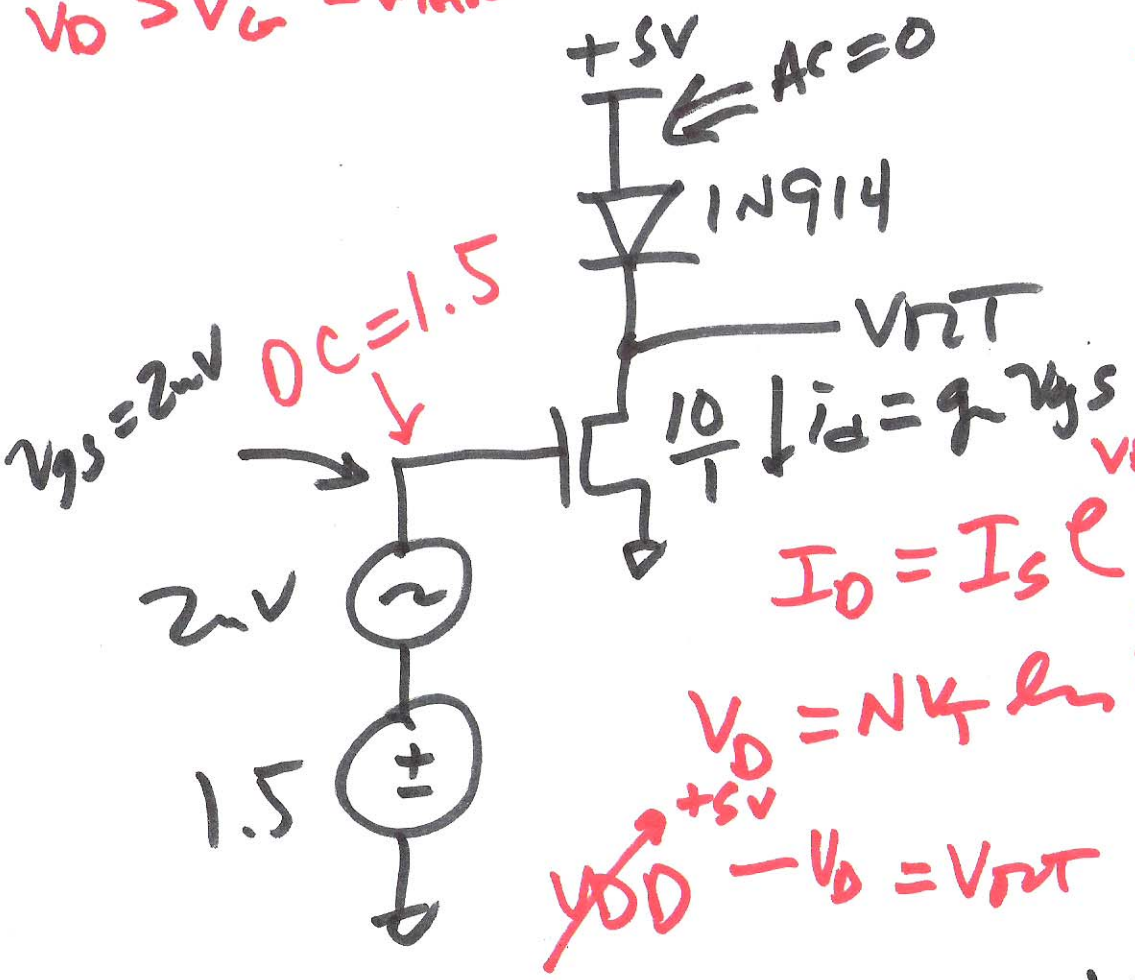
Lecture 17

April 2, 2014

EE 320!

