Circuit Sticker Sketchbook

LEDs, Switches & Sensors
by Jie Qi

and you:

_____

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HOW TO USE THIS BOOK

Welcome to the Circuit Sticker Sketchbook!

This book will guide you through the process of building paper circuits. You can craft your circuits right on the pages, following the explanations and templates.

Start with the **Components & Materials** section to get familiar with all the parts in your kit. Then go through the activities. Each chapter introduces a new idea that builds on previous chapters. Once you've built your **template circuit**, check out the **drawing activity**. Half the fun of creating circuits is telling stories with light! The **Your Turn** page lets you be even more creative by building your own circuit and story. The **Try This!** section gives ideas for even more things to explore.

If you run into problems, check out the **debugging** section in the back for answers to common questions. If you need more help, please visit our forum at **chibitronics.com/community**.

Happy circuit crafting!

Components & Materials

COMPONENTS & MATERIALS

Coin cell battery

top (+) **bottom (–)** **side view**

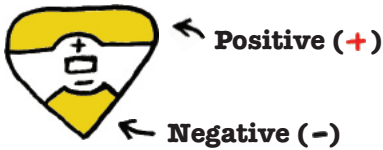
A battery provides power to your circuit. The top side is marked "+" and the edges of the battery are also positive. The bottom side is negative. Simply touching conductive material to the battery causes an electrical connection.

Note: *store your batteries separately, and away from other bits of metal. This avoids accidental connections that can drain the batteries.*

Binder clip

Binder clips are handy for holding your battery in place. You can also use other types of clips. For more battery holder ideas, go to **chibitronics.com**

LED stickers



LEDs, which stand for **light emitting diodes**, glow when powered. The LED sticker is shaped like an arrow pointing from + to -. The wide, flat metal pad is the "+" end and the pointy metal pad is the "-" end.

Connections to the LED sticker are made by sticking the metal pads on top of conductive materials. You can also solder to the metal pads, for a robust, permanent connection. Stickers can also be sewn into material using conductive thread. Small starter holes in each pad help a sewing needle pass through easily.

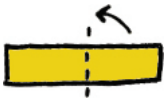
LED stickers come in clusters of 6 stickers. W is for white, R for red, B for blue and Y for yellow.

Copper foil tape

Copper foil tape is made of copper metal, so it is a great conductor of electricity. It also solders just like metal wire, and the adhesive on the back is partially conductive.

Copper tape is soft enough to cut, fold and tear by hand so you can treat it like regular tape. Thinner tape is easier to work with, so we recommend cutting your tape in half length-wise.

A connection works best when made with a continuous strip of tape. Thus, when turning corners it's recommended to fold the tape, rather than cut the tape and stick it together.



Fold tape back, exposing the sticky side

Flip and turn the tape, to form a corner

Flatten the corner and you're done!

Black conductive plastic sheet

The black plastic sheet conducts electricity, but not nearly as well as metal foils. Also, its conductivity changes when you press or stretch the sheet. We will use this material to create do-it-yourself pressure sensors.

Extra double-sided adhesive sheet

Use this double-sided conductive adhesive to recycle used stickers that have lost their tack. This is the same adhesive that comes on the back of the stickers.

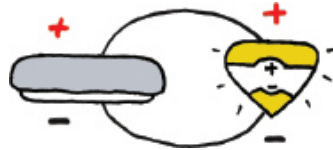
To “resticker” old stickers, carefully clean off the old adhesive on the bottom of the sticker. Be careful not to fold or crease the sticker, as this can break the internal circuitry.

Peel the paper backing off one side of the double-sided adhesive, and apply the adhesive to the cleaned sticker. Finally, cut away any extra adhesive, and your circuit sticker is ready to use again!

1. SIMPLE CIRCUIT

1. SIMPLE CIRCUIT

Let's get started by lighting an LED! We will use the foil tape to connect a battery to the LED in a loop. The "+" side of the LED sticker needs to connect to the "+" side of the battery and the "-" point of the sticker to the "-" side of the battery. This continuous loop is a **complete circuit**.



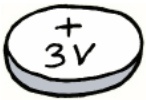
Battery **LED**

Electrons only flow in loops, and this complete circuit allows electrons to flow from the battery, through the LED, and back into the battery. This round-trip flow of electrons, called **current**, causes the light to turn on and shine.

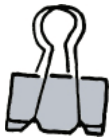
Electrons are lazy, and always take the path of least resistance. Since electrons prefer to take a "shortcut" through foil, rather than do work lighting an LED, an accidental foil connection from + to - will quickly drain the battery, and the LED will not light. This condition is called a **short circuit**.

