Experiment 9: Electrical Measurements

1. Obtain 3 batteries with holders, 2 identical flashlight bulbs with holders, leads (wires) with alligator clips, and a multimeter.

2. Using the Multimeter

   a. There are 2 probes that fit in the holes near the bottom of the meter. Put the black probe in the COM (Common) hole and the red probe in the VΩmA hole. By convention, black represents the negative side and red represents the positive side. If you mix them on a digital meter it's generally ok; as the meter will just read negative values.

   b. Examine the different Voltage dial settings. Between the 9:00 position and 12:00 are various "DCV" settings ("V=" on the black meters). These are for measuring Direct Current Voltage (batteries produce direct current; house wiring uses alternating current or "AC"). Each position represents the maximum voltage for that setting. The "2000m" setting means "2000 millivolts" maximum.

   c. Turn the dial through the different settings (600, 200, 20...) and notice what happens to the decimal point. Measure the voltage of a single battery, first using the "600" scale, then progressively lower scales. Notice that if you measure a small voltage with a high setting, you lose precision. E.g., if you want to measure a voltage of 4 volts, you should use the "20" scale to get the maximum precision (although 200 and 600 will work).

3. Put together a simple circuit with 1 battery and 1 bulb, but unscrew the bulb. Measure the voltage (use the 20 DCV scale)

   a) across (i.e, *in parallel with*) the battery terminals: ______

   b) across the ends of the wires at the bulb fixture: ______

4. Now screw-in the bulb and repeat the voltage measurements:

   a) across the battery terminals: ______

   b) across the ends of the wires at the bulb fixture: ______

They should be somewhat lower than before, and very slightly different from each other.

5. Measuring current is more complicated than measuring voltage because all the current must flow through the multimeter. This means the meter must be *in series with* the component who's current is to be measured.

   a) Turn the dial to the 10A setting, and move the red probe to the 10A hole. [FYI, ideally, we would use smaller settings than 10A but the lower ranges available on this meter (covered with masking tape) are too small for our labs: 0.2amps max.]

b) *Disconnect* one of the wires in your circuit, and place the meter into the circuit, so the meter fills the gap made by the broken connection (a series connection). Read the current (in amps): _______

c) Now unscrew the bulb and measure the current: _______

So the presence of voltage does not guarantee that current will flow. There must be a complete circuit.

When a voltage is present, it means electrical energy either has the potential to flow, or is flowing.
When a current is present, it means electrical energy is indeed flowing.

An analogy with water: the water in a pipe has pressure (voltage) whether the faucet is open or closed. But water has flow (current) only when the faucet is open.

6. Rules for Measuring Voltage and Current:
   - Voltage is measured across a circuit element or elements. (in parallel)
   - Current is measured with the meter as part of the circuit. (in series)

7. a) Measure the voltage of two batteries (independently, outside the circuit)

   Battery 1: _____

   Battery 2: _____

   b) Put the two batteries in series, in standard +/- arrangement.

   Predict the voltage measured across both batteries: ______

   Measure this voltage: ______

   c) Put the two batteries in series, this time in the +/+ or -/- arrangement.

   Predict the voltage measured across both batteries: ______

   Measure this voltage: ______

8. Examine the diagram for Circuit #1 on the following page. In the table for Circuit #1, make predictions about what voltages you expect to see between the nodes.

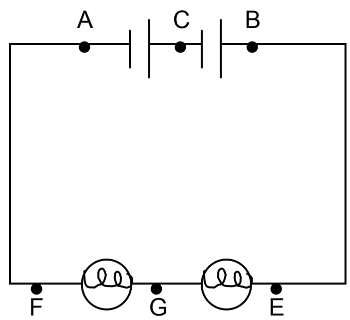
9. Now build circuit #1 and measure those voltages.

10. Measure the current for circuit #1, following the table on the following page.

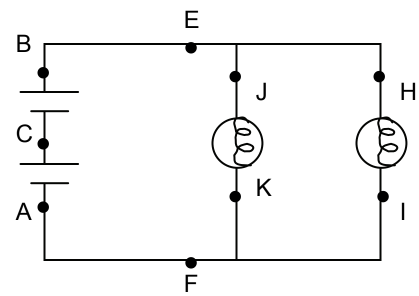
11. Repeat steps 8 – 10 for Circuit #2.

12. Examine your results for both Voltage and Current, and discuss:

Circuit #1

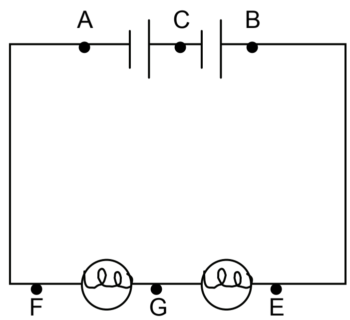


Circuit #2

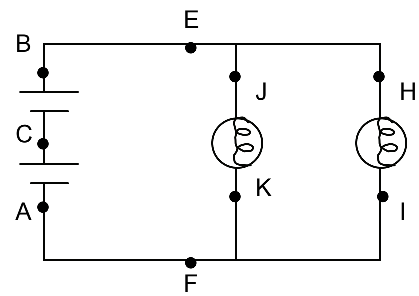


VOLTS	Circuit #1: Predicted	Circuit #1: Actual	Circuit #2: Predicted	Circuit #2: Actual
A – B (all batteries)				
A – C			X	X
C – B			X	X
B – E (battery-bulb)			X	X
F – A (battery-bulb)			X	X
E – F (all bulbs)				
E – G			X	X
G – F			X	X
J – K	X	X		
H - I	X	X		
E - H	X	X		

Circuit #1



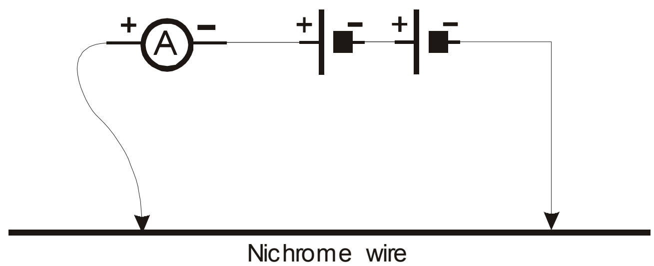
Circuit #2



AMPS	Circuit #1	Circuit #2
A		
B		
C		
E		
F		
G		X
H	X	
I	X	
J	X	

13. Obtain 2 batteries with holder, a meter stick, a length of Nichrome wire, masking tape, leads, and a multimeter. Tape the Nichrome wire to the meter stick.

14. Set up the circuit pictured below, use the multimeter as an ammeter.



15. How do you know that the Nichrome wire between the arrows is part of the circuit, but the part of the Nichrome outside the arrows is NOT part of the circuit?

16. Recall Nichrome wire is a *resistor.* Will the amount of current through the circuit change if you change the length of the Nichrome wire between the arrows? Explain your reasoning.

17. Check to see if the current changes for various lengths of wire in the circuit. Make a data table, recording the length of the wire in the circuit and the current in amps. Be sure to take readings at very short lengths of wire as well as medium and long lengths (this gives the best graph). Then graph the relationship.

18. a) Let's see if we can make sense of this graph. Which of the following does it look like (circle)?

$y=kx$

$y=kx^2$

$y=kx^{1/2}$

$y=k/x$

The longer the Nichrome wire, the more its *resistance.* So the graph above could also be thought of as a plot of current vs. resistance (where length is proportional to resistance). Now write the equation relating current (i) and resistance (R), and discuss: