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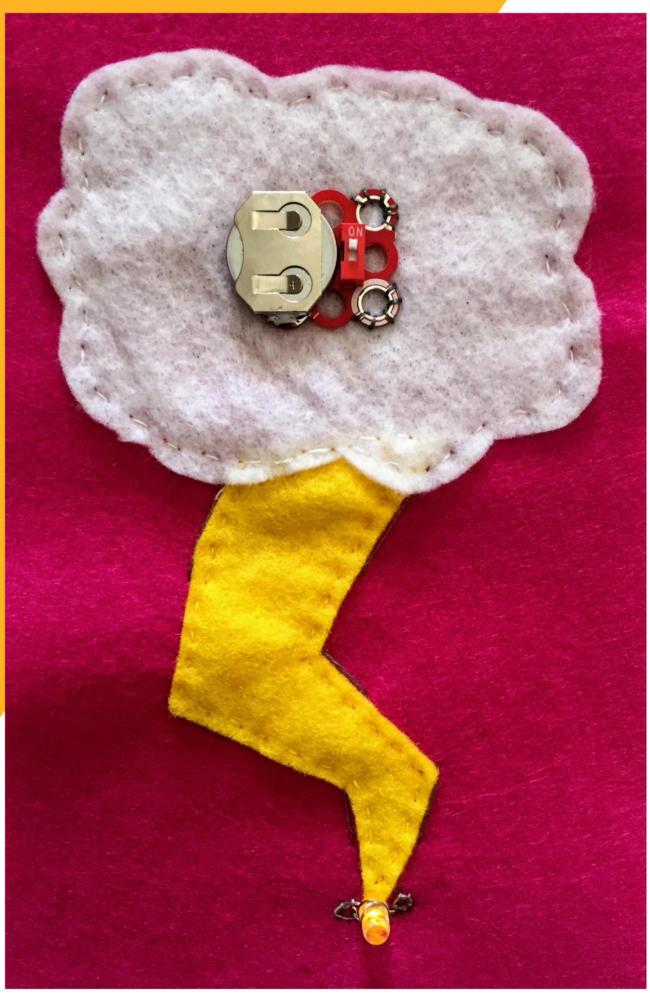
SEWN CIRCUITS

A Guide from the Creativity Lab



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Based on
An activity from the Tinkering Studio

About This Project

Sewn circuits are more complex than their paper counterparts, but they still enforce the fundamentals of circuitry. Their materials are more specialized, but with them students can create wearable, flexible projects, and think critically about the flow of electricity. After acquiring a basic comprehension, students will strengthen their understanding of circuitry by integrating sewn circuits into personal sewn art projects.

Sewn circuits are another low-barrier, high-ceiling project, building on basic concepts of circuitry. Once students create fundamental sewn circuits, they can explore the realm of wearable technology. This project is designed to give students ownership of their learning by offering minimal instruction. Students learn through the iterative process of design, test, and redesign. This is a crucial element of the 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 guide starts with some tips on material management, then delves into a potential inquiry model to use with students. A step by step guide is included for creating a simple sewn circuit, followed by possible extension projects.

Our Story

This activity is primarily for middle school students and older, but it can be introduced gradually to younger students.

At Lighthouse, we created different versions of this project for middle and high school classes, with varying complexity. The products range from simple light-up pillows to programmed LED t-shirts. At Lodestar, we're implementing this activity in elementary school making classes, using multiple weeks to scaffold the projects and guide students.

Materials & Tools

- Non-fraying fabric (e.g. felt)
- Sewing thread
- Conductive thread
- Needles (Tapestry & Sewing)
- Pins
- Fabric glue
- Needle nose pliers
- Beading pliers
- Battery packs
- Metal sew-on snaps
- Tilt switches
- 3 to 5 mm LEDs
- 3V coin cell batteries
- Scissors
- Buttons / decorations
- Assorted Batteries (Optional)
- Hobby Motors (Optional)

For a detailed list of materials:
lcl.how/SewnCircuitParts

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 & identify short circuits.
- I can learn all **bolded keywords**.

TIME: a couple of class periods or more, depending on age of students

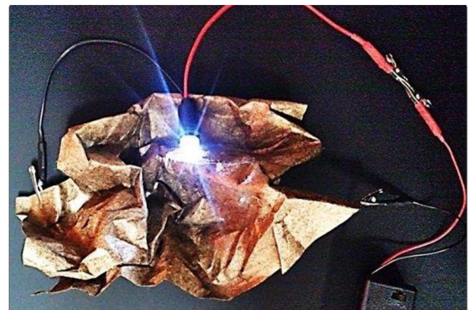
Context: Before we make...

Sewn circuits are a great application of basic circuitry. Students learn standard 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!

Pauline Van Dongen

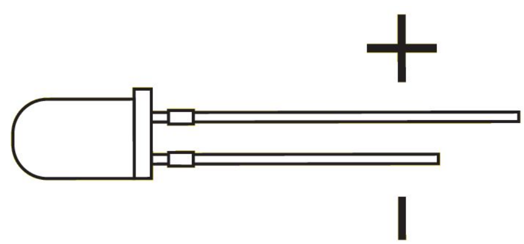
The Tinkering Studio



Adafruit's Wearable Wednesday Blog

Material Management

When introducing sewn 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, it is helpful to do sewing skill builders and projects, as well as start with paper circuits to reinforce basic concepts. Copper tape is easier to manipulate than conductive thread, and the LEDs are easier to attach to paper circuits than loop through with conductive thread. From this, students can move on to creating their sewn circuits.

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. These containers can also be useful to store other related odds and ends, such as sew-on metal snaps, tilt switches, battery packs, buttons, etc.

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 battery 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 it. 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

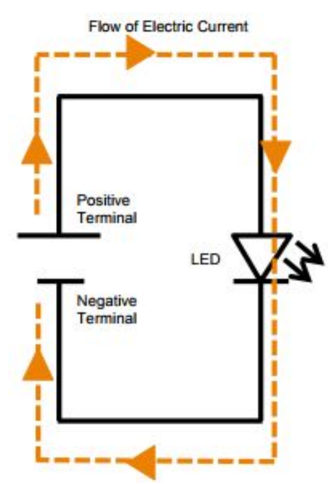
Ask students if they have ideas as to what causes their LEDs to light up. Depending on the age group, they may or may not have heard of electricity. We use the term **electric current**. Just like a river current flows downstream, electric current flows from a battery's positive terminal to its negative 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 (positive to negative lead), 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 the orientation of the motor's leads on the battery, 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 & holders, and conductive thread! Have students first explore with the LED and battery inside its sew-on holder. It is important that they notice the areas to sew through also have directionality - the positive lead of the LED needs to be connected with the conductive thread to the positive hole of the battery holder.



When actually creating circuits, start out with simple circuits - just an LED, battery & pack, and conductive thread. It could be beneficial to demonstrate how to loop the thread through the LED leads and battery holder.

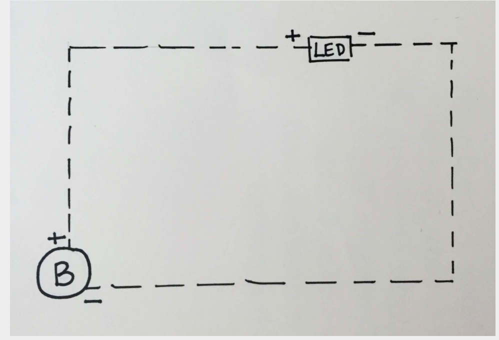
Step-By-Step Guide

1. To a circuit to a detailed design, sew your design first with normal fabric/thread.
2. Sketch your circuit out on paper or on the fabric.
    a. Note where the positive and negative ends of the battery pack and LED will go.
3. Get a coin cell battery, battery pack, and LED; determine the positive and negative ends.
4. Take the LED and extend the leads out to the side (like for a paper circuit). Use a sharpie to mark the positive lead, then use the beading pliers to bend the leads into loops.
5. Place the battery pack down and loop the conductive thread through the positive side, then connect it to the positive (sharpied) LED lead.
    a. Knot the thread, then cut it.
6. Repeat with the negative LED lead and negative side of the battery pack.
7. Repair any breaks in the circuit, and watch it shine!

Troubleshooting

- Sometimes a faulty circuit is 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.
- Make sure the conductive thread creates a full connection among the parts of the circuit.
    - Loop thread through the battery pack holes/LED legs/snaps about 5 times.
- If a circuit includes multiple parts, like snaps or tilt switches, make sure to map out how the current flows beforehand and orient the battery packs.
- **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 conductive thread. If you notice students creating short circuits, pause the class to discuss them together.

1. (optional)



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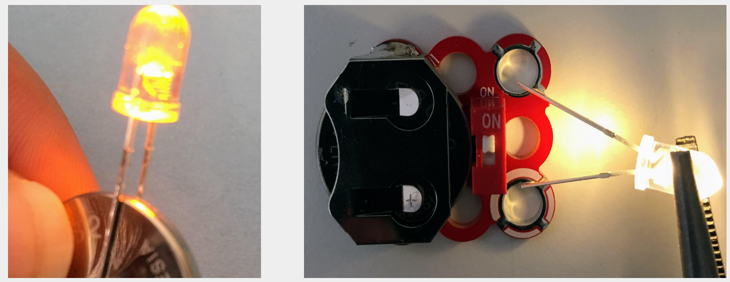

