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INTRODUCTION TO WEARABLES



About this series

I'm learning: Wearables

1 These Sushi Cards will introduce you to Wearable Electronics. These are electronic circuits made using components (parts) especially designed to be sewn directly into clothes or accessories.

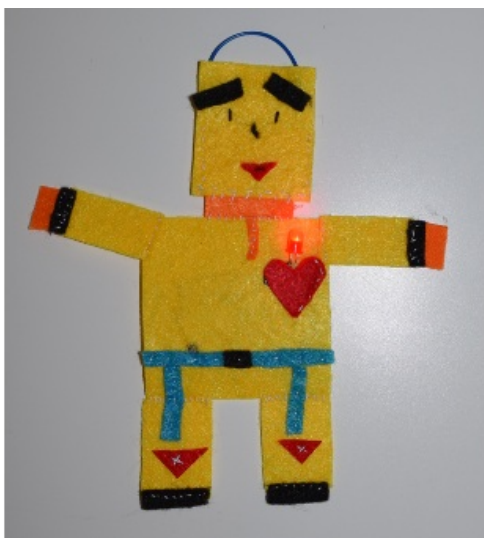
2 You will get to learn about and make electronic circuits and also do some sewing.

3 You are going to make a felt badge or patch that lights up



4 You can also design the badge so that lots of them can be joined together to make a glowing patchwork. This might be fun to do together with other Ninjas!

5 You can use this stuff to decorate clothes, bags, hats... The possibilities are unlimited!

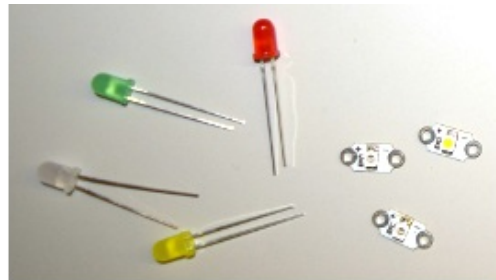


1 The different parts of an electronic circuit are called **components**. Here is a list of the components you'll be using:

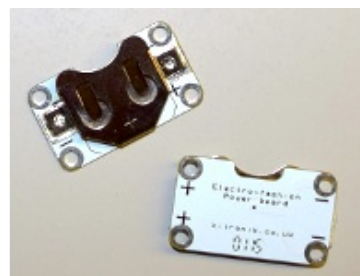
- A battery



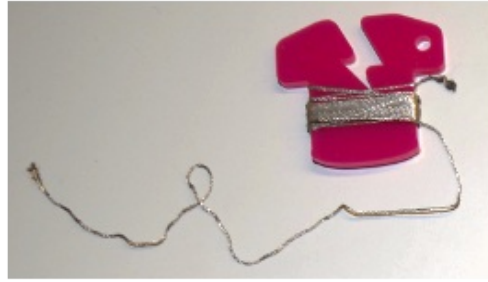
- LEDs—an LED is a small light. They can come in different colours, some of them can even flash or change colour. You can also get special sewable LEDs. Any kind can be used for this project.



- A sewable battery holder. This is a battery holder that's attached to a special board (called a **printed circuit board** or **PCB**) that you can sew onto your project



- Conductive thread. This is like embroidery thread but it contains metal so that electricity can flow through it. We say that it **conducts** electricity.



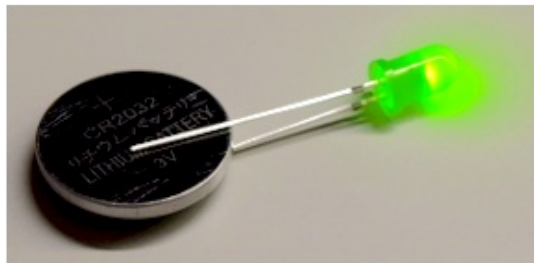
- Crocodile clips (optional)



- A switch (optional). You will see there are lots of different kinds of switches.
- Some fabric to sew the components onto. This could be a piece of clothing or a bag or anything you like. I will use regular craft felt.
- Sewing needle, e.g. embroidery needle
- Regular embroidery thread (or any kind of thread) (optional)
- Scissors
- Pliers (optional, preferably round-nosed)
- Tape-electrical or masking tape, or any other removable tape
- A safety pin or any kind of badge pin

- 1 Let's create your first circuit! Take a regular LED (one with two pins rather than a sewable one) and connect it to a battery by holding both pins to the battery, one on either side. Notice that one of the pins of the LED is longer than the other one. The longer one should be connected to the side of the battery marked with a plus sign '+'. Watch your LED light up!

