5.2.6

$K_p' = 20\ \mu A / V^2$

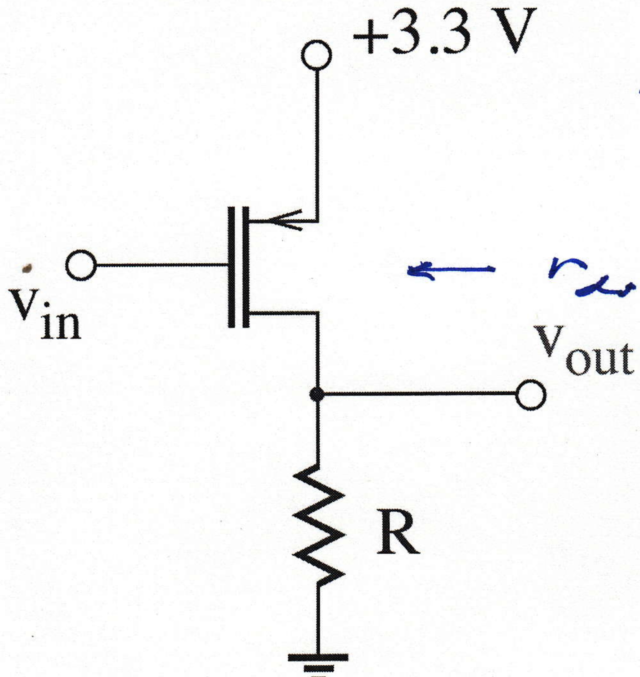
$V_{tp} = -0.6\ V$

$v_{in} = 0$ (Low) $\longrightarrow$ $v_{out} = 3.1\ V$

$$3.3 \frac{R}{R + r_{ds}} = 3.1$$

power $\longrightarrow$ $\frac{(3.3)^2}{R + r_{ds}} = 0.5$ (kΩ resistors)

$R + r_{ds} = \cancel{21.78}\ 21.78\ k$



$$R = \frac{3.1}{3.3} \times (21.78) = 20.46\ K$$

$\longrightarrow r_{ds} = 1.32\ K$

$$\frac{1}{r_{ds}} = K_p' \left(\frac{W}{L}\right) |V_{gs} - V_t|$$

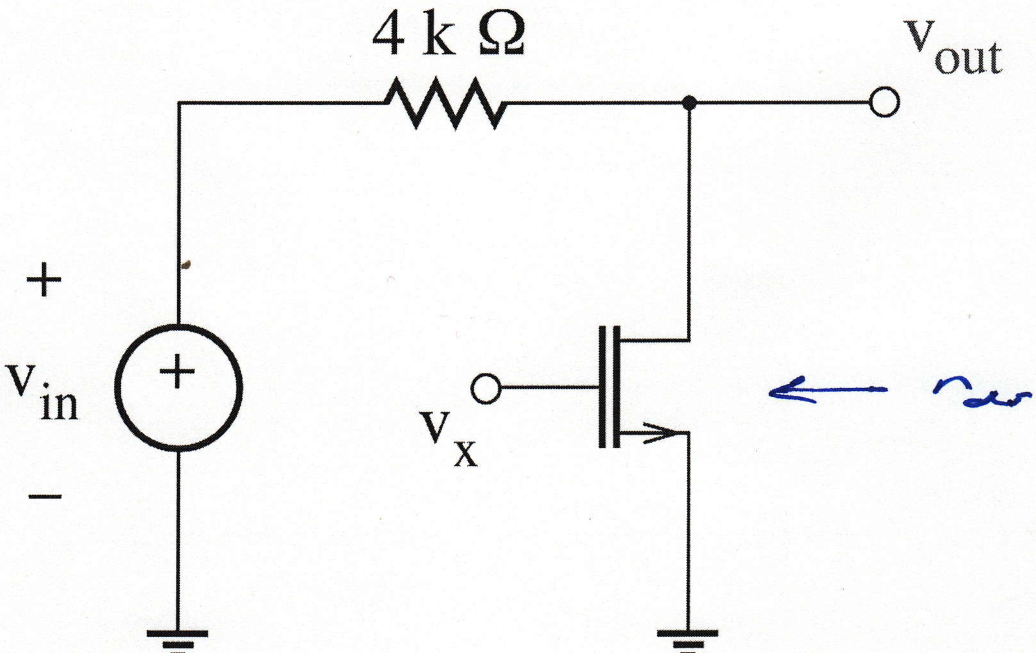
$$\frac{W}{L} = \frac{1}{r_{ds} \times K_p' \times |V_{gs} - V_t|}$$

