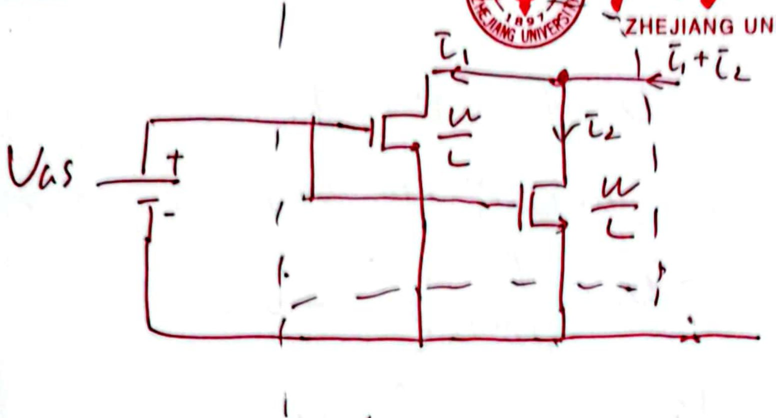
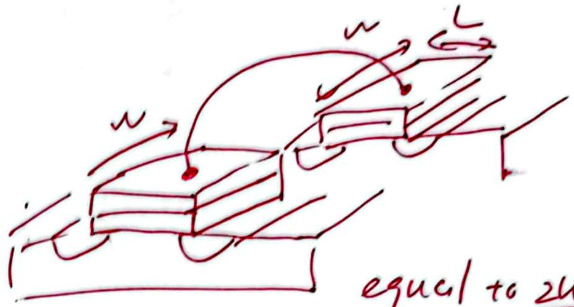


~~its~~ in thee dimension



equal to $\frac{2W}{L}$

derive in math:

$$I_1 = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2$$

$$I_2 = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2$$

$$I = I_1 + I_2 = \frac{1}{2}\mu_n C_{ox}\frac{2W}{L}(V_{GS}-V_{TH})^2$$

g_m:

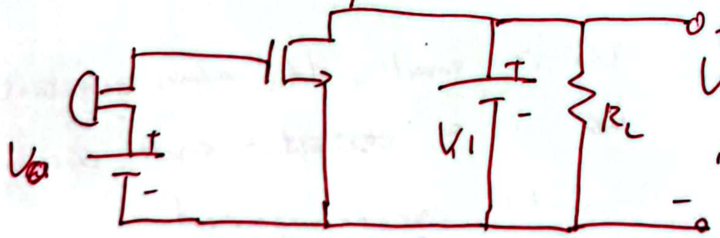
$$g_{m1} = \frac{2I_1}{V_{GS}-V_{TH}} \qquad g_{m2} = \frac{2I_2}{V_{GS}-V_{TH}}$$

$$g_m = \frac{2(I_1+I_2)}{V_{GS}-V_{TH}} = \frac{4I_1}{V_{GS}-V_{TH}} = 2g_{m1}$$

Let's build an amplifier:

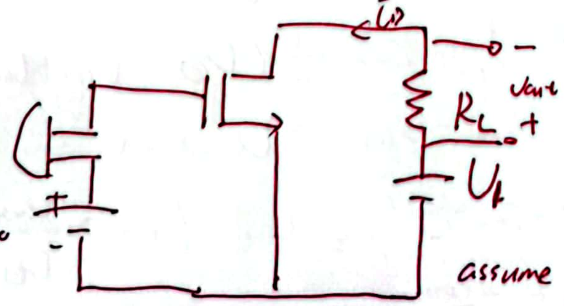
Last day we didn't consider V_{DS}.

Actually we must keep it in Sat.



is it true?

X the V_{out} is alway V_1



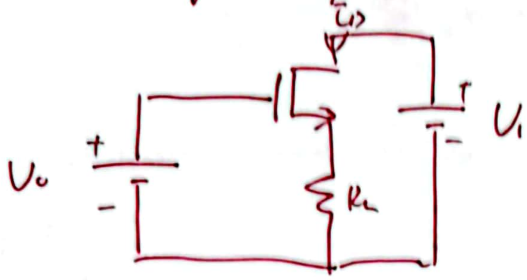
assume $V_D = 0.9V$. $V_{TH} = 0.5V$.