- Did it work? If not, check that that the pins are the right way round.



- Try flipping the battery over so the pins are connected the wrong way around, with the shorter one on the '+' side of the battery. Does it still work?

- 2 In every circuit there is a **positive**, + and a **negative**, - direction. For electricity to flow you need to match up the + to + and the - to - between your components. This is why the LED doesn't light up when you flip the battery around.

- 3 On the LED, the longer pin is + and the shorter pin is -. You can also identify - by looking closely at the bulb: it is the side with the flat edge.

- A sewable LED is built onto a tiny **printed circuit board** so it has holes instead of pins. The holes are marked with + and - signs.

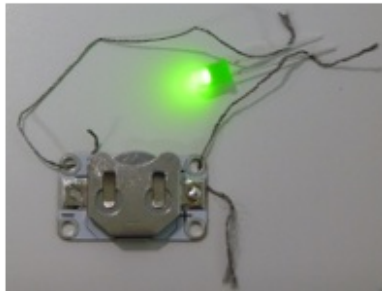


4 Separate the LED and the battery and pop the battery into a battery holder, with the + facing up (the holder will have a mark to show you the + side too). Team up with the person next to you and get two pieces of conductive thread.

5 Put one end of the first thread through the + hole of the battery holder, making sure it touches the metal, and hold the other end to the **positive** pin of the LED. You can use tape if you need to, although this will fray the thread a lot. If you have crocodile clips you can use these instead of thread.



6 Now take the second thread. Put one end through the - hole of the battery holder and hold the other end to the **negative** pin of the LED.



7 Make sure the two threads are not touching or crossing over at any point. If they do this will cause a **short** in your circuit and it will not work properly.

- When you have a **short circuit**, the electricity tries to go a shorter way through the circuit, skipping some of the components, and that's why it stops working.

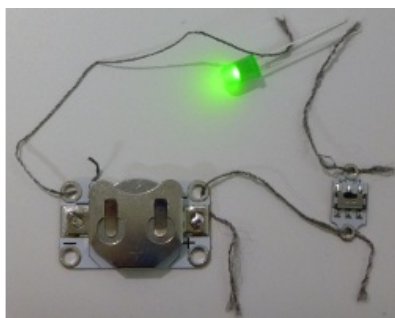
8 Now you have a circuit and are ready to make a light-up badge!

- 1 What if you want to turn your circuit off? To do this you need a break somewhere in the connections to stop the electrical flow. A **switch** is a component that allows you to turn a circuit off and on easily. There are lots of different types of switches: buttons, sliders, even magnetic or tilting ones. Some battery holders even have a built-in switch.



- 2 On your circuit, detach the thread from the **positive** hole of the battery holder. Take a new piece of thread and put one end of the new piece through the hole where the other thread was. You might need to team up with a third person here, for some extra hands! Otherwise you can always use tape, or use crocodile clips instead of thread.

- 3 If you have a ready-made switch, hold the other end of the new thread to one end of it. Then take the thread you removed from the battery holder (it should still be attached to the LED) and hold it to the other end of the switch. Now you can use the switch to turn the LED off and on.



- Notice there is no positive or negative side on a switch

- 4 If you don't have a switch, you can make one very easily. Take the two loose ends of thread in your circuit and hold them together to make your LED light up. When you separate them it turns off again. You have just created a simple switch!

