Series and Parallel DC Circuits

Basic Circuits

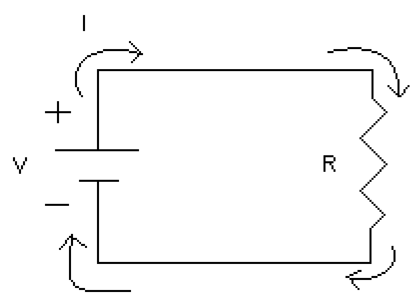
An electric circuit is closed loop of conductive material (metal wire) that connects several circuit elements together (batteries, resistors, capacitors, etc.) which produce, use, or store electrical energy. The energy flow within the circuit is represented by three main quantities. The first is *voltage*, with units of *volts* (V), which represents the difference in electric potential energy between two different points in the circuit. The second is *current*, with units of *amperes* (A), represents the movement of charge through the circuit over time. The last is *resistance*, with units of *ohms* (Ω), which is specific to resistors and represents the difficulty of charge flow through that element. These three quantities are related through *Ohm's Law*:

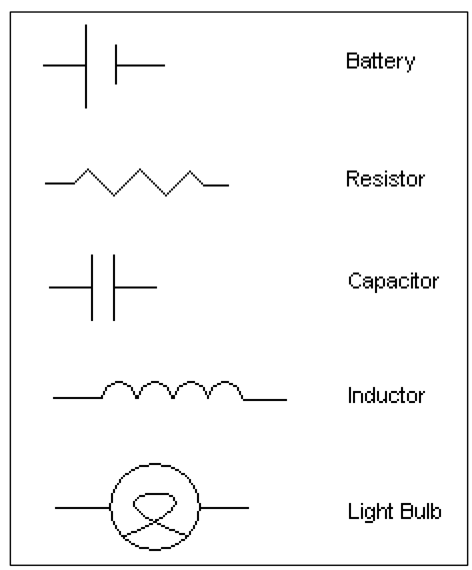
$$\textbf{(1)} \qquad \mathbf{V = IR}$$

where

V ≡ "voltage"
I ≡ "current"
R ≡ "resistance"

When a circuit has a constant, unchanging current, it is called a DC (Direct Current) circuit. Below is a diagram of a DC circuit with one battery and one resistor. Next to it is the key of symbols used for drawing circuits.





In this circuit, the battery on the left is called the *power source*, since it "adds" voltage, **V,** to the circuit. The resistor with resistance, **R,** is called the *load*, since it uses up all the voltage supplied by the battery. The current, **I,** flows in the direction of the arrows in the diagram, and can be found with Ohm's Law.

The resistor in the circuit above can represent anything attached to the circuit that uses up voltage, including light bulbs, toasters, televisions, or anything that requires electrical power to operate. *Electrical power*, **P,** is how much energy the resistor uses up over a finite amount time. This power will determine how bright the light bulbs burn in this lab.

$$\textbf{(2)} \qquad \mathbf{P} = \mathbf{IV}$$

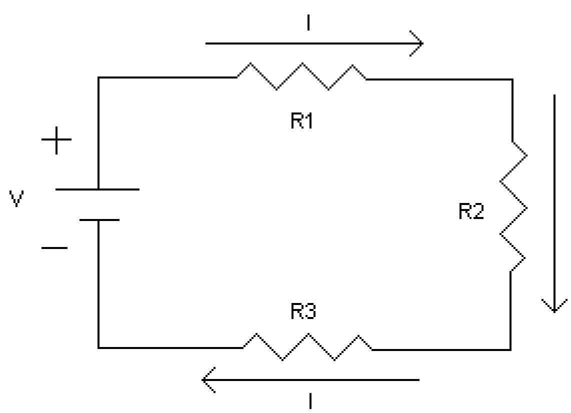
where

P = “power”
I = “current flowing through resistor”
V = “voltage lost across the resistor”

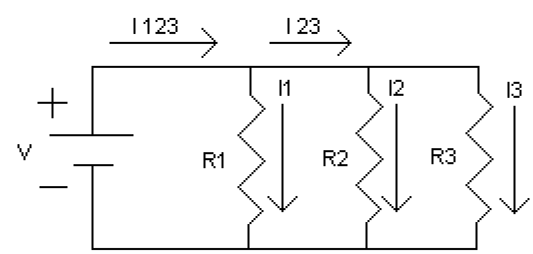
Resistors in Series and Parallel

In the above circuit, there is only one resistor. If there is more than one resistor in a circuit, how they are arranged makes a difference in how charge flows through that circuit. If several resistors are arranged in a straight line, without any splits in the wire between them, these resistors are said to be in series. If several resistors are connected to the circuit, but the wire splits into separate paths before reaching them, they are said to be in parallel. See the diagrams below that represent series and parallel circuits for three resistors.

