SCRAPPY CIRCUITS ZINE

By Michael Carroll
@scrappymaker

A PDF Preview of the Scrappy Circuits book

www.scrappycircuits.com

This Scrappy Circuits Zine is an abbreviated preview of the Scrappy Circuits book for Kickstarter backers. You are welcome to share this zine with friends.

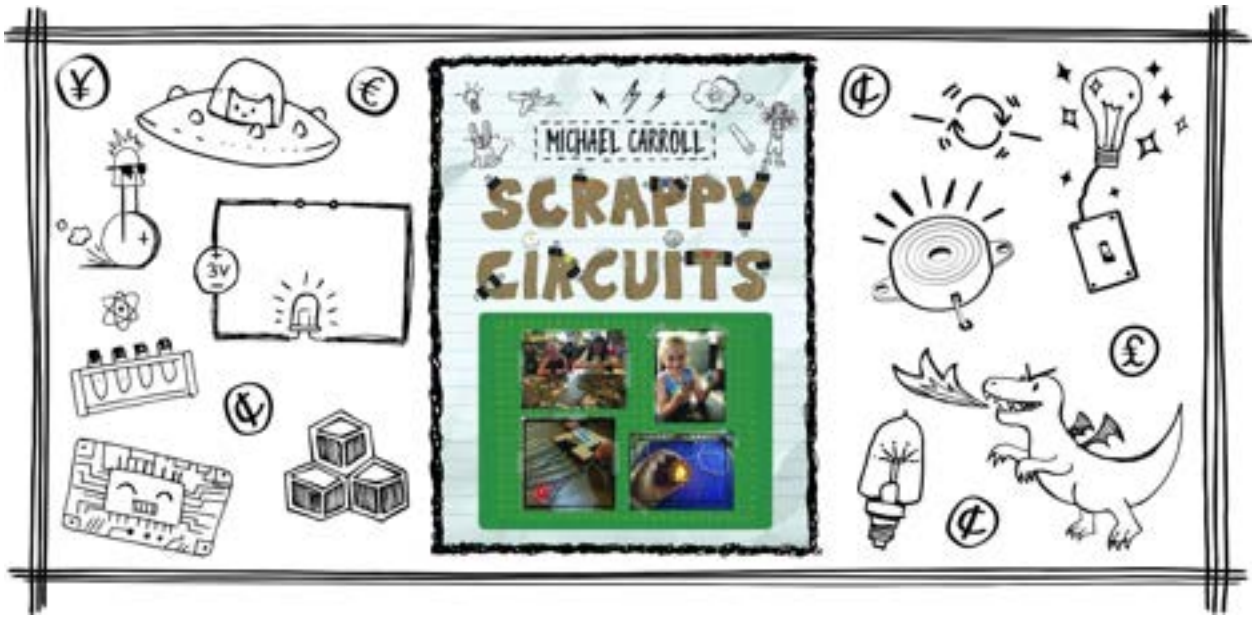
The full version has …

- A higher quality dpi
- More projects with the Core Bricks
- More Action Bricks that buzz, shake, spin, and change colors
- 15 more switches that can be made to work with Scrappy Circuits that can be triggered by waving a wand, blowing air, tilting, stepping, and many different arcade-game-style switches
- Bricks that can control the flow of electricity
- Ways to make electricity for Scrappy Circuits without using a battery
- Over 10 projects to make with all of the different Scrappy Circuits bricks.
- A guide to inventing your own bricks and projects
- Tips for leading groups making Scrappy Circuits
- A fun and engaging background to many of the different scientific ideas

If you are using this preview, and not an original Kickstarter backer, we ask a few things.

- If you like this preview, please visit Amazon.com or cmkpress.com to purchase the full version of Scrappy Circuits written by Michael Carroll.
- Spread the word about Scrappy Circuits to friends far and wide. You can share this zine PDF with them.

Please enjoy this preview zine of Scrappy Circuits.



The full Scrappy Circuits book is available at Amazon.com & CMKPress.com.

SCRAPPY CIRCUITS

A self-made electronic invention learning system sourced from an imagination and a fifty-cent LED tea light.

Michael Carroll

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NOTE: Some of these projects call for tools and materials that can be dangerous if used improperly. Always follow manufacturer's guidelines, safety rules, and use common sense.

The Scrappy Circuits Community was started by

Michael Carroll

Chris Connors

Eva Luna

and more

scrappycircuits.com

SCRAPPY SUPPLIES

"To invent, you need a good imagination and a pile of junk." —Thomas Edison

TOOLS

Part of the Scrappy Circuits ethos is accessibility. We want all classrooms, clubs, kids, and kids-at-heart to be able to create, experiment, and invent with Scrappy Circuits with relative ease and convenience. Most of these tools needed for Scrappy Circuits are commonly found or easily acquired. If you don't already have them, many can be found at a local dollar store or sourced for a fair price in bulk online. It is recommended that these tools be on hand to make Scrappy Circuits to avoid frustration. The tools marked with a $ can usually be found at a dollar store.

- Small screwdrivers $
- Scissors (or a cardboard saw)
- Pliers $
- Wire cutter $
- Wire stripper $
- Glue sticks $
- Sand paper (emery boards and nail files can work too) $

Scissors are usually sold at the dollar store, but sometimes the quality is very poor, especially when used to cut cardboard. A cardboard saw will be the hardest to find, possibly the most expensive, but also potentially the most valuable. They range from around $5 to $8 on Amazon—electric versions are around $35. These are highly recommended for large groups. They are much safer than cutting cardboard with scissors or a box cutter knife. They also can create a much more precise and clean slice.

LED TEA LIGHT

Scrappy Circuit's foundational item is an LED tea light. It's as important as a cup is to coffee. I have yet to find a dollar store that doesn't carry a two pack. In fact, my local dollar store carries a variety: glittered, color changing, star-shaped, and more. For your first set of Scrappy Circuits, stick with the simple white-cylinder LED tea light. Feel free to experiment later. I mean, glitter makes everything better. Tea lights from the dollar store are best because they are the easiest to take apart. If buying in bulk, Amazon.com or a craft store with a large-percentage-off coupon may be a cheaper option than a dollar store.

Once you take the tea light apart, you will need the LED, the 3V battery, and the cylinder enclosure for Scrappy Circuits. The other internal parts are too unique to the different brands and styles to give them a specific brick or function. Feel free to be creative and invent your own brick with any of these remaining parts.

For many different reasons, readers might want to make Scrappy Circuits from individual parts bought in bulk instead of a deconstructed dollar store LED tea light. This is totally fine and encouraged. The reason the Scrappy Circuits system is based around the tea light is because you might not know how or where to purchase LEDs and 3V batteries in bulk. It is always recommended to have extra LEDs on hand just in

case some of the legs break off. Below is a list of some great electronics suppliers that carry a wide variety of great LEDs. The solid color (not RBG) 5mm LEDs are recommended.

- SparkFun Electronics – sparkfun.com
- Adafruit Industries – adafruit.com
- Jameco – jameco.com
- Mouser – mouser.com

BINDER CLIPS

The next item you'll need to make Scrappy Circuits are some small metal binder clips, sometimes called butterfly clips. These clips perform two functions on a Scrappy Circuit brick. First they are used to hold the different components to the cardboard. They also act as a terminal for electricity to enter and exit a brick. Sometimes the arms are used as movable parts to control electricity, like in the Binder Clip Switch.

Binder clips work well as electricity terminals for Scrappy Circuits since both the black and the silver parts conduct electricity. The most common color for binder clips is black, but they may come in other colors. Those work just as well as long as they are metal. When using binder clips to conduct electricity they often resemble Dr. Jekyll and Mr. Hyde. Sometimes they're wonderful, but other times they can be horrible disappointments. Sanding the mouth (point of contact) of the binder clip and adding some aluminum foil to the element being clipped will help a lot. Also try squeezing the binder clip mouth gently to make sure it is resting on the item it is supposed to transmit electricity to. If those tricks don't work. Try opening and reclipping the binder clip until you find a good connection.

Binder clips are usually sold in packs of twelve. Oftentimes these packs of twelve are sold in sets of twelve—a total of 144 small binder clips for around ten dollars. This will produce either 13 or 14 sets of Core Bricks and cost about seven to ten cents per clip.

In most cases the word small is for a specific size that is perfect for Scrappy Circuits. Some stores and unfamiliar

brands use the word small as a general adjective, not a specific size. Size small binder clips measure exactly ¾ inches across the longer side of the black base. If you are buying from a store, I'd recommend borrowing a ruler from the shelf and measuring. You should be able to trust the bigger chain office supply stores that their "small binder clips" are actually the proper size. Visit scrappycircuits.com for links to recommended parts on Amazon for the exact size needed.

The silver arms of the binder clips can sometimes get in the way once they become part of a brick. They also can accidentally flip below the brick and touch. This creates a shorter path for the electricity and makes the brick no longer function correctly. To remove an unneeded arm, first pull the arm back so it touches the black part of the binder clip and not the other arm. Then squeeze the arm like you're closing a pair of scissors. Pull the tightened arm to one side of the binder clip. The opposite side should dislodge. With one side out, the other side can easily dislodge. Keep the removed arms. If you have to fix your brick or readjust the binder clip, you will need to reinsert the arm. They can also be repurposed for Bonus Bricks like the Thread the Needle Brick.

Sanding Your Binder Clips

To make the black (or other color) part of the binder clip more conductive you will need to sand some of the paint off. A little bit of sanding can greatly increase the clip's conductivity. This is not necessary for all bricks, but is necessary for some where there is a small physical connection between the binder clip and the electrical element. Sanding is often needed on the LED Brick for this reason.

The real challenge of sanding the binder clips is making sure you sand exactly where the binder clip contacts the brick element. Assemble your brick. Then note the exact point of contact. Disassemble and sand at that exact point and the surrounding areas. About five to ten seconds of sanding will greatly improve your connection.

Sandpaper, a sanding block, a nail file, or an emery board can all get the job done. They can also be purchased in bulk at most dollar stores. Many teachers prefer to use emery boards because they are stiffer than sandpaper and small enough to easily get inside the mouth of the binder clip. They don't last long, so a nail file might be a more cost effective long-term choice.

PAPER CLIPS

The Core Bricks also require two paper clips per set. Size doesn't really matter (with Scrappy Circuits). What does matter is that the paper clips are made out of steel and do not have a plastic coating (usually bright colors). This is because one of the two paper clips needs to conduct electricity. Colorful plastic-coated paper clips will not conduct electricity. Unfortunately the paper clips from the dollar store are often made from plastic, but are painted silver to look like regular metal paper clips. This is hard to tell without touching the paper clips. Tricky, right? As a safe rule, if you need to buy paper clips get them from somewhere other than the dollar store.

Now you only need two paper clips to make a set of Scrappy Circuit Core Bricks, and only one of them needs to conduct electricity. Look around your house or ask someone for a paper clip at a bank, copy center, library, or school. People usually don't mind giving away paper clips, especially to a polite and curious child.

Large, Medium, and Small

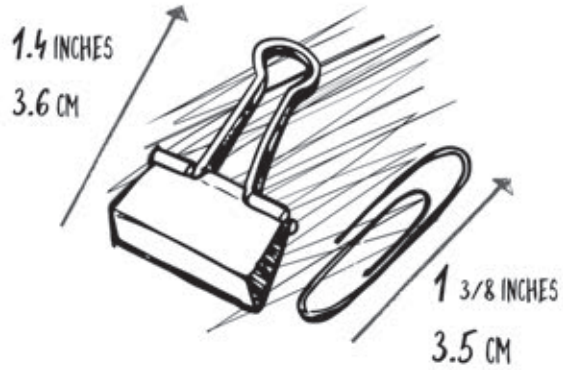
One day my dad asked me to pick up a ton of sand to make a beach-like area at a lake. I said, "Sure, but exactly how much do you want?"

He replied, "A ton."

I asked again, "Right, but specifically how much?"

He answered, "A ton. Two thousand pounds. I want exactly one ton of sand."

When he asked for a ton of sand, I thought he meant that he wanted a lot of sand, not exactly two thousand pounds. I'm sharing this story not because of its potential to become a modern-day "Who's on First?" comedy routine, but because sometimes specific amounts turn into general expressions. And then general expressions turn into sometimes varying specific amounts–a medium soda at the movie theater is a lot larger than at a restaurant. The word "ton" is probably used more often to describe a generally large amount of something rather than exactly two thousand pounds. The opposite is true, too. Sometimes general expressions become specific sizes. This is very true with office supplies, the bulk of the materials for Scrappy Circuits.



What is frustrating is sometimes the words "small, medium, and large" are not used for specific sizes, but more a general description. This confusion can become multiplied online where all the pictures of products appear as the same size. As someone who has been the victim of mislabeled office supplies in the past, here are some labeled scientific drawings to help.

If you go to scrappycircuits.com you will find Amazon links to the exact binder clips needed. These are always the correct size and usually the best price. Full disclosure: we do get some money back from these affiliate links. If you have come to terms with Amazon's eventual world domination, then this is your best bet.

CARDBOARD

Cardboard is the best material for all makers, educators, parents, and humans. Cardboard can be recycled, but it is better when it's reused for education, art, and/or fun. With the proliferation of online retailers, the amount of cardboard that is accessible has increased for most houses, schools, and libraries. Stop thinking of those cardboard boxes, no matter the size, as trash to dispose of or recycle. Think of them as potential canvases, building structures, robot costumes, marble mazes, project enclosures, and much more. Cardboard rocks! A five to seven inch square piece of cardboard is a sufficient amount to make one set of the five Core Bricks. Each brick is usually a rectangle with each side measuring between one to three inches.

Most teachers and librarians can have some cardboard saved for them with a few day's notice to someone who handles shipping or building maintenance. If you don't have easy access to cardboard try posting on local social media groups or calling local businesses. You do not need large boxes, which are the popular boxes for people moving. If all of these options fail, order yourself a pizza. You deserve it. Then use the pizza box.

After you have built many different bricks, the next step is to start to invent toys, games, tools, and more gadgets with Scrappy Circuits. Typically, cardboard is used as the main building material. Later in the book there is a chapter dedicated to how you can join, connect, cut, and sculpt cardboard for all of your needs.

Some teachers have shared the tip that if you are building Scrappy Circuits with a large group, it is recommended to have many bricks pre-cut. Others have said that this was their student's favorite part. I think the difference is in the tools. Cardboard can be very frustrating to cut with scissors, especially small ones. It can be a blast to cut with a cardboard saw, cardboard scissors, or an electric cardboard saw. This added fun is because students are learning how to use a new tool. Some bricks require specific sizes or might need trimming. You can have the learners find or cut the best size brick through trial and error.

ALUMINUM FOIL

Aluminum foil has an interesting history that consists of a lot more than just keeping leftovers edible. Aluminum is the most common metal found on the Earth's crust. Despite this fact, it was also the most expensive metal for many years. Even though aluminum was plentiful, it was a challenge to extract in large chunks. This caused the price of aluminum to exceed both silver and gold. In fact, aluminum was so precious at a time that an aluminum pyramid used to adorn the top Washington Monument. It now sits in a museum in Washington DC next to a plaque explaining the rise and fall of this metal.

For our scrappy purposes, aluminum is cheap, flexible, easy to use, plentiful, and most of all—conducts electricity. Did I mention it's cheap? Rolls and sheets of aluminum foil can be found in most dollar stores or other similar stores. Sheets often work better for large groups since it is easier to distribute equally.

Aluminum foil is to Scrappy Circuits what duct tape is to every other thing in the world. Adding even a small piece of aluminum foil to the point of connection between two things (example: binder clip and LED) will help the electricity find a strong path so it can travel. Voilà! Aluminum foil no longer just hugs your burritos, holds your half-eaten chicken dinner in a swan-shaped body, or makes a cool hat to keep aliens out of your brain.

BATTERY

The power source for Scrappy Circuits is a 3 volt (3V) coin cell battery, sometimes called a button cell battery, model number CR 2032. Both names are because the battery is about the shape and size of a thick nickel or a button. Each side of the "coin" is a different terminal for electricity to travel in or out of the battery. The positive side is smooth and has text on it. The negative side is outlined with a ring, usually rough, and never labeled.

A 3V coin cell battery is found inside of an LED tea light. I have yet to find a tea light that uses a different battery. They are also commonly used in wristwatches, keychain lights, bicycle lights, calculators, and some hearing aids. These versatile, inexpensive, and common batteries are perfect for Scrappy Circuits. They can be purchased inexpensively in bulk (cheapbatteries.com is a great place to start looking). A real head-slapper is that most dollar stores sell a single 3V battery for a dollar, even though their two-packs of LED lights have two of the same batteries inside. Now you know!

The other good thing about coin cell batteries is they are relatively safe. You cannot be shocked by holding them in your hand or using them in Scrappy Circuits. However, there are precautions to take to make sure no one gets hurt.

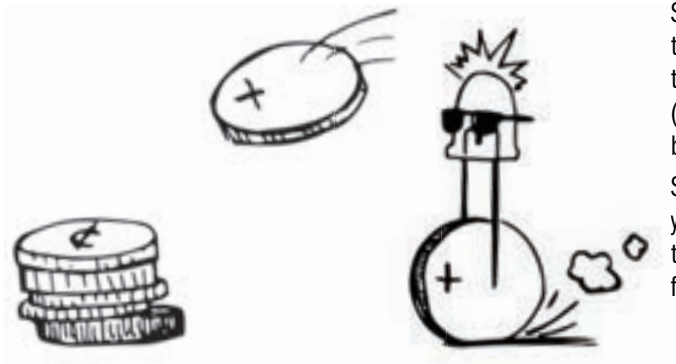
These batteries can quickly discharge a lot of current and become hot if placed in a short circuit—a circuit that directly connects the positive side of the battery to the negative side.

In electrical terms, a short circuit does not have a load that consumes electricity. An example would be if you connected your battery brick to a binder clip switch and then back to the battery. The current will ruin the battery as it runs fruitless laps to and from the battery. This is to be carefully avoided and specifically instructed against in large groups.