You will need:

x 1 LED circuit sticker



x 1 3V coin cell battery



x 1 binder clip

conductive foil tape

Directions:

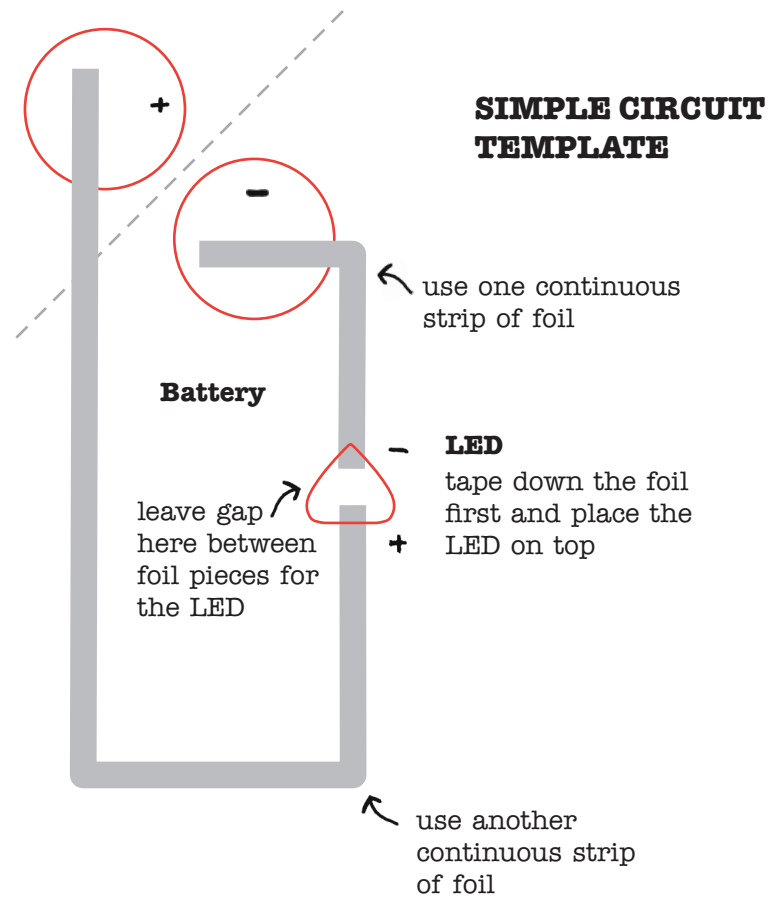
1. Turn to the template on the next page and stick foil tape over the gray lines.

Note: *Apply the foil as a continuous piece, rather than separate pieces, even when turning corners. The adhesive on the bottom side of the foil makes a weak connection.*

2. Fold the page corner along dotted line and place the battery "+" side-up over the "-" circle.

3. Fold the corner flap over, and clip the battery in place with a binder clip.

4. Stick the LED sticker onto the foil, over the footprint. The light will turn on!

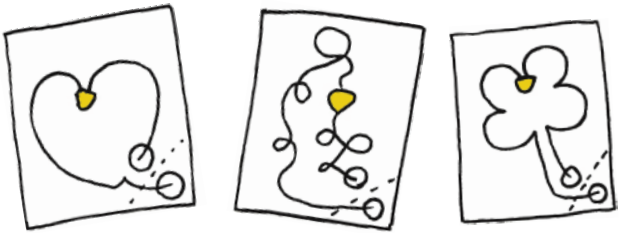

SIMPLE CIRCUIT TEMPLATE
+
−
use one continuous strip of foil
Battery
− LED
tape down the foil first and place the LED on top
+
leave gap here between foil pieces for the LED
use another continuous strip of foil

5. With the LED on, flip to the next page. You've turned on the lightbulb! What is the lightbulb illuminating? Complete the scene with your own drawing!

What does the lightbulb illuminate?
Draw it here!

YOUR TURN!

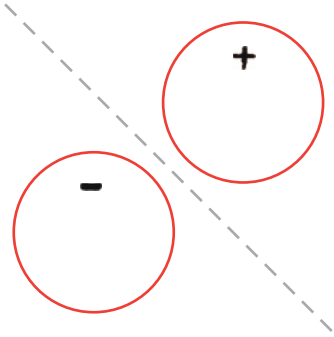
On the blank template to the right, build another circuit that turns on a light. Play with the foil to make different lines and shapes!



Make sure that the two pieces of copper do not touch or cross, or else you will create a short circuit.

If you want two pieces of copper to cross without connecting, just place a piece of paper in between the two copper foils.

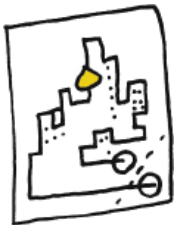
To connect two pieces of copper foil, tape one piece over the other and press the tape down firmly for the conductive adhesive to make a good contact. For more permanent connections, you can also solder the copper tape pieces together.



TRY THIS!

