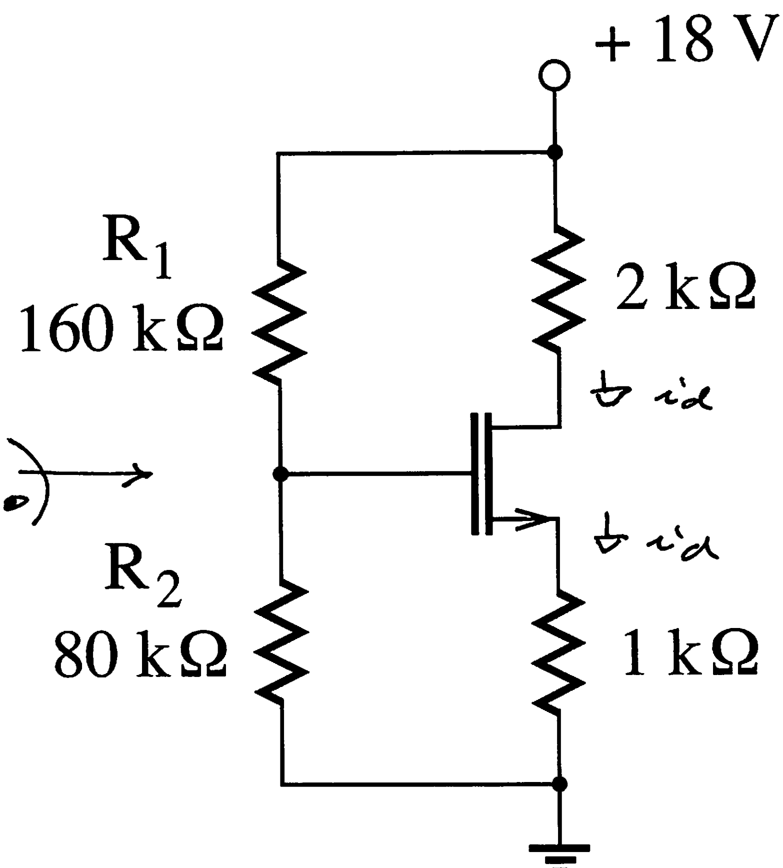
7.1

$K'\frac{W}{L} = 8\ mA/V^2$

$V_T = 1V$



$18\left(\frac{80}{80+160}\right) = \underline{6\ V}$

$v_{gs} = 6 - i_d \cdot 1 = 6 - 4(v_{gs} - 1)^2$

$v_{gs} = 6 - 4v_{gs}^2 + 8v_{gs} - 4$

$4v_{gs}^2 - 7v_{gs} - 2 = 0 \longrightarrow v_{gs} = \cancel{-0.25},\ 2$

$i_d|_Q = 4(2-1)^2 = 4\ mA$

$v_{ds}|_Q = 18 - 4(1+2) = 6\ V$

7.4

$K'\frac{W}{L} = 8\ mA/V^2$

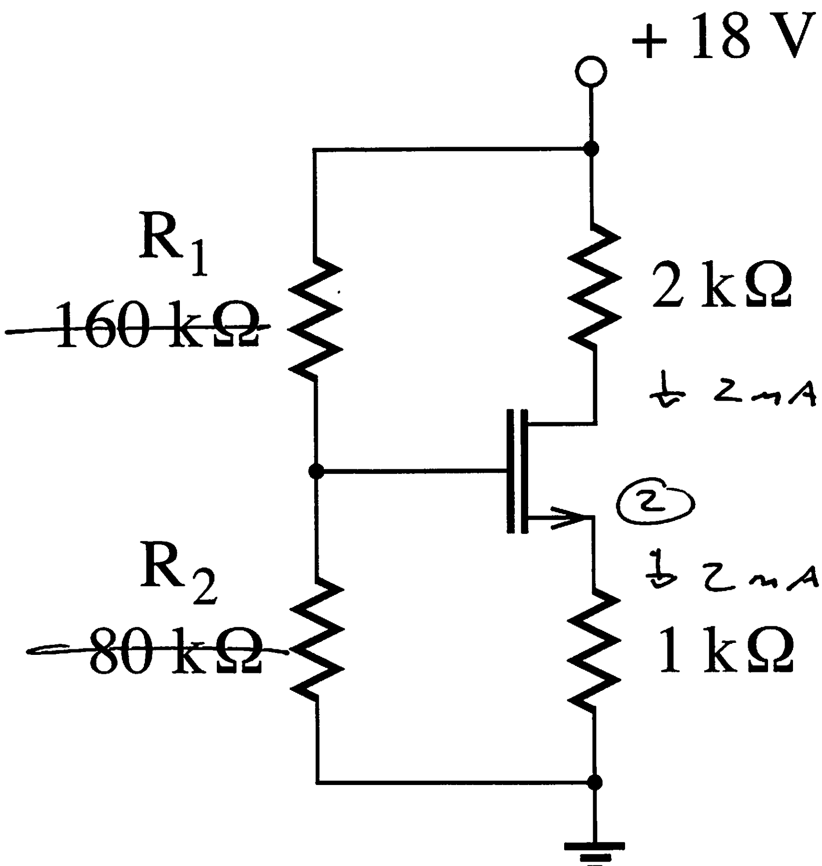
$V_T = 1\ V$