$$= \frac{1}{1.32 \frac{V}{mA} \times 0.02\ mA/V^2 \times |-3.3 + 0.6|\ V}$$

$$= 14$$

5.29 $K_n' = 50\ \mu A / V^2$ $V_T = 0.6\ V$

$v_x = 5V$ $\underbrace{\dfrac{r_{ds}}{r_{ds} + 4k}}_{\text{attenuation factor}} = 0.1 \rightarrow r_{ds} = 0.444\ k$



$$\frac{1}{r_{ds}} = K_n' \left(\frac{W}{L}\right)(v_{GS} - v_T)$$

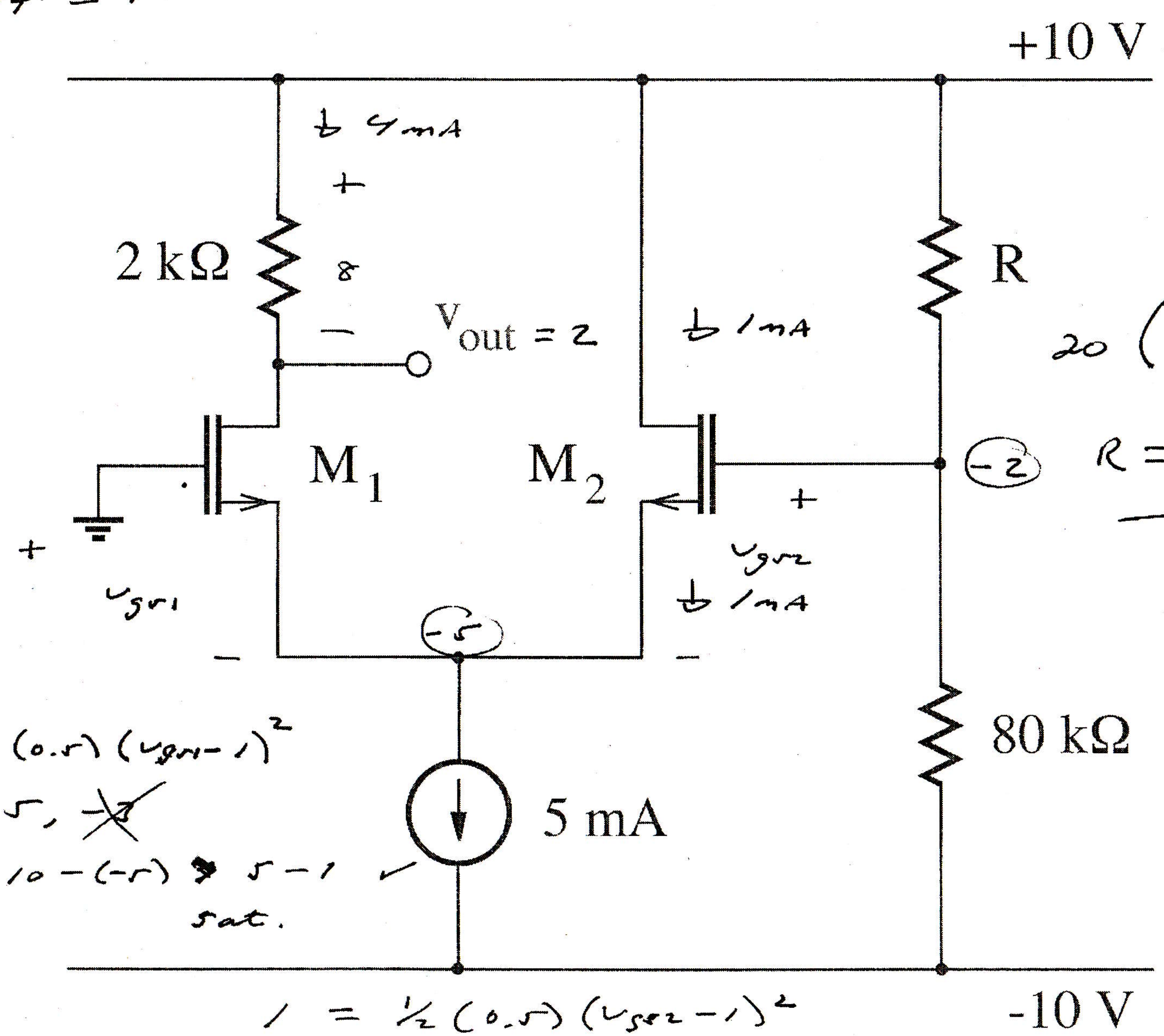
$$\left(\frac{W}{L}\right) = \frac{1}{0.444\ \frac{mA}{V} \times 0.05\ \frac{mA}{V^2} \times (5 - 0.6)}$$

