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# LilyPad

## SEWABLE ELECTRONICS KIT GUIDE

v1.0



# LilyPad Sewable Electronics Kit Guide

v1.0



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# LilyPad Sewable Electronics Kit Guide

v1.0

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## Introducing the LilyPad Sewable Electronics Kit

Welcome to the LilyPad Sewable Electronics Kit, designed to help you explore the world of **e-sewing (electronic sewing)\*** through a series of introductory activities using the LilyPad system. This kit is for crafters and creatives of all ages, whether you are brand new to electronics or looking for a new way to explore building circuits. The guide begins with an introduction to basic e-sewing techniques and a simple **circuit** project. You then move on to more complicated projects involving multiple circuits (**parallel circuits**), **buttons**, and **switches**. Finally, you'll use the pre-programmed LilyMini to create a project with advanced behaviors limited only by your imagination. At the end of each project chapter are images and variations to spark your creativity. The Troubleshooting section (page 70) helps you identify and solve problems you may encounter with your circuits. By the end of this guide, you will have crafted a glowing pin, an illuminated mask using three **LEDs (Light-Emitting Diodes)**, a plush that lights up using a button and switch, and a pennant that displays a pre-programmed light pattern. Let's get started!

**\*See Glossary for definitions of terms in this style.**



## What Are Sewable Electronics?

Sewable electronics combine traditional craft processes (sewing, fashion design, and textile design) with electrical engineering, computer science, and hardware skills.

With sewable electronics you can create **e-textiles (electronic textiles)**, which are often wearable, flexible projects that look less like traditional electronics and more like craft and art projects. Many e-textile projects replace wiring with flexible conductive materials such as **conductive thread** and fabric. For the projects in this guide, we will be sewing circuits together with conductive thread.

## What Is LilyPad?

The LilyPad system is a set of sewable electronic pieces designed to help you build soft, sewable, interactive e-textile projects. Using LilyPad pieces is a great way to

experiment with electronics through the lens of crafting. Each LilyPad piece has large conductive **sew tabs** for easy sewing and a rounded shape so as not to snag fabric or cut thread.

The LilyPad system was designed by Leah Buechley while pursuing her Ph.D. in computer science at the University of Colorado Boulder. The commercial version of the kit, which launched in 2007, was collaboratively designed by Leah and SparkFun Electronics. You can learn more about LilyPad at [SparkFun.com/LilyPadSewKit](http://SparkFun.com/LilyPadSewKit).



LilyPad Creator Leah Buechley



## Kit Contents

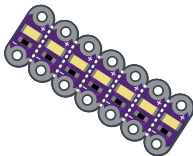
The **LilyPad Coin Cell Battery Holder** has space for a 20mm coin cell battery and four sew tabs (two positive, two negative). A slide switch turns it on/off.

Used in Projects 1, 2



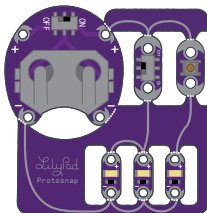
All the projects in this kit are powered by **3V Coin Cell (CR2032) Batteries**. The top of the battery (marked with a + sign) is positive, and the bottom is negative.

Used in Projects 1, 2, 3, 4



**LilyPad LEDs (Light-Emitting Diodes)** have two sew tabs (one positive, one negative), marked (+) and (-), which connect to a power source. *LEDs come in a panel and must be snapped apart before using individual LEDs in projects.* The LED's color is labeled on the back of each piece.

Used in Projects 1, 2

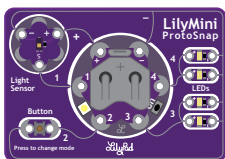


The **LilyPad E-Sewing ProtoSnap** is a set of LilyPad pieces connected together on a single, snappable board, allowing you to explore the circuit's function before you sew it into a project. This ProtoSnap includes a LilyPad Button connected to a LilyPad LED, a LilyPad Slide Switch connected to two LilyPad LEDs, and a LilyPad Coin Cell Battery Holder.

Used in Project 3



# INTRODUCTION



The **LilyMini ProtoSnap** is a pre-wired circuit using a LilyMini, a LilyPad Light Sensor, LilyPad Button, and two pairs of LilyPad LEDs. The LilyMini comes pre-programmed with a set of behaviors.

Used in Project 4



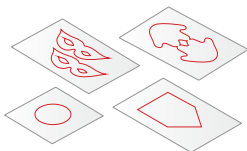
**Conductive Thread** is a specialty thread made with stainless steel fibers. It can be used instead of copper wiring to connect LilyPad (or other e-textile) pieces together to create circuits.

Used in Projects 1, 2, 3, 4



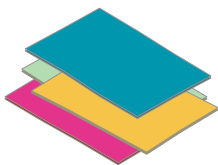
**Needles** included with this kit were chosen to fit through LilyPad sew tabs. Two sizes are provided. Choose the one that works best for you.

Used in Projects 1, 2, 3, 4



**Templates** with circuit diagrams and labels are included for each project in this guide.

Used in Projects 1, 2, 3, 4



**Felt** is a great material to start sewing with because it is sturdy and won't fray. Find additional colors and sizes at your local craft store.