want $i_d|_Q = 2\ mA$, $R_1 \| R_2 = 100K$

$2 = 4(v_{GS}-1)^2 \longrightarrow v_{GS} = 1 \pm \frac{1}{\sqrt{2}}$

$\longrightarrow 1 + \frac{1}{\sqrt{2}}$

$= 1.707\ V$



$18\left(\frac{R_2}{R_1+R_2}\right) = 3.707$

$\frac{R_1 R_2}{R_1+R_2} = 100K$

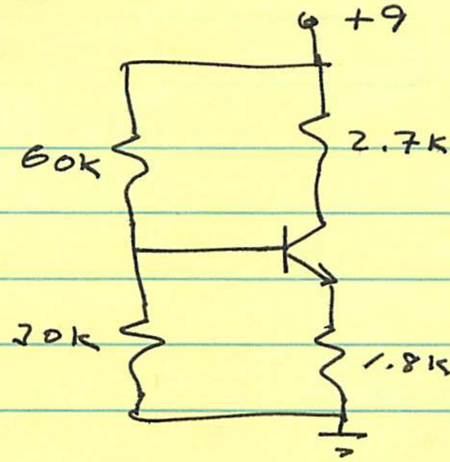
$\longrightarrow R_1 = 100K\left(\frac{18}{3.707}\right)$

$R_1 = 486K$

$100(486) + 100R_2 = 486R_2$

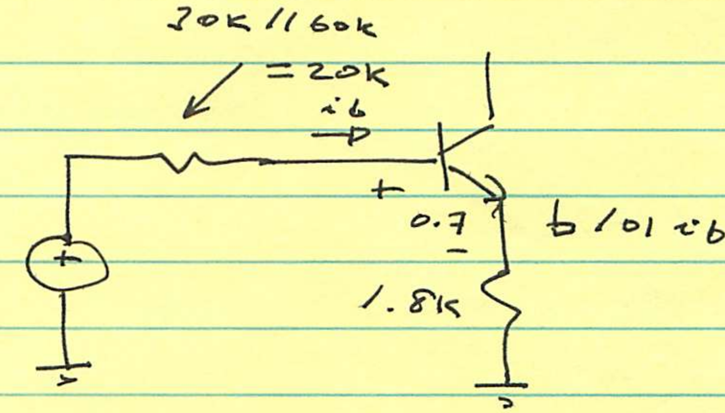
$\longrightarrow R_2 = 100K\left(\frac{486}{386}\right) = 126K$

