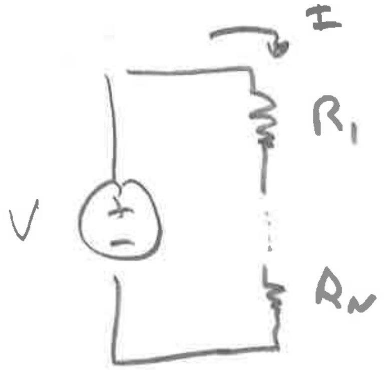
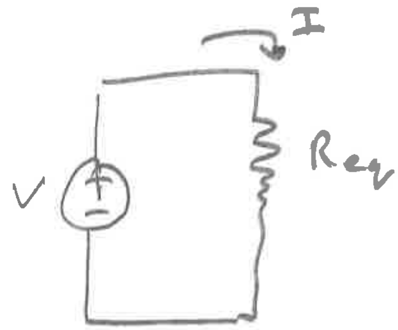
HW 1 Solutions

1)

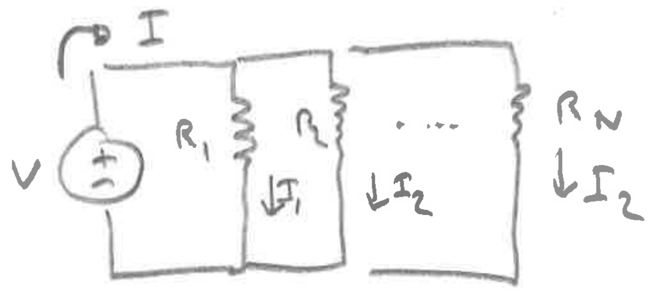


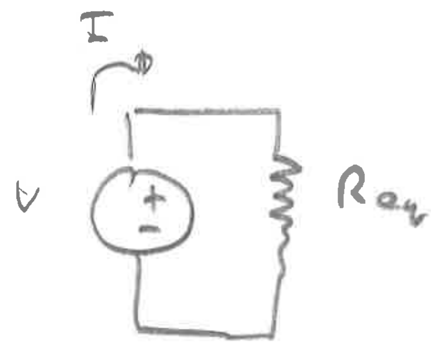


From KVL:

$$V = \sum_i R_i \cdot I = R_{eq} \cdot I$$

$$\Rightarrow \quad R_{eq} = \sum_i R_i$$





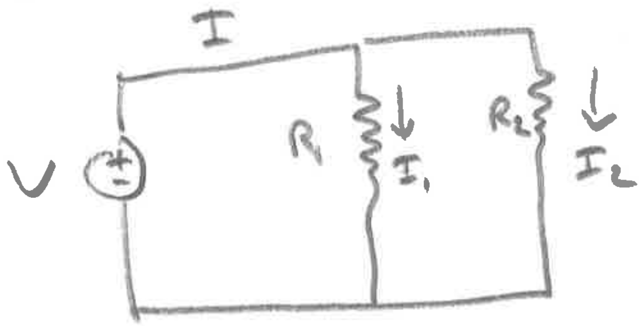
From KCL $\quad I = \sum_i I_i$

From KVL $\quad V = I R_{eq} = I_i R_i$

$$\Rightarrow \quad I_i = \frac{V}{R_i} \qquad I = \frac{V}{R_{eq}}$$

$$\Rightarrow \quad \frac{V}{R_{eq}} = \sum_i \frac{V}{R_i} \quad \Rightarrow \quad \boxed{\frac{1}{R_{eq}} = \sum_i \frac{1}{R_i}}$$

2)



From KVL: $V = I_1 R_1 = I_2 R_2$

$$\Rightarrow \quad \frac{I_1}{I_2} = \frac{R_2}{R_1}$$

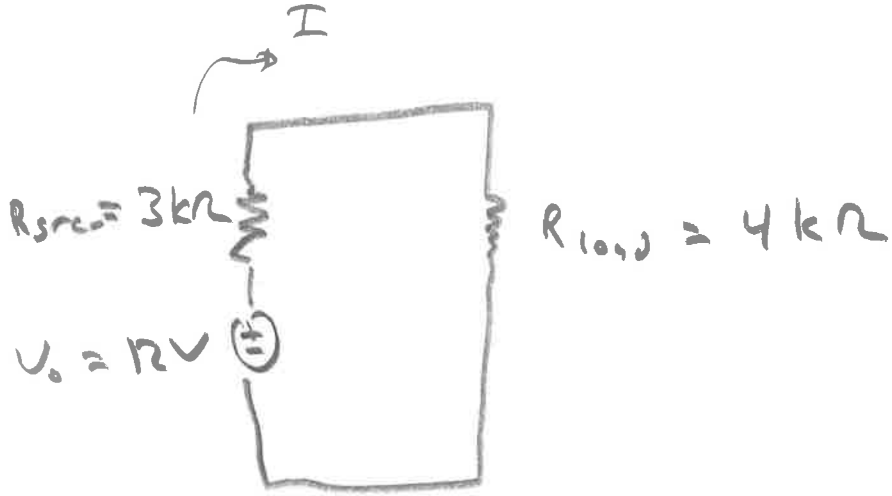
3) $P = UI$, but $U = IR$ for resistor

$\Rightarrow \quad P = I^2 R$

4) $P = UI$, but $I = U/R$

$\Rightarrow \quad P = U^2/R$

5)