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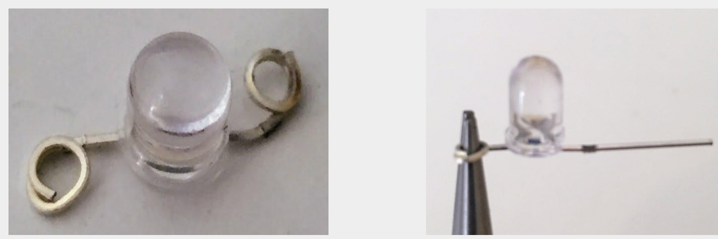

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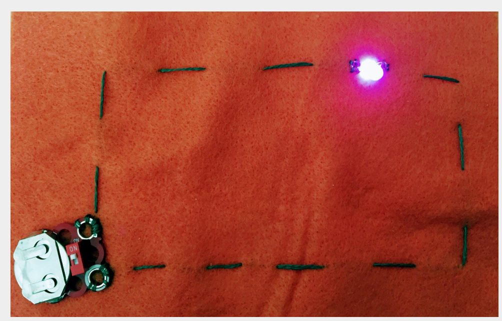

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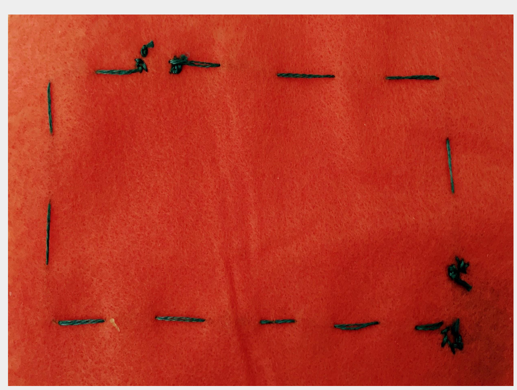


Back of sewn circuit

Sewn Circuits with Older Students

COMPLEX SEWN CIRCUITS

For students who want to create more challenging sewn circuits, there are many avenues to explore. One method is to use switches. Metal, sew-on snaps (switches) are readily available at most fabric stores, and they can be incorporated almost anywhere in a circuit - the snaps themselves don't have directionality. Tilt switches are another type of switch; they have holes to sew through that are similar to the battery holders, but do not have directionality.

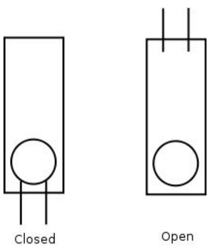
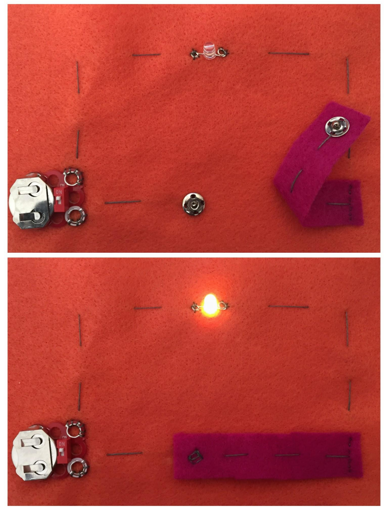


Photo: varesano.net

These switches only work in a certain orientation, e.g. if the circuit is right side up vs. upside down. To add multiple lights to their circuit, students can investigate **parallel circuits** .

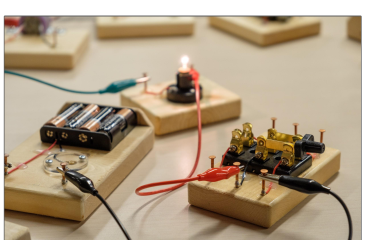

Sewn circuit with snap

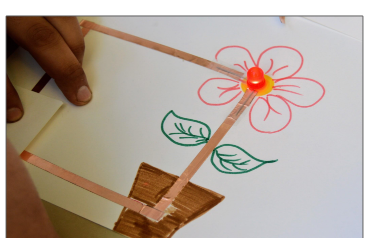
Sewn circuit with tilt switch (correct vs. incorrect orientation)

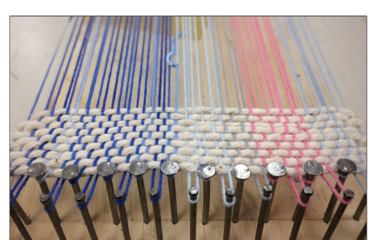

WEARABLES

One of the major extensions of simple sewn circuits is wearable technology. Students can investigate transferring their simple circuit into something that can be worn, like a bracelet or a necklace. They can even add lights to hats, ties, or anything else they can think of. For necklaces and bracelets in particular, students need to include metal sew-on snaps to make sure they fit snugly.

Related Extension Projects


Circuit Blocks


Paper Circuits


Weaving