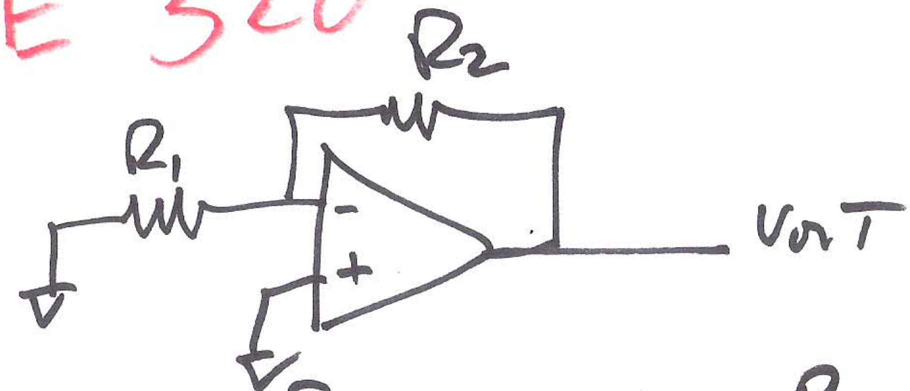
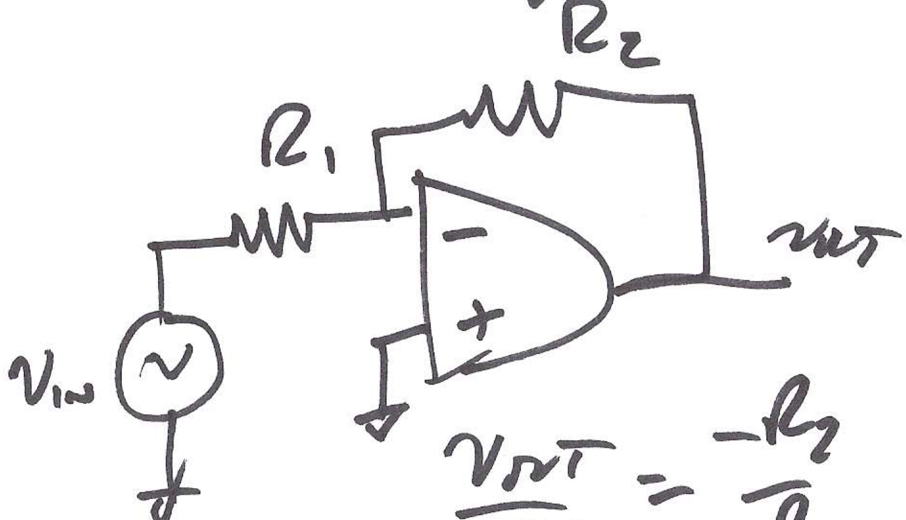
Lecture 13

