STEM on Site Summer Program

Light My Home

Recommended for Grade Levels: 6-8

Content Notice

This activity has been put together as a free, open source resource from the Milwaukee School of Engineering STEM team for self-guided, at home learning. Unless otherwise noted, in person or live instruction is not provided and questions should be directed to stem@msoe.edu.

Safety Notice

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Goals

- Understand the use of various electrical components
- Learn how to build basic circuits

Learning at Home

- While we have tried to select activities that utilize materials you might have around your home or able to procure without too much difficulty, we know that may not be the case for everyone.

- One of our favorite parts of engineering is the problem solving and critical thinking skills required, and we encourage you to consider the following question when looking at the materials list for this activity:

- **If I don't have a certain material, what is the material being used for in this activity?** Is there something else I could substitute that serves the same or a similar purpose? How can I modify this activity with what I have at home?

Materials List

Note that items marked with an asterisk (*) are not included in your kit if you ordered one from MSOE

	NAME
	Breadboard
	100 ohm resistors
	1k Ohm resistor
	100K Ohm resistor
	Photoresistor
	Jumper Wire (various lengths)
	Alligator clip heads
	AAA Battery Pack
	Push Button Switch
	Assorted color LEDS
	Decorations for cardboard house (*)

REQUIRED TOOLS/Supplies

	AAA Batteries

Background Knowledge

Introduction

In this activity, you will learn how to wire a circuit using a breadboard and use that knowledge to design and wire a house! You will use a cardboard box, decorated however you would like, and wire it to give it that final touch!

Background Knowledge

Basic Terminology

Before we can talk about how circuits work, there are a few terms that we need to define in order to understand what is happening inside our circuits.

- Load – a load is something that we put in our circuits that converts electrical energy to something else. For example, a light bulb is a load that we can add to our circuit, the light bulb will convert electrical energy into light. **Can you think of another example of a load?**
- Electrons/electricity – electrons are extremely small particles that have a negative charge. You might have heard the term electrons before when talking about Atoms. Every atom as at least one electron and the movement of these electrons is what we call electricity. When we connect a battery to a circuity, the battery has enough stored energy to push elections through our wires to create electricity.
- Voltage – Voltage is the stored energy that something, like a battery, has. The higher the voltage the more energy the battery has.
- Current – Current is the flow of electrons inside a circuit. Current is very similar to our definition to elections/electricity, but the main difference here is when we talk about current we are specifically talking about the activity in our circuit.
- Resistance – resistance can be considered the objects willingness to pass electricity. The more resistance an object has, the harder it is for electricity to flow through it. When an object has really high resistance, this object is usually called an insulator, like rubber. When an object has really low resistance, this object is usually called a conductor, like a copper wire.
- Branch – In this activity when we get into parallel circuits, we will be creating multiple branches. A branch is a single path that an electron can take from the battery, to **one** of the LEDs and back to the battery. Later in the activity you will see that the more LEDs we have in our parallel circuit, the more branches we have.

These terms will be used extensively throughout the activity. If you see a word or term that you don't recognize, come back to this section.

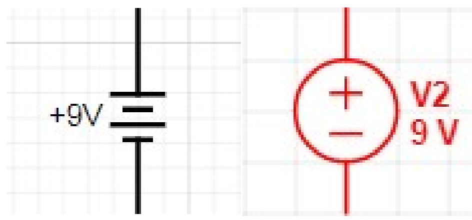
Drawing schematics

There are many ways that we can draw our circuits. In this activity, we will draw our circuits just like electrical engineers. Electrical engineers use a number of symbols to represent electrical components, such as a battery, or a light bulb. Below are all of the electrical components that we will be using, along with a side by side of what the component looks like and what it's symbol looks like.