Coin cell batteries are lithium batteries and require some special handling.

- Coin cell batteries should not be taken apart.
- Coin cell batteries usually can not be disposed of in local trash collections for environmental reasons. Local big-box hardware stores will dispose of them properly. If that is not an option for you, search online for proper disposal instructions.
- Coin cell batteries should not be stored loosely in a bin. If they touch each other back to front you may create short circuits and extreme heat, enough to catch fire. If you have extra batteries, lay them on a line of masking tape and cover them with more masking tape.
- Lithium batteries have special instructions for shipping them in packaging. They may not be left in checked baggage on an airplane. If you are shipping or traveling with coin cell batteries, be sure to follow all instructions.
- Coin cell batteries can be very dangerous if swallowed. According to Poison Control (poison.org/battery/stats), this happened over three thousand times in 2017. The risk is more than just choking. The battery can become lodged in your esophagus and burn a hole. About 4% of the battery swallowings in 2017 had moderate to severe outcomes. An average of 2.5 people a year have died from swallowing a coin cell battery from 2007-17. These numbers have increased over the years and show no signs of waning.

If swallowed, contact your local poison control immediately.



LEDS

LEDs can be found in most modern electronics. This is because they are inexpensive to make, use very little electricity, are durable, emit a bright light, and give off very little heat. LED stands for Light-Emitting Diode. The first two letters stand for the LED's main function to emit (give off) light. The final letter stands for diode, a semiconductor that allows electricity to flow in only one direction. This is why the LED will only emit light when the longer positive leg is connected to the positive terminal of the 3V coin cell battery. If your LED is connected to the battery differently, it will not light.

LEDs have polarity, which means electricity travels in one direction. This means that the LED won't work if electricity is traveling into the wrong leg. The easiest way to identify the LED's polarity, or positive and negative legs, is through length. The longer leg is positive. The shorter leg is negative.

The shorter, negative terminal/leg is called the "cathode." The longer, positive terminal/leg is called the "anode." Some people like to remember this by thinking that the positive leg has had something added to it, and that is why it is longer and marked with a plus sign (+). The negative leg is marked with a minus sign (-), because it is shorter and had something taken away.

Sometimes if you are using an LED from a tea light, you have it cut it out, and you won't be able to tell if the legs are different lengths. In that case, here are a few ways to identify the positive and negative legs.

Test It

Put your 3V coin battery in between the legs of the LED. If it doesn't light up, flip the battery so it touches the opposite legs. Once illuminated, the leg that is touching the positive side of the battery (marked with a plus sign) is the positive leg. The other leg is negative.

Look Inside the LED

You will see two metal pieces inside the dome of the LED. The larger one connects to the negative leg. The smaller one connects to the positive leg. This is the easiest way to label the binder clips on your LED Brick as positive and negative without disassembling the brick.

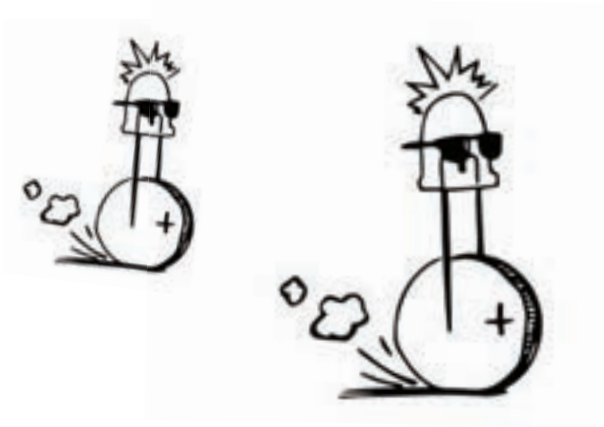
Find the Flat Edge

If you look at the rimmed edge of the LED's casing you will notice that there is one small flat section. The leg closest to the flat edge is negative. This is another easy way to tell the polarity of your LED without breaking apart an already built LED Brick.

HOW TO TAKE APART AN LED TEA LIGHT

As you take apart the LED tea light, you should have three parts to use for your Core Bricks: the LED, the 3V battery, and the plastic cylinder enclosure. Be sure that these parts are kept safe and not thrown out. Be gentle with the LED. The LEDs inside tea lights are cheaply made and too much twisting can easily break a leg off.

There are many different styles of LED tea lights. Typically, the cheap dollar store LED tea lights are very easy to take apart. The more expensive ones you might find in a craft store or home decor store are built a little better and may take a little bit longer to dissect. Since there are so many different types of LED tea lights, here are general directions for taking one apart.



STEPS 1-2

1. Open the battery compartment. You might need a small screwdriver to remove a screw.
2. Remove the battery. Set it aside for later.

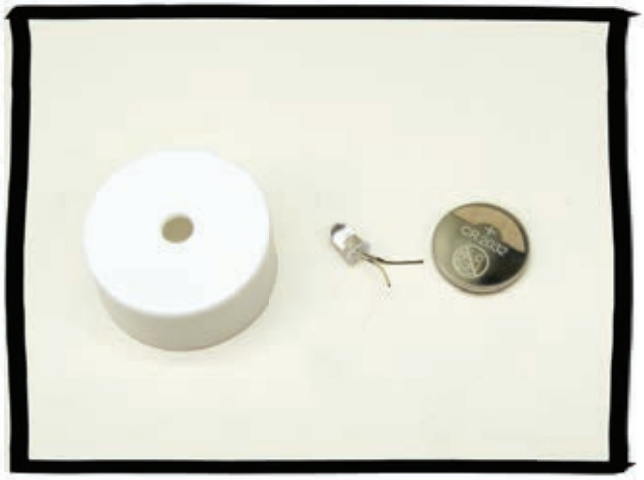
STEP 3

3. Use a small screwdriver to pry apart the cylinder housing from the battery holder bottom. In most tea lights, you can insert the screwdriver into a hole in the battery compartment and use the screwdriver as a lever to pop the battery holder bottom away from the cylinder body. Try not to crack the plastic body of the tea light.

STEP 4

4. Often times the LED is loose inside the tea light, but sometimes you might need scissors or wire cutters to cut the legs free. Cut so that you save as much of the LED legs as you can.

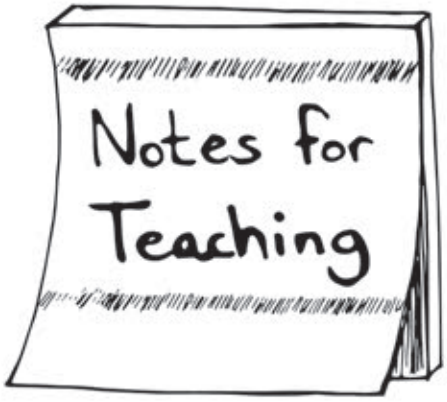
STEP 5



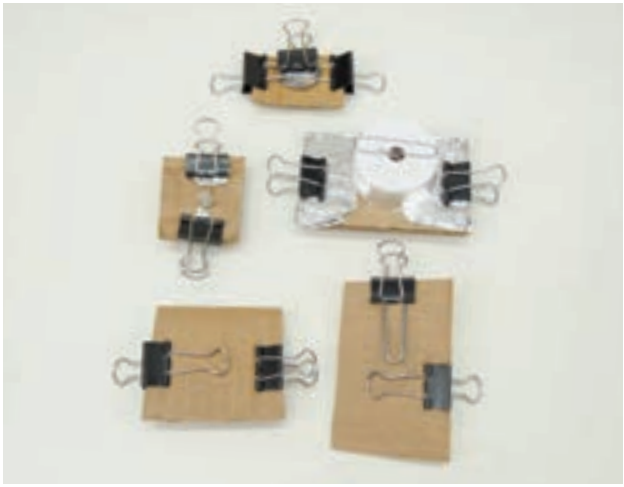
5. Carefully remove the LED, do not bend the legs more than necessary. Set the LED aside for later use.

Lighting the LED (AKA: Simplifying the Tea Light; AAKA: The Most Important Step)

Now that you have an extracted 3V battery and an LED, it is important to show how these two elements work together. Outside of the obscuring enclosure it is easy to understand how simple an LED tealight is. To light the LED, have the legs straddle the 3V battery. Remember: the longer LED leg needs to touch the positive (+) side of the battery. If the LED doesn't light, it is because the legs are touching the wrong sides of the battery. Have the learners remove it from the battery and spin it so the legs touch opposite sides of the battery. The path of electricity can be traced out of the battery, through the leg, into the LED, back down the opposite leg, and finally returning into the battery. Have everyone disconnect one leg to stop the flow of electricity. This will turn the LED off.



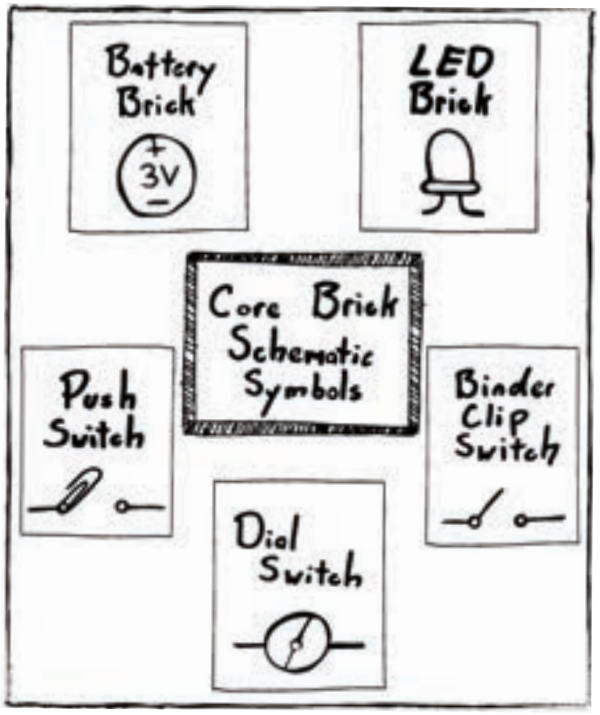
There are few things more enjoyable than seeing a child's face glow with amazement as they watch an LED light up. As soon as a child sees their LED light by simply holding the extracted parts in their simplest and most essential form, their mind races with curiosity and understanding at the same time. There is no more mysterious black box (or in this case a white cylinder) guarding the understanding about how LEDs work. In that moment they have been given a lifetime pass to understanding the simple and amazing power of electricity. That is why this is the most important step. Discuss what is happening. Let them explain their theories without correction. You may be surprised that even young children have ideas about electricity. Expressing those ideas is an invitation to do more, play more, and invent more. Do not rush this moment! Let the illuminated LEDs inspire everyone to be lifelong curious hackers. At all costs do not skip this step. However, this is not the time to stop and deliver a long lesson about electricity. Those understandings will come naturally as they play with the bricks. Let the inventing continue!



CORE BRICKS

"There are not more than five musical notes, yet the combinations of these five give rise to more melodies than can ever be heard." —Sun Tzu, The Art of War

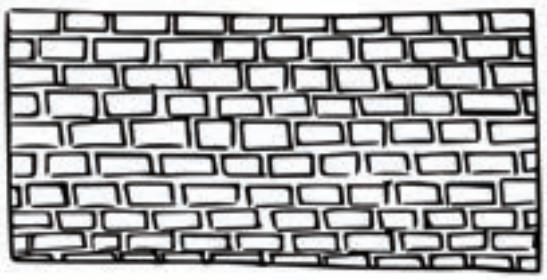
Start your Scrappy Circuits journey by making the five Core Bricks. The parts for these five bricks can be sourced locally by taking apart dollar store tea lights, and finding or purchasing office supplies as described in the previous chapter. If you are leading a larger group, you may want to purchase the parts in bulk online. But no matter if you are making these by yourself, for a small group, or a large group, start here. The five Core Bricks contain three different elements for a simple circuit: a power source (Battery Brick), an action (LED Brick), and three switches (Binder Clip Switch, Push Switch, and Dial Switch). Everyone, especially large groups, should write the website URL (scrappycircuits.com) somewhere on each brick so they can continue their learning journey after the group.



Still not convinced to start your Scrappy Circuits journey with the five Core Bricks? Here's a list of reasons you should:

1. These five bricks can be made for around one dollar.
2. All the parts are common and can be found in most communities.
3. Since the parts are common, it helps makers redefine and repurpose items they are familiar with.
4. You create two of the most essential Bricks: the LED Brick and the Battery Brick
5. The remaining three bricks, the Binder Clip Switch, Push Switch, and Dial Switch, are all simple and creative switches that demonstrate the many different ways we can control electricity.
6. These bricks will all work with and are essential to the Bonus Bricks.
7. These five bricks can easily be made in around 5 to 15 minutes by yourself or in a small group.
8. There are very few prerequisite skills or knowledge needed to make these bricks.
9. The Core Bricks are a great sampling of Scrappy Circuits, so you will know quickly if you don't like this or if you're in love.
10. There isn't a tenth reason. Lists of nine just look weird.

Don't dawdle or dilly-dally. Let's get started!



BATTERY BRICK (POWER SOURCE)

Like doughnuts to Homer Simpson, every Scrappy Circuit is powered by a Battery Brick. The 3 volt coin cell battery can be taken from a tea light or bought separately. Electricity travels in and out of a 3V coin cell battery through the opposite faces (flat sides) of the battery. The positive side of the battery is smooth and labeled with a +. The negative side is outlined with a ring, usually rough, and never labeled. Be sure to mark which binder clip arm is touching the positive side of the battery with a plus sign and the negative side with a minus sign. You will thank yourself later!

The original design of the battery brick used three binder clips: positive terminal, negative terminal, and one to hold everything together tightly. This version was very reliable, but used an extra binder clip. At the end of 2018, Carrie Leung, Ben James Simpson, and Olivier Schwert were involved in a Scrappy Circuits workshop in Germany. With supplies being short, and necessity being the mother of invention, a two-binder clip version was created.

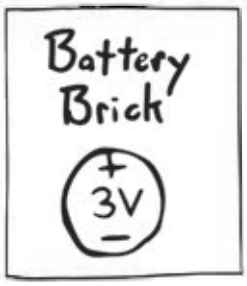
Both versions are here so you can choose what works best for you. The original three binder clip version is notably more reliable, which is very important if you're working with a large group. The two binder clip version requires either perfect positioning or extensive sanding. Though less reliable, this version uses one less binder clip. This could cut costs if holding a Scrappy Circuits workshop. You will only need eleven binder clips to make all five Core Bricks.

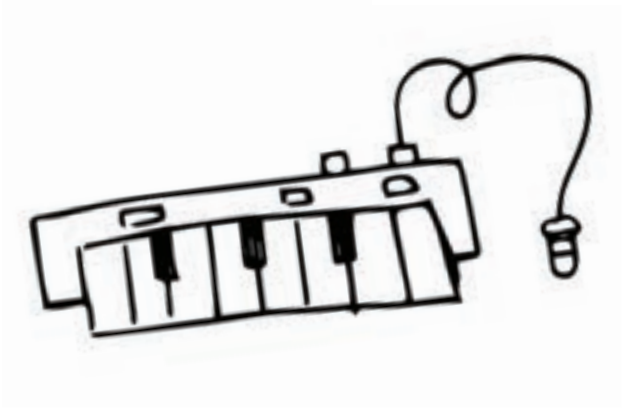
Materials

- Cardboard
- 3V coin cell battery (CR 2032)
- 2 or 3 small binder clips

Tools

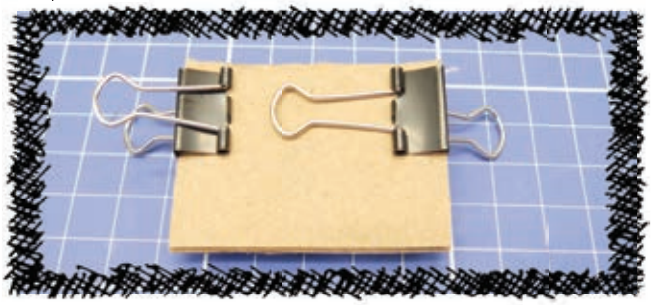
- Scissors





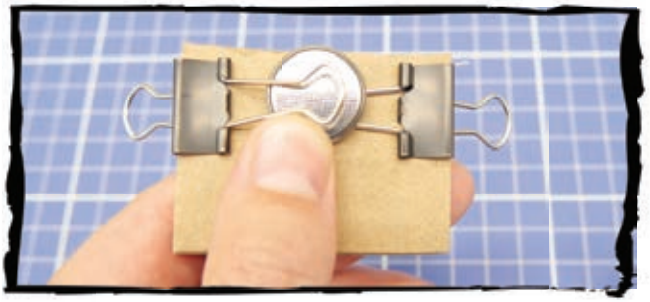
Three Binder Clip Version

STEPS 1–3



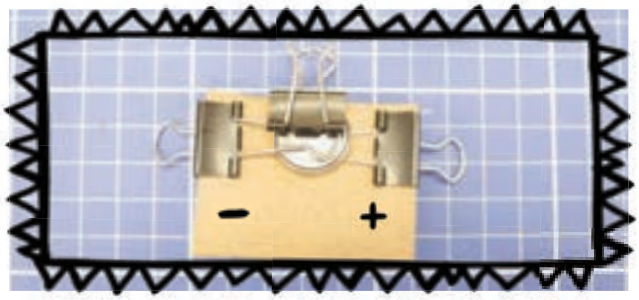
1. Cut a cardboard rectangle with each side measuring about 2–3 inches.
2. Clip a binder clip to each side of the cardboard brick toward the top.
3. Flip one binder clip arm down.

STEPS 4–5



4. Place the battery on top of the binder clip arm. It works better with the positive (+) side down.
5. Flip the other binder clip arm down on top of the battery.

STEPS 6–7



6. Use a third binder clip to hold the top arm firmly to the battery and brick.
7. Label each binder clip as positive (+) or negative (–) based on which side of the battery the arm touches. This will make it easier to build a working Scrappy Circuit.