$\therefore V_{DS} \geq V_0 - V_{TH} = 0.4V$.

assume $\mu_n C_{ox}$; ~~assume~~ let $I_{Dmin} = 1mA$, assume $R_L = 1k\Omega$

$\therefore V_1 \geq I_{Dmin} \cdot R_L + V_{DS} = 1.4V$.

Large - Signal Operation



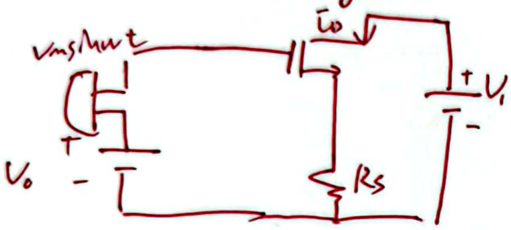
$$V_0 = V_{GS} + I_D \times R_L$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2$$

$$\Rightarrow V_{GS} = \sqrt{\frac{2I_D}{\mu_n C_{ox}\frac{W}{L}}} + V_{TH}$$

$$\therefore V_0 = \sqrt{\frac{2I_D}{\mu_n C_{ox}\frac{W}{L}}} + V_{TH} + I_D R_L$$

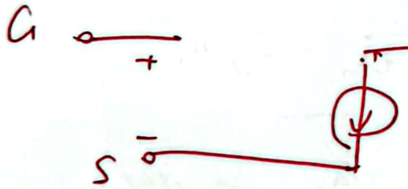
Let's add a signal



$$V_0 + V_m \sin\omega t = V_{GS} + I_D R_S$$

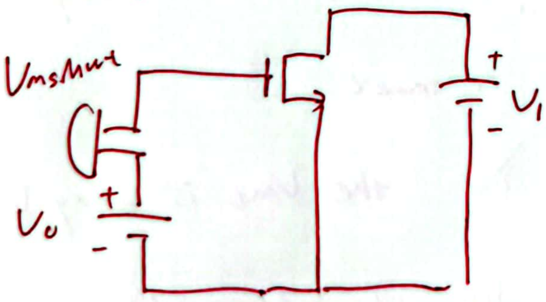
$$= \sqrt{\frac{2I_D}{\mu_n C_{ox}\frac{W}{L}}} + I_D R_S + V_{TH}$$

Large-signal operation (if V_m is not "small")



$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2$$

Small - Signal Operation



V_m is small, V_{GS} almost a constant

I_D is a ~~constant / small~~ constant

$\therefore R_S$ can be ignored

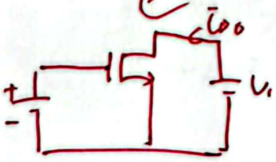
$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_0 - V_{TH} + V_m \sin\omega t)^2$$

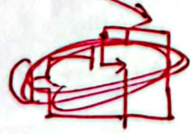
$$\because V_{GS} - V_{TH} >> V_m \sin\omega t$$

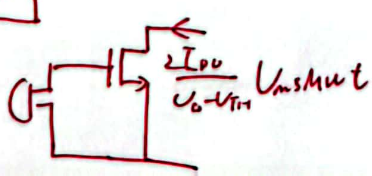
$(1+\varepsilon)^2 \simeq 1+2\varepsilon$

