Instructors Guide to:

Series Circuits and Ohm's Law

This exercise is designed to build upon knowledge of parallel and series circuits, and teach students to calculate the properties of the circuits that they have built.

Ohm's Law describes the relationship between the voltage, current, and resistance of a circuit. This relationship is given in the relationship Voltage = Current x Resistance. Knowing this relationship, it is possible to find any of the three values as long as the other two are known.

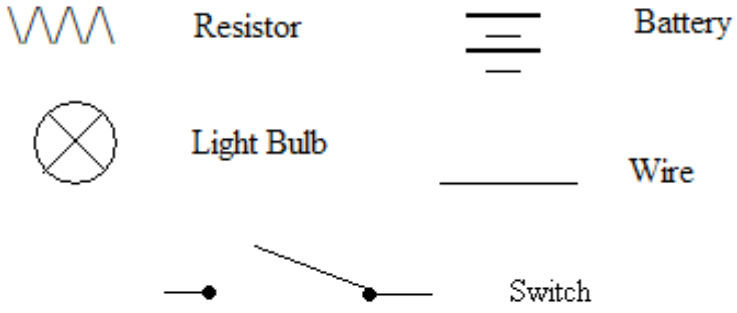
Electrical concepts such as voltage and current are abstractions that can be difficult to grasp at first. The following analogy is useful as a visual representation.

One way to think about circuits is to imagine electricity as water flowing through a pipe. If the pipe represents the wire, then the water flowing through it represents the moving electrons. Just like a circuit has a battery that pushes the electrons through it, our imaginary pipe has a pump that pushes water. The size of the pump determines how hard the water gets pushed though the pipe – a larger pump will be able to push more water than a smaller one.

Of the three variables that we're trying to calculate, the voltage is usually the easiest – usually, you can find it written on the side of the battery that you're using. Resistance, however, can be a little more complicated. Going back to our water pipe example, resistance in a circuit can best be compared to the size of the water pipe. The smaller the pipe, the more difficult it is for the pump to push water through the system.

Now that we have two of the three values, we can calculate the final one. The current in a circuit can be thought of as the amount of water flowing through the pipe. For example, say that you have two water pumps of the same size. The first one is connected to a large pipe, while the second one is connected to a pipe that is half the size of the first one. Because the second pipe is only half the size, we would say that it has twice the resistance. Because Voltage = Current x Resistance, we can rearrange this relationship to say that Current = Voltage / Resistance. Seeing as the second system has twice the resistance of the first system, it would make sense to say that it has half the current. This means that the bigger pipe can deliver twice as much water as the smaller pipe given the same amount of time.

In order to design and analyze circuits, electrical engineers use symbols to represent wire and components. Below are some of the symbols that we will be using to represent circuits in our activities.



In the Classroom:
Grade Level: 5 **Time:** 60 Minutes

Ohm's Law And Series Circuits

Materials

- 24 Gauge AWG wire, cut to 8" lengths with stripped ends.
- 9V Battery with connector plate
- ~1 Watt Light bulbs with lamp bases.
  (There are a number of different light bulbs at radio shack that meet this requirement. The wattage of a light bulb can be calculated by multiplying its rated voltage with its rated current. Radio Shack part #272-1120 is a good choice.)
- Toggle Switches
- Alligator clips (these are optional, but will aid in the quick assembly of circuits.

Concepts

This activity uses concepts of series circuits, calculations using Ohm's law, and basic circuit construction skills.

Procedure

- This activity requires that you construct a sample circuit in preparation and display it to the class. You may construct any circuit you like as long as it contains only a single loop with light bulbs, batteries and switches. Below is a suggestion of a sample circuit.

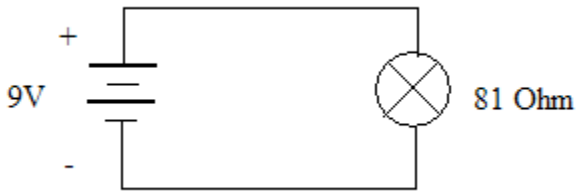
- Go through slides 6 through 8 of the powerpoint with the class.
- Break the class down into groups of two.
- Distribute worksheets and building materials. Each group should receive the following components.
  - 1 9V battery with connection plate
  - 5 or 6 lengths of wire with stripped ends and alligator clipped ends (optional, but suggested)
  - 2 light bulbs

- 2 toggle switches
- Assist the students as they work through the activity.

