

Simple Electric Circuits

Goal: To build and observe the operation of simple electric circuits and to learn measurement methods for electric current and voltage using ammeters and voltmeters.

Lab Preparation

Electric charges move through electrical conductors in response to a potential difference or voltage. The electric current is the rate that these charges move through the circuit. Electric current is measured in amperes (A) or amps. Current direction is defined as the direction positive charges will flow (opposite to the electrons in the conductors).

The electric circuits in this lab are built with batteries, light bulbs, switches, and wires. The batteries provide a potential difference or voltage. The characteristics and arrangement of the light bulbs will determine how much current flows.

Series circuits are ones where all devices are connected end-to-end, forming a single path for electrons to flow. The same current exists almost immediately through all the devices and also in the battery that is providing the voltage.

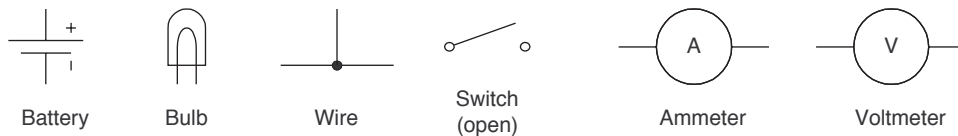
Parallel circuits have at least two or more devices connected in such a way that the same voltage acts across each one and any single one completes the circuit independently of the other devices.

Equipment

Ammeters. Electric current is measured with an ammeter. In order for the meter to measure the current, the electric charges must flow through the meter, that is, they enter through one terminal (the red or positive terminal) and exit from another terminal (usually indicated by black, or labeled negative). In a circuit, an ammeter should be hooked up in series.

Voltmeters. Measuring potential difference or voltage is done with a voltmeter (which measures in volts). Unlike ammeters measuring current at a single point in the circuit, voltmeters compare the electric potential at two different points in a circuit. Voltmeters are hooked up in parallel in a circuit.

There are many electrical components used in this lab. Batteries, light bulbs, and switches are all used. The schematic symbols of the components used in this lab are shown below.



The wire example shows a "junction," where electrically connected wires are indicated by the solid circle.

Procedure

I. Qualitative observations.

- A. Without using any meters yet, begin by building the simplest of circuits using the battery pack, one light bulb, and the switch, along with necessary wires to make the connections, shown in Figure 2. Place your components as shown in the schematic as closely as possible. The switch is “normally open.” When the switch is pushed to bring the two sides into contact, it is referred to as being *closed*. Close the switch and observe what happens and record your observation.

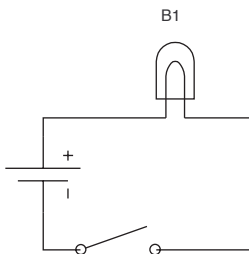


Figure 2

- B. Continue by building the *series* circuit in in Figure 3. Close the switch and observe what happens.

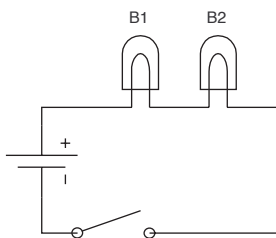


Figure 3

Make a table similar to Table 1 below and rank the brightness of the bulbs for your circuit. Let 3 represent the brightest and 1 represent the dimmest.

	Bulb 1	Bulb 2	Bulb 3
1 Bulb - Series	3	-	-
2 Bulbs - Series			-
3 Bulbs - Series			
2 Bulbs - Parallel			-
3 Bulbs - Parallel			
Combined			

Table 1

- C. Build the *series* circuit in Figure 4. Close the switch, observe what happens, and rank the brightness of the bulbs in your table.

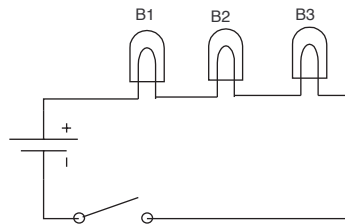


Figure 4

- D. Return to the starting circuit (Figure 2) and add a second bulb in *parallel* with the original as shown in Figure 5. Close the switch, observe what happens, and rank the brightness of the bulbs in your table.

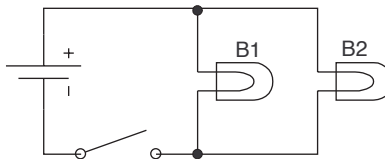


Figure 5

- E. Add a third bulb in parallel as shown in Figure 6. Close the switch, observe what happens, and rank the brightness of the bulbs in your table.

