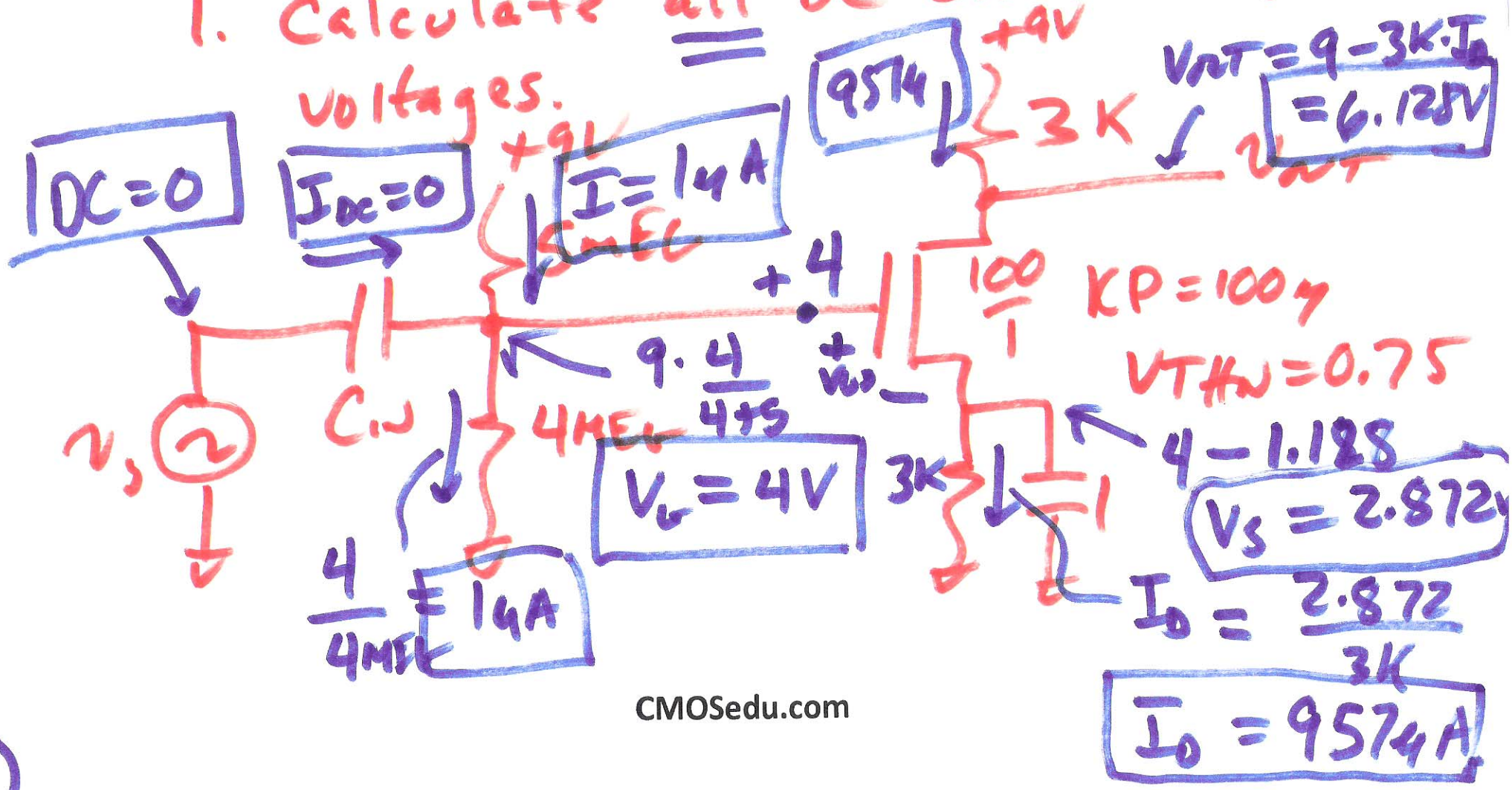
EE 320 Intro. to Electronics

4/24/13 Lecture 23

TEST #1

1. Calculate all DC currents & voltages.



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$$V_G = 4 = V_{GS} + I_D \cdot 3k$$

