


Ages 8+



# circuit scribe

CIRCUIT DRAWING KITS

## INVENTOR'S NOTEBOOK

***Switch on the fun!***

Hands-On Experiments  
and Space to Doodle

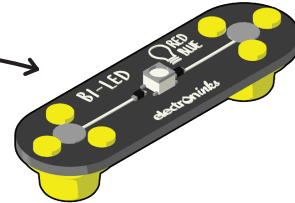


CircuitScribe.com

Circuit Scribe is no ordinary pen! Our silver ink formula is electrically conductive, letting you doodle circuits by hand.

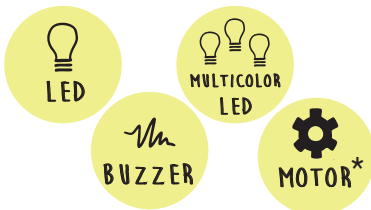
Use this kit to add lights to your artwork, or to invent something new. The Super and Ultra Kits come with everything you need to start drawing your own circuits:

- Circuit Scribe conductive ink pen
- Magnetic steel sheet
- 11 or 18 Magnetic modules
- Circuit stencil
- Jumper stickers



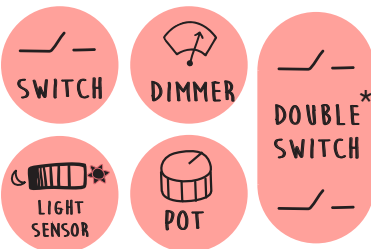
## meet the modules

Your conductive ink pen draws circuits between our electronic modules. Each module is color coded by function, and has its own symbol.



### output = yellow

Modules that emit light, make sound, or move. Includes two types of LED module.



### input = red

Modules that you interact with. The switch turns things on and off, and the Dimmer controls voltage.



### connection = gray / clear

Modules that control and direct the flow of current. The Blinker flashes lights on and off.

\* Items found only in Ultra Kit



### power = blue

Modules that provide the voltage source for your circuit, like the 9V Battery and Adapter.

Using Circuit Scribe is as easy as drawing with a normal pen. However, that means you'll have some of the same issues like clogged pen tips. Here are some tricks for successful sketching!

### drawing with the pen

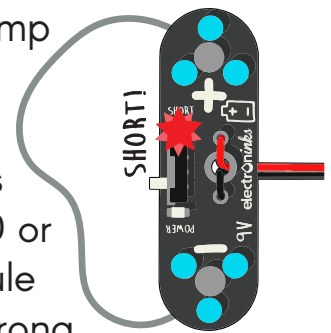
- No need to scribble back and forth! A slow steady line with a light touch actually gets more ink to flow.
- Pens draw better when held upright instead of angled.

### pen storage

- Store your Circuit Scribe pen tip down or on its side.
- When you're not sketching, keep the cap on so the tip doesn't dry up.

### troubleshooting

- The silver flakes in the ink might settle towards the tip, the top, or to one side. This is normal! Shake vigorously, or store the pen in the opposite orientation for an hour.
- If the tip dries out, try scribbling on a damp paper towel to re-wet.
- “Shorting” the battery happens when its two sides are connected without an LED or another load. The red light on the module will light up so you know something is wrong.



#### VISIT US ONLINE!

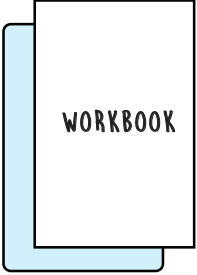
Discover lessons, projects, and more from our community of users at: [sketch.circuitscribe.com](https://sketch.circuitscribe.com)

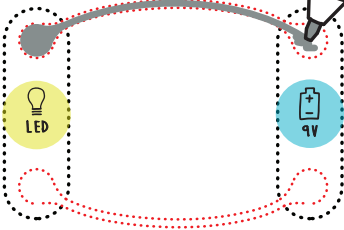
Keep in touch with @circuitscribe on:

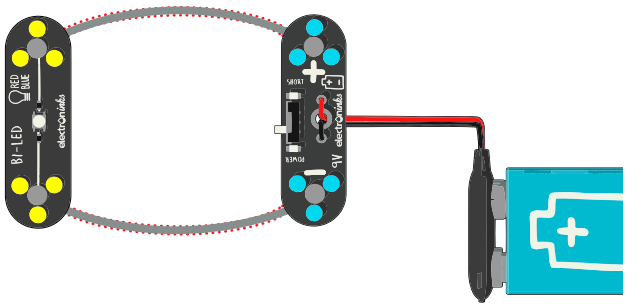


## drawing in the workbook

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- 1 Get your book page ready by slipping the steel sheet behind it, like a bookmark. 

