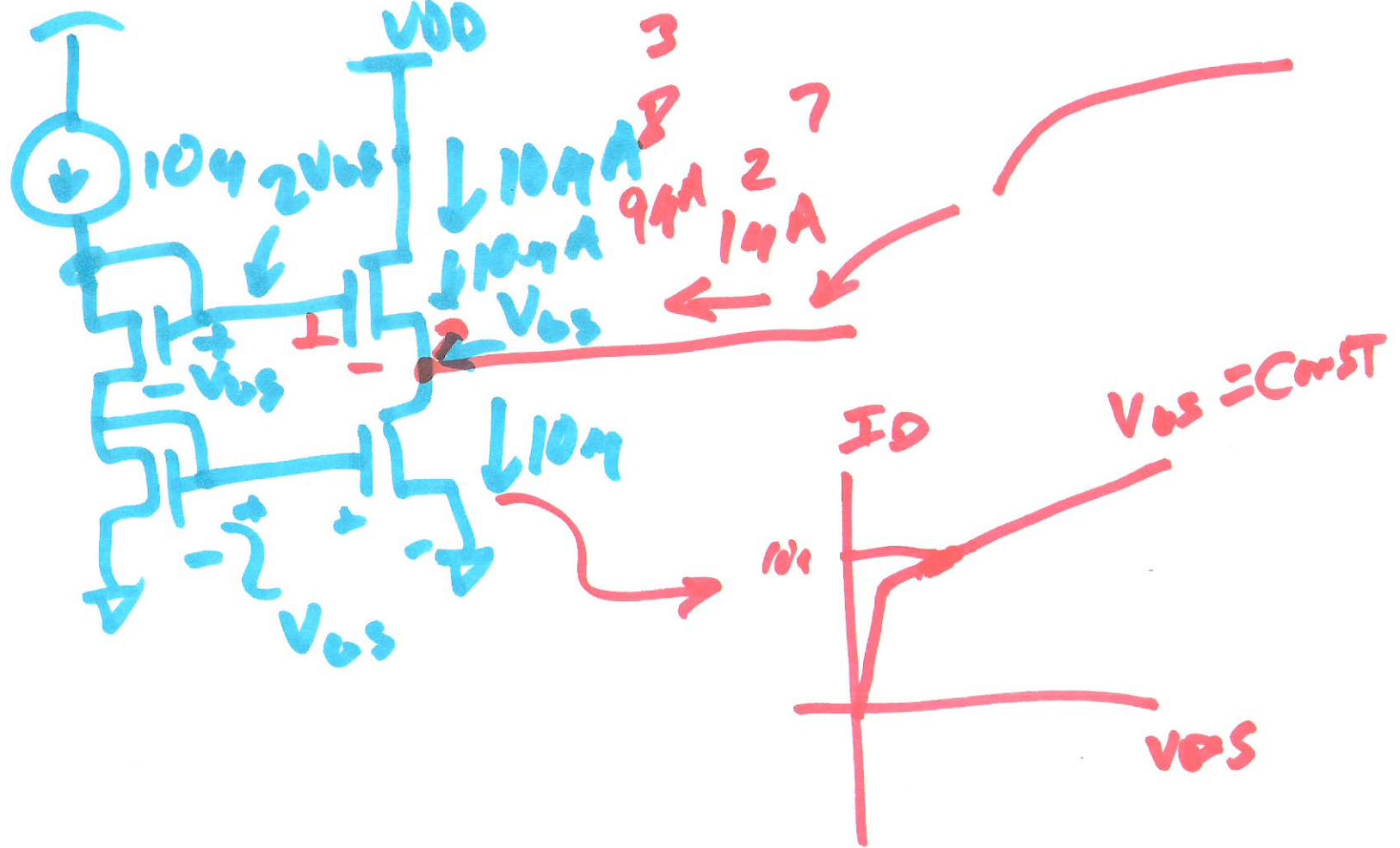
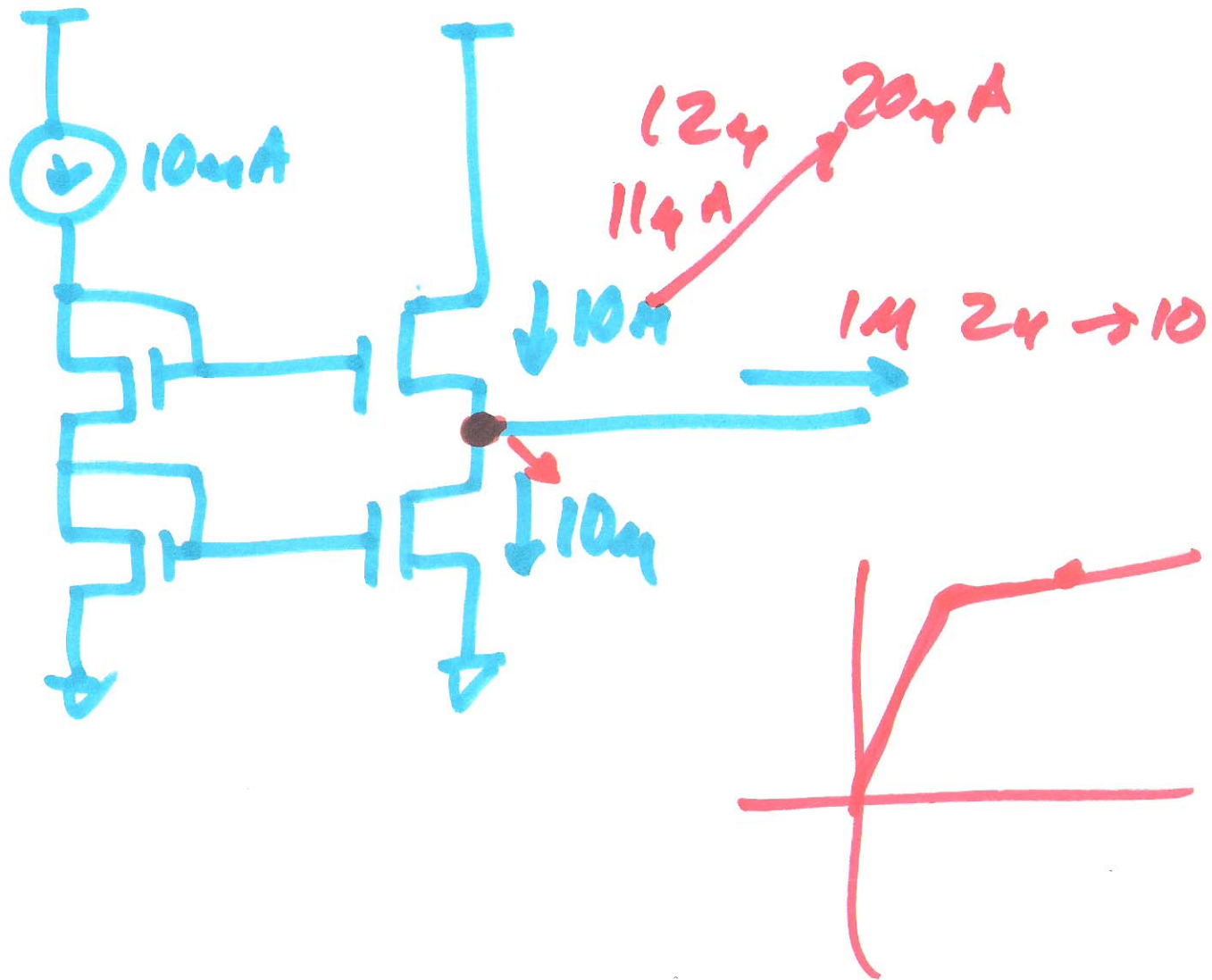