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

$V_D > V_G - V_{tnN}$



$I_D = \frac{K_{PN}}{2} \cdot \frac{W}{L} (V_{GS} - V_{tN})^2$

$= \frac{120\mu}{2} \cdot \frac{10}{1} (1.5 - .8)^2$

$V_D/nV_T = 600\mu \cdot .49$

$\approx 294\mu A$

$I_D = I_S e^{V_D/nV_T}$

$V_D = nV_T \ln \frac{I_D}{I_S}$

$I_S = 2.52N$

$N = 1.752$

$V_D = 1.752(26mV) \ln \frac{294\mu}{2.52N}$

$V_D = .568V$

$V_{DD} - V_D = V_{DT}$ (+5V)

$V_{DT} = 4.432V$

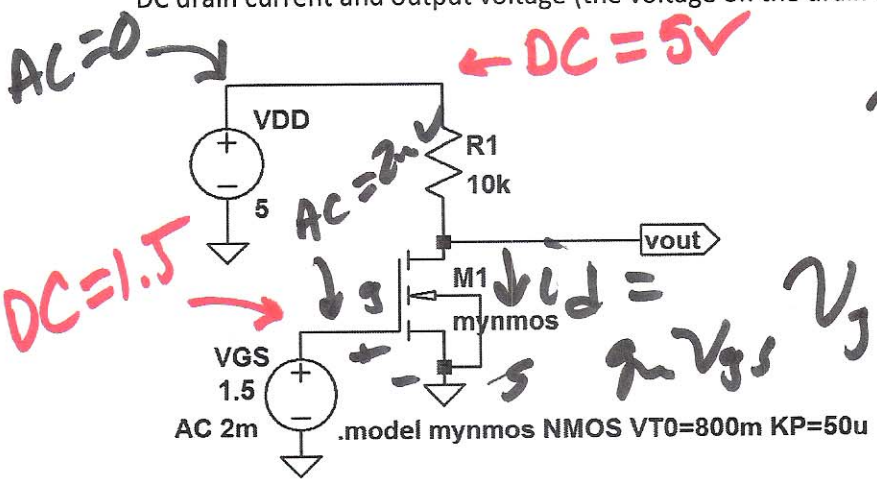
$V_{DT} = 5 - .568$

1)

Quiz 9 EE 320 Electronics, Spring 2014 Name:_____

Open book and closed notes.

1. If the transconductance, g_m, of M1 is 200 µA/V then calculate the AC drain current, i_d, and the AC output voltage, v_{out}. If the width of the MOSFET is 10 µm and the length is 5 µm calculate the DC drain current and output voltage (the voltage on the drain of M1).