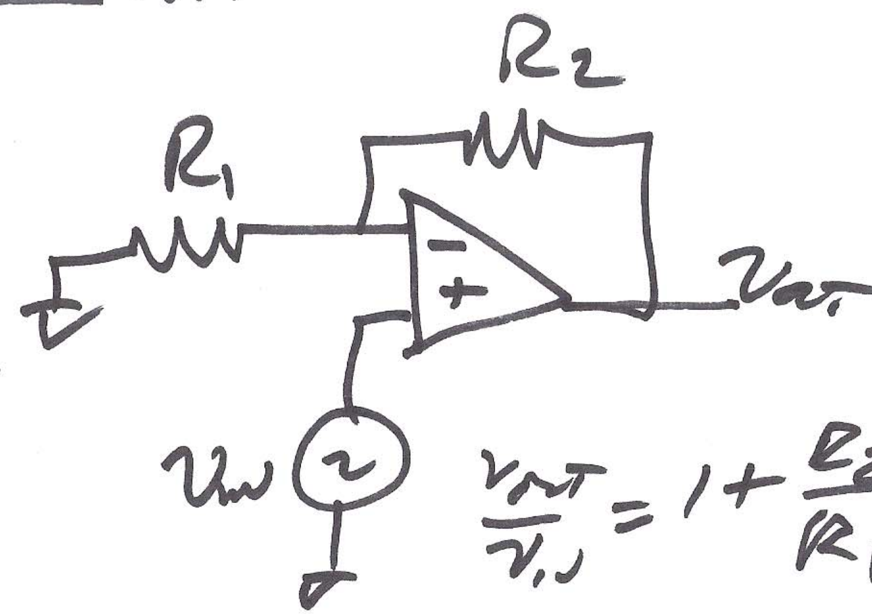
3/12/14

EE 320

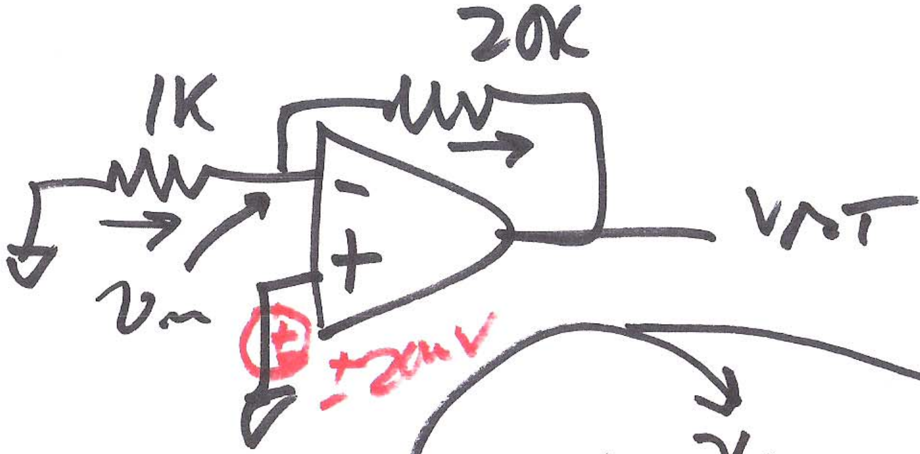




$$\frac{v_{OUT}}{v_{IN}} = \frac{-R_2}{R_1}$$



$$\frac{v_{OUT}}{v_{IN}} = 1 + \frac{R_2}{R_1}$$



a) $v_{OUT} = 0$

b) $v_{OUT} = 0$

c) $v_{OUT} = \pm 20mV\left(1+\frac{20}{1}\right) = \pm 420mV$

$$\frac{0 - v_{in}}{1K} = \frac{v_{in} - v_{OUT}}{20K}$$

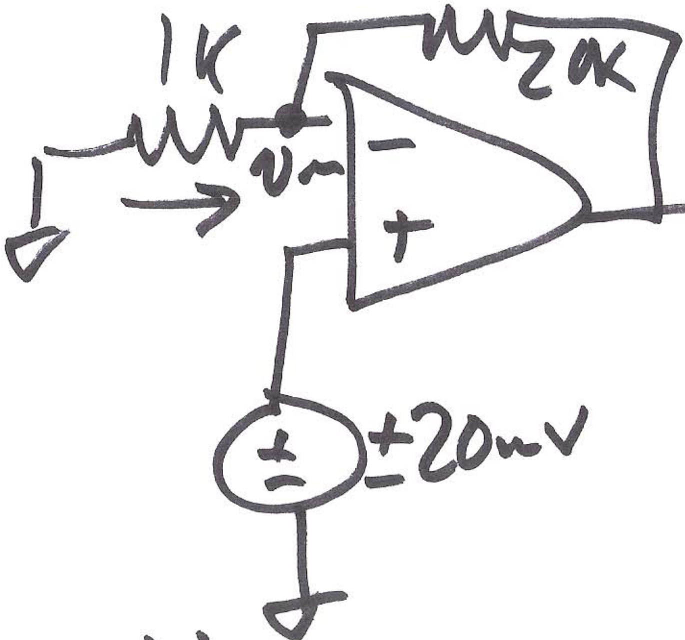
$$v_{OUT} = A_{OL}(0 - v_{in})$$

$$v_{in} = \frac{-v_{OUT}}{A_{OL}}$$

$$\frac{v_{OUT}}{A_{OL}\cdot 1K} = \frac{-v_{OUT}}{A_{OL}\cdot 20K} - \frac{v_{OUT}}{20K}$$

$$v_{OUT} = 0$$

2)



$2 = 0.02 \times 100$

$v_{OUT} = A_{OL}(v_p - v_m)$

$v_{OUT} = 100(\pm 20mV - v_m)$

$$\frac{0 - v_m}{1K} = \frac{v_m - v_{OUT}}{20K}$$

$$v_m = \frac{\pm 1}{60.5}$$

$$v_{OUT} = 100\left(\pm .02 \pm \frac{1}{60.5}\right)$$

$\pm 2 \mp 1.7$

$\pm .3V$?

