

Lab 04 - Electricity and Electric Circuits

NAME: _____

Time spent on Lab 04 = approximately 2 hours, does not need to be done at one sitting **Materials needed** = Access to computer and high speed internet, Java installed on the computer, one lemon, one 2" copper wire, one paper clip

Learning Objectives:

- Experiment with electricity principles
- Test various materials as having electrical properties or not
- Design electrical Circuits
- Test Kirchoff's loop and junction rule

Mini-Experiment:

To begin this week's experiment, you will need some copper wire, a lemon, a paperclip, and possibly some knife or wire cutter. We will first test out some theories on what electricity is and how it is generated! To begin the experiment, please follow the procedure below.

- First cut off a 2-inch piece of copper wire, and remove the insulation, if any. This is best done with a wire stripper, but you can use a kitchen knife if you are careful not to cut the copper wire itself!
- Unfold the paper clip and make sure it is about the same length as the copper wire. If not, clip it to the same size.
- Now roll the lemon around on the table applying gentle pressure. **Do NOT break the skin of the lemon.** We simply want to squeeze the juice of the lemon out of its interior cells, so that there is plenty of juice to power our electrical circuit (hint, hint!!).
- Now, stick the copper wire about 1 inch into the lemon. Or until it is slightly more than $\frac{1}{2}$ way through the lemon.
- CAREFULLY touch the end of your tongue to the tip of the copper wire that is NOT inside the lemon.

1. Do you notice anything, besides a sharp piece of wire resting against your tongue?

No. the circuit was incomplete

- Now, stick the paperclip into the lemon at about the same depth as the copper wire and near to it, BUT NOT TOUCHING IT!
- The image below shows how the "battery" should look.

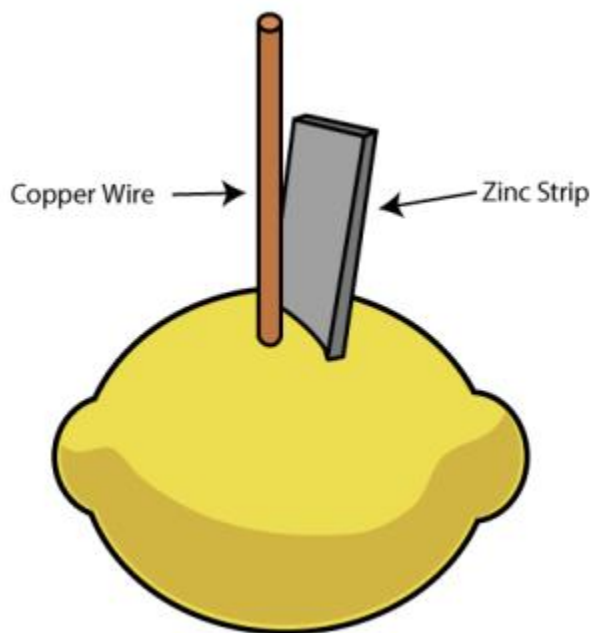


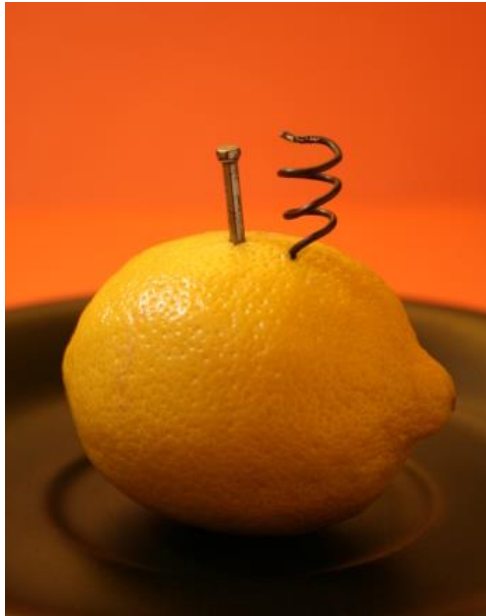
Figure #1

Now, touch the tip of your tongue to the ends, both the copper wire and the paperclip

2. Do you notice anything now? Maybe a slight tingling on your tongue? Or a metallic taste? Describe what you noticed below.