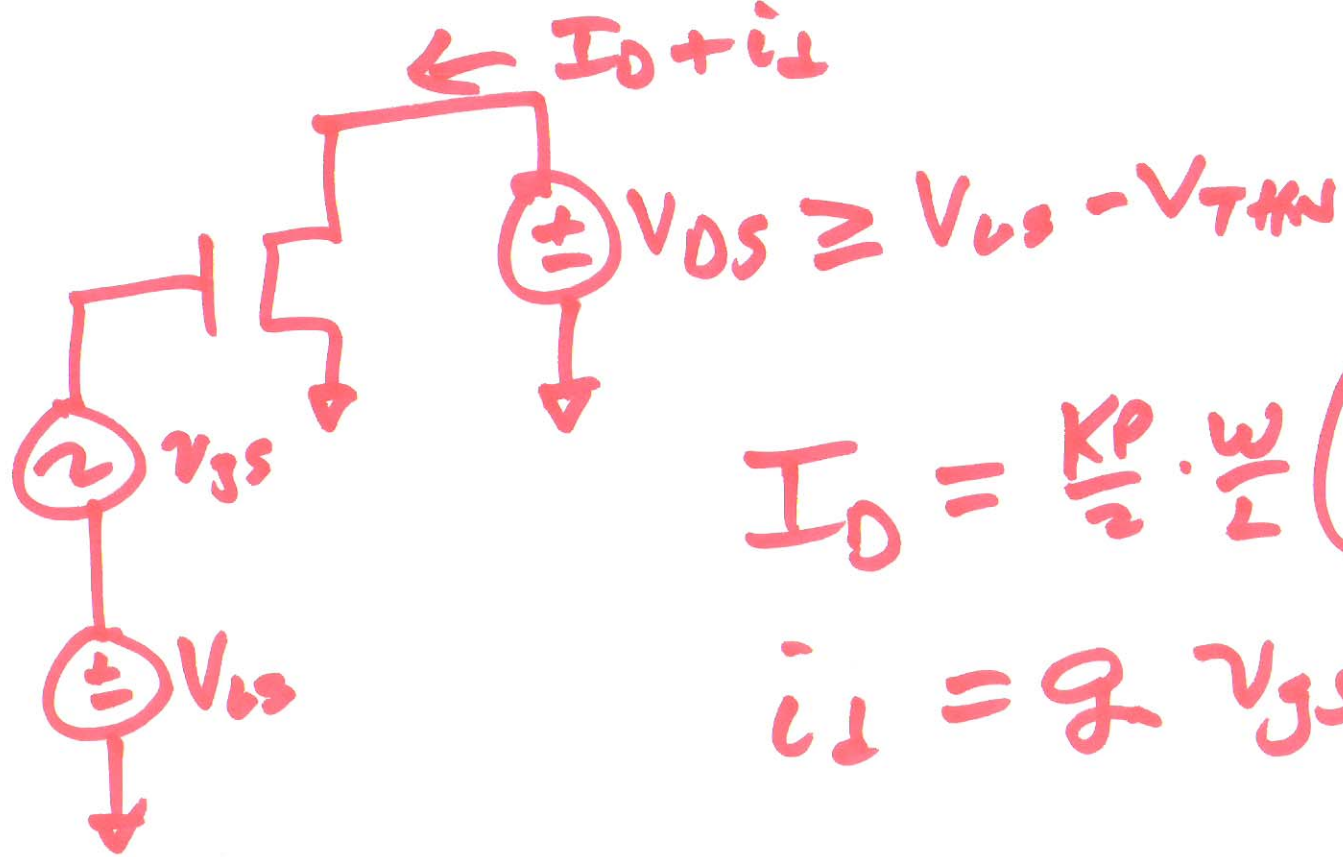
EE 420 / ECL 620

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Lecture 2



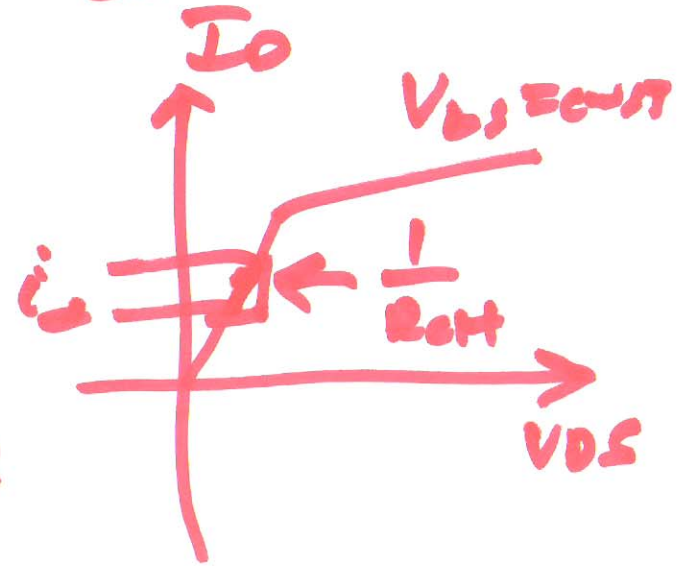