$v_{gs} = v_g - v_s$

$= 2mV$

$v_g = 2mV$

$v_s = 0$

$i_d = g_m v_{gs}$

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

$= \frac{50\mu}{2} \frac{10}{1} (1.5 - .8)^2$

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

$i_d = g_m V_{gs} = \frac{200\mu A}{V} \cdot 2mV$

$i_d = 400\mu A$

400µA, 10K, v_{out}

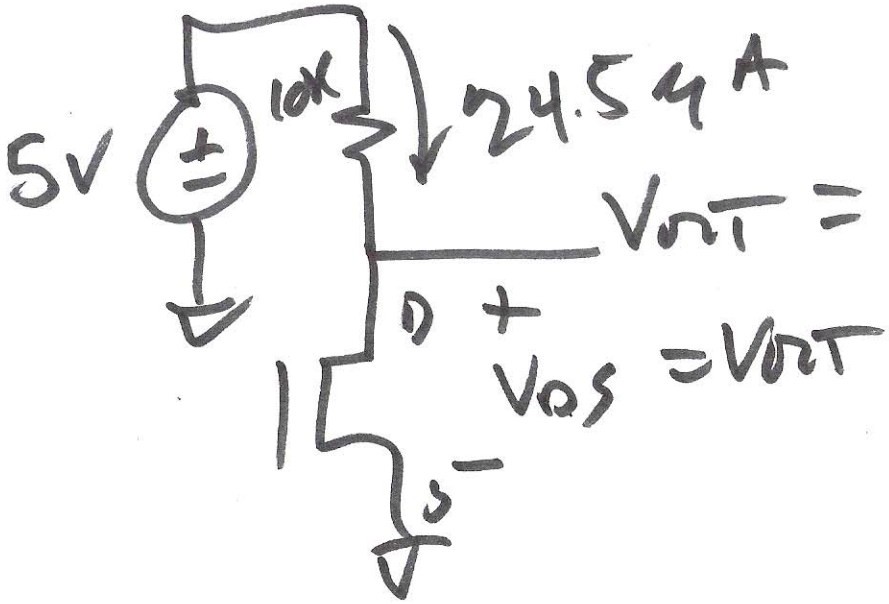
$v_{out} = -400\mu A \cdot 10K$

$v_{out} = -4mV$

2)

$$I_D = \frac{50\mu}{2}\frac{10}{5}(1.5-.8)^2$$

$$= 50\mu \cdot .49 \simeq \boxed{24.5\mu A}$$

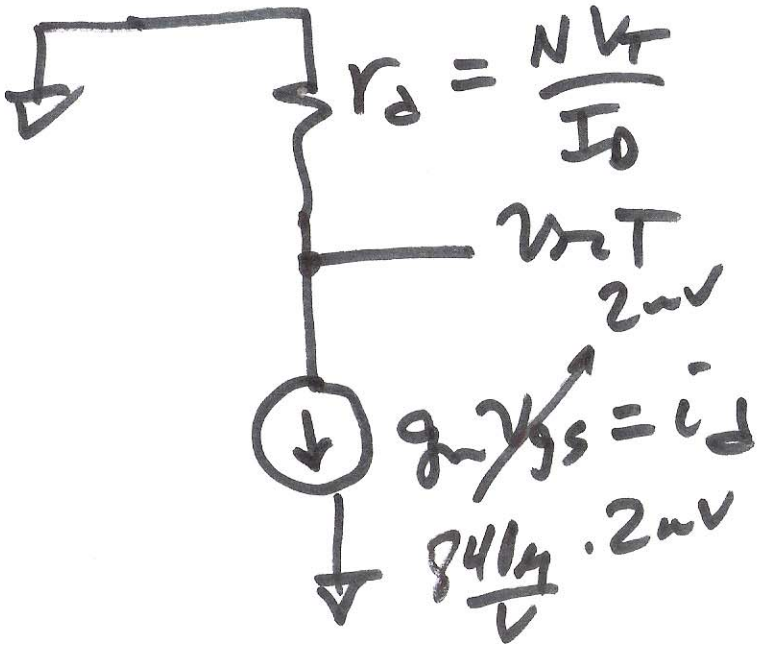


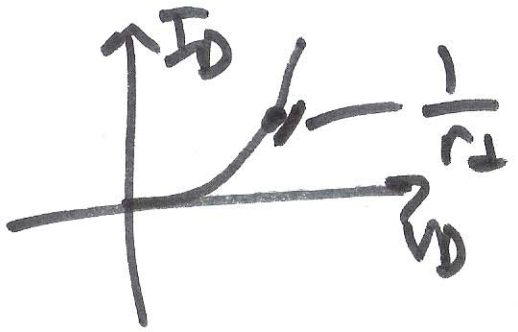
$245\ 10^{-3}$

$$V_{OUT} = 5 - 24.5\mu A \cdot 10K$$

$$= 2\cancel{1}.55V = V_{OS}$$

$$\boxed{4.755V}$$





$$r_d = \frac{1.752 \cdot 26mV}{295\mu}$$

$$r_d = 154\Omega$$

$$i_d = 1680\mu \cdot v_{gs} = 120\mu\frac{A}{V^2} \cdot \frac{10}{1}(1.5 - .8)V$$