I felt a slight tingle on the tip on my tongue and it tasted something metallic. Touching copper and zinc strips completes the circuits.

3. Insert a photo of your experimental apparatus below



So what just happened? By now you may have the impression that charges are everywhere, and in SOME cases, charged particles can move. In this case, there are charged particles in the lemon which are allowed to move through the one piece of metal, through your tongue, and back to the lemon through the other piece of metal. This movement of charged particles is what we refer to as current denoted with the symbol I .

Current always moves from high potential (V) to low potential. Without a connection between high and low potential, no current will flow! If current were to flow without a connection between high and low potential that would be something like the mechanical equivalent of water flowing uphill. You would have to give the water energy to counteract gravity! Similarly, something would have to provide energy to current to have it flow when there is not a complete connection.

4. Looking back on #1, explain your observations given what you know now about current flow.

The current flows from high potential difference to low potential difference. If there is no connection between the high and low potential differences, no current flows and hence nothing was felt.

Now that we know there are such things as moving charges that are called current, which are generated between high and low potential, let's move on to the idea of current flow creating something useful, like electricity!

Virtual Lab:

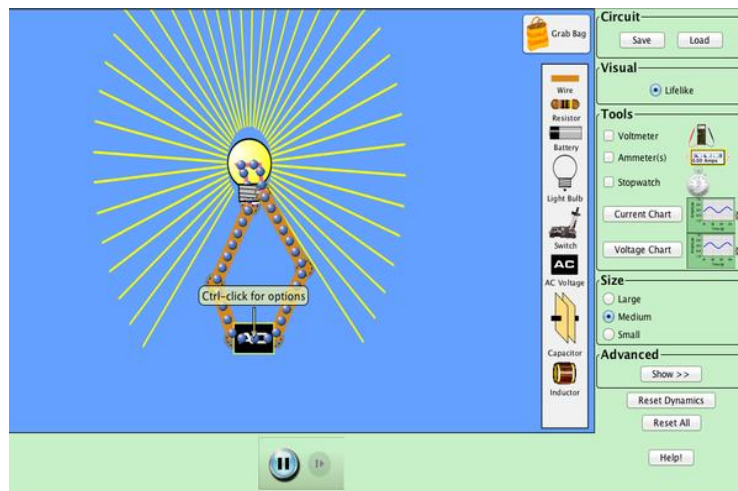
To begin the virtual lab, you will need to use a computer with Java installed on it. Directions to install Java are [here](#).

Once you have a computer with a working version of Java, proceed to this website to download a virtual lab:

<https://phet.colorado.edu/en/simulation/legacy/circuit-construction-kit-dc-virtual-lab>

Download the java file and make sure you can open it outside of the web browser. Most browsers will have Java disabled by default. If you have any troubles please contact your instructor.

5. Let's start out "easy" by making a light bulb light up. Use ONLY one battery, two wires, and a light bulb. You may want to refer to the textbook for help in what each component in a circuit should look like. Take a screen-shot of your lite bulb and place it below.



6. What seems to be making the light bulb turn on in your circuit? (what do you think electricity is based on the simulator?)

The flow of charges from the cell makes the current flow causing the light to light.