$$I_D = \frac{K_N'}{2} \cdot \frac{W}{L} \left(V_{GS} - V_{TH_N}\right)^2$$

$$I_D = \frac{100\mu}{2} \cdot \frac{100}{1} \left(V_{GS} - 0.75\right)^2$$

$$I_D = 5\frac{mA}{V^2} \left(V_{GS} - 0.75\right)^2$$

$$I_D = 5mA\left(V_{GS}^2 - 1.5V_{GS} + .5625\right)$$

$$I_D = 5mA\,V_{GS}^2 - 7.5mV_{GS} + 2.8125m$$

$$4 = V_{GS} + 3(5V_{GS}^2 - 7.5V_{GS} + 2.8125)$$

$$4 = V_{GS} + 15V_{GS}^2 - 22.5V_{GS} + 8.4375$$

$$0 = 15V_{GS}^2 - 21.5V_{GS} + 4.4375$$

$$V_{GS}^2 - 1.433V_{GS} + 0.2958$$

$$V_{GS} = \frac{1.433 \pm \sqrt{2.053 - 4(0.2958)}}{2}$$

1.1872

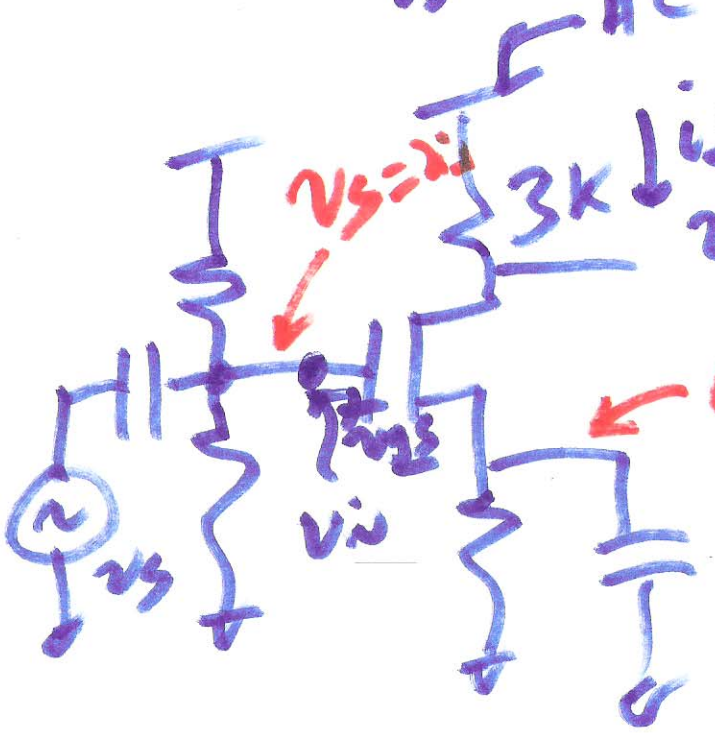
$$V_{GS} = \frac{1.433 \pm .9326}{2}$$

$$V_{GS} = \frac{1.433 + .9326}{2}$$

$$= 1.1828V$$

3)