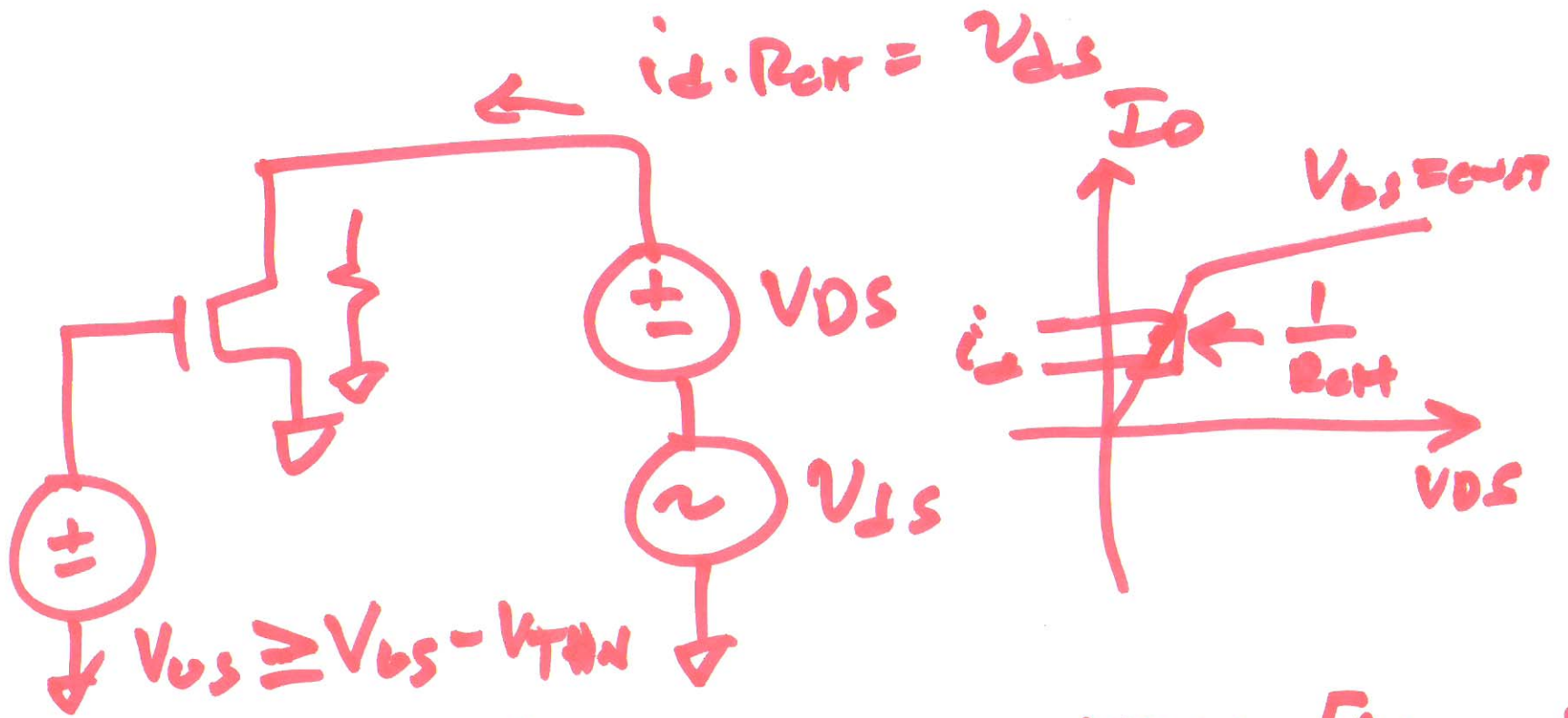




$$I_D = \frac{K_P}{2} \cdot \frac{W}{L} (V_{GS} - V_{THN})^2$$

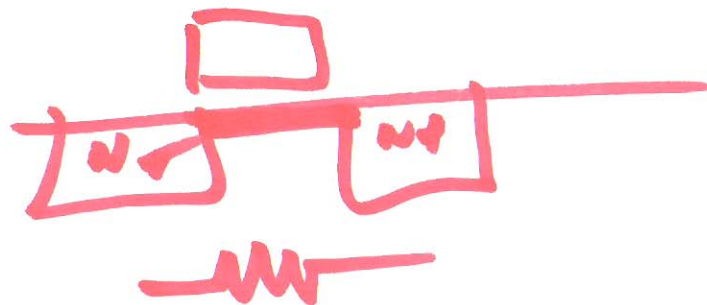
$$i_d = g_m v_{gs}$$

3)