Two Binder Clip Version

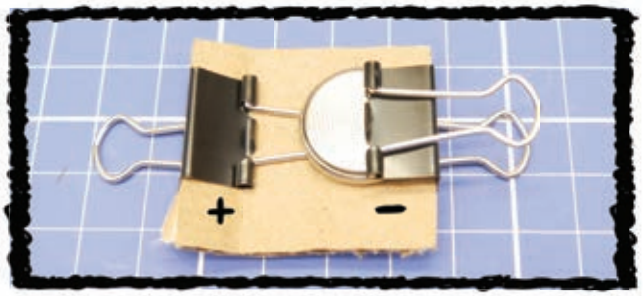
STEPS 1-3

1. Cut a cardboard rectangle with each side measuring about 2-3 inches.
2. Clip a binder clip to the cardboard.
3. Flip the binder clip arm down.

STEPS 4-5

4. Trim the cardboard on the opposite side of the binder clip arm slightly longer than the extended arm.
5. Place the battery on top of the binder clip arm with the positive (+) side down.

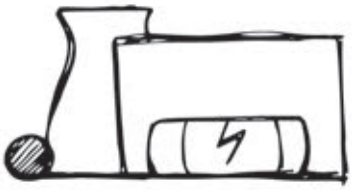
STEP 6



6. Clip a binder clip on the opposite side from the first binder clip. It should go over the cardboard and the battery. This is the binder clip that might need additional sanding.

Pros and cons of each style Battery Brick

Three Binder Clip Version		Two Binder Clip Version	
Pros	Cons	Pros	Cons
• More reliable	• Takes one more binder clip • Slightly more expensive	• One less binder clip • Slightly cheaper	• Many times the outside binder clip requires a lot of sanding. • Can be frustrating with a large group.

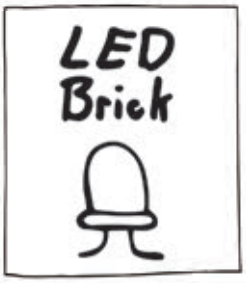


LED BRICK (ACTION BRICK)

Of the five Core Bricks the LED Brick is the only load, or element that is activated (turned on) by the flow of electricity. In Scrappy Circuits we call these "Action Bricks," and they are the parts of a circuit most people are familiar with when we think of electricity. A television, lamp, microwave, and electric toothbrush are all loads that consume electricity. The number of Action Bricks in a circuit will affect the life of the battery. More Action Bricks will cause the battery to drain faster or not perform at its peak.

Of the five Core Bricks, the LED Brick is easily the most temperamental. I would recommend sanding the binder clips for this brick and adding aluminum foil to the LED legs. You can use sandpaper, a sanding block, a nail file, or an emery board—all of which can be found at most dollar stores. Details about sanding binder clips can be found in the previous chapter. In addition to sanding the binder clip, it is recommended to add some aluminum foil to each LED leg. Make sure the aluminum foil touches the LED leg and the binder clip. Make sure the foil doesn't go near the LED or the opposite LED leg. Be sure to make sure the bottom binder clip arms are not touching underneath the brick. These actions will help your LED Brick work better, be brighter, and have leaders of large groups not lose their heads.

LEDs are sold in a wide range of different colors and sizes. Don't feel like you need to stick with the boring and bland white light from an LED tea light. Experiment with different colors and styles of LEDs. No matter the color or size, your LED Brick will be made the same way.



Materials

- LED
- Cardboard
- 2 small binder clips
- Aluminum foil

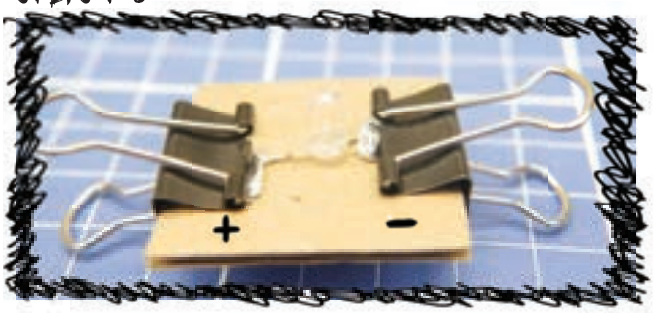
Tools

- Scissors
- Sandpaper, a sanding block, a nail file, or an emery board

STEPS 1–3

1. Carefully stretch the legs of the LED apart. Mark or remember which leg is longer.
2. Cut a piece of cardboard that is slightly longer than the stretched out legs of the LED.
3. Crumble some aluminum foil around each LED leg.

STEPS 4–5



4. Clip a binder clip around the legs of the LED and cardboard, one on either side.
5. Label with "LED Brick" and write a plus sign near the clip for the longer LED leg and a minus sign near the other clip.

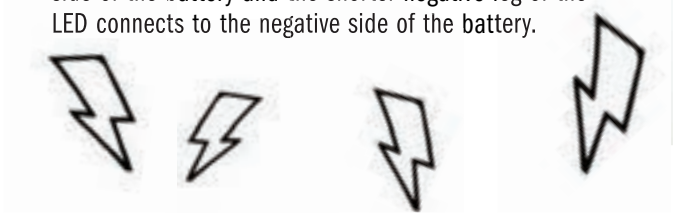
Get Creative

The LED Brick is like the sun that the universe of Scrappy Circuits revolves around, at least at the beginning. Feel free to have some fun and get creative with how your LED Brick looks. Look around yourself and see if you can repurpose anything to make your brick more fun and exciting.

Troubleshooting

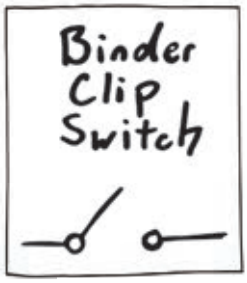
Repurposing office supplies sometimes means that they don't work perfectly at their new job. Here are some tips for getting your LED Brick to work if it does not at first.

- Sand each binder clip where it touches the LED leg.
- Wrap the LED legs in aluminum foil.
- Give the binder clip an extra squeeze to tighten the connection between the clip and the LED leg.
- Remove the binder clip and then reclip the LED leg to find a more conductive area.
- Fold a small rectangle of aluminum foil and place it under the binder clip and LED leg. Make sure it does not connect to the foil or binder clip on the other side of the LED.
- Flip your binder clip to try a different side, or try a different binder clip altogether.
- Check to make sure your LED legs are not broken. If so, replace your LED. The best way to test your LED is to have the legs straddle a spare 3V battery.
- Remember that LEDs have polarity. Your battery might be hooked up backwards or mislabeled. Make sure the longer positive LED leg connects to the positive side of the battery and the shorter negative leg of the LED connects to the negative side of the battery.



BINDER CLIP SWITCH

This simple brick is an example of a toggle switch—a switch that stays on after you flip it. The only way this switch turns off is if you flip the binder clip arm back. Toggle switches are very common. Light switches are a perfect example. Your lights stay on after you flip the light switch. They go off again once you flip it back.



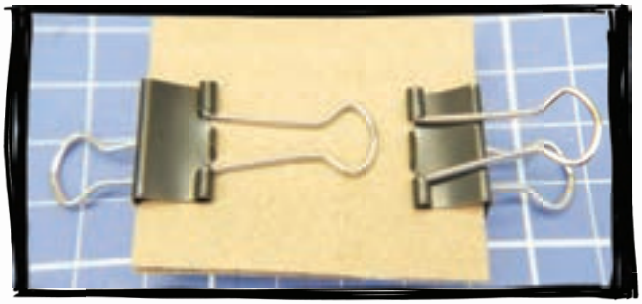
Materials

- Cardboard
- 2 small binder clips

Tools

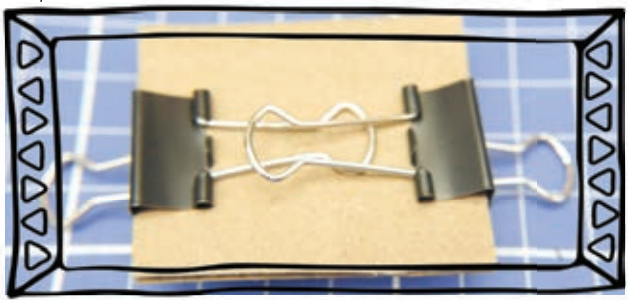
- Scissors

STEPS 1-3

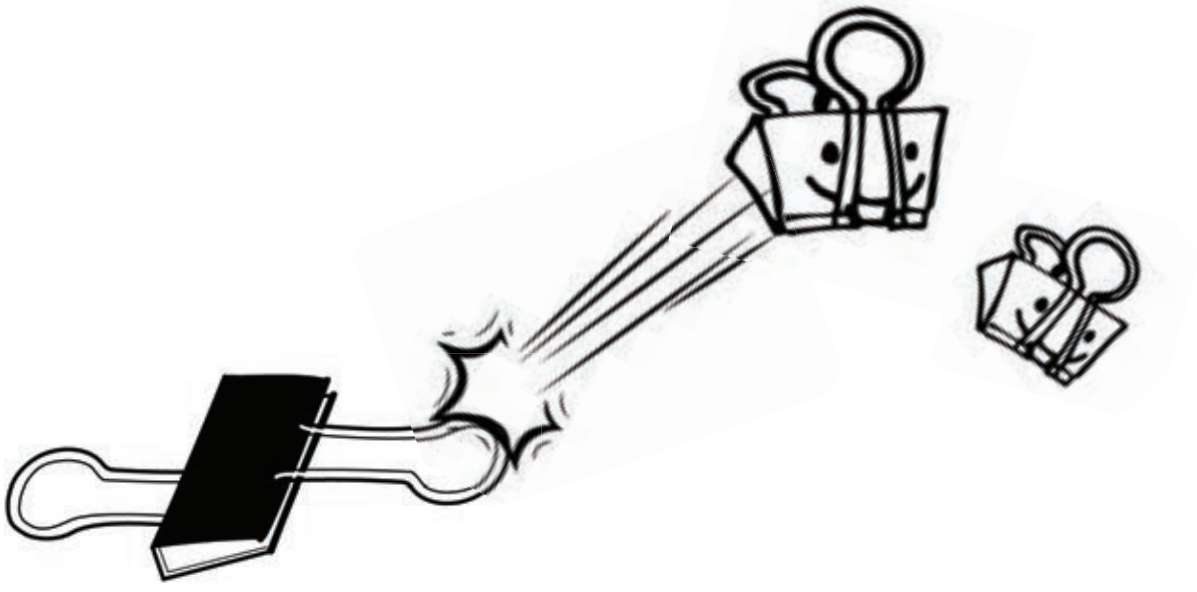


1. Clip two binder clips to opposite sides of a cardboard brick.
2. Flip one arm flat against the brick. If it touches the other binder clip's base, cut a larger brick.
3. Leave one arm down.

STEPS 4-5



4. When you flip the opposite arm down, it should touch the other binder clip's arm and complete the circuit (turn on). When you lift the arm, it turns the circuit off.
5. Label with "Binder Clip Switch."



PUSH SWITCH

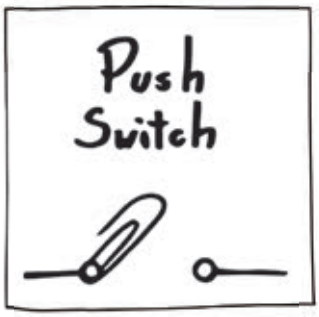
A push switch is an example of a momentary switch. It only completes or turns on when the paper clip is pressed. When released, the circuit will open and turn off. This is the opposite of a toggle switch like the Binder Clip Switch. This switch is most similar to the buttons on a remote control. When we want to change the channel, we push once and then release. The Push Switch operates the same way. Some aluminum foil can be added to the base of the paper clip to help allow electricity to travel through.

Materials

- Cardboard
- 2 small binder clips
- 1 large paperclip

Tools

- Scissors



STEPS 1-3

1. Clip one binder clip to a cardboard brick.
2. Lower one arm.
3. Lay a paper clip perpendicular (at a right angle) over the binder clip arm.

STEP 4

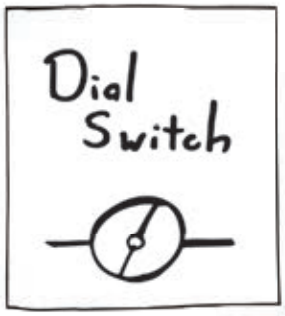
4. Use your second binder clip to hold the paper clip in place.

STEPS 5-7

5. After it is clipped, bend the paper clip up slightly so it is no longer touching the binder clip arm.
6. To close the switch and turn the circuit on, push the paper clip down.
7. Label with "Push Switch."

DIAL SWITCH

This switch uses the cylinder body of the LED tea light in a fun and creative way. It works because the aluminum foil covering half of the cylinder can be spun so it connects the foil on each side or only touches one side. When it connects both sides, the switch is closed and the LED will light up. When it only touches one side, the circuit does not complete and will be off. Of the five core bricks, this is the most complicated to build. It can also be the most fun. Educators like Gerald Aungst (@geraldaungst) will often skip making the dial switch, especially with younger students. The choice is yours.



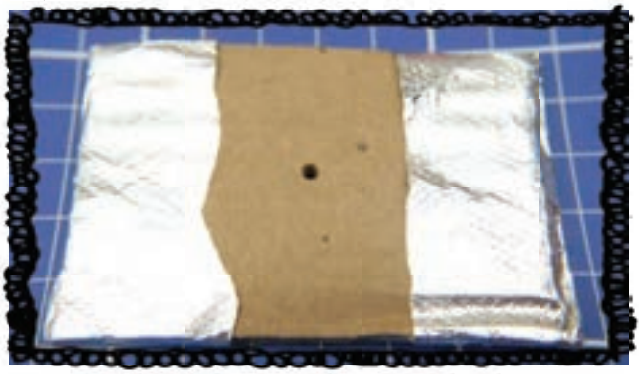
Materials

- Cardboard
- 2 small binder clips
- Aluminum foil
- 1 paper clip

Tools

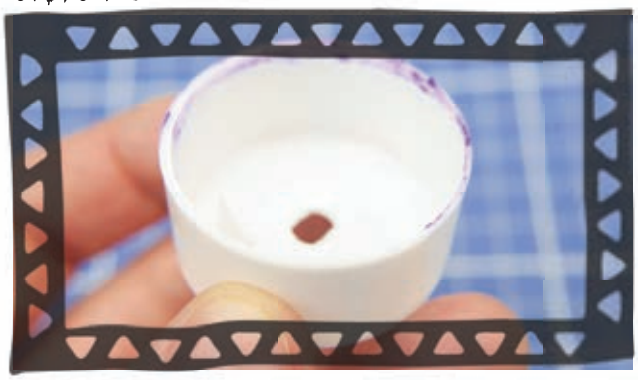
- Scissors
- Glue stick
- A thumbtack or something else to (safely) poke a hole with

STEPS 1-3



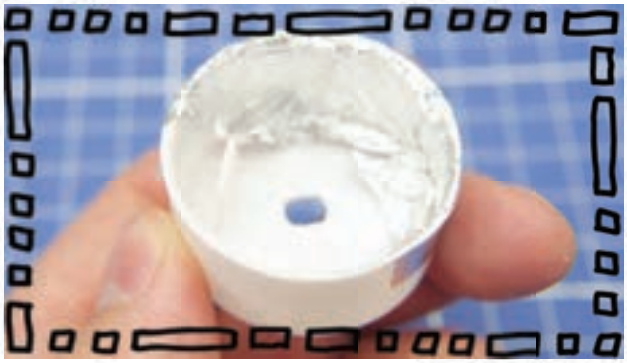
1. Cut a strip of aluminum foil that is the width of your cardboard brick.
2. Cut in half.
3. Use a glue stick to attach the aluminum foil to each side of the cardboard. Be sure the two pieces do not touch in the center.

STEPS 4-5



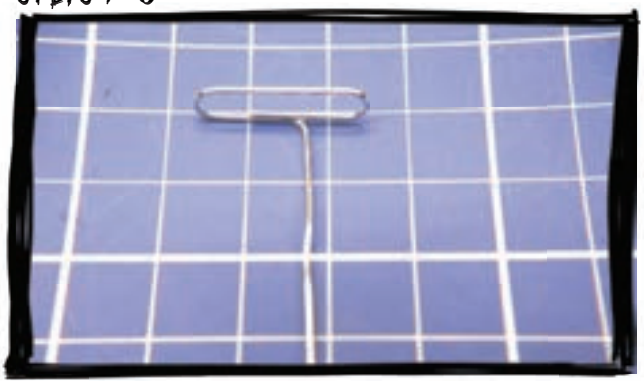
4. Add binder clips to each aluminum foil-covered end.
5. Add some glue from a glue stick to about 50 - 75% of the inside, outside, and lower edge of the white cylinder enclosure.

STEP 6



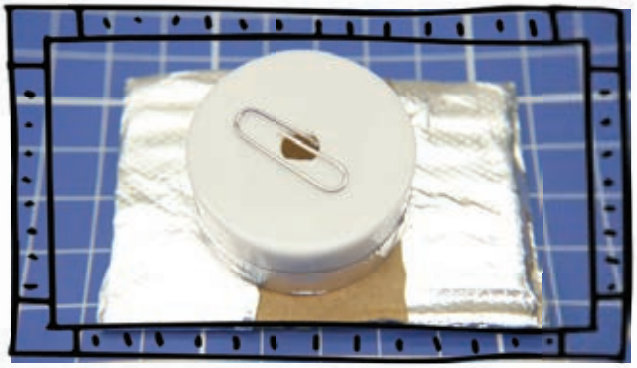
6. Cut a piece of aluminum foil to cover the glued section. Make sure it wraps around the outside and tucks into the inside. The bottom edge of the cylinder enclosure needs to be 50–75% covered in aluminum foil.

STEPS 7-8



7. Poke a hole through the cardboard using a thumbtack or small screwdriver.
8. Straighten enough of a paper clip so it is taller than the cylinder.

