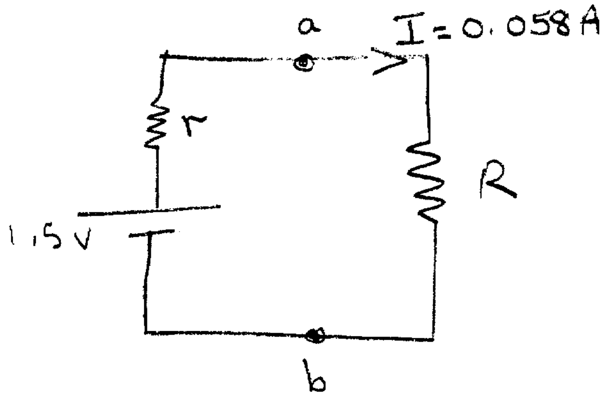
ENGINEERING 2C3 Assignment #2 Solution

1. [Serway Chapter 28 Problem 6, pg 821]
A typical fresh AA dry cell has an emf of 1.50 V and an internal resistance of 0.311 Ω. (a) Find the terminal voltage of the battery when it supplies 58 mA to a circuit. (b) What is the resistance R of the external circuit?



(a) Terminal voltage (i.e across ab):

$$V_{ab} = 1.5 - Ir$$

$$= 1.5 - 0.311 \cdot 0.058$$

$$= 1.482\,V$$

(b) $$R = \frac{V_{ab}}{I} = \frac{1.482\,V}{0.058\,A} = 25.55\,\Omega$$

2. [Serway Chapter 28 Problem 12, pg 821]
(a) You need a 45-Ω resistor, but the stockroom has only 20-Ω and 50-Ω resistors. How can the desired resistance be achieved under the circumstances?
(b) What can you do if you need a 35-Ω resistor?

(a) Recall that resistors in series add, ie:

$$R_T = R_1 + R_2 + \cdots$$

While resistors in parallel follow:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

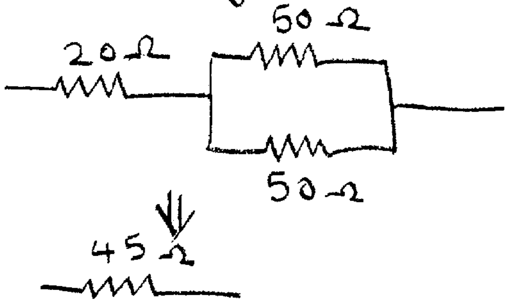
Note that if $R_1 = R_2$ we get

$$\frac{1}{R_T} = \frac{2}{R_1} \Rightarrow R_T = \frac{1}{2} R_1$$

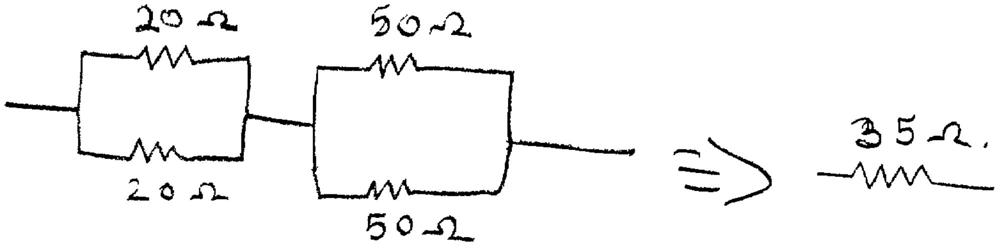
ie two like resistances in parallel cuts the resistance in half.

Now, $\frac{1}{2}$ of 50 is 25, which is just what we need.

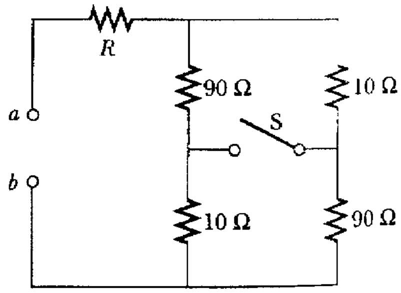
∴ wire up as follows:



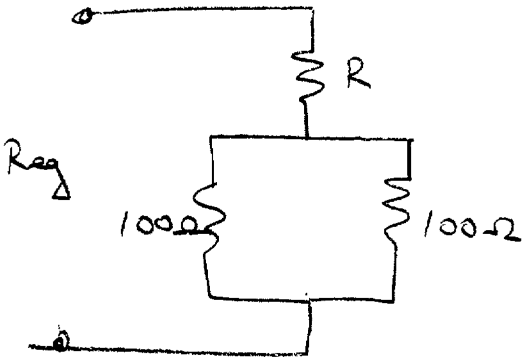
(b) To get 35 Ω, put 2 – 20's in parallel to give 10 Ω and 2-50's in parallel to give 25 Ω. Thus:



3. [Serway Chapter 28 Problem 22, pg 822]
The resistance between points a and b in the figure drops to ½ its original value when S is closed. Determine the value of R.