Challenges

1. Build the following circuit using a 9V Battery, 2 wires, and a 1 Watt light bulb.

   When attached to a 9V battery, a 1 Watt light bulb gives about 81 Ohms of resistance.



   What is the current running through the circuit? ___1/9 amps

   What does this number tell you about the size of 1 Amp? Compared to the current running through the circuit that you just built, is one amp a lot or a little?
   One amp is actually quite a lot of current. Most currents that run through circuits of this size are between 0 and ½ an amp.

   If you add another lamp in series to the circuit, will the lamp get brighter or dimmer? Why, and how much brighter or dimmer? Try it after writing down your prediction.
   The lamp will get dimmer. Adding another lamp will double the resistance, so the current will decrease by ½.

2. Calculate the current in the circuit below.

Use these steps to calculate the current in the circuit.

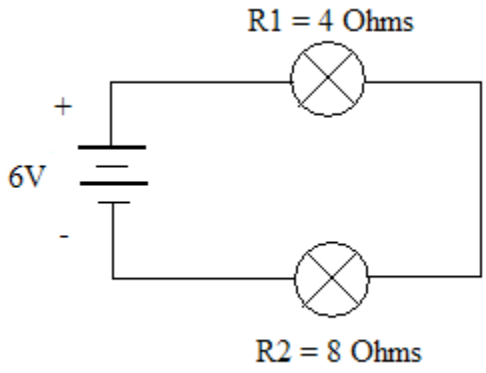
A. Voltage = ___10____ Volts

B. Resistance = __5____ Ohms

C. Voltage / Resistance = Current

___10___ / ___5___ = __2__ Amps

3. Calculate the current in the circuit below



A. Voltage = ___6_____ Volts

B. When two resistors come right after each other without anything in between them, their resistances add to each other.

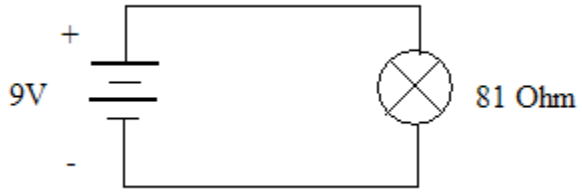
Resistance = (R1) __4___ + (R2) ___8_____ = ___12____Ohms

C. Voltage / Resistance = Current

___6___ / ___12___ = __1/2__ Amps

4. Build the following circuit using a 9V Battery, 2 wires, and a 1 Watt light bulb.

   When attached to a 9V battery, a 1 Watt light bulb gives about 81 Ohms of resistance.

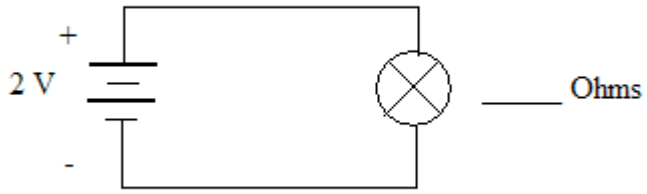


   What is the current running through the circuit? ___1/9 amps

   What does this number tell you about the size of 1 Amp? Compared to the current running through the circuit that you just built, is one amp a lot or a little?

   One amp is actually quite a lot of current. Most currents that run through circuits of this size are between 0 and ½ an amp.

5. The circuit below will be used to turn on a light bulb in a kitchen. Because the house is old, the fire marshal told you that if the current in the circuit is greater than .25 Amps, then the kitchen might catch on fire. When you go to buy a light bulb for the kitchen, what is the smallest resistance that you should look for to make sure that the current in the circuit doesn't go above .25 amps?

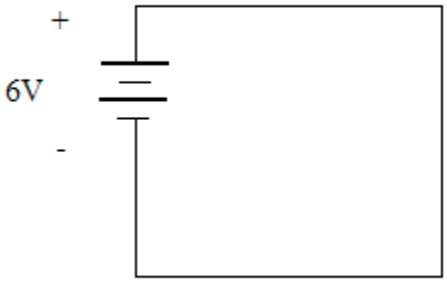


You should use a light bulb of at least 8 ohms.

