Paper Circuits Level 2

Circuit Sticker Sketchbook

LEDs, Switches & Sensors
by Jie Qi

and you:

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Third Edition

A digital version of this book is available to download for free at:
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CONTENTS

HOW TO USE THIS BOOK

Welcome to the Circuit Sticker Sketchbook!

This book will guide you through the process of building paper circuits. You will be crafting your circuits right onto the pages of this book!

Start with the COMPONENTS & MATERIALS section to learn some key concepts and get familiar with all the parts included in your kit. We've put key words in **bold**, which you can up in the GLOSSARY & INDEX section on page 105 to learn more. Be sure to review BATTERY SAFETY on page 99 to learn how to use and dispose of your batteries safely.

Then go through the CHAPTER ACTIVITIES. Each chapter introduces new circuit concepts that build on previous chapters. Once you've built your *template circuit,* try the *drawing activity.* Half the fun of making paper circuits is bringing stories to life with light!

The *YOUR TURN* sections give you space to create further by designing and building your own circuits and stories from scratch. The *TRY THIS!* sections share even more ideas to explore.

The chapter activities also come with online companion videos. You can find them at this link:
go.chibitronics.com/CSVideo

If you run into problems, check out the HELP & DEBUGGING section on page 85 for answers to common questions. It's okay if your circuit doesn't work at first. In fact, debugging is a natural part of the learning and making process!

If you ever feel stuck, want to ask a question, or have something to share, please reach out to us at:
help@chibitronics.com

We're here to help and excited to hear from you!

For a free PDF download of this book, as well as other language translations, go to this link:
go.chibitronics.com/CSBook

Happy making :)

—Jie & Chibitronics Team

Components & Materials

COMPONENTS & MATERIALS

LED Stickers

LEDs, which stand for **light emitting diodes**, shine when powered by **electricity**. All LEDs have a **positive** "+" side and a **negative** "-" side. This is called the **polarity**.

The **LED stickers** in your kit are shaped like arrows pointing from "+" to "-." The wide, flat metal pad is the "+" end and the pointy metal pad is the "-" end.

You can connect LED stickers to circuits by simply sticking the metal pads over **conductive** materials. Conductive means that electricity can flow through it. Advanced users can also solder to the metal pads on top for a more permanent connection.

LED stickers come in different colors, marked by the first letter of the color: "R" for red, "O" for orange,

"Y" for yellow, "G" for green, "B" for blue, "P" for pink, and "W" for white. LED stickers also come in various effects, such as blinking or color-changing. These LED stickers have different shapes:

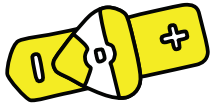
Color Changing

Blinking

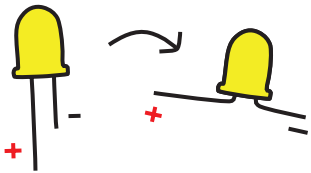
Fading in and out

LEDs also come in many different shapes and sizes other than stickers.

For example **Launchpad LEDs** have large pads for easy taping.

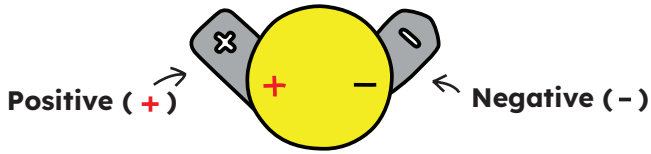


Through-hole LEDs, which are commonly found in everyday electronics products, have a dome shaped lens and wire legs. The longer leg is "+" and the shorter leg is "-."



These legs can be bent out, so the LED lays flat on the page, and taped down for making paper circuits.

Battery



A battery provides power to your circuit. Batteries also come in many shapes and sizes. The **Launchpad Battery** in your kit has two metal tabs: one marked "+" for positive and the other marked "-" for negative. Touching conductive material to the battery's tabs creates an electrical connection.

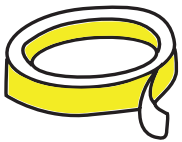
Note: *Store your batteries separately and away from metal. This avoids accidental connections that can drain the batteries. Check out the BATTERY SAFETY section on page 99 for more important information.*

Binder Clip

The **binder clips** in your kit are handy for holding the Launchpad Battery in place and connecting it to your circuit.

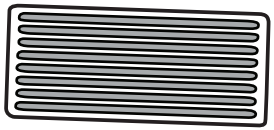
Conductive Tapes

Conductive tapes allow electricity to flow just like wires. They come in many forms like shiny metal **copper tape** and **conductive fabric tape**, which feels like ribbon. They also come in different shapes and sizes like rolls, **strips**, or sticker **patches**.

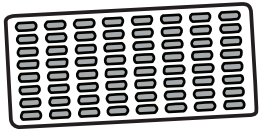


Copper Foil Tape

Conductive Fabric Tape



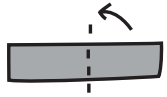
Fabric Tape Strips



Fabric Tape Patches

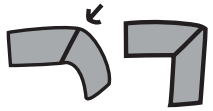
The conductive fabric tape in your kit, which comes in a roll and as strips on a sticker sheet, is soft but also very sturdy. Just like regular ribbon, you you will need scissors to cut it. You can also stick pieces of conductive fabric tape together to create an electrical connection because its adhesive is conductive too.

To turn corners with tape, rather than cutting and sticking multiple pieces together, try this folding trick instead for a stronger electrical connection:



1. Fold the tape back, exposing the sticky side

2. Flip and turn the tape in the new direction, creating a corner



3. Flatten the corner and you're done!

This is especially important for working with copper tape because its adhesive is not as conductive as the adhesive on conductive fabric tape.

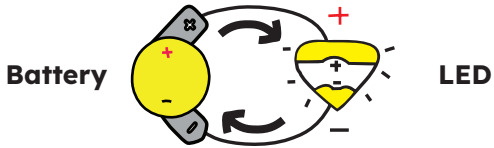
Conductive Pressure Sensor Sheet

The **conductive pressure sensor sheet** is a black plastic sheet that conducts electricity, but not as well as conductive tapes or metal wire. What's unique about this material is that its conductivity changes when you press on or squeeze the sheet. We will use it to create **pressure sensors** in CHAPTER 5, page 71.

1. Simple Circuit

1. SIMPLE CIRCUIT

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

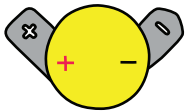


A complete circuit allows **electrons** in the circuit to flow from the battery, through the LED, and back into the battery. This round-trip flow of electrons through the circuit, called **current**, is the **electricity** that powers your light and makes it turn on.

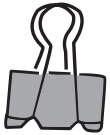
Electrons are lazy, and always take the path of least resistance. Since electrons prefer to take a "shortcut" through the tape, rather than do work lighting an LED, an accidental connection from + to - will quickly drain the battery, and the LED will not light. This condition is called a **short circuit**.

YOU WILL NEED:

x 1 LED Sticker



x 1 Launchpad Battery



x 2 Binder Clips

Conductive Tape or Tape Strips

Scissors

DIRECTIONS:

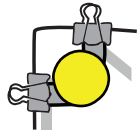
1. Turn to the template on the next page and stick conductive tape over the light blue line. Cut any extra tape with scissors.