- 9 Volt Battery – A battery is what supplies a voltage to our circuit. This voltage ultimately drives how bright our light can shine.
    - Physical image:

(Image taken [from](#))

    - Schematic Drawing: Batteries can be drawn in two different ways. There is no right or wrong way, it is up to you on which one you would like to draw

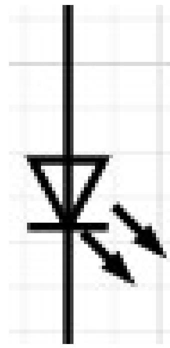


- LED – LED stands for Light Emitting Diode. Diodes are a special tool that only let current flow one way. If the LED is backwards in the circuit, then electricity will not flow through it, meaning the light will not shine. Just like a battery, every LED will have a positive end and a negative end. The positive end is called the anode and the negative side is called the cathode. You can tell which one is which on a physical LED because the cathode is longer than the anode. **Important:** if your LED is not shining, but everything is plugged in correctly, then flip the LED in your circuit.
    - Physical image:

Image taken [from](#)

Before you move on, can you identify the anode and the cathode of the LED shown above?

- Schematic drawing:



As mentioned above, a LED is a special kind of diode. All diodes are drawn as a triangle with a line at one end. How electrical engineers tell the difference between diodes is the arrows drawn next to it. The anode for all diodes are at the base of the triangle and the cathode is at the top of the triangle.

- Wire – wires are usually made of copper with a rubber insulator wrapped around it. Since copper has so many electrons it makes for a great conductor of electricity. The reason we usually find copper in all of our wires is because it is cheap and easy to use.
  - Physical image:

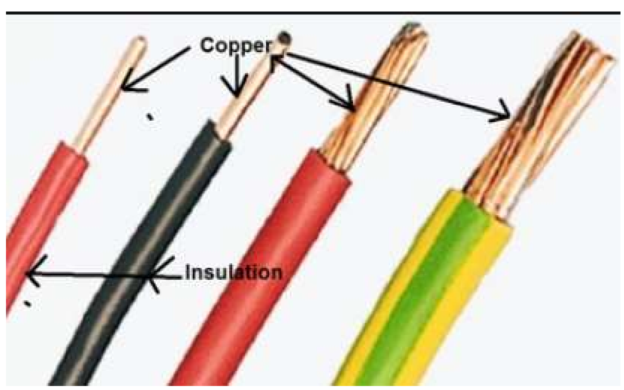
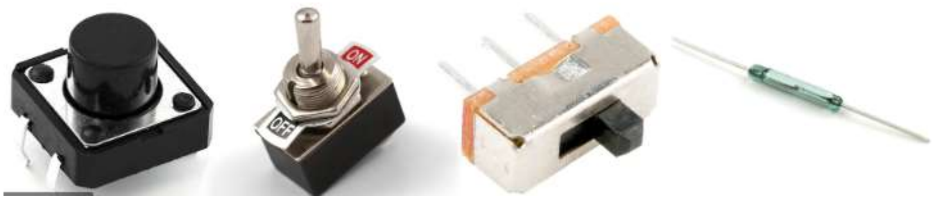


Image taken [from]

  - Schematic Drawing:

This is one of the easiest components that you will have to draw. However, when you are drawing your wires, be sure to make them as straight as possible and use right angles when connecting components. You want your schematics to be as easy as they can to read.

- Switch – Switches can open and close your circuit just by a simple action like pushing a button. Switches come in all sorts of varieties.
    - Physical Image:



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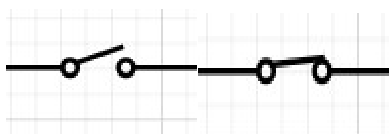
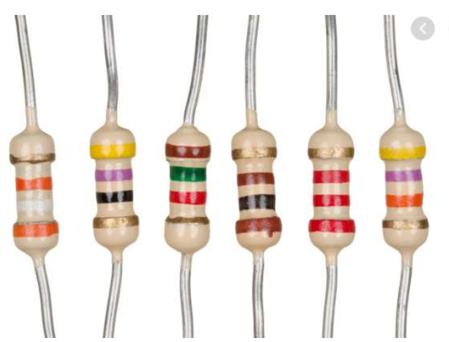
- Schematic Drawing:



The switch on the left shows the circuit is open, so no electricity is flowing. The switch on the right shows the circuit is close, so electricity is going to the light.

