

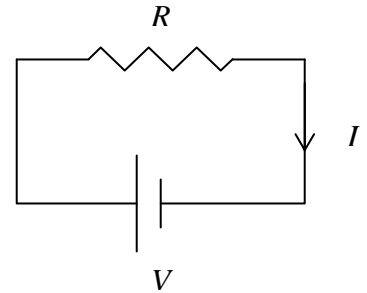
DC Circuits – Colorado PhET Applet Lab

Go to: <http://phet.colorado.edu/>

Launch the Circuit Construction Kit (DC only) applet.

Construct each of the circuits and answer the accompanying questions.

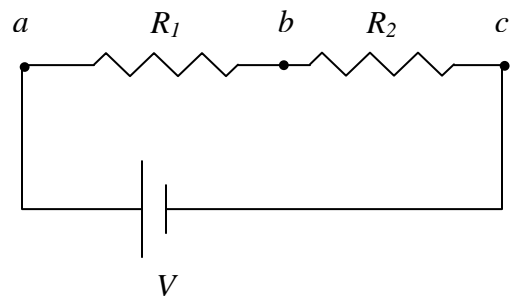
1. Build the circuit shown. Set the resistance to $3\ \Omega$ and the potential, V , at 6 volts.
 - a. Using Ohm's Law, determine the current in the loop.
 - b. Predict: If the resistance were halved, what would happen to the current?



Verify your prediction by checking the current in the circuit. Do so by correctly wiring an ammeter into the circuit. Explain how this is done?

- c. If the voltage of the battery were tripled, what would happen to the current? Explain.
- d. How many junctions are in this circuit?

2. Build the circuit shown. Set the V to 12 volts, R_1 to $2\ \Omega$, and R_2 to $1\ \Omega$.
 - a. Using the relationship derived in class, calculate the equivalent resistance of the two resistors in series. $R_{EQ} = \underline{\hspace{2cm}}\ \Omega$.



- b. Using Ohm's Law, calculate the current in this circuit. $I = \underline{\hspace{2cm}}\ \text{A}$.
- c. Given the construction of this circuit, what is the current through R_1 ? Through R_2 ?
Verify these predictions using an ammeter.
- d. Using the voltmeter, measure the potential "drop" across R_1 , from a to b ?
 $V_{ab} = \underline{\hspace{2cm}}\ \text{V}$.
- e. Using the voltmeter, measure the potential "drop" across R_2 , from b to c ?
 $V_{bc} = \underline{\hspace{2cm}}\ \text{V}$.

- f. What do you notice about the two voltages that you just measure?
- g. As we saw in class, the power output, P , is equal to the product of the current through the circuit element and the voltage drop across the element ($P = IV$). Calculate the rate at which energy is lost (P) for each resistor?

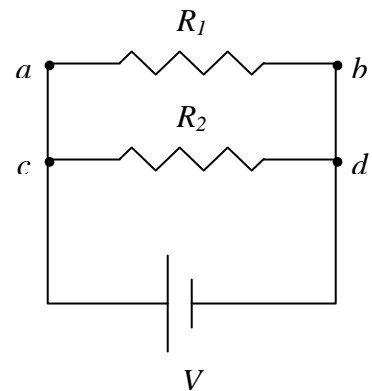
$$P_1 = \underline{\hspace{2cm}} \text{ W.}$$

$$P_2 = \underline{\hspace{2cm}} \text{ W.}$$

- h. Replace R_1 and R_2 with bulbs of the same resistances as the original resistors. What do you observe about the bulbs? Why is this not unexpected?

3. Build the circuit shown. Set the V to 12 volts, R_1 to 4Ω , and R_2 to 2Ω .

- a. How many junctions are in this circuit? What labeled points on this circuit are junctions?



- b. How many branches are in the circuit?

- c. Using the voltmeter, measure the potential “drop” across R_1 , from a to b ?

$$V_{ab} = \underline{\hspace{2cm}} \text{ V.}$$

- d. Using the voltmeter, measure the potential “drop” across R_1 , from c to d ?

$$V_{cd} = \underline{\hspace{2cm}} \text{ V.}$$

- e. What do you observe about the “drops” across these two resistors? Explain this observation.