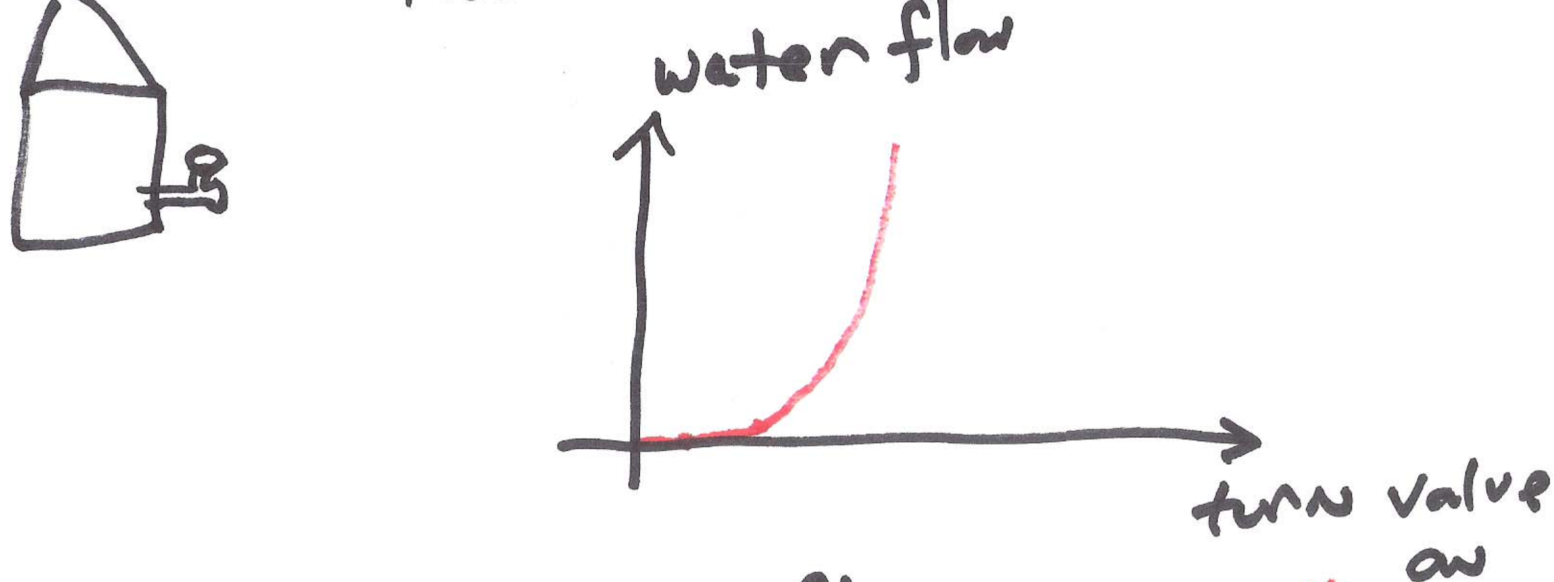
.347

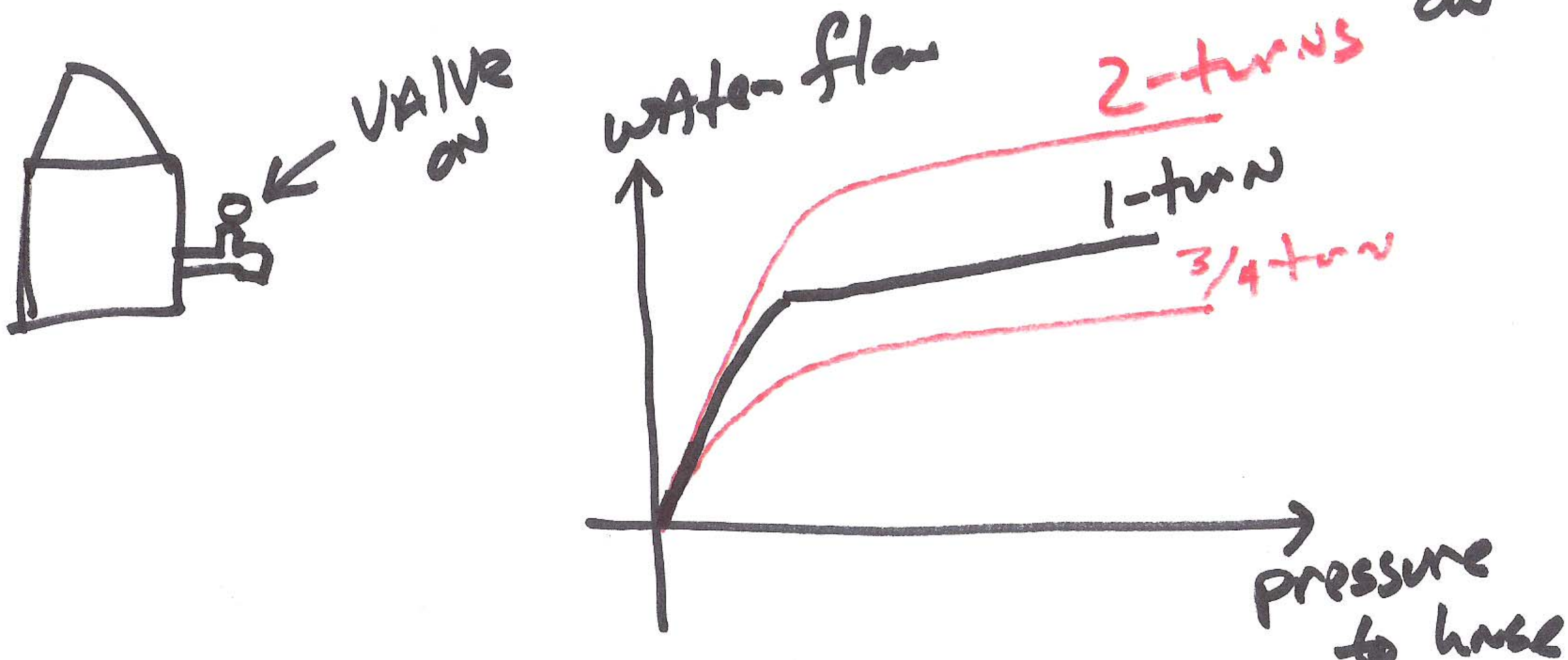
$$-\frac{v_m}{1K} = \frac{v_m}{20K} - \frac{100(\pm 20mV - v_m)}{20K}$$

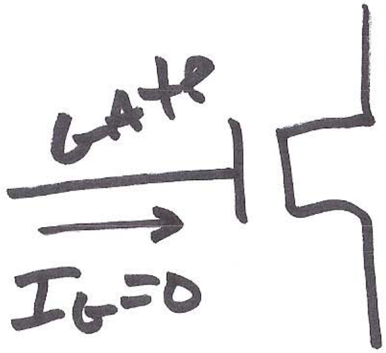
$$-v_m\left(\frac{1}{1K} + \frac{1}{20K} + \frac{100}{20K}\right) = \frac{\pm 1}{10K}$$

