



Lighthouse Community Public Schools

*in collaboration with*

Maker **Ed**

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# **PAPER CIRCUITS**

*A Guide from the Creativity Lab*

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**Based on**

*An activity from the Tinkering Studio*



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[www.lighthousecreativitylab.org](http://www.lighthousecreativitylab.org)

[www.makered.org](http://www.makered.org)

# About This Project

Paper circuits are quick projects that engage students in basic circuitry. Using simple materials, students will construct working circuits and think critically about the flow of electricity. After acquiring a basic comprehension, students will strengthen their understanding of circuitry by integrating circuitry into personal art projects.

Paper circuits are a low-barrier, high-ceiling project. What begins as a basic introduction to circuitry is easily expanded upon to include more complexity. This project is designed to give students ownership of their learning by offering minimal instruction. Students learn through the iterative process of designing, testing, and redesigning. This is a crucial element of this project and should not be viewed as supplemental. We encourage you to customize this project to the needs of your class, but maintain the ideal of students learning through exploring.

This project guide provides helpful tips and processes on the introduction of circuit blocks in the classroom, including an inquiry cycle as well as a step by step guide. Educators can choose to extend this project through art and more complex circuits, or create a community project with a paper circuit mural.

# Our Story

This activity can be tailored to different ages, and can be used with teachers as well as students.

At Lighthouse, we've done this activity in anywhere from middle school making classes to professional development sessions. At Lodestar, we've started introducing paper circuits in our makerspace time, which includes students anywhere from Kindergarten to 3rd grade, and we've lead more structured projects with middle school students.

# Materials & Tools

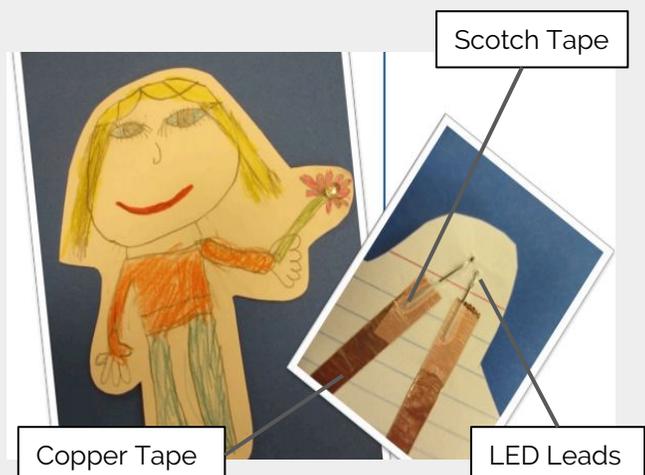
- Scotch Tape
- Paper / Construction Paper
- Binder Clips
- Aluminum Foil
- Copper Tape
- 3 to 5 mm LEDs
- 3V coin cell batteries
- Scissors
- Markers
- Assorted Batteries (Optional)
- Hobby Motors (Optional)

For a detailed list of materials:  
[lcl.how/PaperCircuitParts](http://lcl.how/PaperCircuitParts)

# Learning Targets

- I can construct a working circuit.
- I can describe the flow of electricity.
- I can record observations.
- I can differentiate conductive and nonconductive materials.
- I can draw a circuit schematic.
- I can explain and identify short circuits.
- I can learn all **bolded keywords**.

**TIME:** 50 minutes



# Context: Before we make...

Paper circuits are a great introduction to circuitry. Students learn basic conventions, such as positive and negative leads / terminals, along with keywords, like LEDs (Light Emitting Diode), closed circuits, open circuits, short circuits, etc. This project is also a way to bridge science with art - once students master the circuitry basics, they can integrate light into their own pieces of art.

For inspiration and further resources, check out the links below!



[Leah Buecheley](#)



[The Tinkering Studio](#)



[Jie Qi](#)

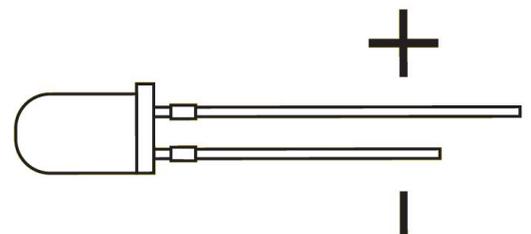
# Material Management

When introducing paper circuits, it's helpful to limit materials to just LEDs and batteries. Students can then investigate these two pieces, and determine how to make the LED light up. This is a good time to discuss the conventions of positive and negative, and how to tell which side of the battery / leg of the LED is positive (the positive side of the battery is labeled with a "+", and the positive leg of the LED is longer).

After students have become familiar with LEDs and batteries, they can move on to creating circuits, which requires copper tape. When distributing the copper tape, it's often easier to have pre-cut pieces on the table, so the entire roll of tape isn't destroyed.

For LED storage, look for small plastic containers with screw-on lids. On the outside of the container, it's helpful to put colored tape or paper corresponding to the color of the LED.

Finally, when distributing the copper tape, pre-cut strips so the whole roll isn't undone by excited students.



# Looking Closely

## EXPLORE

Pass the materials out to students. As a class, identify the **battery** and the **LED**. Ask students to spend three minutes exploring their materials. Have them write observations in a journal. Come back together as a class to talk about their discoveries. Students should have discovered:

- The LED has two "legs." These are called **leads**.
- One lead is longer than the other. This is the **positive lead**. The shorter is the **negative lead**.
- The battery has two faces. These are called **terminals**.
- One terminal is (usually) marked with a "+". This is the **positive terminal**. The other is the **negative terminal**.

**Supplement:** Batteries come in all shapes and sizes, but they all have positive and negative terminals. Give students a variety of batteries, and challenge them to find the positive and negative terminals on each kind.

Were any students able to make their LEDs light up? If so, ask how they did so. If not, challenge them to spend another two minutes trying to. There is exactly one way to illuminate their LEDs: by connecting the LED's positive lead to the battery's positive terminal, and the negative lead to the negative terminal.

## CONSIDER

Ask students if they have ideas as to what causes their LEDs to light up. Depending on the age group, they may or may not have heard of electricity. We use the term **electric current**. Just like a river current flows downstream, electric current flows from a battery's positive terminal to its negative terminal, provided there is a complete path for it to follow.

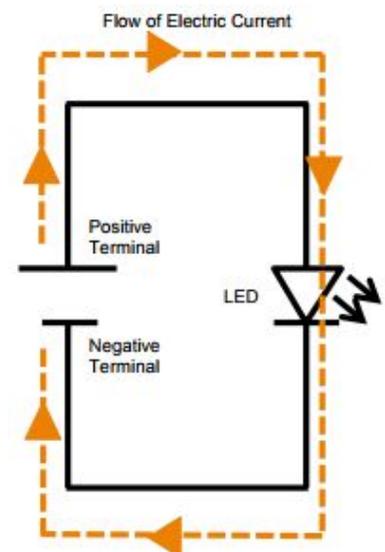
Challenge students to identify how the electric current could be flowing from their battery's positive terminal to its negative terminal. The current is able to flow from the battery's positive terminal through the LED and into the negative terminal. Current flowing through the LED makes it shine. They have completed a circuit. A complete circuit is called a **closed circuit**. An incomplete circuit is an **open circuit**.

**Supplement:** Give students a hobby motor. What happens when they connect each lead (wire) to a battery's different terminals? No matter how the motor's leads are connected, the motor will still turn on. Why isn't this true for the LED? It is because LED stands for "**Light Emitting Diode**," and a **diode** is a special component that only lets current flow one direction.

## EXTEND

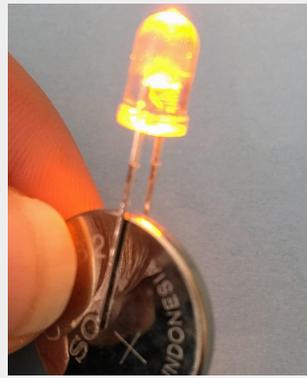
Have students move on to create their own circuits with LEDs, batteries, and copper tape / aluminum foil! Give students copper tape, and suggest they use it to create the bridge between their batteries and LEDs. Demonstrate how the back of the copper tape can be removed and how the tape can be stuck directly to the paper. Then give the students ten minutes to explore on their own or in small groups.

At this stage, consider giving students a wide variety of materials, such as scotch tape, popsicle sticks, paper clips, rubber bands, copper wire, aluminum foil, etc. Have students try completing their circuits using the different materials. Which work, and which don't? What patterns do students notice? For example, most metals allow current to flow through them. They are **conductive**.

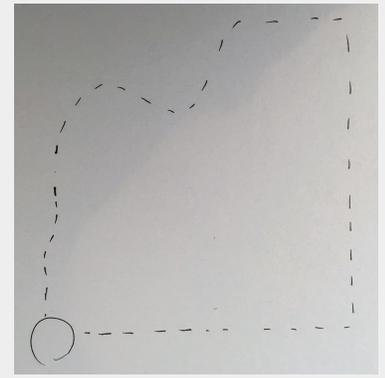


# Step-By-Step Guide

1. Get a coin cell battery and LED; determine the positive and negative ends
2. Sketch your circuit out on paper
  - a. Note where the positive and negative ends of the battery and LED will go
  - b. For younger students (or if your class period is short), it might be helpful to print out a circuit template that shows where the copper tape, battery, and LED will go
3. Add copper tape (or aluminum foil) to the track
  - a. Leave a break for the LED and overhanging copper tape or foil for the top of the battery
4. Use clear tape to attach the leads of the LED over the copper tape
5. Repair any breaks in the circuit and watch it shine!



1.



2.



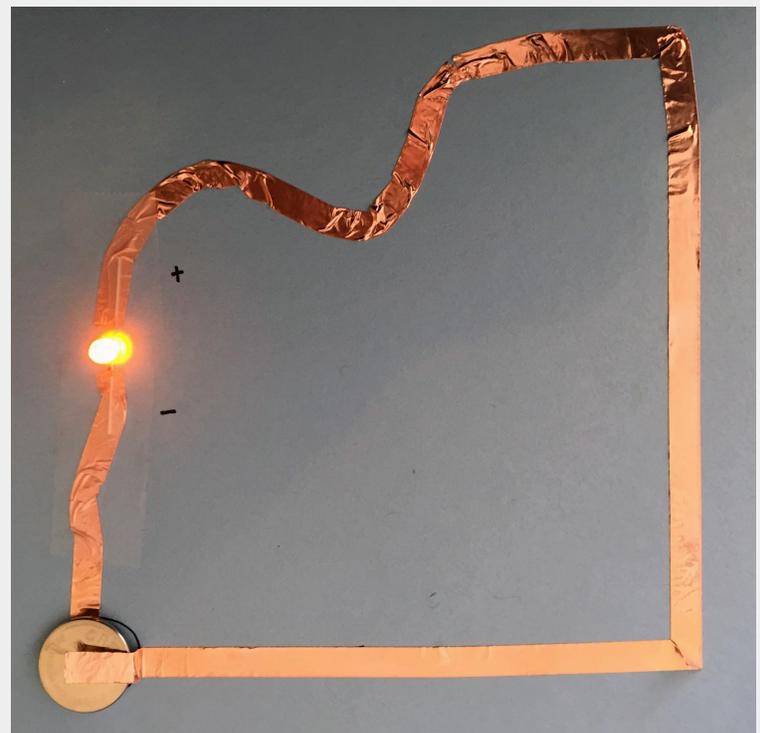
3.



4.

# Troubleshooting

- Sometimes a faulty circuit occurs simply because of a dead battery or LED. Testing them against each other before spending time constructing an entire circuit is a good habit to get into.
- The back of the copper tape is not conductive because of the adhesive backing. To overcome this:
  - To form a corner, gradually and carefully bend the copper tape.
  - Use aluminum foil to create a patch for any tears in the circuit.
  - Fold the end of the copper tape so that its sticky side connects to itself. This creates a tip that is conductive on both sides.
- **Short circuits** occur when electric current takes a shortcut without passing through the LED. If the circuit looks closed, but the LED is not shining, have students search for any spots where the current might be able to bypass the LED. The current will always take the path of least resistance (not distance); going through the LED is harder than going through the copper tape. If you notice students creating short circuits, pause the class to discuss them together.

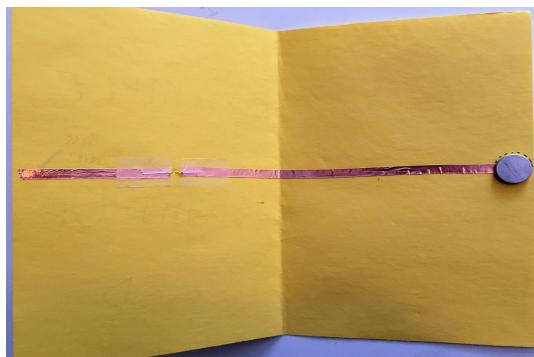
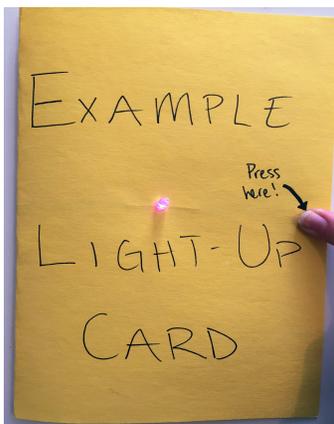


5.

# Paper Circuit Extensions

## ADD ART!

Students can create a drawing or painting accented with an LED. Poke an LED through the front of the paper so the leads are on the back and the lens is on the front. Complete the circuit on the back of the paper (out of sight).



## PAPER CIRCUIT CARDS

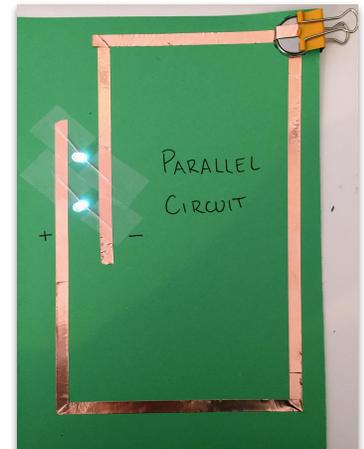
Another extension for students are paper circuit cards! These have an LED on the front of the card and a circuit on the inside. In this project, the LED lights up when an area on the front of the card is pressed, which connects the copper tape and completes the circuit. Students can design the card first or create the circuit first.

This is a good project to do in conjunction with holidays!

## COMPLEX PAPER CIRCUITS

Students can also add complexity to their circuits, like a switch or a **parallel circuit**. To make a switch, leave a gap in the copper tape and connect it with anything conductive, like a paperclip. To add multiple lights, students should create parallel circuits, which are closed circuits where the electric current divides into two or more paths before recombining to complete the circuit.

Classes can spend more time discussing different types of circuits and how to replicate them with LEDs and copper tape.



# Paper Circuit Extensions cont.

## PAPER CIRCUIT MURALS

**1. CREATE THE BOARD** To form a mural board, use copper tape to make two parallel "tracks" on the foam board (differentiate them by putting colored duct tape under one track). The tracks should never touch, and each track must have a distinct start and end point. Attach a AA battery pack to the board with velcro. Use scotch tape (or solder) to connect one wire on each track. This creates a large parallel circuit.



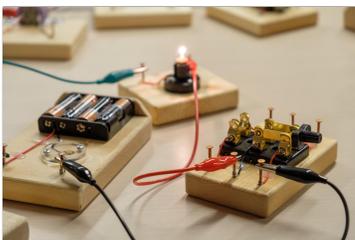
**2. CREATE THE ORNAMENTS** Next, make ornaments from construction paper, cardstock, or foam (whatever is inspiring). When you have your ornament, poke an LED through the front so the leads are on the back. Put copper tape underneath the leads to extend them, then attach the leads on top of the copper tape with clear tape.

**3. COMPLETE THE MURAL** Use thumbtacks to secure ornaments to the foam board (it's best to place the tacks over the leads of the LED to ensure a good connection with the copper tape). The positive lead of the LED must connect to the board's positive track; same with the negative. When it's connected, watch your ornament shine!

This activity can be great for an intro to circuits, or as a team building exercise where participants must figure out how to add an ornament to the board.



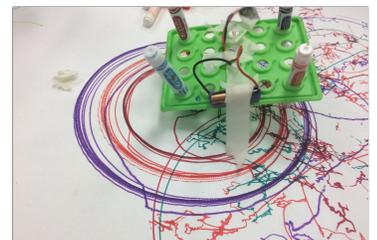
## Related Extension Projects



[Circuit Blocks](#)



[Sewn Circuits](#)



[Scribble Machines](#)