- f. Using an ammeter, measure the current coming out of the battery (between the battery and Pt. c). This is the total current in the circuit. $I_{\text{total}} = \underline{\hspace{2cm}} \text{ A.}$

- g. Using an ammeter, measure the total current returning to the battery (between Pt. d and the battery). Why is this value the same as the value found above?

- h. Using Ohm’s Law, given the potential of the battery and the total current in the circuit, calculate the equivalent resistance of the circuit. $R_{\text{EQ}} = \underline{\hspace{2cm}} \Omega.$

i. As discussed in class, the equivalent resistance of parallel branched of a circuit is a “flip-add-flip” relationship, $\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$. Calculate the equivalent resistance of the circuit by this method and compare the answer to that found in the previous question.

j. What must happen to current coming from the battery when it arrives a junction?

k. Compare the resistances of each branch of this circuit. Would you expect the current to split equally at junction *c*? Which branch would you expect to carry more current? Predict how much current would flow through each branch:

$$I_1 = \text{_____} \text{ A.}$$

$$I_2 = \text{_____} \text{ A.}$$

l. Using an ammeter, measure the current in each branch. How did the values compare with your predictions?

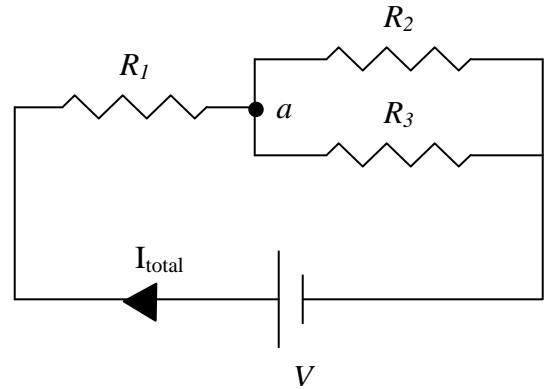
m. Using $P = IV$, calculate the power output (rate of energy loss) at each resistor.

$$P_1 = \text{_____} \text{ W.}$$

$$P_2 = \text{_____} \text{ W.}$$

n. If R_1 and R_2 were bulbs, which would be brighter? Why?

4. Construct the circuit shown. Set V to 24 volts, R_1 to $3\ \Omega$, R_2 to $12\ \Omega$, and R_3 to $4\ \Omega$.
- a. Are resistors 2 and 3 wired in series (end-to-end) or parallel? Explain.



- b. Given that they are wired in parallel, use the appropriate relationship for parallel resistors and calculate the equivalent resistance of this portion of the circuit.

$$R_{\text{EQ}23} = \underline{\hspace{2cm}} \Omega.$$

- c. If you were to replace R_2 and R_3 with a single equivalent resistor, $R_{\text{EQ}23}$, how would R_1 and $R_{\text{EQ}23}$ be wired, in series or in parallel? Explain.
- d. Given that you should have answered “in series” for the previous question, use the appropriate relationship for series resistors and find the equivalent resistance produced by all three resistors. Show your work.

$$R_{\text{EQ}} = \underline{\hspace{2cm}} \Omega.$$

- e. Using Ohm’s Law, calculate the total current in the circuit.

$$I_{\text{total}} = \underline{\hspace{2cm}} \text{ A}.$$

- f. Using an ammeter, measure the total current coming out of (or returning to) the battery. Does this value agree with the number calculated in the previous problem? If yes, proceed; if not, figure out what you did wrong!

- g. Using a voltmeter, measure the potential drops across each resistor.

$$V_1 = \underline{\hspace{2cm}} \text{ V.} \quad V_2 = \underline{\hspace{2cm}} \text{ V.}$$

$$V_3 = \underline{\hspace{2cm}} \text{ V.}$$

What do you notice about $V_1 + V_2$, $V_1 + V_3$, and V_{BATT} ? Explain these relationships.

h. Given the total current that flows out of the battery toward R_1 , what must be the current that flows through R_1 ? Explain your response.

i. How much current must flow toward the junction (Pt. *a*) between R_2 and R_3 ?