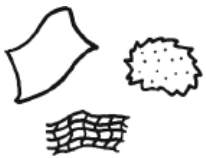
Now that you've learned how to make a light shine, here are some more things to try!

Make a circuit drawing

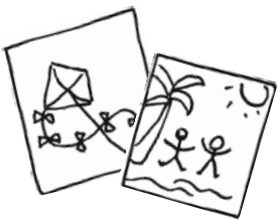


Use the foil tape in your circuit to create a design. Decorate your circuit with other craft materials to complete the scene.

Play with light diffusion



What happens when you put a tissue over the light? How about a piece of fabric? Or even a photograph?

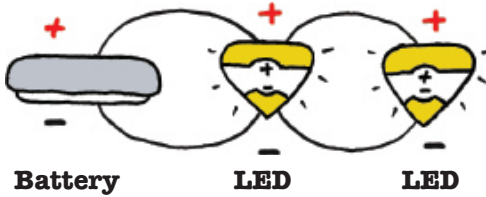


Try diffusing your LED's light through different materials and see what effects you can come up with!

2. PARALLEL CIRCUIT

2. PARALLEL CIRCUIT

Now add more lights to your circuit! To turn on multiple LEDs with one battery, you can make a parallel circuit. Here, we connect the "+" end of multiple LED stickers to the "+" side of the battery and the "-" points of the LEDS to the "-" side of the battery.

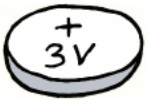


This creates multiple loops for electricity to flow, turning on all of the LEDs at the same time with only one battery.

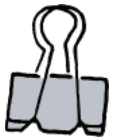
This is called connecting LEDs **in parallel**. You can add as many LEDs as you want, though the LEDs will all get slightly dimmer as you add more to the circuit.

You will need:

x 3 LED circuit stickers



x 1 3V coin cell battery



x 1 binder clip

conductive foil tape

Directions:

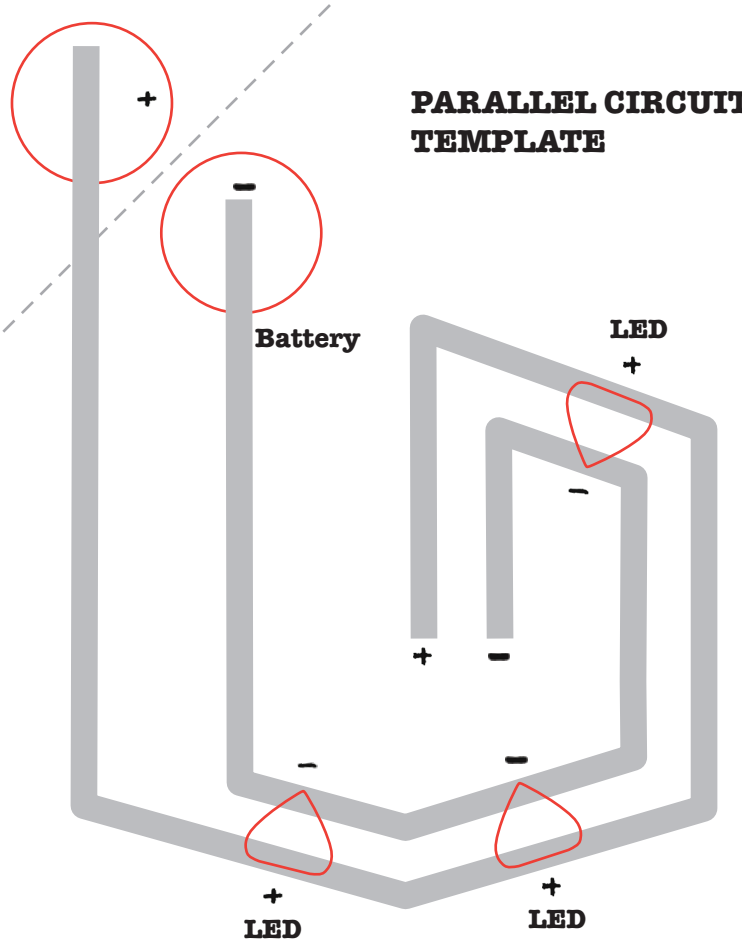
1. Turn to the template on the next page and stick foil tape over the gray lines to create a "track" for your LED stickers. You will be able to place stickers anywhere along this track.

2. Fold the page corner along dotted line and place the battery "+" side-up over the "-" circle.

3. Fold the corner flap over, and clip the battery in place with a binder clip.

4. Stick LED stickers onto the foil track, over the footprints. Choose any colors you like. All the lights will turn on!

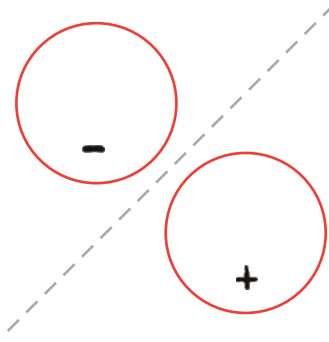
5. Now flip to the next page. You've created stars! How would you add more stars to the constellation? Try adding another LED to your parallel circuit.