7.10



$\beta_F = 100$

$$9\left(\frac{30k}{30k+60k}\right) = 3V$$



$$3 = 20 i_b + 0.7 + 1.8 \times 101 i_b$$

$$i_b = \frac{2.3}{201.8} \qquad i_c|_Q = \frac{230}{201.8} = 1.14 \text{ mA}$$

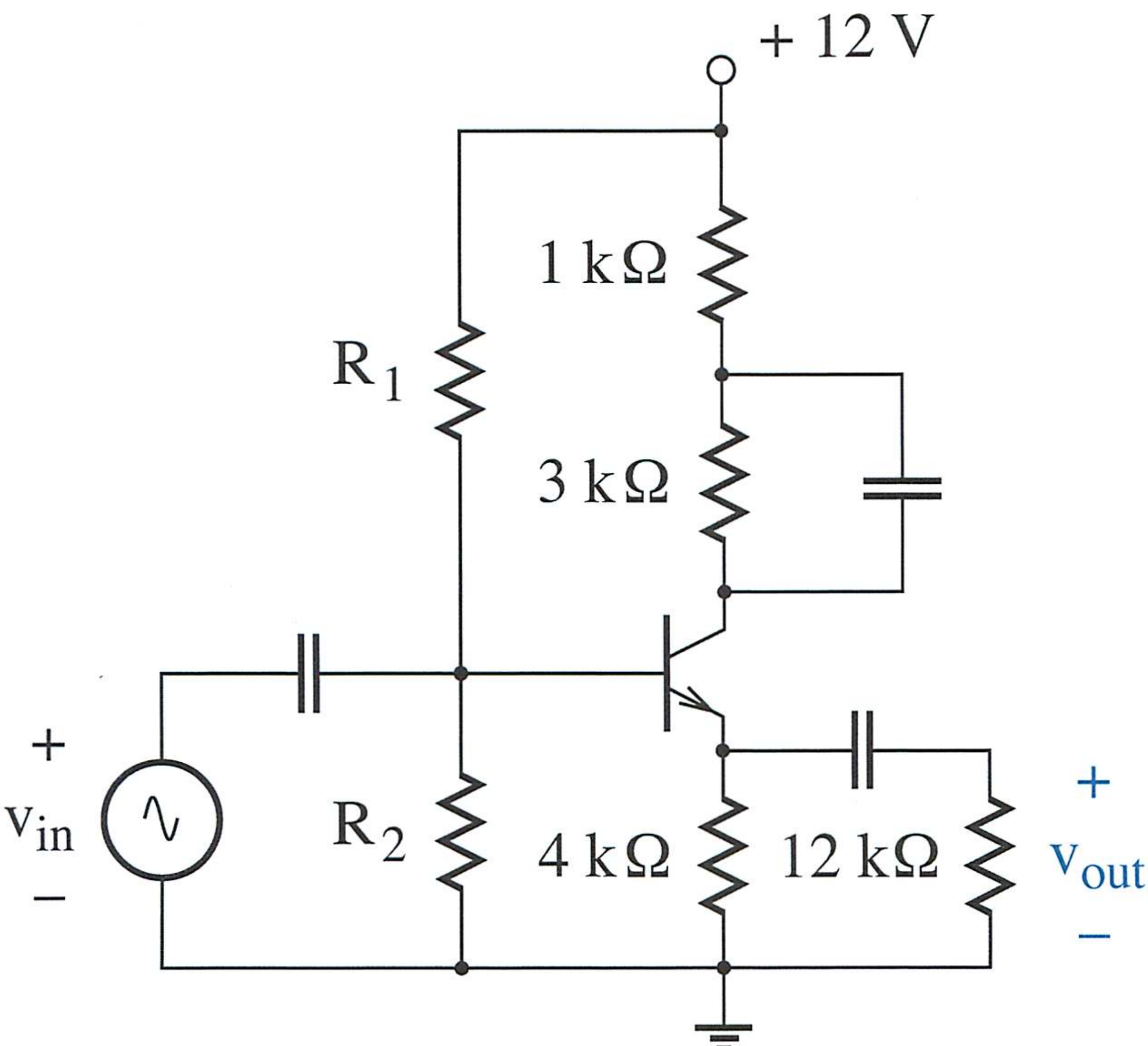
$$v_{ce}|_Q \approx 9 - 1.14(2.7 + 1.8) = 3.87 \text{ V}$$