$$-v_m\left(10 + \frac{1}{2} + 50\right) = \pm 1$$

Hose Bib


water flow
turn valve on

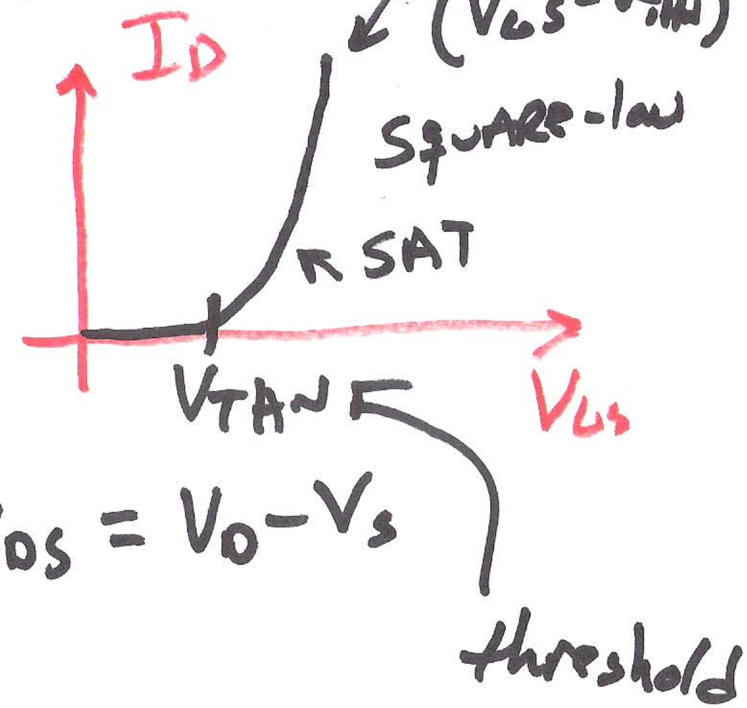

VAlve on
water flow
2-turns
1-turn
3/4-turn
pressure to hose

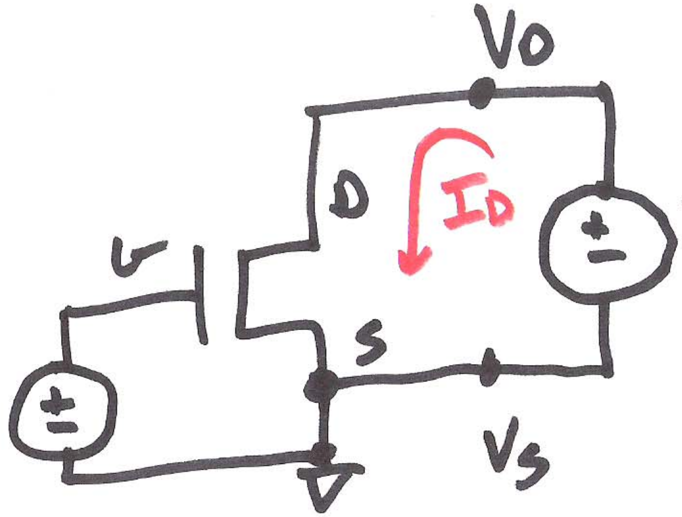


I_D = drain current

$I_S = I_D$

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



