

Summer 2009

Concepts of this Module

- Resistance
- Ohm's Law
- Series and Parallel Circuits
- Electric Power

The Activities

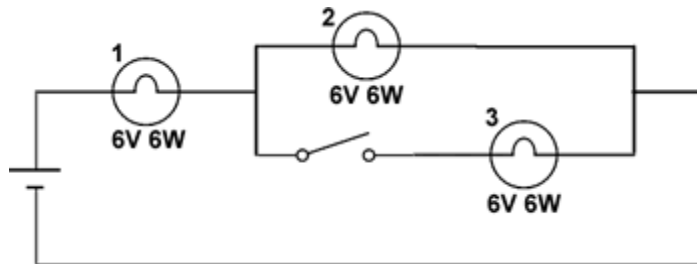
Note: each time you are finished with a circuit we ask that you disconnect all wires, so that the next circuit you investigate starts with a “blank slate”.



Course Concepts

Electricity and Magnetism Module 4, Activity 1

Consider the circuit shown to the right using three of the supplied light bulbs labeled $6V\ 6W$. The label means the bulb is rated for 6 watts at 6 volts



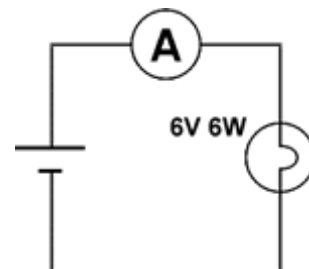
- Without doing any calculations, *predict* what will happen to the brightness/dimness of Bulb 1 when the switch is closed. Explain your prediction without equations.
- Wire the circuit and check your prediction. Was your prediction correct? If not, describe what happened.
- How does the brightness of Bulb 2 change when the switch is opened and closed?
- With the switch closed, how does the brightness of Bulbs 2 and 3 compare?



Expt

Electricity and Magnetism Module 4, Activity 2

In Module 2 you used a $6V\ 6W$ light bulb and measured the voltage drop ΔV across it and the current I flowing through it in a circuit such as shown to the right. Repeat those measurements for each of the three supplied $6V\ 6W$ light bulbs. Are all the values



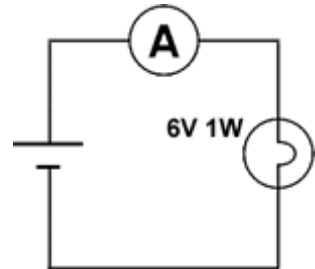
exactly the same? Quantify the spread in values by assigning an uncertainty to the voltage drops and currents.



Course Concepts

Electricity and Magnetism Module 4, Activity 3

- A. The light bulb labeled $6V\ 1W$ is rated for 1 watt at 6 volts. Measure the current I and the voltage drop ΔV across it in the shown circuit. Compare the brightness and the values for the voltage and current to those of the $6V\ 6W$ light bulb.
- B. Can you combine the numbers from Part A and Activity 2 to give a single formula that gives the rated wattage for each bulb? What is the unit of the quantities that are combined in the formula to give the wattage?



Course Concepts

Electricity and Magnetism Module 4, Activity 4

In **Electricity and Magnetism Module 2**, an analogy of current flowing in a wire was made to water flowing in a garden hose. A Flash animation of this analogy is available at <http://faraday.physics.utoronto.ca/IYearLab/Intros/DCI/Flash/WaterAnalogy.html>. We shall be extending that analogy in the next Activity. Open the animation and explore the two possible values of the *Voltage/Pressure* that are available.

- A. In the animation of the electric circuit, the movement of the negatively charged electrons in the conducting wire is shown. Is this in the same direction as the *conventional* current that you explored in Module 2?
- B. As discussed in Module 1, in the 1700's Benjamin Franklin and William Watson arbitrarily called the charge on a glass rod after being rubbed with silk *positive* and the charge on rubber after being rubbed with fur *negative*. If they had made the opposite choice, how would your answer to Part A change?



Course Concepts

Electricity and Magnetism Module 4, Activity 5

For a garden hose a pressure difference Δp generates the flow of the water. We shall give the symbol w to the volume of water per time passing a cross-section of the wire in m^3 / s . The hose has a resistance R to the flow of the water and we can define the resistance as:


$$R \equiv \frac{\Delta p}{w} \quad (1)$$

This resistance is approximately constant for a given hose.

Similarly, a voltage difference ΔV causes the electric current I to flow in the wire, and the wire has a resistance R to the flow:

$$R \equiv \frac{\Delta V}{I} \quad (2)$$

Just as for the hose, for a given conductor the resistance is usually approximately constant. Equation 2 is called *Ohm's Law*. The unit of resistance is *volts / ampere*, which is called an *ohm* Ω . (Ω is the Greek letter *omega*.)