PARALLEL CIRCUIT
TEMPLATE
+
−
Battery
LED
+
−
+
−
−
−
+
LED
+
LED

Add more stars to the sky by
lighting up more LEDs!

YOUR TURN!

Complete the nighttime scene by making another glowing parallel circuit on the blank template.

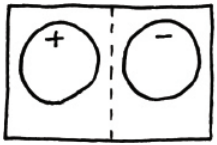


TRY THIS!

Here's how to take your circuits off the page and make anything shine!

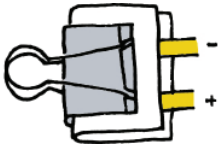
Make your own battery holder

1. Fold a small piece of paper in half and trace an outline of the battery on each side of the fold. Mark one circle "+" and the other circle "-".

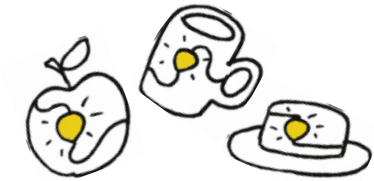


2. Make leads by sticking copper tape onto each circle, with the rest of the leads extending off the paper.

3. Clip your battery in place. You just made a battery holder!



Decorate with circuits

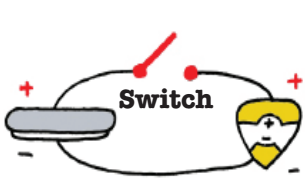


Decorate your favorite things with LED circuits! Avoid metal surfaces as these may cause unwanted short circuits.

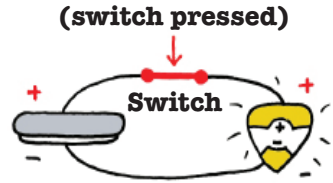
3. DIY SWITCH

3. DIY SWITCH

You can make your projects interactive by using a switch to control your lights! A **switch** is a gap in your circuit that can be connected and disconnected using another piece of foil, turning things on and off.



OPEN switch:
LED is OFF



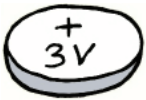
CLOSED switch:
LED is ON

When the switch is **closed** the light turns **on** because the loop is complete and electrons will flow through your circuit. When the switch is **open**, electrons cannot find a closed loop; so, they will stop flowing, and the light will turn **off**.

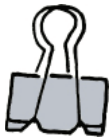
Let's make a paper push-button switch that turns a LED on when you press the button!

You will need:

x 1 LED circuit sticker



x 1 3V coin cell battery



x 1 binder clip

conductive foil tape

Directions:

1. Turn to the template on the next page and stick foil tape over the gray lines.

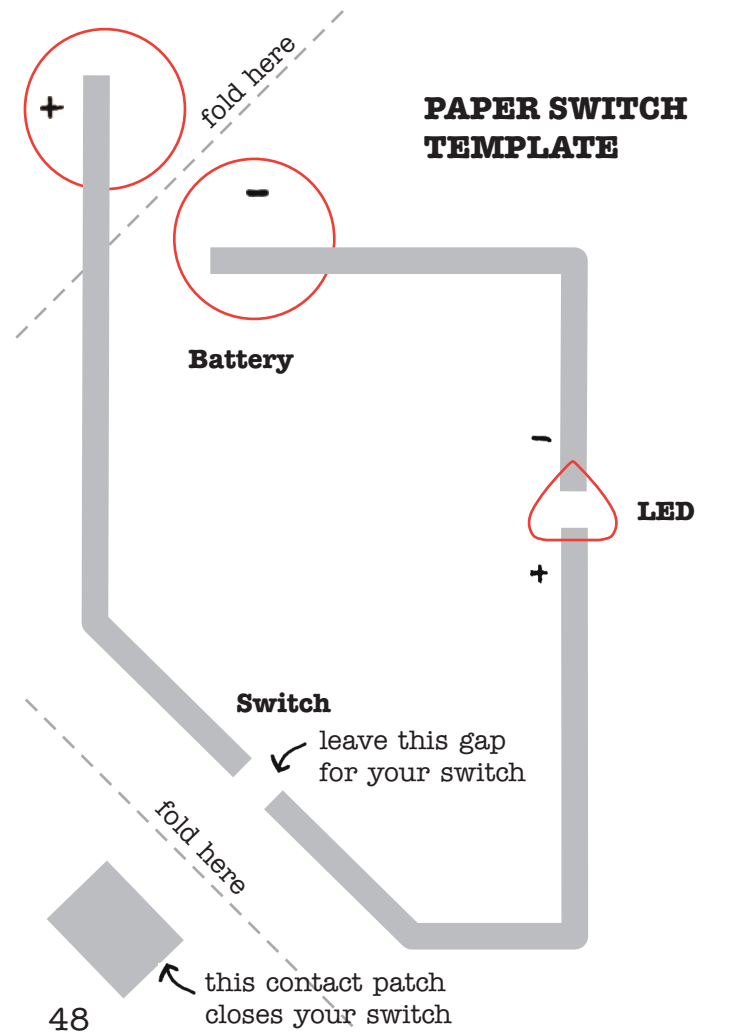
2. Cover the lonely gray patch with conductive foil. This forms the contact of the switch.