- Resistor – each resistor has a certain resistance value associated with it. This resistance value can be determined by the colored bands on the physical resistor. In this activity we will not be going over how to determine the resistance of a resistor.
    - Physical Image:



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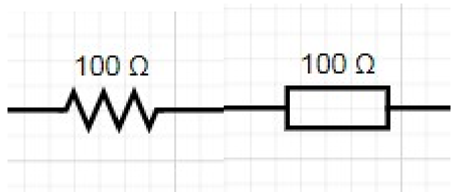
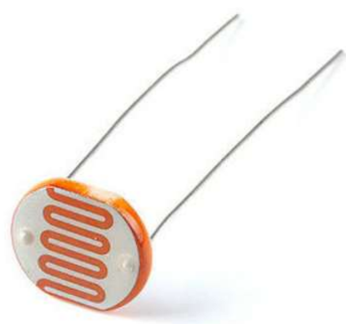
- Schematic Drawing:



Resistors can be drawn in two ways, traditionally the resistor on the left is how electrical engineers draw it.

- Photoresistor – A photoresistor is another special kind of resistor. This kind of resistor can change the value of resistance by the amount of light that is exposed to it. If you have ever seen a light that turns on after the sun has gone down and the lighting level has reached a certain point, chances are that light uses an element similar to a photoresistor.
    - Physical Image:



- Schematic Drawing:

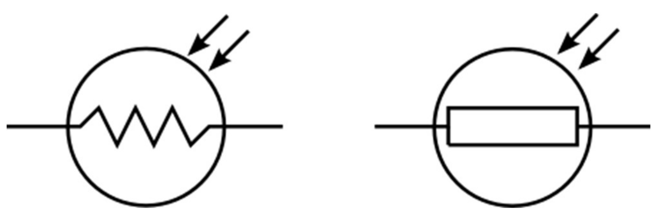
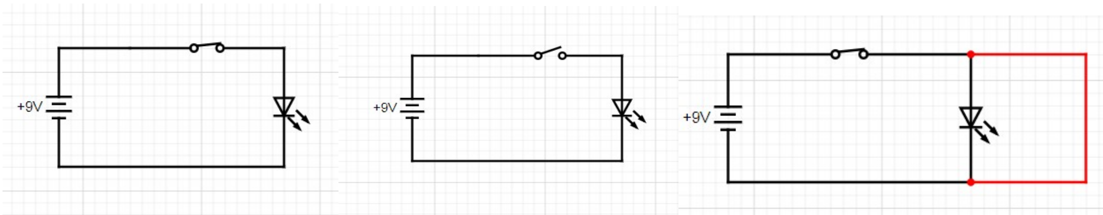


Image taken from

Open, Closed, and Short Circuit

Before we can build a circuit, we need to know how a basic circuit works. When a battery is connected to a load the battery pushes elections through a wire to the load. This can only be done if the circuit is complete. If there is a break in the wire, the electrons in the wire have nowhere to go, so they will stop moving and when the electrons are not moving, we don't have electricity.



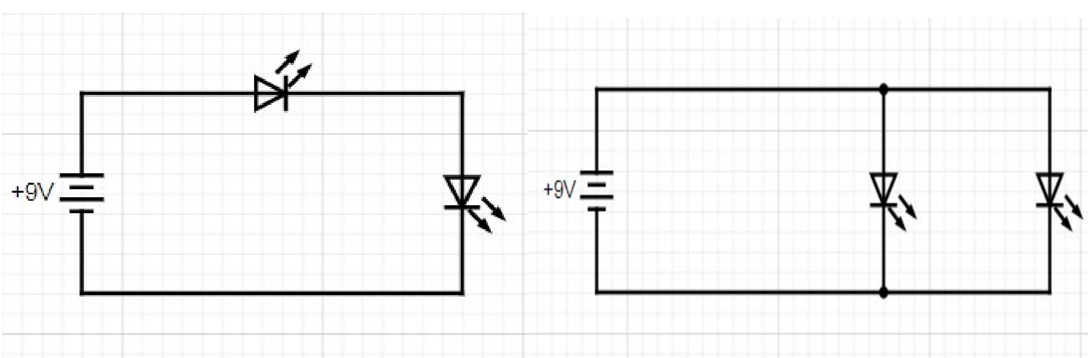
When we say that we have an open circuit, that means that there is a break in the wire and there is no flow of electrons in the circuit. If we were to have a light bulb as our load, the light would appear off or not shining.

When we have a closed circuit, that means that all of the wires are connected, and the circuit is complete. We can tell that our circuit is closed when our light is shining.

