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Partners:-----

Date:-----

Light Bulbs in parallel and in series Computer Simulation

The electrical resistance of a light bulb filament does not stay constant over a wide range of voltages. As a result, the relationship between voltage across a light bulb and the current through it is not perfectly linear. However, if the voltage does not vary too much, a light bulb can be treated as an ohmic device and the equation $I=V/R$ can be used to relate voltage, current, and resistance.

In this experiment you will see how voltage and current for a light bulb change

- when the bulb is connected in series to other bulbs and
- when it is connected in parallel to other bulbs.

You will also investigate the role of batteries in a circuit.

Light bulbs are primarily used in this experiment instead of resistors because the brightness of the bulb provides a visual representation of the current through the filament.

Procedure

Go to <http://phet.colorado.edu/web-pages/simulations-base.html> and open the Circuit Construction Kit. In the activities described below, don't make the circuits too large, so that you can fit two or three circuits in the work area. For "size" use "small" on the right side of the screen.

Light Bulbs in Series

1. Drag and drop one light bulb and one battery in the work area. Drag and drop wires to connect the battery to the light bulb. Once the circuit is completed, the bulb should light and you should see the flow of charge from positive to negative end of the battery through the circuit. This is circuit 1.
2. Use a voltmeter (check the box next to voltmeter on the right side of the display) to measure the voltage across the bulb. Use the **non-contact ammeter** to measure the current in the wires. Use Ohm's Law ($V=IR$) to Calculate the resistance of the bulb. Right click on the light bulb and check "show value" box. Does this agree with your calculations? Record results below.

Voltage across light bulb=

Current in the wires=

Is the current the same in all wires?-----

Calculate R:

Value shown for R=

3. Set up another circuit with one battery and two light bulbs connected in series (everything is in one single loop). This is circuit 2. Use the voltmeter and the non-contact ammeter to measure the values listed below.

Circuit 2. Two bulbs in series

	Bulb 1	Bulb 2	Battery
Voltage across V			
Current through I			

Show that $V_1 + V_2 = V_{\text{battery}}$

Is the current almost the same in all the wires?-----

Calculate the resistance of Bulb 1 (R_1), resistance of Bulb 2 (R_2), and the total resistance connected to the battery.

4. Set up another circuit with three bulbs in series. This is circuit 3. Use the voltmeter and the non-contact ammeter to measure the values listed below.

Circuit 3. Three bulbs in series

	Bulb 1	Bulb 2	Bulb 3	Battery
Voltage across V				
Current through - I				

Show that $V_1 + V_2 + V_3 = V_{\text{battery}}$

Is the current almost the same in all the wires?-----

Calculate the resistance of Bulb 1 (R_1), resistance of Bulb 2 (R_2), resistance of Bulb 3 (R_3), and the total resistance connected to the battery.

5. What happens to the brightness of the bulbs as you add more bulbs in series?
6. What happens to the overall resistance connected to the battery as you add more bulbs in series?
7. What happens to the current through the battery as you add more bulbs in series?

Straws in series

Obtain four straws and a few inches of masking tape. Tape two of the straws together end to end with about an inch of tape to make a new straw twice as long. Now add the third straw to make a straw three times as long. Be careful to keep the ends of the straws open and avoid gaps that might leak.

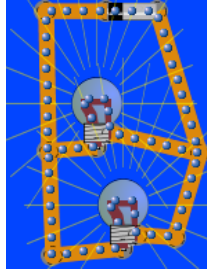
To gain additional insight about light bulbs in series, compare the level of difficulty in blowing air through a single straw, and three straws in series. Which one is more difficult to blow through?

How does the experiment with straws resemble the behavior of bulbs connected in series? Please explain.

When finished, remove circuits 2 and 3 (select each item, right click, then remove). Keep circuit 1.

Light Bulbs in Parallel

1. Set up a second circuit with one battery and two bulbs in parallel as shown below. This is circuit 2. Use the voltmeter and the non-contact ammeter to measure the values listed below.



Circuit 2. Two bulbs in parallel

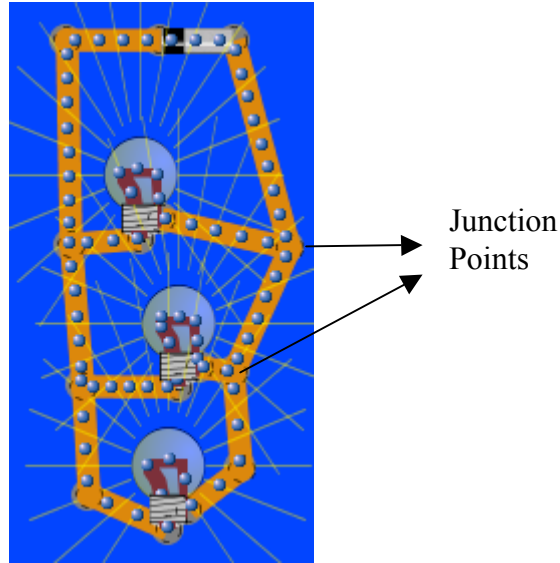
	Bulb 1	Bulb 2	Battery
Voltage across V			
Current through I			