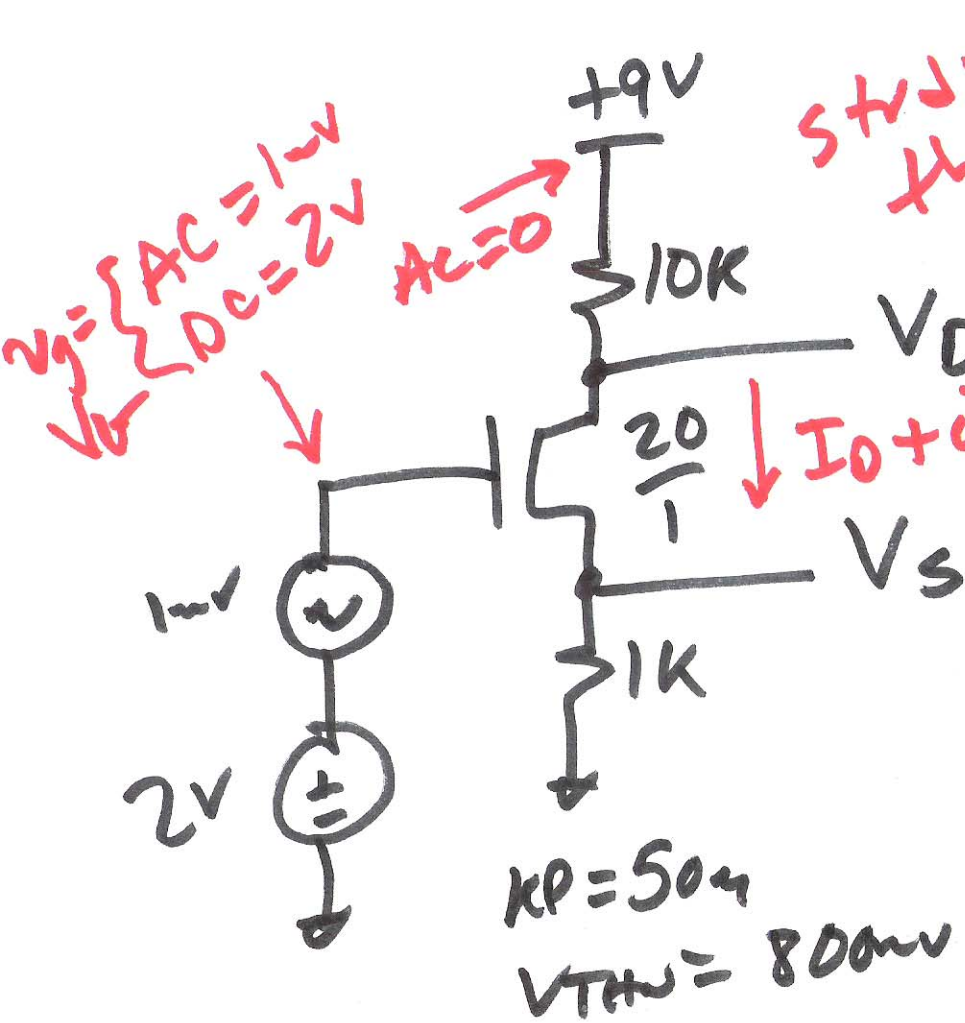
$$\boxed{i_d = 1.68\mu A} = 1.2\mu\frac{A}{V^2} \cdot .7$$

$$= 840\mu\frac{A}{V}$$

$$v_{out} = -i_d \cdot r_d$$

$$= -1.68\mu \cdot 154$$

$$\boxed{= -258\mu V}$$



study this!