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Adding a switch

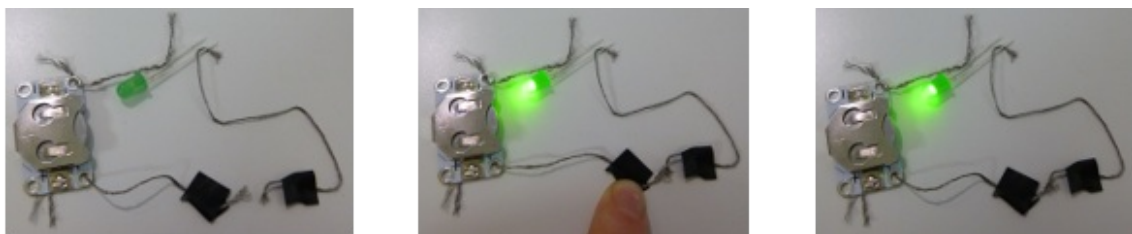
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5 How does it work? As you've seen, electricity flows all the way around the circuit to make the LED light up. For the electricity to flow, there needs to be a connection between each component in the circuit.

- When you separate the two threads, you have broken the connection between them and the electricity can no longer flow.
- When you make the threads touch, they are connected and the electricity is able to flow once more.

6 I've put tape near the end of each thread so you can more easily see where the break is in the circuit. This will be the switch. Here it is in action.



7 In a ready-made switch the part where the connection gets broken and reconnected is usually hidden inside so you can't see it. Now you know what is really happening when you switch it on or off!

8 Different types of switches work by breaking the circuit in different ways. You can use a switch in your wearables project to give you control over when the circuit is on or off.

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Sewing on components

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1 Cut a piece of felt to the size you want for your badge. Decide where you are going to put the LED and mark the spot on the felt. Now decide where to put your battery holder. It could be on the back! Mark the spot for one of the positive holes and one of the negative holes with a + and -.

2 If you are using a regular LED, you will need to bend the pins into loops. A pliers can be helpful here. If you have a sewable LED, skip this step!



3 Thread your needle! Take a piece of conductive thread, about 30cm long, and pull one end of it through the hole in the needle (called the **eye**). This can be pretty fiddly. If the thread is frayed at the end, cut off the frayed bits with a scissors. Once the needle is threaded, the thread will be hanging out in two pieces. Pull one of them so it is a good bit longer than the other and tie a knot in the very end of the long piece.

4 Ready to start sewing? Place your LED onto the felt at the spot you have chosen. With one hand, hold onto the felt and the LED. With the other hand, place the tip of the needle **behind** the felt and push it through so that it comes out through the - hole of the LED.



5 Pull the needle and thread all the way through at the front. Try holding the needle by the eye and pinching the thread tightly there to keep it from falling out of the needle while you pull (if it does fall out, it's ok, you can re-thread it). You want to keep pulling until only the knot remains at the back.

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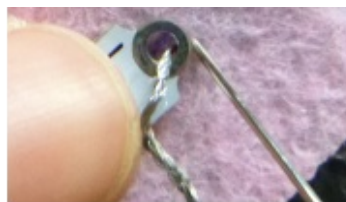
Sewing on components

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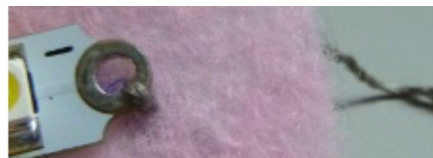
6

Now, place the tip of the needle *right beside* the - hole of the LED (the one it just came through), but *not inside* it. Like this:



7

Push the needle through the felt so it comes out the back. Grab the needle behind the felt and pull it all the way through, just like you did at the front. You've just sewn your first stitch! It should look something like this:



8

Repeat steps 6 and 7 three more times. Be sure to pull the thread tight each time. This will create a good connection and keep the LED secured tightly to the felt.

9

You have now learned how to attach wearable components to your project. Almost there!