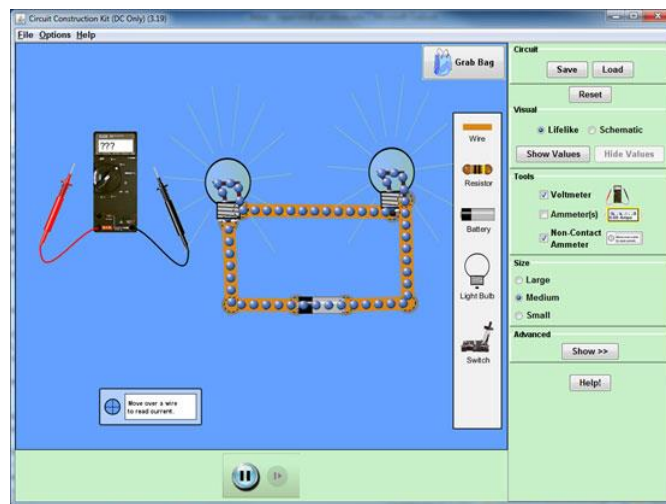
7. Make a gap in the circuit, then go to the grab bag and test each of the items there to see if they allow #6 to happen. Do so by placing these items in the gap you just created

Insulators and conductors

Objects that allowed electricity flow	Objects that did not allow the electricity flow
Copper wire, aluminum plate, gold strip, silver strip	Plastic, paper, glass, rubber, wood

8. Now take two bulbs, and one battery, and as many wires as you like, and create a circuit which makes BOTH bulbs light up, but when the connection is broken, BOTH bulbs go out. Once you have found the correct mechanism, attach a screenshot of your circuit below:

Screenshot



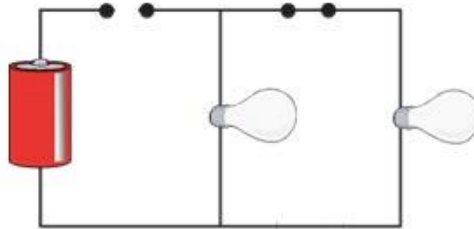
9. Why did BOTH bulbs go out when you broke the connection?

The two bulbs went off when the screen was disconnected since they are in series and the current did not flow after disconnection.

This is called a [series](#) circuit where all circuit components are in one line. The line is not necessarily straight!

10. Now take your two bulbs, a battery, and as many wires as you like, and make a circuit which lights BOTH bulbs, but when you break the connection, only ONE bulb is NOT light. Attach a screenshot of the circuit below

Bulbs in parallel



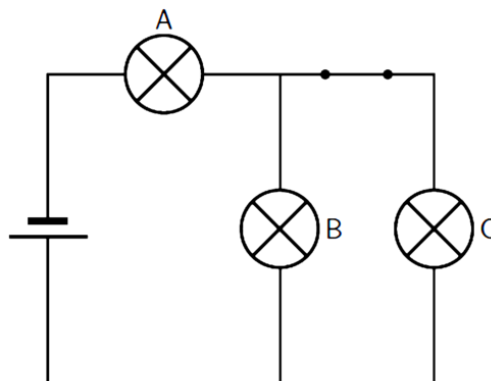
11. When you break the connection, why does one bulb stay light?

This is a simple parallel circuit which consist two bulbs and each have different circuit path wired to the dry cell. When break the connection at one bulb the circuit remain complete though only one bulb light.

This is called a [parallel](#) circuit and contains two, or more!, individual loops that connect to the battery.

12. Now add in a third bulb, keeping the one battery, and as many wires as you like, create a circuit which has BOTH series and parallel components, which also lights up all three light bulbs. Once you have this completed, attach a screenshot below.

Three bulbs A, B and C connected in series and parallel



13. You design toys for a toy company. Your boss wants you to hook up the lights in the toy car you are working on in the cheapest way possible, without consideration of the quality of the toy. Which circuit should you use if you want to save money by using fewer parts? Why would this circuit be cheaper?

Series connection. Parallels circuits have few parts as compared to series circuits. The currents supplied will take long time and hence cheap.

14. You are an electrician working on a house. What type of circuit should you use for the house so that the owners don't call to complain about their wiring? Why use this circuit?