TRIODE

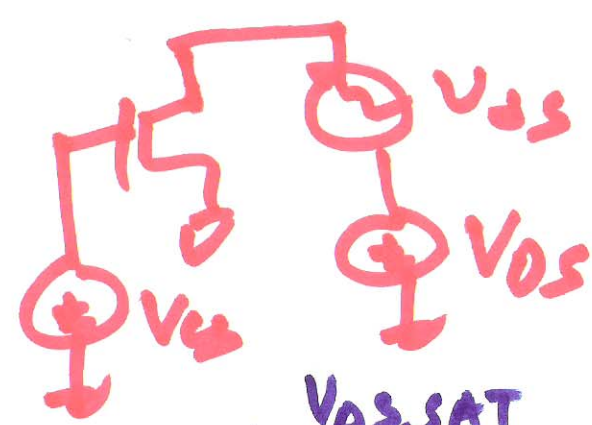
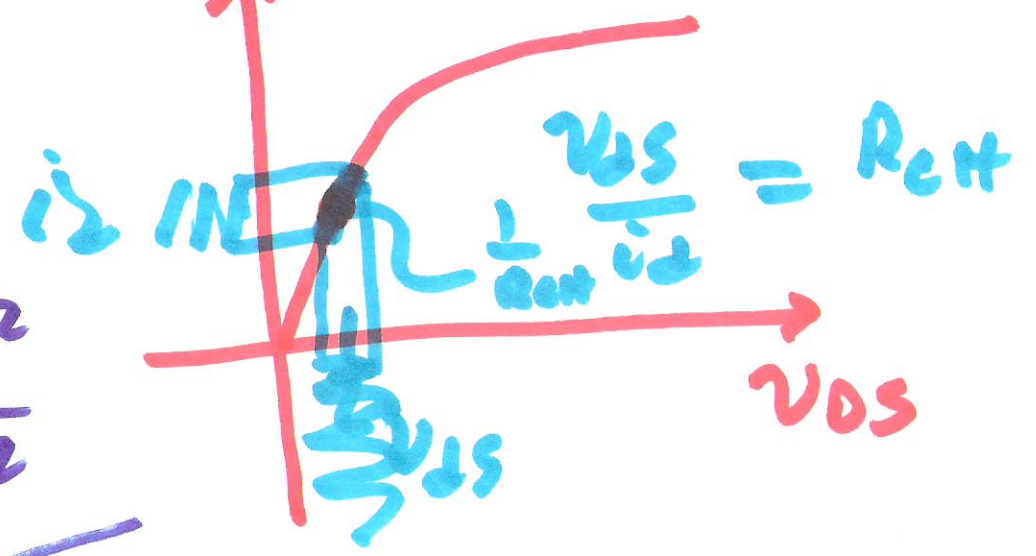
$$i_d + I_D = K_P \cdot \frac{W}{L} \cdot \left[(V_{gs} - V_{THN}) \cdot V_{ds} - \frac{V_{ds}^2}{2} \right]$$



$$V_{gs} + v_{ds}$$

$$I_D + i_d = \frac{\mu K_P}{2} \left[(V_{GS} - V_{THN}) (V_{DS} + v_{ds}) - \frac{(V_{DS} + v_{ds})^2}{2} \right]$$