$$I = \frac{V_0}{R_{src} + R_{load}} = \frac{12\,V}{(3 + 4)\,k\Omega}$$

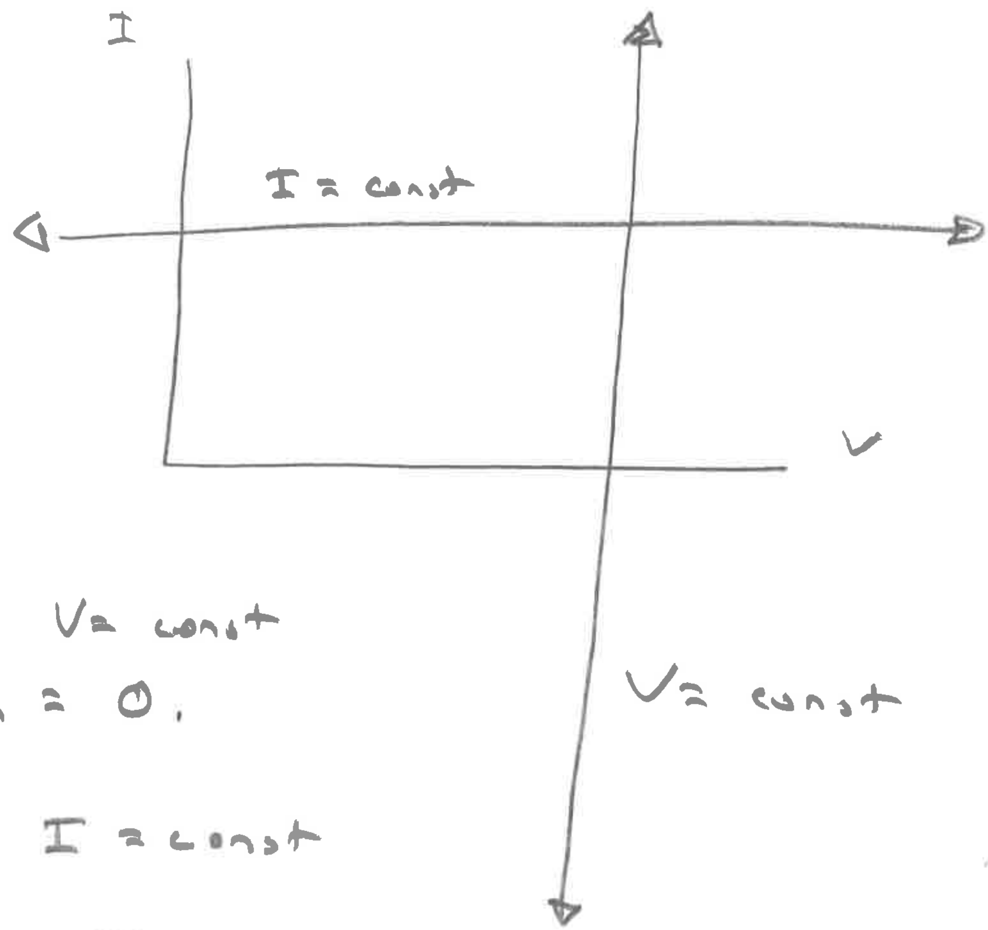
$$= \frac{12}{7}\,mA \approx \boxed{1.7\,mA}$$

$$V = R_{load} \cdot I = 4\,k\Omega \cdot 1.7\,mA$$

$$= \boxed{6.8\,V}$$

These values agree well with the indicate Q point.

6)



Slope of V= const is ∞, R = 0.

Slope of I = const is 0, R = ∞.

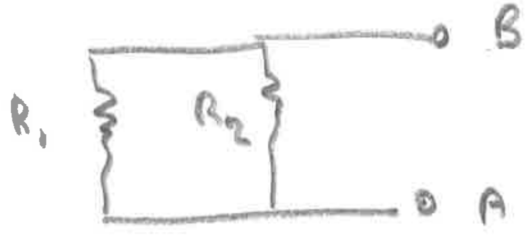
Current Supply:

If $R_{src} \gg R_{load}$,

$I = \frac{V_{src}}{R_{src}}$

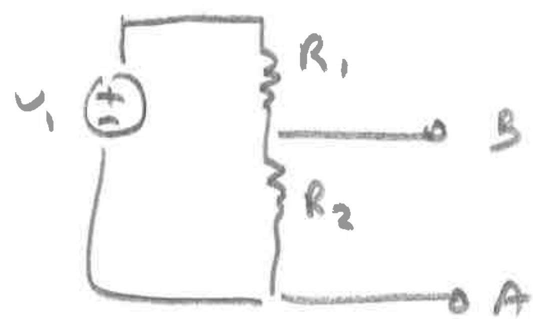
independent of R_{load}. In this case $R_{src} \to \infty$, as expected by slope.

