Circuit Builder – Voltage Drops

Goal: To analyze circuits in order to discover some patterns regarding voltage drops.

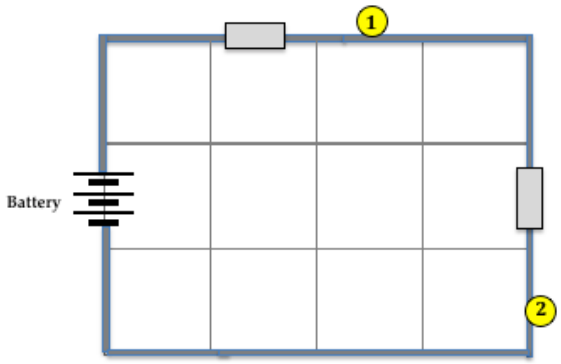
Getting Ready: Open your browser and go to:

http://www.physicsclassroom.com/Physics-Interactives/Electric-Circuits/Circuit-Builder

Build, Measure, Analyze:
Use the tools (at the bottom of the screen) to build the circuit below. You need a battery, two bulbs, and two ammeters. Position them as shown.

To build a circuit, click on a bulb, resistor, wire or ammeter (the rectangular box) and click in the workspace where you wish it to be located. When the circuit has been completed, charges should flow and the bulbs should light.

Circuit 1



1. Use red, blue, and yellow markers to color the three wires in the diagram according to their electric pressure. We will refer to locations around the circuit using their designated colors.
2. Set the **voltage of the battery** to 12 Volts. (Tap the Modify icon. Then tap on the battery and use the arrows to increase/decrease the voltage to 12 V.)
3. Set the **resistance** of Bulb 1 to **3 Ω** and the resistance of Bulb 2 to **3 Ω**. (Tap the Modify icon. Then tap on a bulb and use the arrows to increase/decrease the resistance values.)
4. Electric pressure (i.e., voltage) values for each wire are listed inside circles on the wire. Record the electric pressure values for the red, blue, and yellow wires.

   V_{red} = _____ Volts V_{yellow} = _____ Volts V_{blue} = _____ Volts
5. Observe that there is a difference in color (i.e., electric pressure) on opposite sides of **Bulb 1**. The same is true for **Bulb 2**. We refer to this as a **voltage drop** since the values of voltage undergo a downward change (drop) as charge passes through the bulbs. Use the values in Q#4 to calculate the voltage drops (ΔV) for the two bulbs.

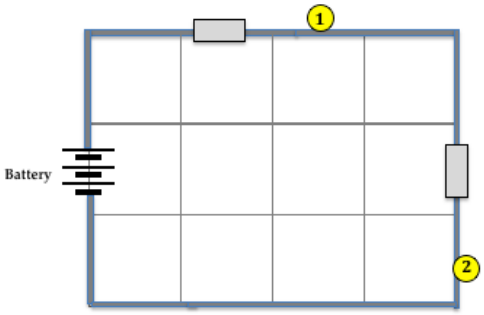
   $\Delta V_{Bulb\ 1}$ = _____ Volts $\Delta V_{Bulb\ 2}$ = _____ Volts
6. The current values are listed inside the ammeter boxes for each wire. Observe that the **current is the same in each wire**. The current is _____ A.
7. Use the current (Q#6) and the resistance (Q#3) values to calculate the I•R product for the two bulbs.

   $I \cdot R_{Bulb\ 1}$ = _____ A•Ω $I \cdot R_{Bulb\ 2}$ = _____ A•Ω
8. How does the $\Delta V_{Bulb\ 1}$ of Q#5 compare to the $I \cdot R_{Bulb\ 1}$ value of Q#7?

   How does the $\Delta V_{Bulb\ 2}$ of Q#5 compare to the $I \cdot R_{Bulb\ 2}$ value of Q#7?

Circuit 2

Create a similar circuit with a 12 Volt battery, two ammeters, and two light bulbs with resistance values of 4 Ω for **Bulb 1** and 2 Ω for **Bulb 2**. Color code the drawing with **red**, **green**, and **blue** markers.



Determine the following values. The first two rows are read from the **Circuit Builder** program. The last two rows are calculated.

I = _____ A

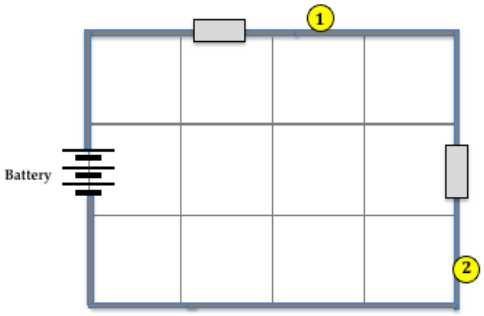
V_{red} = _____ Volts V_{green} = _____ Volts V_{blue} = _____ Volts

$\Delta V_{Bulb\ 1}$ = _____ Volts $\Delta V_{Bulb\ 2}$ = _____ Volts

$I \cdot R_{Bulb\ 1}$ = _____ A•Ω $I \cdot R_{Bulb\ 2}$ = _____ A•Ω

Circuit 3

Create a similar circuit with a 12 Volt battery, two ammeters, and two light bulbs with resistance values of 2 Ω for **Bulb 1** and 4 Ω for **Bulb 2**. Color code the drawing with **red**, **orange**, and **blue** markers.