$$i_D = I_D + i_d$$



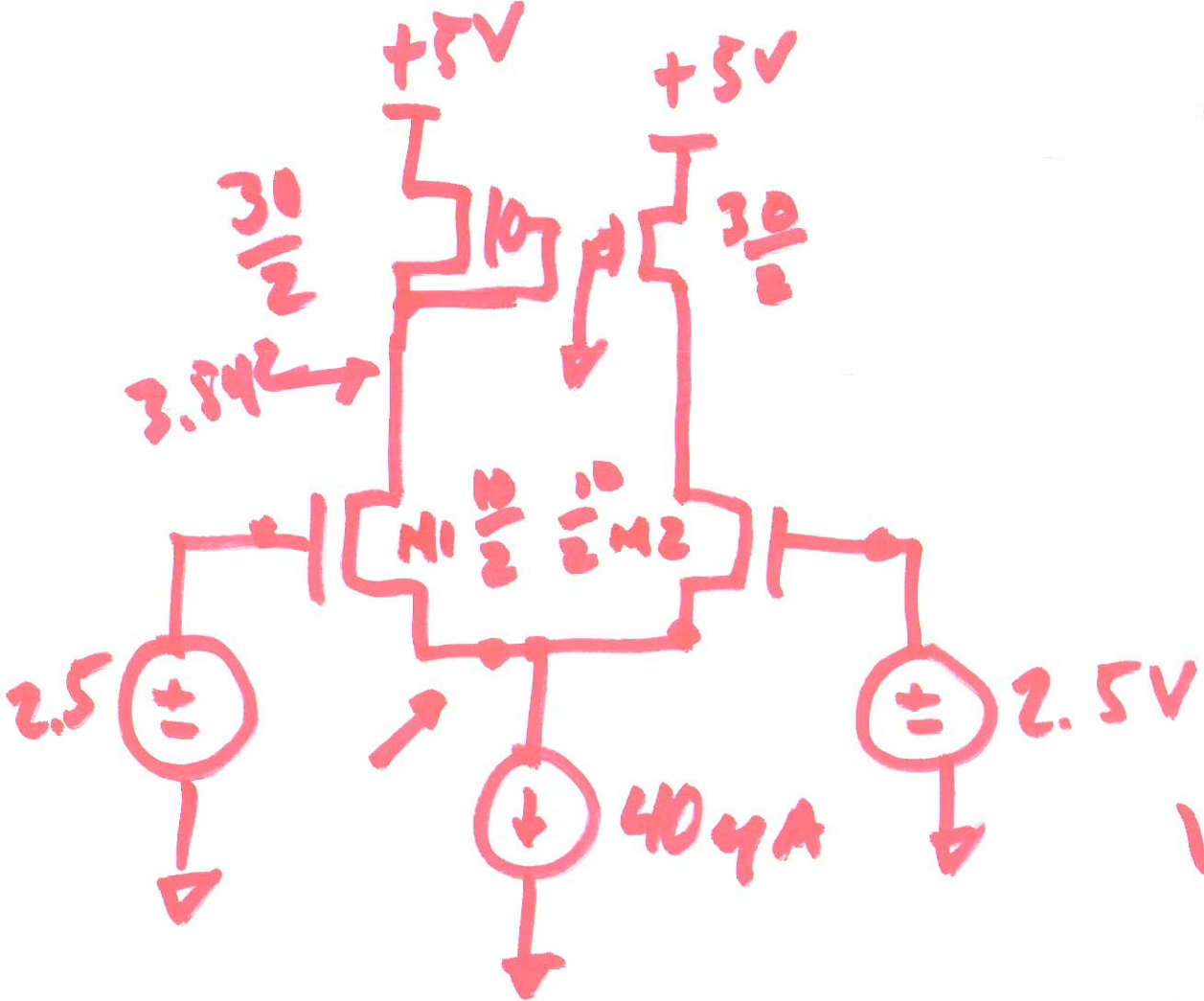
$$\frac{\delta y / y}{\delta x / x} = x$$

$$\frac{\delta i_D}{\delta v_{DS}} \Bigg|_{\substack{I_D = \text{const} \\ V_{GS} = \text{const}}} = \frac{1}{R_{eff}} = \frac{\mu}{L} K_P \left[(V_{GS} - V_{THN}) + v_{DS} \right]$$

If $v_{DS} \ll V_{GS} - V_{THN}$

$$R_{eff} = \frac{1}{K_P \cdot \frac{\mu}{2} (V_{GS} - V_{THN})} = \frac{1}{g_m}$$

5)



$$I_{O1} = I_{O2} = 20\mu A$$

$$V_{GS1} = V_{GS2} = 2.5V$$

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

$$V_{GS} = \sqrt{\frac{2I_D}{K_P \cdot \frac{W}{L}}} + V_{TH}$$

$$V_{GS} = \sqrt{\frac{40\mu A}{120\mu A \cdot 5}} + 0.8V$$

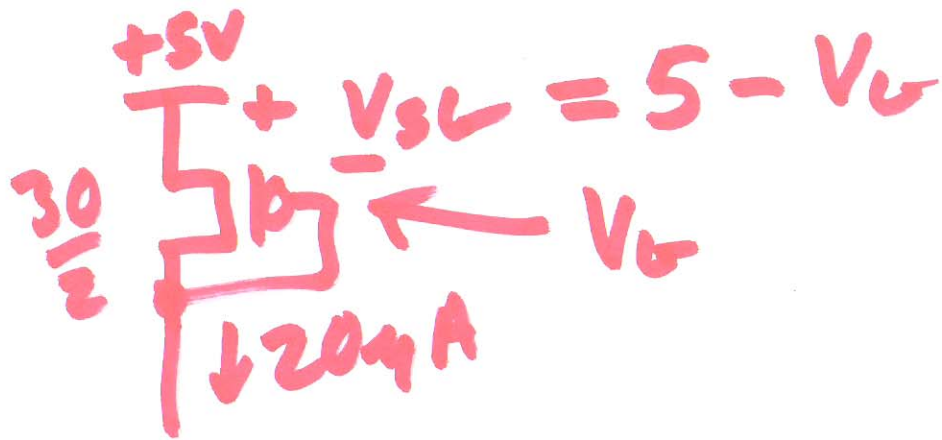
$$= \sqrt{\frac{1}{15}} + 0.8$$

$$V_{GS} = 1.058$$

$$2.5 - V_S = V_{GS} = 1.058$$

$V_{S1, \bar{2}} = 1.44V$

6)