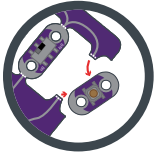
Used in Projects 1, 2, 3, 4



**Fiberfill Stuffing** is included to add some fluff to the plush project.

Used in Project 3

**Also Included:** Embroidery Thread, Elastic Cord, Pin Back, and Sewing Thread.



## ProtoSnap Components

Some LilyPad pieces come in a ProtoSnap configuration, which means all of the individual components – such as LEDs, battery holder, switches, buttons, etc. – are attached to one another in a single functioning circuit board. ProtoSnap boards are designed to be easily snapped apart into individual pieces when you're ready to begin creating LilyPad projects.



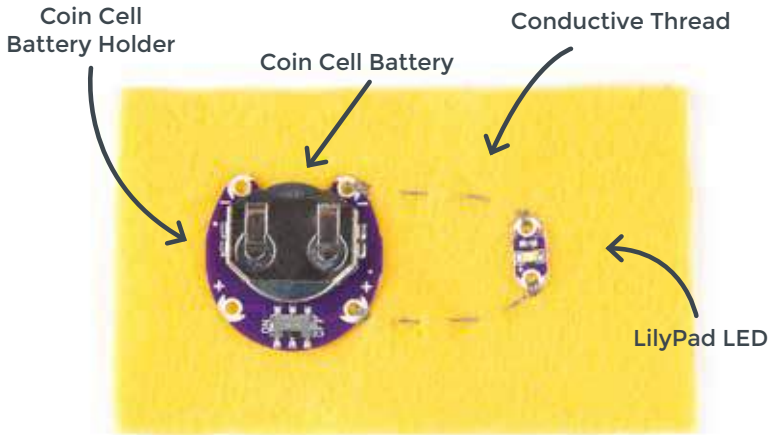
Don't snap apart your ProtoSnap components quite yet. We'll use the unsnapped parts to demonstrate how different types of circuits work.

## You Will Also Need

To complete the projects in this kit, you will also need to collect:

- **Scissors**
- **A fabric marker or pen to mark felt or trace templates; for an erasable option, try chalk or disappearing ink**
- **Extra sewing thread for finishing or decorating projects**
- **Hot glue gun (with extra glue) or fabric glue, to help attach LilyPad pieces to fabric before sewing**
- **Extra fabric, printable fabric, and/or craft supplies for decorating your projects**

# LILYPAD BASICS



**Parts of a LilyPad Circuit**

## Sewing With Conductive Thread

The projects included in this kit use conductive thread to complete electrical circuits. This section will introduce you to some basic sewing techniques as well as a few special pointers for using conductive thread to build working circuits.

Even if you're already familiar with using a needle and thread, this section may still be useful to you, specifically where it pertains to sewing with LilyPad parts. Throughout the guide you will find icons reminding you to use these techniques.



## Securing Your Components

We recommend using a small dot of hot glue (preferred) or fabric glue to attach each LilyPad piece to the fabric to keep it from moving while you sew. Make sure not to accidentally seal up the holes in the sew tabs.



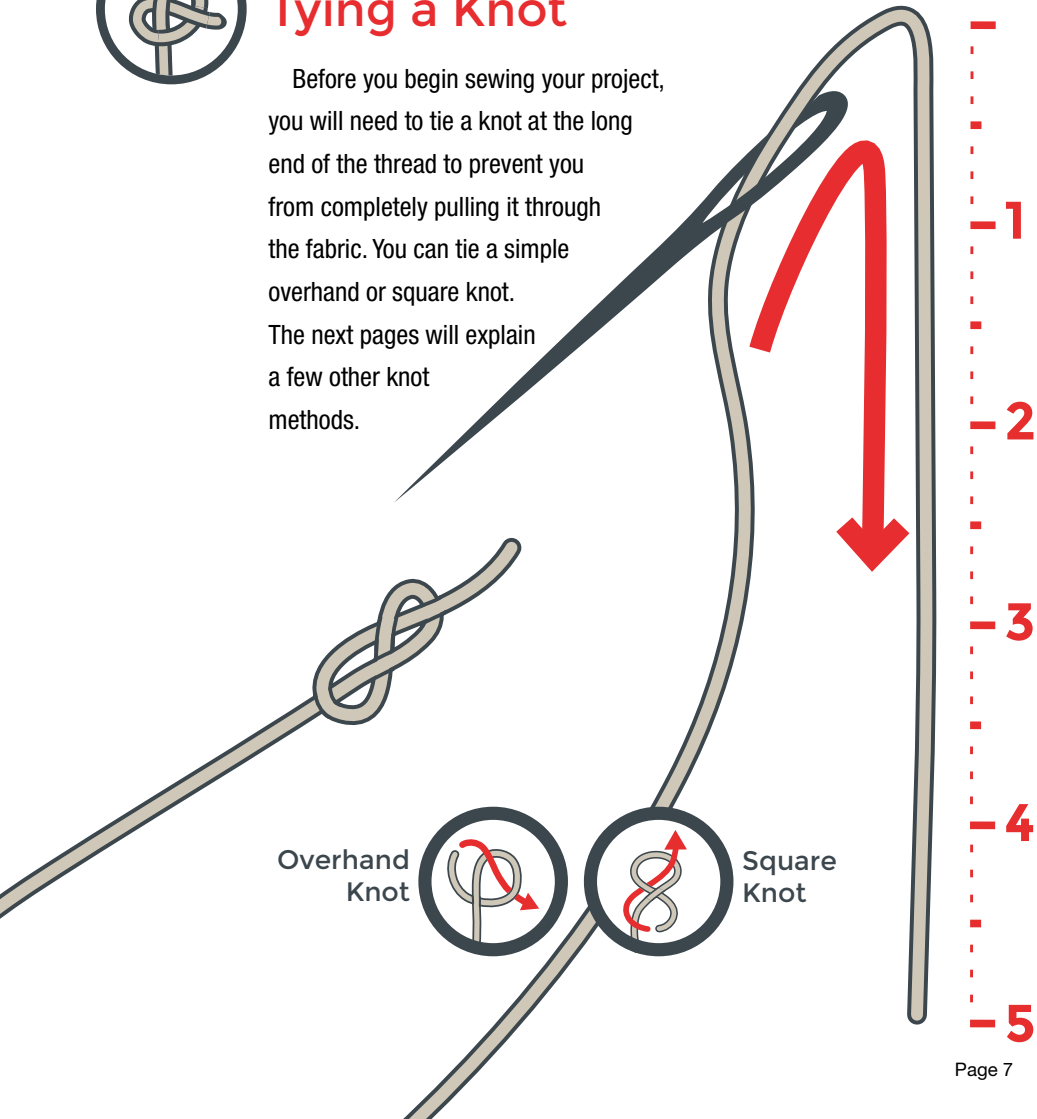
## Threading a Needle

Cut a piece of conductive thread approximately 2 feet long. Push one end of the thread through the eye (opening) of the needle and pull through, leaving a tail of about 5 inches.



## Tying a Knot

Before you begin sewing your project, you will need to tie a knot at the long end of the thread to prevent you from completely pulling it through the fabric. You can tie a simple overhand or square knot. The next pages will explain a few other knot methods.



Overhand Knot



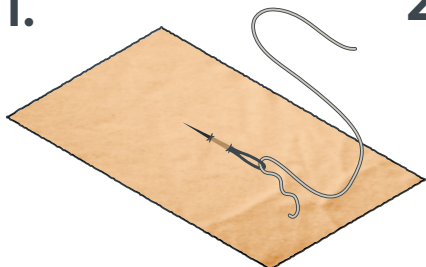
Square Knot



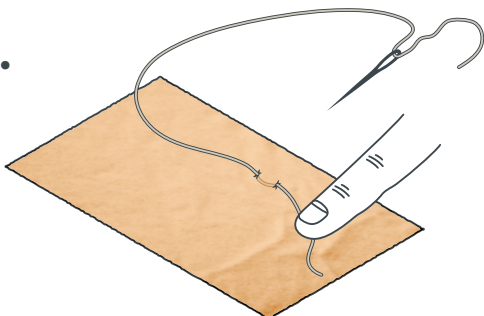
## The Starter Knot

A starter knot is a method of starting your stitch with a knot directly on your fabric.

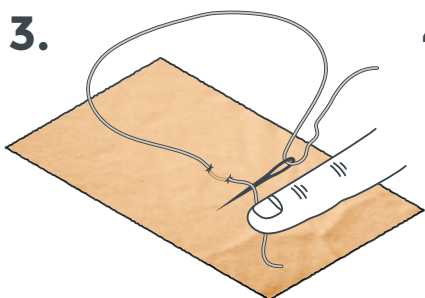
1.



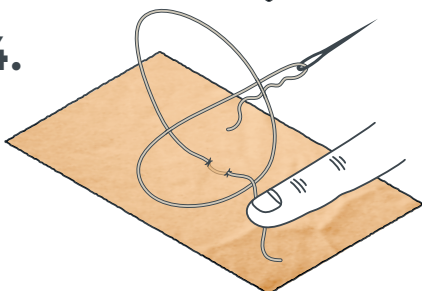
2.



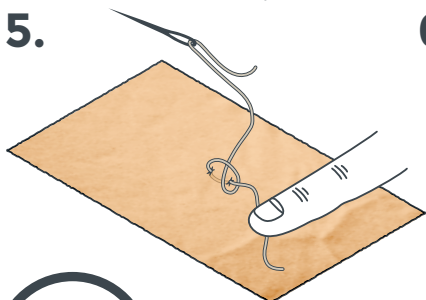
3.



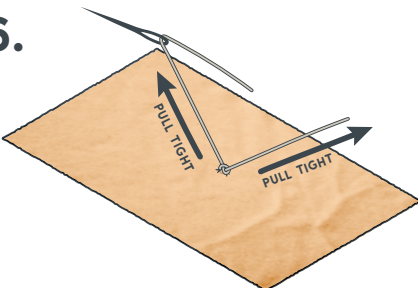
4.



5.



6.



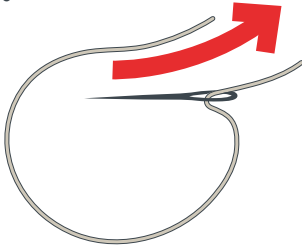
Repeat, making a few more loops through the fabric before trimming the loose tail.



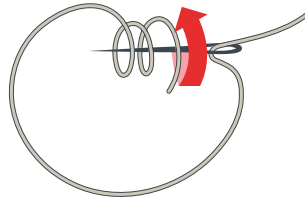
## The Quilter's Knot

The slightly more advanced quilter's knot is a way to tie a quick, secure knot on the thread. After some practice, this knot can be tied very quickly.

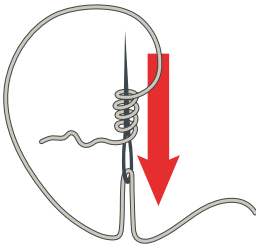
1.



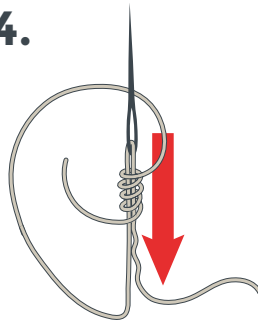
2.



3.



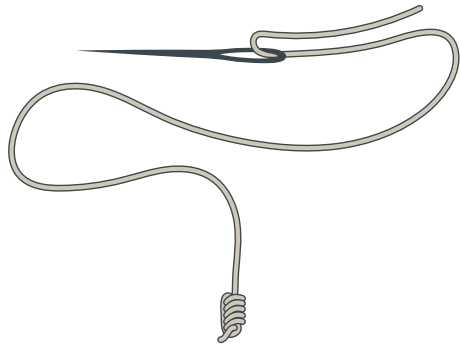
4.



5.



6.

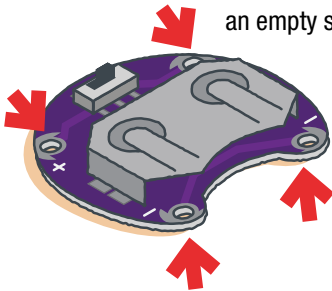




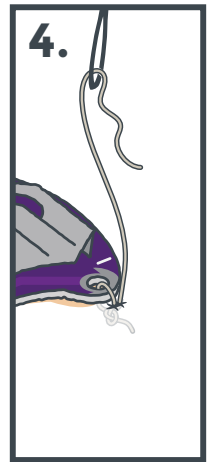
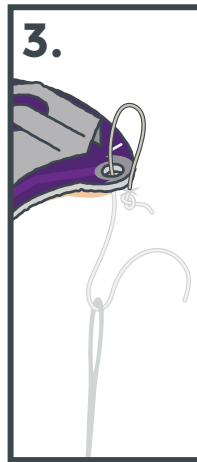
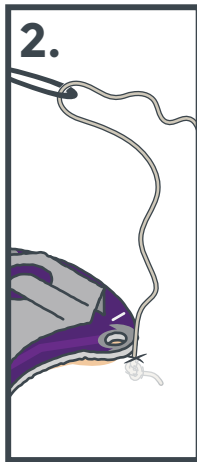
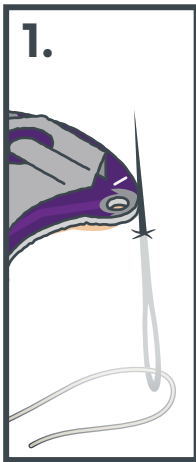


## Connecting to LilyPad Sew Tabs

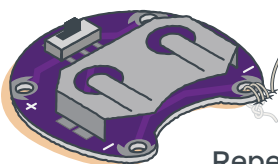
sew tabs x4



We'll stitch conductive thread around LilyPad sew tabs in our circuits to connect the pieces together. It's important that you make three to four loops each time you connect your thread around an empty sew tab and pull the thread snug with each pass. This ensures you have made a strong electrical and physical connection between the thread and the sew tab. Pull loops tight before continuing your stitch.



5.



Repeat to make three to four loops.



Don't cut your thread yet. You'll need it to connect the next piece.



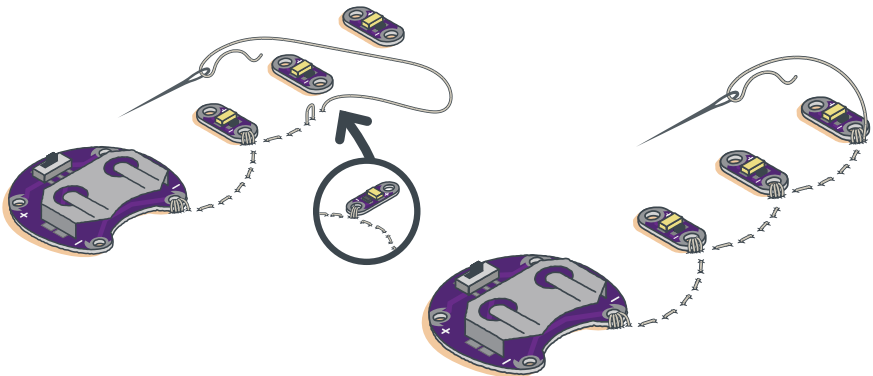
## Connecting LilyPad Pieces

A running stitch (see page 12) will enable you to connect LilyPad components together with a single length of conductive thread. To connect two LilyPad pieces, stitch three to four loops around the sew tab and continue the stitch.



## Multiple LilyPad Pieces

To connect more than two LilyPad pieces, instead of trimming your thread and starting over, continue stitching to the next piece, make three to four loops, and repeat as necessary. There is no need to use a new length of thread if the pieces will share a connection.

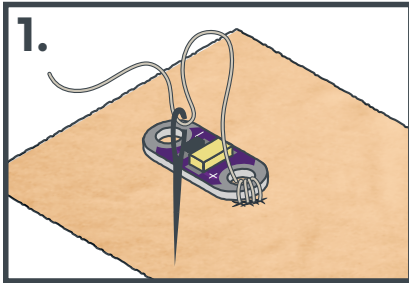


To complete the line of stitching, see page 14 for Finishing Your Connection.

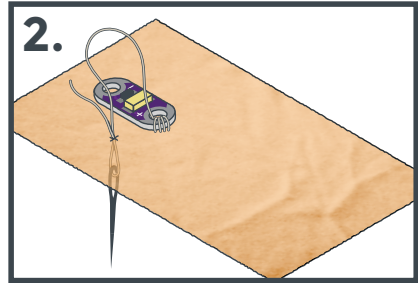


## Sewing Basics

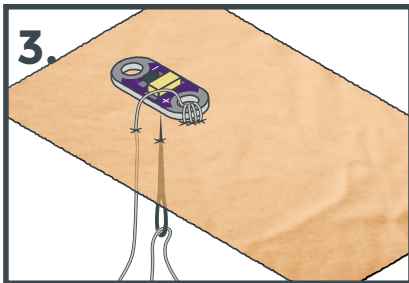
After sewing loops around a sew tab, a running stitch will enable you to connect LilyPad pieces together with a continuous length of conductive thread. Follow these steps:



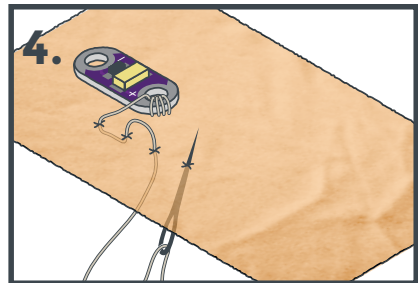
**1.** Push the needle through the fabric about 1/4" in the direction of your stitch path.



**2.** Pull the slack of the thread through so it sits flush with the fabric.



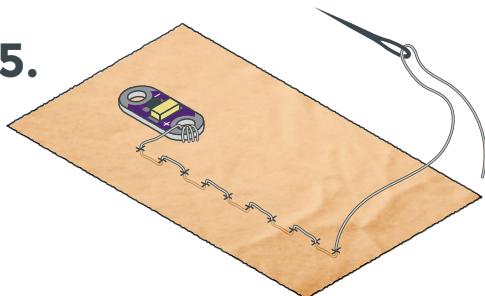
**3.** Push the needle back up through the fabric another 1/4" along the stitch path.



**4.** Pull the slack of the thread through so it sits flush with the fabric.

Repeat this process to travel along the path to the next LilyPad piece you want to connect to, keeping stitches evenly spaced.

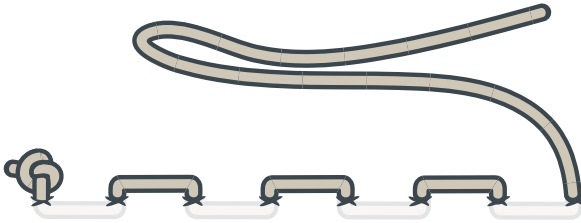
**5.**



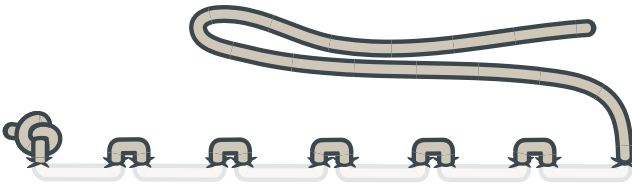


## Running vs. Hidden Stitch

In a basic running stitch, the stitching will be even on both sides of the fabric.



To hide the stitches so that they are not seen on the outside of the project, make a longer stitch on the back of the project and a very small stitch on the front of the project. This method is called a “hidden stitch.”



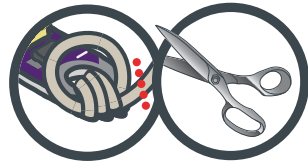
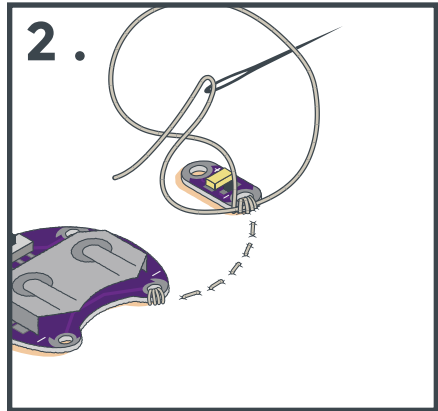
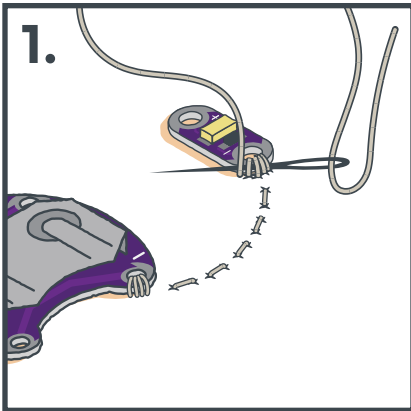
### Tip:

As you sew, flip your fabric over every so often to make sure the conductive thread isn't getting knotted or tangled. If you are just starting out with sewing, your stitching may take some practice before it feels comfortable or easy. Remember to be patient with yourself and take your time while stitching. If your thread breaks, you can stitch onto existing conductive thread to continue the electrical connection.

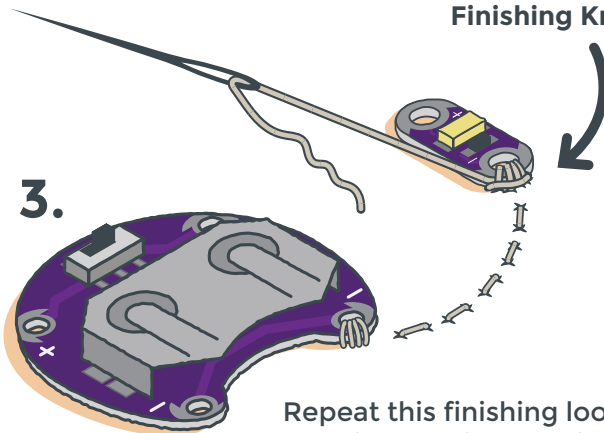


## Finishing Your Connection

When you have completed connecting components, use a finishing knot. Thread tails can cause electrical shorts, so be sure to trim your thread afterward.



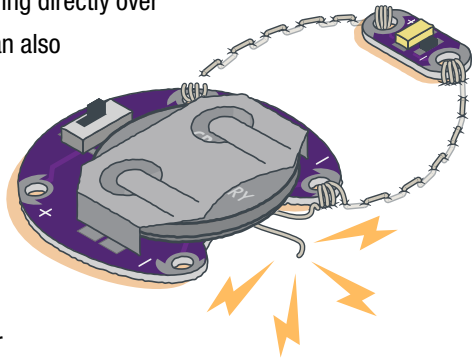
Finishing Knot



Repeat this finishing loop two times before cutting.

## Checking for Conductive Thread Short Circuits

Watch out for any loose threads or knot tails in your project. If any piece of the conductive thread from the **positive (+)** side of your circuit accidentally touches the **negative (-)** side, it can cause a **short circuit**. A short circuit connects the battery to itself and bypasses the rest of your project – and will discharge your battery almost immediately. Stitching directly over stitches in another part of the circuit can also cause a short. It's important that your stitches do not cross over each other or touch other parts of the circuit. The batteries used in these projects shouldn't burn or shock you if they short circuit (although they may heat up), but higher voltage projects or power sources could be dangerous.



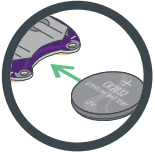
See the Troubleshooting section on page 70 for more information on identifying and correcting short circuits with conductive thread.



### First Steps

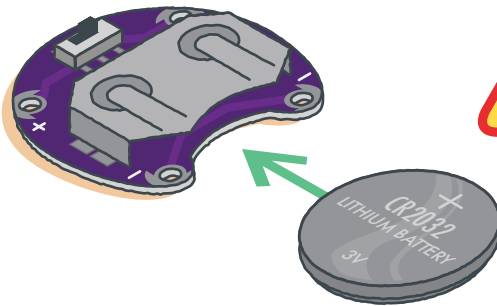
A green highlight on a step indicates it's the first in a sequence of steps. Make sure to address this step first!





## Installing Your Battery

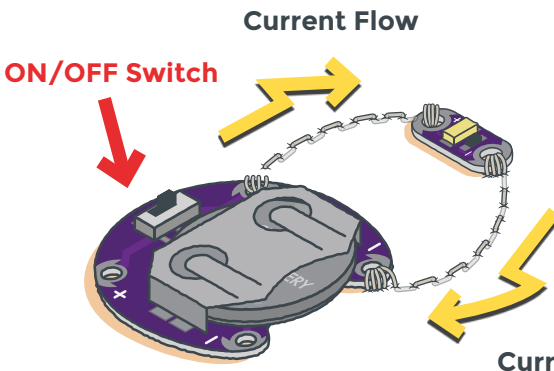
Once all your pieces are connected with conductive thread, your finished circuit needs a power source. Install your coin cell battery, positive (+) side up, into the battery holder.



Always remove your battery when working on your circuit to avoid damaging your components.

## Testing Your Finished Circuit

Switch your circuit on and see what it can do! If the circuit fails to work, you may have a short, a loose connection, a reversed component, or even something as simple as a dead battery. Check out the Troubleshooting section on page 70.

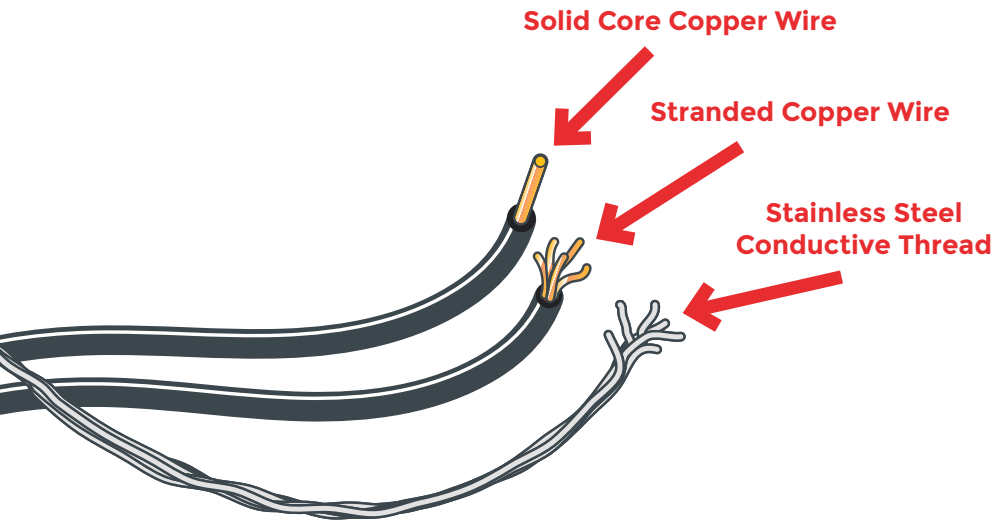


When you turn on the battery holder switch, **current** flows through the conductive thread to the other parts of your circuit. Learn more on page 21.

## Caring for Your Project

Unlike copper wire, which has a coating, conductive thread is uninsulated. This means the thread behaves like bare wire and can accidentally short circuit if stray strands come in contact with each other.

To avoid any accidental short circuits after the project is stitched and tested, we recommend covering the thread with a thin layer of fabric glue, fabric paint, or an additional layer of fabric. This is especially important for projects that are wearable or three-dimensional. Never work on a metal surface when using conductive thread.



## Cleaning Your Project

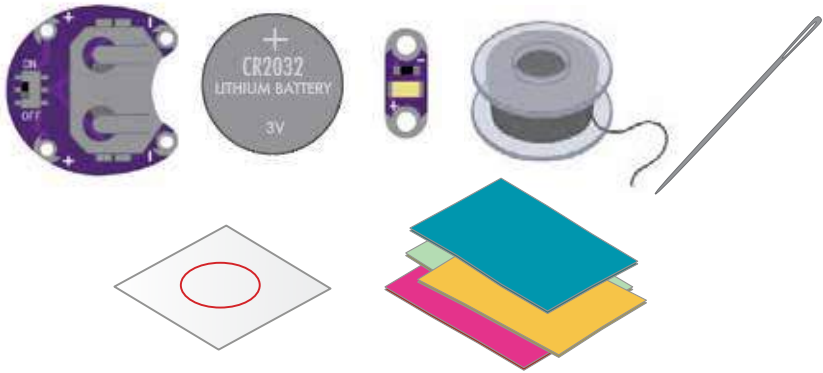
If your project gets dirty, remove the battery and carefully hand wash with mild detergent. Let your project air dry; a dryer can damage the LilyPad pieces or stitching.

Project 1:

# Glowing Pin

🕒 30 minutes – 1 hour





For our first project, we'll create a wearable pin using conductive thread to connect a LilyPad LED to a battery holder. Follow along by drawing your own design on a piece of fabric, or download and print one of SparkFun's designs.



SparkFun has some ready-made design templates, examples, and tips online!

Visit [SparkFun.com/LilyPadSewKit](http://SparkFun.com/LilyPadSewKit)

to view and download.

