



<BUILD. LEARN. TEACH. INSPIRE>

PAPER LED CIRCUITS

Tinker Robotics (K-2nd Grade)

Revision 1.01



REVISION HISTORY

Revision 1.01

Date: 10/14/2018

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Revision History

- 1.00: First revision
- 1.01 Updated materials list, Reformatted and NGSS standards

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ACTIVITY MATERIALS LIST

Below is a list of all materials required for this activity along with sources to purchase and estimated costs *per student*:

ITEM	QTY	COST PER UNIT	SUBTOTAL COST	NOTES	HOW TO PURCHASE
3V LED	1				
2-sided Conductive Tape	1			12" long piece	
3V Coincell Battery	1				
Oversized Rocker Switch	1				
Sticky Foam	2			For switch and battery	
Cardstock Paper	1				
Standard Craft Materials					
Scissors					
Markers					



PAPER LED CIRCUITS

Lesson Plan

Overview

Learn about electricity while building your very own operation game!

Topics Covered

Circuits, Schematics, Open-Circuit, Closed-Circuit, Conductivity

Disciplinary Core Ideas

Engineering Design (K-5th Grade)

- ETS1.A: Defining and Delimiting Engineering Problems
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

Energy (3rd Grade)

- PS3.B: Conservation of Energy and Energy Transfer

Project Steps: Day 1

Welcome (5 min)

Talk about tinkering = inventing, and that we are learning how to experiment. We also focus on helping each other, so if you finish the step first, see if your neighbor needs help.

Circuits and Schematics (5 min)

1. A circuit is a path of electricity. Like a street.
2. A schematic is the plan of a circuit. Like a city map.

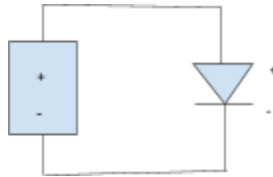
Explaining the LED (2.5 min)

1. VOCAB WORD: Light Emitting Diode. This is something that is used a lot in electrical engineering. Engineers use this when they want electricity to only flow in one direction.
2. LEDs (like motors) have a plus and minus side. It is important that we keep track of which is plus and which is minus, because electricity can only flow through the LED in one direction. It is kind of like a one way street.

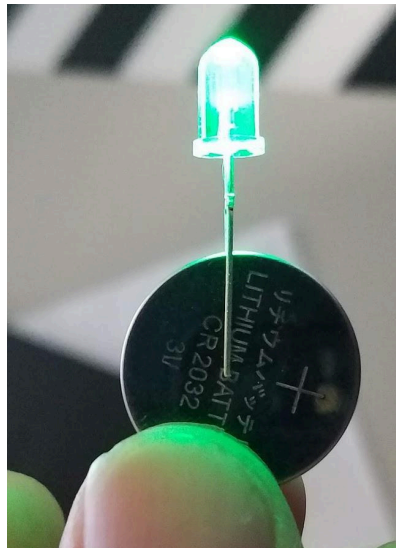
3. Look at the legs of the LED. Notice that one leg is long (this is the plus) and one leg is short (this is the minus).

LED Experimentation (2.5 min)