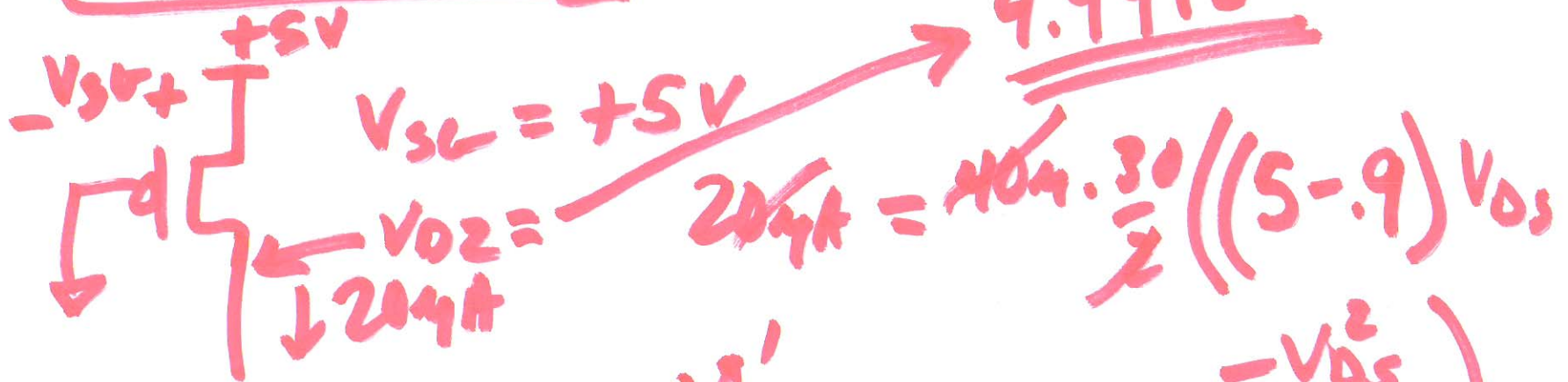


$$V_{SG} = \sqrt{\frac{2 \cdot 204A}{K_P \cdot \frac{30}{2}}} + 0.9$$

$$1.158 = 5 - V_G$$

$$V_G = 3.842V$$

$$V_{SG} = 1.158V$$



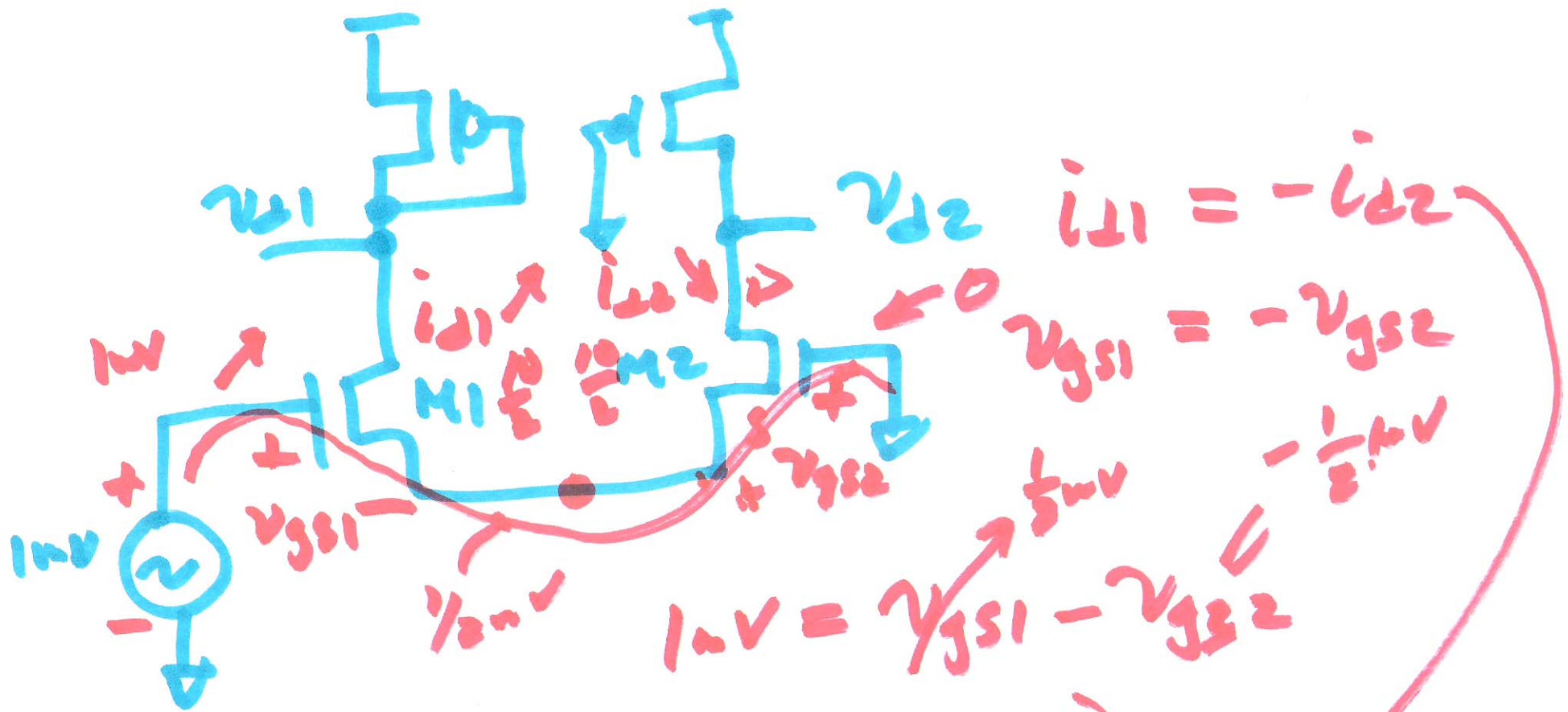
$$V_{SD} = 8.14 \approx V_5 \quad \frac{V'}{R}$$

$$V_{SD} = 5 - V_{D2} = \frac{1}{30} = 4.1V_{D2} - \frac{V_{D2}^2}{2}$$

$$\frac{V_{os}^2}{2} - 4.1V_{os} + \frac{1}{30} = 0$$

$$15V_{os}^2 - 123V_{os} + 1 = 0$$

$$V_{os} = \frac{123 \pm \sqrt{(123)^2 - 60}}{30}$$
$$= \frac{123 \pm 122.7559}{30}$$
$$= \underline{\underline{8.14 \text{ mV}}}$$