3. Fold the bottom page corner along the dotted line so that the patch closes the gap. Congrats! You just made a switch.

4. Crease the top page corner along the dotted line and clip your battery in place with a binder clip (see previous activities for details).

5. Stick an LED sticker over the footprint. When you press down on the switch, your LED will glow!

6. Now turn the page. What happens when you press the “do not press” button? Draw it on the page!

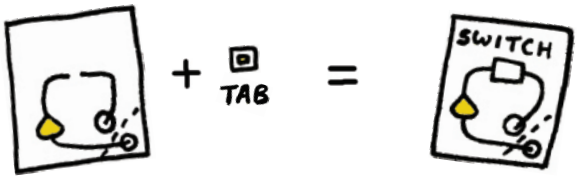

+
fold here
PAPER SWITCH TEMPLATE
−
Battery
−
LED
+
Switch
leave this gap for your switch
fold here
this contact patch closes your switch

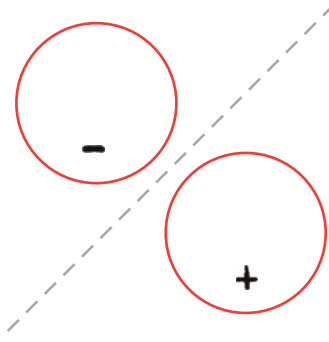
DO NOT
PRESS

What happens when you press the button? Draw it here!

YOUR TURN!

Switches don't have to be just at the corner of the pages. Just glue or tape a flap of paper with copper foil on the bottom side anywhere on the page, and use this to close the gap in your switch. Try making a switch somewhere in the middle of the page!

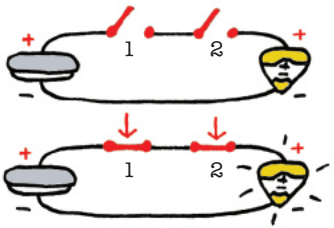




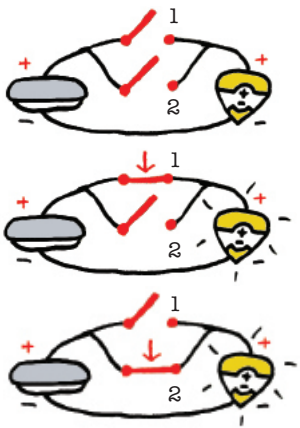
TRY THIS!

Putting multiple switches in one circuit creates even more complex interactions. Create a story for these types of logic switches!

AND/OR Switch logic



If you put multiple switches in a single loop ("in series"), you have to press all the switches at the same time to turn on your light. This is called a logical **AND** because you have to press *Switch 1* ***and*** *Switch 2* to make a complete circuit.



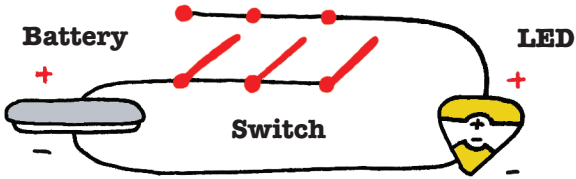
You can also connect multiple switches using different branches ("in parallel"), so that pressing any one of them will turn on your circuit. This is called a logical **OR** because you can press *Switch 1* ***or*** *Switch 2* to make a complete circuit.

4. BLINKING SLIDE SWITCH

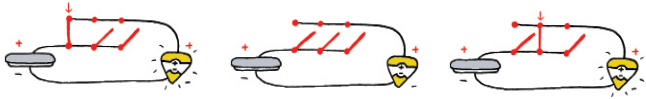
4. BLINKING SLIDE SWITCH

You can craft all sorts of switches that open and close gaps in the circuit, or even combine them to create more complex switches.

In the blinking slide switch, there is one long gap and multiple places you can press to close the circuit. This is an implementation of the "OR" switch logic introduced on page 55.



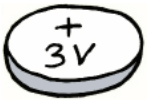
Here, as you press down and slide your finger along the switch, the gap opens and closes, causing the light to blink on and off!



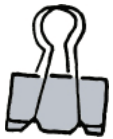
LED ON **LED OFF** **LED ON**

You will need:

x 1 LED circuit sticker



x 1 3V coin cell battery



x 1 binder clip

conductive foil tape

scissors

Directions:

1. Turn to the template page and stick foil tape over the gray lines.

2. Stick the LED sticker onto the foil, on the footprint

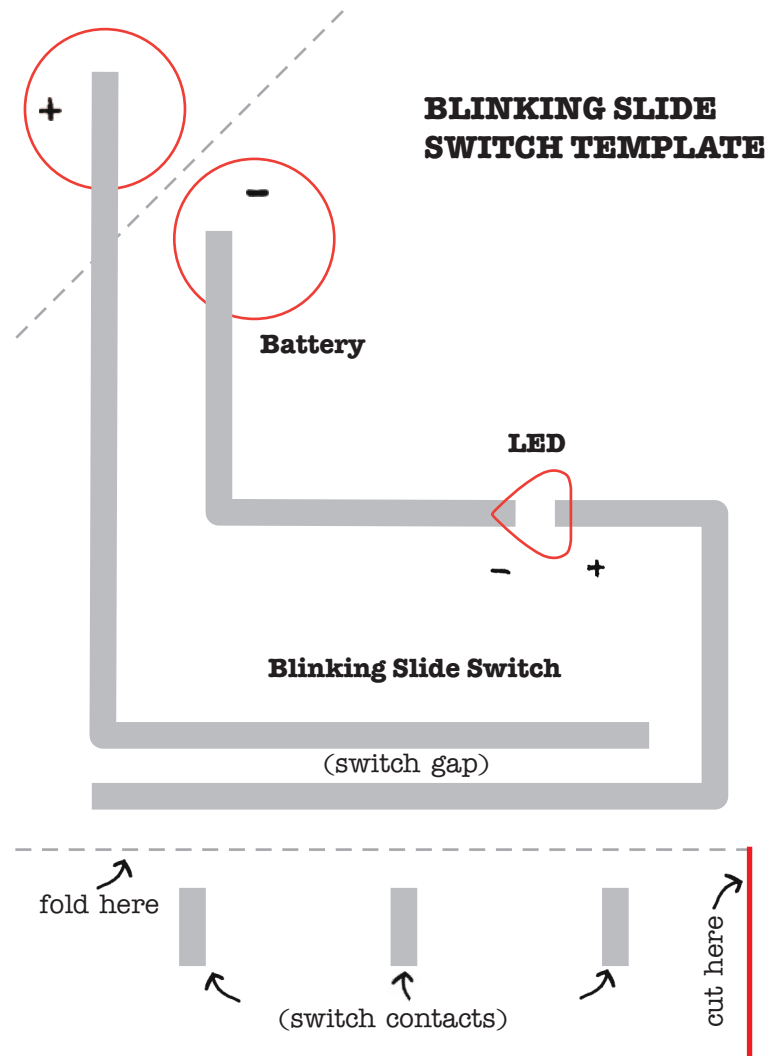
3. Create your battery holder and clip your battery in place (see previous activities for details).

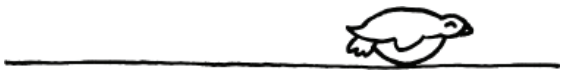
4. Cut along the bold red line

5. Fold up along the horizontal dotted line to make your blinking switch. Press and slide your finger across this switch, and the light will blink on and off!

6. Change the blinking pattern by moving or adding switch contact pieces!

press and slide here

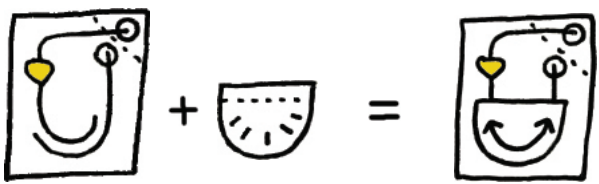

BLINKING SLIDE
SWITCH TEMPLATE
+
−
Battery
LED
−
+
Blinking Slide Switch
(switch gap)
fold here
(switch contacts)
cut here

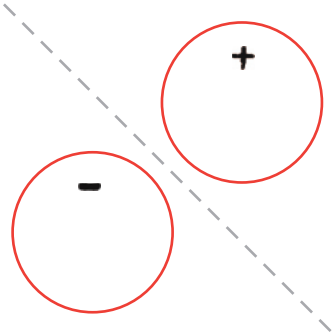


What happens when the penguin slides across the page? Draw it here!

YOUR TURN!

You can make a blinking slide switch in any shape — not just a straight track. Just make the gap in your switch a different shape and glue a corresponding flap for the switch contacts. Try making a curved, or even circular path!

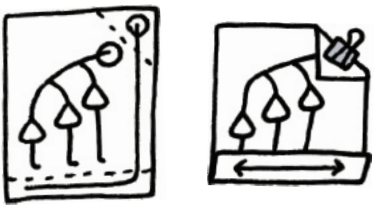




TRY THIS!