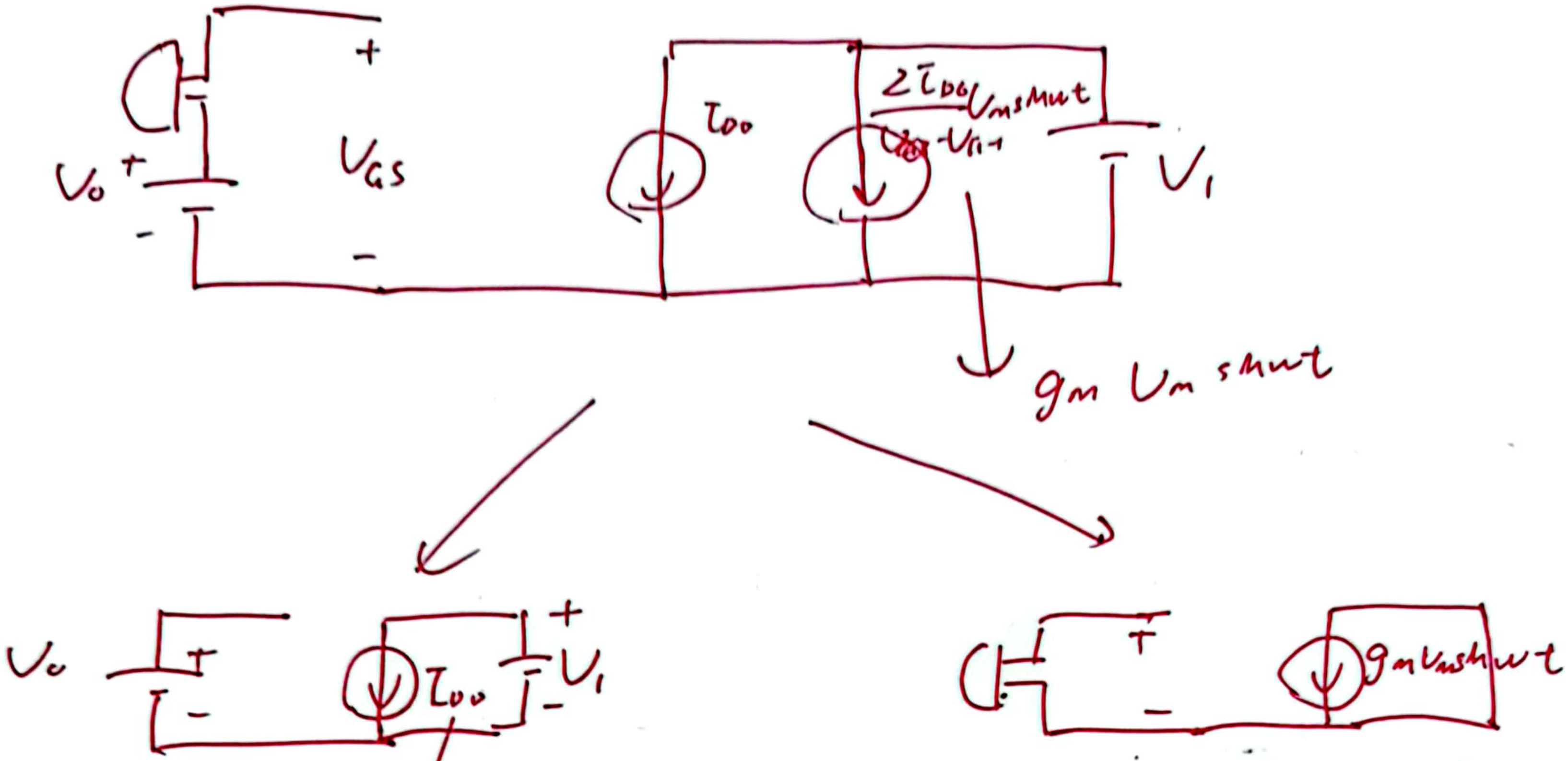
$$\Rightarrow I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_0 - V_{TH})^2\left(1 + 2\frac{V_m \sin\omega t}{V_0 - V_{TH}}\right)$$

$$= \underbrace{I_{D0}}_{\text{Bias current}} + \underbrace{\frac{2I_{D0}}{V_0 - V_{TH}} V_m \sin\omega t}_{\text{signal current}} \quad (V_0 \simeq V_{GS})$$









$\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2$

Small signal mode

DC and AC. t-dependent and not t-dependence

Large and small