2.) $\frac{v_{in}}{v_s} = ?$ $\frac{v_{out}}{v_{in}} = ?$



$$\frac{v_{in}}{v_s} = 1$$

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

$$= 100\mu \cdot \frac{100}{1}(1.1825 - .75)$$

$$g_m = 4.328 \frac{mA}{V}$$

$i_d = g_m v_{gs}$

$i_d = v_g \cdot g_m$

$i_d = g_m \cdot v_{in}$

$i_d = g_m v_s$

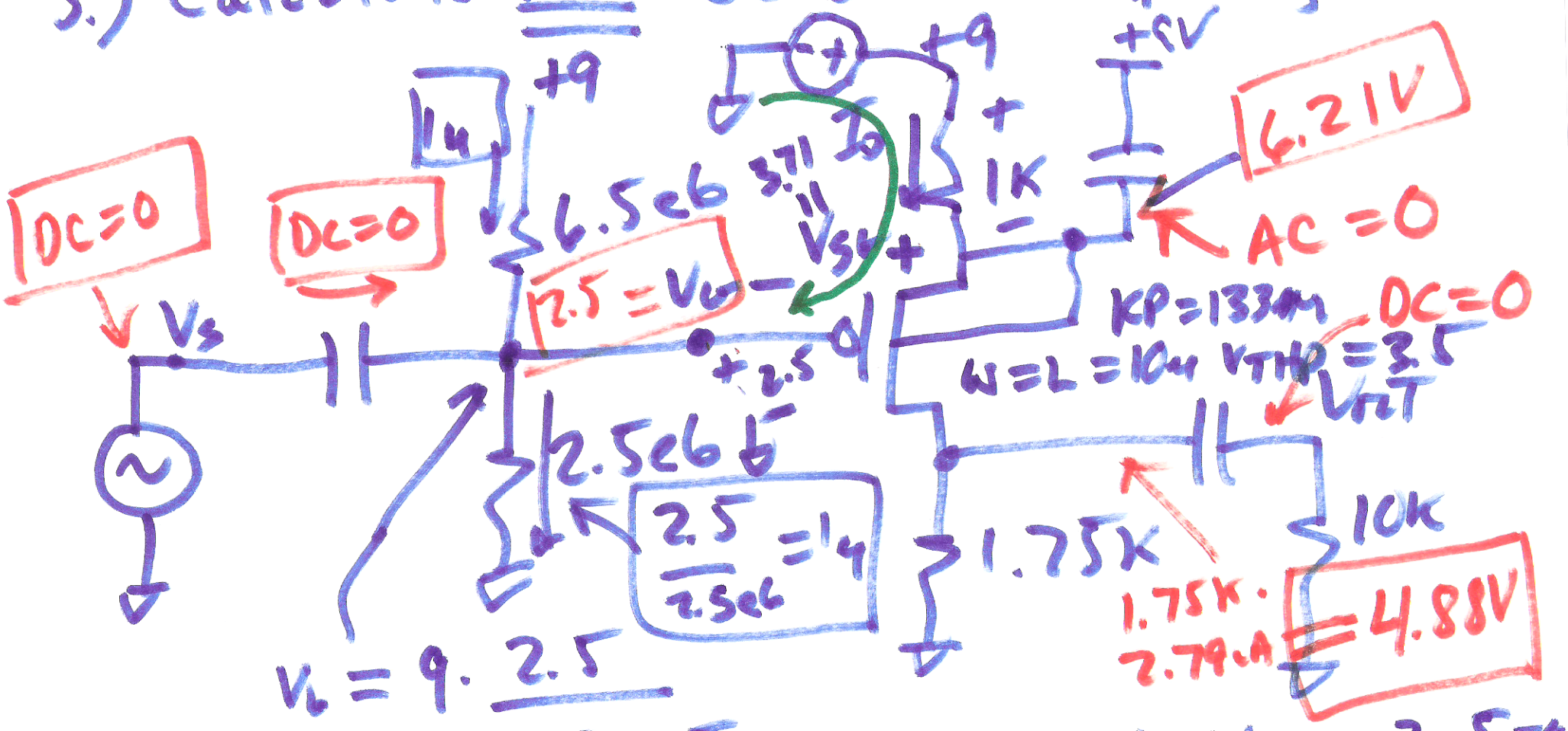
$$\frac{v_{out}}{v_{in}} = \frac{-id \cdot 3k}{id/g_m} = -g_m \cdot 3k$$

$$\frac{v_{out}}{v_{in}} = -4.328 \cdot 3$$

$$\frac{v_{out}}{v_{in}} = -12.98$$

4)

