Physics 261
Exam 1

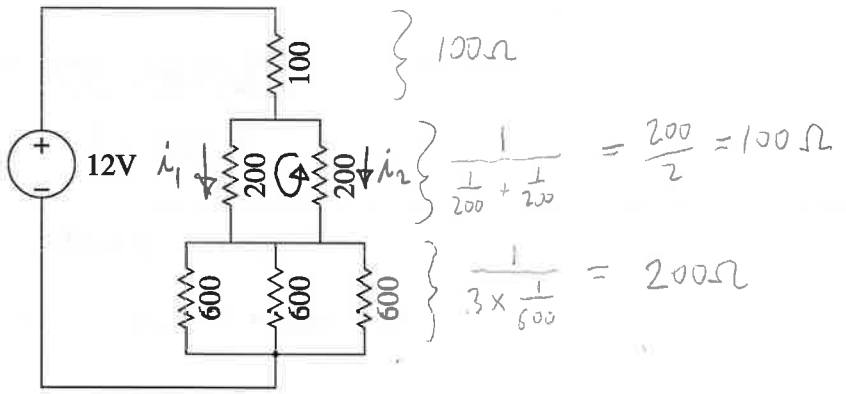
70 points possible.

Remember to show your work.

Name: Solution

12:02 - 12:10

1. Six resistors are attached to a power supply, as shown.



(a) (*5 points*) Find the equivalent resistance.

(b) (*5 points*) How much power is dissipated in this circuit?

(c) (*5 points*) Use Kirchoff's Voltage Law to show that the two 200 Ω resistors must have equal current.

(a) $100 + 100 + 200 = \boxed{400\,\Omega}$

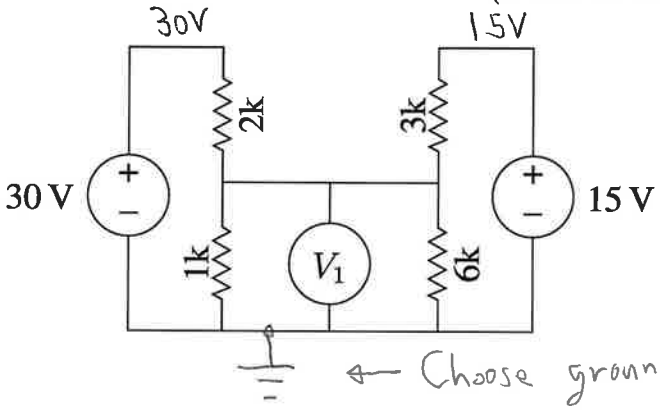
(b) $P = IV$; $I = \frac{12\,V}{400\,\Omega} = 0.03\,A = \boxed{30\,mA}$

$P = 30\,mA \times 12V = \boxed{360\,mW}$ or $\frac{144}{400}W$

(c) KVL: $i_1(200\Omega) - i_2(200\Omega) = 0$

$\Rightarrow \quad i_1 - i_2 = 0 \quad \Rightarrow \quad i_1 = i_2$

2. (*20 points*) Use Node Voltage Analysis to find the voltage measured by the meter, V_1. Assume that the meter is ideal (draws no current).



← Choose ground. +5

KCL:

$$\frac{30V - V_1}{2k\Omega} + \frac{0 - V_1}{1k\Omega} + \frac{15V - V_1}{3k\Omega} + \frac{0 - V_1}{6k\Omega} = 0$$