1. Draw the circuit of a LED with the 3V battery.



2. Now build the circuit!
3. The LED should turn on.



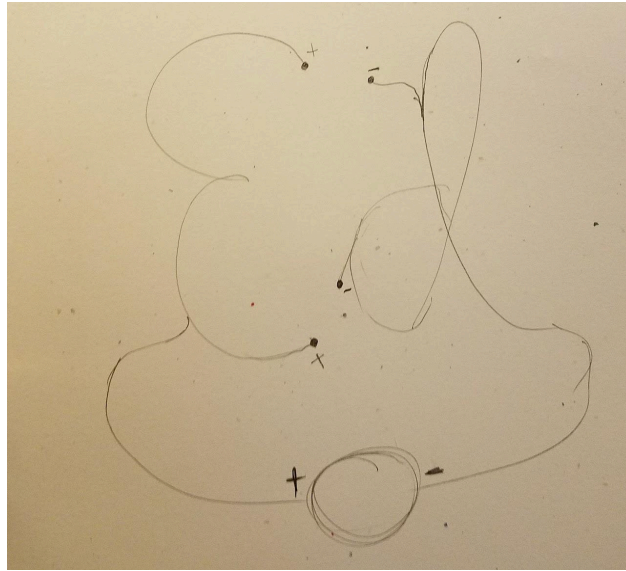
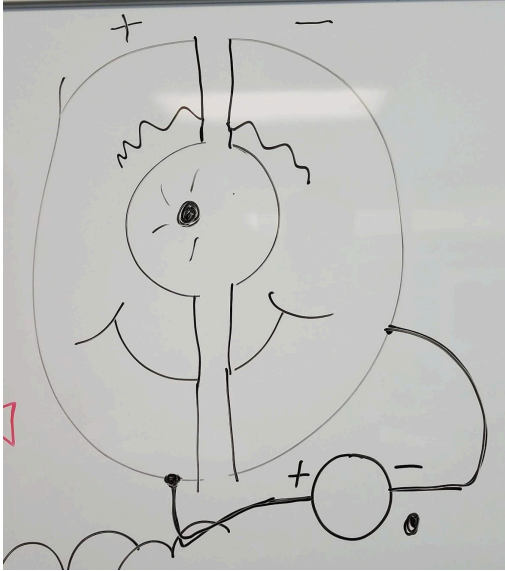
4. What happens if you flip the plus and minus? You will notice that the light doesn't turn on anymore. This is because the LED only allows electricity to flow in one direction!

Drawing A Paper Circuit (10 min)

Hand out the cardstock and have everyone draw a paper circuit. Make sure to have the few key things:

1. Space for a LED that has both a plus and minus side
2. Make sure that the plus of the LED connects to the plus of the battery
3. Make sure that the minus of the LED connects to the minus of the battery

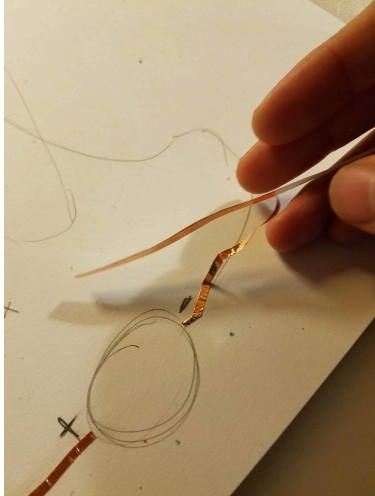
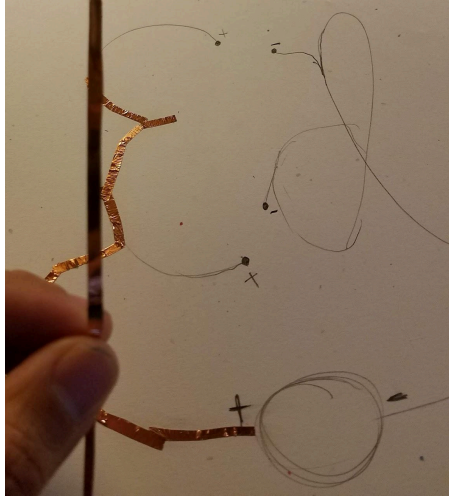
One way to do this is to draw a simple picture and then erase a line down the middle of it. One side will be plus, and the other side will be minus.

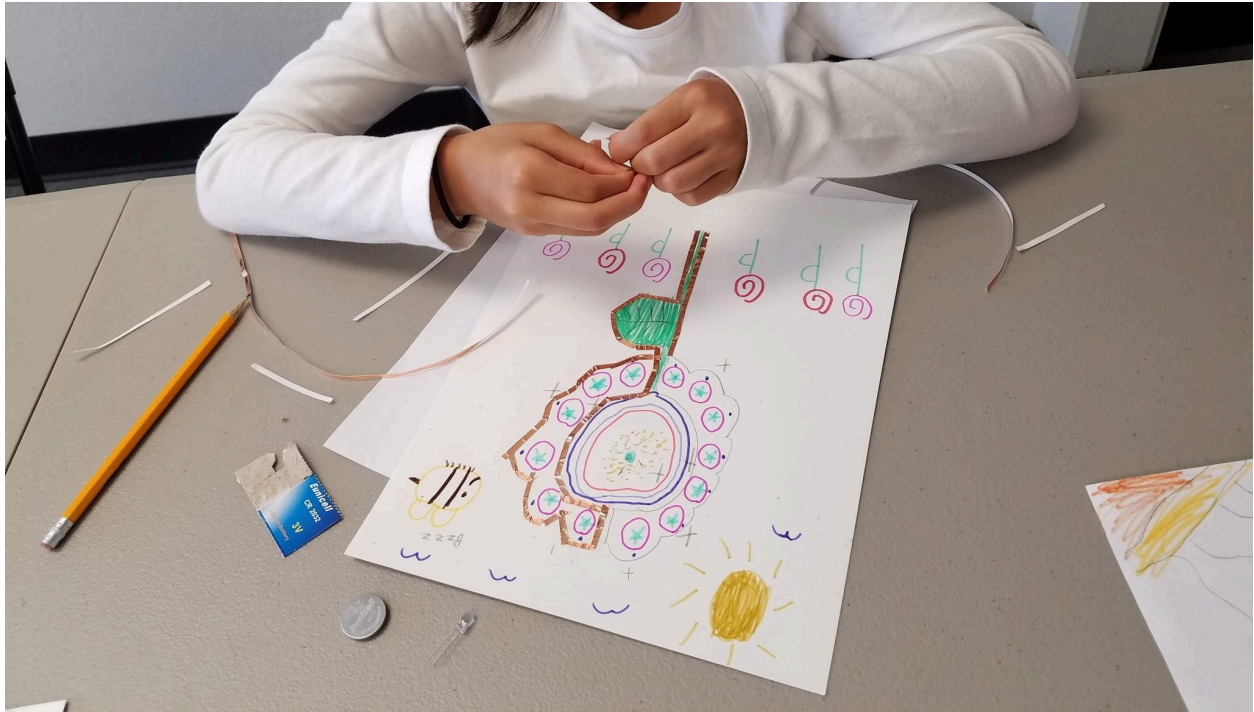


Note: This photo on the right has room for two lights instead of just one.

Placing The Conductive Tape (10 min)

Hand out the conductive tape and have the students slowly place the tape over the pencil traces.



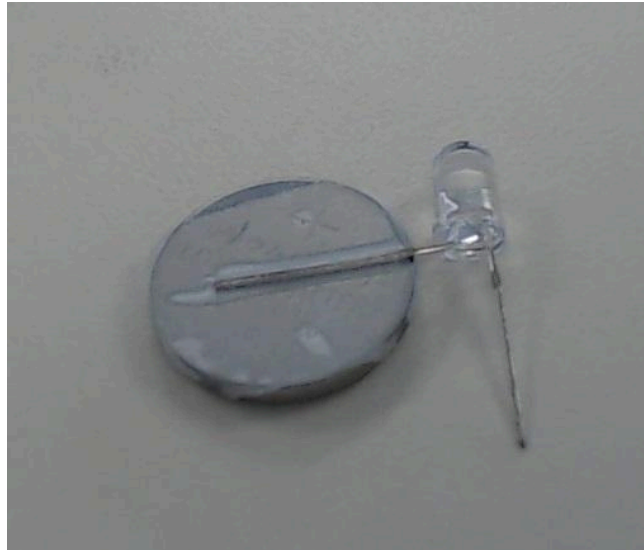


Troubleshooting (15 min)

If the LED does not light up while testing the circuit, you will need to troubleshoot the circuit before moving on. Troubleshooting this project in particular is challenging because there are numerous points along the circuit at which it can fail. Every point where one piece of

conductive tape touches another must be scrutinized. This leaves us with two problems: how do we test so many points effectively? and how do we test any of these points to begin with?

The answer to both of these questions comes in the form of a simple tester. The tester consists of a LED with its long leg taped to the + side of a coin cell battery:



If the loose leg of the LED were to touch the underside of the battery, it would light up, as it creates a closed circuit. Alternatively we could place a conductive surface (something metal) between those two points, which will also create a closed circuit and allow an electric current to flow. Check out the examples below:

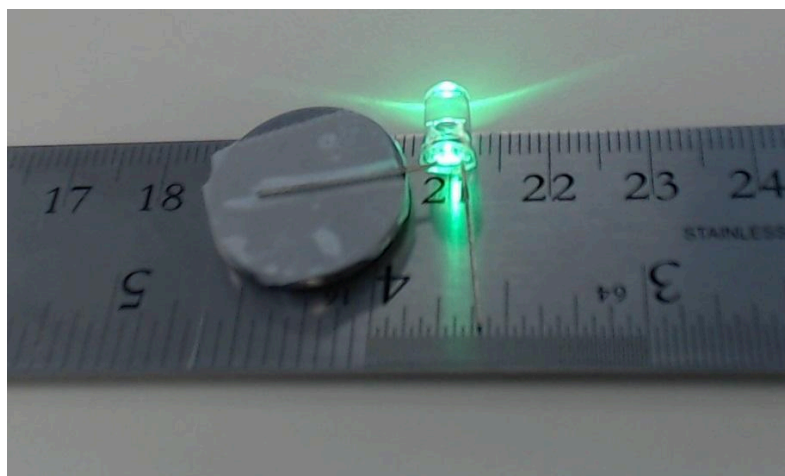


Fig. 1

In figure 1 the tester is laying on a metal ruler, with both the loose leg of the LED and the underside of the battery touching the metal conducting surface of the ruler.

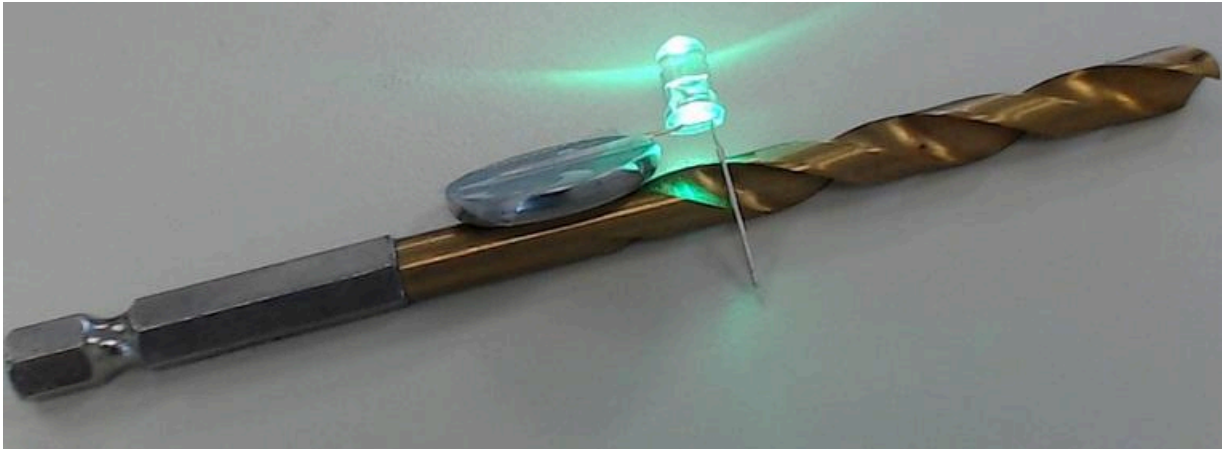


Fig. 2

In figure 2 the tester is leaning against a metal drill bit. Once again the metal surface of the drill bit is touching both the loose leg of the LED *and* the underside of the battery, allowing electricity to flow from one to the other across the conductive surface.

We can go a step further than that. What if we have several conductive surfaces all touching each other? Will touching one end of our tester to one of the surfaces and the other end to another create a closed loop?



Here I have two key chains, and you can see at the top of the picture that they are touching. In addition the tester is laid between two keys on separate keychains, with one end touching each one. Everything you see in the picture here is contributing towards making a closed circuit. This will be how we will test our paper circuits. We will place the tester so that one side touches one piece of conducting tape and the other touches the piece of conducting tape immediately next to it (those pieces of tape should be touching).



CONDUCTIVITY: Bring several conductive items to class and use the tester to show the class that they are, in fact, conductive. Then challenge the students to place each of these conductive items so that they make a chain, with one item touching another and that one touching another and so on. Be sure your students understand that both ends of the chain need to be close together so the test can touch both sides. The best case scenario is that it works the first time, but I wouldn't count on it. Make sure the students understand not to touch the chain of items at this point, some may insist on "fixing" other student's contributions. Instead ask the students which part of the chain breaks the circuit. Hopefully you have something close to a consensus or at the very least, a few good, testable suggestions. Go through this process until the chain

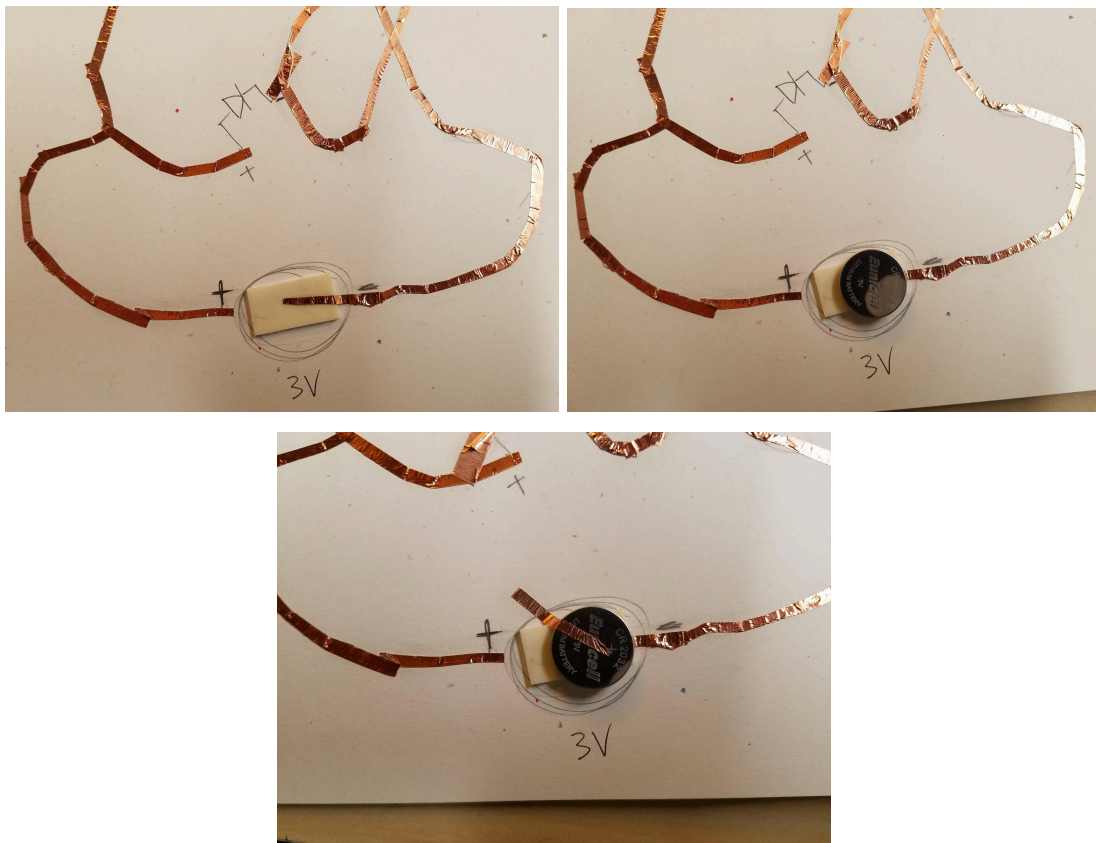
tests positive and lights the tester. At the end of this activity ask each student to bring an item to the next class that they think is conductive.

Decoration (10 min)

Take time to decorate your drawing using markers.

Place the Battery (5 min)

Place the sticky foam down and extend the minus side onto the foam. Next, place the minus side of the battery onto the sticky foam so that it touches the copper tape. Once that is done, add a piece of copper tape from the plus side of the battery to the paper.



Testing Your Circuit (5 min)

Connect the top of the battery to the + signal of your circuit to see if your LED turns on. If not, you will need to push down on the tape to make sure the metal connections are solid!

Clean Up and Reflection (5 min)

Project Steps: Day 2

Review (5 min)

1. A circuit is a path of electricity. Like a street.
2. A schematic is the plan of a circuit. Like a city map
3. LED = light emitting diode
4. Draw the LED circuit on your paper

Conductivity Activity (10 min)



Start class with the second half of last week's activity. Have the students come up, one at a time, and add their conductive items to the chain of items that will ultimately be tested, reminding them that the two ends need to be close together. If the chain does not properly conduct electricity use the same troubleshooting method as before. Have the students come to something loosely resembling a consensus and tackle that specific part of the chain, making sure that electricity conducts between the two items in question. Rinse and repeat until the circuit at large works.

Adding Decoration (10 min)

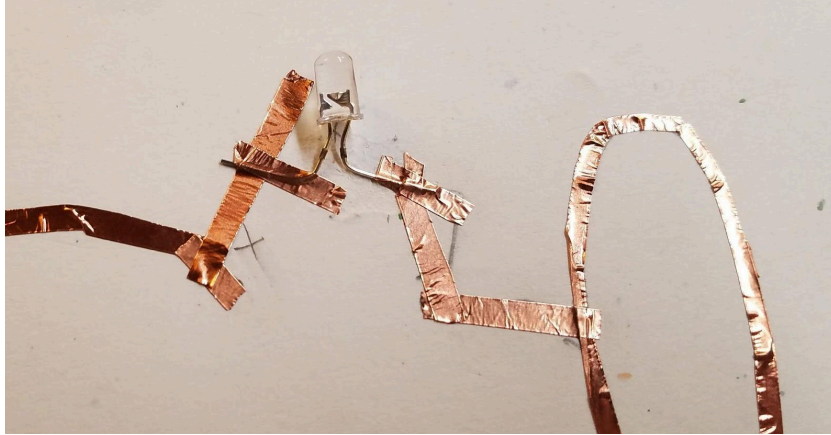
Take some time to add more decoration to your artwork.

Repairing Your Path (10 min)

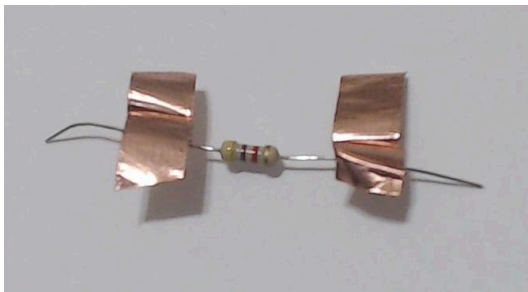
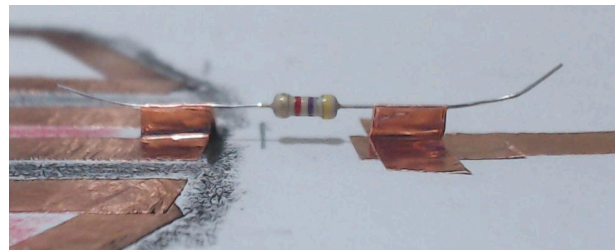
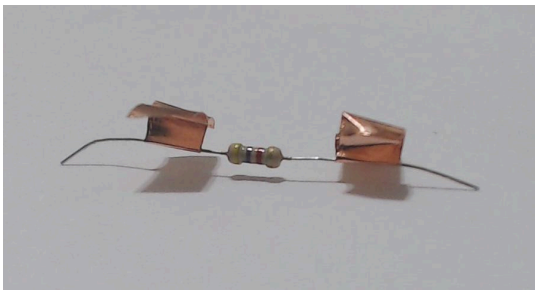
Connect the top of the battery to the + signal of your circuit to see if your LED turns on. If not, you will need to push down on the tape to make sure the metal connections are solid! Take time to put extra copper tape along your path to make sure the electricity has a good path to travel on.

Place the LED (5 min)

Make sure to connect the long led to the + connection and the short leg to the minus connection!



It is best to wrap the conductive tape around the LED legs. This will allow for a better connection between the LED and the conductive tape. This will result in the LED being slightly raised above the paper. See the figures below.