7) To find R_{Th}, set $V_1 = 0$ and find R_{eq}:



$$R_{Th} = R_{eq} = R_1 // R_2 = \boxed{\frac{R_1 R_2}{R_1 + R_2} = R_{Th}}$$

The T.E. voltage is simply the output of ~~the~~ voltage divider:



$$\boxed{V_{Th} = \frac{R_2}{R_1 + R_2} V_1}$$

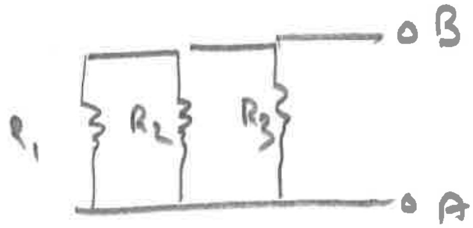
The short-circuit current is

$$I_{sc} = \frac{V_{Th}}{R_{Th}} = \frac{\frac{R_2}{R_1 + R_2} V_1}{\frac{R_1 R_2}{R_1 + R_2}}$$

$$\boxed{I_{sc} = \frac{V_1}{R_1}}$$

Makes sense:

8) Calculate R_{Th} by setting $V_1 = V_2 = V_3 = 0$ and finding equivalent resistance:



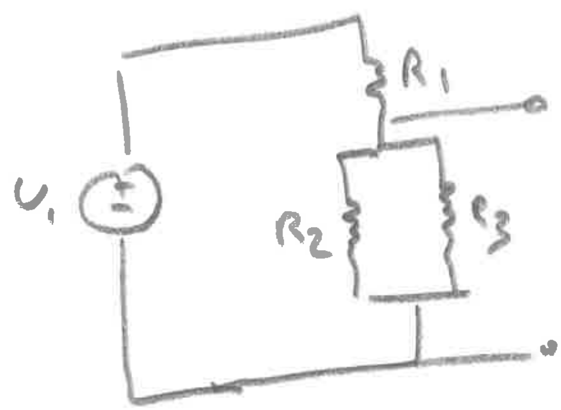
$$R_{Th} = R_{eq} = R_1 \,//\, R_2 \,//\, R_3$$

$$\boxed{R_{Th} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}}$$

For V_{Th}, use superposition principle and calculate partial solutions:

Set $V_2 = V_3 = 0$

$$V_{Th}^{(1)} = \frac{R_2 \,//\, R_3}{R_1 + R_2//R_3} V_1$$



Similarly:

$$V_{Th}^{(2)} = \frac{R_1 /\!/ R_3}{R_2 + R_1 /\!/ R_3} V_2$$

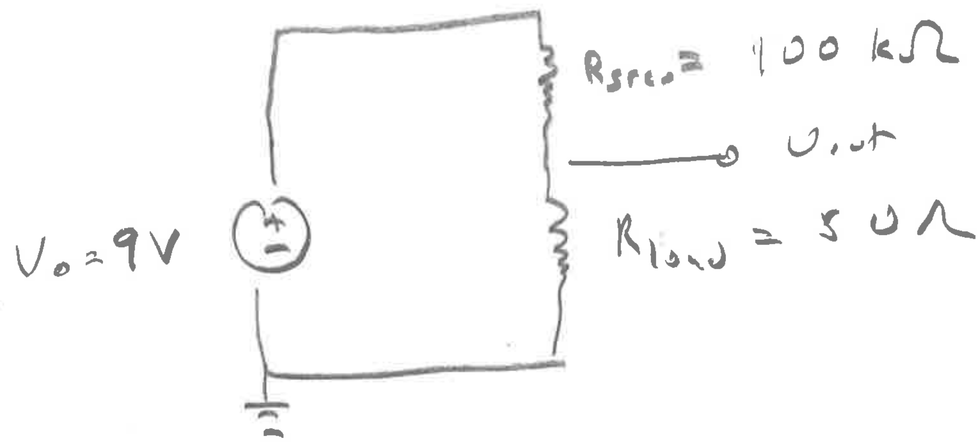
$$V_{Th}^{(3)} = \frac{R_1 /\!/ R_2}{R_3 + R_1 /\!/ R_2} V_3$$

$$V_{Th} = V_{Th}^{(1)} + V_{Th}^{(2)} + V_{Th}^{(3)}$$

$$= \frac{R_2 /\!/ R_3}{R_1 + R_2 /\!/ R_3} V_1 + \frac{R_1 /\!/ R_3}{R_2 + R_1 /\!/ R_3} V_2 + \frac{R_1 /\!/ R_2}{R_3 + R_1 /\!/ R_2} V_3$$

$$\boxed{V_{Th} = \frac{R_2 R_3 V_1 + R_1 R_3 V_2 + R_1 R_2 V_3}{R_2 R_3 + R_1 R_3 + R_1 R_2}}$$

9)



$$V_{out} = \frac{R_{load}}{R_{src} + R_{load}} V_0$$

$$= \frac{50\ \Omega}{100k\Omega + 50\ \Omega} 9V$$

$$\sim 0.5\ mV \quad << \quad 1V$$