Determine the following values. The first two rows are read from the **Circuit Builder** program. The last two rows are calculated.

I = _____ A

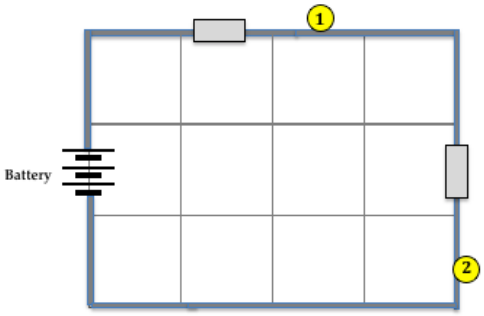
V_{red} = _____ Volts V_{orange} = _____ Volts V_{blue} = _____ Volts

$\Delta V_{Bulb\ 1}$ = _____ Volts $\Delta V_{Bulb\ 2}$ = _____ Volts

$I \cdot R_{Bulb\ 1}$ = _____ A•Ω $I \cdot R_{Bulb\ 2}$ = _____ A•Ω

Circuit 4

Now create a different circuit with a 24 Volt battery, two ammeters, and two light bulbs with resistance values of 3 Ω for **Bulb 1** and 5 Ω for **Bulb 2**. Color code the drawing with **red**, **orange**, and **blue** markers.



Determine the following values. The first two rows are read from the **Circuit Builder** program. The last two rows are calculated.

I = _____ A

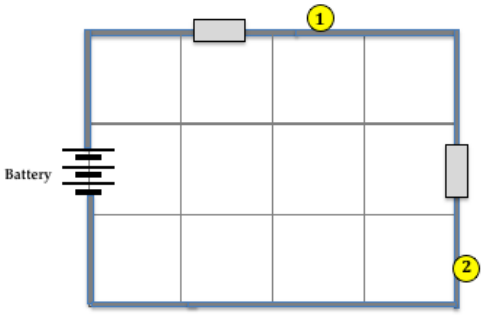
V_{red} = _____ Volts V_{orange} = _____ Volts V_{blue} = _____ Volts

$\Delta V_{Bulb\ 1}$ = _____ Volts $\Delta V_{Bulb\ 2}$ = _____ Volts

$I \cdot R_{Bulb\ 1}$ = _____ A•Ω $I \cdot R_{Bulb\ 2}$ = _____ A•Ω

Circuit 5

Create Circuit 5 using a 36 Volt battery, two ammeters, and two light bulbs with resistance values of 12 Ω for **Bulb 1** and 6 Ω for **Bulb 2**. Color code the drawing with **red**, **green**, and **blue** markers. Determine the following values. The first two rows are read from the **Circuit Builder** program. The last two rows are calculated.



I = _____ A

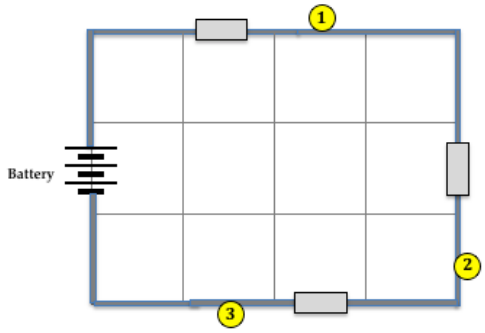
V_{red} = _____ Volts V_{green} = _____ Volts V_{blue} = _____ Volts

$\Delta V_{Bulb\ 1}$ = _____ Volts $\Delta V_{Bulb\ 2}$ = _____ Volts

$I \cdot R_{Bulb\ 1}$ = _____ A•Ω $I \cdot R_{Bulb\ 2}$ = _____ A•Ω

Circuit 6

Circuit 6 will contain three bulbs. Build it as shown and as described. Use a 24 Volt battery, three ammeters, and three light bulbs with resistance values of 3 Ω for **Bulb 1** and 4 Ω for **Bulb 2** and 5 Ω for **Bulb 3**. Color code the drawing with **red**, **orange**, **green**, and **blue** markers.



Determine the following values. The first two rows are read from the **Circuit Builder** program. The last two rows are calculated.