STEP 9

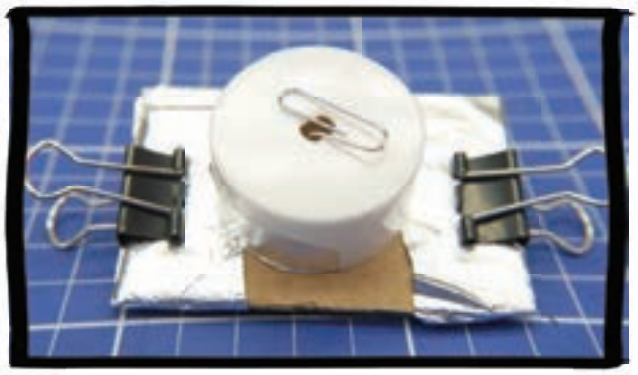


9. Thread the paper clip through the cylinder enclosure.

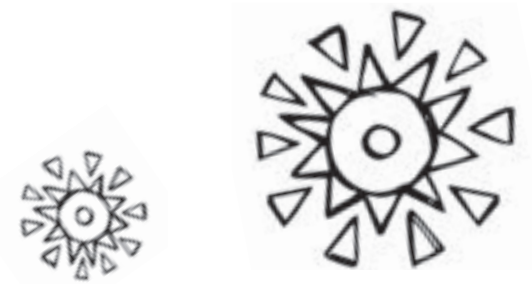
STEP 10

10. On the bottom of the brick, bend the paper clip and tape it down.

STEPS 11-12



11. Spin the cylinder to turn on or off.
12. Label with "Dial Switch."



SCRAPPY CLIPS

"When one is nothing, one invents. It fills a void." —Diane Setterfield

Once you have built your Core Bricks, you will want to connect them. You could just try to hold them so the binder clip arms touch, but that takes a lot of hands! What you need now is a way to connect your bricks so that electricity can flow from one to the other, all the way around your circuit.

There are multiple ways to connect your bricks, each with pros and cons. The most common choice is using alligator clips (also known as test leads, crocodile clips, gator clips, or Bob. Okay, I made the last one up). These can be purchased in bulk for a relatively inexpensive price. They last a long time and are very reliable.

Making your own Scrappy Clips is an alternative to purchasing alligator clips. Scrappy Clips are made of twisted aluminum foil with paper clips at each end. It is cheaper to make Scrappy Clips than buying alligator clips, but are not the most reliable which can become frustrating.

It is recommended to use alligator clips when you first build your Scrappy Circuits. Your bricks are made by you from cheap scraps; they won't work perfectly the first time every time. Using alligator clips will help you problem solve what is wrong with your brick because they are much more reliable than Scrappy Clips. After your bricks all function correctly, then if you want to you can switch over to Scrappy Clips.

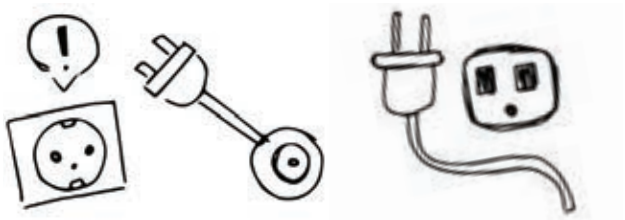
In a take-home workshop, each student should leave with at least three Scrappy Clips or alligator clips. This is the minimum number needed to connect the LED, battery, and a switch. As they invent more bricks, they will need more clips to connect their bricks.

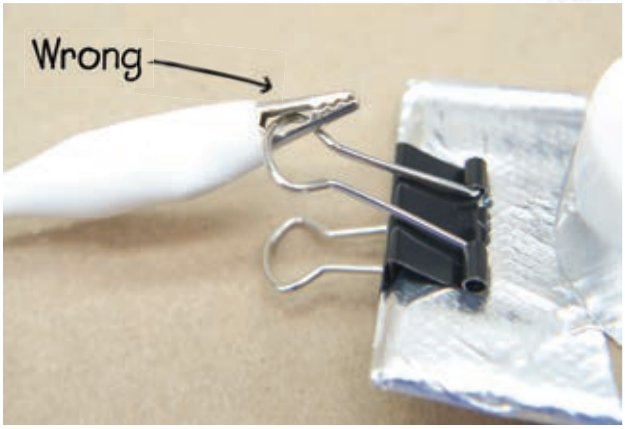
ALLIGATOR CLIPS

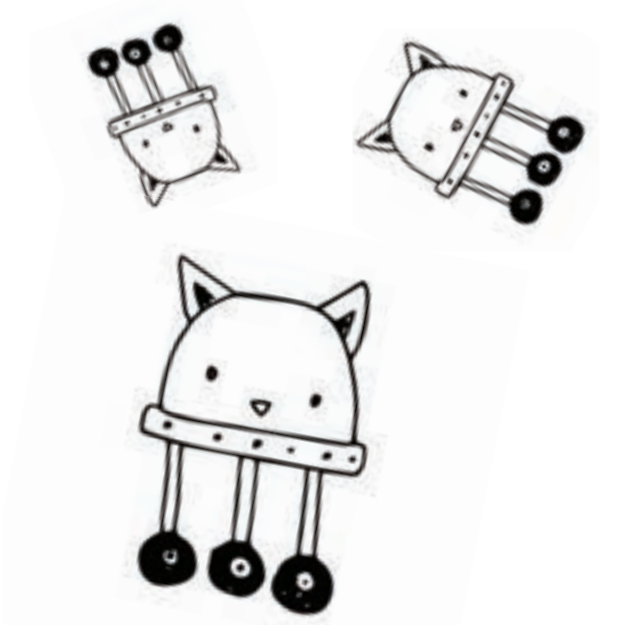
The most reliable way to connect your bricks is with alligator clips. They are flexible and if attached correctly (make sure you use the clip's teeth), they make a tight conductive connection. If alligator clips are an option, it is highly recommended that you use them. Yes, they cost some money, which isn't scrappy. But they can be used and reused over and over again. Three alligator clips (if bought in bulk) will cost between about one dollar and fifty cents to three dollars. Many educators who lead Scrappy Circuit groups use alligator clips in class, but have the students make their own Scrappy Clips to take home. Alligator clips are 99.999% reliable and will in turn increase the reliability of your circuit. They are completely

necessary when trying to troubleshoot a circuit that is not working correctly. If you do want to purchase these, see the list of online vendors at the beginning of the book, or Amazon links can be found on scrappycircuits.com.

The best way to connect your bricks using alligator clips is to have them grip onto the binder clip arm. Make sure the teeth are fully and tightly closed on the arm. Sometimes they might seem connected, but if the teeth are not gripping the binder clip arm, it wiggles in the "mouth" of the clip and causes the circuit to act up.







ALUMINUM FOIL SCRAPPY CLIPS

The easiest and most popular way for schools, libraries, and clubs to make Scrappy Clips is by using aluminum foil. Aluminum foil is cheap and can be purchased at the dollar store or at grocery stores in larger quantities for a similar per-square-foot-price. It is also much more accessible than any other material used to make Scrappy Clips. Aluminum foil can be purchased as a roll or as pre-cut sheets. The sheets are the perfect size for making Scrappy Clips, easy to distribute to a large group, and don't tempt students to make the world's biggest foil ball. For these reasons, foil sheets are recommended, but either a roll or sheets will do.

Your aluminum foil Scrappy Clip can be twisted, rolled, or folded into a thick wire. All that is needed is that the foil has a tight connection with itself (don't we all need that). Thread each end of your aluminum foil wire through a paper clip and fold it back on itself. Squeeze the foil around the paper clip connection with pliers to make it as tight as possible. If you hold the Scrappy Clip by the aluminum foil and wiggle it, the paper clip should be held firmly. You can keep this a tight, secure connection by adding some hot glue around the point of contact between the paper clip and foil. The clip will still work without the hot glue, but it will make the clips more reliable and longer lasting.

To use your Scrappy Clips in your Scrappy Circuit, slide the paper clips onto the base of the binder clips. Make sure they do not slide off. The connection between the paper clip and the binder clip is pretty reliable when connected this way. If your circuit is not working, check the connection between the aluminum foil and the paper clip and tighten that.

The aluminum foil Scrappy Clips will conduct electricity from one paper clip to the other. Normally wires have a conductive core surrounded by an insulating (not conductive) protective layer. However, Scrappy Clips are safe to touch without insulation. This is because Scrappy Circuits only use 3 volts of electricity, which is not enough to produce a shock if you touch the bricks, wires, or battery.

Even though it is safe, using Scrappy Clips without insulation makes it easier for wires to touch each other and produce a short circuit. This is when electricity takes the shortest route and often bypasses parts of your circuit. This can cause your battery to drain quickly. For these reasons, it can be a good idea to cover your Scrappy Clips with an insulating layer. There are a few easy and inexpensive ways to insulate your Scrappy Clips. First, you can wrap the wire in tape. Any kind of tape will do. Another option is to paint each wire with cheap nail polish. This way is

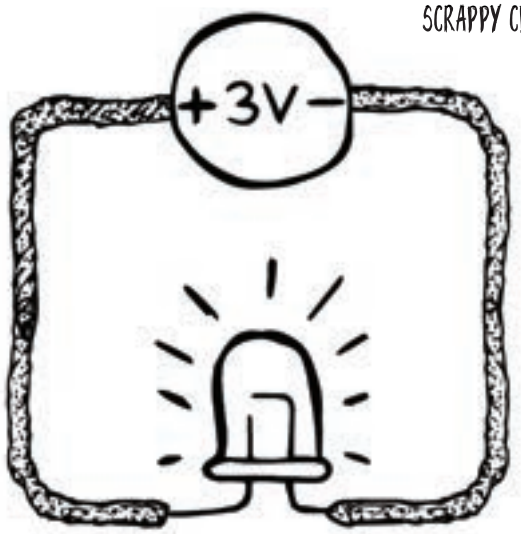
fun because your Scrappy Clips will look pretty cool since most of the cheap nail polish colors are bright neon. For a good layer of insulation, you will need to apply two coats.

Materials

- 2 small paper clips (per Scrappy Clip)
- Aluminum foil (roll or sheets)

Tools

- Pliers
- Hot glue gun (optional)
- Nail polish (optional)
- Tape (optional)



STEPS 1–3

1. Get a piece of aluminum foil that is about six to ten inches long.
2. Roll or fold the aluminum foil repeatedly around something thin like a coffee stirrer.
3. Give the foil some pinches to make sure it is connected firmly to itself.

STEP 4

4. Wrap the end of the aluminum foil around the short single-loop end of a paper clip. Give each wrapped end a good squeeze with some pliers to make sure the connection is tight. The paper clip should not wiggle when you shake the Scrappy Clip while holding the aluminum foil.

STEP 5

5. (Optional, but recommended) Cover the wrapped aluminum foil and paper clip connection with hot glue to keep it secure.

RECYCLED WIRE SCRAPPY CLIPS

Search around your home for some scrap wire. This can be from old computer cables, audio cables, or other electronics. Stay away from power cables just to be safe. Cut the connectors off of each end and throw them out. Then cut the wire into lengths that are about one foot long, or whatever you prefer.

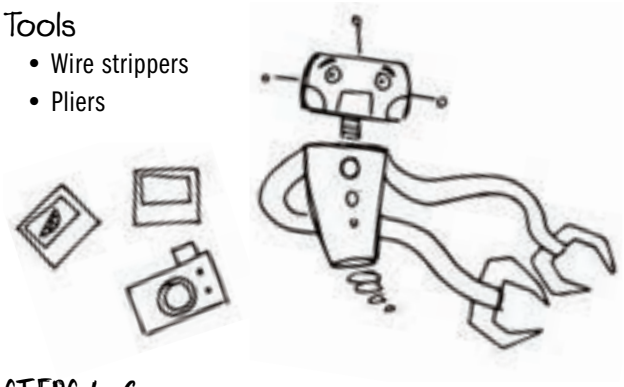
Some scrap wire will contain a few smaller and individually insulated wires inside. Carefully cut the outside insulating coating and try to separate the inner wires (with their colored insulation intact). Be careful; the wires may be sharp. This might be hard, but each individual wire can be used for a Scrappy Clip. Separating these wires will be much easier with a good pair of wire strippers and pliers.

Materials

- Recycled wire
- 2 small paper clips (per scrappy clip)

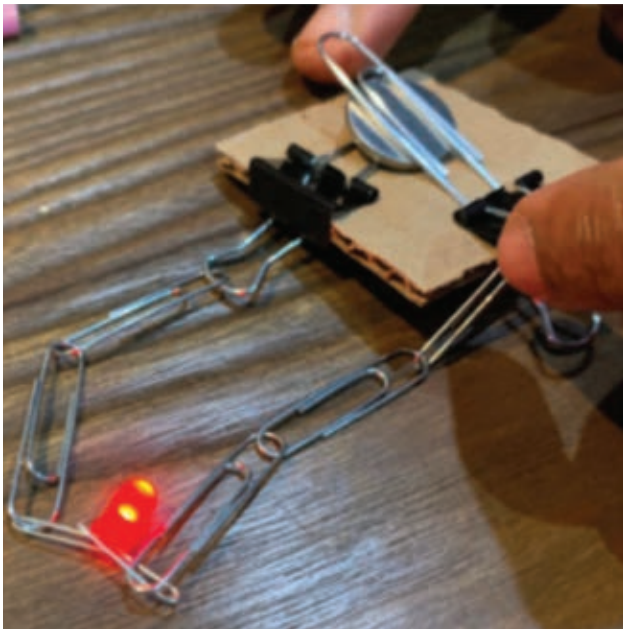
Tools

- Wire strippers
- Pliers

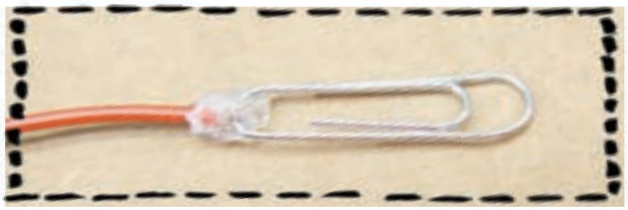


STEPS 1–3

1. Cut the scrap wire to desired length (about one foot is preferred).
2. Strip the insulating coating off the wire at each end.
3. Wrap the uncovered metal end of the wire around the single-loop end of the paper clip a few times with pliers.



STEPS 4–6



4. Squeeze and pull on this connection with pliers to make it as tight as possible.
5. Repeat on the other side.
6. Hot glue can be added to keep each connection secure.

Get Creative

These are not the only ways to make a Scrappy Clip. Remember: the goal of a Scrappy Clip is simple—get electricity from one brick to another. Anything that is conductive can accomplish this. Feel free to invent your own Scrappy Clips, like many others have already done.

Here is a short list of some conductive items that could be used to make really cool and creative Scrappy Clips:

- Paper clips (stretched out or chained together)
- Copper tape
- Staples, brads, and other metal office supplies
- Kitchen whisks
- Screws
- Nails
- A sanded wire coat hanger
- Jeweler's wire
- Water beads
- Smartphone screen protectors

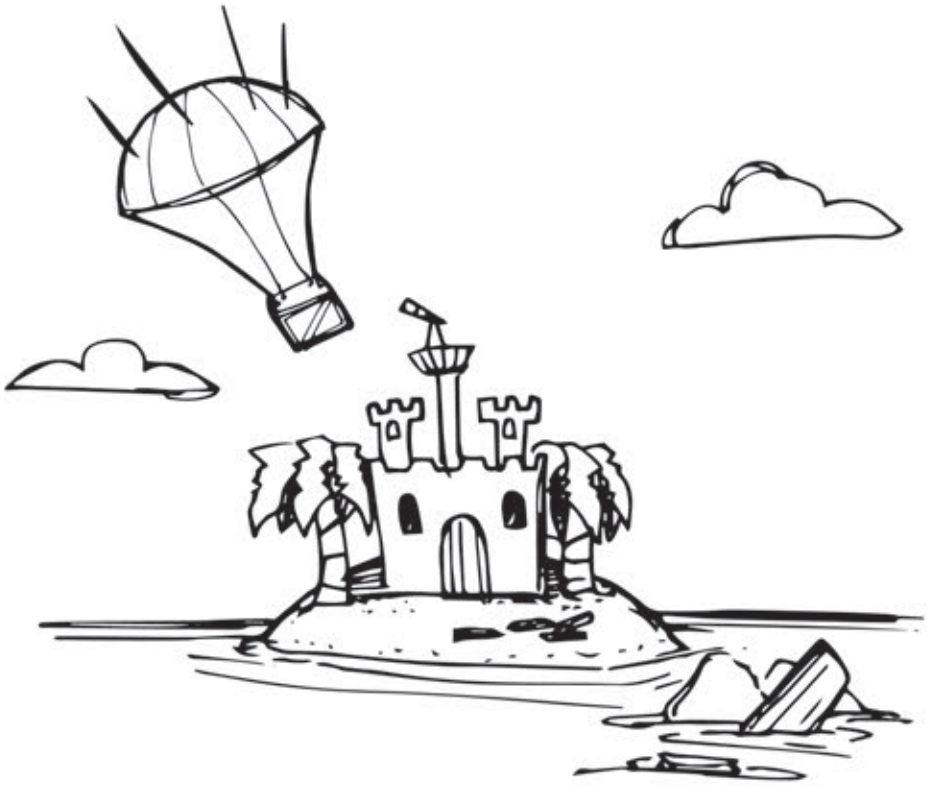
WHICH CLIP TO CHOOSE?

When recommending which Scrappy Clip to choose, it usually comes down to money. That being said, alligator clips are a great investment. Many educators use alligator clips during their lesson, then have the students make Scrappy Clips to take home. For around four dollars you can make about fifty aluminum foil Scrappy Clips. Even if you decide to use Scrappy Clips, I would recommend having a few alligator clips on hand to troubleshoot connection issues.

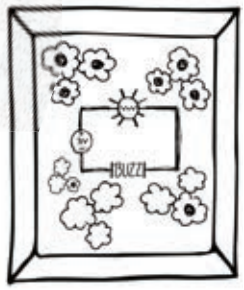
If you have access to unused wire, then the recycled wire version might be the best. It will be more reliable than the aluminum foil version but cheaper than alligator clips.

For large groups we recommend a minimum of three Scrappy Clips per participant. This way they can connect their LED Brick, Battery Brick, and a switch. More Scrappy Clips can be made as more Bricks are made down the road.

