

Circuits and Continuity

Objective

The purpose of this experiment is to investigate simple circuits and to understand the concept of continuity.

Materials

1. 6-volt lantern battery
2. Alligator-alligator clip wires (small)
3. Battery packs
4. Circuit board (with 2 bulbs and a diode)
5. Fluke digital multimeter

Background Information

An electric circuit has a source, a battery or power supply, which acts like a charge pump that raises electric charge to greater electrical “height” (voltage) at one end so that it can run “downhill” through connected devices to the other “end” of the source. This movement of charge is called *electric current*. Conducting wires let charge move with little friction. Light bulbs and some other devices provide considerable friction; these devices are said to have resistance. Whether through wires or devices with considerable resistance you have to have a complete circuit to have a current; i.e. there must be a path for the charge to circulate around. If there is a break in the path, e.g. a broken or disconnected wire, there is a loss of continuity, an open circuit, and there will be no current.

Procedure

Part I: Simple Circuits

1. Set the multimeter on DC volts, and determine and record the voltage of each of the four D-cell batteries provided. [Q1] What is the relationship between the single battery voltage and the voltage of the pack? [Q2] What voltages can you get from two batteries end-to-end?

With the battery holders, arrange the batteries in different ways, then measure and record the voltage of each combination. [Q3] How does it compare with the voltage of an individual battery? [Q4] What is the maximum voltage you could get from the battery pack?

Warning: In the following exercises immediately disconnect any arrangement that does not light the bulb within two seconds! Some incorrect connections can quickly lead to hot wires and a dead battery.

- Remove one bulb from its holder. Using the materials in the circuit packet, arrange the removed bulb, one battery, and one wire in as many ways as you can to make the bulb light. Diagram each arrangement, both those that light the bulb and those that do not. Label the sketches that are successes. [Q5] What is similar about the successes?
- Replace the bulb in the holder and put all batteries back into the battery pack in the arrangement that gives the largest voltage. Make one bulb light. Sketch your arrangement. [Q6] How does the brightness compare to that with just one battery?

Part II: Continuity

Diagrams for electric circuits use symbols like the ones shown in Table 1. Using this information and the circuit diagrams, wire each circuit on the board provided.

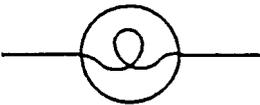
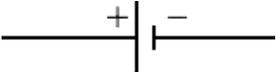
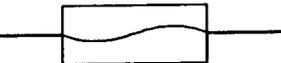
wire		switch	
lamp		battery	
circuit breaker or fuse		resistor or any device that uses electrical energy to make heat	

Table 1: *Examples of symbols for components of electric circuits*

- The components of this circuit are a switch, lamp, connecting wires, and circuit breaker connected to a power source (a 6-volt lantern battery). The purpose of the circuit breaker is to prevent excessive current in case the circuit resistance is too small. Most inexpensive circuit breakers are simple thermal switches that “open” when heated by excessive current. Most circuit breakers can be “reset”.

Wire the circuit as in Figure 1. Trace the path the current makes.

Short circuit the lamp by touching the two ends of a wire to the two terminals of the lamp. Excessive current should “trip” the circuit, and the lamp should go off. With the short circuit removed “reset” the circuit breaker, and the lamp should go on.

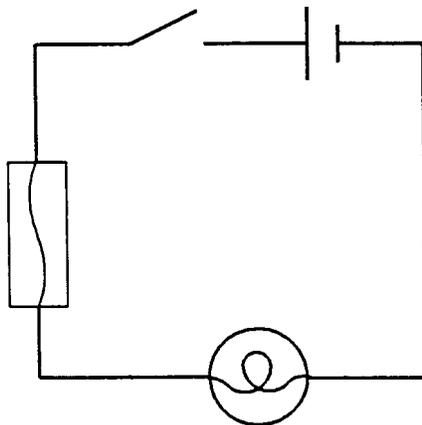


Figure 1: *Diagram for #1.*

2. Connect each of the circuits shown in Figure 2. In each case trace with your finger the path of the current.

For each circuit, explain what happened when S1 and S2 were closed. ... and opened. Construct a table similar to Table 2 to record your observations.

S1	S2	Fig2:left		Fig2:right	
		L1	L2	L1	L2
closed	closed				
closed	open				
open	closed				
open	open				

Table 2

For each of the circuits, remove one bulb and see what happens to the other bulb when both switches are closed. Report what you see.

[Q1] How does what you have done relate to electricity in your home? [Q2] How do you think your house is wired and [Q3] why?