j. Compare the resistances of R_2 and R_3 . Which branch would you expect to carry more current? Predict how much current would flow through each resistor:

$$I_2 = \text{_____ A.}$$

$$I_3 = \text{_____ A.}$$

k. Using an ammeter, measure the current through these two resistors. Do these values agree with your predictions? If yes, proceed; if not, stop and figure out what went wrong!

l. Calculate the power output ($P=IV$) for each resistor. Which resistor would be the hottest?

$$P_1 = \text{_____ W.}$$

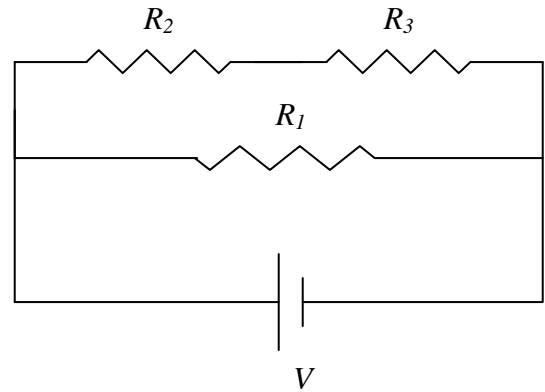
$$P_2 = \text{_____ W.}$$

$$P_3 = \text{_____ W.}$$

5. Construct the circuit shown. Set V to 24 volts, R_1 to $4\ \Omega$, R_2 to $9\ \Omega$, and R_3 to $3\ \Omega$. Using the skills you have developed thus far, start by calculating:

a. the equivalent resistance of each branch;

b. the R_{EQ} of all 3 resistors in this circuit;



c. the total current coming out of the battery, according to Ohm's Law.

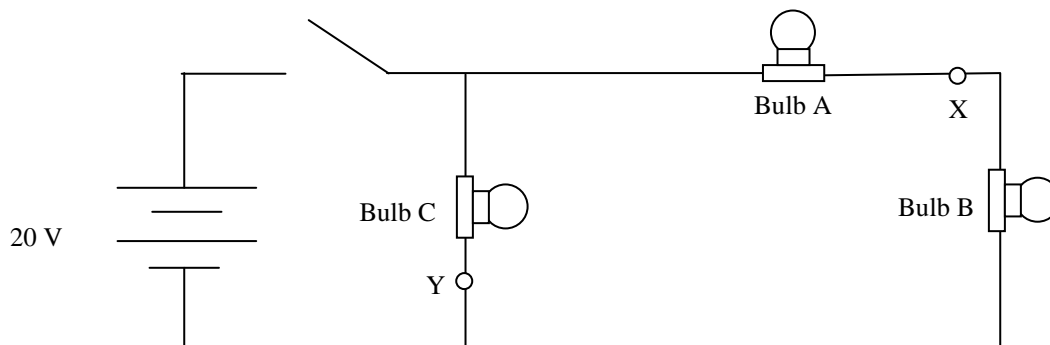
Now determine how the total current divides when it hits a junction and, therefore, how much current ultimately flows through each resistor.

Put the values for the current through each resistor in the following table. Once you have that information, calculate the potential drop across each resistor and the power output of each.

R	I	V	P
$R_1 = 4\ \Omega$			
$R_1 = 9\ \Omega$			
$R_1 = 3\ \Omega$			

Verify your results by measuring the current through each resistor (using an ammeter) and the voltage across each (using the voltmeter).

6. Build the three bulb circuit as shown below. Make sure all the bulbs have the same resistance ($10\ \Omega$) and that the switch is left open so the bulbs are not lit. Points X and Y are labeled for reference.



Answers the following questions and check your predictions using the circuit you constructed.

- a. Rate the bulbs in order from brightest to dimmest, noting any ties, when the switch is closed. Explain your reasoning.

The following questions describe changes made to the circuit shown above. Treat each change separately — they are *not* done in combination.

- b. Briefly explain what would happen to the brightness of the remaining bulbs if Bulb A were unscrewed.

- c. Briefly explain what would happen to the brightness of the remaining bulbs if Bulb C were unscrewed.

- d. If points X and Y were connected by a wire, briefly explain what would happen to the brightness of the bulbs.