✦ ***Note:*** *Try using a continuous piece of tape and folding at the corners (see Folding Technique on page 13).*

2. Stick conductive tape over the red line.

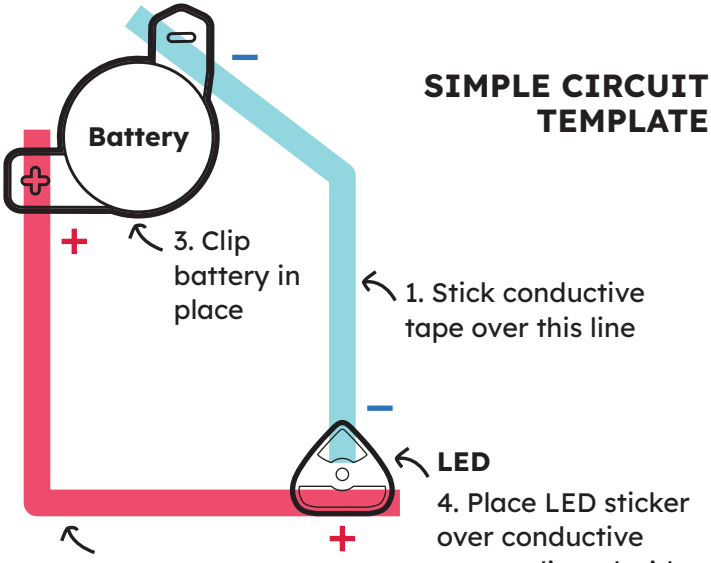
3. Place the Launchpad Battery over the footprint. Make sure the + and - battery tabs line up over the conductive tapes.

Clip the battery tabs in place using the two binder clips.



4. Stick the LED sticker over the footprint and press firmly. The light will turn on!

SIMPLE CIRCUIT TEMPLATE



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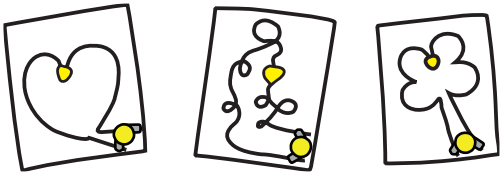
5. With the LED on, flip to the next page. You've turned on the lightbulb! What does it illuminate? Complete the scene with your own drawing!

Note: *Is your LED not lighting up? No worries! Check out the HELP & DEBUGGING section on page 85 for common issues and tips on how to troubleshoot circuits.*

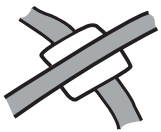
What does the lightbulb illuminate?

YOUR TURN!

On the blank template to the right, build another circuit that turns on a light. Play with the tape to make different lines and shapes! Don't forget to leave a small gap between the + and - tapes for the LED sticker.



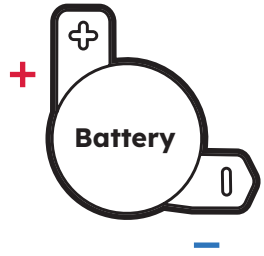
Make sure that + and - conductive tapes do not touch or cross to avoid a short circuit.



If you want two conductive tapes to cross without connecting, place a piece of paper between them.

To connect two pieces of conductive tape, stick one piece over the other with plenty of overlap and press down firmly to make good contact.

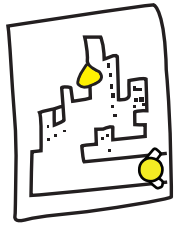
If you're using copper tape, you can also solder the pieces together.



TRY THIS!

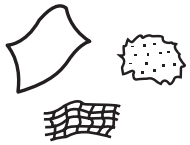
Now that you've learned how to make a light shine, here are some more things to try!

Make a Paper Circuit Collage

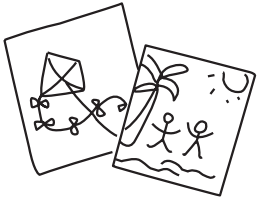


Use the conductive tape in your circuit as lines for drawing. Decorate the circuit with other craft materials to complete your paper circuit collage!

Play with Light Diffusion

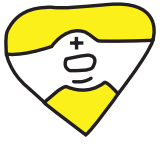


What happens when you put colored tissue paper over the light? How about a piece of fabric? Or even a photograph?



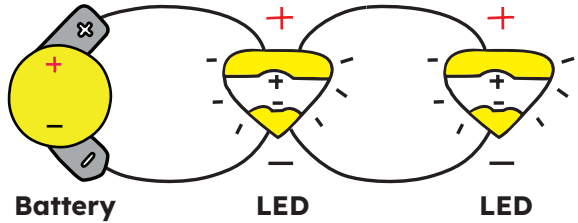
Try diffusing your LED's light through different materials and see what effects you can come up with!

2. Parallel Circuit



2. PARALLEL CIRCUIT

Now let's 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 + tab of the battery and the - points of the LEDs to the - tab of the battery.

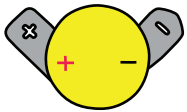


This creates multiple loops for electricity to flow, turning on all of the LEDs at the same time with only one battery.

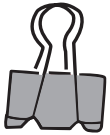
This is also called connecting LEDs **in parallel**. You can add as many LEDs as you want, though the LEDs will all get slightly dimmer as you add more to the circuit. Your battery will also drain more quickly as you add more LEDs since it's working harder to power more lights.

YOU WILL NEED:

x 3 LED Stickers



x 1 Launchpad Battery



x 2 Binder Clips

Conductive Tape or Tape Strips

Scissors

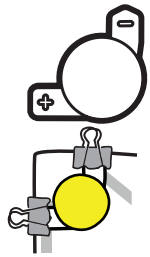
DIRECTIONS:

1. Turn to the template on the next page and stick conductive tape over the blue and red lines, like the Simple Circuit (page 20). This makes a "track" for your LED stickers.

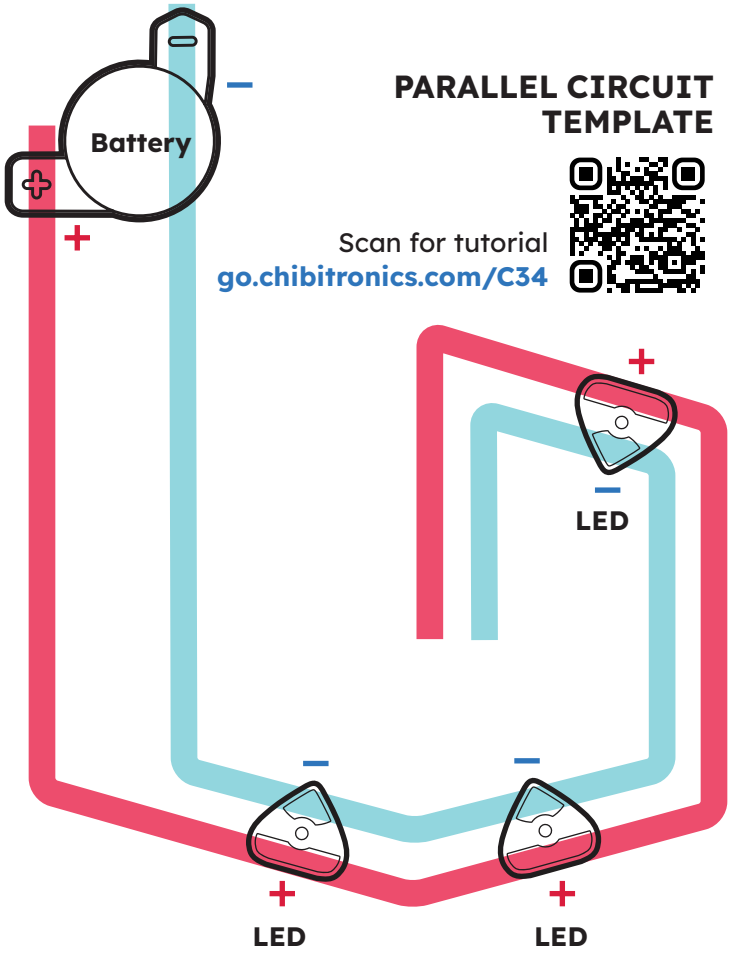
✦ ***Note**: You can place LED stickers anywhere along this track to turn them on. Just make sure the direction of + and - ends match on the battery and LEDs.*

2. Place the Launchpad Battery over the footprint. Make sure the + and - battery tabs line up over the conductive tapes.

Clip the battery tabs in place using the two binder clips.