3.) Calculate All DC currents & voltages



$$V_b = 9 \cdot \frac{2.5}{2.5+6.5}$$

$$V_b = 2.5V$$

$$9 - I_D \cdot 1K - V_{SG} - 2.5 = 0$$

$$I_D = \frac{.133}{2} \cdot \frac{10}{10}\left(V_{SG} - 3.5\right)^2$$

$$= 2.79mA$$

$$9 - \frac{137}{2}\left(V_{SG}^2 - 7V_{SG} + 12.25\right) - V_{SG} - 2.5 = 0$$

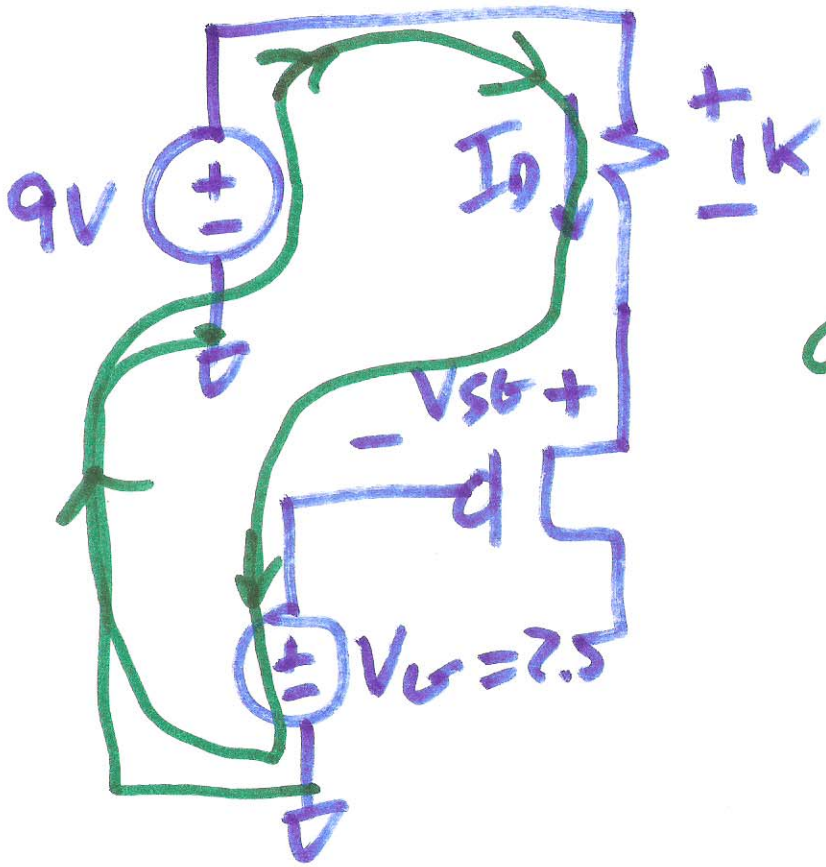
$$9 - 66.5 V_{SG}^2 + 465.5 V_{SG} - 814.625 - V_{SG} - 2.5 = 0$$

$$-66.5 V_{SG}^2 + 464.5 V_{SG} - 808.125 = 0$$

$$V_{SG}^2 - 6.985 V_{SG} + 12.15 = 0$$

$$V_{SG} = \frac{6.985 \pm \sqrt{48.79 - 4(12.15)}}{2}$$

$$3.71\,V = V_{SG} = \frac{6.985 \pm .435}{2}$$



$$9 - I_D 1k - V_{SG} - 2.5 = 0$$

6)

$$I_D = \frac{9 - 6.21}{1K} = \boxed{2.79\,mA}$$

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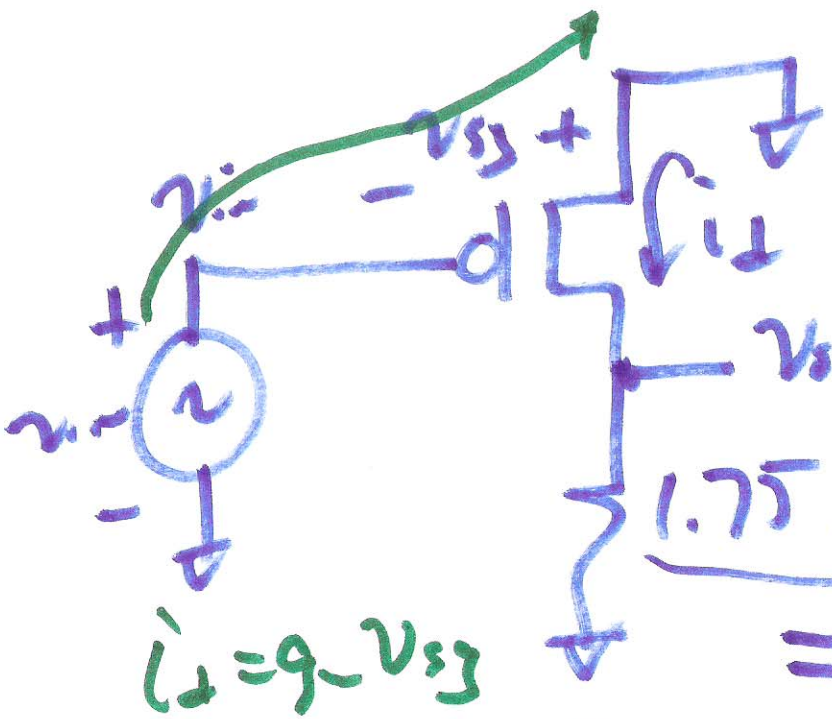
4) Calculate v_{out}/v_{in}