- 2 Draw inside the red dotted templates. 

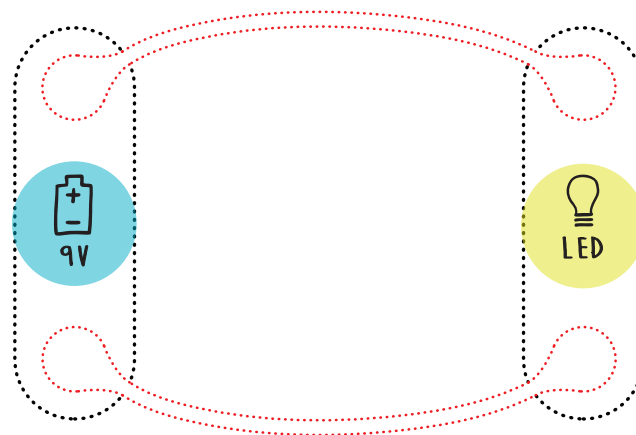
- 3 Snap magnetic modules onto your circuit, over the matching icons. 

## your first circuit

Try using your kit to light up an LED! Place the steel sheet behind this page. Draw over the template and snap on the LED and battery modules.

You need at least a **power module**, an **output module**, and **conductive ink** to make a complete circuit.

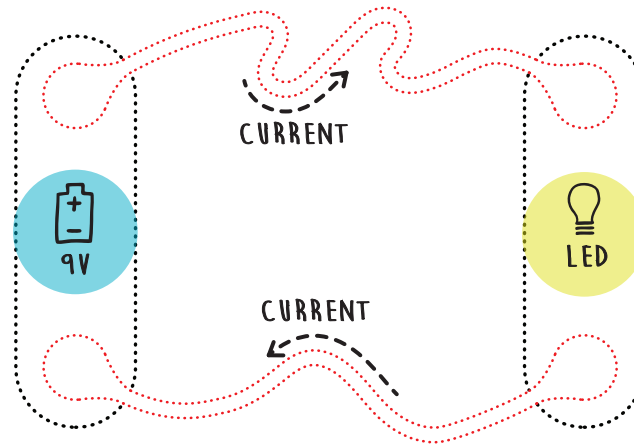
FLIP THE BATTERY SWITCH ON!



## current (i.e., electricity)

Current is the flow of tiny particles called electrons that exist in all materials. On its path, current can light up LEDs, spin motors, and buzz buzzers. Its value is measured in Amperes or Amps.

Draw on the template below, and imagine current flowing along the wavy silver lines.

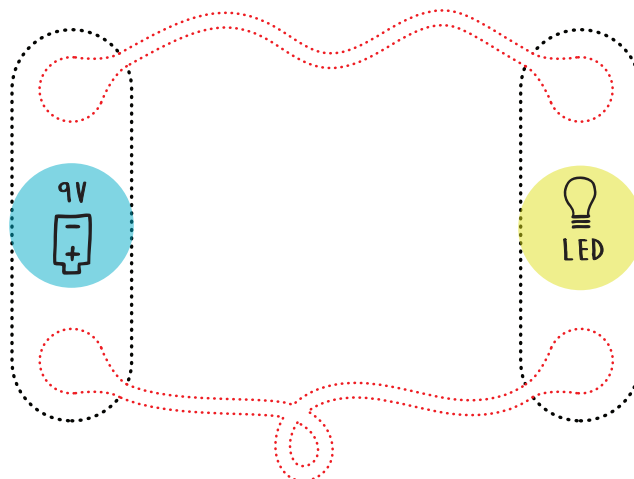


## voltage

The 9 Volt battery in your kit provides energy that current needs to flow. In circuits we call this a voltage source.

Voltage sets the strength of current and its direction. In the circuit above, current flows from the positive (+) side of the battery, through the silver lines & LED, to the negative (-) side.