3. Stick the LED stickers onto the tape track, over the footprints. Choose any color LEDs you like. They will all turn on!

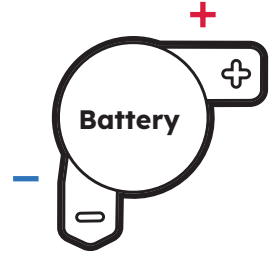


4. Now flip to the next page. You've created stars! Can you add more stars to the constellation? Try adding another LED to your parallel circuit.

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

YOUR TURN!

Complete the nighttime scene by making another glowing parallel circuit track for your LEDs on the blank template to the right.

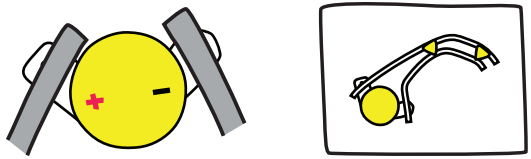


TRY THIS!

Let's try taking your circuits off the page and into the world. You can make anything shine!

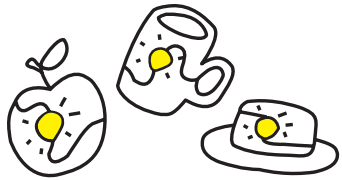
Tape Directly to the Battery

In addition to binder clips, you can also tape directly to your battery tabs using conductive tape.



The conductive tape holds the battery in place while also creating electrical connections to your battery. This way your battery can go anywhere on a flat surface, not just clipped to the edge!

Decorate with Circuits

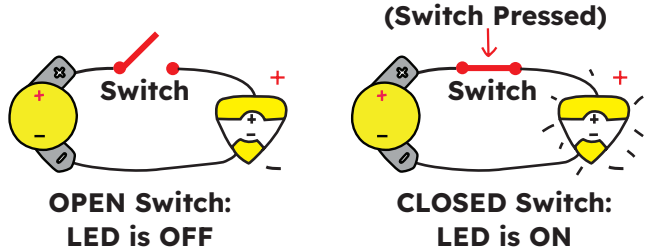


Try decorating your favorite things with LED circuits! Make sure to avoid metal surfaces as these may cause unwanted short circuits.

3. DIY Switch

3. DIY SWITCH

You can make your projects interactive by using a switch to control your lights! A **switch** is made up of two parts: a **switch gap** in your circuit and the **switch contact**, another piece of conductive material that can connect and disconnect the gap, turning things on and off.

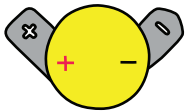


When the switch is **closed**, and the gap is connected, the light turns ON because the loop is complete and electrons are able to flow through your circuit. When the switch is **open**, and the gap is disconnected, electrons cannot find a closed loop. So they will stop flowing, and the light will turn OFF.

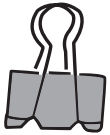
Let's make a paper push-button switch that turns an LED on when you press the button!

YOU WILL NEED:

x 1 LED Sticker



x 1 Launchpad Battery



x 2 Binder Clips

Conductive Tape or Tape Strips

Scissors

DIRECTIONS:

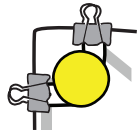
1. Turn to the template on the next page and stick conductive tape over the blue and red lines.

2. Cover the lonely gray patch with a few pieces of conductive tape. This forms the contact of the switch.

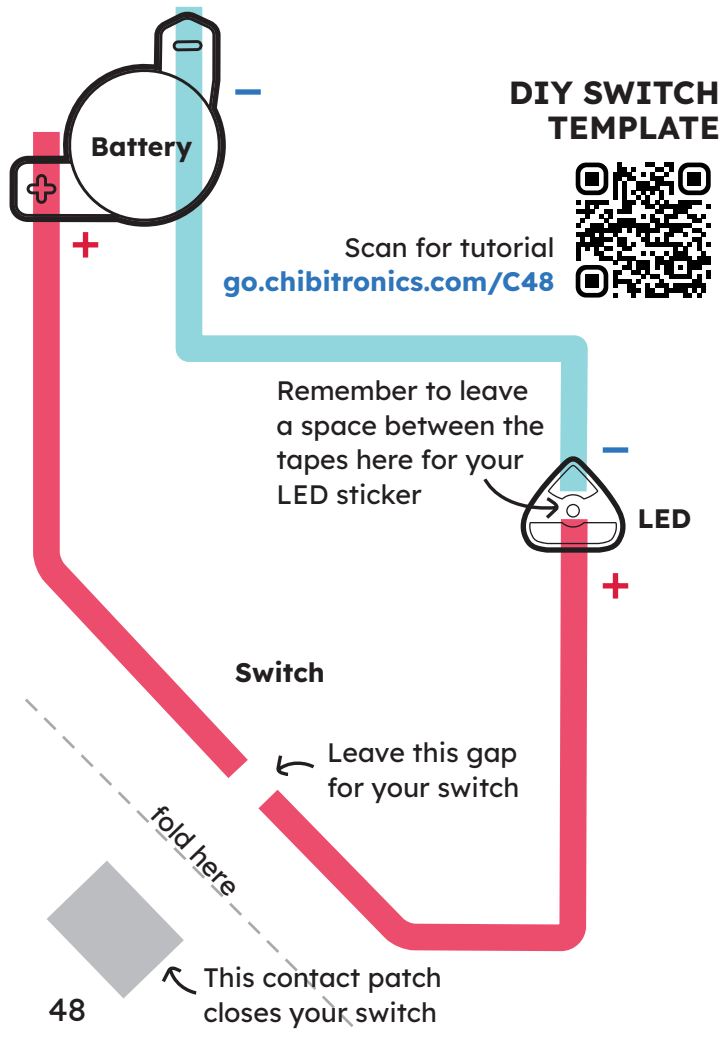
3. Fold the bottom page corner along the dotted line so that the patch can close the gap. Congrats! You just made a switch.

4. Place the Launchpad Battery over the footprint. Make sure the + and - battery tabs line up over the conductive tapes.

Clip the battery tabs in place using two binder clips.

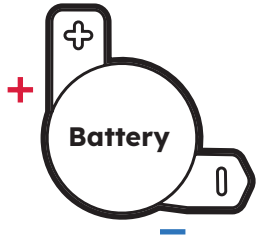


5. Stick an LED sticker over the footprint. When you press down on the switch, your LED will shine!



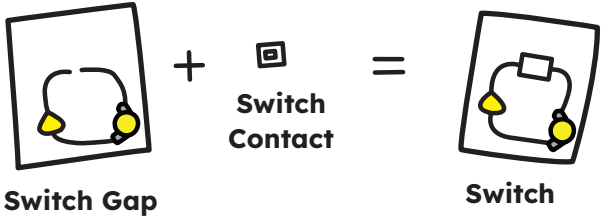
6. Now turn the page. What happens when you press the "?" button? Draw it on the page!

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



YOUR TURN!

You can add a switch anywhere on the page! Just create a switch gap in your circuit and then glue or tape a flap of paper with a conductive tape patch on it to make the switch contact.



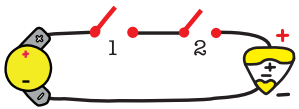
This way, when you press the flap with the conductive patch, it will close the gap in your switch and turn on the light. Try making a switch somewhere in the middle of the page!

TRY THIS!

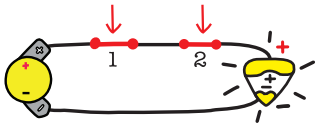
Putting multiple switches in one circuit lets you create even more complex interactions. Create a story for these different types of logic switches!