Notice that the current coming from the battery splits. Some of it goes to bulb 1 and the rest goes to bulb 2. Show that $I_1 + I_2 = I_{\text{battery}}$

Is the voltage across bulb 1 almost the same as the voltage across bulb 2, and is this almost the same as the voltage across the battery?-----

Calculate the resistance of Bulb 1 (R_1), resistance of Bulb 2 (R_2), and the total resistance connected to the battery.

2. Set up another circuit with three bulbs in parallel as shown below. This is circuit 3.
3. Use the voltmeter and the non-contact ammeter to measure the values listed below.



Circuit 3. Three bulbs in series

	Bulb 1	Bulb 2	Bulb 3	Battery
Voltage across V				
Current through - I				

Once again current splits at each junction point. Show that the current going into a junction is equal to the current coming out of the junction. Do this for both junction points.

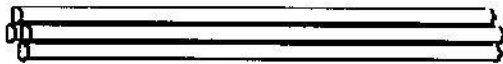
Is the voltage across bulb1, bulb2, bulb3, and the battery almost the same?-----

Calculate the resistance of Bulb 1 (R_1), resistance of Bulb 2 (R_2), resistance of Bulb 3 (R_3), and the total resistance connected to the battery.

3. Does the brightness of the bulbs change as you add more bulbs in parallel?
4. What happens to the overall resistance connected to the battery as you add more bulbs in parallel?
5. What happens to the current through the battery as you add more bulbs in series?

Straws in parallel

We can sense this same phenomenon with air flow through straws. Obtain four thin straws. Compare the level of difficulty of blowing through one straw with blowing through three straws that are placed side by side (in parallel). Does it seem that blowing through three straws is more difficult or easier than one straw?



FOUR 'PARALLEL' STIRRERS

How does the experiment with straws resemble the behavior of bulbs connected in parallel? Please explain.

The Role Of Batteries In A Circuit

Clear the screen then set up the following circuits:

- Circuit 1 – One light bulb connected to one battery.
- Circuit 2 – One light bulb connected to two batteries. Batteries should be connected in series, so that the positive end of one is connected to the negative end of the other one.
- Circuit 3 – One light bulb connected to three batteries. Put the batteries in series.

Notice the brightness of the bulbs and the rate of flow of charge in the circuits as more batteries are added.

Use the voltmeter and the non-contact ammeter to measure the voltage across each bulb and the current through it. Record your results below.

Adding more batteries to a light bulb

	Current through the bulb	Voltage across the bulb
Circuit 1 -One battery		
Circuit 2 - Two batteries		
Circuit 3 - Three batteries		

What happens to the current in the circuit as more batteries are added?

Does the charge flowing in a circuit come from? Does it originate from the battery?
What is your evidence?

Light Bulbs in parallel and series Hands-on

Introduction

In these activities we use light bulbs to note their brightness in various circumstances. But to take measurements, we replace light bulbs with resistors.

In this experiment you will

- explore various ways to light a bulb with one battery and one wire;
- compare a hand operated generator with batteries to better understand the function of batteries in a circuit;
- see how voltage and current for a light bulb or resistor change when it is connected to another bulb or resistor **of different resistance** in series and in parallel.

Apparatus

1 10 Ω resistor	Battery holder
1 47 Ω resistor	Connecting wires (10)
2 long light bulbs	Straws and coffee stirrers (one of
2 round light bulbs	each/person)
2 sockets	voltmeter
3 D-Cell batteries	ammeter

Procedure

I. Lighting a bulb

Use one battery, one wire, and one bulb to make the bulb light. Draw sketches of various successful configurations below.

II. Hand Held Generator-Genecon

Put a bulb in a socket. Connect the socket to the hand held generator(Genecon). Turn the crank on the Genecon at a steady rate of one or two revolutions each second, and feel the effort needed for lighting the bulbs. **Caution:** if you turn the crank too rapidly you may burn out the bulbs!

Remove the bulb to break the circuit. Turn the crank at about the same speed as before. Is there any difference in the “effort” that is required to keep the Genecon turning at the same speed? Explain.

When using a Genecon, where does the charge originate that moves through the bulbs?