AC LKT

$$i_{d1} = -i_{d2}$$

$$v_{gs1} = -v_{gs2}$$

$$v_{ds1} = -v_{ds2}$$

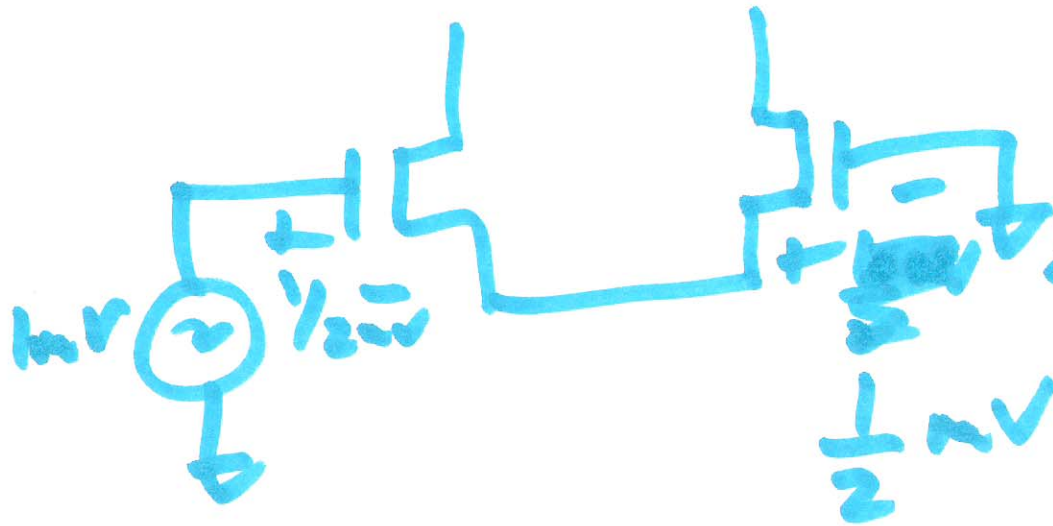
$$1\mu V = v_{gs1} - v_{gs2}$$

$$1\mu V = v_{gs1} - v_{gs2}$$

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

$$1\mu V = \frac{i_{d1}}{g_m} = \frac{i_{d2}}{g_m}$$

$$1\mu V = i_{d1} \cdot \frac{2}{g_m}$$



$$g_m = \sqrt{2 \cdot k_A \frac{W}{L} \cdot I_D}$$

$$= \sqrt{2 \cdot 120 \mu\text{A/V}^2 \cdot 5 \cdot 20 \mu\text{A}}$$

$$= 150 \frac{\mu\text{A}}{\text{V}}$$