A term that you might not have heard before is a short circuit. Electrons are extremely lazy, and they like to take the path of least resistance. In the image above, all electrons will travel down the red portion of the circuit. This is because there is no load in that part of the circuit and every load offers some sort of resistance.

Series Vs Parallel

When we start making our circuits and start adding lights to our house, there are two ways we can string together our lights. We can either put them in series or in parallel. What does that mean? Below is a schematic drawing of two LEDs, the drawing on the left shows the LEDs in series and the one on the right shows the two LEDs in parallel.



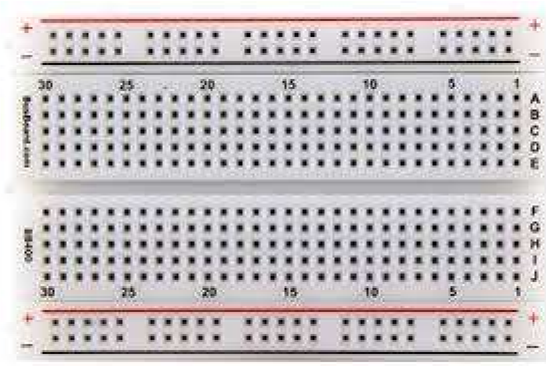
Before we continue, do you think there is a difference in the brightness between these two circuits? If so, what is are the differences?

When LEDs are wired together in series the electrons must pass through each load. When the electrons pass through each load, there is a loss of energy. That means that when the elections pass through the first LED, there will be less energy to power the second LED which will cause the second LED to be dimmer than the first one. If we string together three light bulbs in series and the first one was to burn out, all the remaining light blubs would also go out. This is because when the light bulb burns out it creates and open circuit and the elections have nowhere to flow to.

When LEDs are wired in parallel, the electrons are divided up evenly between branches. This means that both LEDs will be at the same brightness. If we were to string together three light bulbs in parallel and one of the bulbs burns out, the other two would still shine. In fact, they would shine brighter. The reason the other two bulbs don't go out is because there are other paths that the electrons can take to complete the circuit. We will test this out later in the activity.

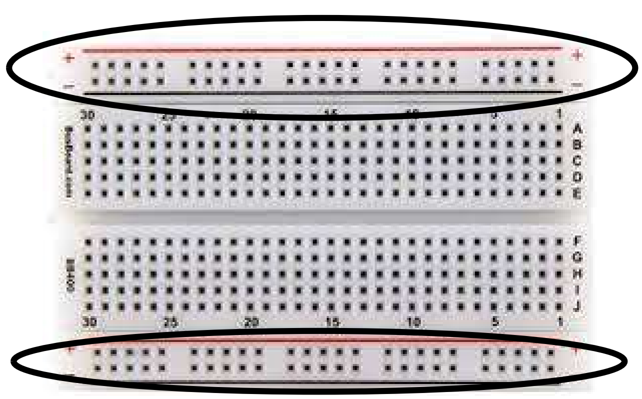
Breadboards

Breadboards are used by electrical engineers to prototypes of their circuits. Breadboards allow us to put in and remove any electrical component (like a LED) with ease. A close-up picture of a breadboard is below:

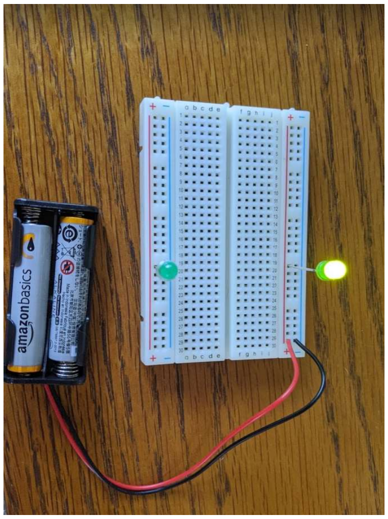


Before we can wire our circuits, we need to know how to use the breadboard. In this next part, we are going to name and talk about each part of the breadboard. Please note, the names given are not the official scientific name for each part described.