I = _____ A

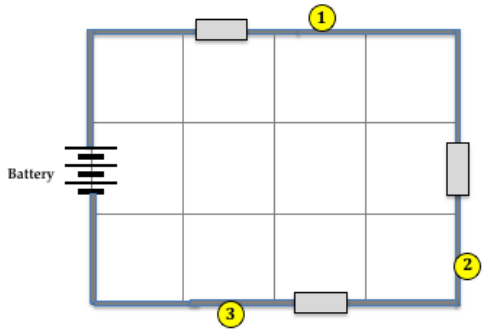
V_{red} = _____ V V_{orange} = _____ V V_{green} = _____ V V_{blue} = _____ V

$\Delta V_{Bulb\ 1}$ = _____ V $\Delta V_{Bulb\ 2}$ = _____ V $\Delta V_{Bulb\ 3}$ = _____ V

$I \cdot R_{Bulb\ 1}$ = _____ A•Ω $I \cdot R_{Bulb\ 2}$ = _____ A•Ω $I \cdot R_{Bulb\ 3}$ = _____ A•Ω

Circuit 7

Create Circuit 7 using a 24 Volt battery, three ammeters, and three light bulbs with resistance values of 1 Ω for **Bulb 1** and 2 Ω for **Bulb 2** and 3 Ω for **Bulb 3**. Color code the drawing with **red**, **orange**, **green**, and **blue** markers. Determine the following values. The first two rows are read from the **Circuit Builder** program. The last two rows are calculated.



I = _____ A

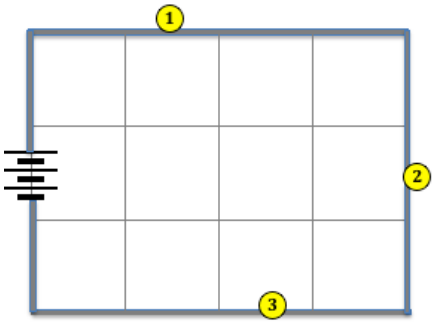
V_{red} = _____ V V_{orange} = _____ V V_{green} = _____ V V_{blue} = _____ V

$\Delta V_{Bulb\ 1}$ = _____ V $\Delta V_{Bulb\ 2}$ = _____ V $\Delta V_{Bulb\ 3}$ = _____ V

$I \cdot R_{Bulb\ 1}$ = _____ A•Ω $I \cdot R_{Bulb\ 2}$ = _____ A•Ω $I \cdot R_{Bulb\ 3}$ = _____ A•Ω

Summary and Application:
Conduct voltage drop analysis without using the program. Base answers on the patterns learned from analyzing **Circuits 1 – 7**.

1. Consider the 3-bulb circuit at the right. Color code the diagram with **red**, **yellow**, **green**, and **blue** markers. Suppose you know that …



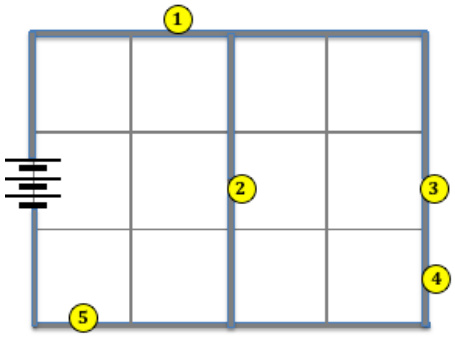
   Battery voltage = 12 V, Current = 2 A, and

   $R_1 = 3\ \Omega$ $R_2 = 2\ \Omega$ $R_3 = 1\ \Omega$

   Use I•R values to determine the values of electric pressure for the four different wires:

   V_{red} = _____ V V_{yellow} = _____ V V_{green} = _____ V V_{blue} = _____ V

2. Consider the 5-bulb circuit at the right. It is **not** a series circuit. Yet color coding and voltage drop fundamentals still apply. Color code the diagram with **red**, **orange**, **yellow**, **green**, and **blue** markers. Suppose you know that …



   Battery voltage = 48 V, and

   $R_1 = 4.0\ \Omega$ $R_2 = 12.0\ \Omega$ $R_3 = 4.0\ \Omega$
   $R_4 = 8.0\ \Omega$ $R_5 = 2.0\ \Omega$

   Because of how the circuit is built, the current is not the same in all five bulbs like it would be in series circuits. The current (**I**) values at the various bulb locations are …

   $I_1 = 4.0$ A $I_2 = 2.0$ A $I_3 = 2.0$ A $I_4 = 2.0$ A $I_5 = 4.0$ A

   Use the current and resistance values to calculate the voltage drops for each bulb.

   ΔV_1 = _____ V ΔV_2 = _____ V ΔV_3 = _____ V ΔV_4 = _____ V ΔV_5 = _____ V

   Finally, use the voltage drop (ΔV) values to calculate the electric pressure values for the five different wires (referenced here by their colors):

   V_{red} = _____ V V_{orange} = _____ V V_{yellow} = _____ V
   V_{green} = _____ V V_{blue} = _____ V