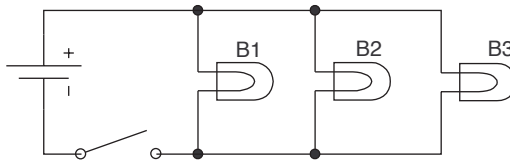


Figure 6

- F. Lastly, build the three-bulb combined circuit shown in Figure 7. Again, close the switch, observe what happens, and rank the brightness of the bulbs in your table.

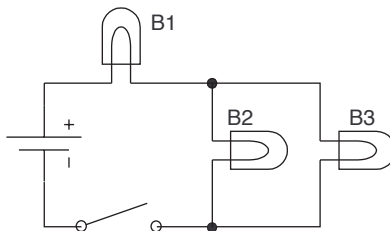


Figure 7

II. Measuring electric current.

*Ammeters are easily damaged or destroyed by allowing currents to flow that are larger than the full-scale value for a given setting. They are the least durable of electrical instruments you will use in lab. Always double check the wiring and range selection before operating your circuits.

When using ammeters always begin measuring using the largest current range available (5 A). If the meter produces a small reading or deflection, then change the range to the next more sensitive setting (.5 A). Do not use a range that will send the meter beyond the full-scale value.

- A. Once again build the circuit in Figure 2. The ammeter will be put in the circuit at 3 different places: a , b , & c as shown in Figure 8a. To measure the current at point a , the circuit must be dis-assembled a bit so that the ammeter in the circuit is “in series” with the light bulb as shown in Figure 8b. Be sure to connect the ammeter so that current enters (one of) the + or red terminals and exits the – or black terminal to the rest of the circuit.

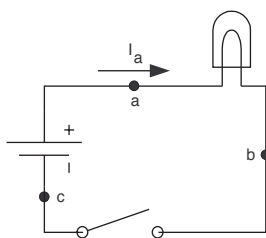


Figure 8a

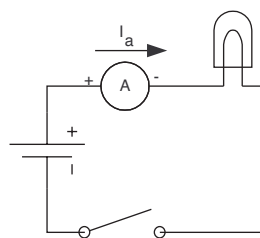


Figure 8b

Measure I_a the current leaving the battery and entering the ammeter and record on your data worksheet. Take the ammeter out of the circuit and assemble it at point b to measure I_b and assemble it again at point c to measure I_c . How are I_a , I_b , and I_c related in this circuit?

- B. Make and record current measurements for the series circuit S2 at the lettered points in Figure 9.

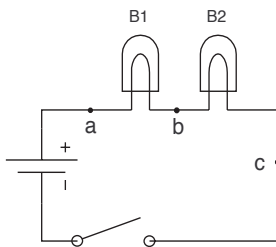


Figure 9

From your observations of the currents in these series circuits, answer the following questions.

1. How is the brightness of the bulb related to the current flowing?
2. What can you say about the current flowing through each bulb in a series circuit?

- C. Make and record current measurements for the parallel circuit P2 at the lettered points in Figure 10. Hooking up the ammeter at points *b* and *c* can be a little tricky so you might want to check with your TA to make sure the ammeter is hooked up correctly.

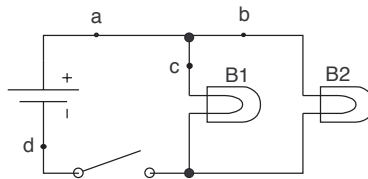


Figure 10

From your observations of the currents in this parallel circuit, answer the following questions.

1. How does the current through Bulb 1 compare to the current through Bulb 2?
2. What is the likely mathematical relationship between I_a , I_b , and I_c ?

- D. Make and record current measurements for the combined circuit at the lettered points in Figure 11.

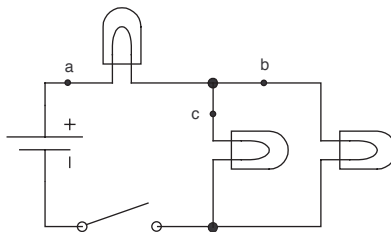


Figure 11

From your observations of the currents in this combined circuit, answer the following questions.