Power Rails

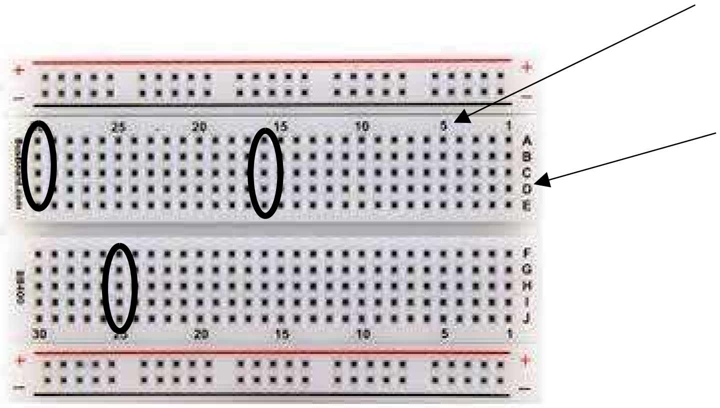


Most breadboards will have two INDEPENDENT power rails. What does that mean? That means if we plug a battery into the top power rail, the top rail will have power but the bottom one will not. In order to have both rails supply power to our circuit, we need to plug one battery into the top and one into the bottom. In the image below, you can see that the batteries are plugged into the top rail and the LED that is plugged into that rial is shining, however the LED plugged into the bottom rail is not shinning.

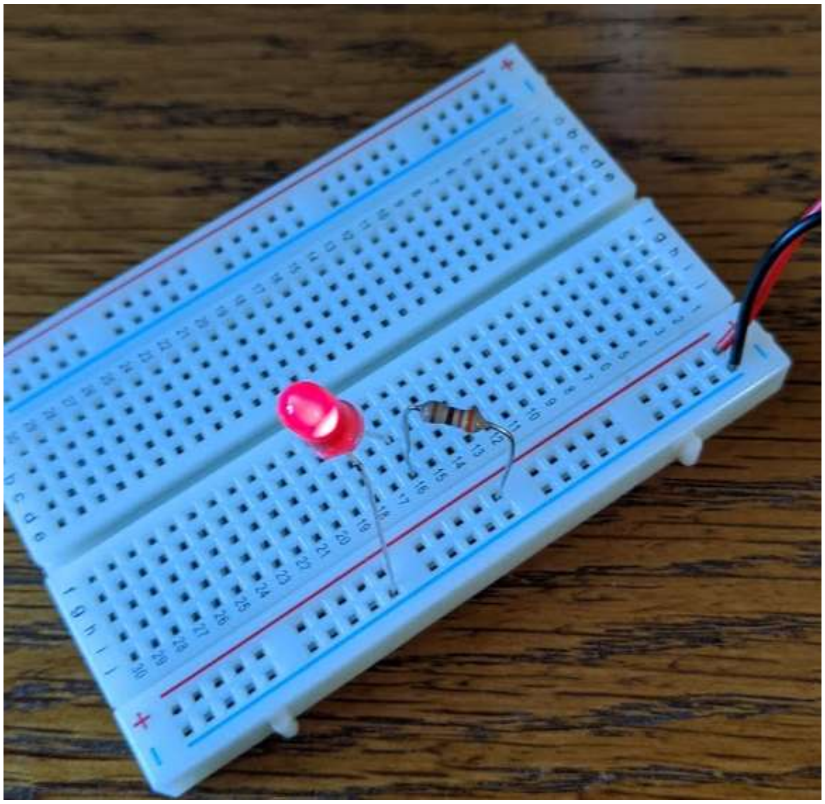


When we plug a battery into one of the power rails the entire strip (aka all the holes in one circle) is active. **Very Important**: each power rail has a positive side and a negative side. In order for your circuit to be complete, one wire must be going out of the positive side and another wire must be going into the negative side.