Exensions

1. Design on paper a circuit of your choice, using whatever size battery and resistors you want. Calculate the Voltage, Resistance and Current in your circuit and write them below.

2. What is the current in the circuit below?



The resistance in the circuit above is 0, so the calculation of the current would be 6 volts / 0 ohms. This says, theoretically, that the current should be infinite. Because the wire itself has resistance, the current is not actually infinite, but nonetheless remains very high/

3. Your teacher will show you a circuit that she or she has built. Draw a circuit diagram representing it in the space below.

Student worksheet

Name: _____ Date: _____

Partner's Name: _____

Ohm's Law and Series Circuits

Challenges

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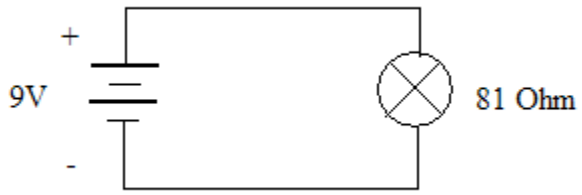


   What is the current running through the circuit? _____

   What does this number tell you about the size of 1 Amp? Compared to the current running through the circuit that you just built, is one amp a lot or a little?

   If you add another lamp in series to the circuit, will the lamp get brighter or dimmer? Why, and how much brighter or dimmer?

2. Calculate the current in the circuit below.

Use these steps to calculate the current in the circuit.

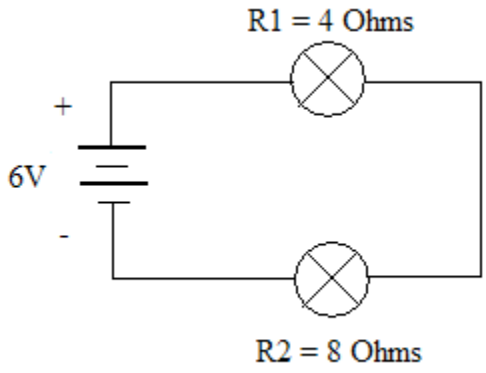
A. Voltage = _____ Volts

B. Resistance = _____ Ohms

C. Voltage / Resistance = Current

_____ / _____ = _____ Amps

3. Calculate the current in the circuit below



A. Voltage = _____ Volts

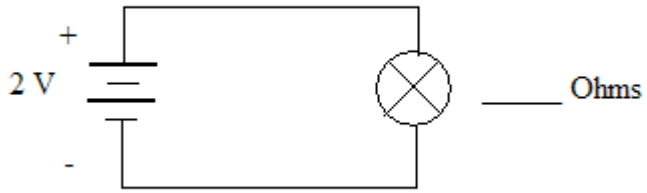
B. When two resistors come right after each other without anything in between them, their resistances add to each other.

Resistance = (R1) _____ + (R2) _____ = _____Ohms

C. . Voltage / Resistance = Current

_____ / _____ = _____ Amps

4. The circuit below will be used to turn on a light bulb in a kitchen. Because the house is old, the fire marshal told you that if the current in the circuit is greater than .25 Amps, then the kitchen might catch on fire. When you go to buy a light bulb for the kitchen, what is the smallest resistance that you should look for to make sure that the current in the circuit doesn't go above .25 amps?



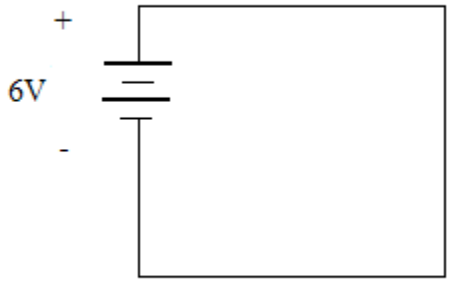
Discussion

Is it possible to put so much resistance into a circuit that it has a current of 0? Why or why not?

Exensions

5. Design a circuit of your choice on the back of this sheet, using whatever size battery and resistors you want. Calculate the Voltage, Resistance and Current in your circuit and write them below.

6. What is the current in the circuit below?



3. Your teacher will show you a circuit that she or she has built. Draw a circuit diagram representing it in the space below.