forward active mode requires $v_{ce} > 0.2V$

7.17

a) $R_{dc} = 1K + 3K + 4K = 8K$

$r_{ac} = 1K + 4K // 12K = 4K$



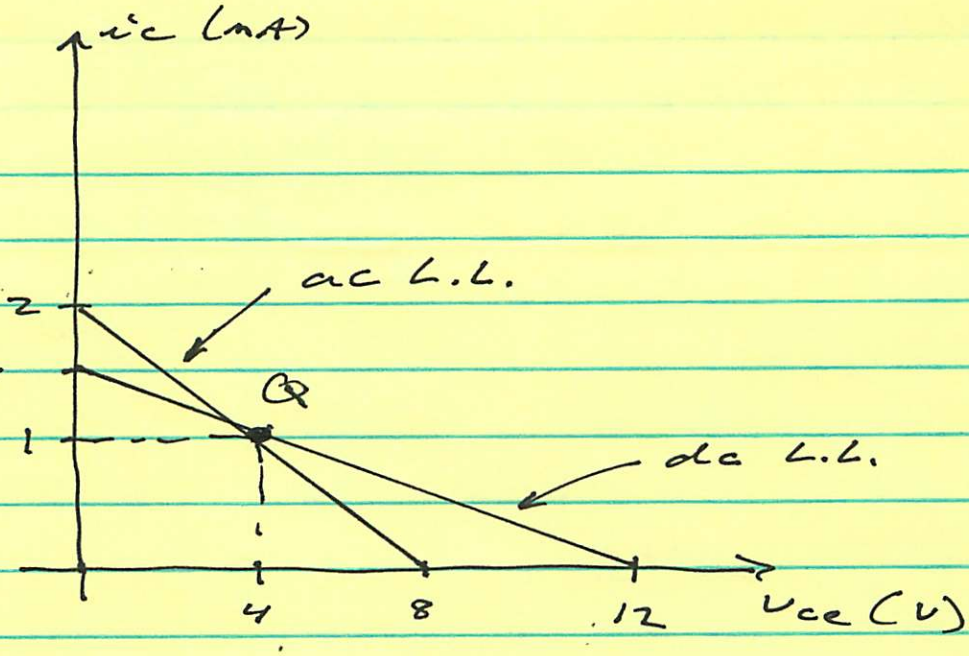
For maximum excursion along ac load line,

$$i_{CQ} = \frac{12}{r_{ac} + r_{dc}} = 1\text{ mA}$$

$$V_{CEQ} = i_{CQ}\, r_{ac} = 4V$$

b)

$\approx \frac{12}{r_{dc}} = 1.5\,mA$



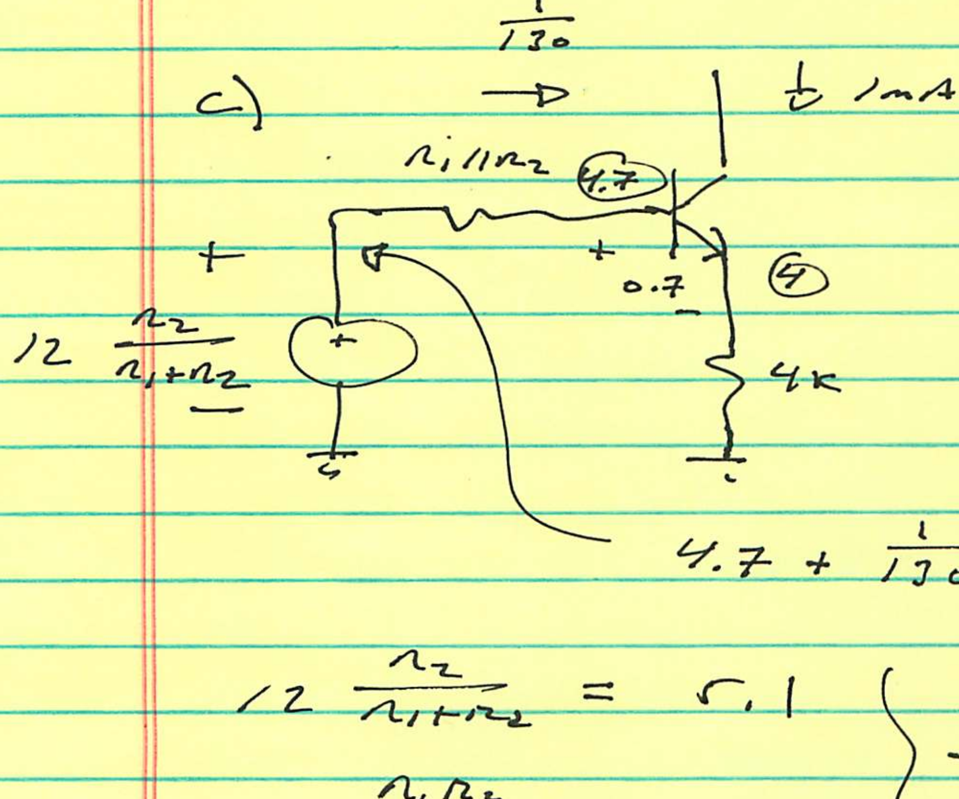
c)