2. A hair dryer is a pump for air. Do a battery and a Genecon act like a pump for charge? Explain.

3. How is increasing the number of battery similar to cranking a Genecon faster?

III. Different Light Bulbs or Resistors In Series

- 1- Set up a circuit with one long light bulb and three batteries. Note the brightness of the bulb.
- 2- Replace the long bulb with the 47Ω resistor. Use an ammeter to measure the current through the resistor, and current through the battery. Ammeter should be placed in series with the light bulb as shown in figure 1. Record your results in Data Table 1.

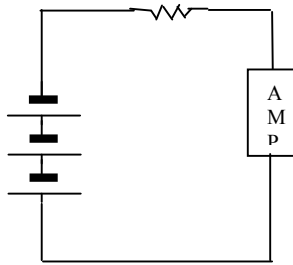


Figure 1

Is current “used up” in the resistor? What is your evidence?

- 3- Use a voltmeter to measure the voltage across the $47\ \Omega$ resistor, and the voltage across the battery. Voltmeter should be placed in parallel with the resistor (or battery) as show in figure 2. Record your measurements in Data Table 1.

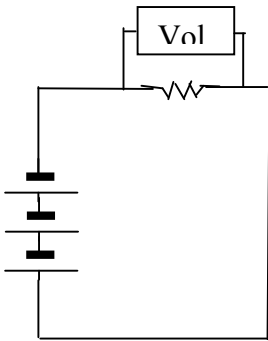


Figure 2

Is the voltage across the resistor the same as the voltage across the battery? Why do you think this is?

- 4- Repeat steps 1-3 with the round bulb. For measurements, replace the round bulb with the $10\ \Omega$ resistor. Record results in Data Table 1. Calculate the resistance of each resistor based on the current and voltage measurements.

- 5- Construct a circuit with three batteries and one round bulb and one long bulb in series as shown in figure 3.

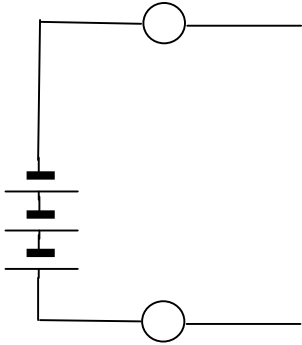


Figure 3

Do both bulbs light? What do you think accounts for this observation?

- 6- Describe what happens when you remove one of the bulbs from its socket. How do you explain this observation?
- 7- Replace the Long bulb and round bulb respectively with the 47Ω and 10Ω resistors. Measure and record current through each resistor and the battery, and voltage across each resistor and the battery. Record measurements in Data Table 2. Calculate the overall resistance of the circuit.
- 8- How does the current through each resistor and the voltage across it change when another resistor is connected in series with it?

III. Different Light Bulbs In Parallel

- 1- Construct a circuit with three batteries and one round bulb and one long bulb in parallel as shown in figure 4.

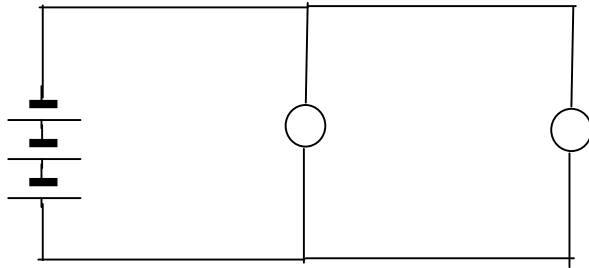


Figure 4

- 2- Compare the brightness of the bulbs in this circuit with their brightness when each bulb was by itself.
- 3- What happens if you remove one bulb from its socket? How do you explain this observation?
- 4- Replace the bulbs with the resistors. Measure and record the current through each resistor and the battery, and the voltage across each resistor and the battery. Record measurements in Data Table 3. Calculate the overall resistance of the circuit.
- 5- How does the current through each resistor, the voltage across it change when another resistor is connected in parallel with it?
- 6- Explain why all the wirings in buildings are done in parallel.

- 7- Consider what happens to the current through the battery when more branches are added in parallel to explain why overloading a circuit in which devices are connected in parallel is a serious fire hazard? How does a circuit breaker or fuse protect the circuit?

Data Table 1 – circuit with one bulb/resistor

	Current through resistor	Voltage across the resistor	Current through the battery	Voltage across the battery
47 Ω resistor				
10 Ω resistor				

Calculate resistance of each resistor using voltage and current.

Data Table 2 – circuit with two bulbs/resistor in series

	Current through	Voltage across
47 Ω resistor		
10 Ω resistor		
Batteries		

Calculate the total resistance of the circuit (Resistance connected to the batteries):

Show that the sum of voltages across the resistors is approximately equal to the voltage across the batteries.

Data Table 3 – circuit with two bulbs/resistors in parallel

	Current through	Voltage across
47 Ω resistor		
10 Ω resistor		
Batteries		

Calculate the total resistance of the circuit (Resistance connected to the batteries):

Show that the sum of currents through the resistors is approximately equal to the current through the batteries.