## REQUIRED MATERIALS

### Included in This Kit:

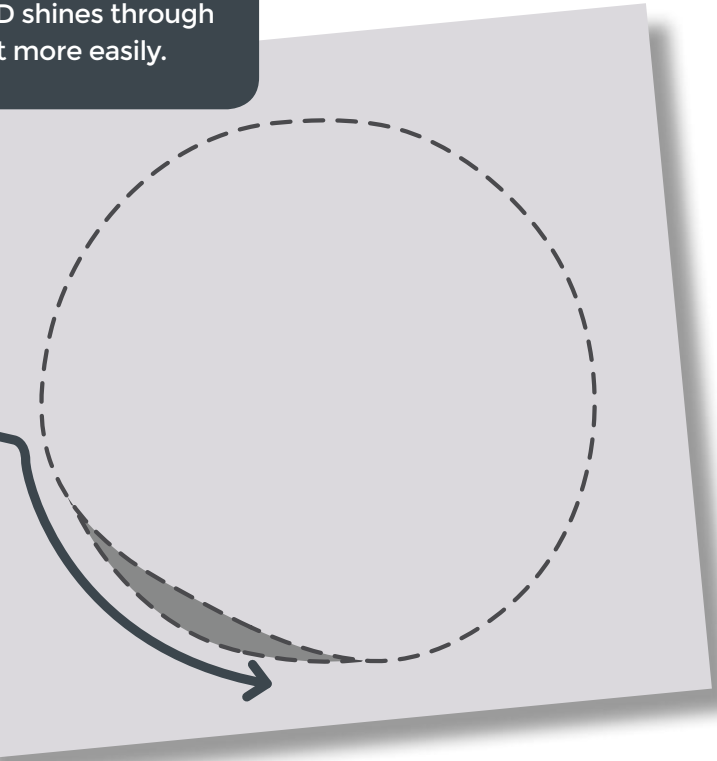
- Coin Cell Battery Holder
- 3V Coin Cell Battery
- 1 LED (carefully snap out from panel)
- Conductive Thread
- Needle
- Pin Template (1 piece)
- White Felt (you will need at least 3 square inches)
- Pin Back

### You Will Also Need:

- Pen, marker, or chalk
- Fabric to draw a design on or printable fabric (optional)
- Scissors
- Hot glue gun (with extra glue)
- Printer if you are downloading and printing one of SparkFun's pin designs

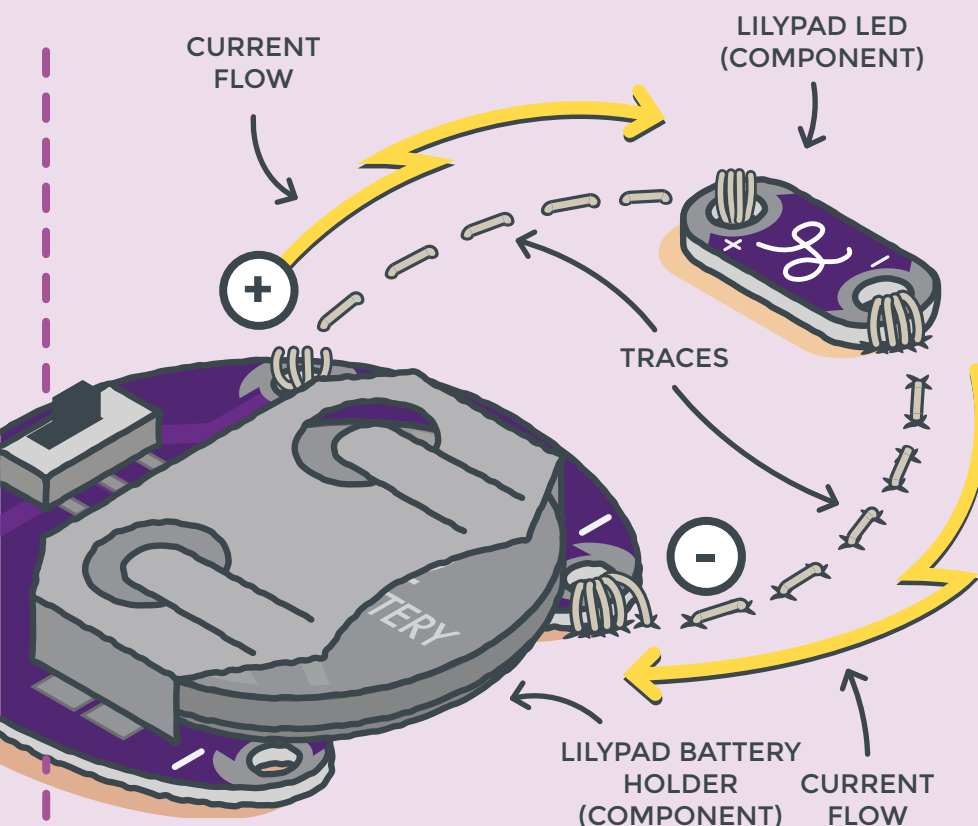


We recommend white felt for this project so that the LED shines through the felt more easily.



## Planning Your Project

Trace the pin template on white felt and cut out. We'll be building our circuit on the felt piece, then adding a decorative layer of fabric with designs on top of it. Trace and cut a slightly larger circle or SparkFun design (see [SparkFun.com/LilyPadSewKit](http://SparkFun.com/LilyPadSewKit)) out of thin fabric (or a second piece of felt) for the top layer of the pin.



## Understanding Your Circuit

This project is an example of a basic circuit – an electrical loop that travels from a power source along a path (called a **trace**) to a component (or components) that uses the electricity to function, and then back to the power source. For our project, we'll use an LED (Light-Emitting Diode). When this loop is completed by stitching the pieces together with conductive thread traces, electricity from the power source is able to flow from the positive (+) side of the battery through to the LED (lighting it up) and back to the negative (-) side of the battery. This electric flow is called current. As you build the projects in this book, you will learn different ways to design conductive thread circuits and experiment with additional pieces that help control or use the flow of electricity. **In this circuit configuration, the LED is facing the fabric to shine through the other side.**