Three Resistors in Series



Three Resistors in Parallel



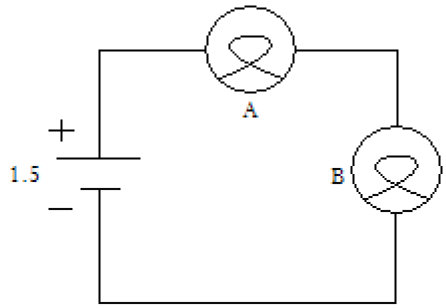
When resistors are in series, the current (I) flowing over each of them is the same. However, the voltage drop over each resistor may not be the same. This is because the charges have no choice but to flow through each of them in order to complete the loop back to the other end of the battery.

When the resistors are in parallel, however, the current flowing over each resistor is different. This is because the path splits before reaching the resistors, giving the charges a choice of direction to flow. If the resistances are different, so too will be the current. The voltage drop across each resistor in parallel; however, is the same.

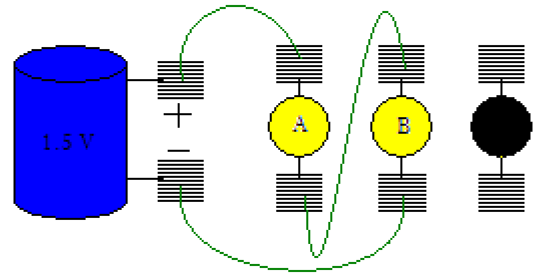
In this lab, you will be experimenting with different series and parallel configurations of light bulb resistors to determine how the current and voltage across the bulbs are affected. You can determine this by examining how bright, or dim, the bulbs become, and comparing that information with equation **(2)**.