$$v_{in} + v_{sg} = 0$$

$$v_{in} = -v_{sg}$$

$$g_m = 0.133\,(3.71 - 3.5)$$

$$g_m = 27.9\,mA/V$$

$$v_{in} = -\frac{i_d}{g_m}$$

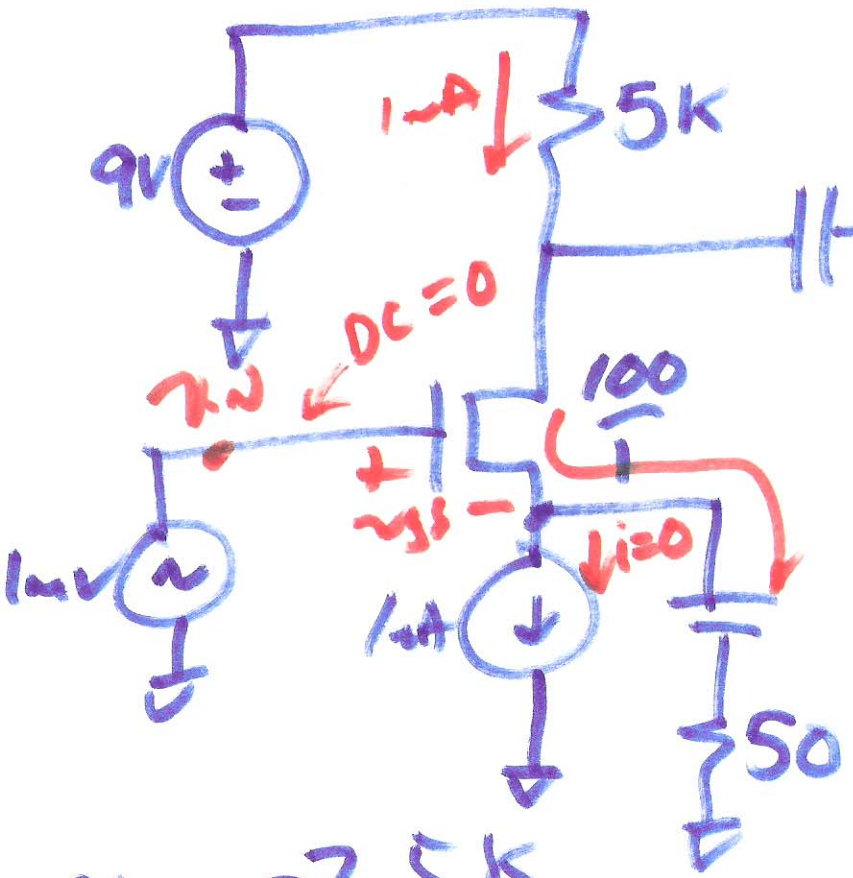
$$\frac{v_o}{v_{in}} = \frac{i_d \cdot 1489}{-i_d / 27.9m}$$

$$\frac{v_o}{v_i} = 1.489 \cdot 27.9$$

$$\frac{v_o}{v_i} = \boxed{-41.54\,V/V}$$

7)