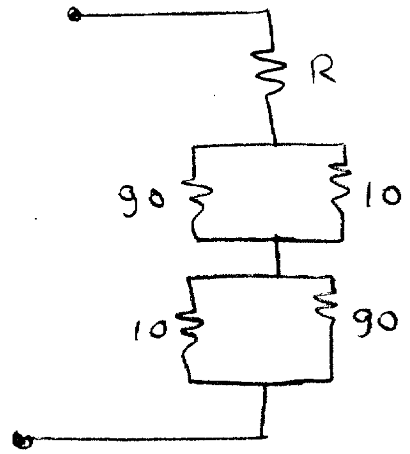


When the switch is open the circuit is

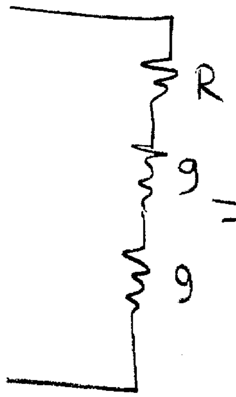


$\Rightarrow \quad R_{eq} = R + 50\,\Omega.$

When the switch is closed, the circuit is



$\Rightarrow$



$\Rightarrow \frac{1}{2} R_{eq} = R + 18$

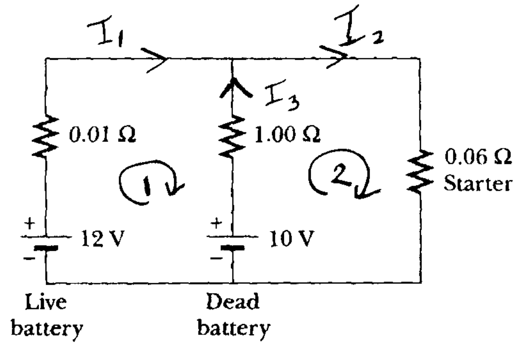
ie $R_{eq} = R + 50$

$\frac{1}{2} R_{eq} = R + 18 \Rightarrow R_{eq} = 2R + 36$

Subtracting the two equations:

$0 = -R + 14 \quad \Rightarrow \quad \underline{R = 14\,\Omega}$

4. [Serway Chapter 28 Problem 29, pg 823]
A dead battery is charged by connecting it to the live battery of another car as shown. Determine the current in the starter and the dead battery.



Loop 1

$$12 - 0.01 I_1 + 1.00 I_3 - 10 = 0 \quad \text{— (1)}$$

Loop 2

$$10 - 1.00 I_3 - 0.06 I_2 = 0 \quad \text{— (2)}$$

Junction

$$I_1 + I_3 = I_2 \Rightarrow I_1 = I_2 - I_3 \quad \text{— (3)}$$

Substituting (3) into (1):

$$12 - .01(I_2 - I_3) + I_3 - 10 = 0$$

ie
$$2 - .01 I_2 + 1.01 I_3 = 0 \quad \text{— (4)}$$

Now: (2) − 6 × (4) gives:

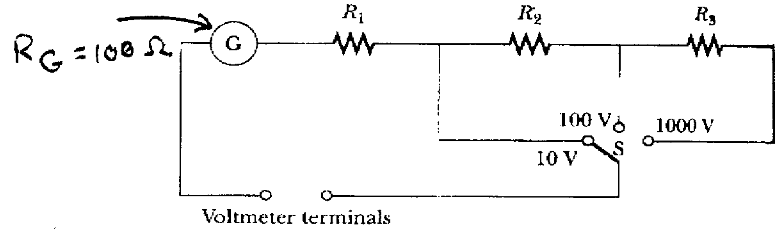
$$10 - 0.06 I_2 - I_3 = 0$$
$$- \quad 12 + 0.06 I_2 - 6.06 I_3 = 0$$
$$-2 - 7.06 I_3 = 0$$

$$\therefore I_3 = -\frac{2.00}{7.06} = -0.283 \text{ A} = \text{current in battery}$$

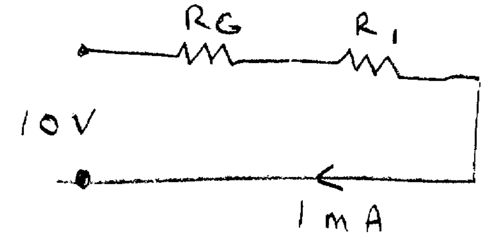
ie opposite the direction shown.