	Pros	**Cons**
Aluminum Foil	• Cheap • Accessible	• Not a great conductor • Time spent making them • Reliability can vary based on construction
Recycled Wire	• Great conductor • Reuse & reduce waste	• Not around your average house • Time spent making them
Alligator Clips	• Great conductor • Very reliable • Already made for you	• More expensive



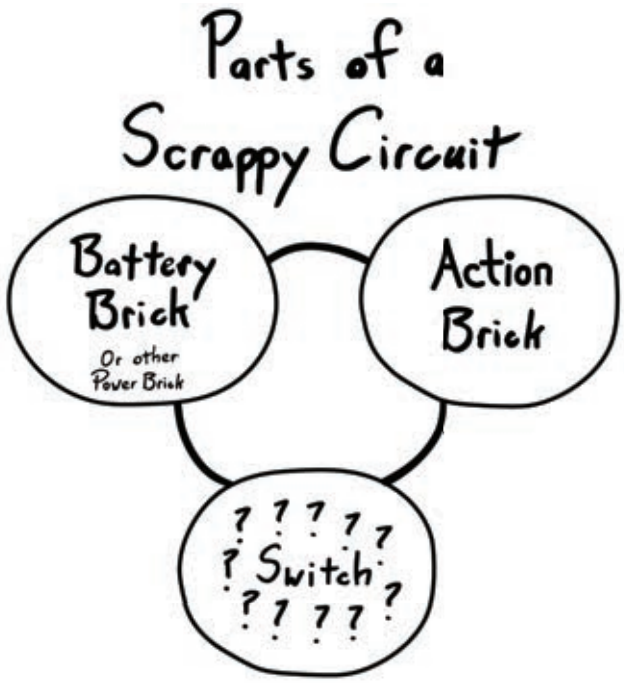
YOUR FIRST SCRAPPY PROJECTS

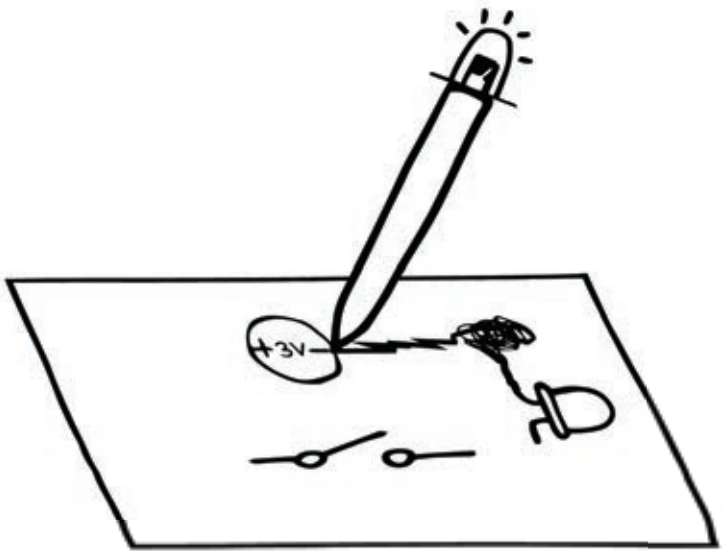


"The imaginative child will become the imaginative man or woman most apt to create, to invent, and therefore to foster civilization." —L. Frank Baum, The Lost Princess of Oz

PARTS OF A SCRAPPY CIRCUIT

Every Scrappy Circuit needs to include at least two things: A Battery Brick (or alternate Power Brick) and an Action Brick. The Battery Brick and LED Brick are part of the five Core Bricks because each circuit needs a power source and a load or Action Brick to perform a task. If a circuit does not contain a Power Brick, it will not work. These circuits need electricity. If your circuit doesn't contain an Action Brick, then the electricity will have nothing to do. This is called a short circuit and can also be potentially harmful. At the very least, it will drain your battery very quickly. It can cause far worse problems as the battery can potentially overheat causing more problems. Make sure every circuit contains an Action Brick. Switches are optional, but potentially the most fun. Technically, each circuit already has a switch included because you can disconnect any element to stop the flow of electricity.





FIRST SCRAPPY CIRCUIT

The first circuit you should make is going to be simple—light the LED Brick with no switches. Gather two alligator clips, the Battery Brick, and the LED Brick to make a circuit. It is important to remember that electricity needs to travel in a circuit, which means it needs to leave the Battery Brick and then return to the Battery Brick. Connect the positive (+) side of the Battery Brick to the positive (+) side of your LED Brick. Next connect the two remaining negative sides (-) to illuminate your LED.

If your LED doesn't light up, it is possible that your positive (+) and negative (–) sides are mixed up. Try disconnecting the LED Brick and reconnecting in the opposite way. Another common barrier to working is the connection between the binder clips and the LED. You might need to sand the mouth of your binder clips, add some aluminum foil, and squeeze your binder clips closed with your hands. If your LED is still not illuminated, or is very dim, try removing your alligator clips and then holding them right against the leg of your LED. If this works, reassemble one binder clip at a time. Find the problematic clip and sand more, add more aluminum foil and give it an extra-loving squeeze—sometimes we all just need a hug. Keep repeating until this works. More troubleshooting tips can be found later in the book, if needed.

We're going to assume your LED is shining bright and proud at this point. YEAH!!! This moment should be celebrated. If you are working with a group of students, maybe have some DIY badges ready to celebrate this amazing moment. Badge or not, this moment should be celebrated to the fullest. It will be memorable to many students. I remember making my first circuit work in Miss Miller's sixth grade class. Thanks Miss Miller!

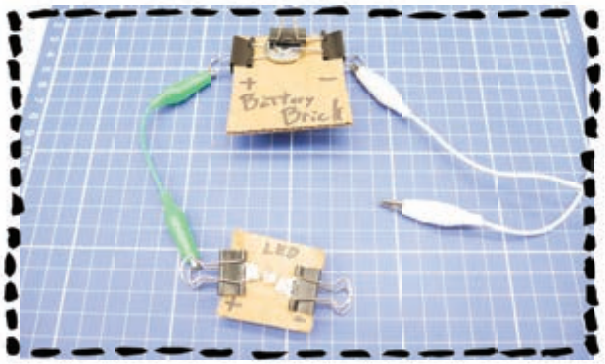
Bricks Needed

- Battery Brick
- LED Brick

Materials

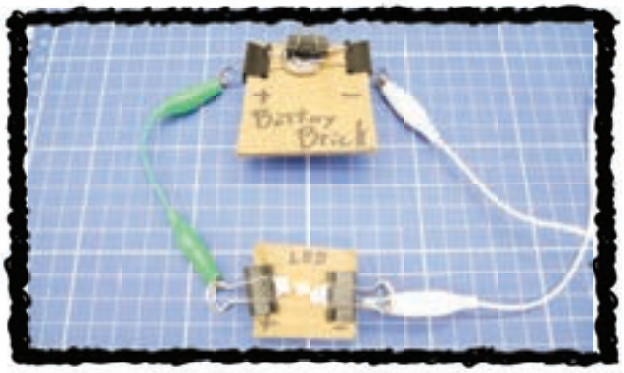
- 2 Alligator clips

STEP 1

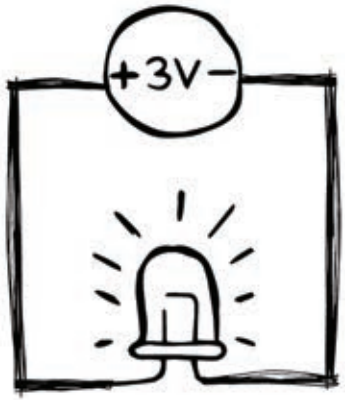


1. Use an alligator clip to connect the positive (+) side of the Battery Brick to the positive (+) side of the LED Brick.

STEPS 2-3



2. Connect the two remaining negative (-) terminals together with an alligator clip.
3. Marvel at your amazingness!



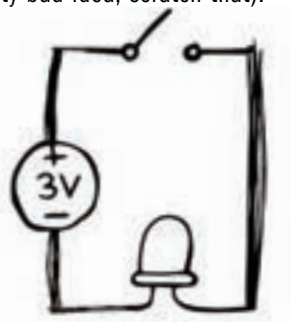
BINDER CLIP LIGHT SWITCH

Now that you're back from your celebration, get your Binder Clip Switch and another alligator clip to learn how you can control electricity. The circuit you are creating is going to operate just like the one commonly found on walls to control lights. It has a toggle switch, which means it stays on by itself. This makes sense for the lights in a room since you want them to stay on for a long time without doing anything.

To build this simple and controlled circuit, disconnect any clip and connect it to your switch. Scrappy Circuit switches do not have polarity. This means they do not have a positive and negative side. It does not matter which way the electricity travels or which binder clip connects to the positive or negative binder clip or the LED Brick or Battery Brick. Use a third alligator clip to connect the open binder clip on your switch to the open binder clip on your brick. The switch now controls the LED light! You have the power to control electricity!!!! Climb a mountain and tell the world. Do cartwheels as you climb down (actually that's a pretty bad idea, scratch that).

Bricks Needed

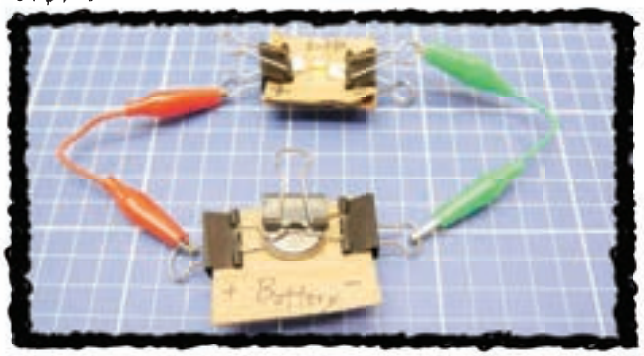
- Battery Brick
- LED Brick
- Binder Clip Switch



Materials

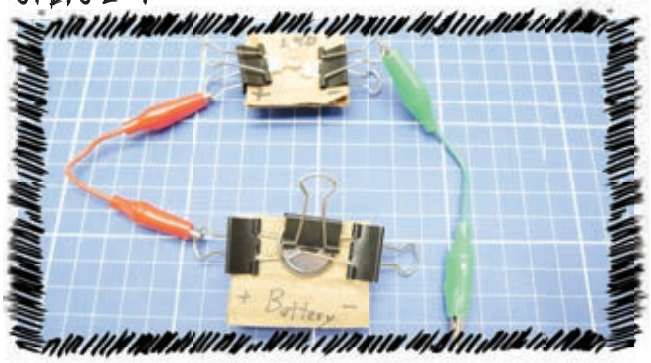
- 3 Alligator clips

STEP 1



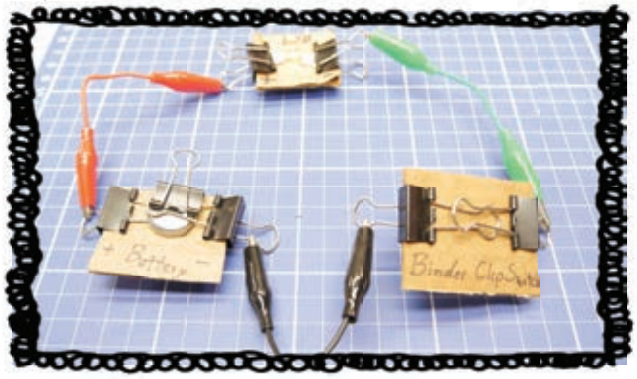
1. Test to make sure that the circuit works with your Battery Brick and LED Brick.

STEPS 2-4



2. Disconnect an alligator clip from anywhere in your circuit.
3. Take a third alligator clip and connect it to either side of your Binder Clip Switch.
4. Connect the open end of your third alligator clip to the vacant binder clip.

STEP 5



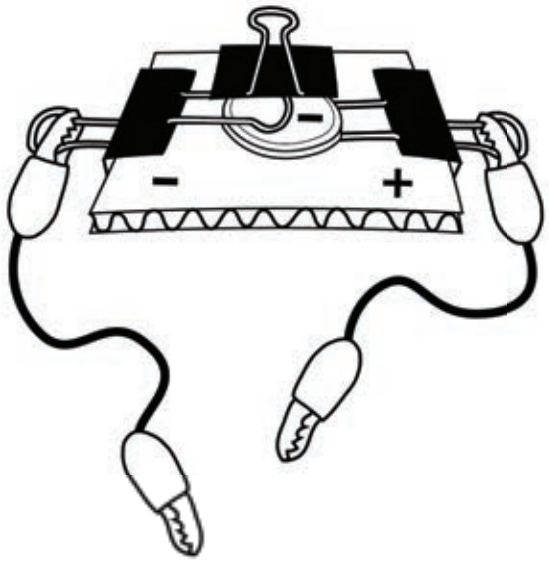
5. Now your Binder Clip switch controls the LED light. When both binder clips arms are folded down and touching, the light is on. When one is folded up, and they are no longer touching, the light is off.

Experiment by swapping to a different type of switch. Now add two switches. Notice how both switches need to be on for the LED to light. This is because the circuit you are creating is in series. In an upcoming chapter we are going to look at what a series circuit and a parallel circuit are and the similarities and differences between them.

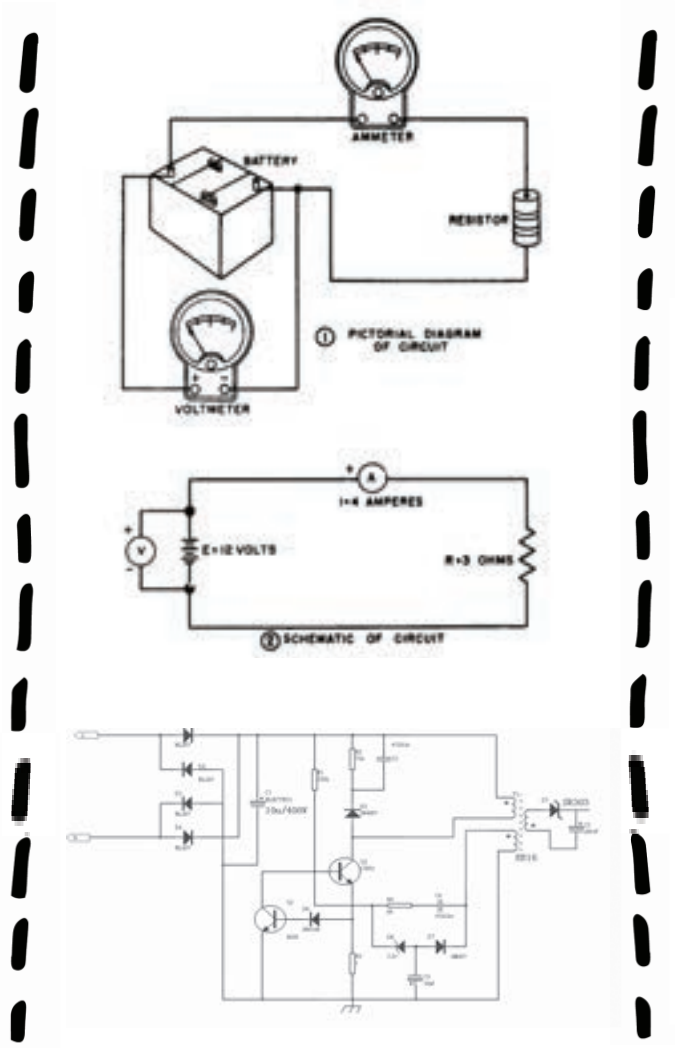
Scrappy Schematics

Schematics are plans for electrical circuits. They use their own language of symbols to represent different electrical elements. This is very helpful when building a circuit, especially a complicated one, because you can look at a schematic to see where and how each element is added. Scrappy Schematics are similar, but more fun and have a lot fewer rules. Each brick has its own Scrappy Schematic Symbol. Each project will have a schematic diagram to show where each brick should be added in the circuit.

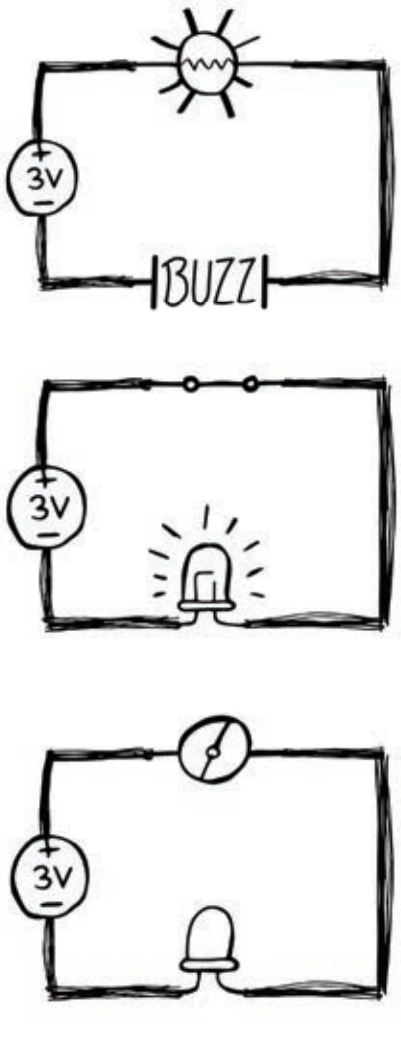
When you make your own inventions with Scrappy Circuits, it is recommended to use a Scrappy Schematic to publish and share your invention with the world.