- Practice makes perfect! If you have never sewn before it can be quite tricky in the beginning. Don't worry, you'll get the hang of it 😊
- This video might be helpful if you are new to sewing: dojo.soy/wear-stitches

- 1 By now you have needle and thread coming out of the felt where the LED has been attached. Imagine a line between this spot and the spot you marked for the - of the battery holder. If it helps, you could draw the line on the felt. You will sew a **running stitch** along this line to connect the LED to the battery holder.
- 2 Place the tip of the needle on the line about 1cm away from where the thread is coming out of the felt and push it through, pulling the needle and thread all the way through as before.
- 3 On the other side of the felt, repeat step 2. Keep doing this until you reach the spot you marked for the - hole of the battery holder.
- 4 Next, put your battery holder into place on the felt. Then, just like you did for the LED, attach the battery holder by sewing three stitches through the - hole. Remember to make sure they are good and tight!
- 5 To finish, sew about three tiny stitches right next to where you attached the battery holder, all in the same place. This will secure the end of the thread to stop your work unravelling.
- 6 Cut the thread so that only a tiny bit is hanging out of the felt.

- Here is a video of the last bit: dojo.soy/wear-finishing



- 7 You now have half of your circuit sewn. To complete the circuit, you need to connect the + hole on the LED with the + hole on the battery holder. Use the same method you already used to connect the **negatives**. I am not including a switch in this circuit, but you could if

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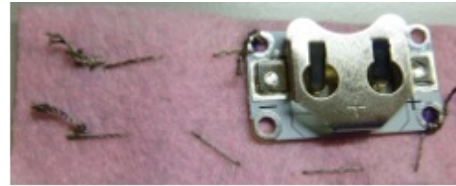
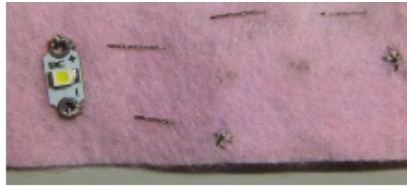


Complete a wearable circuit

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you wanted, using a third piece of thread as before.

- **Important!** Make sure the path for your **positive** thread *does not cross or touch* the **negative** thread or any edges of the battery holder anywhere. Remember, this would cause a **short circuit** (a bad thing)!



8 Insert a battery into the battery holder and watch your LED light up 😊

9 If you are attaching a pin to your badge, it is a good idea to put it onto a separate piece of felt that you attach to the back of your badge. This ensures the pin does not touch any part of your circuit—since the pin is metal that would cause a short circuit. Use ordinary ordinary thread for the extra sewing—or you could use glue or tape instead.



10 If you like, you could cover the battery holder with an extra piece of felt too. You can also decorate your badge with different coloured felt or thread. Covering the LED with felt will give it a soft glow. You design your own fashion!

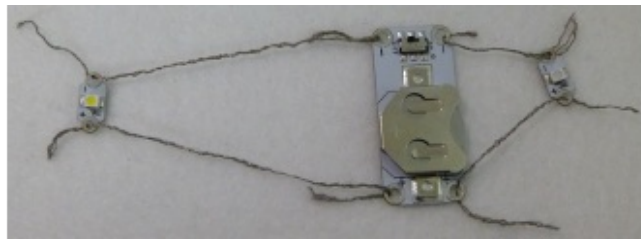
11 Congratulations! Your badge is done and you have sewn a complete wearable circuit. The following extra Sushi Cards show you how to add more LEDs and are optional.

1 Adding more LEDs to a circuit is easy! You don't need any additional batteries.

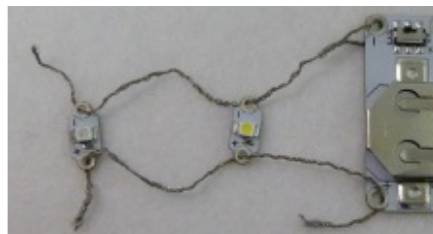
- The LEDs must be of the same type, either all sewable or all non-sewable. It works best with sewable LEDs as you can connect many more of them to the same battery without the power being reduced.

You will connect the LEDs in **parallel**. There are two ways to do this.