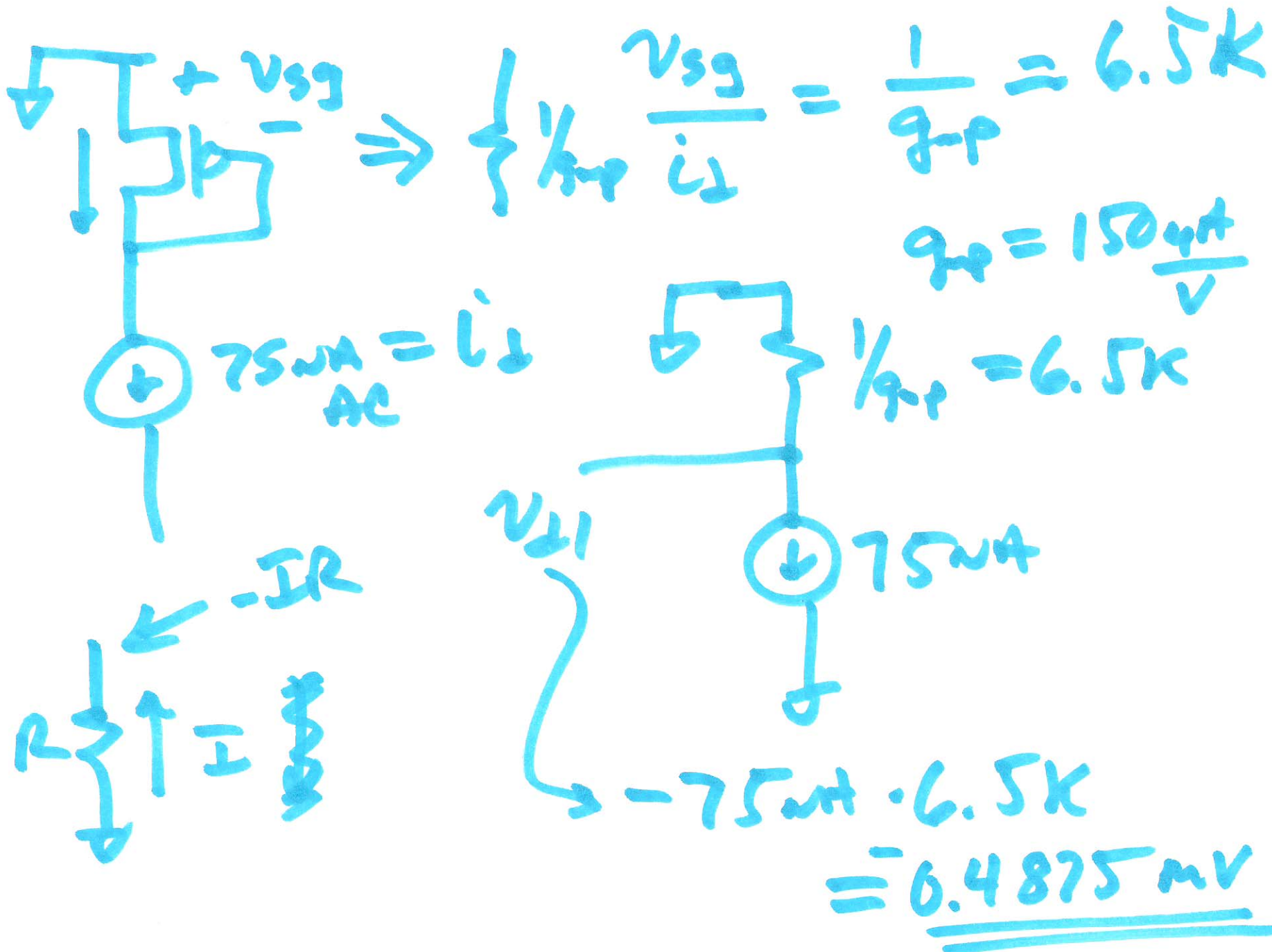
$$v_{gs2} = -\frac{1}{2} \mu\text{V}$$

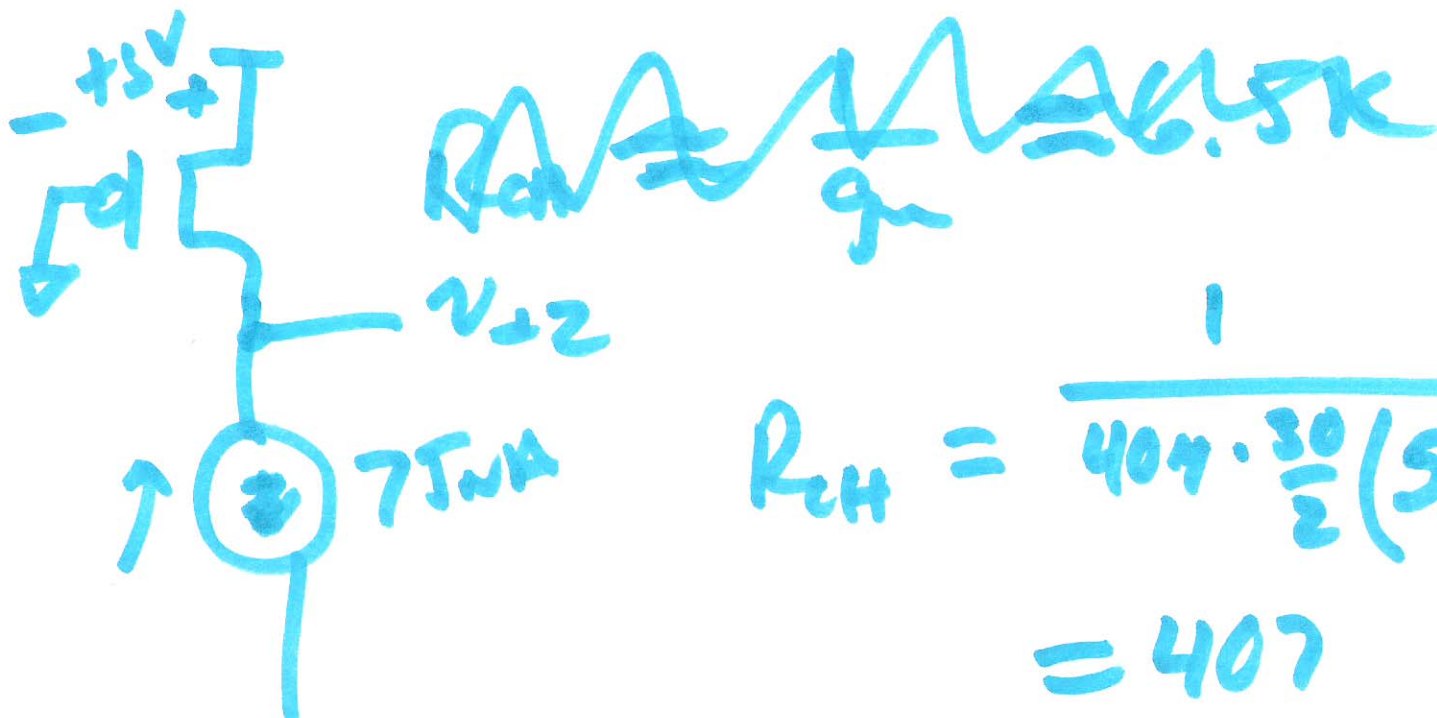
$$i_{d1} = g_m v_{gs} = 150 \frac{\mu\text{A}}{\text{V}} \cdot \frac{1}{2} \mu\text{V}$$

$$= \underline{\underline{75 \text{ nA}}}$$

$$i_{d2} = -75 \text{ nA}$$

10)





$$R_{th} = \frac{1}{\frac{1}{404} + \frac{30}{2} (5 - .9)}$$

$$= 407$$

$$v_{d2} = +75 \text{ nA} \cdot 407$$

$$= \underline{\underline{30.4 \text{ } \mu\text{V}}}$$