Real Schematics

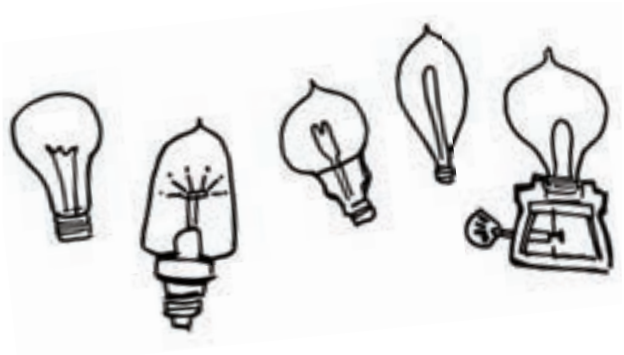


Scrappy Schematics



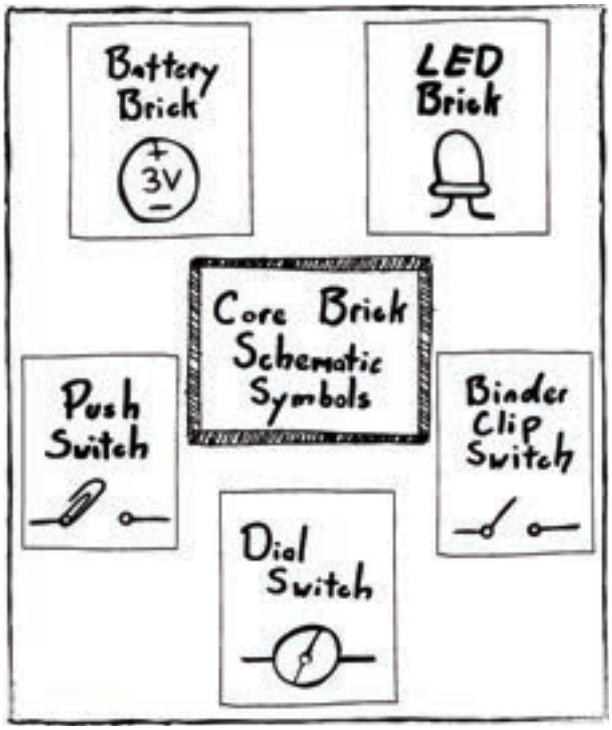
FIVE STARTER PROJECTS WITH THE CORE BRICKS

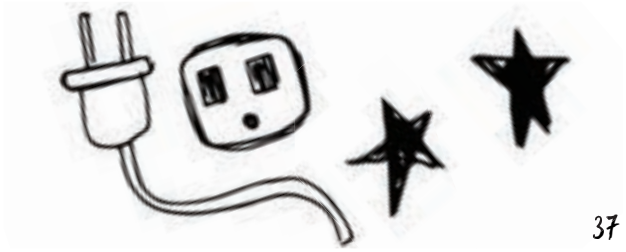
All of these Scrappy Circuit projects use the five Core Bricks: one light, one battery, and three switches. Similar to how a few chords can be rearranged to create many different songs, these five bricks can be used to create numerous amazing projects, much more than the ones listed here. The missing piece is your creativity. Use these projects as inspirations and get those creative juices flowing to invent other projects. Flashlights, security alarms, and traffic lights all basically function the same way—they turn a light on and off. The difference is in their purpose and how they are controlled. New inventions do not have to be new circuits, they can be new applications of existing circuits. Many inventions are things that existed before and someone improved them. Many people credit Thomas Edison with inventing the light bulb. He didn't. Lewis Latimer did. Thomas Edison made Latimer's light bulb better. The problem of having trouble seeing in the dark can always use new solutions.



The other way similar inventions differ is how they are triggered. The Assistive Technology Industry Association defines assistive technology as, "Products, equipment, and systems that enhance learning, working, and daily living for persons with disabilities." In a conversation with maker and occupational therapist Jennifer Schank (@mOTivatorlabs), I asked what were some of her favorite scrappy assistive technology switches. She explained that technology shouldn't have a subcategory of assistive technology. Any switch can be positioned, adapted, and integrated to make technology assistive—for anyone.

As you make these five beginning projects, think about how they could be positioned, adapted, and integrated differently to create a new invention without changing the wiring of the bricks at all. Be creative and come up with your own projects, problems, purposes, and solutions with these Core Bricks. Simple projects can solve complex problems.





MORSE CODE

The first Morse code message was sent in 1844. This simple code is based on two symbols: long dash and short dot. What is nice about Morse code is that the long and shorts can be written (– and •), can be a long and a short sound, or can be long and quick blinks from a light. The many different ways a Morse code message can be transmitted has led to its popularity. The shortcoming of this code is that it takes a long time to send a long message. Because of this Morse code is often used for short messages. The most popular message is easily S.O.S., which translates to "Save Our Ship." This is a distress signal that can be used in any dangerous situation: a sinking ship, a radioactive chemical leak, or someone ate your ham sandwich. The message is simply three shorts to represent the letter S, followed by three longs to represent the letter O, and then three shorts again to represent the letter S. The Morse code alphabet is on this page so you can send your own messages, about desserts, ham, or other passionate topics.

Here are some messages in Morse code:

Pizza: • – • • • – • • – • • •

Scrappy Circuits: • • • – • – • • – • • – • – • • – • – – • – – • – • • • – • • • – • – • • • • – • • – • • •

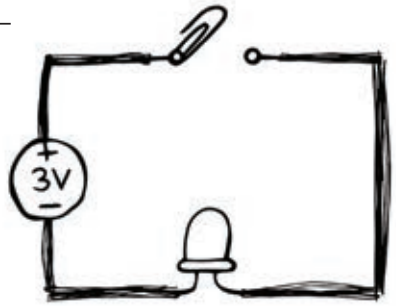
Ham: • • • • • • – –

Bricks

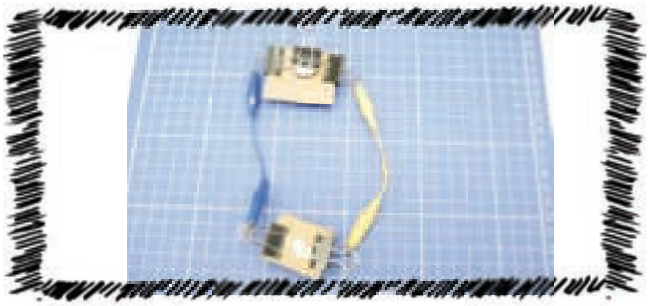
- Battery Brick
- LED Brick
- Push Switch

Materials

- 3 Alligator clips

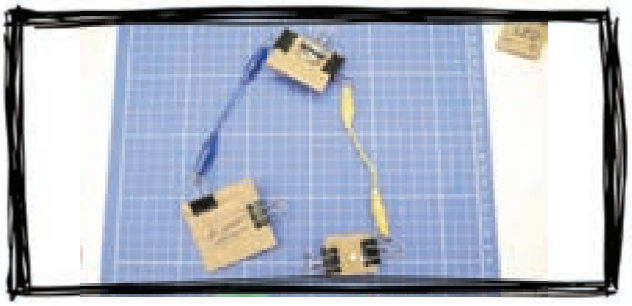


STEP 1



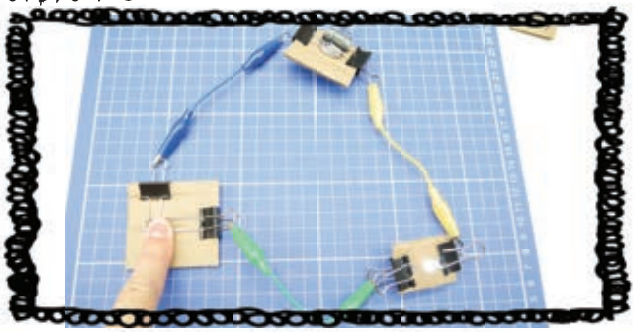
1. Use two alligator clips to connect your Battery Brick to your LED brick. Remember to connect the negative (–) side of the battery to the negative (–) side of the LED, and the two remaining positive terminals together. Once connected correctly, the LED should light up.

STEPS 2-3



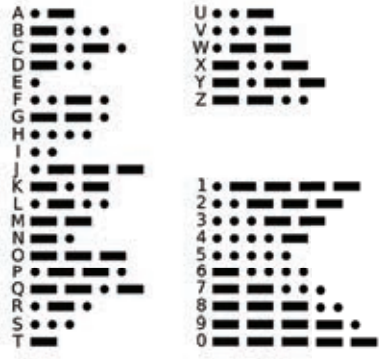
2. Disconnect an alligator clip anywhere in the circuit.
3. Connect one of your empty clips to your Push Switch. Add a third alligator clip to connect the open binder clip of your switch to the place you disconnected your clip from the last step.

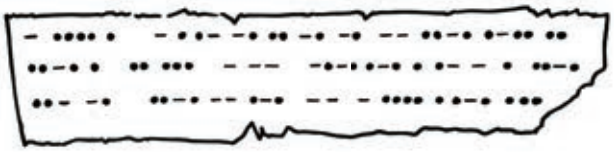
STEPS 4-5



4. Now your switch should control the LED light. Test your Push Switch.
5. Send a message to your friends, or to warn your enemies.

INTERNATIONAL MORSE CODE





PUSH ALARM

This is a very simple alarm using your Push Switch as the trigger. You will either need to be close to the item, or have some long wires. When the object you're guarding is resting peacefully on top of the switch, the LED will be on. Then imagine some incorrigible rogue comes to pilfer your kaboodle (translation: a thief comes to steal your stuff). As they lift your kaboodle (stuff), the LED light will turn off. That is how you'll know that you've been pilfered. Now it is time to face off with the scornful scallywag (approach the person who took your stuff).

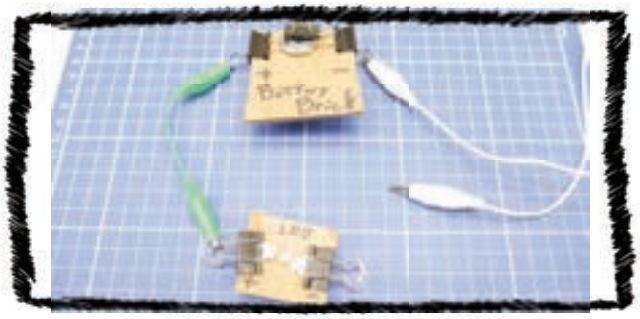
Bricks

- Battery Brick
- LED Brick
- Push Switch

Materials

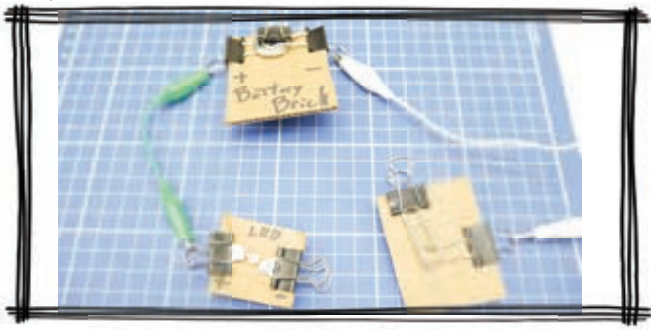
- 3 Alligator clips

STEPS 1-2



1. Use two alligator clips (one long and one short) to connect your Battery Brick to your LED Brick. Remember to connect the negative (–) side of the battery to the negative (–) side of the LED, and the two remaining positive terminals (+) together. Once connected correctly, the LED will light up.
2. Disconnect the long alligator clip from either binder clip.

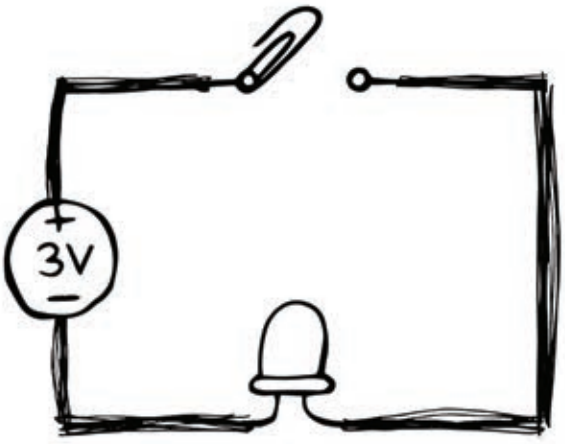
STEPS 3-4



3. Connect this long alligator clip to your Push Switch. Add a third long alligator clip to connect the binder clip of your switch to the place you disconnected your clip from the last step.
4. Test your circuit by pushing down on the Push Switch.

STEPS 5-7

5. Test your circuit by pushing down on the Push Switch.
6. Now position the item you want to watch on the push switch. It should make the LED illuminate.
7. Position the LED where you can see it, but out of sight of the switch.



FALLING TARGET

The Falling Target uses the falling movement of an item to turn the Dial Switch on. When you hit it, the item will fall back and spin the dial switch to turn on the light. The falling item can be anything–some fruit, an action figure, or a sibling's prized possession*. You will need a tall and sturdy cardboard box to use as a base for this project. The target will stand on top of the box, the LED will be seen from the front, and the Dial Switch can be hidden behind the box on the top.

*Scrappy Circuits does not recommend stealing valuable items from your siblings and using them as target practice, unless your sibling really is a gigantic brat and has it coming. Even then we don't recommend it, but–wink, wink.

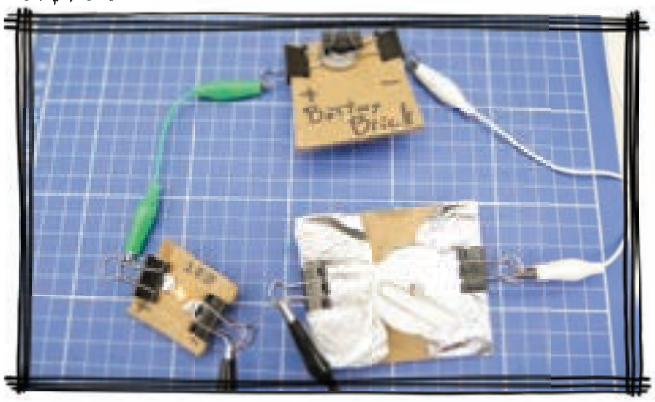
Bricks

- Battery Brick
- LED Brick
- Dial Switch

Materials

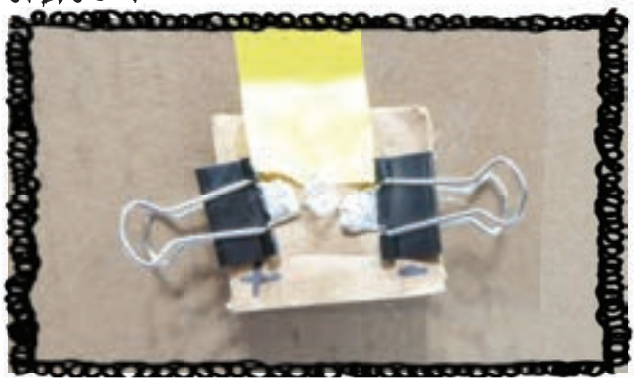
- A small, but tall cardboard box–at least twice the height of your falling object
- Some household twine or anything similar
- Hot glue gun
- Tape
- 3 Alligator clips

STEPS 1-2



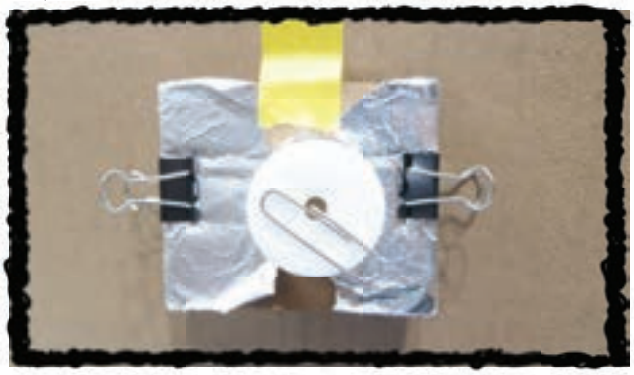
1. Cut the flaps of one side of the cardboard box off. Remember you will need your box to stand tall for this project to work. The open side of the box will be the bottom.
2. Connect your LED Brick, Dial Switch, and Battery Brick to create a working circuit.

STEPS 3-4



3. Disconnect your bricks.
4. Tape or hot glue your LED Brick to the front side of the box.

STEP 5



5. Tape or hot glue your Dial Switch to the back of the box toward the top.

STEPS 6-7

6. Take your three alligator clips and connect your three bricks. This can happen on the outside of the cardboard box or, if you cut some holes, on the inside of the box.
7. Tape or hot glue your Battery Brick to the outside of the box somewhere near it is currently hanging. Disconnect your bricks again.

STEPS 8-10

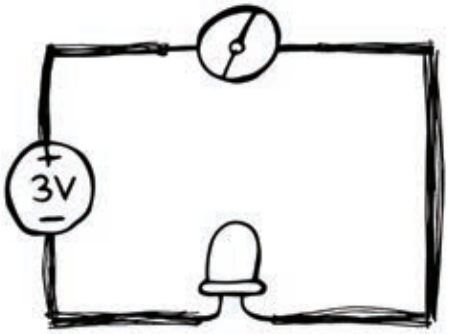
8. Turn your Dial Switch to the on position. Rotate the switch 180 degrees. Make sure it turns off. If not, find an on position for your dial switch that turns off when half-rotated (180 degrees).
9. Return your Dial Switch to the on position. Hot glue a piece of twine/string to the bottom of the white cylinder. Make sure you glue it to the cylinder and not to the aluminum foil or cardboard.
10. Turn your Dial Switch a half rotation to off.

STEPS 11-13

11. Tie or hot glue the other end of your twine/string to the object that is your target. Make sure you give enough slack that the object can stand freely on top of the box. Too much slack might prevent the dial switch from being spun if the target object hits the ground before the string/twine is pulled tight. This step will require a fair amount of testing and tweaking.
12. Reconnect your bricks.
13. Place the target on top of the box.

STEP 14

14. Knock it off to illuminate your LED.



SUPERHERO SIGNAL

Whenever Commissioner Gordon needed Batman's help, he would turn on a large light that would project the bat signal into the sky. You are a superhero. Create your own personal signal. It can be whatever you want: a bat, a paintbrush, a sun, or a ham like the one below.

Bricks

- Battery Brick
- LED Brick (You will remix this brick, so an LED and 2 binder clips will work just as well)
- A switch of your choice

Materials

- 3 Alligator clips
- Toilet paper tube
- Corrugated cardboard (boxes from the mail)
- Paperboard (the material cereal boxes are made from)
- Wax paper
- An adult (If you do not have one, they can often be trapped in the morning using coffee as bait.)