∴ from (2): $I_2 = \frac{10 - I_3}{0.06} = \frac{10.283}{0.06} = 171.39\text{A}$ in starter in direction shown

5. [Serway Chapter 28 Problem 54, pg 826]
For each voltage setting, a galvanometer having an internal resistance of 100 Ω deflects full scale when the current is 1.0 mA. For the multiscale voltmeter in the figure, what are the values of R_1, R_2 and R_3?



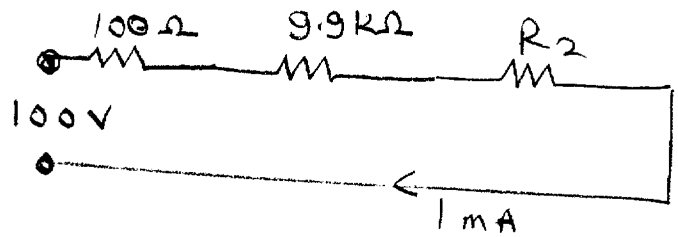
When the switch is in the 10 V position, get 1 mA full scale, ie 1 mA at 10 Volts.



$$\therefore \quad 10 = (R_G + R_1)(0.001) = (100 + R_1)(0.001)$$

$$\therefore \quad R_1 = \frac{10 - 0.1}{0.001} = \underline{9.9\ \text{k}\Omega}.$$

When S is in the 100 V position;



$$\therefore \quad 100\ \text{V} = (100 + 9{,}900 + R_2)(0.001)$$

$$= (10{,}000 + R_2)(0.001)$$

$$\therefore \quad R_2 = \frac{100 - 10}{.001} = \underline{90\ \text{k}\Omega}$$

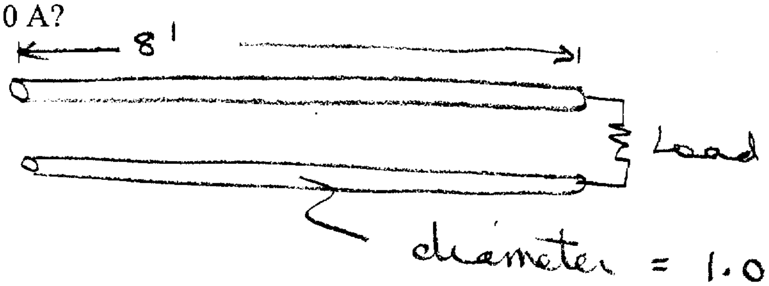
+ Finally, For the 1000 V case!

$$1000 = (100 + 9{,}900 + 90{,}000 + R_3)(.001)$$

$$\therefore \quad R_3 = (1000 - 100{,}000 \times .001) / (.001)$$

$$= \underline{900\ \text{k}\Omega}$$

6. [Serway Chapter 28 Problem 67, pg 827]
An 8-foot extension cord has two 18-gauge copper wires, each having a diameter of 1.024 mm. How much power does this cord dissipate when carrying a current of (a) 1.0 A and (b) 10.0 A?



$\rho = 1.7 \times 10^{-8}\ \Omega \cdot m$ from Serway table 27.1

For one wire, $R = \frac{\rho L}{A} = \frac{1.7\times10^{-8}\ \Omega m \times 16' \times .3048\ m/ft}{\pi \left(\frac{1.024\times10^{-3}}{2}\right)^2}$

$= 0.101\ \Omega$

(a) $I = 1.0\,A$ $\therefore$ $P = I^2 R = 1^2 \times (0.101) = \underline{0.101\ W}$

(b) $I = 10.0\,A$ $\therefore$ $P = I^2 R = (10)^2 \times (0.101) = \underline{10.1\ W}$

(At 10 A, you'd feel the heat generated – so it is not a good idea to push this much current through an extension cord of this type. Use one with a heavier gauge wire.)