5) Calculate V_{out}/V_{in}



$$g_m = \sqrt{2 \cdot 1mA \cdot 100\mu \cdot \frac{100}{1}}$$

$$= \sqrt{2 \cdot I_D \cdot K_P' \cdot \frac{W}{L}}$$

$$= \sqrt{2 \cdot 10}\ mA$$

$$g_m = 4.47\ mA/V$$

$V_{THN} = 0.75$

$KP = 100\mu$

$$\frac{v_o}{v_{in}} = \frac{-v_d \cdot 5K \| 5K}{v_{gs} + v_d \cdot 50}$$

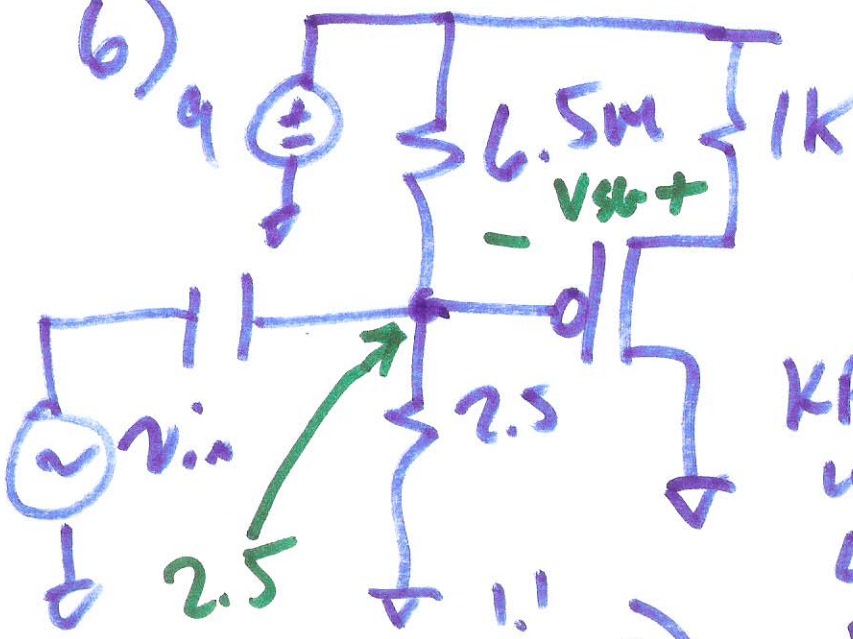
$$\frac{v_o}{v_i} = \frac{-2.5K}{\frac{1}{4.47m} + 50}$$

$$= \frac{-2.5K}{224 + 50}$$

$$= -9.12\ V/V$$

8)

6)