$$= \underline{10.2}$$

5.42

$K'\frac{W}{L} = 0.5\ mA/V^2$

$V_T = 1V$



$20\left(\frac{80}{80+R}\right) = 8$

$R = 120K$

$4 = \frac{1}{2}(0.5)(v_{gs1}-1)^2$

$v_{gs1} = 5, \cancel{-3}$

$v_{ds1} = 10-(-5) > 5-1$ ✓

sat.

$1 = \frac{1}{2}(0.5)(v_{gs2}-1)^2$

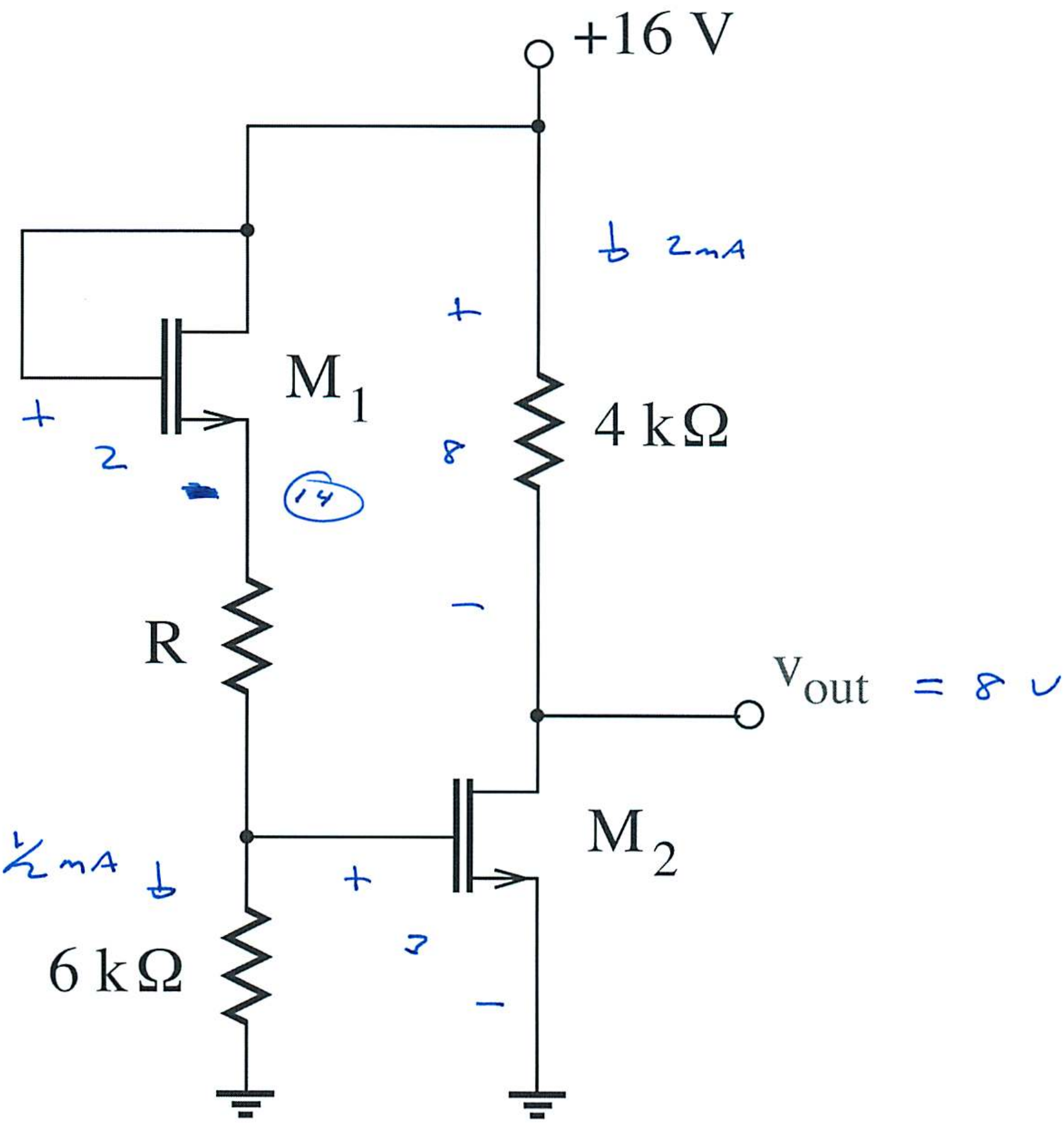
$v_{gs2} = 3, \cancel{-1}$

$v_{ds1} = 10-(-5) > 3-1$ ✓

5.43 $\quad k'\frac{W}{L} = 1\ mA/V^2, \quad V_T = 1\ V$

$M_2 \rightarrow \quad 2 = \frac{1}{2}(1)(V_{GS2} - 1)^2 \quad \longrightarrow \quad V_{GS2} = 3V$

$\cancel{V_{GS2} = -1V}$



$m_1 \rightarrow \quad \frac{1}{2} = \frac{1}{2}(1)(V_{GS1} - 1)^2 \quad \rightarrow \quad V_{GS1} = 2V$