Tools

- X-Acto knife
- Scissors
- Marker (a skinny Sharpie works best)

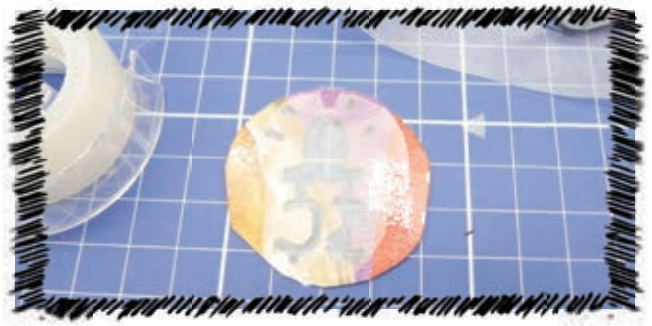
STEPS 1-2

1. Trace the circle end of a toilet paper tube on some paperboard. Then trace it again on some cardboard.
2. Cut both circles out.

STEPS 3-4

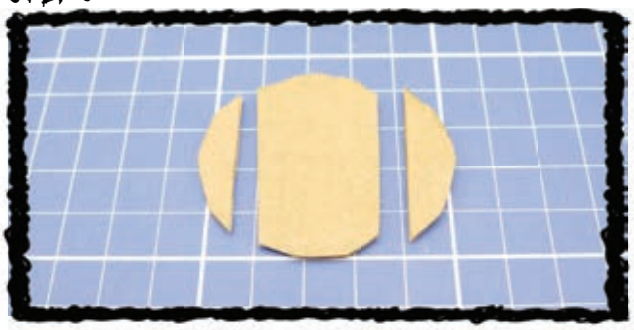
3. Design your superhero symbol on the paperboard being careful to stay away from the edges.
4. Have an adult cut out your symbol. You want your symbol to be a cut out area of your circle. This can be done with an X-Acto knife or scissors. If it is easier and safer, cut the circle in half first, then cut out your symbol, then tape it back together.

STEP 5



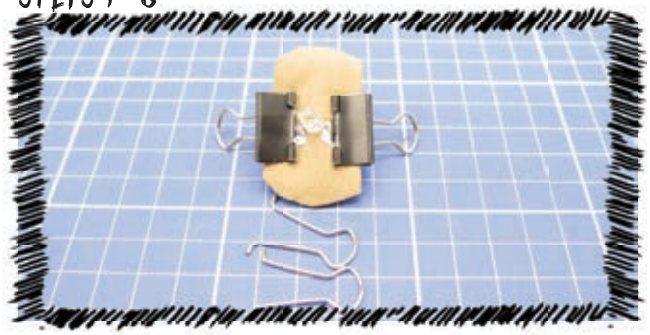
5. Cut enough wax paper to cover your superhero symbol. Tape to the side of the paperboard that will not be showing when finished. If you need to, add some details on the wax paper with a marker to finish your symbol.

STEP 6



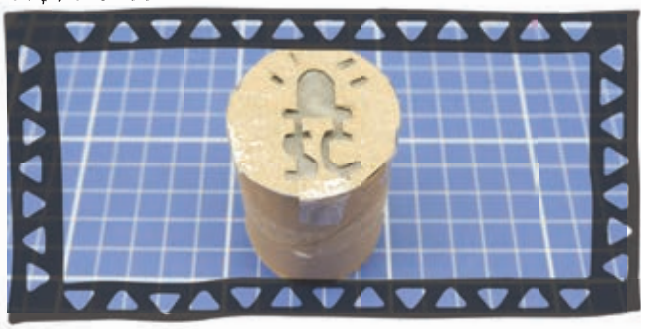
6. Take your cardboard circle and trim a little off of one edge. Do the same to the opposite side of the circle.

STEPS 7–8



7. Reassemble your LED Brick with this piece of cardboard. Be sure to place your binder clips snuggly along the flat sides.
8. Remove the arms of the LED Brick that are on the side with the LED.

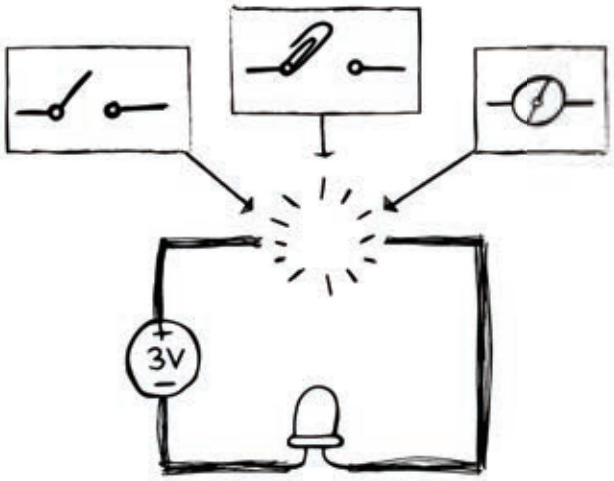
STEPS 9–11

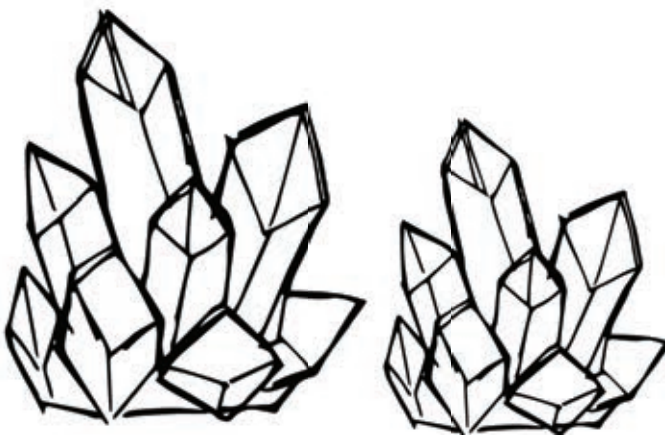


9. Cut your toilet paper tube in half.
10. Tape your superhero symbol to the end of the toilet paper tube.
11. Create a circuit with your LED Brick, Battery Brick, and a switch of your choice.

STEPS 12–15

12. Slide your new LED Brick into your toilet paper tube. It should be held snuggly, but if you need to add tape you can.
13. Turn out the lights.
14. Turn on your superhero symbol.
15. Now go fight crime.





LIGHT UP A PICTURE

This is a fun project to make a picture much cooler. You can use a photograph or a drawn picture. The picture just needs to be printed on something thin like computer paper. You can choose any part of a picture to light up: the eyes, a sun in the background, yourself in a family photo, or anything else your crazy heart desires.

Once finished, you can even add a switch to the circuit. This can be used to conserve the battery and only have the circuit on when guests are in the room. It can also be used as a trigger. If you find some long wires, you can add a push switch under a couch cushion. Now when someone sits on the couch, the circuit will turn on and grandma's eyes will turn red. Just an idea. If you find speaker wire or door bell wire, that should be long enough. Wire like this usually comes with two insulated wires connected. At one end, connect the stripped ends to the binder clips of a switch. Then at the other end connect one wire to the LED Brick and the other to the Battery Brick.

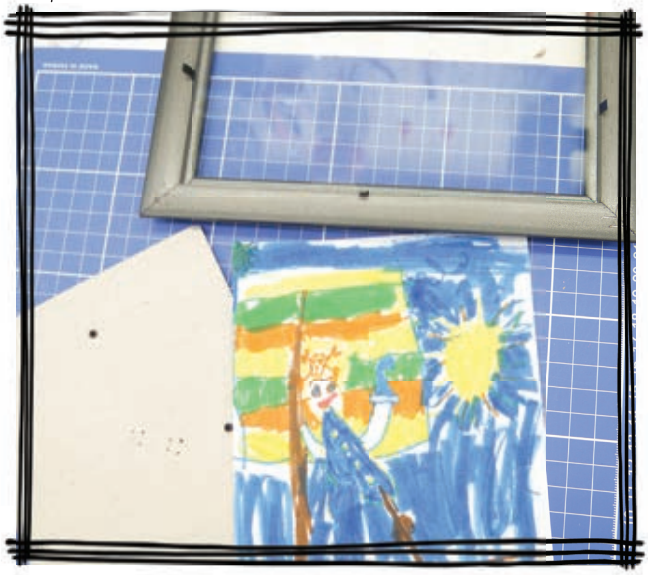
Bricks

- Battery Brick
- LED Brick

Materials

- A picture frame (that you can put a hole in without getting grounded)
- A picture drawn or printed on paper
- A hole poker
- Marker
- 2 Alligator clips

STEP 1

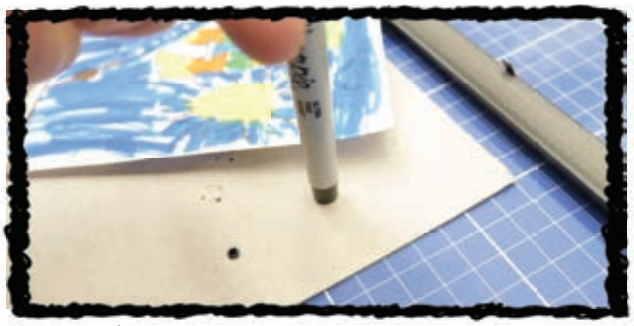


1. Open picture frame.

STEPS 2-3

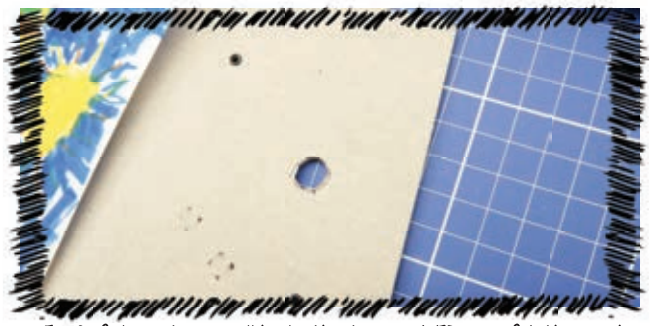
2. Align drawing to the picture frame backing.
3. Hover a marker over where you want your LED light.

STEP 4



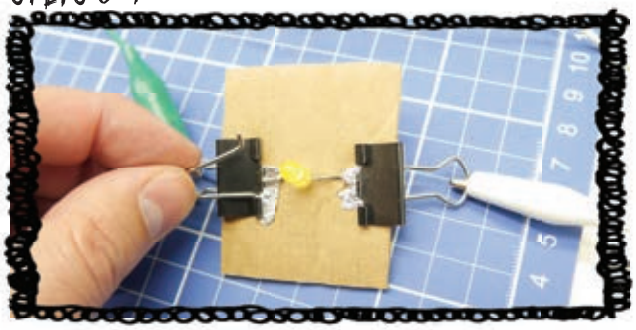
4. Carefully remove the drawing and lower the marker to mark where you want the LED light.

STEP 5



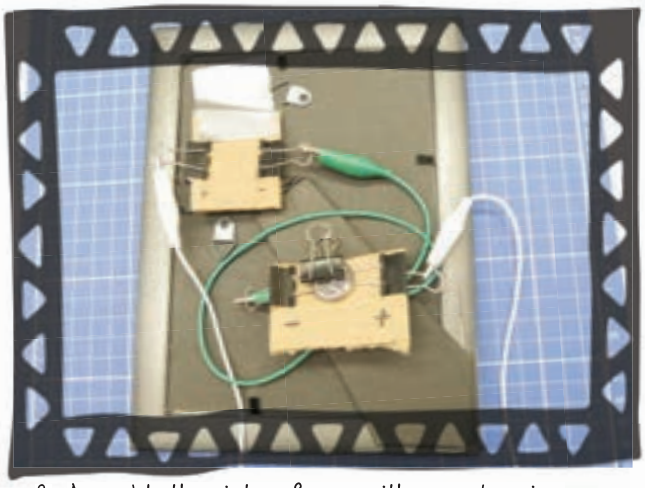
5. Safely cut a small hole that your LED can fit through.

STEPS 6-7

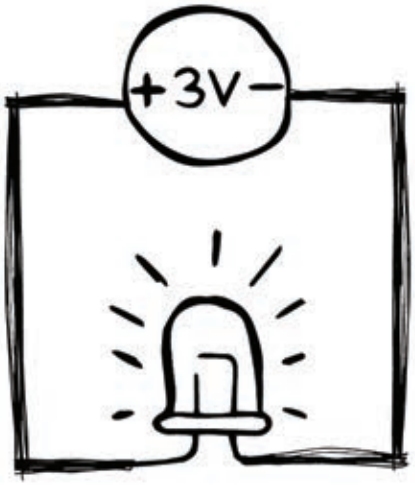


6. Remove the front arms of the binder clips from your LED Brick by squeezing them.
7. Copy the plus and minus signs from the front of your LED Brick to the back.

STEPS 8-10



8. Assemble the picture frame with your drawing.
9. Tape your LED Brick so the LED is poking into the hole on the back of the picture frame.
10. Connect your LED Brick and your Battery Brick with two alligator clips.



STEP 11

11. Place your picture frame somewhere and surprise, scare, and/or inspire people with your light up picture frame.

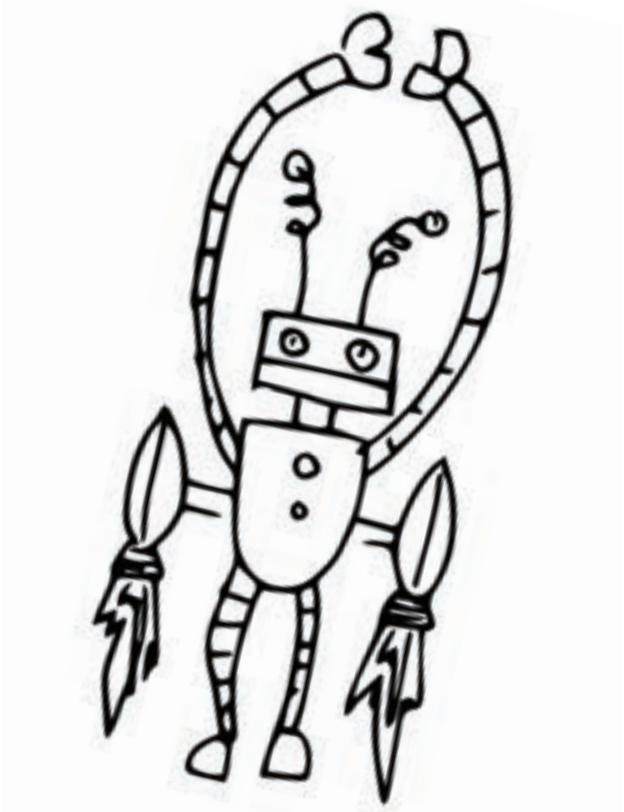
SCRAPPY DESIGN CHALLENGES — CORE BRICKS

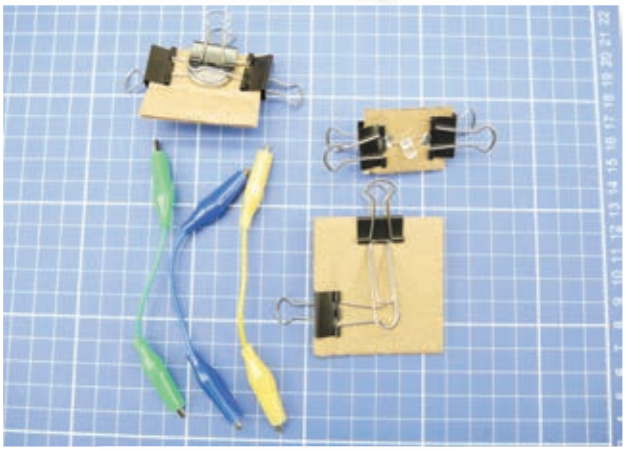
These simple scrappy design challenges are meant to get your creative juices flowing instead of your direction-following-juices (worst juicebox flavor ever). Instead of a list of steps for a project, here are some situations that curious minds can solve using Scrappy Circuits. While challenging learners to solve these problems, be sure to have them use design thinking. This is an important process of thinking that has helped inspire many different companies, products, and apps that make our lives better.

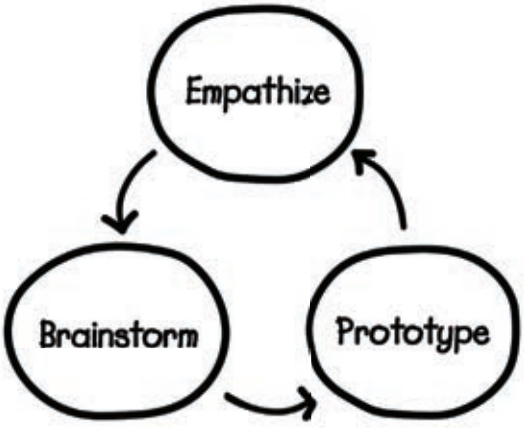
The first pillar is the most important: empathize. Have students really imagine themselves in these situations and what the best solution would be. Since these challenges use just the Core Bricks, essentially all of these problems can be solved by providing light. What will make each solution unique is how the light is provided and controlled.

The next pillar of design thinking is ideation or brainstorming. Quantity over quality is recommended for this step. I find that if you try and think of every possible solution, even some crazy or nonsensical ones, that you will oftentimes find amazingly unique and new ideas hidden inside of your silly ones.

The last pillar of design thinking is to prototype a model for your invented solution. These pillars of design thinking, along with many other more specific steps, are often presented in the shape of a circle with curved arrows continually connecting each step. This is because after you have experimented with your prototype solution, you might want to continue the process and improve your invention. The design thinking process has been expanded beyond these pillars and many books have been written on this topic. Even though this process can seem mechanical at times, it truly is human. Design thinking might produce a tool to control fire or recycle trash. It is important to help students understand this process, especially making sure they give the first step of empathizing its proper time and importance.