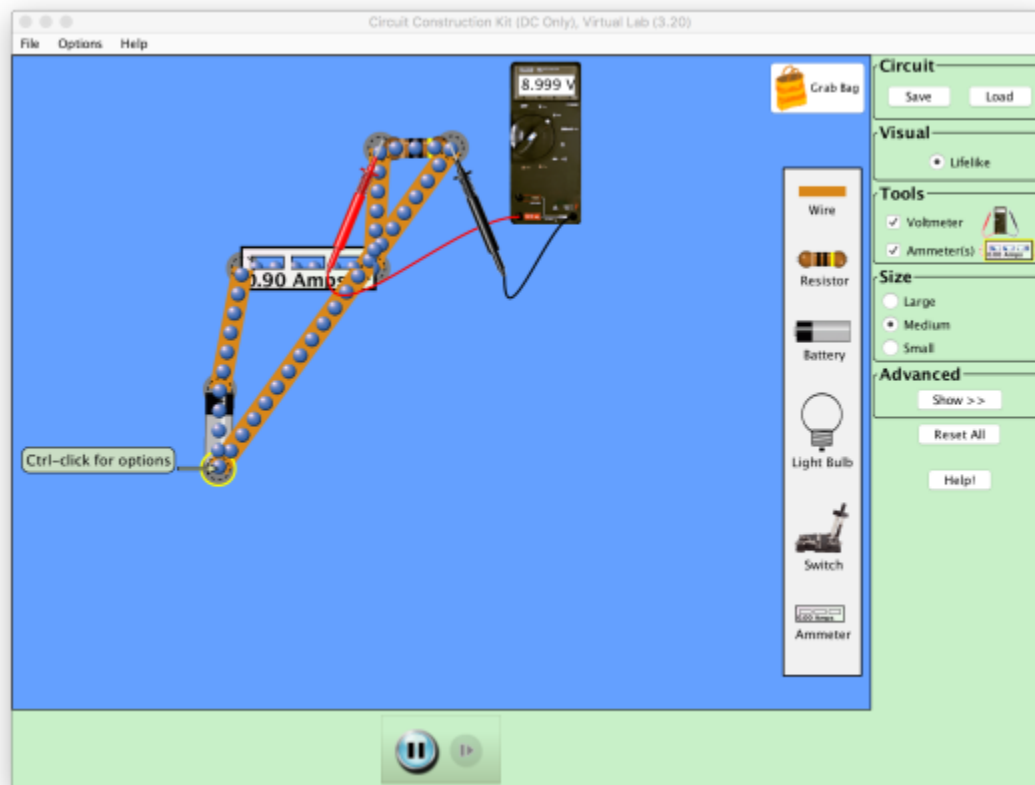
Parallel, house equipment such as fan, refrigerator, bulbs and should be in parallel since the disconnection does not affect the other devices.

It's sufficient to say that a light bulb behaves pretty similar to a resistor. Something that "resists" the flow of electricity. Why would we want something to resist the flow? For the very reason we like to have a light bulb in a lamp to read at night. The energy taken from the flow can be converted into many other forms, including light! Sometimes resistors are useful in "reducing" the electric potential energy so it does not overwhelm a single electrical component. For example, power lines can have up to 750,000 Volts running through them! Your outlet at home has 110V. Imagine plugging in your cell phone directly into the powerlines! It would likely explode!

So let's take a moment to quantify resistors! It's worth noting at this point that

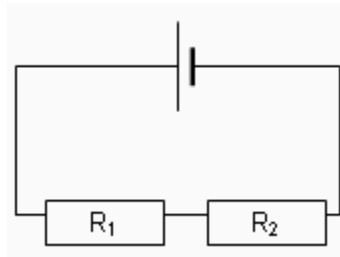
- To measure current with an ammeter, you must put the ammeter in SERIES with the component you want to measure current for.
- To measure voltage with a voltmeter, you must put the voltmeters in parallel with the component you want to measure voltage for.

- Here is a screenshot of how one might plug in each sensor to measure the voltage and current in one resistor.



15. Now try setting up a circuit with TWO resistors in series, and measure the current and voltage for each resistor. Take a screenshot of the circuit you build in the simulator and attach it below.

Diagram of two resistors in series with ammeter and voltmeter



16. In the area below, write in the currents and voltages for each resistor, and write a summary statement which explains voltage and current in a series circuit, i.e. “The current is constant everywhere in a series circuit.” or similar.