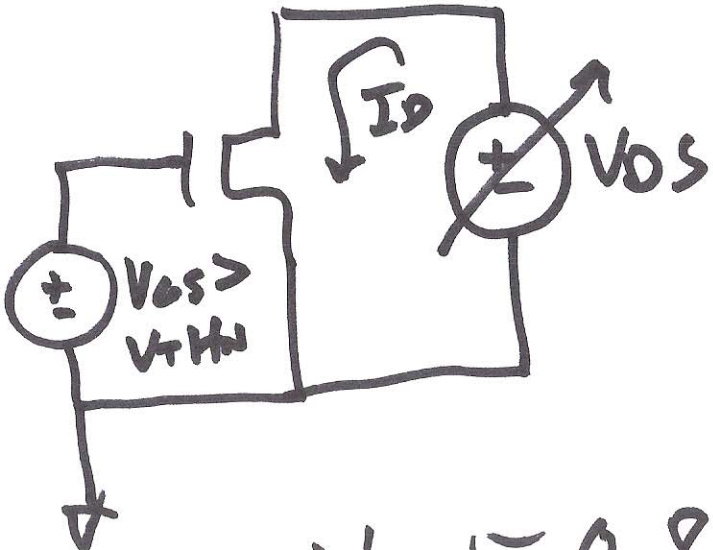


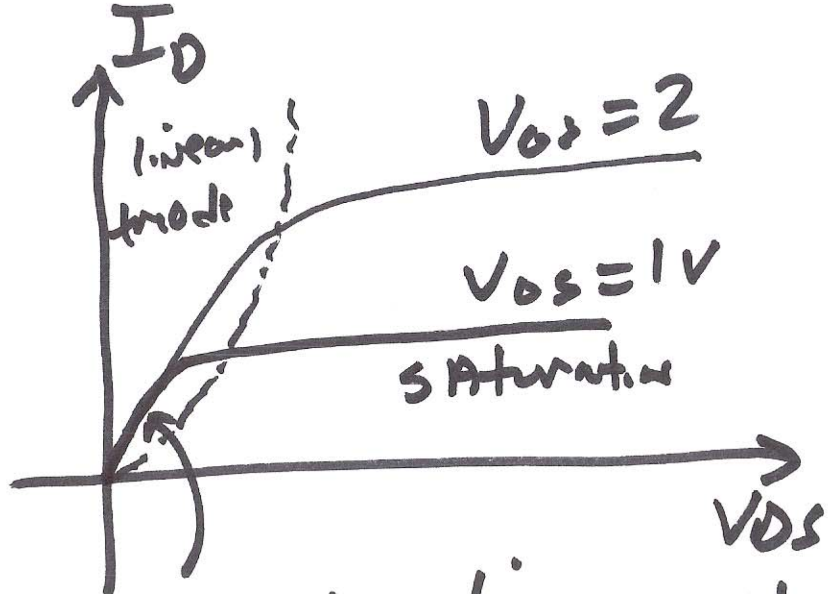
$V_{DS} = V_D - V_S$

$V_G - V_S = V_{GS}$

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

$K_n' = KP$ ← transconductance





triode, linear, ohmic

$V_{THN} = 0.8$

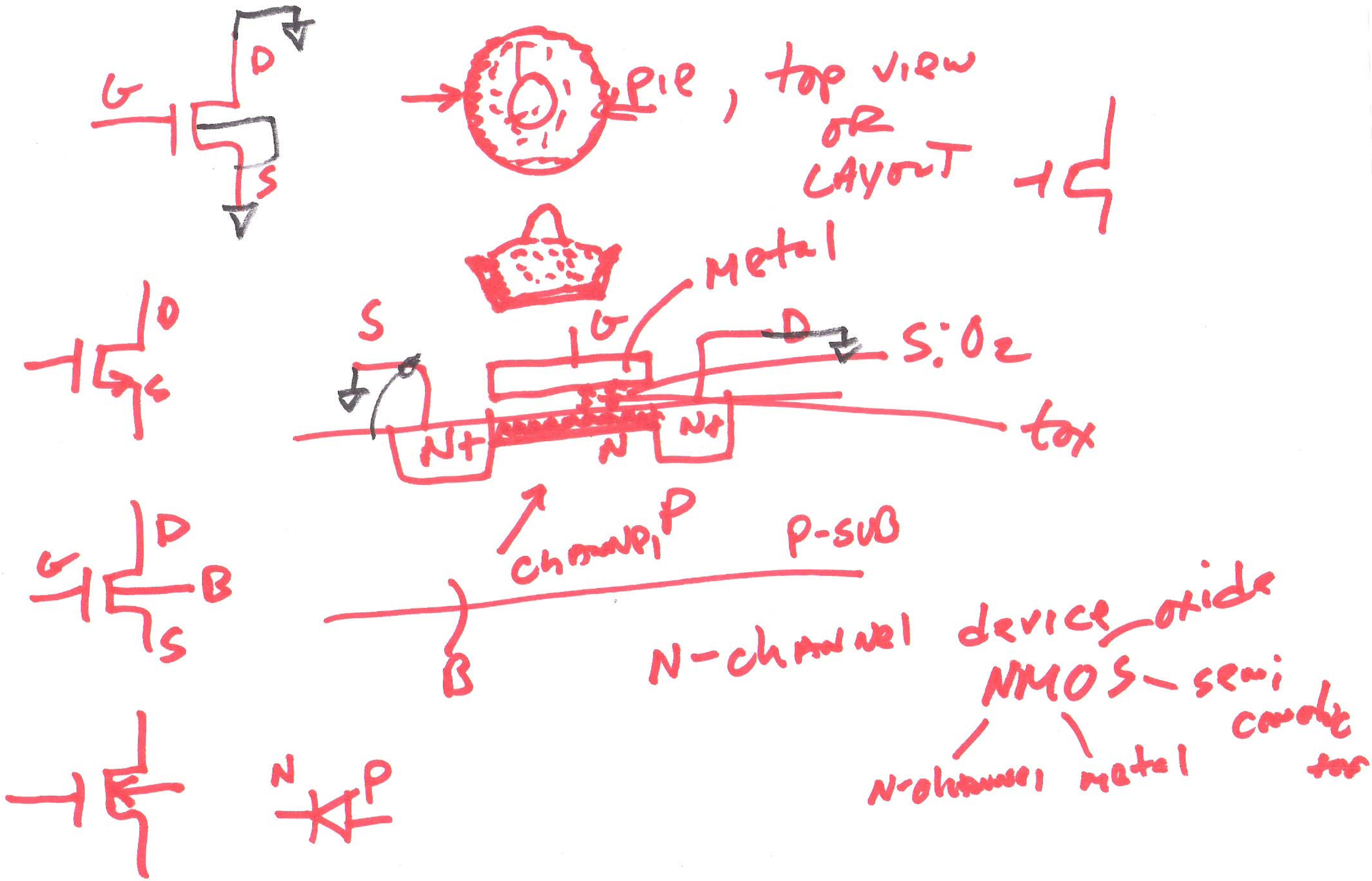
$V_{GS1} = 1V$

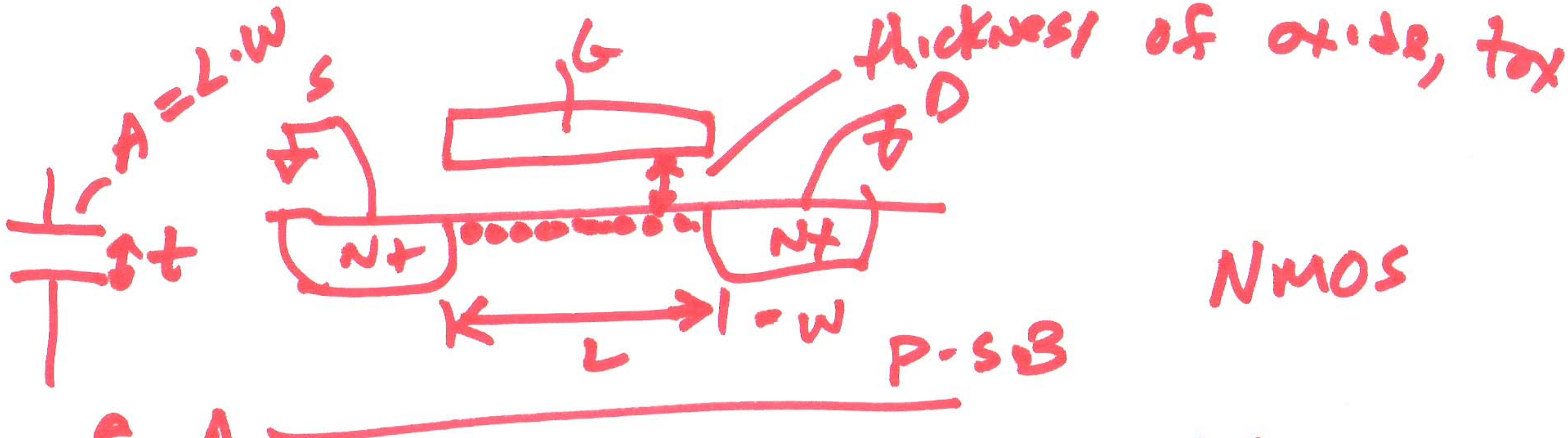
$V_{GS2} = 2V$

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

$V_{GS} > V_{THN}$

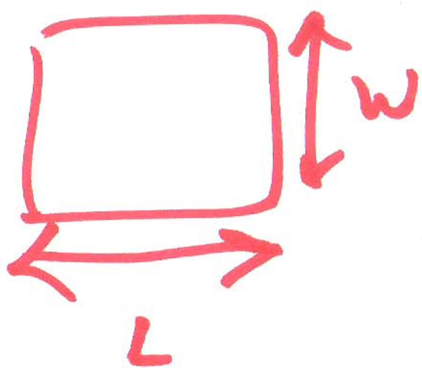
$V_{DS} \geq V_{GS} - V_{THN}$


G
D
S
Pie, top view
OR
LAYOUT
Metal
S
G
D
SiO2
N+
N
N+
tox
channel
P
P-SUB
B
D
S
D
G
B
S
N
P
N-channel device
NMOS
oxide
semi
conductor
N-channel
metal
tox