Challenge * 1

Jennifer has just discovered a passion for reading and is constantly thinking about what will happen next in her book. She finds some time throughout her day to read, but not a lot. She can always find time to read right before bed. Unfortunately, the sun is starting to set at that point and it becomes a challenge to clearly and easily read each page. Jennifer also likes to read in different parts of her room: on her bed, pillows on the floor, and under her window. The solution to her problem would need to be portable.

Challenge * 2

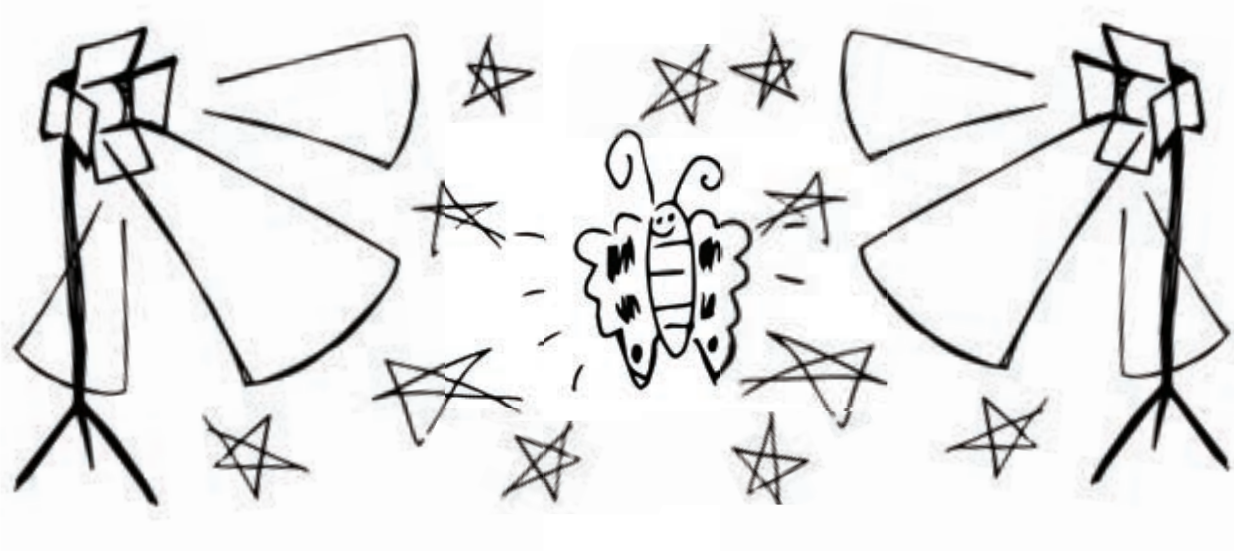
Lucy has her science fair in ten days. Her project is about the different stages of plant growth. She plans to plant a new seed every two days. Her Science Fair project will be five different plants at different stages of growth as examples of how a plant grows. She has discovered that her first plant is not growing as fast as she would like. The plant gets the proper amount of water and sits near a window during the day to get sunlight. She wants to give the plant some light at night, but not block the sun during the day time.

Challenge *3

Ed works the help desk at a local library. When he gets up to help someone else, people think the help desk is closed permanently. When he is at his desk, oftentimes people do not know that it is his job, one that he enjoys a lot, to answer questions. He has a small paper sign that says “open” on one side and “closed” on another. His desk is in a dim corner of the library and the sign is not large enough to see. Ed doesn’t want a very large sign, because he doesn’t want it in his way while he works.

Challenge *4

A husband and wife work different schedules. When they run out of milk, oftentimes they both accidentally buy it. Then they have too much milk and it goes bad. Other times they assume the other person is getting the milk and then have no milk. Sometimes one person gets the milk and everything works out perfectly. Can you invent a system to signal who should buy the milk? Should they take turns?



About the Author

Michael Carroll is an instructional coach in the amazing Abington School District located outside of Philadelphia. Before becoming an instructional coach, Mike was an elementary school teacher at Overlook Elementary for over a decade. He has been working to show kids the value of learning by doing and trying to find ways to take away many of the prerequisite barriers like money, access, complicated skills, and more. Mike lives in Chalfont, Pennsylvania with his wife Kate and his daughter Lucy. He believes cardboard, duct tape, and office supplies can solve most problems.

Instagram & Twitter: @ScrappyMaker

YouTube: Scrappy Circuits

Dedication

Thank you to all of the curious makers in the world, especially the first Scrappy Circuits maker, my biggest supporter, and book cover model, my daughter Lucy Carroll. Remember to never fear failing. Stay curious, kind, and wonderful.

To my wife Kate, thank you for being understanding of me taking apart everything in our house, especially when the mess starts to creep out of the basement. Your support means the world to me. I love you.

This Scrappy Circuits Zine is an abbreviated preview of the Scrappy Circuits book for Kickstarter backers. You are welcome to share this zine with friends.

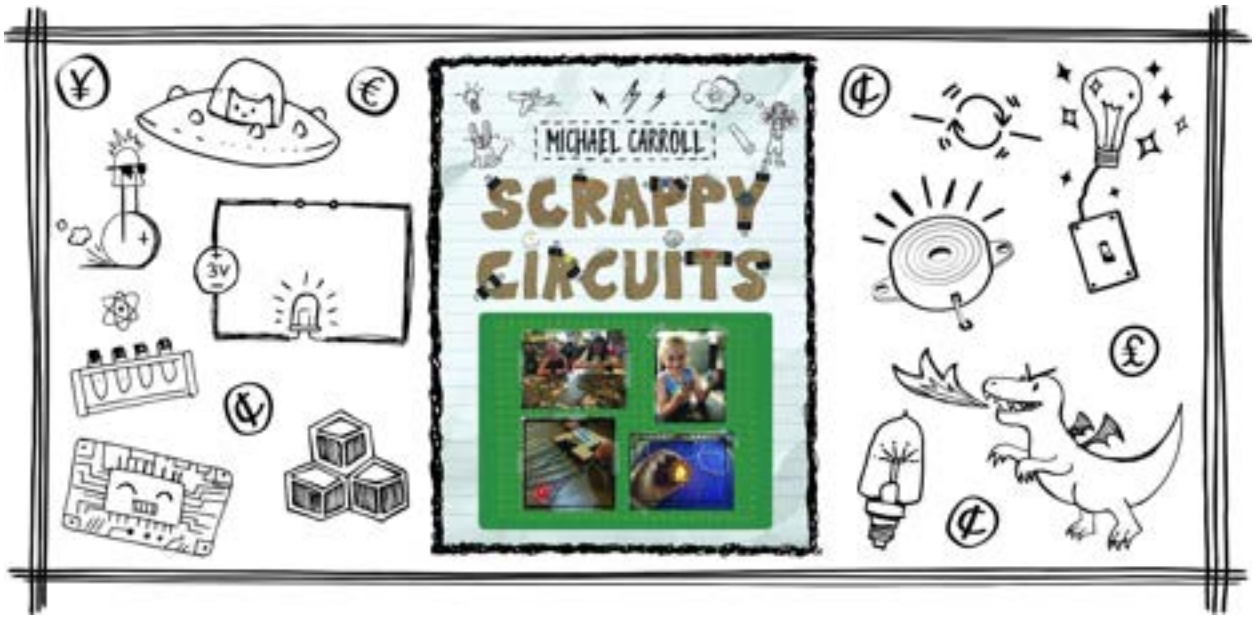
The full version has …

- A higher quality dpi
- More projects with the Core Bricks
- More Action Bricks that buzz, shake, spin, and change colors
- 15 more switches that can be made to work with Scrappy Circuits that can be triggered by waving a wand, blowing air, tilting, stepping, and many different arcade-game-style switches
- Bricks that can control the flow of electricity
- Ways to make electricity for Scrappy Circuits without using a battery
- Over 10 projects to make with all of the different Scrappy Circuits bricks.
- A guide to inventing your own bricks and projects
- Tips for leading groups making Scrappy Circuits
- A fun and engaging background to many of the different scientific ideas

If you are using this preview, and not an original Kickstarter backer, we ask a few things.

- If you like this preview, please visit Amazon.com or cmkpress.com to purchase the full version of Scrappy Circuits written by Michael Carroll.
- Spread the word about Scrappy Circuits to friends far and wide. You can share this zine PDF with them.

Please enjoy this preview zine of Scrappy Circuits.



The full Scrappy Circuits book is available at Amazon.com & CMKPress.com.

Zine Extras

Videos

Scrappy Circuits co-creators have done a series of different webinars about Scrappy Circuits that can be found online. If these links do not work, a quick search on YouTube for the title will.

Build Videos

- Take Apart an LED - https://www.youtube.com/watch?v=Zr5akgMcLOI
- Battery Brick - https://www.youtube.com/watch?v=kDHhIWTdGFg
- LED Brick - https://www.youtube.com/watch?v=d_ki3m9IvU4
- Binder Clip Switch - https://www.youtube.com/watch?v=39JFfhcrdVk
- Push Switch - https://www.youtube.com/watch?v=Snprt8P5QsQ&t=2s
- Dial Switch - https://www.youtube.com/watch?v=sLV7VBoORY0
- 5 Core Brick Montage - https://www.youtube.com/watch?v=WOB16WPgC0g&t=1s

Virtual Maker Faire – https://www.youtube.com/watch?v=DVydTl3OAfY&t=2s

Maker Camp

- 5 Core Bricks
- Magic Wand & Buzzer Brick
- Arcade Bricks
- Light Up Superhero Beacon
- Operation Game Brick
- Clothespin Switch
- Connector Bricks
- Scrappy Power Sources
- Scrappy Speakers
- Game Day
- Game Day II and Next Steps

Scrappy Playlist

Music plays a large role in the life of Scrappy Circuits author Mike Carroll. He tinkers to music. He writes to music. He does most things to music. This is a playlist of some of his favorite songs to write and tinker to. All of these songs are instrumentals, a little weird, and a great help for someone to get lost in the creative world.

Direct Link: click here

URL: https://open.spotify.com/playlist/4vfCVErCMqD0JivmNw6hrY?si=4105aff52ec0407f

Spotify Code:

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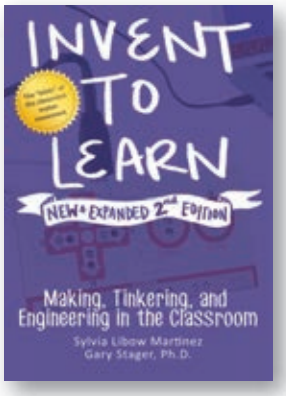
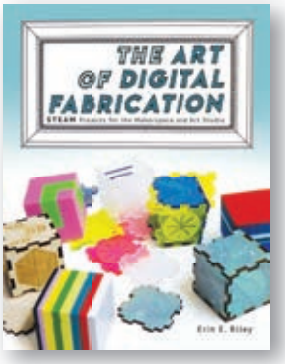


Invent to Learn: Making, Tinkering, and Engineering in the Classroom

by Sylvia Libow Martinez and Gary S. Stager

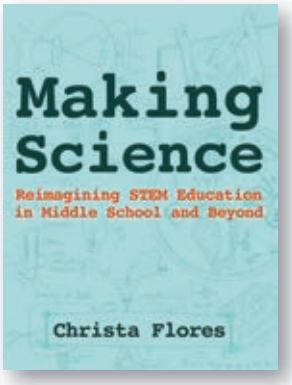
An all new and expanded edition of the book called "the bible of the Maker Movement in classrooms," *Invent To Learn* has become the most popular book for educators seeking to understand how modern tools and technology can revolutionize education.



The Art of Digital Fabrication: STEAM Projects for the Makerspace and Art Studio

by Erin E. Riley

Integrate STEAM in your school through arts-based maker projects using digital fabrication tools commonly found in makerspaces like 3D printers, laser cutters, vinyl cutters, and CNC machines. Full color pages showcase the artistic and technical work of students that results from combining art with engineering and design. Written by an educator with experience in art and maker education, this volume contains over twenty-five makerspace tested projects, a material and process inventory for digital fabrication, guides for designing with software, and how-to's for using digital fabrication machines.



Making Science: Reimagining STEM Education in Middle School and Beyond

by Christa Flores

Anthropologist turned science and making teacher Christa Flores shares her classroom tested lessons and resources for learning by making and design in the middle grades and beyond. Richly illustrated with examples of student work, this book offers project ideas, connections to the new Next Generation Science Standards, assessment strategies, and practical tips for educators.

Sylvia's Super-Awesome Project Book: Super-Simple Arduino

by Sylvia (Super-Awesome) Todd

In this superfun book, Sylvia teaches you to understand Arduino microcontroller programming by inventing an adjustable strobe and two digital musical instruments you can play! Along the way, you'll learn a lot about electronics, coding, science, and engineering.

Written and illustrated by a kid, for kids of all ages, Sylvia's whimsical graphics and clever explanations make powerful science, technology, engineering, and math (STEM) concepts accessible and fun.

Invent to Learn Guides

The Invent to Learn Guide to Fun

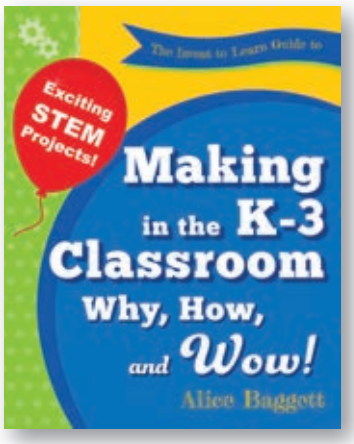
by Josh Burker

The Invent to Learn Guide to Fun features an assortment of insanely clever classroom-tested maker projects for learners of all ages. Josh Burker kicks classroom learning-by-making up a notch with step-by-step instructions, full-color photos, open-ended challenges, and sample code. Learn to paint with light, make your own Operation Game, sew interactive stuffed creatures, build Rube Goldberg machines, design artbots, produce mathematically generated mosaic tiles, program adventure games, and more!

The Invent to Learn Guide to MORE Fun

by Josh Burker

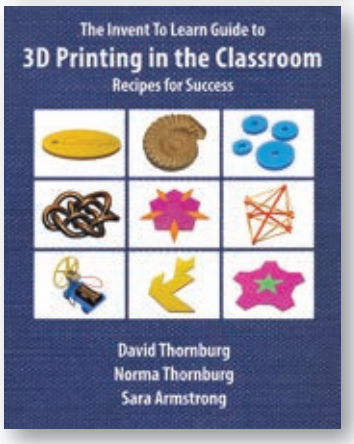
Josh Burker is back with a second volume of all new projects for learners who just want MORE! Insanely clever classroom-tested “maker” projects for learners of all ages with coding, microcontrollers, 3D printing, LEGO machines, and more! The projects feature step-by-step instructions and full-color photos.



The Invent to Learn Guide to Making in the K-3 Classroom: Why, How, and Wow!

by Alice Baggett

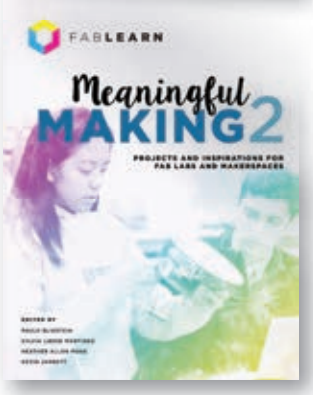
This full color book packed with photos is a practical guide for primary school educators who want to inspire their students to embrace a tinkering mindset so they can invent fantastic contraptions. Veteran teacher Alice Baggett shares her expertise in how to create hands-on learning experiences for young inventors so students experience the thrilling process of making—complete with epic fails and spectacular discoveries.



The Invent to Learn Guide to 3D Printing in the Classroom: Recipes for Success

by David Thornburg, Norma Thornburg, and Sara Armstrong

This book is an essential guide for educators interested in bringing the amazing world of 3D printing to their classrooms. Eighteen fun and challenging projects explore science, technology, engineering, and mathematics, along with forays into the visual arts and design.

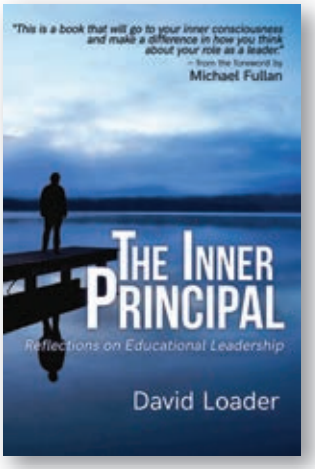


Meaningful Making: Projects and Inspirations for Fab Labs and Makerspaces (Volumes 1 & 2)

Edited by Paulo Blikstein, Sylvia Libow Martinez, Heather Allen Pang

Project ideas, articles, best practices, and assessment strategies from educators at the forefront of making and hands-on, minds-on education.

In these two volumes, FabLearn Fellows share inspirational ideas from their learning spaces, assessment strategies and recommended projects across a broad range of age levels. Illustrated with color photos of real student work, the Fellows take you on a tour of the future of learning, where children make sense of the world by making things that matter to them and their communities. To read this book is to rediscover learning as it could be and should be—a joyous, mindful exploration of the world, where the ultimate discovery is the potential of every child.

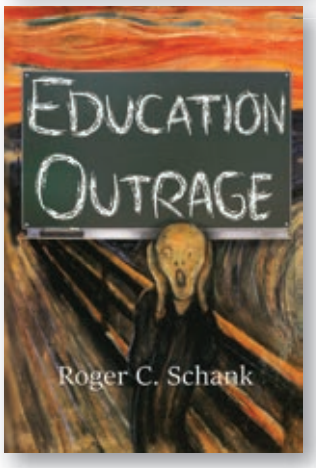


The Inner Principal: Reflections on Educational Leadership

by David Loader

Remarkably candid reflections by one of the most consequential school leaders of the past 50 years.

“This is a book that will go to your inner consciousness and make a difference in how you think about your own role as leader.” – from the foreword by Michael Fullan



Education Outrage

by Roger C. Schank

Roger Schank has had it with the stupid, lazy, greedy, cynical, and uninformed forces setting outrageous education policy, wrecking childhood, and preparing students for a world that will never exist. No sacred cow is off limit – even some species you never considered. The short essays in this book will make you mad, sad, argue with your friends, and take action.