Try drawing the similar circuit below, but reverse the battery signs. Can you draw arrows showing the direction of current flow?

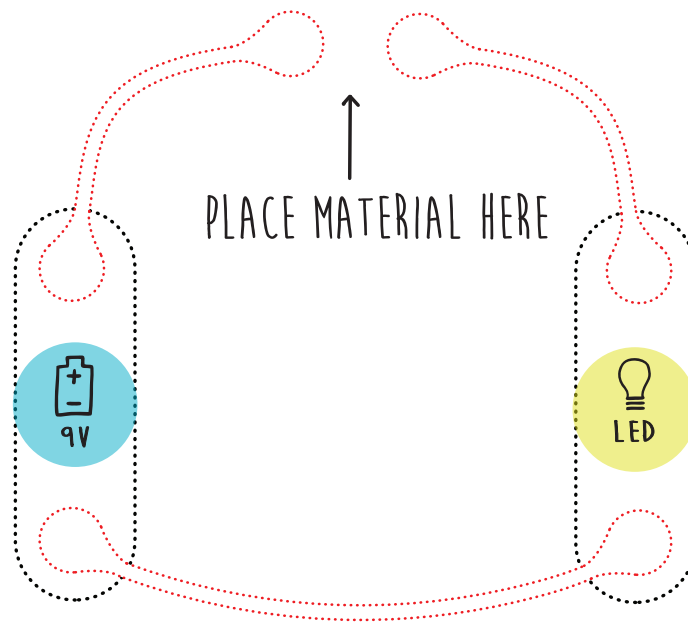


## complete circuit

In a circuit, current needs a complete loop to flow through, without any gaps. A circuit with a gap is called an open circuit. A complete circuit is called closed circuit.

## conductivity meter

Electrically conductive materials allow electrons to flow from one end to the other. Conductivity is a measure of how easily current flows through a material.



Leave a gap in the circuit above. Press materials from around your home or classroom over the gap to “close” the circuit.

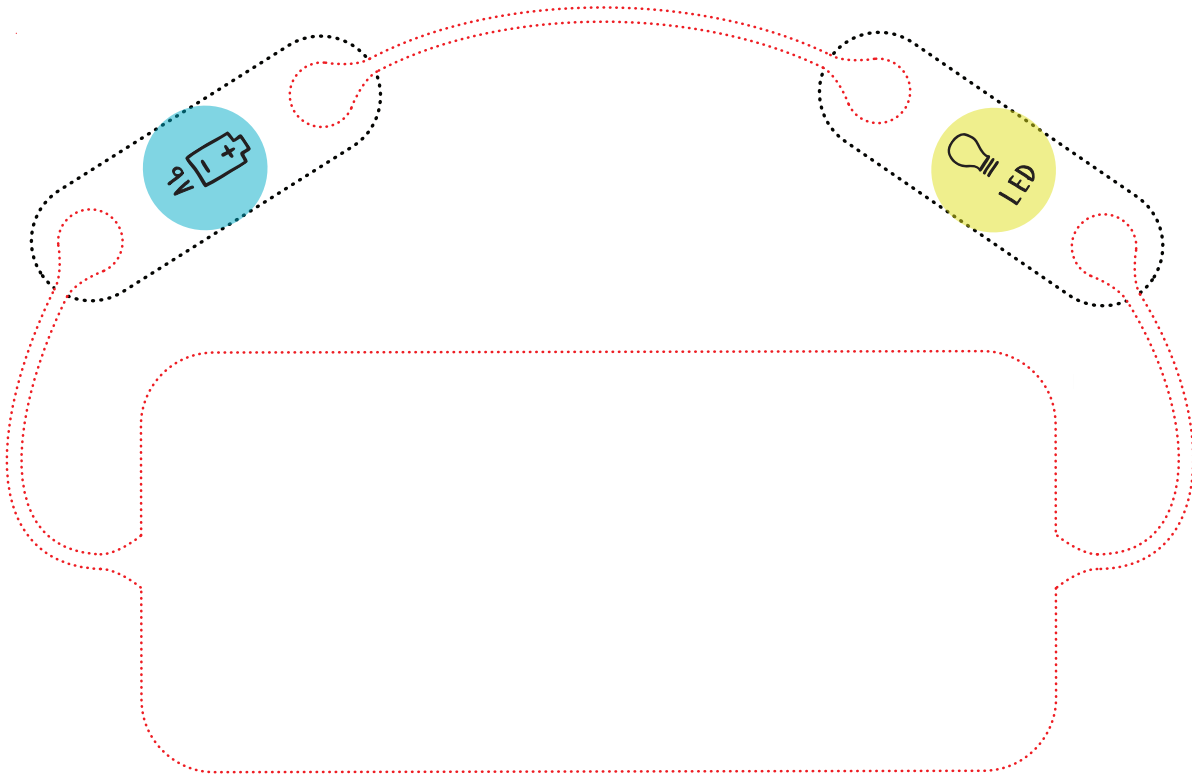
Using the LED as an indicator, which of these common items are conductors and which are insulators (i.e., do not let current flow)?

