**An introduction to electric circuits:**

**Current, voltage, and series and parallel circuits**

**Materials:**

2 digital multimeters

DC power supply

three identical 3V light bulbs in sockets (must match!)

~8 jumper wires

scissors

**Introduction:**

In this lab, you will measure both electric currents and potential differences using your digital multimeters (DMMs). Your instructor will show you how to set up your DMM for each kind of measurement.

To measure the electric current in a circuit, you will need to break the circuit, reconnecting it so that current is forced to flow through the meter, as shown below. (The “A” is the symbol for a current meter, or ammeter.)

*To measure current in this wire:*

*…and reconnect through the ammeter.*

*Break the circuit somehow…*

A

Your DMM can also measure the potential difference, in volts between any two points in the circuit. For this measurement, keep your circuit intact, and simply touch the two leads of the DMM to the two places in the circuit you want to measure between.

***For all parts of this lab, keep your power supplies set to a voltage of 3.0 volts, and use the 10A or 20A range of your DMM for measuring currents. Otherwise we’ll blow out lots of bulbs and fuses.***

**Activity 1: current and voltage measurements.**

a. The circuit below consists of a power supply, two ammeters, and a single lightbulb. For the following circuit, predict which of the two ammeters will measure the larger current. (Or will they be the same?)

A

A

Prediction:

b. Build the circuit above, using your two DMMs to measure the current that flows at the two points in the circuit shown. Record your measurements. Was your prediction correct?

c. Remove one of your two DMMs from the circuit, and use it to measure some voltage differences in the circuit as shown. Hold the black lead at point a, and move the red lead to b, c, and d, recording the results.

A

a

b

c

d

V

*Measuring potential difference between points a and b.*

d. Predict the voltage difference between the two points c and d in the circuit above. Test your prediction with a measurement. Do they agree?

Prediction:

Measurement:

e. How big is the voltage difference between the two ends of a typical wire in your circuit?

f. How big is the voltage difference across your ammeter?

g. Is it reasonable to approximate either or both of the voltage differences in (e) and (f) as zero?

**Activity 2: Two light bulbs in parallel**

a. Add a second light bulb to your circuit, as shown. These bulbs are connected “in parallel.” Make a prediction: If you add the second light bulb to your circuit as shown, will the current in the first light bulb increase, decrease, or stay about the same? Build the circuit and test your prediction.

A

Prediction:

Measurement:

b. In the circuit you have just built, how much current is flowing from the power supply? Make a prediction, and use a second ammeter to test your prediction.

Prediction:

Measurement:

*This is a good time to check with your instructor to be sure your measurements are on the right track.*

c. What is the voltage difference across each of the two light bulbs in the circuit above? Use one of your DMMs as a voltmeter to test your prediction.

Prediction:

Measurement:

d. Here’s a neat way to visualize electric potential, using an analogy with gravitational potential energy. For the simple circuit that you made in activity one, imagine the circuit drawn on a piece of paper shaped like a loop, with the paper folded so that height above the table corresponds to electric potential as shown below.

On the last pages of this lab are some big circuit diagrams for you to cut out. First, find the diagram of the circuit with two light bulbs, and use scissors to cut it into a shape with two loops. Then fold your paper so that the height above the table corresponds to changes in potential energy. Discuss your figure with your instructor. Yes, you REALLY have to do this.

e. Is your power supply acting more like a source of fixed current, or a source of fixed voltage? (What changes and what stays the same when you connect one or two bulbs to your power supply?) Explain.

**Activity 3: Two light bulbs in series:**

a. The circuit below shows two light bulbs connected to the power supply in series. Make predictions for the current in each of the bulbs, and the voltage difference across each bulb. Then build the circuit and test your predictions with measurements.

Predictions: Measurements:

A

A

b. Cut out the picture of this circuit from the final pages of your lab, and fold it so that height above the table represents electric potential. Discuss your figure with your instructor.

*(A quick note: for those who have studied circuits before. You may have expected the current in each of the bulbs to be exactly half of the current through a bulb in the previous exercises. That would be true if the bulbs were regular resistors. But in fact, the “resistance” of these bulbs change as they get hot, so they don’t obey ohm’s law.)*

**Activity 4: Bulbs in series and in parallel:**

a. The circuit shown below includes light bulbs in series and in parallel with each other. Predict the values of the currents and voltage differences for each bulb, and then test your predictions. Which bulb or bulbs will be brightest?

Predictions: Measurements:

A

A

a

b

c

e

d

Brightest Brightest

Bulb? Bulb?

b. What is the relationship between bulb brightness and current through the bulb?

c. What is the relationship between bulb brightness and voltage difference across the bulb?

d. If we define the electric potential at the negative terminal of the power supply to be at Volts, what is the potential at each of the points a, b, c, d, and e in the circuit drawing above?

**Homework:**

Problem 1: consider the following circuit:

a

b

c

f

e

d

g

3 volts

a. If we define the electric potential at the negative terminal of the power supply to be at Volts, what is the potential at each of the points a, b, c, d, e, f, and g?

b. Rank from smallest to largest the current at each of the lettered points in the circuit. (You can write “” or something like that.)

c. Which bulb or bulbs will be brightest? Which bulb or bulbs will be least bright?

Problem 2: Consider the following circuit:

a

b

c

e

d

f

3 volts

a. Which is greater, or ? Why?

b. Which bulb is brighter, the one between a and b, or the one between e and f? Why?

c. Which is greater, or ? Why?

d. Which is greater, or ? Why?

e. Which is greater, or ?

f. Cut out the circuit on the last page of this lab, and fold it so that height above the table represents electric potential. Now that you have folded it, are there any answers above you’d like to change? Bring your folded paper to class, and prepare to discuss your figure with your instructor.

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