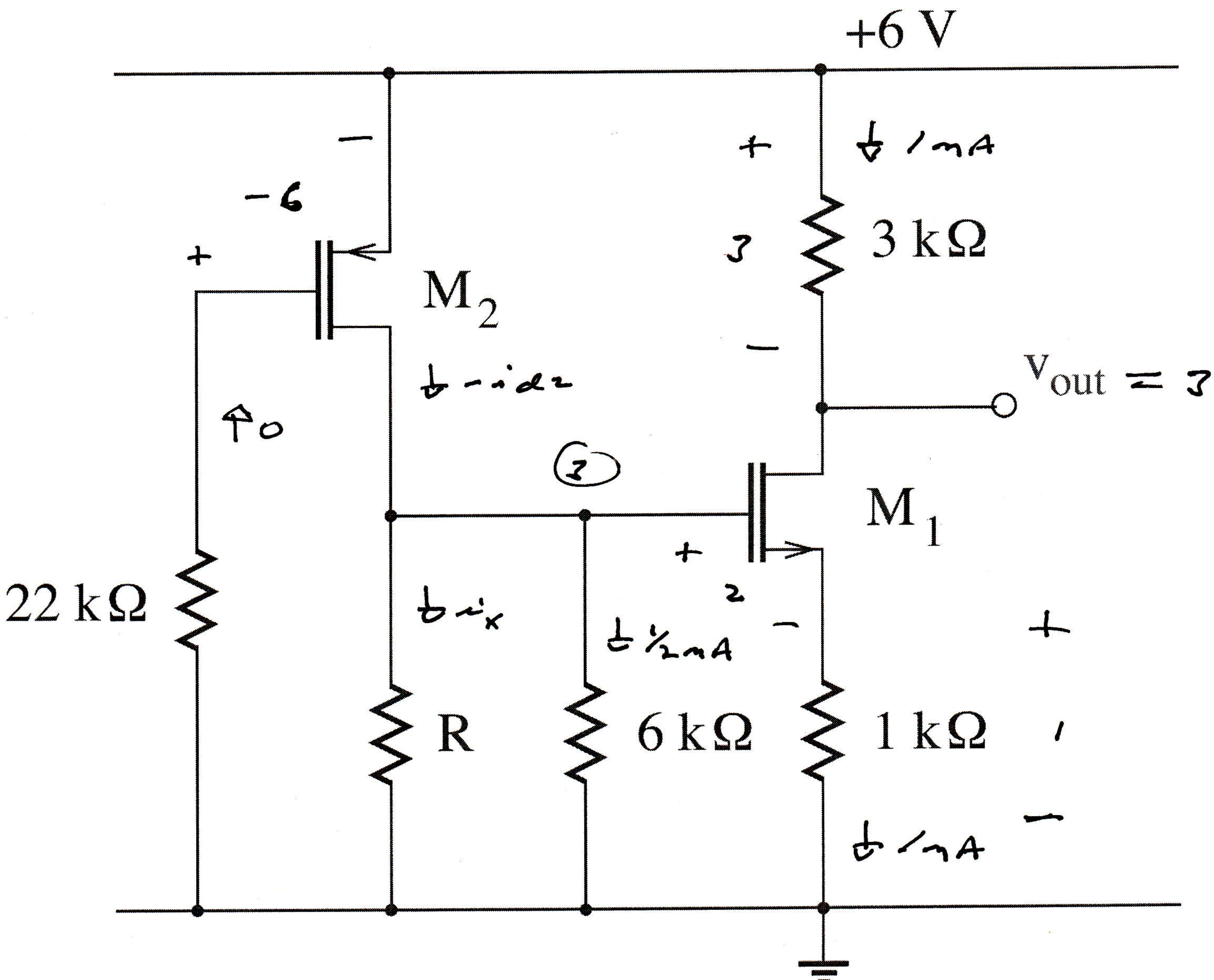
$\cancel{V_{GS1} = 0V}$

$R = \frac{14 - 3}{0.5} = 22\ k\Omega$

5.45 $\quad M_1: \; K_n' \frac{W}{L} = 2\,mA/V^2 \quad V_T = 1V$

$\quad\quad\; M_2: \; K_p' \frac{W}{L} = 0.25\,mA/V^2 \quad V_T = -1V$

$M_1: \quad i_d = 1 = \frac{1}{2}(2)(v_{GS} - 1)^2 \rightarrow v_{GS} = 2, \cancel{0}$