paper clip  
pencil  
pipe cleaner  
fabric  
bottle cap  
rubber band  
key

aluminum foil  
refrigerator magnet  
mechanical pencil lead  
your finger  
hair clip  
paper  
coin

## your name in lights

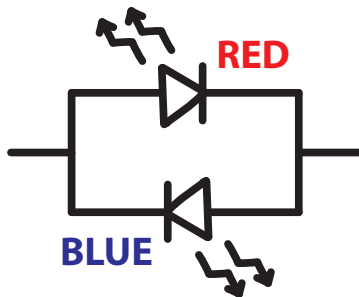
Get creative with sketching and try writing your name in cursive in the box to connect the battery and LED. The circuit needs to be a complete loop, so make sure there are no gaps in your writing!



### light emitting diode (led)

The light emitting diode (LED) lights up if a large enough voltage is applied across it.

The LED is a type of “diode,” which is like a one-way street for current flow. Current only flows in the direction of the arrow symbol, and is blocked in the other direction.



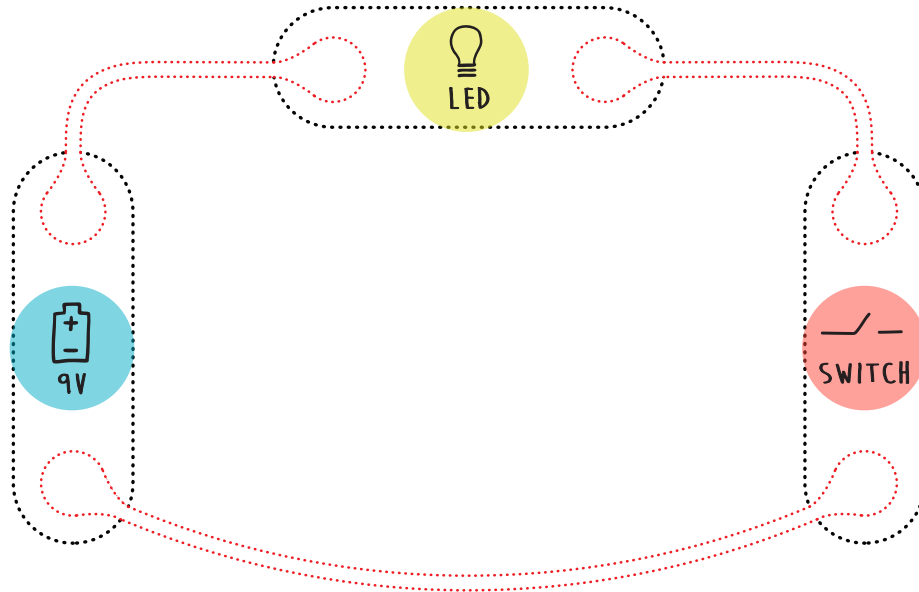
Our LED module has 2 LEDs wired up in opposite directions. Flip the module around to switch its color between red and blue.

**Try it!** Rotate the LED in your circuit above 180 degrees to change its color. What happens if you flip the battery around instead?

