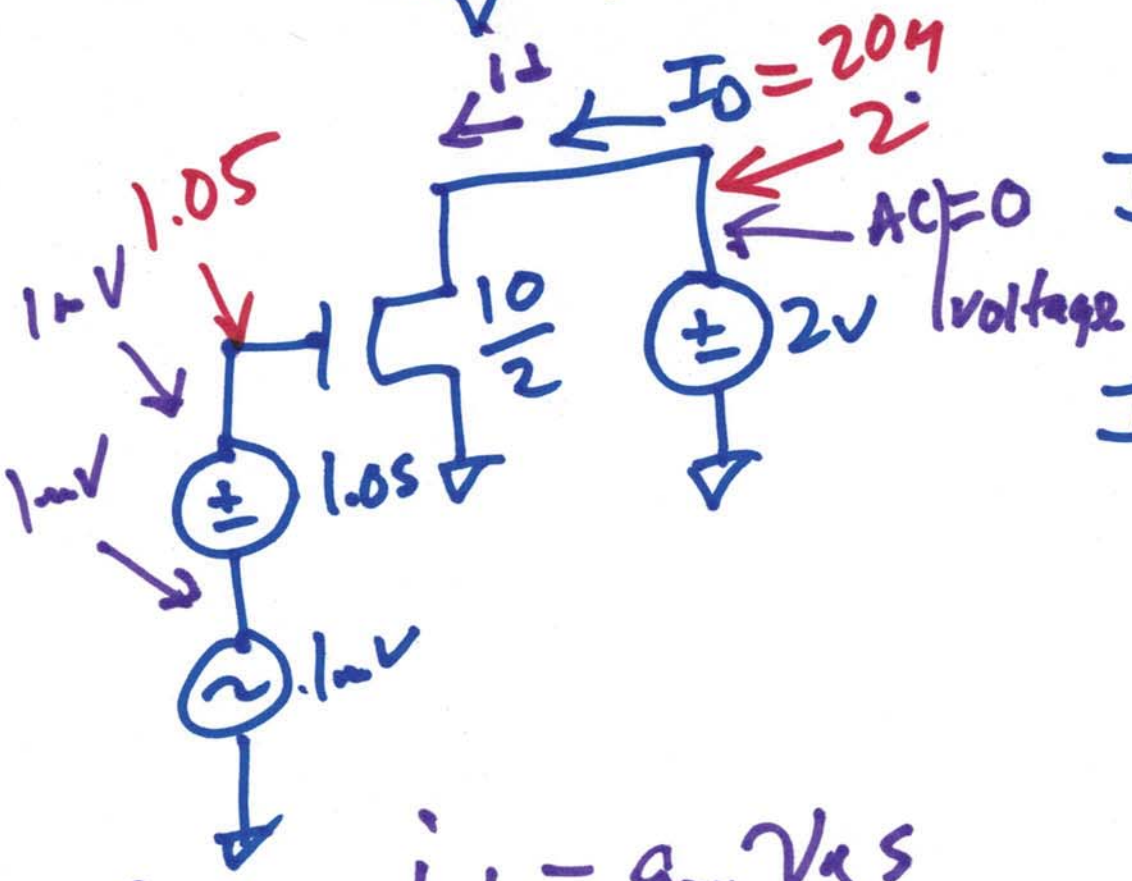
$$I_D + i_d = \frac{KP_N}{2}\cdot\frac{W}{L}\left(V_{GS} + v_{gs} - V_{THN}\right)^2$$

$$g_m = \left.\frac{\delta i_D}{\delta V_{GS}}\right|_{\substack{I_D = CONST \\ V_{DS} = CONST}} = KP_N \cdot \frac{W}{L}\left(V_{GS} + v_{gs} - V_{THN}\right)$$

$V_{GS} \gg v_{gs}$ — small-signal approx.

