1. A mechanic drops a wrench across both terminals of a 12 V motorcycle battery. This puts 120 A through the wrench. *Assume all the resistance is inside the motorcycle battery ($R = 0$ for the wrench.)*

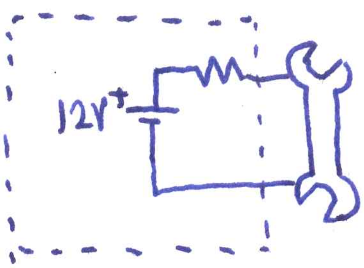
   (a) (*4 points*) What is the total resistance of the circuit?

   (b) (*4 points*) How much power is dissipated? ← I MEANT TOTAL. THIS WAS CLARIFIED IN THE AFTERNOON.

   (c) (*3 points*) What is the voltage across the wrench?

   (d) (*6 points*) Find and draw Thevenin and Norton equivalents for the battery (without the wrench).

MOTORCYCLE BATTERY



(a) $V = IR$

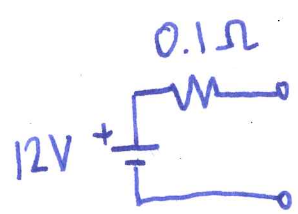
$R = 12\text{V}/120\text{A} = \underline{0.1\ \Omega}$

(b) $P = IV = 12\text{V} \cdot 120\text{A} = \underline{1440\ \text{W}}$

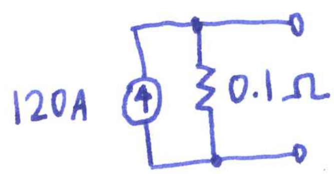
(c) SINCE THE WRENCH HAS $R=0$, $\underline{\Delta V = 0}$.

(d) $\left.\begin{array}{l} V_{oc} = 12\text{V} \\ I_{sc} = 120\text{ A} \end{array}\right\} \Rightarrow R_{TH} = 0.1\ \Omega$

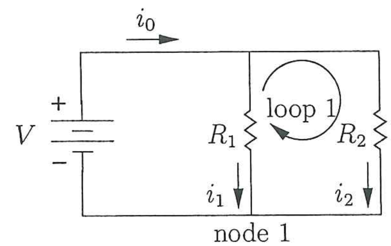
THÉVENIN:



NORTON:



2. Consider the following circuit.



(a) (*4 points*) Write KVL for loop 1.

(b) (*4 points*) Write KCL for node 1.

(c) (*4 points*) Combine the above to eliminate i_2 and solve for i_1.[1]

(a) $-i_1 R_1 + i_2 R_2 = 0$

(b) $i_0 = i_1 + i_2$

(c) $i_2 = i_0 - i_1$; SUBSTITUTE THIS INTO (a):

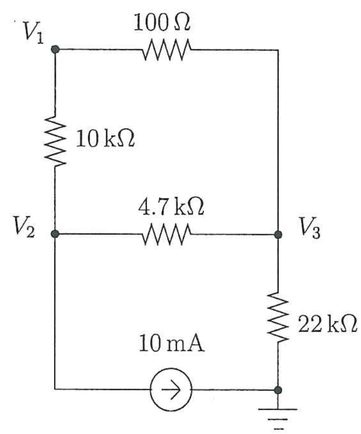
$$-i_1 R_1 + (i_0 - i_1) R_2 = 0$$

$$\Rightarrow \quad i_0 R_2 = i_1 (R_1 + R_2)$$

$$\boxed{\therefore i_1 = \left(\frac{R_2}{R_1 + R_2}\right) i_0}$$

OR EQUIVALENTLY: $i_1 = \left(\frac{G_1}{G_1 + G_2}\right) i_0$.

[1]The result should be the familiar current divider formula.



3. (*11 points*) Set up, but do not solve, the equations for node voltage analysis of this circuit. The only unknowns should be V_1, V_2 and V_3.

NODE 1: $\dfrac{V_3 - V_1}{100} + \dfrac{V_2 - V_1}{10k} = 0$

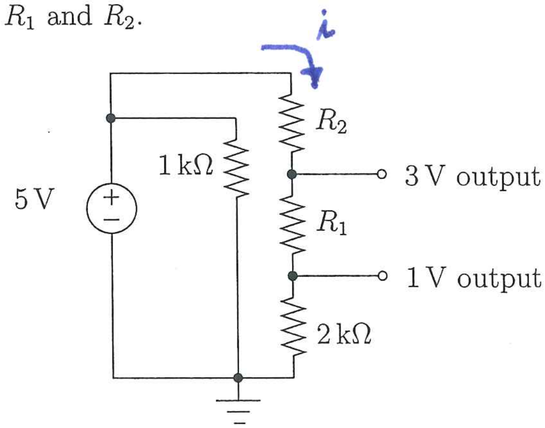
NODE 2: $\dfrac{V_1 - V_2}{10k} + \dfrac{V_3 - V_1}{4.7k} - 10\,mA = 0$

NODE 3: $\dfrac{V_2 - V_3}{4.7k} + \dfrac{V_1 - V_3}{100} + \dfrac{0 - V_3}{22k} = 0$

ALTERNATIVELY, FOR NODE 3 WE COULD GET THE VOLTAGE DIRECTLY:

$$V_3 = (22\,k\Omega)(-10\,mA) = -220\,V.$$

4. (*10 points*) Find R_1 and R_2.



NOTE THAT THE 1k RESISTOR IS IRRELEVANT!

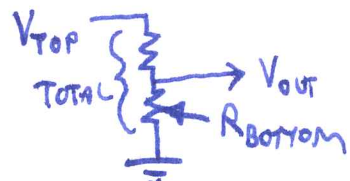
METHOD 1: $1V = i \cdot 2k\Omega \Rightarrow i = \frac{1}{2} mA$

$3V = 1V + iR_1 \Rightarrow R_1 = \frac{2V}{i} = \underline{4k\Omega}.$

$5V = 3V + iR_2 \Rightarrow R_2 = \frac{2V}{i} = \underline{4k\Omega}.$

COULD ALSO USE VOLTAGE DIVIDER FORMULA:

METHOD 2: $V_{OUT} = \left(\frac{R_{BOTTOM}}{R_{TOTAL}}\right) V_{TOP}$



SO $1V = \left(\frac{2k\Omega}{R_1 + 2k\Omega}\right) 3V \Rightarrow R_1 = \underline{4k\Omega}.$

$3V = \left(\frac{R_1 + 2k\Omega}{R_1 + R_2 + 2k\Omega}\right) 5V = \left(\frac{6k\Omega}{R_2 + 6k\Omega}\right) 5V$

$\Rightarrow R_2 = \underline{4k\Omega}.$