You can make all sorts of effects by crafting new kinds of connections and arranging your lights.

Animate with lights



Try connecting different LED branches along a single slide switch.

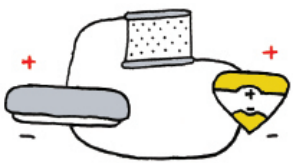
When you press your finger along this path, the LEDs will turn on in order, creating an animation!

5. DIY PRESSURE SENSOR

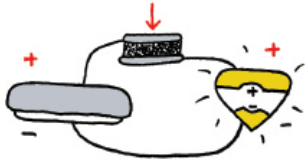
5. DIY PRESSURE SENSOR

Rather than turning your lights fully on or fully off with a switch, you can gradually fade your LEDs in and out using a pressure sensor. The black conductive plastic in your kit has a **resistance** that changes with pressure. In other words, how well it conducts electricity changes when you press on it. We can use this to make a pressure sensor.

The harder you press, the better the material conducts, and the brighter your light shines.



Sensor NOT pressed: LED is dim

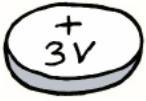


Sensor pressed: LED is bright

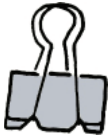
When you don't press, conductive particles in the plastic are far apart. Electrons cannot flow well, so your light is dim. When you do press, the particles are squashed together and the electrons can find more and easier paths to flow, and likewise the light gets brighter.

You will need:

x 1 LED circuit sticker



x 1 3V coin cell battery



x 1 binder clip

conductive foil tape

black conductive plastic

Directions:

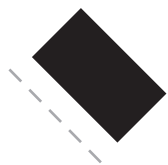
1. Turn to the next page and stick foil tape over the gray lines.

2. Fold the top page corner along dotted line and clip your battery in place with a binder clip.

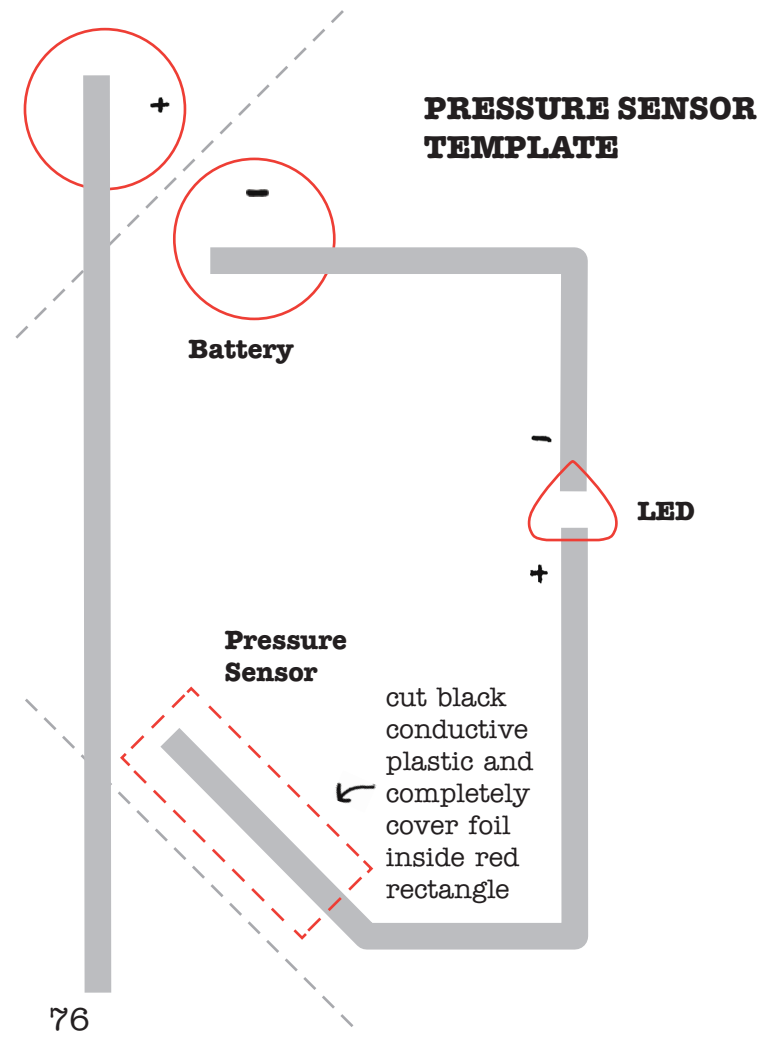
3. Stick an LED sticker over the footprint and fold along the dotted line at the bottom of the page. Your LED will turn on, since you've just made a switch!

