

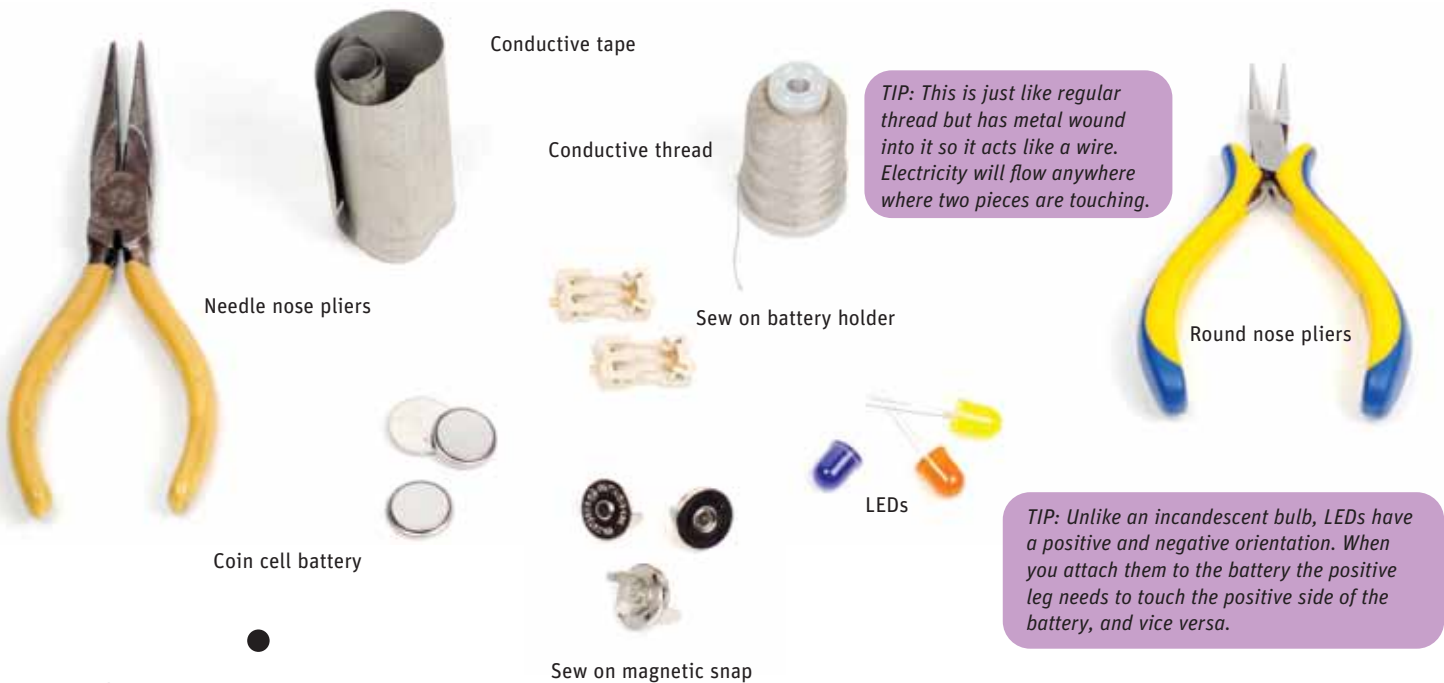
# SEWN CIRCUITS



Sewn circuits uses conductive thread, batteries, and LEDs to embed technology into pieces of fabric. It's a materials mash-up that combines traditional crafting techniques with newer technologies. It's also a playful way to develop an understanding of circuitry through the process of creating a personal project.

## BUILD IT!

Collect these things:



the  
tinkering  
studio

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## General Materials:



## TRY IT!

### Getting started:

This activity builds on basic sewing techniques and working with simple circuits. If you've sewn before, great! Those techniques will come in handy for creating your sewn circuit. If you haven't used a needle and thread before, find a book or tutorial online and try some sewing basics with non-conductive thread. Try running a stitch and making knots (we like this [Instructable \(link\)](#) on sewing basics).

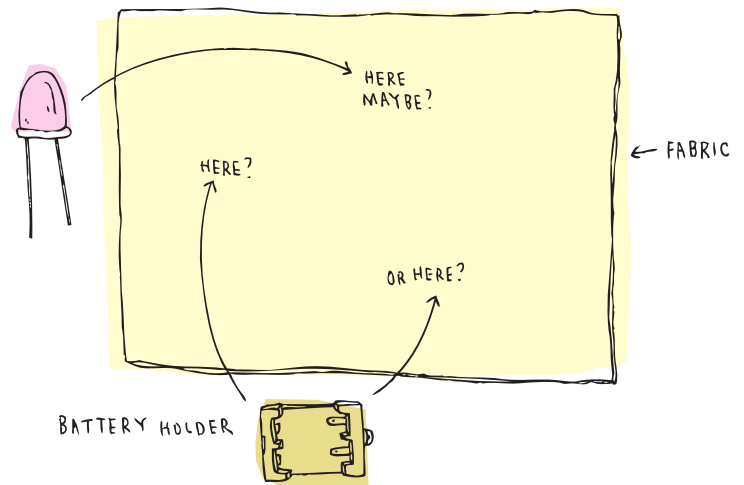
Likewise, if you haven't played with LEDs much before, try turning on the light by touching the leads to either side of your battery. Use a sharpie to mark the positive leg of your LED (the one touching the positive side of the battery). This will come in handy later.

Think about what you'd like to make for your first project. You could make a patch, cuff, pillow, or something to wear. These can get complicated pretty quickly, so at first you might just focus on lighting up one LED and expand from there.

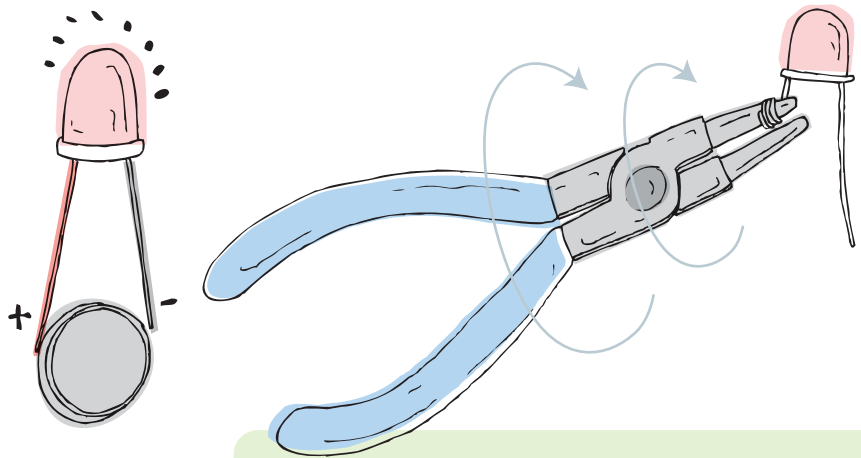
And no matter what, give yourself some time to work this out.

**Layout the circuit on your piece of fabric.** Think about where you want to place your battery holder and your LED.

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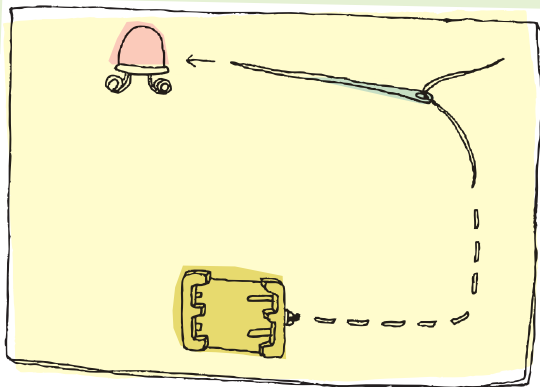
**Prep your LED to make it a sewable component.** Test your LED by placing one leg on either side of the coin cell battery. You might notice that the LED works when oriented one way on the battery but not the other. When lit, mark the leg that is touching the positive (smooth) side of the battery with a sharpie.



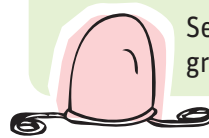
**You can make the LED sewable** by using jewelry pliers to curl it into a circle.

- Pinch the end of the LED leg in the pliers.
- Turn the pliers away from you to begin curling the leg.
- Before you loop around both tips of the pliers, pause, open the pliers and rotate them back, then repeat the first two steps.
- Continue turning until you reach the LED.
- *TIP: They don't have to be perfect circles, any kind of loop will work! You can practice on a scrap piece of wire to get the hang of it before you try on your LED.*

**Sew one side of the battery holder onto your fabric.** Make sure your needle is small enough to fit through the hole in the battery holder. *TIP: It helps to loop it through the hole several times so it's very secure.* Once one side is in place, sew away from the battery pack towards the place where you want to connect one leg of your LED.



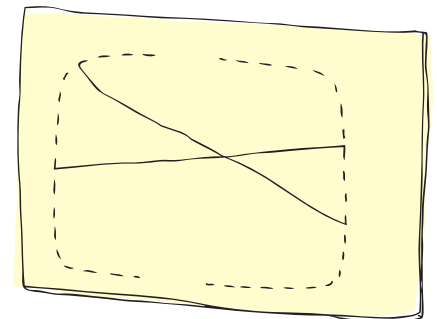
Set aside your LED for now and grab your needle and conductive thread.



Now that you have half your circuit complete, it's a good opportunity to test it out before you sew the rest. Use another piece of thread to connect the opposite leg of LED to the other side of the battery pack. If it works you're good to go! If not, here are a couple things to check:

- *Is your LED oriented the right way?*
- *Is there a short circuit somewhere?* It's easier for the electricity to go through the thread than the LED. If a piece of thread is accidentally crossing both lines of thread the light will not light. Sometimes this happens on the back of the piece and you can't see it from the front.

Complete your circuit by sewing the opposite side of the battery pack to the other leg of the LED.



When you've stitched to the place where your LED will go, **grab your prepped LED to sew it on.** If you started by sewing on the negative side of the battery pack, you'll want to sew on the negative leg of the LED (and vice versa). Loop the thread around the LED leg several times to secure it (just like you did with the battery pack). Tie a knot and snip off the excess thread.

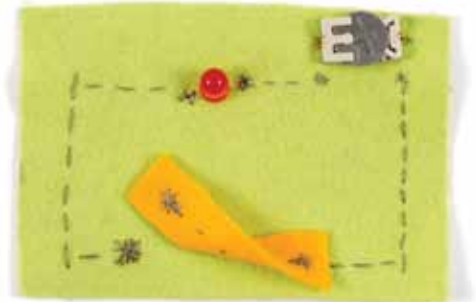
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**Now for the fun part:** What felt scraps can you sew around your LED to make it unique? You can use embroidery thread to enhance the design or cover up the ugly bits.



**Making a sewn circuit doesn't have to stop with a single LED. Here are a few ideas for things you can try using the same materials.**

**Experiment with switches:** A switch can be created by making a break in your thread somewhere between your battery and your LEDs. Create two conductive connection points that you can separate and bring together to turn your LED on and off. You can use conductive thread sewn to a flap of fabric to make a surface switch. Metal snaps are great for making switches on wearable cuffs. Metallic beads connecting to patches of conductive thread or fabric make great tilt switches. You can even experiment with putting conductive materials inside a stuffed object to make squeezable switches.



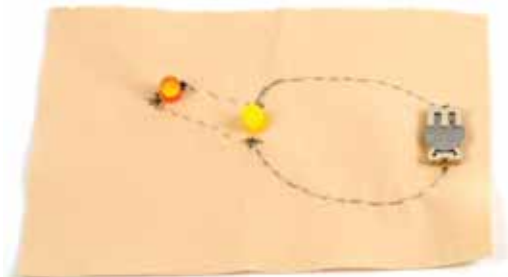
switches

**Experiment with multiple LEDs:** You can create sewn circuits with many LEDs. Add on to your first circuit by extending the positive and negative lines with more thread and sewing on additional LEDs.

When using multiple LEDs, it helps to organize them in a parallel circuit. It's possible to create series circuits too, but you'll need to add in a battery pack for each light.

**To make a parallel circuit** you can create two different pathways, one from the negative side of the battery and one from the positive side. LEDs can go anywhere those pathways come together.

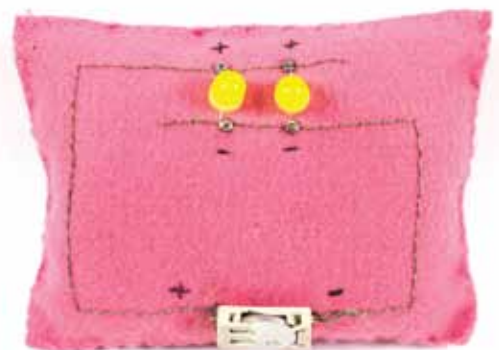
**You can branch the traces** in many different directions to create organic shapes or geometric pathways with lines and sharp corners. When making complicated pathways, make sure your positive and negative traces don't touch or you could end up with a short circuit.



multiple LEDs

*TIP: Some LEDs don't get along with others (blue is not very compatible with other colors). Test your LEDs' color compatibility by placing them all on your battery before you sew them down.*

**Make something wearable:** Incorporate LEDs into your clothes or make accessories like light-up neckties, brooches, headbands, hats, and more. Conductive fabric can also be a great material for extending your explorations into wearable circuits.



parallel circuit



# TAKE IT FURTHER

- **Computation:** You can get as intricate or complex as you like. Use a LilyPad or a chip to make the LEDs blink, or add a sensor so your sewn circuit responds to the environment.

- **Explore textiles:** Try needle-felting wool roving into a three-dimensional object that incorporates LEDs. You can even sew through your needle-felted creation after it is formed. Or try other fabrics with the LEDs. Things that could be illuminated by the LEDs are fun. Reflective materials are also interesting to use.

- **Sewing machines:** Use conductive thread in your sewing machine to extend the possibilities of what you can sew, or add machine-sewn elements to your hand-sewn circuit.



# EDUCATOR ADDENDUM

## *A note on our philosophy:*

*The Tinkering Studio is based on a constructivist theory of learning, which asserts that knowledge is not simply transmitted from teacher to learner but actively constructed by the mind of the learner. Constructionism suggests that learners are more likely to make new ideas while actively engaged in making an external artifact. The Tinkering Studio supports the construction of knowledge within the context of building personally meaningful artifacts. We design opportunities for people to “think with their hands” in order to construct meaning and understanding.*



Sewing circuits is a fun new way for the learner to investigate concepts at the intersection of art, science, and technology. Here are a few principles that exemplify the design goals of this activity:

- STEM (science, technology, engineering, and mathematics) education is a means not an ends. Building a functioning circuit is at the heart of this activity. Participants are also intrinsically motivated to construct circuits using these unusual materials to create something of their own design that is personally meaningful to them.
- Activities and investigations can encourage learners to complexify their thinking over time. By making several iterations on their designs, incorporating switches or more complex circuits, or even adding in computation, learners have many opportunities to create ever more complicated designs.
- Activity station design enables cross-talk and invites collaboration. The communal table is a social aspect perfectly suited to sewing. It’s easy to see and hear what others are working on. Solutions to similar problems can be shared and iterated upon from one builder to the next.

## **Environment** (the elements of the space that support tinkering)

*In the Tinkering Studio there are many things that we keep in mind when setting up an environment for a successful tinkering activity.*

*Since learners often work with us for an extended period of time, we try to create a warm and welcoming workspace with comfortable seating, sturdy worktables, and good lighting. We often display exhibits or examples from past projects and current activities throughout the space to seed ideas and provide an introduction to what is happening that day. Materials are easily accessible and in close proximity to the tinkerers. We often work at large, communal activity stations to enable cross-talk and invite collaboration between participants, allowing them to look to each other for answers and solutions*

When creating an environment for sewn circuits, you'll want to prepare a separate space for materials because this is a fairly materials intensive activity. We like to have a larger separate area for working. Once participants choose their initial materials they generally work in their own space when they're sewing, and only need to go back to the materials table if they're changing their design or need additional supplies.

We strongly suggest that you try the activity beforehand to discover what materials work well for you and to get comfortable with the process. This experience will help you figure out the variety of materials you'd like to work with. Setting up the materials so they're visible and accessible to the participants is helpful because this activity is such a personalized creation. It's also helpful to keep the conductive materials like conductive thread, battery holders, and LEDs together and separate from the more general sewing things. You can incorporate all kinds of additional sewing materials and notions, but the conductive elements are the basic ones to start out with.



**Facilitation** (the things we say and do to support learning through tinkering)

*Facilitation is a way of teaching in which you support the learner's own investigations, questions, and ideas within the framework of an activity. In the Tinkering Studio, we strive to practice a kind of facilitation that respects the individual path of the learner. As facilitators, we watch and wait until the right moment to jump in and offer a hint, a material, or a new way of looking at a problem. As educators, we allow learners to feel frustration and encounter moments of failure as they work with real materials to try to solve their own challenges.*

*There are many ways that the facilitator can influence the interactions with participants in an activity. We help people get started with the activity by giving a quick sense of the goals. We invite them into the space and introduce the materials and tools they might use. We spark interest and sustain learner's engagement by asking questions about their work and responding to their answers. We support multiple outcomes of the activity and are open to the possibility of new ideas, different solutions, and changing goals of the individual learners. We try to practice a style of facilitation in which we are not teachers who transmit knowledge to passive learners, but rather are guides and co-learners on a path to understanding.*

For sewn circuits there are a few things to keep in mind as a facilitator. It can be a challenge to help a learner get started with how to think about sewn circuits if they don't have a lot of experience with circuits in general. Sewing with unusual materials is what makes this activity fun, but it can also make thinking about circuits a little trickier. Frustration is part of the process, and is a fruitful place for learners to overcome challenges. We like to have circuit boards nearby to use as a refresher on how to complete a circuit. For some people drawing out the circuit they'll be sewing can also help. Remember, you don't have to explain everything about circuits at the start; learners will develop an understanding as they design and make their sewn circuits. Having many different types of examples on hand can help to inspire possibilities and provide ways of explaining the more complicated elements of this activity. (pictures of some of our favorite examples)



When testing your sewn circuits for the first time, the LED may not light. Don't worry, it's actually useful to figure out why it's not working. This is when we like to use a multimeter to test the connections, to see if the thread isn't tight enough or if the LED isn't oriented in the correct direction (these two things are the most common problems we encounter).

# RELATED TINKERING ACTIVITIES

**Toy Take-Apart:** Collect discarded mechanical stuffed toys and dissect them to find battery packs, switches, sensors, and motor-driven mechanical elements similar to the parts used for circuit boards. You can use the circuit board components to test the things that you find inside, and some of these parts can even become new circuit board blocks.

<http://tinkering.exploratorium.edu/toy-take-apart>



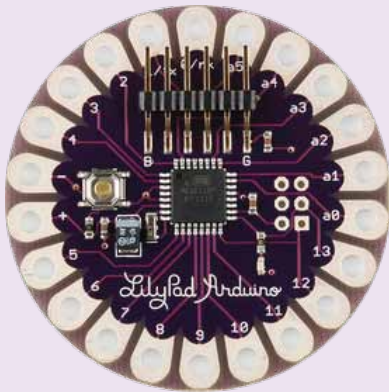
**Paper Circuits:** Paper circuits is another exploration of electrical circuits inspired by artist Jie Qi that incorporates traditional paper-folding techniques into electronic projects. In this activity, you can use copper tape, surface mount LEDs, and watch batteries to bring a greeting card or piece of origami to life. As in the circuit board activity, participants build understanding of circuits as solutions to problems that come up as they engage with materials.

<http://tinkering.exploratorium.edu/paper-circuits>



## ARTIST CONNECTIONS

*(inspiring connections to the Circuit Boards activity)*



**Leah Buechley** is the developer of the LilyPad Arduino toolkit, in addition to other smart textiles and soft-circuit solutions. She was an associate professor at the MIT Media Lab, where she directed the High-Low Tech research group. Her work explores the integration of high and low technology from cultural, material, and practical perspectives, with the goal of engaging diverse groups of people in developing their own technologies.



**Grace Kim** is a San Francisco-based wearable technology designer. Her work centers on incorporating traditional crafts such as embroidery, knitting, applique, and sewing, into circuitry. She teaches soft circuitry workshops in the Bay Area.

<http://www.iamgracie.com>