AND Switch

If you put multiple switches one after the other **in series** in a single loop, like beads on a thread, 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:

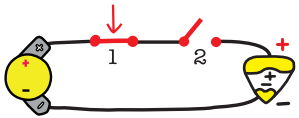


LED Off

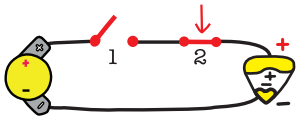


LED On

If you press only one of the switches, then there is still an open gap in your circuit, so the electrons won't flow and your light will be off.



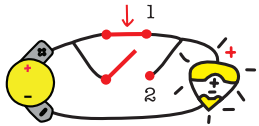
LED Off



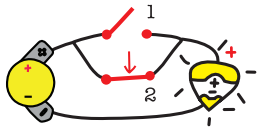
LED Off

OR Switch

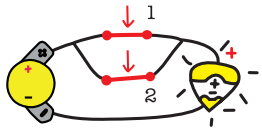
You can also connect multiple switches **in parallel** using different branches so that pressing any one of them will turn on your circuit. This is called a logical **OR** because you can press *Switch 1* ***or*** *Switch 2* to make a complete circuit:



LED On

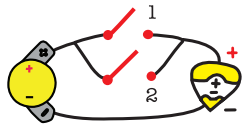


LED On



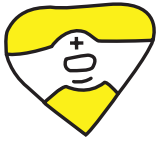
LED On

In an OR switch, the light is off only when none of the switches are pressed:



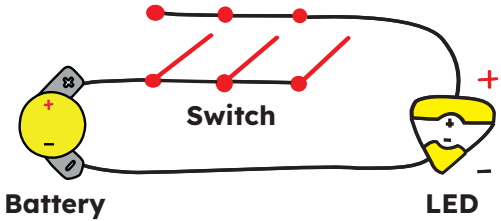
LED Off

4. Blinking Slide Switch



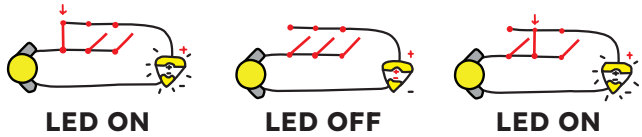
4. BLINKING SLIDE SWITCH

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



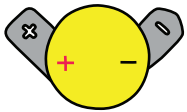
In the **blinking slide switch**, there is one long gap and multiple switch contacts that you can press to close the circuit. This is a version of the “OR” logic switch introduced on page 55.

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!

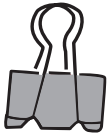


YOU WILL NEED:

x 1 LED Sticker



x 1 Launchpad Battery



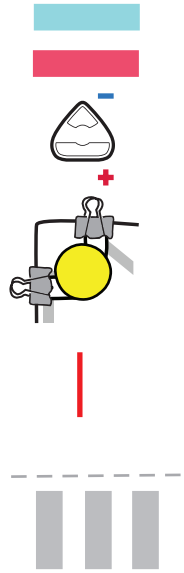
x 2 Binder Clips

Conductive Tape or Tape Strips

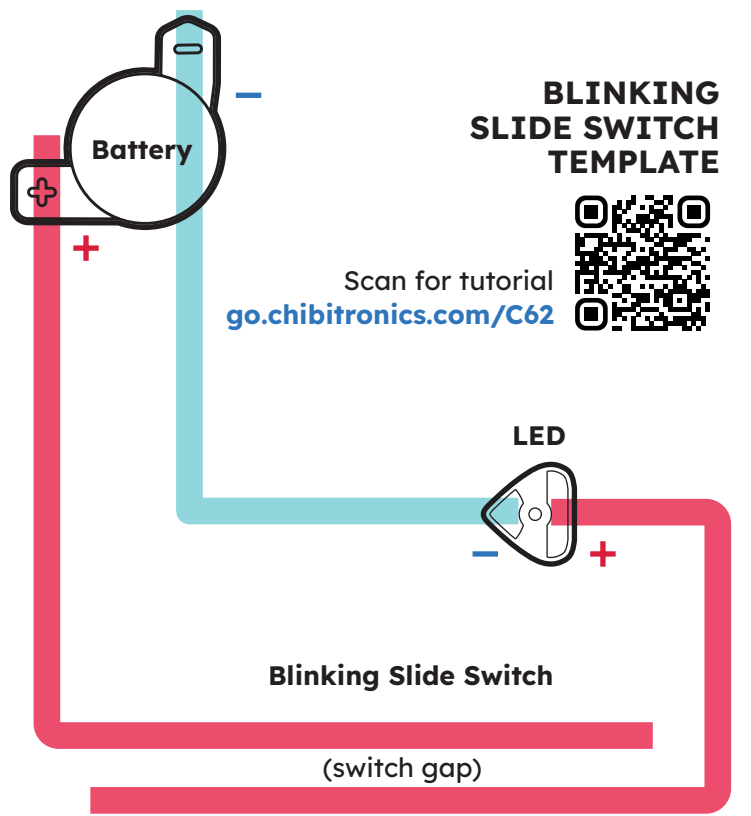
Scissors

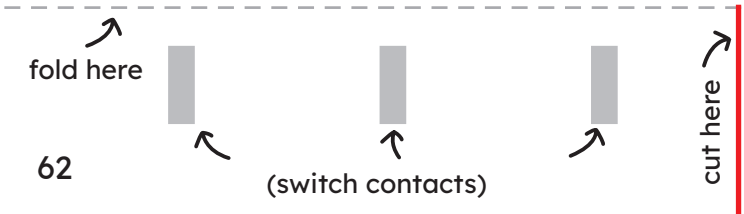
DIRECTIONS:

1. Turn to the template on the next page and stick conductive tape over the blue and red lines.
2. Stick an LED sticker over the footprint.
3. Place the Launchpad Battery over the footprint and clip the battery tabs in place.
4. Cut the page along the thin vertical 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!



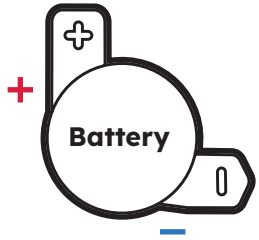
Press and Slide Here





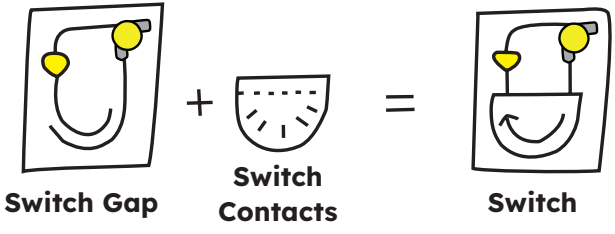
Note: *You can change the blinking pattern by moving the switch contacts. Try adding, removing, or spacing them out differently to see how the blinking pattern changes!*

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. To do this, make the gap in your switch a different shape and glue a corresponding flap for the switch contacts. Try making a curved or even wiggly path!

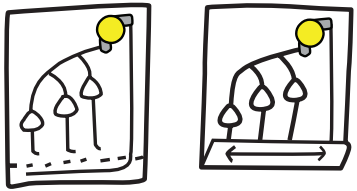


TRY THIS!

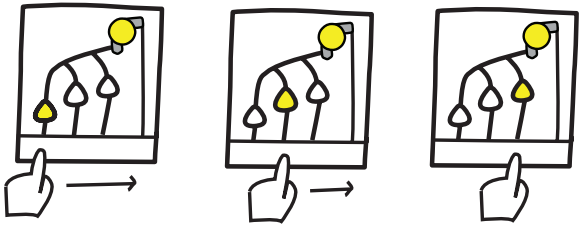
Switches let you create all sorts of different effects depending on how your switches branch and where you put the lights in your circuit!

Sequence Slide Switch

Try connecting different LED branches along a single slide switch.



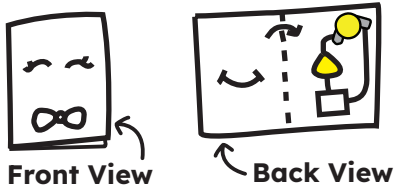
When you press your finger along this path, the LEDs will turn on in order, creating an animation!



Secret Messages

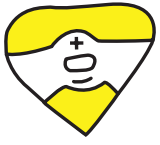
You can also create cool effects by drawing images on the back side of the page covering your light!

When the light is off, you will not be able to see the message since it's on the back of the page. When the light is on, it lights up your image from behind so that the image shows through the paper.



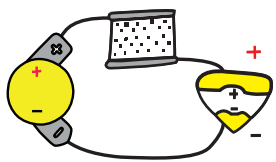
You can use this effect to create secret messages or hidden images that only appear when you press the switch!

5. DIY Pressure Sensor

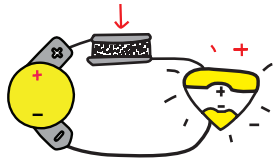


5. DIY PRESSURE SENSOR

Rather than turning your lights fully on or off with a switch, you can gradually fade your LEDs in and out using the black pressure sensor sheet to make a **pressure sensor**. How well it lets electricity flow through depends on how hard you press on it. This property of making it more difficult to let electricity flow is called **resistance**.



Sensor NOT Pressed: Light is Dim



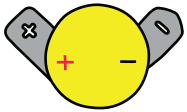
Sensor IS Pressed: Light is Bright

The harder you press, the lower the resistance, and the brighter your light shines.

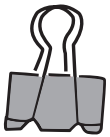
When you don't press, conductive particles in the plastic are farther apart. Electrons cannot flow well, so your light is dim. When you do press, the particles are squashed together and the electrons can find more paths to flow through, and so the light gets brighter.

YOU WILL NEED:

x 1 LED Sticker



x 1 Launchpad Battery



x 2 Binder Clips

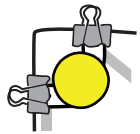
Conductive Tape or Tape Strips

Conductive Pressure Sensor Sheet

Scissors

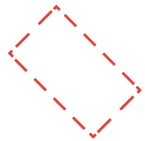
DIRECTIONS:

1. Turn to the template on the next page and stick conductive tape over the blue and red lines.

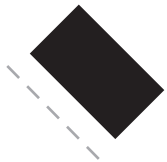


2. Place the Launchpad Battery over the footprint and clip the battery tabs in place.

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!

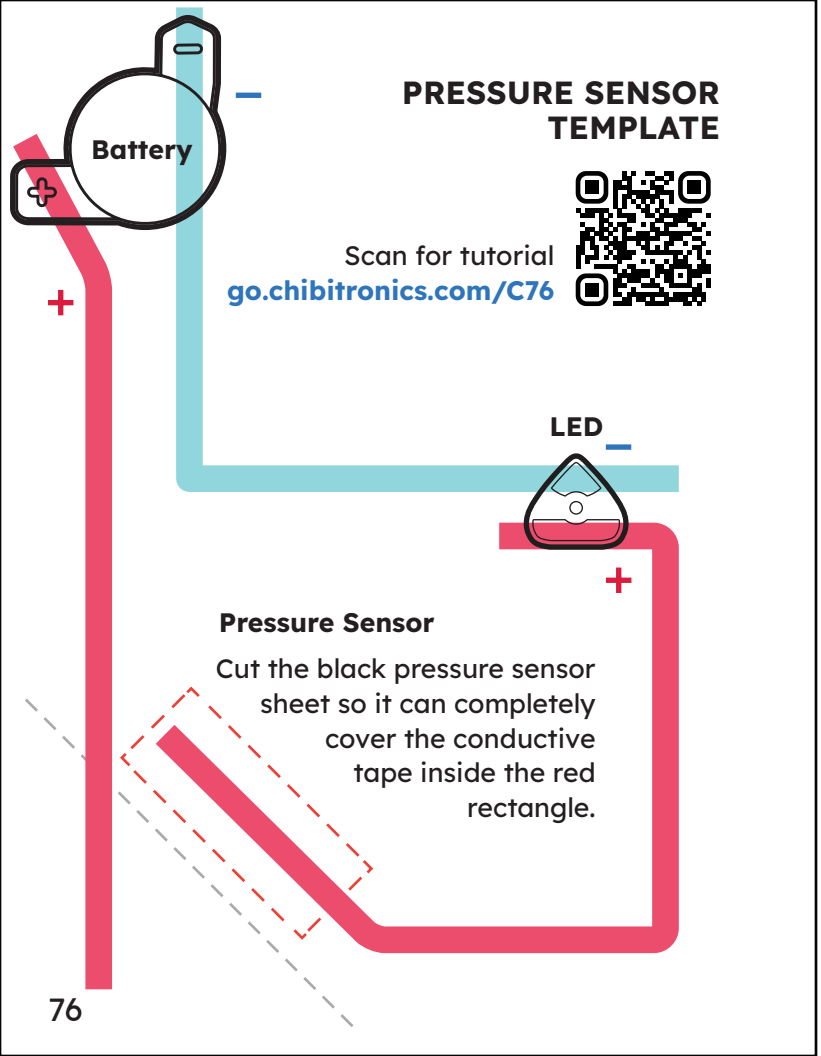


4. Unfold the switch and cut the black conductive pressure sensor sheet into the shape of the red dotted rectangle.



5. Put the conductive pressure sensor sheet over the dotted rectangle and fold the bottom flap up again. The light will become brighter the harder you press.

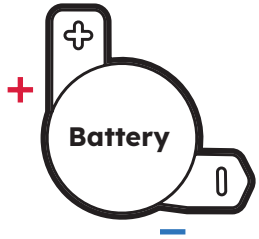
You just made a pressure sensor!



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

Note: *You can use a small piece of tape to hold the pressure sensor sheet in place. Just make sure that you don't cover up where the conductive tape touches the sheet or it won't connect to your circuit!*

What comes to life when you press the heart?
Draw it here!



YOUR TURN!

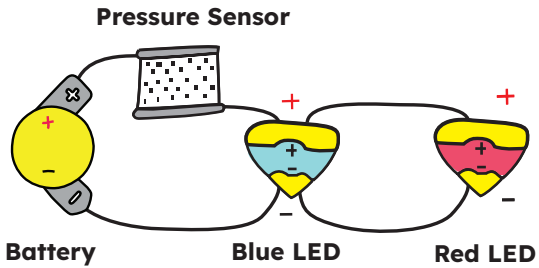
You can turn any of the switches we have made into pressure sensors just by placing a piece of black pressure sensor sheet in between the switch contact and the switch gap.

Try making a switch on the next page using a flap of paper, and then turn it into a pressure sensor!

TRY THIS!

You can combine pressure sensors and LEDs of different colors to create a magical light-up sequence effect!

For example, try connecting a red LED sticker and a blue LED sticker in parallel, and add a pressure sensor like this:



Now try pressing on the pressure sensor. What happens?

You should see the red LED come on first and then the blue LED as you press harder. It actually doesn't matter where you put the red and blue LEDs in the parallel circuit. The red LED stickers will always comes on before the blue LED stickers!

This is because LEDs of different colors require different amounts of energy, called **voltage,** to turn on. The pressure sensor allows you to control the voltage going to your LEDs. The harder you press, the higher the voltage.

Voltage is measured in **Volts**, often shortened to **V**. The Launchpad Battery supplies about 3V when full and the voltage slowly decreases as the battery drains. This table shows approximately how many volts you need to turn on each color LED sticker.

LED Sticker Color	Voltage Needed to Turn On	Pressure Needed to Turn On
Red, Orange, and Yellow	2.0V	Low
Green	2.3V	Medium
Blue, Pink, and White	2.8V	High

Try making more parallel circuits of different shapes and with different colored LEDs. See what effects you can come up with!