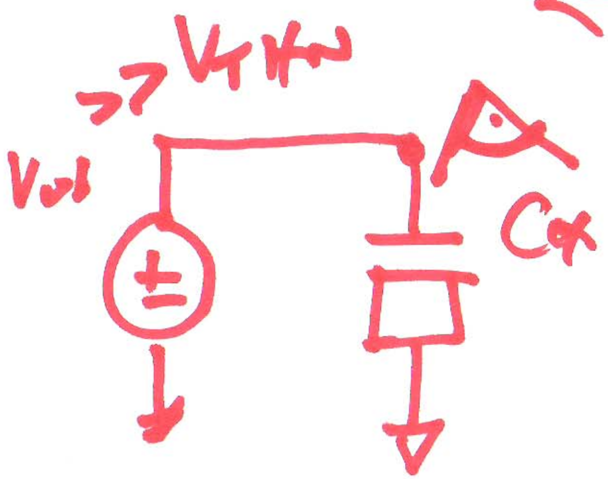
NMOS

$$C = \frac{\varepsilon}{t} \cdot A$$



$V_{GS} \gg V_{THN}$

strong inversion

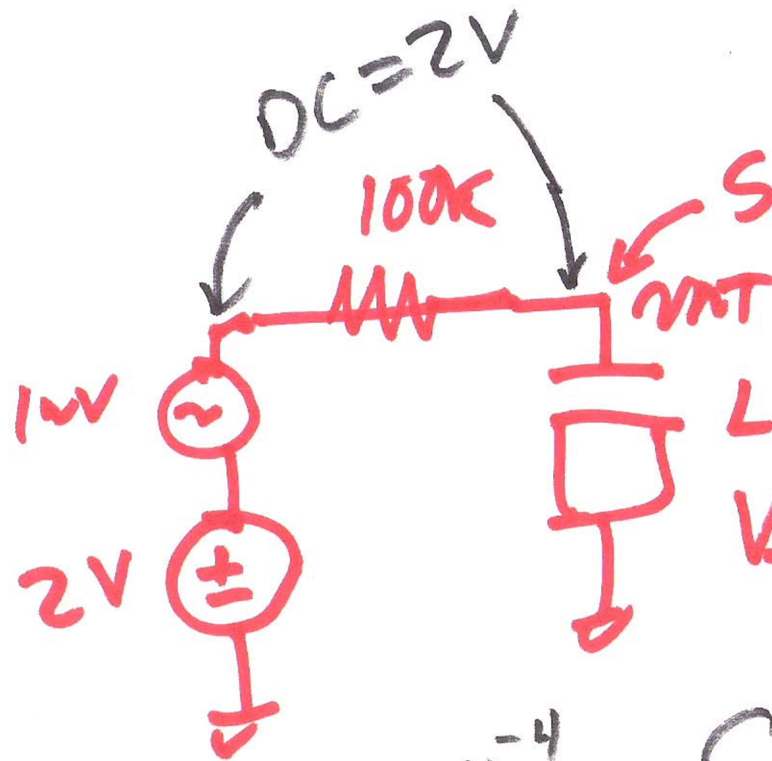


$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} \cdot W \cdot L$$

$$= C'_{ox} \cdot W \cdot L$$

$1\,\mathring{A} = 10^{-10}$

Sketch v_{OUT}.



$t_{ox} = 100\,\mathring{A} = 10\,nm$

$L = W = 100\,\mu m$

$V_{THN} = 1V$

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} \cdot W \cdot L$$

$$\epsilon_0 = 8.85 \times 10^{-14}\,F/cm \cdot \frac{10^{-4}}{10^{-4}}$$

$$\downarrow$$

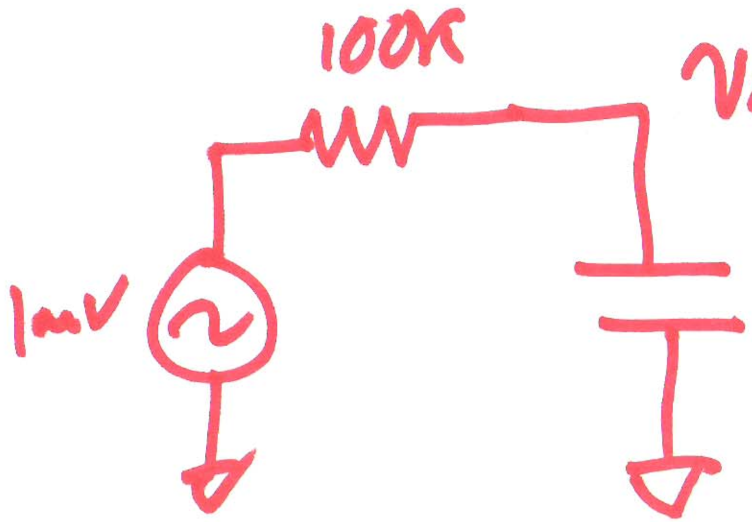
$$8.85 \times 10^{-18}\,\frac{F}{\mu m}$$

$$\epsilon_{ox} = 3.9 \cdot \epsilon_0$$

$$= \frac{3.9 \cdot 8.85 \cdot 10^{-18}\,F/\mu m \,(100 \cdot 10^{-6})^2}{10 \cdot 10^{-9}} \rightarrow 10 \cdot 10^{-3} \cdot 10^{-6}$$

$$= \frac{3.9 \cdot 8.85 \cdot 10^{-15} \cdot 100^2}{10 \cdot 10^{-3}}$$

$$= 34.5\,pF$$



$v_{out} = \frac{1}{2}$ mV @ what f ? ← frequency

$$\frac{v_{out}}{v_{in}} = \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + R} = \frac{1}{1 + j\omega RC}$$

$$\left|\frac{v_{out}}{v_{in}}\right| = \frac{1}{2} = \sqrt{\frac{1}{1 + (2\pi f \cdot 100k \cdot 35pF)^2}}$$

$$\frac{1}{4} = \frac{1}{1 + (\quad)^2}$$

$$1 + (2\pi f \cdot 100k \cdot 35pF)^2 = 4$$

$$2\pi f \cdot 100k \cdot 35pF = \sqrt{3}$$

$$f = \frac{\sqrt{3}}{2\pi \cdot 100k \cdot 35pF} = 78.8kHz$$

$$20 \log 10^{-3}$$

$$-60 \log 10 = -60dB$$