1. If a bulb is not glowing, does that mean there must necessarily be no current flowing? Explain.
2. Test your mathematical relationship between I_a , I_b , and I_c that was developed for part C.

III. Measuring voltage. Unlike hooking up an ammeter, a voltmeter can be used without disassembling the circuit. The voltmeter leads or probes can be attached (or touched) at two different points in the circuit. The voltmeter reports the potential difference, ΔV , between the two probe locations, $V_+ - V_-$ or $V_{red} - V_{black}$. This difference is usually called simply “the voltage” or “the voltage drop” between the points.

It is a good idea to use color-coded probes or leads with the voltmeter to keep the proper sense of polarity in the measurements. Let’s represent these differences by a simple notation: $V_{AB} = V_A - V_B$, so that V_{AB} would be measured by placing the red (+, or high) probe at point A and the black (- or low) probe at point B. The real voltmeter used here is a digital multimeter that can be used to measure voltage, current, and resistance. Be sure to select the appropriate function – DC voltage measurement, not AC – and a suitable range for the measurements at hand. Ask your lab instructor for assistance in interpreting the various icons on the meter if necessary. Be sure *not* to use a current-measuring scale!

A. Begin with the simple one-bulb circuit again and with the switch closed measure and record the voltage drop V_{BC} across the light bulb as in Figure 12.

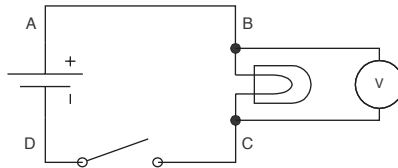


Figure 12

Also measure the voltage drops along the wire from the + battery terminal to the light bulb, V_{AB} , and from the bulb back to - terminal of the battery, V_{CD} . To finish, measure V_{DA} and V_{AD} (reversing the roles of red and black leads).

Now measure the above values when the switch is open. List all measurements (switch closed and open) in a table.

From your observations of the voltages in this simple circuit, answer the following questions.

1. How are V_{DA} and V_{AD} related?
2. How does $V_{AB} + V_{BC} + V_{CD}$ compare to V_{AD} ?
3. What do you get if you sum up the voltage drops once around the circuit? ($V_{AB} + V_{BC} + V_{CD} + V_{DA} = ?$)
4. With the switch closed does it appear reasonable to neglect the voltage drops V_{AB} and V_{CD} along the wire segments?

- B. For the series circuit S2 measure the voltage drops across each light bulb and the battery again. Refer to Figure 13 and measure V_{AB} , V_{BC} , and V_{CA} around the circuit with the switch closed. What is the sum of the voltage drops around the circuit?

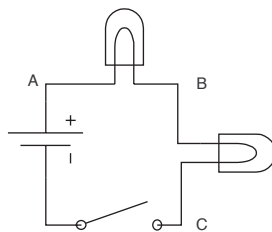


Figure 13

- C. For the parallel circuit P2 (Fig. 5 or Fig. 10) measure the voltage drop across each bulb and the voltage drop across the battery and record. How do the voltage drops compare?
- D. Make voltage drop measurements across all bulbs for the combined circuit, V_{AB} , V_{BD} , V_{CD} , and V_{DA} (Figure 14).

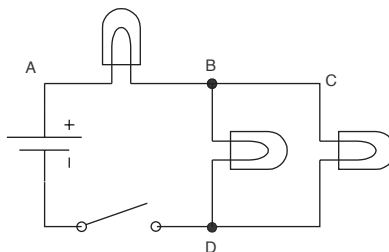


Figure 14

From your observations and measurements of voltages in the combined circuit answer the following questions.

1. Find the sum of the voltage drops along path A-B-D ($V_{AB} + V_{BD}$). Compare this sum to the voltage supplied by the battery, V_{AD} .
2. Find the sum of the voltage drops along path A-B-C-D ($V_{AB} + V_{CD}$). Compare this sum to the voltage supplied by the battery, V_{AD} .

***When finished with your lab clean up your lab station. Make sure you put all of your wires away.**

Homework

1. What can you say about the electric current that flows through two or more bulbs connected one after another in a series circuit?
2. What can you say about the current flowing into a junction of 3 wires compared to the currents that flow out from the junction? State Kirchhoff's junction rule and compare.
3. State Kirchhoff's Loop rule. How does this relate to the combined circuit in part III D?