3. A lamp can be independently controlled by two different switches. This is called a “3-way” hook-up. The switches required have two different “on” (closed) positions. Wire the circuit shown in Figure 3. Determine that either switch can change the on/off condition of the lamp. Draw a neat diagram, perhaps using color, to show the path of

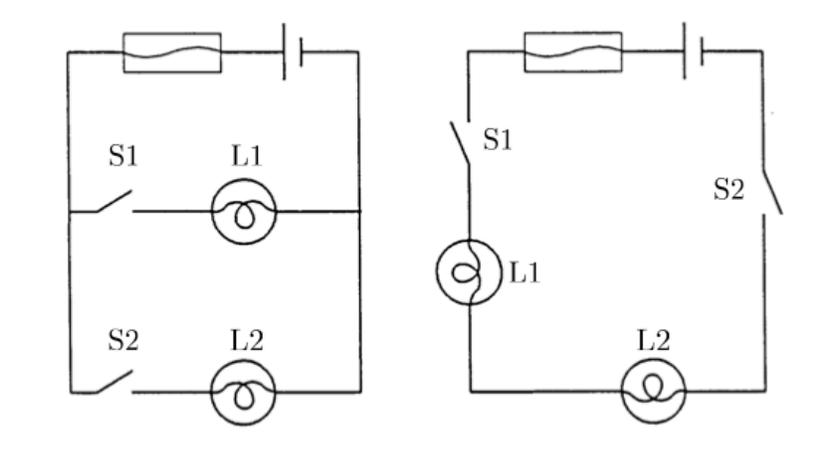


Figure 2: *Diagram for #2.*

the current for each set of switch positions that has the bulb on. [Q4] Where is such an arrangement used in your home?

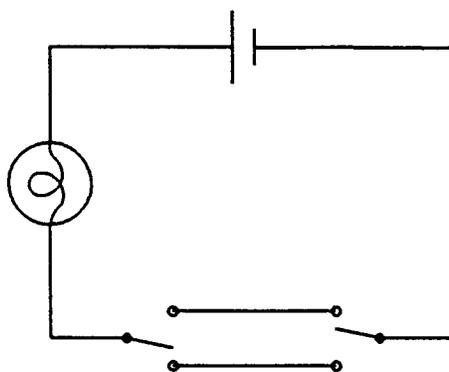


Figure 3: *Diagram for #3.*

4. [Q5] How many different degrees of brightness can you obtain with three bulbs? Sketch your arrangements. Compare with other students.
5. Combine one bulb and the diode in a circuit in which there is one path (series connection). Connect this circuit to the battery. [Q6] What happens? [Q7] What happens if the battery terminals were interchanged? Compare your observations with what other students find. Explain what you observe.
6. Combine your bulbs with those of other students, and light as many bulbs as you can with one 6-volt battery. Describe what you observe. Try different arrangements of the bulbs. [Q8] What arrangement will light the most bulbs? [Q9] Why do you think this is true?

7. A lamp can be controlled by three switches with a “4-way” hook-up. Construct a table similar to Table 3 to record your observations. You will receive bonus credit if you hook this up (see Figure 4), make it work, and show by means of neat diagrams that you understand the paths of the current. You may not get any help from anyone if bonus credit is to be earned. Once you make it work, demonstrate it to your lab instructor. She/He must acknowledge it on your lab report before you leave lab.

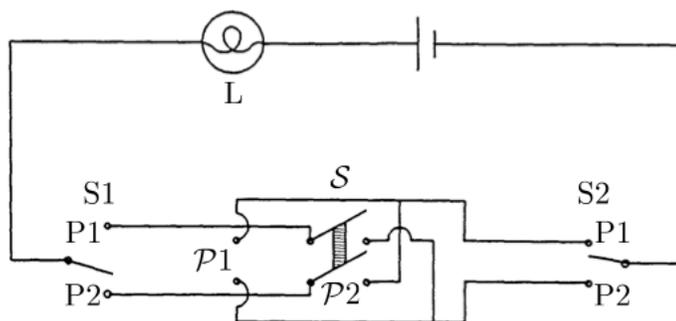


Figure 4: Diagram for #4.

S1	\mathcal{S}	S2	L
P1	$\mathcal{P}1$	P1	
P1	$\mathcal{P}1$	P2	
P2	$\mathcal{P}1$	P1	
P2	$\mathcal{P}1$	P2	
P1	$\mathcal{P}2$	P1	
P1	$\mathcal{P}2$	P2	
P2	$\mathcal{P}2$	P1	
P2	$\mathcal{P}2$	P2	

Table 3: Let $S1$ and $S2$ designate switches 1 and 2, respectively; let L designate the lamp; and let \mathcal{S} designate the large switch. Indicate the state of the bulb (on/off) for each combination of the positions ($P1$ and $P2$) of switches $S1$, $S2$, and ($\mathcal{P}1$ and $\mathcal{P}2$) of \mathcal{S} .