DC AC

$$V_D = 9 - I_D \cdot 10K + (-i_d \cdot 10K)$$

$$V_S = i_D \cdot 1K = \underbrace{I_D \cdot 1K}_{DC} + \underbrace{i_d \cdot 1K}_{AC}$$

$V_G - V_S$

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

$25\mu \quad 20$

$$I_D = \frac{KP}{2} \cdot \frac{W}{L}\left(\underbrace{2 - I_D \cdot 1K}_{=V_{GS}} - .8\right)^2$$

500μ

$\frac{1}{2}m \cdot 3$

$\frac{10}{2}$

$$(1.2 - I_D \cdot 1K)^2$$

5)

$\frac{2I_D}{10^{-3}} = 2000 I_D$ $\quad I_D = \frac{10^{-3}}{2} \cdot (1.2 - I_D \cdot 1K)^2$

$V_D = 9 - I_D \cdot 10K$ $\quad 2{,}000 I_D = (1.2 - I_D \cdot 1K)(1.2 - I_D \cdot 1K)$

$= 9 - 3564 \cdot 10K$ $\quad I_D 2\times10^3 = 1.44 - 2.4K I_D + I_D^2 \cdot 10^6$

$= 9 - 3.56V$

$V_D = 5.44V$ $\quad I_D^2 \cdot 10^6 - 4.4K I_D + 1.44 = 0$

$V_S = 356\,mV$ $\quad I_D^2 - 4.4m I_D + 1.44_4 = 0$

$V_{DS} = 1.644V$ $\quad I_D = \frac{4.4m \pm \sqrt{(4.4-)^2 - 4(1.44_4)}}{2}$ $\quad .00368$

V_D

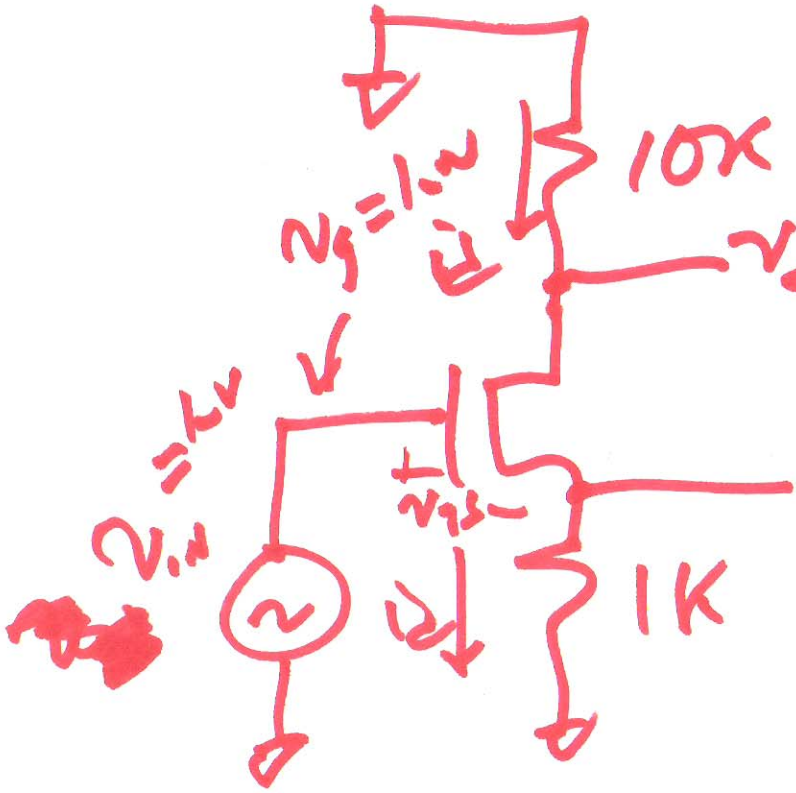
$4.04\,mA$

$3564A$ $= I_D$

UNLV | ELECTRICAL & COMPUTER ENGINEERING

CMOSedu.com

6)