$$g_m \cong KP_N \cdot \frac{W}{L}\left(V_{GS} - V_{THN}\right)$$

$KP_N = 120\frac{\mu A}{V}$, $V_{THN} = 0.8V$



$$I_D = \frac{120\mu}{2}\cdot\frac{10}{2}(1.05-.8)^2$$

$$I_D = 20\mu A$$

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

$$= \frac{120\mu A}{V}\cdot\frac{10}{2}(.25)$$

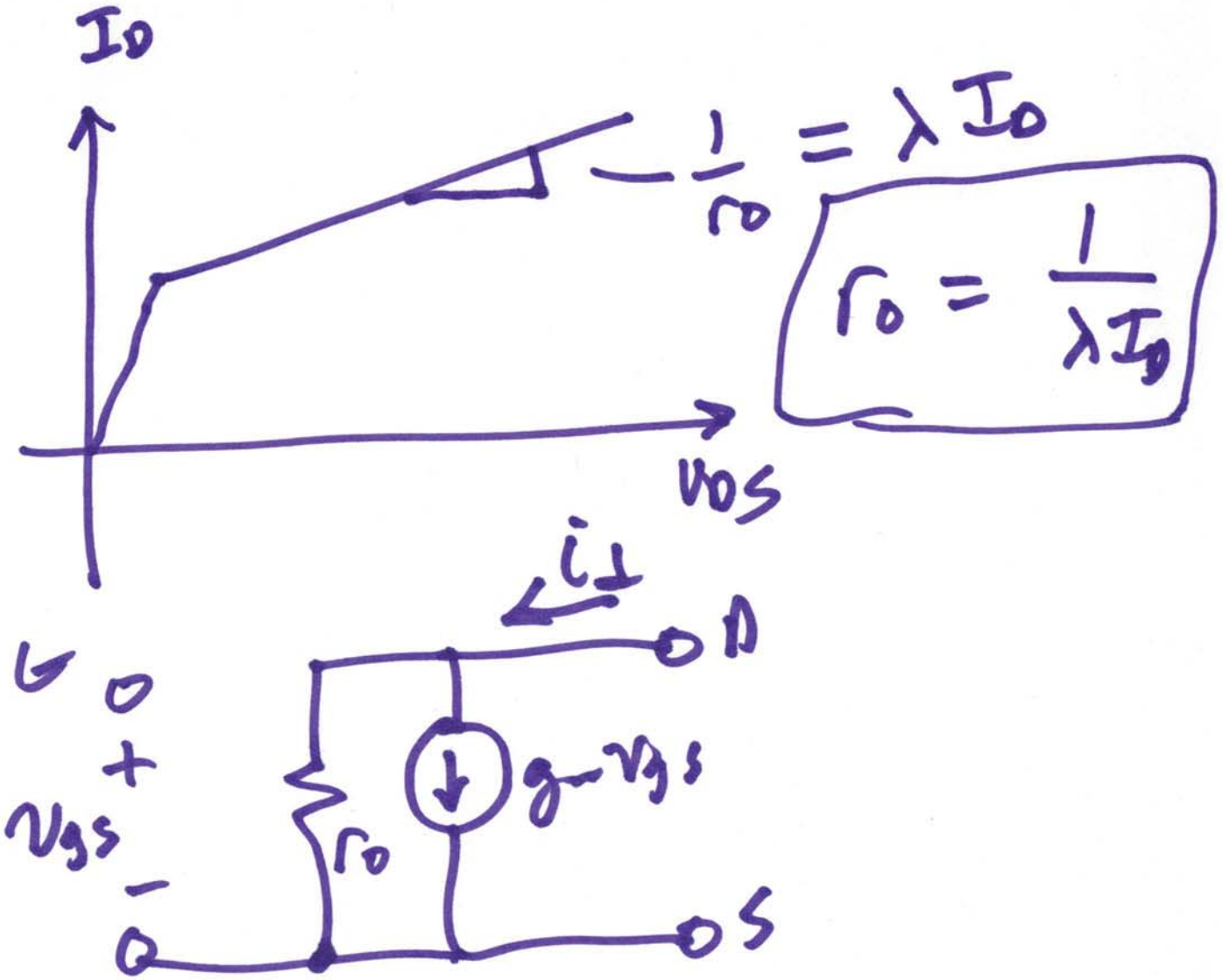
$$= 150\mu A/V$$

$$i_d = g_m v_{gs}$$

$$= 150\frac{\mu A}{V}\cdot .1mV$$

$$= 150nA$$

7)


I_D
$\frac{1}{r_o} = \lambda I_D$
$r_o = \frac{1}{\lambda I_D}$
v_{DS}
i_1
G
D
+
v_{gs}
−
r_o
$g_m v_{gs}$
S