+3 x4 = 12

Multiplying by $6k\Omega$ and collecting terms

$$90V + 30V - V_1(3 + 6 + 2 + 1) = 0$$ +3

$$V_1 = \frac{120V}{12} = \boxed{10\,V}$$

-3 for no NVA but correct

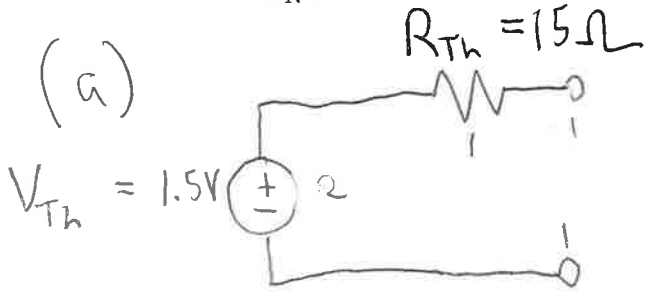
12:16-12:19

3. In the real world, batteries are not ideal voltage sources. A Thévenin or Norton equivalent is a better (though still not perfect) model. Suppose a button cell battery has an output voltage of 1.5 V when connected directly to a voltmeter. It delivers 100 mA when connected directly to an ammeter.

   (a) (*10 points*) Sketch the Thévenin equivalent of the battery and give values for V_{Th} and R_{Th}.

   (b) (*5 points*) Also sketch the Norton equivalent. What are I_{N} and R_{N}?

(a)

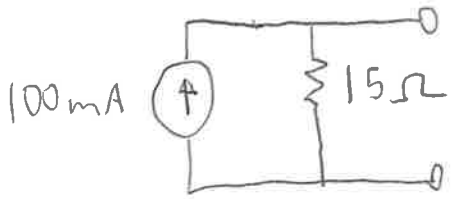


2 $I_{oc} = 100\,mA$

$R_{Th} = \frac{V_{Th}}{I_{oc}} = \frac{1.5\,V}{100\,mA} = 15\Omega$ 2 | 1

(b) $I_N = I_{oc} = 100\,mA$

$R_N = R_{Th} = 15\Omega$ } 2



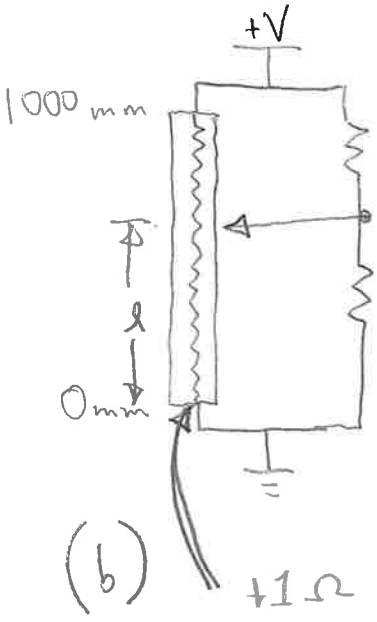
3

12:20 – 12:28

4. Sketch a Wheatstone Bridge similar to the one we used in class. A thin wire, laid along a meter stick, is the potentiometer along one side of the bridge. Assume the wire's total resistance is $10\,\Omega$. Connected at 0 mm is $R_{\text{ref}} = 11\,\Omega$. Connected to the reference and also to the wire at 1000 mm, is $R_{\text{test}} = 99\,\Omega$. A galvanometer connects these two resistors to the potentiometer wiper.

   (a) (10 *points*) At what position along the meter stick must the wiper be set to zero the galvanometer?

   (b) (15 *points*) Unfortunately, the wire just broke somewhere between the 0 mm and 1 mm mark. You try to repair it, but there's an extra $1\,\Omega$ of resistance at the repair. Now where must the wiper be set to zero the galvanometer?



(a) $\frac{\ell}{1000\text{mm}} = \frac{11\,\Omega}{99\Omega + 11\Omega}$

$\ell = 1000\left(\frac{11}{110}\right) = 100\text{ mm}$

$\frac{(\ell/1000\text{mm})10\Omega + 1\Omega}{10\Omega + 1\Omega} = \frac{11\Omega}{99 + 11\Omega} = \frac{1}{10}$

$\frac{\ell}{1000\text{mm}}10\Omega + 1\Omega = \frac{11\Omega}{10} = 1.1\Omega$

$\ell = 1000\text{mm}\ \frac{(1.1\Omega - 1\Omega)}{10\,\Omega} = \frac{1000\text{ mm}}{100}$

$= 10\text{ mm}$