M_2 has $v_{DS} = -3, \; v_{GS} = -6$

$-3 > v_{GS} - V_T = -5 \longrightarrow$ resistive mode

$-i_{d2} = \frac{1}{2}(0.25)\left[2(-6+1)(-3) - (-3)^2\right]$

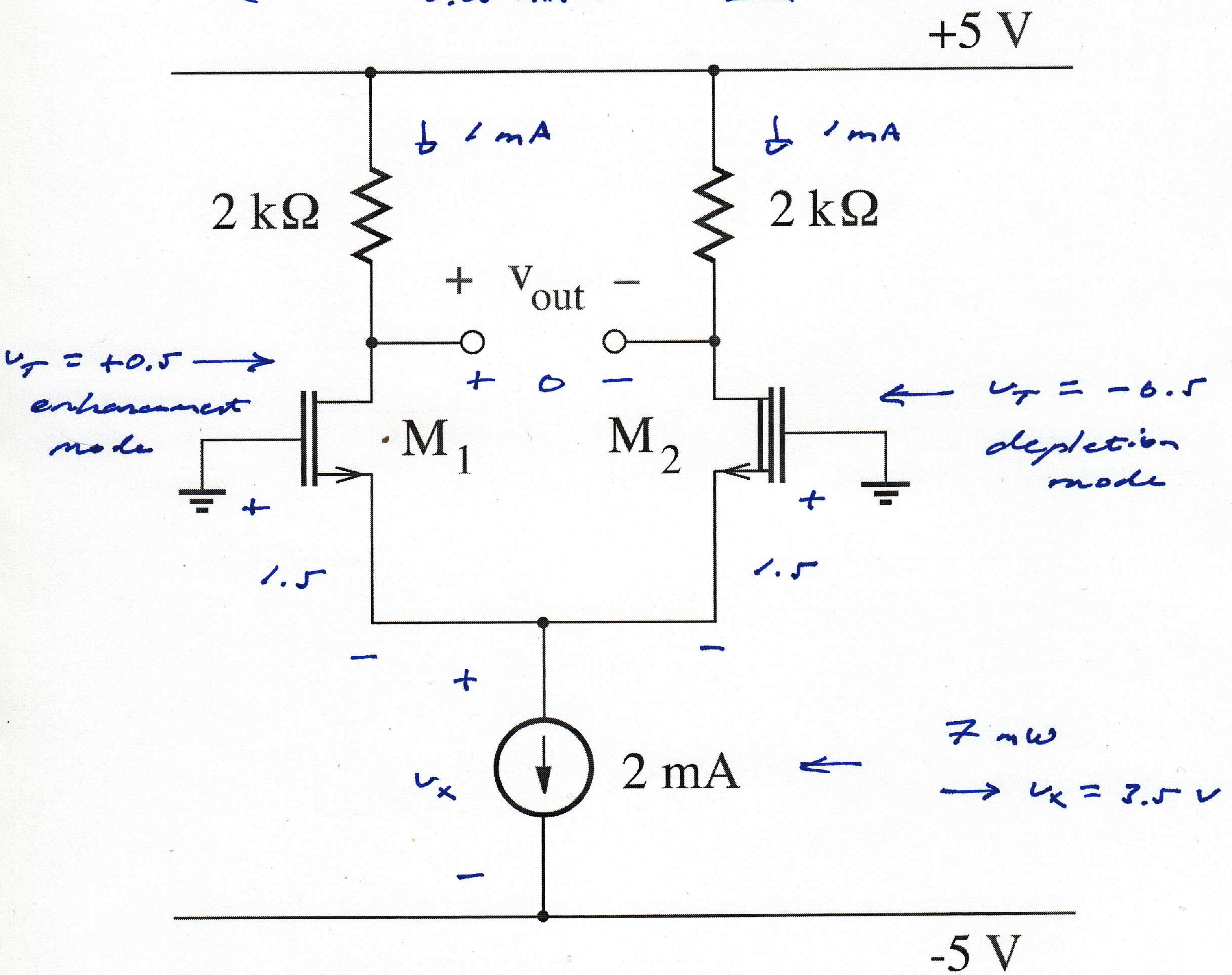
$= 2.625\,mA \longrightarrow i_x = 2.125\,mA$

$R = \frac{3}{2.125} = 1.41\,K$

5.48 $K_n' = 50\ \mu A/V^2$

$M_1: \quad 1 = \frac{1}{2} K_n' \left(\frac{W}{L}\right)_1 (1.5 - 0.5)^2 \rightarrow K_n' \left(\frac{W}{L}\right)_1 = 2\ mA/V^2$

$\left(\frac{W}{L}\right)_1 = \frac{2\ mA/V^2}{0.05\ mA/V^2} = \underline{40}$ $V_{DS} = 4.5 > 1.5 - 0.5$ ✓



$M_2: \quad 1 = \frac{1}{2} K_n' \left(\frac{W}{L}\right)_2 (1.5 + 0.5)^2 \rightarrow K_n' \left(\frac{W}{L}\right)_2 = 0.5\ mA/V^2$

$\left(\frac{W}{L}\right)_2 = \frac{0.5\ mA/V^2}{0.05\ mA/V^2} = \underline{10}$

$4.5 > 1.5 + 0.5$ ✓