$KP = 100\mu$
$W = 10$
$L = 1$
$V_{THP} = 1$

$$9 - 1k \cdot I_D - V_{SG} - 2.5 = 0$$

$$I_D = \frac{0.1}{2} \cdot \frac{10}{1} (V_{SG} - 1)^2$$

$$= 0.5(V_{SG}^2 - 2V_{SG} + 1)$$

$$I_D = 0.5V_{SG}^2 - V_{SG} + \frac{1}{2}$$

$$g_m = 0.1 \cdot \frac{W}{L} (V_{SG} - 1)$$

$$9 - 500V_{SG}^2 + 1000V_{SG} - 500 - V_{SG} - 2.5 = 0$$

$$g_m = \frac{100mA}{V}$$

$$-500V_{SG}^2 + 999V_{SG} - 493.5 = 0$$

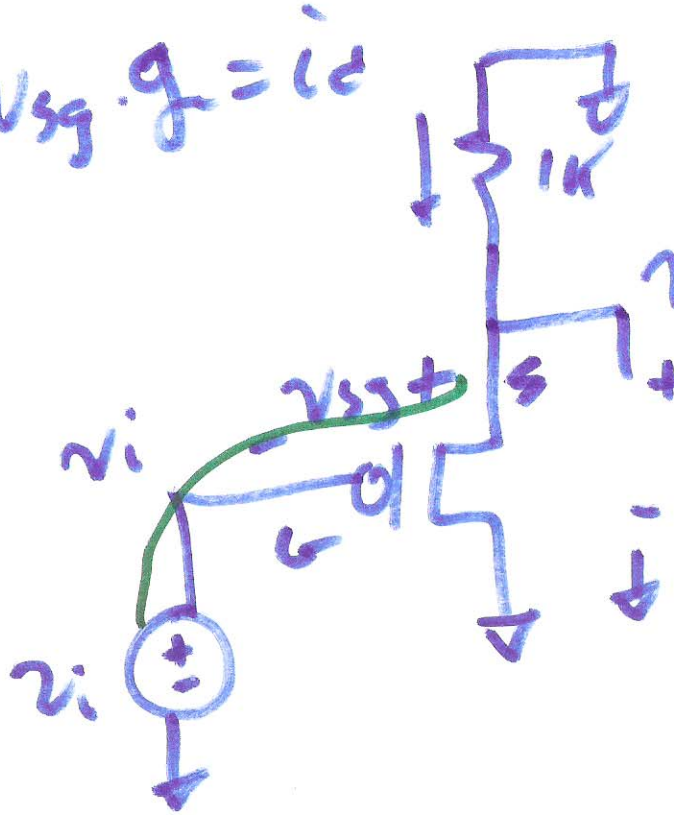
$$V_{SG}^2 - 1.998V_{SG} + 0.987 = 0$$

$$V_{SG} = \frac{1.998 \pm \sqrt{3.992 - 3.948}}{2}$$

$$V_{SG} = \frac{1.998 \pm .204}{2}$$

$$\boxed{V_{SG} = 1.1V}$$

9)



$v_{sg} \cdot g = i_d$

$v_{out} = -i_d \cdot 1K$

$i_d/g_m \quad -i_d \cdot 1K$

$v_i + v_{sg} = v_{out}$

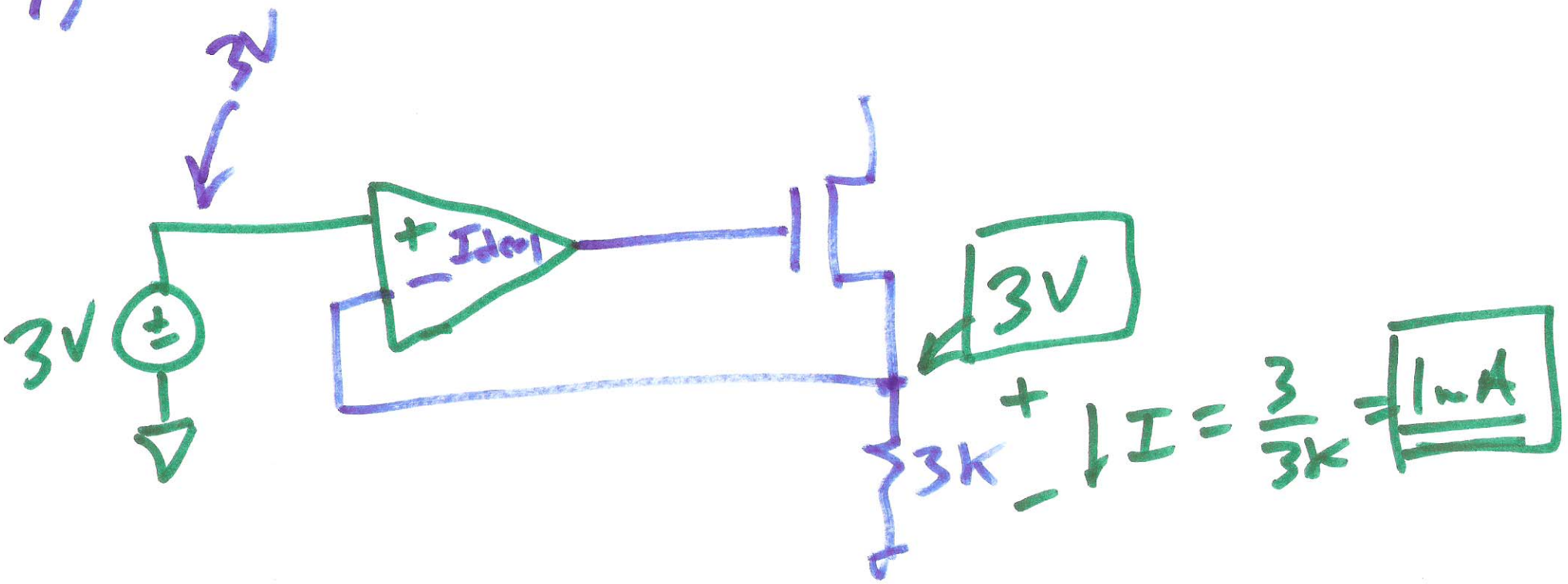
$$\frac{v_{out}}{v_i} = \frac{-i_d \cdot 1K}{-i_d\left(\frac{1}{g_m} + 1K\right)}$$

$$= \frac{1K}{\frac{1}{.1} + 1K}$$

$$= \frac{1K}{1.01K} = .99\frac{V}{V}$$

10)

7)



11)