Physics Laboratory
Electrical Circuits II - Current and Resistance

In this experiment, we construct a model for electric current that we can use to predict and explain the behavior of simple electric circuits.

I. Complete circuits

A. Obtain a battery, a light bulb, and a one piece of wire. Connect these in a variety of ways. Sketch each arrangement below.

<table>
<thead>
<tr>
<th>Arrangements that do light the bulb</th>
<th>Arrangements that do not light the bulb</th>
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<tbody>
<tr>
<td>![Diagram 1]</td>
<td>![Diagram 2]</td>
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<td>![Diagram 3]</td>
<td>![Diagram 4]</td>
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<td>![Diagram 5]</td>
<td>![Diagram 6]</td>
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You should have found four different arrangements that light the bulb. How are these arrangements similar? How do they differ from the arrangements in which the bulb does not light?

Current flows from the battery to either the bottom or side of the bulb then the wire goes from the battery to the side or the bottom of the bulb, respectively.

State the requirements that must be met in order for the bulb to light.

B. A student has briefly connected a wire across the terminals of a battery until the wire feels warm. The student finds that the wire seems to be equally warm at points 1, 2, and 3.

Based on this observation, what might you conclude is happening in the wire at one place compared to another?

Current is the same
C. Light a bulb using a battery and a single wire. Observe and record the brightness of the bulb when objects made out of various materials are inserted into the circuit. Try materials such as paper, coins, pencil lead, eraser, your finger, etc.

What is similar about the objects that let the bulb light?

conductive materials - copper, steel, aluminum, etc.

D. Carefully examine a bulb. Two wires extend from the filament of the bulb into the base. You probably cannot see into the base, however, you should be able to make a good guess as to where the wires are attached. Describe and draw where the wires attach. Explain based on your observations in parts A to C.

On the basis of the observations that we have made, we will make the following assumptions:

1. A flow exists in a complete circuit from one terminal of the battery, through the rest of the circuit, back to the other terminal of the battery, through the battery and back around the circuit. We call this flow electric current.

2. For identical bulbs, bulb brightness can be used as an indicator of the amount of current through that bulb: the brighter the bulb, the greater the current.

Starting with these assumptions, we will develop a model that we can use to account for the behavior of simple circuit. The construction of a scientific model is a step-by-step process in which we specify only the minimum number of attributes that are needed to account for the phenomena under consideration.
II. Bulbs in series

(In this section and in section III, use two batteries in the holder as your source.) Set up a two-bulb circuit with identical bulbs connected one after the other as shown. Bulbs connected in this way are said to be connect in series.

A. Compare the brightness of the two bulbs with each other. (Pay attention only to large differences in brightness. You may notice minor differences because two "identical" bulbs are, in fact, not quite identical.)

Use the assumptions we have made in developing our model for electric current to answer the following questions:

1. Is current "used up" in the first bulb, or is the current the same through both bulbs?
   
   \[
   \text{current in the same = same brightness.}
   \]

2. Do you think that switching the order of the bulbs might make a difference? Check your answer.
   
   \[
   \text{no difference}
   \]

3. On the basis of your observations of the bulbs alone, can you tell the direction of the flow through the circuit?
   
   \[
   \text{cannot tell}
   \]

B. Compare the brightness of each of the bulbs in the two-bulb circuit with that of a bulb in a single-bulb circuit.

\[
\text{the one-bulb circuit \& the bulb is brighter}
\]

Use the assumptions we have made in developing our model for electric current to answer the following questions:

1. How does the current through a bulb in a single-bulb circuit compare with the current through the same bulb when it is connected in series with a second bulb? Explain.
   
   \[
   \text{current is greater through the single-bulb circuit}
   \]

2. What does your answer to question 1 imply about how the current through the battery in a single-bulb circuit compares to the current through the battery in a two-bulb series circuit? Explain.
   
   \[
   \text{more current through the battery in the single-bulb circuit.}
   \]
C. We may think of a bulb as causing an impeding effect (or *resistance*) to the current in the circuit.

1. Thinking of the bulb in this way, would adding more bulbs in series cause the impeding effect (or *total resistance*) to increase, decrease, or remain the same as before.

   *Resistance will increase - a greater impeding effect*

2. Formulate a rule for predicting how the current through the battery would change (i.e., whether it would *increase*, *decrease*, or *remain the same*) if the number of bulbs connected in series were increased or decreased.

   *If the number of bulbs increase, the current decreases.*

III. Bulbs in parallel

Set up a two-bulb circuit with identical bulbs so that their terminals are connected together as shown. Bulbs connected together in this way are said to be connected in *parallel.*

A. Compare the brightness of the bulbs in this circuit.

   *Same brightness.*

1. What can you conclude from your observation about the amount of current *through each bulb*?

   *Same current*

2. Describe the current in the entire circuit. Base your answer on your observations. In particular, does the current *through the battery* seem to divide and recombine at the junctions of the two parallel branches?

   *Current does divide and recombine.*
B. Is the brightness of each bulb in the two-bulb parallel circuit greater than, less than, or equal to that of a bulb in a single-bulb circuit?

brightnesses are the same

How does the amount of current through a battery connected to a single bulb compare to the current through a battery connected to a two-bulb parallel circuit? Explain based on your observations.

The single bulb has half the current being delivered, than the two bulb circuit.

C. Formulate a rule for predicting how the current through the battery would change (i.e., whether it would increase, decrease, or remain the same) if the number of bulbs connected in parallel were increased or decreased. Base your answer on your observation of the behavior of the two-bulb parallel circuit and the model for current.

current increases as the number of bulbs increase

What can you infer about the total resistance of a circuit as the number of parallel branches is increased or decreased?

total resistance decreases as the number of parallel branches increases

D. Does the amount of current through a battery seem to depend on the number of bulbs in the circuit and how they are connected?

yes

E. Unscrew one of the bulbs in the two-bulb parallel circuit. Does this change significantly affect the current through the branch that contains the other bulb?

no change

A characteristic of an ideal battery is that the branches connected directly across it are independent of one another.
IV. Applications of the model

A. The circuit at right contains three identical bulbs and an ideal battery. (If you want to experimentally make the observations, use three batteries in series.) Use the model we have developed to:

1. Predict the relative brightness of the bulbs in the circuit with the switch closed. Explain.
   - A bright, B = C dimmer.
   - A current travels through A that divides between B and C. (less current through B and C).

2. Predict how the brightness of bulb A changes after the switch is opened. Explain.
   - A's brightness decreases. Removing C, the bulbs A and B are in series providing more resistance and less current.

3. Predict the relative brightness of A and B to each other after the switch is opened. Explain.
   - same brightness - same current