Procedure

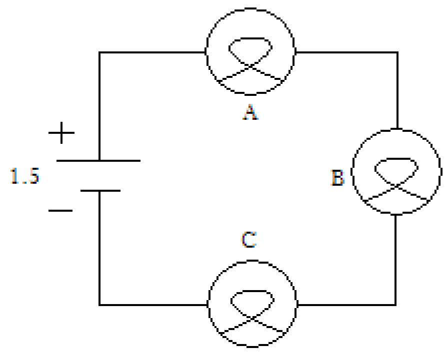
2 Bulbs in Series



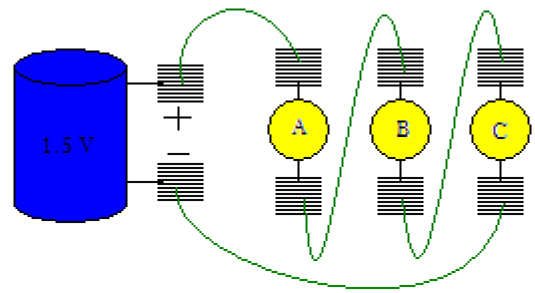
2 Bulbs in Series



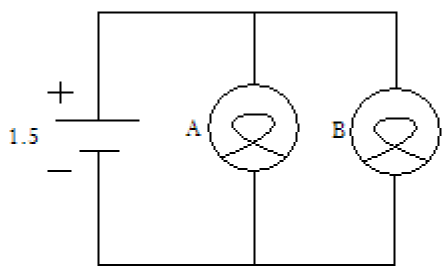
3 Bulbs in Series



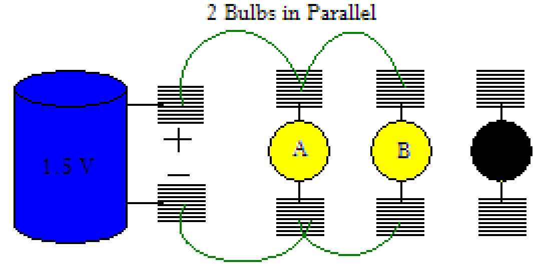
Three Bulbs in Series



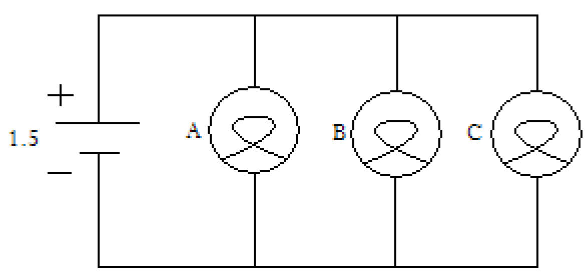
2 Bulbs in Parallel



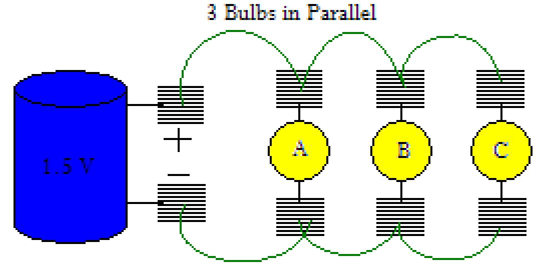
2 Bulbs in Parallel



3 Bulbs in Parallel



3 Bulbs in Parallel



1) Set up two bulbs in series using a 1.5 V battery and the white wires provided, as in the diagram above. Using a voltmeter, you can measure the voltage across the source battery by connecting the black lead to the negative prong and the red lead to the positive prong. Do the same for bulbs A and B by connecting the leads to the prongs above and below the bulb. The voltage should be negative across each bulb. Now record the current across each bulb by disconnecting one end of the wire next to the bulb and bridging the gap with the two leads from your ammeter (which would, at that point, be in series with the bulbs). Fill in Table 1 with the voltages, currents, and powers of your 2 light bulbs in series.

2) Repeat procedure 1 for 3 bulbs in series, then for 2 and 3 bulbs in parallel. Fill in Tables 2-4 with the voltages, currents, and powers of your light bulbs. To find the currents for Tables 2 and 3, refer to the picture for parallel circuits on page 2 to know where to connect your ammeter to the circuit.

Table 1: 2 Bulbs in Series

Bulb	Voltage [Volts]	Current [Amps]	Power [Watts]
A			
B			

Table 1: 3 Bulbs in Series

Bulb	Voltage [Volts]	Current [Amps]	Power [Watts]
A			
B			
C			

Table 3: 2 Bulbs in Parallel

Bulb	Voltage [Volts]	Current [Amps]	Power [Watts]
A			
B			
AB			

Table 4: 3 Bulbs in Parallel

Bulb	Voltage [Volts]	Current [Amps]	Power [Watts]
A			
B			
C			
ABC			

Questions

1) Bulbs in series:

   a) What happened to the bulb brightness when the third bulb was added (in series) to the other two? What is responsible for this result in terms of voltage and current?

   b) What happened to the bulb brightness when one bulb was removed (in series) and the circuit was reconnected with only one bulb? What is responsible for this result in terms of voltage, current, and resistance?

   c) Add together all the voltage drops across three bulbs (in series) and compare with the voltage applied by the battery. What do you notice?

   d) How does the voltage across a bulb relate to its brightness?

2) Bulbs in parallel:

   a) What happened to the bulb brightness when the third bulb was added (in parallel) to the other two? What is responsible for this result in terms of voltage and current?

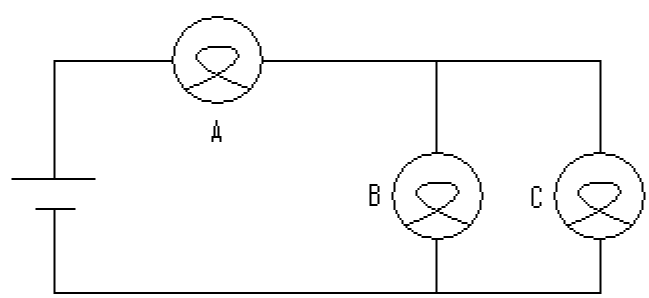
b) What happened to the bulb brightness when one bulb was removed (in parallel) and the circuit was reconnected with only one bulb? What is responsible for this result in terms of voltage, current, and resistance?

c) How did the total current in the circuit change when a third bulb was added to two? How did total current change when one bulb was removed, leaving only one.

d) Suppose another bulb could be added (in series) between the battery and the other three parallel bulbs. How would the brightness of the three parallel bulbs change and why?

3) Bulbs A, B, and C are identical:

a) Rank the bulbs in the order of their brightness.



b) Explain your answers above in terms of voltage, current, and resistance in the circuit.

c) If bulb C was removed, how would the brightness of bulbs A and B change? How then will the brightness of A compare to B?