Help & Debugging

HELP & DEBUGGING

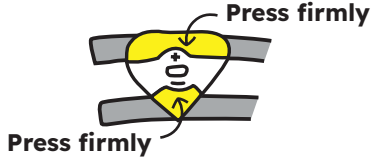
So your light doesn't turn on? No worries! That's what debugging is for!

Debugging means looking closely at the project, finding the problems—also known as **bugs**—and then fixing them so that your project works as expected.

Don't worry when things don't work the first time. Figuring out what went wrong is part of the learning and creative process!

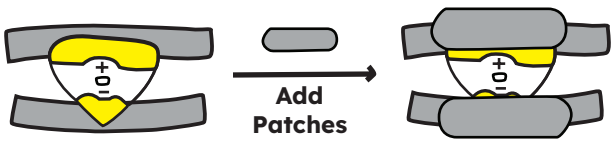
Use this guide to carefully review your circuit for common bugs.

1. Is the LED connected securely?
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 conductive tape.



2. Is the tape wrinkly or bumpy?
The LED stickers stick best to tape that is flat, not wrinkled. Smooth out any wrinkles or bumps by re-sticking your tape down. If you are using copper tape, flatten wrinkled foil by rubbing it flat with a pencil eraser.

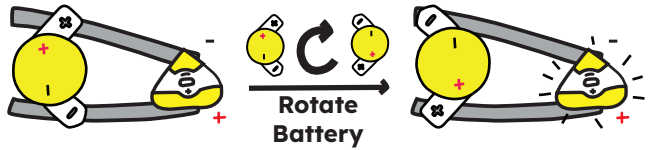
3. Is the LED flickering or often dim instead of staying on?
If an LED sticker is flickering on and off, or only turns on when you hold it down, this means that the connection is not strong. This can often happen if the sticker has been lifted up and stuck down too many times, causing it to get dirty and lose its stickness.



You can fix this by using a conductive fabric tape patch, or cutting a small piece of conductive tape, and sticking it across the metal pad of the LED sticker and the conductive tape. This way, the patch will act as an additional conductive connector.

4. Is the LED connected backwards?

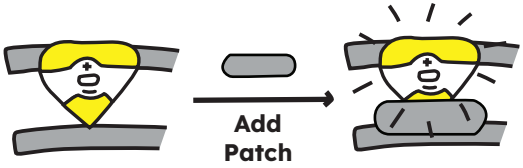
If the positive and negative sides of your LED are connected in reverse from your battery, it won't turn on.



A quick way to check is to rotate your Launchpad Battery so that the + and - tabs switch places and see if the LED turns on. This reverses the + and - connection, matching the reversed LED.

5. Is there enough overlap between the pads of the LED and the conductive fabric tape?

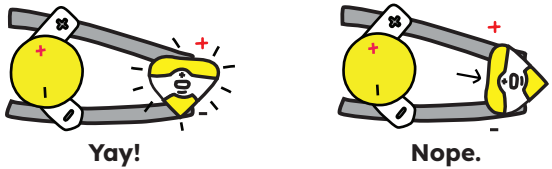
There needs to be plenty of overlap between the metal pad of your LED and the conductive tape for there to be a strong electrical connection. If the overlapping area is too small, then power cannot flow to the LED.



If the overlap is not large enough, use a conductive fabric patch, or cut a small piece of conductive fabric tape, to reinforce the connection between your LED pad and the conductive tape.

6. Is the LED accidentally causing a short circuit, for example if it's connected sideways?

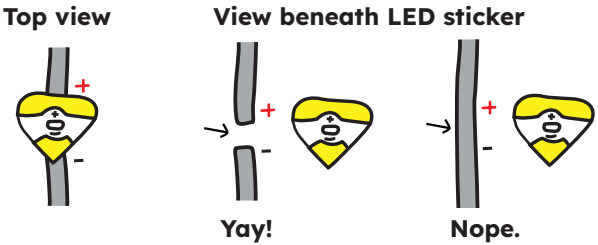
Make sure the shiny metal pads of your LEDs are touching only one strip of conductive tape each. If one pad is touching two different conductive tapes, then there could be a short circuit.



In the example above on the right, the wide + side is accidentally touching both + and - tapes coming from the battery, causing a short circuit!

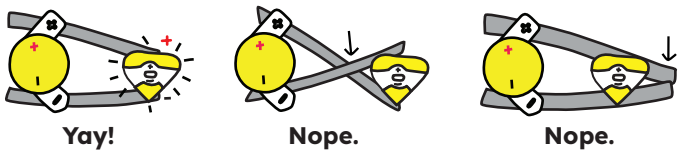
7. Is there a gap in the conductive tape beneath the LED sticker?

Make sure that there is a gap in the conductive tape between the positive and negative pads of the LED. Otherwise if the tape is continuous, it's creating a short circuit that is underneath the LED!



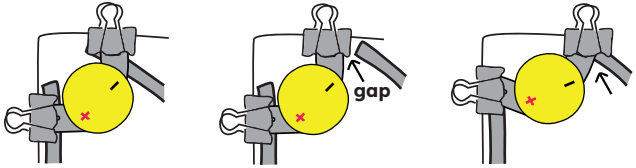
8. Is there a short circuit somewhere?

If the tapes that go to the positive and negative tabs of the battery touch, even the tiniest bit, then there is a short circuit and your light will not turn on. Look through your circuit to make sure that there are no accidental short circuits.

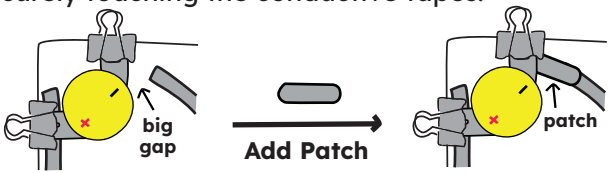


9. Is the battery connected securely?

Just like with the LED stickers, there needs to be plenty of overlap between the tabs of the Launchpad battery and the conductive tapes in your circuit.



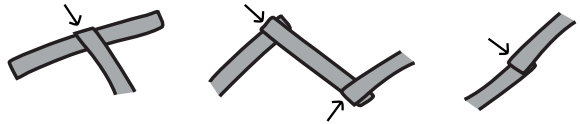
If your battery isn't lined up with your conductive tape, try moving the battery and reclipping the binder clips so that the tabs of the battery are securely touching the conductive tapes.



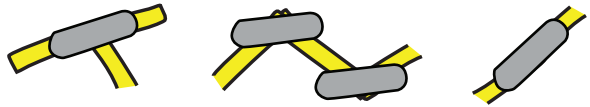
If there is a big gap between the battery and conductive tape, use more conductive tape to extend your conductive tape so that it reaches the battery.

10. Are the connections between different pieces of conductive tape secure?

Try pressing down on all the joints where multiple pieces of conductive tape are stuck together, for example at a turn, a branch, or if you had to extend a piece of tape with a patch.

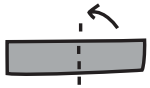


If you notice that the light only comes on when you press on a spot where two tapes come together, and turns off again when you let go, that means the connection isn't strong.



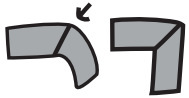
Strengthen the connection by sticking a conductive fabric patch, or a small piece of conductive fabric tape, across the connection. This is especially important if you are using copper tape for your circuit, since the adhesive is not as conductive. With copper tape, we recommend reinforcing all joints with some conductive fabric tape or a fabric patch.

To reduce chances of weak connections at turns and corners, instead of sticking multiple pieces of conductive tape together we recommend using the following folding technique instead:



1. Fold the tape back, exposing the sticky side

2. Flip and turn the tape in the new direction, creating a corner



3. Flatten the corner and you're done!

11. Is the battery out of power?

If all the connections in your circuit look correct but the light is still not turning on at all, it might simply mean that your battery has run out of power. Try testing your circuit with a fresh battery. You can also put the battery on a circuit that you know works properly to test if the battery has power.