# single switch

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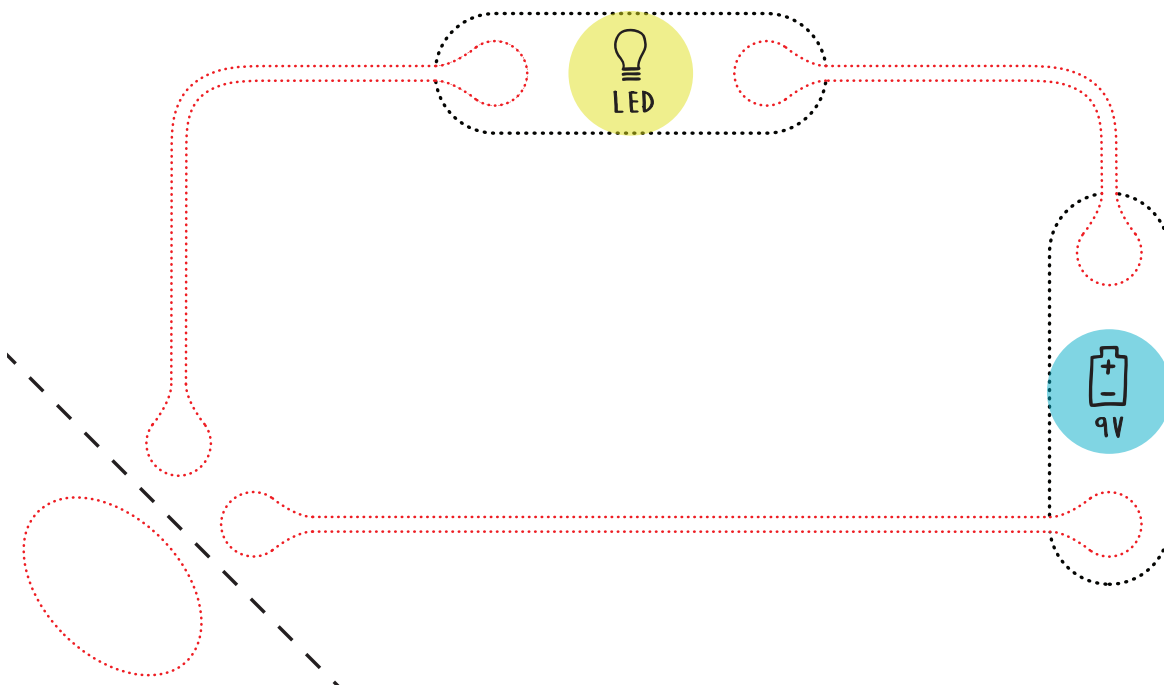
The Switch in your kit is like a regular light switch: in one position, the circuit is closed (connected) and in the other position the circuit is open (not connected). What happens to the LED when you flip the Switch?



## paper "push-button"

This button is also called a momentary switch, meaning the circuit is only closed while you press the button. To make a push-button switch using Circuit Scribe and paper, fill in the large oval and fold the corner over to close the circuit!

Visit [sketch.circuitscribe.com](http://sketch.circuitscribe.com) to learn how to turn origami into a paper push-button.