4. Unfold the switch you just made and cut the black conductive plastic in the shape of the red dotted rectangle.

5. Put the plastic over the dotted rectangle and fold the bottom flap again. Now when you press, the light will become brighter the harder you press – you just made a pressure sensor!



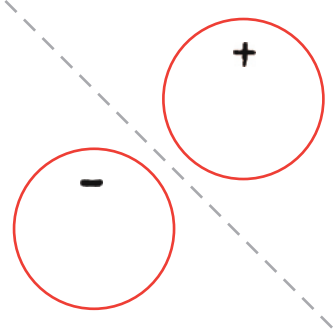
6. Turn the page. When you press on the heart, something comes to life! What is it?


PRESSURE SENSOR TEMPLATE
+
−
Battery
−
LED
+
Pressure Sensor
cut black conductive plastic and completely cover foil inside red rectangle

What comes to life when you press the heart?
Draw it on this page!

YOUR TURN!

You can turn any of the switches we've made into pressure sensors, just by placing a piece of black conductive plastic in between the contact and the gap. Try making a switch somewhere on this page using a flap of paper, and then turn it into a pressure sensor!



TRY THIS!

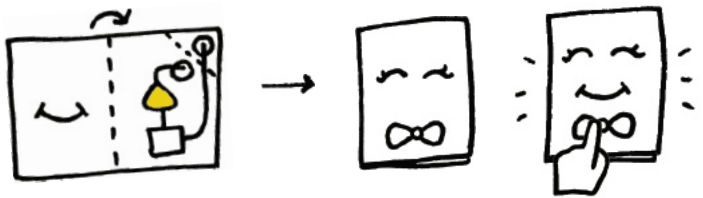
Lots of cool effects happen when fading in and out instead of blinking on and off. Try these!

Make a bend sensor

You can use the conductive plastic to make a bend sensor. Just make a long switch and place the plastic in between the gap and the contact. When you bend the sensor, the light will shine brighter!

Secret messages

By drawing images on the back side of a page so that it covers your light when the page is folded, you can make images that appear only when the light shines through. The brighter the light, the clearer the image's shadow will appear!



DEBUGGING

DEBUGGING

So your light doesn't turn on?

No worries! Use this guide to carefully review the circuit, and it's likely you will discover how to make it shine the way you want.

Is the LED backwards?

If your LED is in reverse, it won't shine. A quick way to check is to flip your battery over in the battery holder. This reverses the + and - terminals, thus matching the connections of a reversed LED.

Is the LED connected?

Sometimes a connection just isn't strong enough. Try pressing on the metal pads of the LED stickers to make sure they are firmly connected to your foil tape. The LED stickers work best with foil that is flat, not wrinkled. Flatten wrinkled foil by rubbing it with a soft pencil eraser.

Is the battery connected?

Try pressing on the battery and re-clipping the battery to ensure that the foil tabs in the battery holder are actually touching the battery's contacts.

Is the battery shorted?

If the + and - sides of your battery are connected directly with a metal such as copper foil, you will drain power from the battery rather than turn on the light. Inspect your circuit and make sure that the foil traces from the + and - sides of the battery are not accidentally touching.

Is the battery dead?

Sometimes the circuit doesn't turn on simply because the battery is out of power. Try switching your battery out for a fresh one.

Are the copper tape connections secure?

If you taped two pieces of copper foil together to make a circuit, try pressing very hard on the intersection to see if there is a connection issue. When overlapping foil, use a large area of overlap to increase connection strength.

Is there a crack in the copper tape?

If you fold copper tape too many times, it can crack and break the connection. Try re-taping that trace with a fresh piece of foil. If you have access to a soldering iron, you can also solder the circuit back together.

Circuit still not working?

For more tips on debugging and more fun project templates, visit our website at:

chibitronics.com

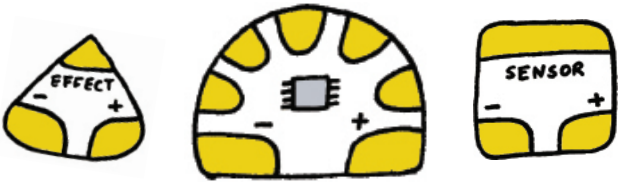
And get your questions answered on the message board at:

chibitronics.com/community

ADDITIONAL RESOURCES

If you had fun crafting with Circuit Stickers, try some of our more advanced projects!

Effects, sensors, microcontroller stickers!



For downloadable tutorials and templates on how to use Effects, Sensors and programmable Microcontroller stickers, please visit

CircuitStickers.com/templates

Share your projects!

Want to share your creations with the world and see what others are making with Circuit Stickers? Submit your projects at

circuitstickers.tumblr.com

AUTHOR'S BIO

Jie Qi is a PhD student at the MIT Media Lab where she looks at new materials and techniques for blending electronics with arts and crafts. She hopes to spread her love of creating imaginative and personally meaningful technology.

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