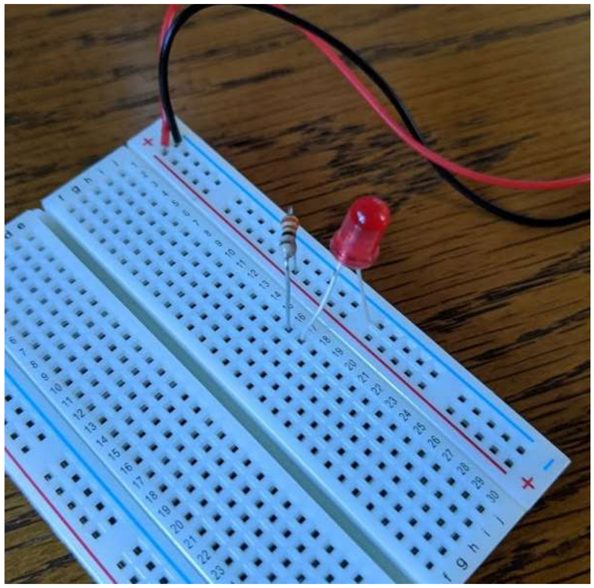
<u>The Grid</u>



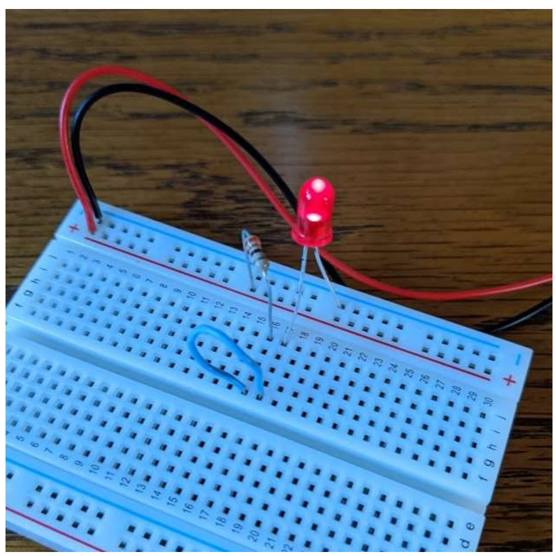
In this activity, the grid will be referring to all the holes in the center of the breadboard. The arrows are pointing to the labels that we will use to help guide you when wiring your circuit. The circle containing holes 16A-E are all connected by a metal bar. Meaning if you were to plug one end of an electrical component (say a resistor) into 16A and the end of another electrical component (say a LED), both of those components would be connect and if the circuit is closed your LED would light up. The image below shows a circuit that is properly wired. In the image below, the resistor is connected to the positive end of the power rail and to hole 16J, the LED is connected to 16H and the other negative end of the power rail.



However, if you were to plug your resistor into hole 30A and your LED into hole 16A, even though they are in the same row (row A) they are not connected since they are not in the same column (column 16 vs column 30). As you can see there is a gap between rows A-E and rows F-J. This gap breaks the connection between row A-E and F-J for each column. Meaning, if we plug a resistor into 16C and a LED into 16 J, the circuit is not complete since they are on opposite sides of that gap. If we were to take a wire and connect hole 16E with 16F, then the resistor and the LED would be connected together since we were able to bridge the gap with a wire. The photos below illustrate this.



In this image the resistor is connected to the positive power rail and to hole 16J. The LED is connected to hole 17J and to the negative power rail. As you can see the LED is not shinning because the circuit is not complete.



This is the same circuit as the image above. In this image there is a wire connecting row 16 and row 17 which completes the circuit and makes the LED shine.

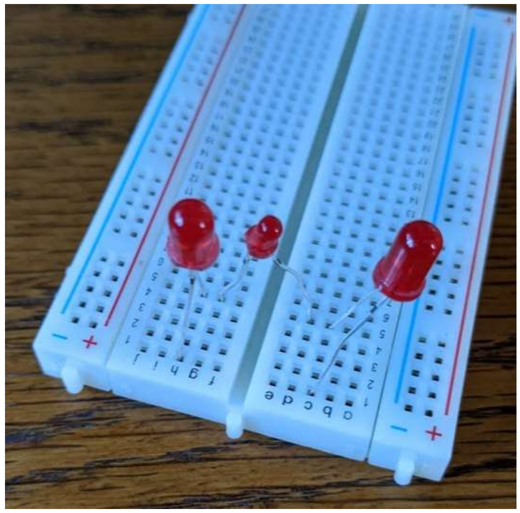
<u>Directions for Exploration</u>

Series vs Parallel

In this part of the activity we will be exploring what happens when we connect our LEDs in a series orientation vs a parallel orientation.