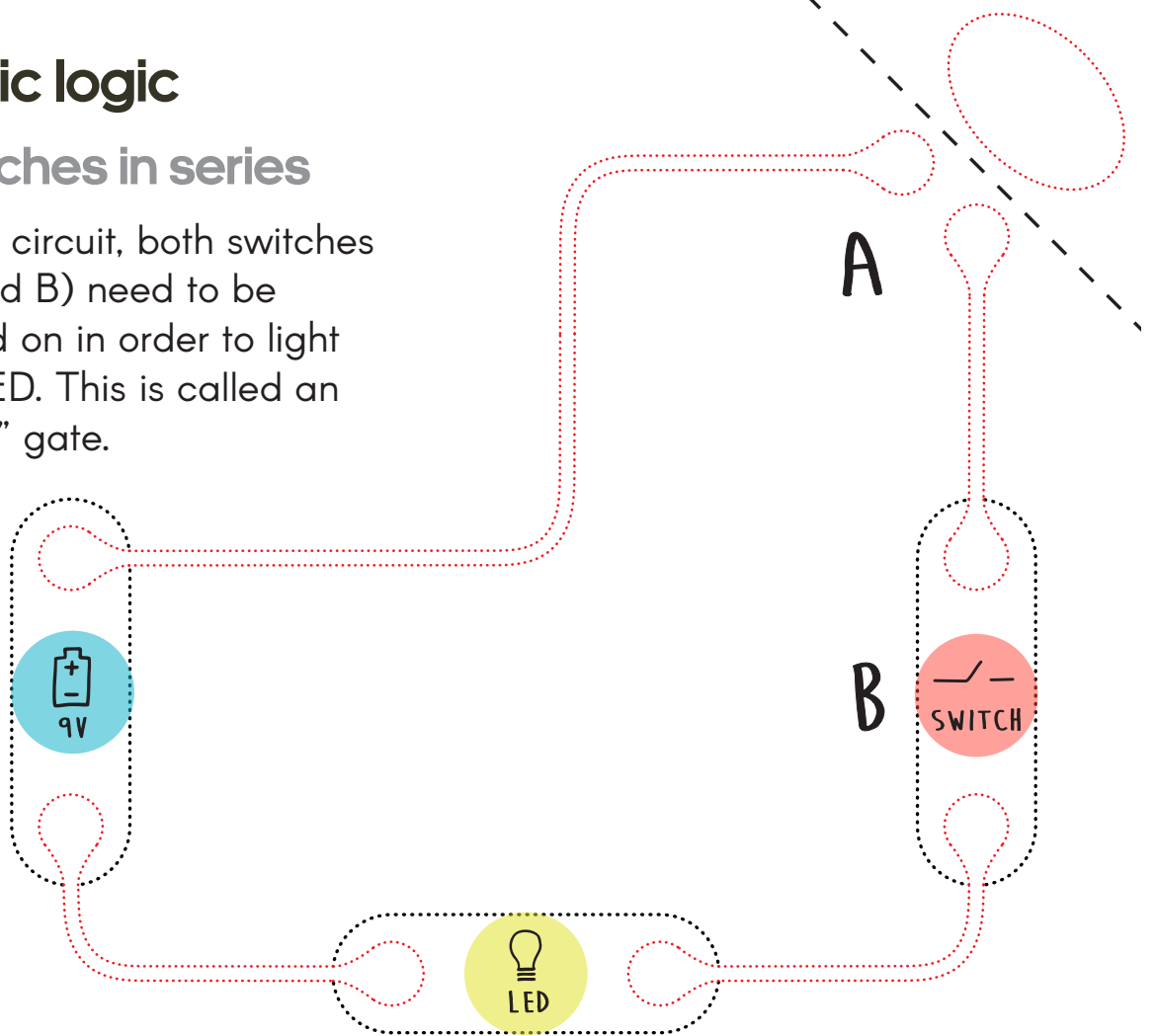




# basic logic

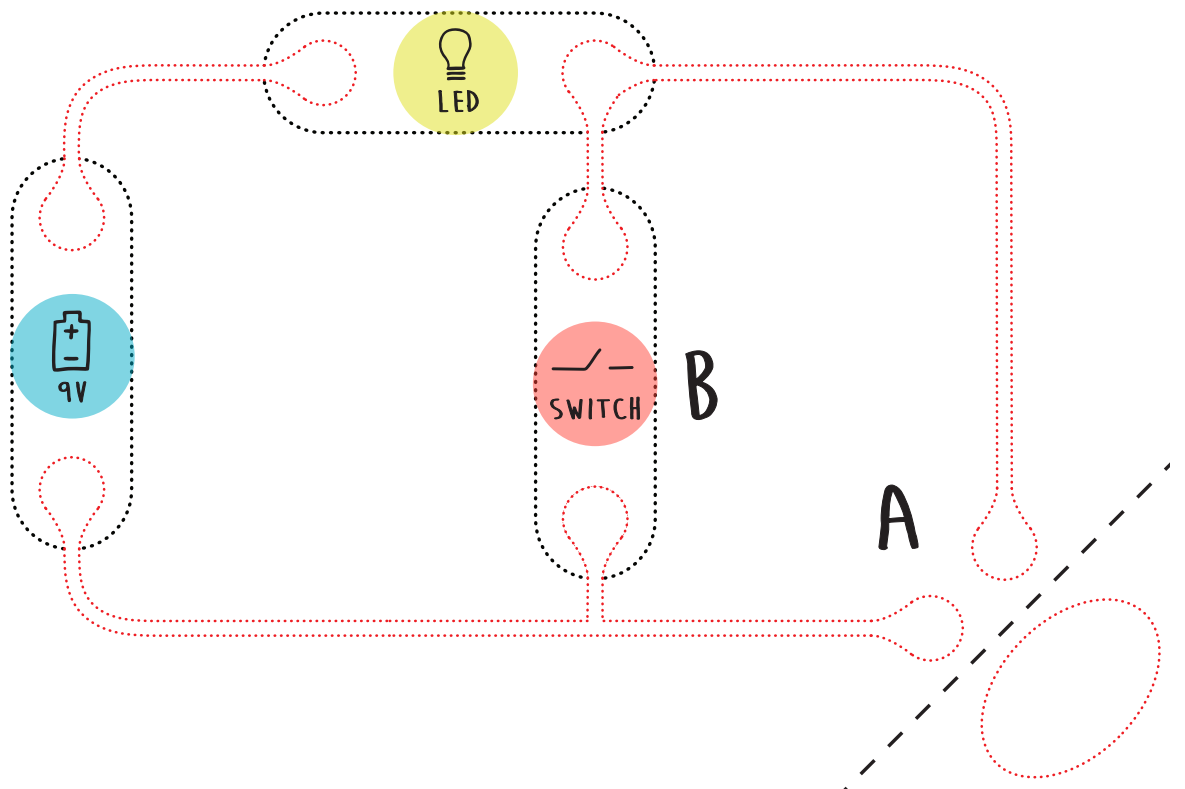
## switches in series

In this circuit, both switches (A and B) need to be turned on in order to light the LED. This is called an “AND” gate.



## switches in parallel

In order to complete the circuit, any combination of switches (A or B or both) can be used to turn on the LED. This is called an “OR” gate.