The circuit diagram symbol for a resistance is: 

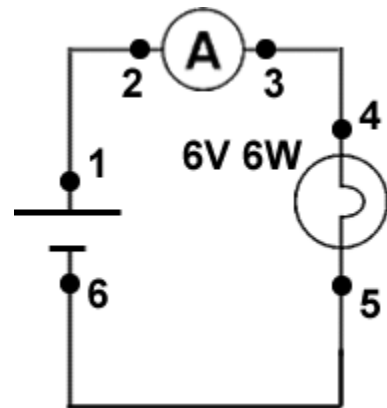
- A. A hose of length L and area A is shown. How would you expect the resistance of the hose to the flow of water to depend on its length? How might the resistance depend on its area?



- B. A wire of length L and area A is shown. How would you expect the resistance of the wire to the flow of electric charge to depend on its length? How might the resistance depend on its area?

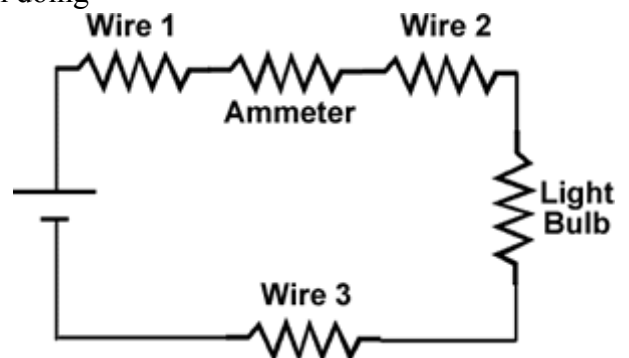


- C. A perfect ammeter and a perfect wire both have zero resistance. In the first circuits module (two weeks ago) you measured a number of voltage differences for the circuit shown to the right. From that data, what is the actual resistance of the ammeter? Of the wires? Calculate the resistance of the $6V\ 6W$ and the $6V\ 1W$ light bulbs; you may already have the data for this calculation.



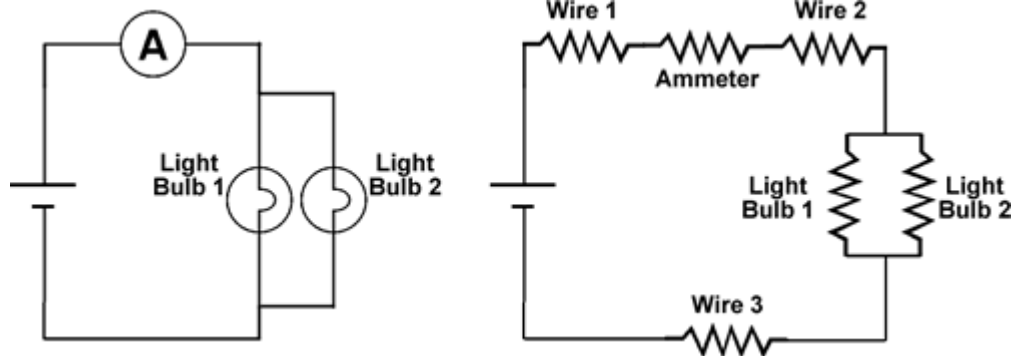
For the light bulb, you will need to know that as it heats up its resistance changes. Thus when doing measurements of a light bulb in a circuit, be sure to give it a few seconds to reach equilibrium.

In terms of the resistances of the wires, ammeter, and light bulb we can represent the circuit as shown: in this representation the lines connecting the circuit elements have zero resistance.




Course Concepts
Electricity and Magnetism Module 4, Activity 6

You are supplied with two short wires which we will assume are perfect and have zero resistance. The plastic cylinder of the banana sockets of the mount for the light bulbs can be unscrewed so that a wire can be inserted into a hole in the conductor. Use the two wires to connect two of the $6V$ $6W$ light bulbs together in parallel and place the combination in a circuit with an ammeter and the battery. On the left is a circuit diagram, and the diagram on the right represents the components as resistors.

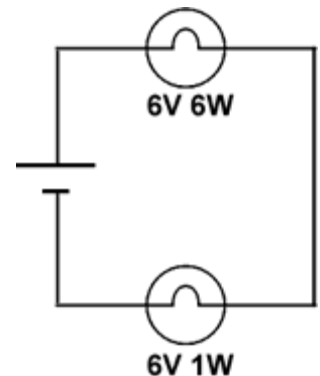


- If the resistance of each light bulb is R , predict the effective resistance R_{eff} of the two bulbs together in the circuit. You may find Activity 5 Part B and a result from Activity 5 Part C useful in making your prediction.
- Measure the effective resistance. Was your prediction correct? Why are we justified in ignoring the resistance of the two short wires? You may find Activity 5 Part B useful here too.

[**STOP!** Please do not attempt this “If you have time” activity until you feel confident that the other activities are completed to the best of your ability.]


Course Concepts
If you have time: Electricity and Magnetism Module 4, Activity 11

- If a $6V$ $6W$ light bulb and a $6V$ $1W$ one are wired in series, as shown, predict which light bulb will be brighter.
- Wire the circuit and check your prediction. Were you correct? Explain.



Last revision to this write-up: July 8, 2009 by Jason Harlow. The E&M Module 4 Student Guide was written in November 2007 by David M. Harrison, Dept. of Physics, Univ. of Toronto.