2 One option is to connect the LED directly to the battery, just like the first LED. It is ok to use the same holes more than once on the battery holder-the only limit is how much thread you can fit through! The circuit in the picture hasn't been sewn onto anything, so you can see the threads clearly.



3 Another option is to attach the new LED to the LED already in your circuit, instead of to the battery. You match up the + to the + and the - to the - as you would if you were connecting it to a battery. In the below example, the same two long pieces of thread are used for both LEDs. You could also use separate pieces of thread for each LED.



4 Deciding which option to use depends on where you are putting the new LED.

- The best place to connect it is usually whichever is closer.
- You also need to make sure all the different threads are kept separate and don't cross

over or touch, so it is a good idea to look at where the +s and -s are when deciding.

- 5 Take an LED and decide where on your badge you want to put it. You will sew it on and connect it to either the battery holder or the LED you already attached-whichever is easier.
- 6 Pop the battery out of the battery holder for now. When working on a circuit, it is important to always make sure is is not **live** by switching it off or taking out the battery.
- 7 Holding the LED in place, use a needle and a new piece of conductive thread to secure the - hole of the LED like you did the first time.
- 8 The next step is the running stitch. If you are connecting the LED to the other LED, then this time the stitches will go in a line towards the - hole of the other LED, instead of to the battery holder. Once you reach the correct hole, do three stitches through the it and three tiny stitches to finish, exactly as you have done before.
- 9 Now connect the + hole of the new LED, using the same method.
- 10 Ta-daa! Your badge has two LEDs on it!



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Make detachable parts

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- 1 You can also extend your badge circuit so that separate pieces of felt with their own LEDs (of the same type) can be joined onto it to make them light up!
- 2 First you will need another badge. This one will not have a battery of its own. But without a battery, where will the threads go?
- 3 When you sew your LED onto this new badge, do the running stitches all the way to the edge of the felt, or near the edge. Remember to keep the **positive** and **negative** threads separate from each other!
- 4 Then sew several medium sized stitches next to each other or in a criss-cross. You want to make it look like a "blob" of conductive thread on the felt. Finish the stitching as normal, by doing three tiny stitches in one spot before cutting the thread short.



- 5 Once you have one blob for the **negative**, and one blob for the **positive**, the new badge is ready. If you want, you can repeat these steps so that you extend the circuit to another pair of blobs at the opposite edge of the new badge, like this:



- 6 Now you just need to extend the circuit on the main badge (the one with the battery). Remember to remove the battery from the holder first.

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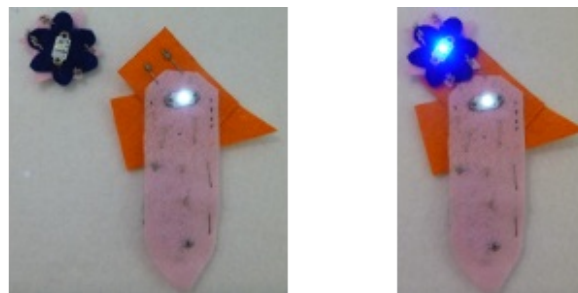
Make detachable parts

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- 7 Decide where you want the badges to join together. You will be sewing stitches from the LED on the main badge to this point, so make sure you can trace a line from the + to the **positive** blob and from the - to the **negative** blob without the lines crossing.
- 8 Mark two spots on the first badge where the **positive** and **negative** blobs touch it. You are going to sew matching blobs here for them to connect to. You can put the new badge to one side for the next bit.
- 9 Taking new thread, sew a bunch of stitches at the spot you marked for the **negative** blob. Then sew a running stitch all the way to the LED on this badge and secure it to the - hole.
- 10 Repeat step 9 to make a **positive** blob that is connected to the + hole of the same LED. When you are done it should look something like this:



- 11 Your badges are ready to be joined together! Pop the battery back into its holder. Place the new badge onto the main badge so the blobs make contact. Remember to match up + to + and - to -. You should see the new badge suddenly light up!



- 12 You could use this technique to make a simple soft switch on your project, for example put a **positive** blob at either end of a bracelet that come in contact when you close it.