Switches vs. Buttons (5 min)

Switches are used to turn things off and on. So are buttons, however, buttons will turn off once you let go. Can you think of some things that use switches?

- Light Switch

Can you think of some things that use buttons?

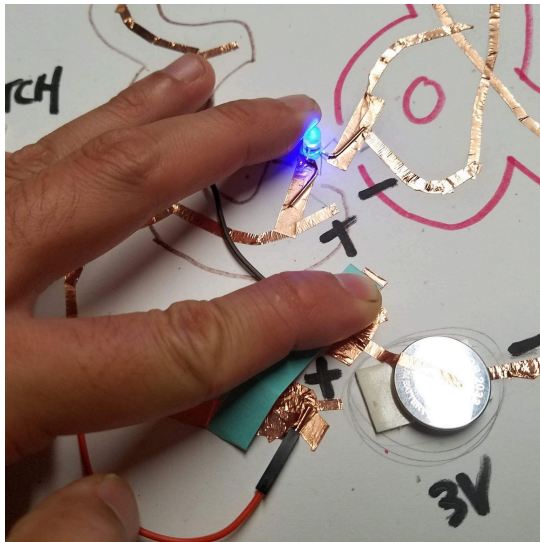
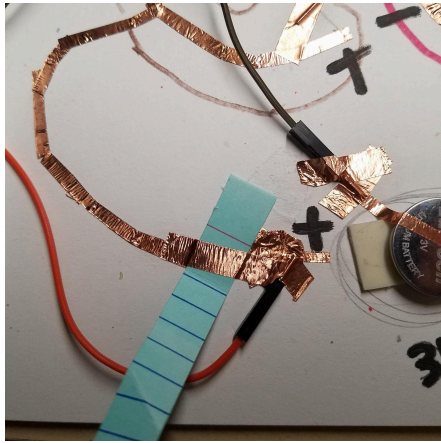
- Samsung home button
- Dialpad on phone

Also take out rocker switch and large emergency button

Making a Button (10 min)

We are going to make a very simple button using cardstock paper and conductive tape.

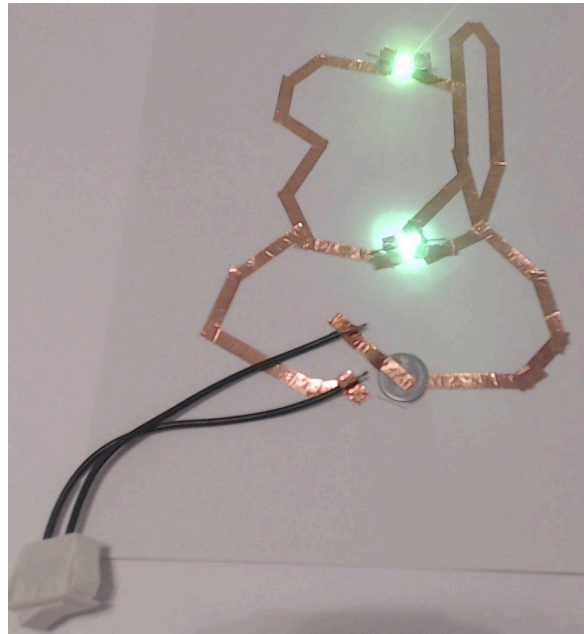
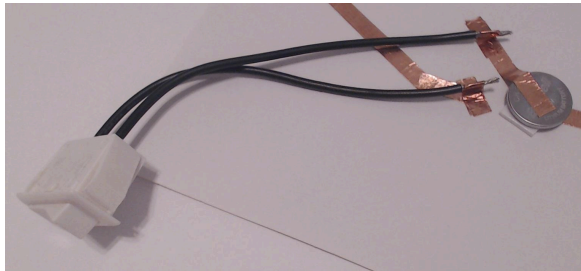
1. Create a break in your + wire to make an open circuit. We will close this gap with a button so that we can turn your artwork off and on.
2. Draw a LED circuit with a button
3. Use a strip of 3x5 card to create a button.



Adding A Switch (10 min)

Add a switch to your circuit so that you have both a button and switch in parallel

Add a switch.



Clean Up and Reflection (5 min)