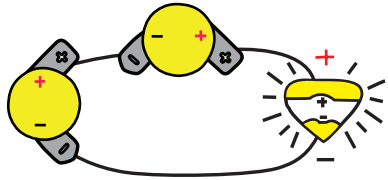
12. Are only the red, orange, and yellow LED stickers coming on but not the green, blue, pink, and white ones?

This could mean that your battery doesn't have enough power to turn on all the colors together.

Different colors require different amounts of power, so only the lower power colors like red, orange, and yellow might come on but not the other colors. Go to *Try This!* on page 82 for more on how this works.

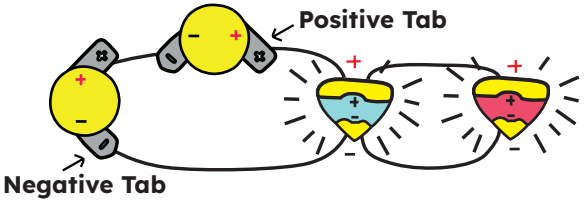
To resolve the issue of only certain colors turning on, try replacing the blue, pink, and white LEDs with red, orange, and yellow LEDs. This way, the battery only needs to work hard enough to power the lower power colors.

If you want to have all the colors turn on, you can try boosting the power by putting in a fresh battery. Another way to boost power in your circuit is by adding another battery.



In this case, you must connect the batteries as shown in the circuit above, where the batteries are connected one after the other like beads on a string. The positive of one battery goes to the negative of the other battery. This is called connecting the batteries **in series**.

Once you have the two batteries connected in series, you can treat them like one large battery with the negative tab on one battery and the positive tab on the other battery. Then you can connect more LEDs in parallel, like in the example circuit below.



Because there are now twice the batteries, your circuit will have double the power of a circuit with only a single battery.

13. Is the LED sticker broken?

If you've tried everything and an LED sticker is still not turning on, try switching it out for a new LED sticker. While this is uncommon, LED stickers can eventually break if they are creased too much.

This can happen if you stick and peel up the LED sticker repeatedly and accidentally break one of the electrical connections inside the sticker.

14. Is your circuit still not working?

No worries! Please reach out by sending a note with pictures of your circuit and the issues you're running into to this email address: **help@chibitronics.com**

We're here to help and excited to debug with you!

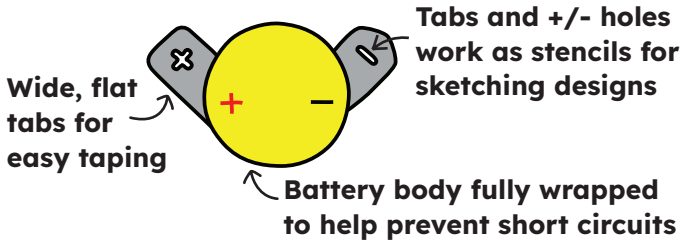
For additional debugging resources:

Explore our online debugging page which has more tips and tutorial videos for debugging: **go.chibitronics.com/CSDebug**

Battery Safety

BATTERY SAFETY

Our Launchpad Batteries are specially designed to be safe and easy to use for learning and creating with paper circuits.



They are enhanced versions of standard CR2032 lithium metal coin cell batteries. Here are some technical features of the Launchpad Battery:

Property	Feature
Voltage	3V
Rechargeable?	No
Safe Usage Temperature	-4°F to 160°F (-20°C to 60°C)
Energy Capacity	230 mAh (**milliampere hour**)

While these batteries are user-friendly, they do contain coin cell batteries, so we remind you to please use, store, and dispose of them responsibly!

The following are some important safety and disposal guidelines. Please follow the instructions provided.

Battery Safety and Disposal Guidelines

1. Please do not disassemble the Launchpad Battery. The yellow plastic wrap helps cover the metal battery contacts in order to prevent accidental short circuits.
2. Keep the ziplock pouch that your Launchpad Battery came in for storing the battery when it's not in use. Store only one battery per pouch in order to prevent accidental short circuits.
3. When storing batteries, make sure to keep them away from metal containers and from other batteries, which have exposed metal parts, in order to prevent accidental short circuits.
4. Do not allow young children (ages 7 or younger) to play with batteries or handle them unsupervised by an adult.
5. Let older kids and siblings know about the risks of batteries, and to keep batteries away from younger kids.
6. Store spare and used batteries out of sight and reach of young children.
7. Do not try to recharge the Launchpad Battery, as they are not rechargeable.
8. When a battery is empty or out of power, immediately dispose of them by taping over the + and - ends and placing them in a secure container until they can be recycled or discarded at a local designated safe battery drop-off location. Do not dispose of used batteries in regular household garbage or incinerate them.
9. Batteries can be extremely dangerous if swallowed or inserted into the nose or ears. If you suspect that this might have happened, seek medical attention immediately and do not induce vomiting.

For more information, please visit:
go.chibitronics.com/CSBattery

Stay safe, and happy making!

Glossary & Index

GLOSSARY & INDEX

For an online, interactive version of this Glossary, please go to this link: **go.chibitronics.com/CSGlossary**

AND (switch): A type of logic switch design where multiple switches are connected in series, so you have to press all the switches in the loop (for example switch A *and* Switch B) in order to turn on the circuit. (p. 54)

binder clip: Common clip that is useful as a battery holder for temporarily holding the Launchpad Battery in place in the circuit. Use one binder clip per Launchpad Battery tab. (p. 11)

blinking slide switch: A type of switch with one switch gap and many switch contacts so that when you slide your finger across the switch, it opens and closes the switch multiple times and makes your LED blink. (p. 59)

bug: In circuits, this means a problem or mistake that causes your project (such as your circuit) to

not work the way you want it to. (p. 87)

closed: In a switch this means when the switch gap is connected, turning the circuit on. (p. 45)

complete circuit: When the components of a circuit are connected in a closed loop so that electricity can flow and turn on the components. (p. 17)

conductive: Able to allow electricity to flow through it. (p. 9)

conductive fabric tape (or fabric tape): A type of conductive tape made from fabric embedded with metal particles. This tape is soft and sturdy, can be folded repeatedly without breaking, and requires scissors to cut. The adhesive on conductive fabric tape is conductive enough to create electrical connections simply by taping two pieces together. (p. 12)

conductive pressure sensor sheet: This black conductive plastic material has a conductivity that changes when pressed and is useful for making paper pressure sensors. (p. 13)

conductive tape: Any tape that is made out of a conductive material so that electricity can flow

through it. (p. 12)

copper foil tape (or copper tape): A type of conductive tape made from thin copper metal foil and soft enough to tear by hand. The adhesive on copper foil tape is not as conductive as the adhesive on conductive fabric tapes. You can solder to copper foil tape. (p. 12)

current: The flow of electrons. (p. 17)

debugging: Process of looking closely at a project (for example your circuit) when it isn't working as you expect, figuring out what the issue is, and fixing it so that the project works the way you would like it to. (p. 87)

electricity: The type of energy that powers circuits. (p. 9 and 17)

electron: A tiny particle, too small to see, in circuits that can flow through components and conductive materials carrying energy. The energy of this flow makes up electricity. (p. 17)

fabric tape patches (or fabric patches): A form of conductive fabric tape that comes in small pieces on a sticker sheet. These patches are

handy for fixing weak electrical connections or bridging gaps in circuits. They are also useful for connecting multiple pieces of conductive copper tape together or making hinges that need to fold repeatedly in copper tape circuits. (p. 12)

fabric tape strips: A form of conductive fabric tape that comes as pre-cut sticker strips in a sheet. These strips are handy for making smaller circuits and easier to peel from the paper backing than traditional conductive fabric tape in roll form. (p. 12)

in parallel: When circuit components are connected side by side like rungs on a ladder. For example with LEDs, it means that all the + sides are connected and all the - sides are all connected. For switches, it means that all the left sides of the switch gaps are connected and all the right sides of the switch gaps are connected. (p. 31 and p. 55)

in series: When circuit components are connected one after the other in a single loop, like beads on a string. For example with LEDs, this means connecting the + of one LED to the - of the next LED. For switches, this means connecting the

right side of one switch gap to the left side of the next switch gap. (p. 54)