## resistance

Resistors are components that restrict or slow down the flow of current. Their main property, called resistance, is measured in units of ohms.

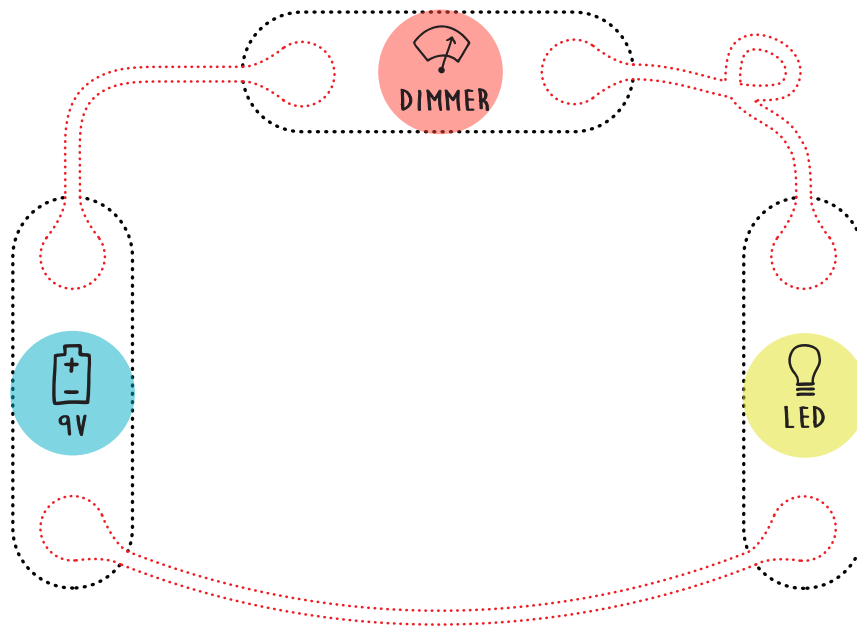
Low resistance: current flows easily, resulting in brighter LEDs, faster motors, and louder buzzers.

High resistance: current is restricted, resulting in dimmer LEDs, slower motors, and quieter buzzers (or no activity at all).

