ELECTRICITY - LESSON 2
SIMPLE LIGHT BULB CIRCUIT

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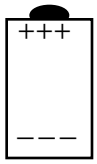
OBJECTIVE

The objective of this lesson is to build and explain the operation of a simple flashlight circuit.

QUESTIONS AND EXPERIMENTS

1. Draw a picture of your battery and then describe in words what you've drawn.

2. From Lesson 1 we know that like charges repel and unlike charges attract. And we know that we can *charge* certain materials like balloons and PVC pipe by rubbing them with things like hair and paper towels. Batteries, on the other hand, use the *magic* of chemistry to force negatively charged electrons to go from one terminal to the other as shown in the following diagram;



   This, as we can see, leaves one end of the battery positively charged and the other negatively charged. The objective of this question is to see what happens when we connect a wire from one terminal to the other.

   a. Draw a picture of your battery with a wire connected from one terminal to the other.
   b. Use sandpaper to remove the shellac from both ends of one of your copper colored wires. Then **very briefly** connect your wire across your battery and describe what happens.
   c. Why do you think the wire is getting hot? Illustrate with a picture showing how the electrons are moving through the circuit.
   d. Now repeat with your other wire without the shellac removed. Why doesn't this wire get even warm?

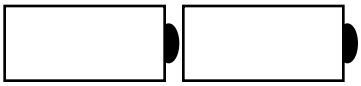
3. In the previous problem we saw that copper is a **conductor** and shellac an **insulator**.
   a. What are the differences between conductors and insulators?
   b. Verify that a piece of string is an insulator.
   c. What are some other good examples of insulators?

4. Draw a picture of your light bulb. Then describe in words what you've drawn including the role played by insulators. Be sure to label the filament and show how it is connected to the outside of the bulb.

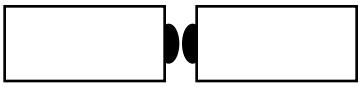
5. Now for a challenge. See if you can put together a circuit containing a battery, a light bulb and a piece of wire that gets the light bulb to light.
   a. Draw a picture of the light bulb circuit that you get to work. Show how the electrons are flowing.
   b. Draw pictures of at least three ways to connect together a battery, light bulb and piece of wire that doesn't get the light bulb to light.
   c. Explain how your circuit that works is different from those that don't work. Describe in particular what is meant by a **complete circuit**.

6. Rebuild your circuit in Question (5) but now with a battery holder, light bulb socket and wire with alligator clips. How does turning the battery around by reversing the alligator clips affect the light bulb?

7. From the previous questions we know that the battery is pushing the electrons through the circuit. We measure the strength of the battery in **volts** - and call it the **voltage**.
   a. Use the multimeter to measure the voltage across your D battery.
   b. Measure the voltage across two batteries connected end-to-end as follows:



   c. How is the voltage of the two batteries connected end-to-end in part (b) related to the voltages of the individual batteries?
   d. Measure the voltage across two batteries connected end-to-end as follows:



   e. Explain why your results in part (b) and (d) are different.

8. From Problems (6) and (7), we know that

   - Electric current tells us the RATE at which electrons (i.e., electric charges) flow through the light bulb.
   - Voltage is an indicator of the strength of the push on the electrons.

   When a flashlight's switch is OFF, the voltage across the bulb's filament is zero, there is zero push on electrons, and there is zero current flow. When the switch is ON, nonzero electric current flows and the battery must supply energy to the light bulb. The RATE at which this energy is supplied is called the POWER, which is usually measured in watts. Although it is not obvious, scientists have shown that

$$\text{Power} = \text{Voltage} \times \text{Current}$$

   Example: If the voltage across a light bulb is 1.5 volts and the current through it is 0.80 amps, then

$$\text{Power} = 1.5 \times 0.80 = 1.2 \text{ watts.}$$

   Suppose light bulbs A and B are connected to batteries that have the same voltage. Both bulbs are designed to operate at 1.5 volts and bulb A has a higher power rating than bulb B.
   a. Which bulb will have the larger current? Why?
   b. Is it easier to push electrons through bulb A or bulb B?

9. Whenever we know a RATE at which something happens, we must multiply by a TIME interval in order to know just how much has happened during that interval. For example, if Elizabeth gets paid 10 $/hour at her job, and she works for 40 hours, the amount she earns is

$$\text{RATE} \times \text{TIME} = 10 \times 40 = \$400.$$

   Similarly, if a 1.2 watt light bulb is used for 100 hours, the ENERGY it uses is

$$\text{Energy} = 1.2 \text{ watts} \times 100 \text{ hours} = 120 \text{ watt hours} = 0.120 \text{ kWh.}$$

Note that kWh is shorthand for kilowatt hours and that

1 kWh = 1000 kilowatt hours of energy.

It's also interesting to note that one gallon of gasoline releases 35 kWh of energy. And 1 kWh is equal to 860 food calories.

a. Which uses more energy, a 25 watt bulb that's ON for 10 hours or a 100 watt bulb that's on for 3 hours?
b. Estimate the energy, in kWh, used by a 1kilowatt electric range burner when you cook dinner. Be sure to state any assumptions you make.