<u>In series:</u>

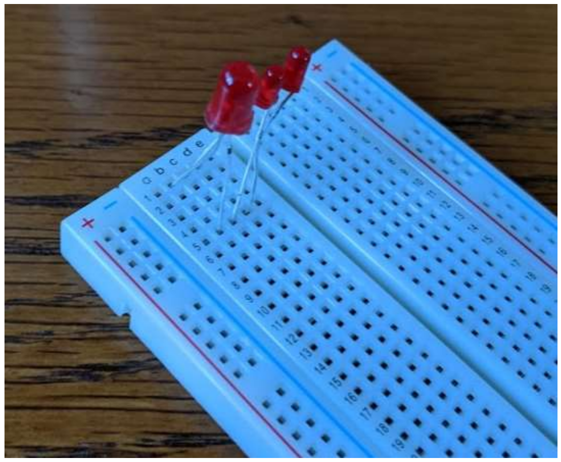
1) Grab your breadboard, 3 LEDs, your battery pack, and some wire.
2) Identify the anode (the longer metal part) of all of your LEDs. Place the anode of the first LED into hole 1C and the other end into 5C. Place the anode of your second LED into hold 5D and the other into 5G. Place the anode of your last LED into 5H and the other end into 1H. Your circuit should look like the one in the image below.



3) Connect your battery pack to the power rails and connect your wires. One wire should go from the positive power rail to hole 1A and the other wire to should from 1F to the negative power rail.
    a. When the circuit is complete, the circuit **might** light up. If it doesn't check all of your connections and make sure that the LEDs are in the correct orientation, meaning the anode are in the holes that they should be.
    b. If you have double checked that everything is the way it should be and it is still not lighting up, move on to step 4.
4) Record your findings.
    a. Did your circuit light up? If yes, what did you notice about the brightness of each LED? If no, why do you think the reason is for not lighting up? would it light up if you had a stronger battery (meaning you plugged in a 9 volt batter instead of 2 AAA batteries)

<u>In parallel</u>

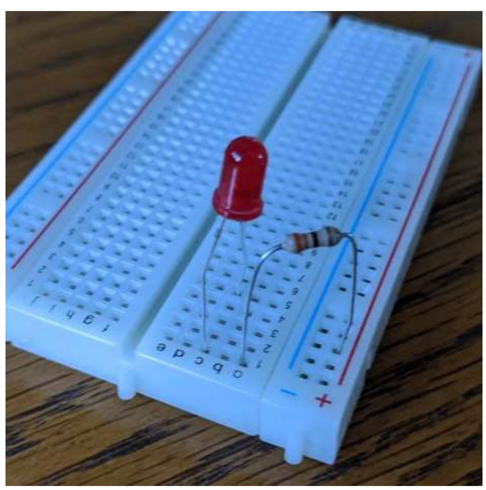
1) Grab your breadboard, 3 LEDs, your battery pack, and some wire.
2) Identify the anode (the longer metal part) of all your LEDs. Place the anode of the first LED into hole 1B and the other end into 5B. Place the anode of your second LED into hold 1C and the other into 5C. Place the anode of your last LED into 1D and the other end into 5D. Your circuit should look like the one in the image below.



3) Connect your battery pack to the power rails and connect your wires. One wire should go from the positive power rail to hole 1A and the other wire to should from 5A to the negative power rail.
    a. When the circuit is complete, the circuit **might** light up. If it doesn't check all of your connections and make sure that the LEDs are in the correct orientation, meaning the anode are in the holes that they should be.
4) Record your findings.
    a. What are the differences that you see between series and parallel?

Resistor vs photoresistor

1) Grab your breadboard, one LED, your battery pack, a resistor, the photoresistor, and some wire.
2) Identify the anode (the longer metal part) your LED. Place the anode of the LED into hole 1C and the other end into 5C. Place one end of the resistor into the positive power rail and the other end into 1A. Your circuit should look like the one below.



3) Connect your battery pack to the power rails and connect your wires. The wire should go from 5A to the negative power rail.
4) Record your findings

5) Switch out the resistor with another resistor and/or the photoresistor. Record your findings with each resistor
    a. What the photoresistor is connected what happens to the LED when you put your finger over the photoresistor?
    b. What do you think photoresistors can be used for?

Building your home

Now that you know how to wire everything, it is time to make your home! By using a cardboard box, decorate your home and then use your new found circuit making skills to light up your house with LEDs. Be as creative as possible. Remember, if the LEDs are not lighting up check all of your connections! Also, try to practice your circuit drawing skills! Before you start wiring your house, draw a schematic of your circuit for fun.