$$\frac{v_s}{v_{in}} = \frac{1K}{\frac{1}{g_m} + 1K}$$

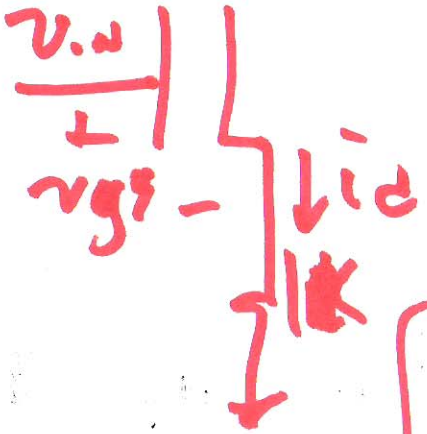
$$v_d = -i_d \cdot 10K \leftarrow$$

$$v_s = i_d \cdot 1K$$

$$i_d = g_m v_{gs} \leftarrow$$

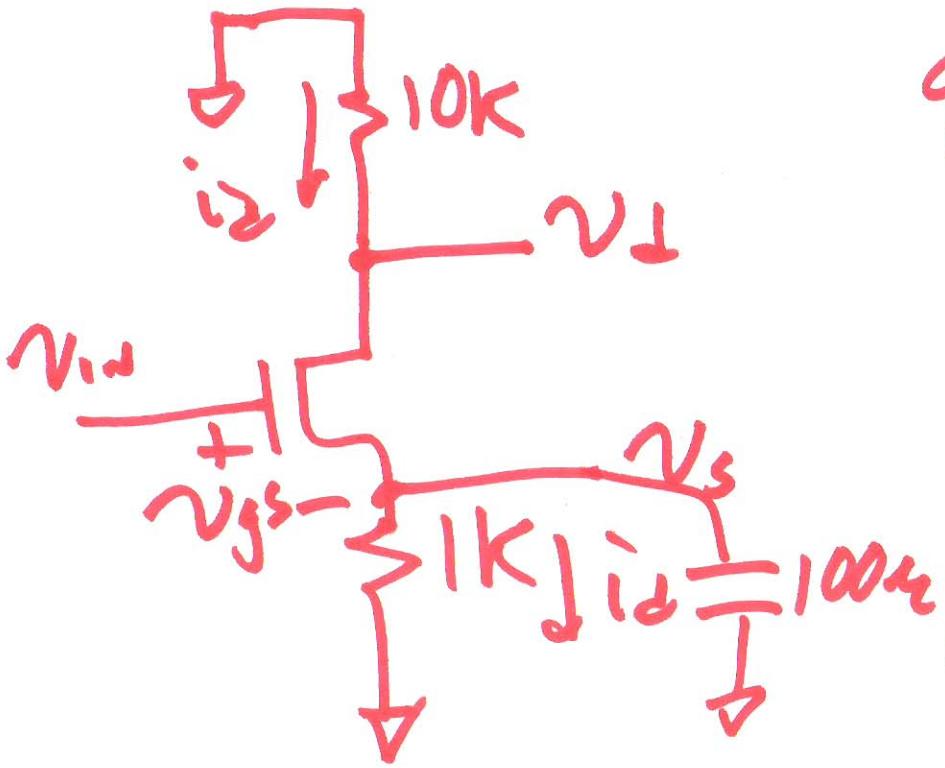
$$v_{in} = v_{gs} + i_d \cdot 1K$$

$$= i_d \left(\frac{1}{g_m} + 1K \right)$$



$$\frac{v_d}{v_{in}} = \frac{-10K}{\frac{1}{g_m} + 1K}$$

B)



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

$$= 120u \cdot \frac{20}{1}\left(1.644 - .8\right)$$

$$g_m = 2.088\,mA$$

$$v_d = -i_d \cdot 10K$$

$$v_{in} = v_{gs} + 1K \cdot i_d$$

$$i_d = g_m v_{gs}$$

$$\frac{v_d}{v_{in}} = \frac{-10K}{\frac{1}{2mA} + 1K} = \frac{-10K}{1500}$$

$$= i_d\left(\frac{1}{g_m} + 1K\right)$$

$$\simeq -6.66 \qquad v_s = i_d \cdot 1K$$

$$\frac{v_s}{v_{in}} = \frac{1K}{1.5K} = .666$$