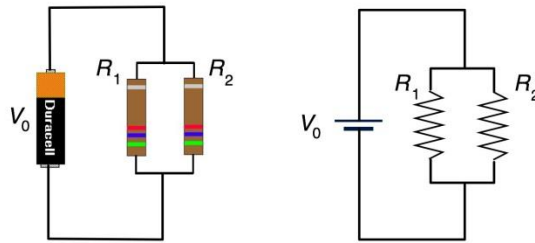
Value of currents and volts

Volts (v)	Current A
10	0.16
220	0.16

The current is constant through the circuit

17. Now try setting up a circuit with TWO resistors in parallel and measure the current and voltage for each resistor. Take a screenshot of the circuit you build in the simulator and attach it below.

A circuit with two resistor in parallel and measure the current and voltage. Take a screen short of the circuit



18. In the area below, write in the measurements for each resistor and write a summary statement for voltage and current in a parallel circuit.

$R_1 = 1\Omega$ and $R_2 = 4\Omega$

In series $R_{\text{total}} = R_1 + R_2$

$= 1\Omega + 4\Omega = 5\Omega$

The two resistances have a common current flowing through them as it can only take one part. Resistors in series are complex and can be replaced by one single equivalent resistor R_{EQ} or impedance Z_{EQ} . All resistors obey ohm's law and Kirchhoff's laws. Each resistor in a circuit has different potential differences. The total voltage is given by the sum of individual voltage.

$$V_{AB} = V_{R1} + V_{R2} + V_{R3}$$

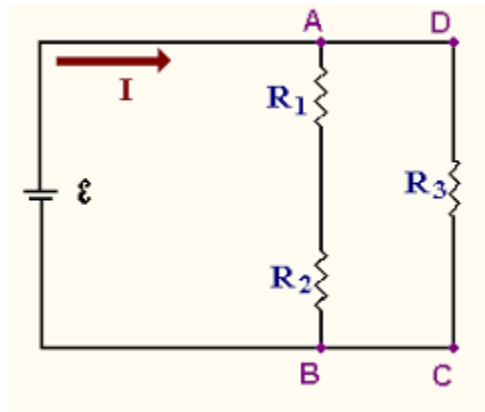
In parallel, $R_{\text{total}} = R_1 \times R_2 / R_1 + R_2$

$1 \times 4 / 5 = 0.8\Omega$

The total resistance is not equivalent to the sum of the resistors used and it is always less than any of the branch resistor. Addition of parallel branches to the circuit, the total current will decrease as stated by ohm's law. The sum of the currents through each path is equal to the total currents and the voltage is same across each component of the parallel circuits.

19. Now try putting THREE resistors in a circuit that contains BOTH a series portion and a parallel portion. Attach a screenshot of your circuit below.

Combination of both parallel and series arrangement of resistors.



20. Write out the values for current and resistor for each resistor. Then confirm that they comply with your statement in questions #16 and #18.

The values for the currents and resistor for each resistor. Then confirm that they comply with the statement above.

Resistor R_1 and R_2 are in series while the combination of resistor R_1 and R_2 are in parallel with R_3

$R_1 = 1\Omega$, $R_2 = 4\Omega$, $R_3 = 5\Omega$

Total for R_1 and $R_2 = 1+4=5\Omega$

The effective resistance for the whole circuit

Total resistance = $4 \times 5 / 5 + 4 = 2.22\Omega$

Current = V / R

$1.5 / 2.22 = 0.675A$



Questions #15-#20 summarize what are known as Kirchhoff's [Loop](#) and [Junction](#) rules of electricity. With these laws, one can simplify the math of even the most complex circuits.

Once you have completed all lab questions, please download this document as a PDF only! Then upload this PDF to Blackboard under the assignment “Lab 04”, for grading.

Portions of this lab were taken from a write-up by Trish Loeblein at Phet - CU Boulder