$\beta_F = 130$

bias stability

$r_1 \| r_2 \sim \frac{1}{10}(131)\,4K$

$\approx 52K$



$$4.7 + \frac{1}{130}(52) = 5.1\,V$$

$$\left.\begin{aligned} 12\,\frac{r_2}{r_1+r_2} &= 5.1 \\ \frac{r_1 r_2}{r_1+r_2} &= 52K \end{aligned}\right\} \rightarrow r_1 = 52K\left(\frac{12}{5.1}\right) = \underline{122K}$$

$$122\,r_2 = 52\,r_2 + 52\,(122)$$

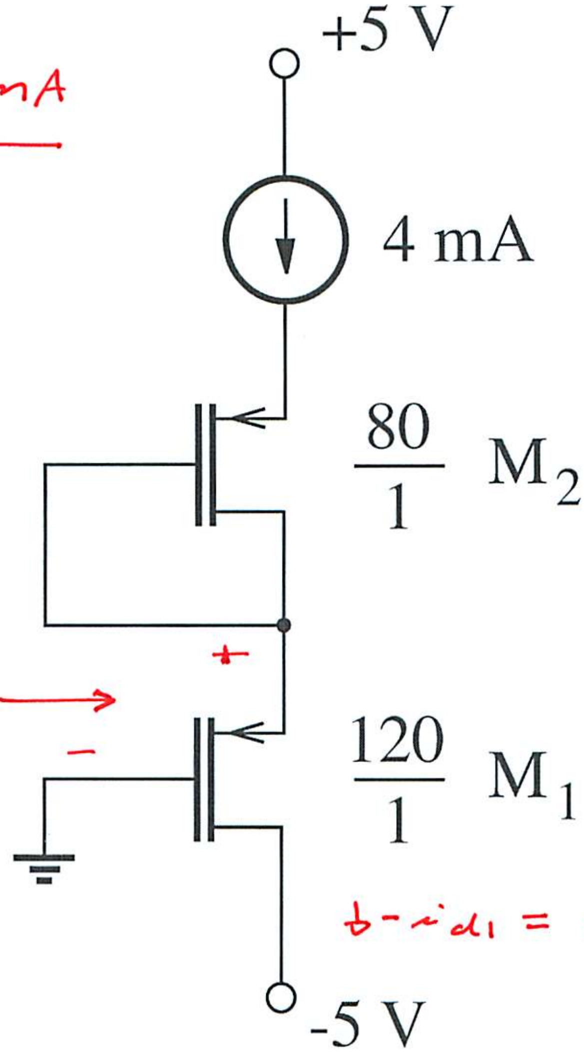
$$r_2 = 52K\left(\frac{122}{70}\right) \approx \underline{91K}$$