Launchpad Battery: A special type of battery made by Chibitronics that has large positive and negative pads for easily taping with conductive tape. The body of Launchpad Batteries are completely wrapped to protect from short circuits, making them safer than standard coin batteries. (p. 11)

Launchpad LED: A special type of LED made by Chibitronics that is reusable and has large positive and negative pads for easily taping with conductive tape. Launchpad LEDs are made up of a rigid circuit board base, an LED, and a resistor. (p. 10)

LED (or light emitting diode): An electronic component that lights up when powered by electricity. (p. 9)

LED sticker: A special type of LED made by Chibitronics that comes in the form of a sticker, so you can connect it to your circuit by sticking it down. LED stickers are made up of an LED and resistor, a flexible circuit board base, and

conductive adhesive. (p. 9)

milliampere hour (mAh): Unit used for measuring how much energy a battery can store and supply and for how long it can keep powering the circuit. (p. 101)

negative (marked with "-"): In batteries it is the side that electricity flows into and in LEDs it is the side that electricity flows out of. (p. 9)

open: In a switch this means when the switch gap is disconnected, turning the circuit off. (p. 45)

OR (switch): A type of logic switch design where multiple switches are connected in parallel branches, so you can press any of the switches (for example Switch A *or* Switch B) to turn on the circuit. (p. 55)

parallel circuit: Type of circuit where multiple LEDs are connected to one battery with all the + sides connected and all the - sides connected. There are other ways to create parallel circuits, but this is what we mean in paper circuits. (p. 31)

polarity: Tells the direction that electricity must flow through electrical components. Batteries and LEDs have polarity. (p. 9)

positive (marked with "+"): In batteries it is the side that electricity flows out of and in LEDs it is the side the electricity flows into. (p. 9)

pressure sensor: A circuit component that can control the brightness of LED lights depending on how hard you press on the sensor. It does this by changing the amount of voltage (or energy) that is going into the lights. (p. 13 and 73)

resistance: The property of a conductive material that describes how much it slows down (or *resists*) the flow of electricity. If resistance is low, electricity can flow well. If resistance is high, electricity cannot flow as well. (p. 73)

short circuit: When electricity flows directly from the positive to the negative sides of a battery, skipping the LED or other component that it is supposed to power. This quickly drains the battery of power and happens when the positive and negative sides of the battery are accidentally connected directly. (p. 17)

simple circuit: A circuit with one battery and one

LED. There are other types of simple circuits, but this is what we mean in paper circuits. (p. 17)

switch: A circuit component that controls when a circuit is on or off by opening and closing a connection circuit loop. When the switch is closed, the loop is complete and electricity can flow, turning the circuit on. When the switch is open, the loop is incomplete and electricity cannot flow, turning the circuit off. (p. 45)

switch contact: A conductive material that can move to either connect or disconnect the switch gap. (p.45)

switch gap: An opening in the circuit that can be left open or connected with a conductive material. (p. 45)

through-hole LED: A common type of LED light that has a round dome lens and two metal legs. Unlike LED stickers and Launchpad LEDs, through-hole LEDs do not have a resistor included in the component. (p. 10)

Volt (or V): Unit used for measuring voltage. (p.83)

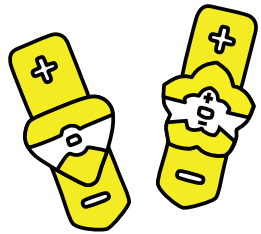
voltage: The amount of energy that a battery has for powering the flow of electricity. It is the amount of "push" that the battery can give to move electrons through the circuit. The higher the voltage, the more power a battery has. (p. 83)

What's Next?

WHAT'S NEXT?

Congratulations on completing the Circuit Sticker Sketchbook! Looking to explore more with paper circuits or dive deeper? Here are some ideas:

Start with STEAM: Launchpad LED Kit

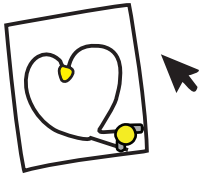


If you had fun with the guided paper circuit template and drawing activities in this book, you will love the START with STEAM: Launchpad LED Kit!

Inside you'll find the Launchpad Sketchbook along with all the supplies you need to complete 10 paper circuit template activities. This book takes you on a deeper dive into paper circuit fundmentals and is a great introduction to our reusable Launchpad LEDs!

Scan to learn more:
go.chibitronics.com/C119

Circuit Sketcher Design Tool



Are you ready to take your creativity beyond the sketchbook and design your own circuits? Give our Circuit Sketcher design software a try!

Our design tool lets you virtually build and simulate circuits in your web browser so that you can make sure your circuit design works just right. Then you can print out your design as a circuit template just like the ones in this book, but created by you!

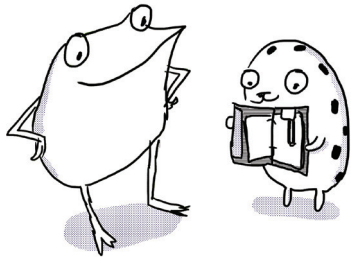
You can also share your digital Circuit Sketcher designs and template creations for others to create with your designs too!

Scan to learn more:
go.chibitronics.com/C120

Love to Code Kit

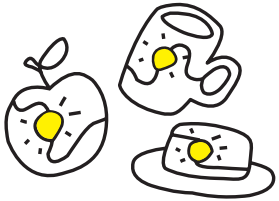
Take your paper circuit projects to the next level by adding code—now your creations can interact and respond in more complex ways thanks to programming! Dive into our Love to Code kit for a fun introduction to coding with paper circuits.

You'll learn how to make more advanced interactive art, meet friendly characters, and follow along with their creative journeys as you build your own coding skills!



Scan to learn more:
go.chibitronics.com/C121

Chibitronics Projects Library



Explore our extensive online resources library packed with paper circuit tutorials and activities for all interests, subjects, and skill levels!

From beginner projects to advanced creative coding creations—like simple holiday cards to light-up costumes and solar-powered paper cities—check it out and see what amazing paper circuit projects you can create next!

Scan to learn more:
go.chibitronics.com/C122

Stay in Touch and Join our Community!

We're always working on new resources, products, and creative ideas for paper circuits. Want the latest updates? Sign up for our newsletter:

Scan to learn more:
go.chibitronics.com/C123

You can also connect with us on our social media channels, where we showcase amazing projects from our creative team as well as the Chibitronics community.

Find us **@chibitronics**:

Share your own creations using **#chibitronics**—you might see your work featured next!

We hope you have enjoyed learning and creating with us :)

– Jie & Chibitronics Team

About the Author

Jie Qi is the cofounder and CEO of Chibitronics, a company that produces creative learning toolkits. She holds a degree in mechanical engineering from Columbia University and a Ph.D. in media arts and sciences from the MIT Media Lab. Her dream is to empower creators of all backgrounds to fall in love with the magic of making expressive and personally meaningful technologies.

Special Thanks

Thanks to BO Haynes, Jasmine Florentine, Jon Samuelson, Jessica Frost-Ballas, Jill Dawson, Shiela Lee, and Pauline Lim for your feedback on this book. Thanks to bunnie Huang for your valuable input on the earlier editions. Thanks to everyone at Chibitronics: this wouldn't be possible without you!

Thanks to my friends and family for your unending support. To May, Michael, Dad, Mom, and Kevin: thank you for your infinite love and light.

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