7.24

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

$V_T = -0.5\ V$

$i_{D1}|_Q = \underline{-4\ mA}$



+

2.33 →

−

$K'\frac{W}{L} =$ $2.4\ mA/V^2$

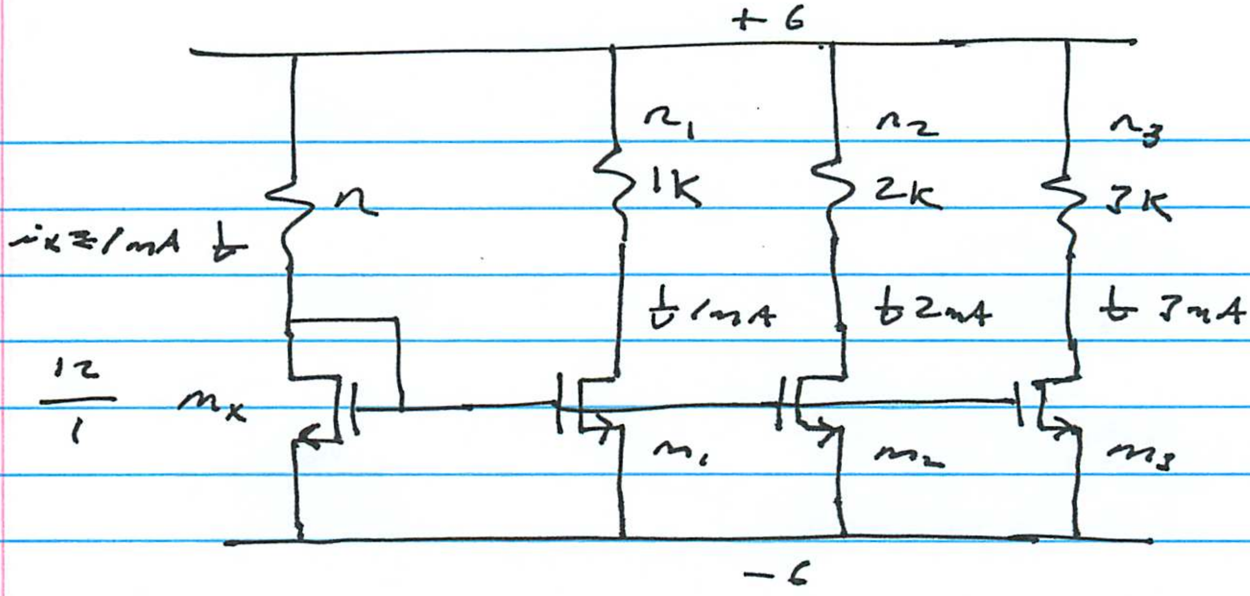
$0 - i_{D1} = 4\ mA$

$+4 = \frac{1}{2}(2.4)(v_{GS1} + 0.5)^2$

$v_{GS1} + 0.5 = \pm 1.83 \qquad v_{GS1} = \cancel{1.33},\ \underline{-2.33\ V}$

$V_{DS1}|_Q = -5 - (2.33) = \underline{-7.33\ V}$

<u>7.25</u>



a) $K_n' = 50\ \mu A/V^2 \qquad V_T = 0.5\ V$

If $i_X = 1\ mA$

$$\left(\frac{W}{L}\right)_1 = \frac{12}{1} \longrightarrow i_{d1} = 1\ mA$$

$$\left(\frac{W}{L}\right)_2 = \frac{24}{1} \longrightarrow i_{d2} = 2\ mA$$

$$\left(\frac{W}{L}\right)_3 = \frac{36}{1} \longrightarrow i_{d3} = 3\ mA$$

b) M_X: $\quad 1 = \frac{1}{2}(0.05)(12)(V_{GS} - 0.5)^2$

$$\longrightarrow V_{GS} = 2.33,\ \cancel{-1.33}$$

$$r = \frac{12 - 2.33}{1} = 9.67\ k$$

c) M_1, M_2, M_3 require $V_{DS} > V_{GS} - V_T = 1.83\ V$

edge of saturation has $V_{DS} = 1.83\ V$

$$r_1(\max) = \frac{12 - 1.83}{1} \approx 10.2\ k$$

$$r_2(\max) = \frac{12 - 1.83}{2} \approx 5.1\ k$$

$$r_3(\max) = \frac{12 - 1.83}{3} \approx 3.4\ k$$