## dimmer module

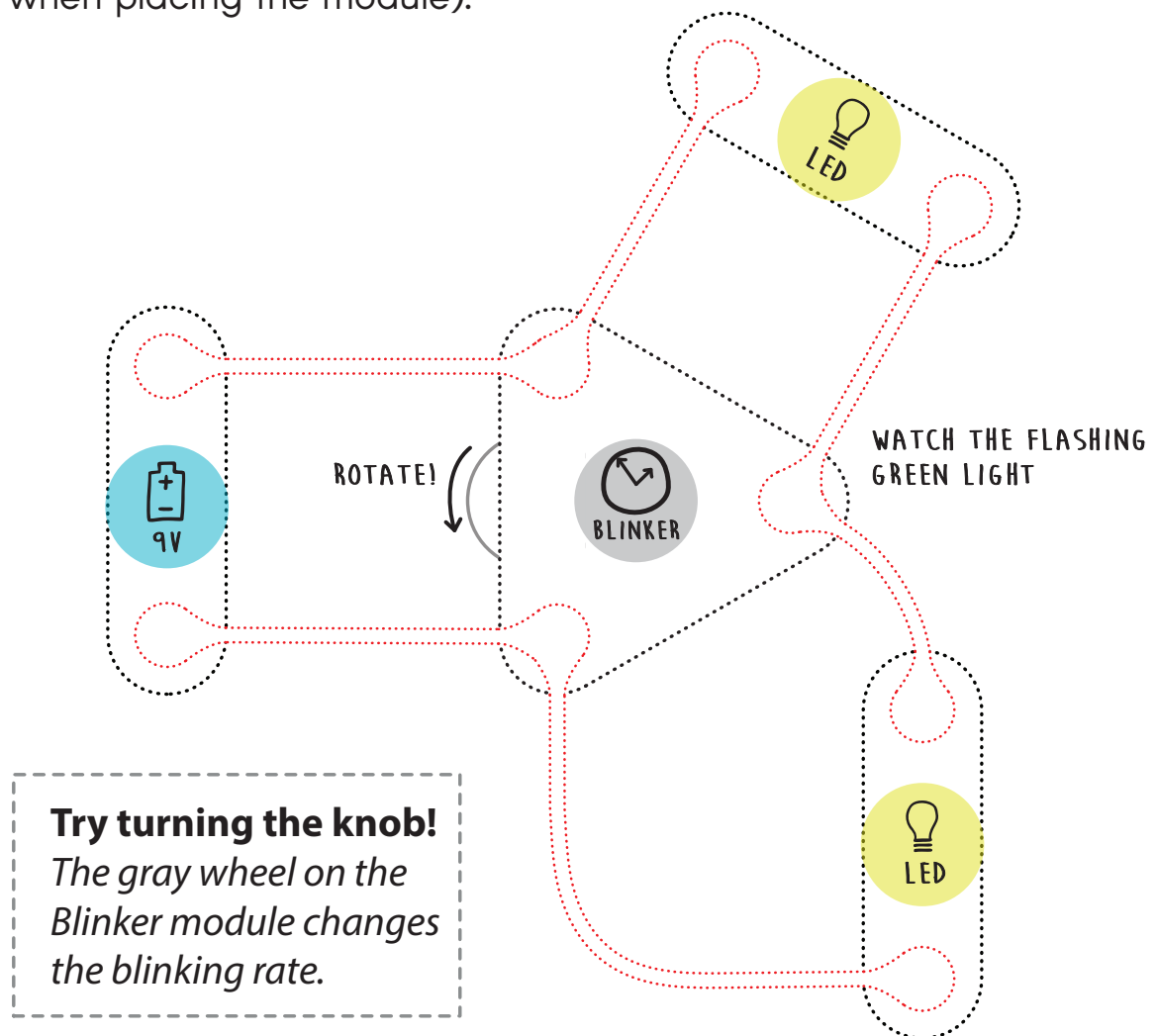
The Dimmer is actually a variable resistor. That means as you slide the handle, the resistance changes from 10 ohms to 100,000 ohms (or “bright” to “dim”).

Use the Circuit Scribe pen and modules to complete the circuit below. What happens to the LED when you move the Dimmer?



**Tip:** The Circuit Scribe ink conducts easily, with a resistance of only about 1 ohm per centimeter.

The Blinker turns outputs on and off at a constant rate. Try it out in the circuit below. Make sure the battery is connected to the VCC and GND feet of the Blinker. (Note position of the Blinker knob when placing the module).



The LEDs in the circuit are connected in two different ways. Do you see the difference after you complete the circuit?

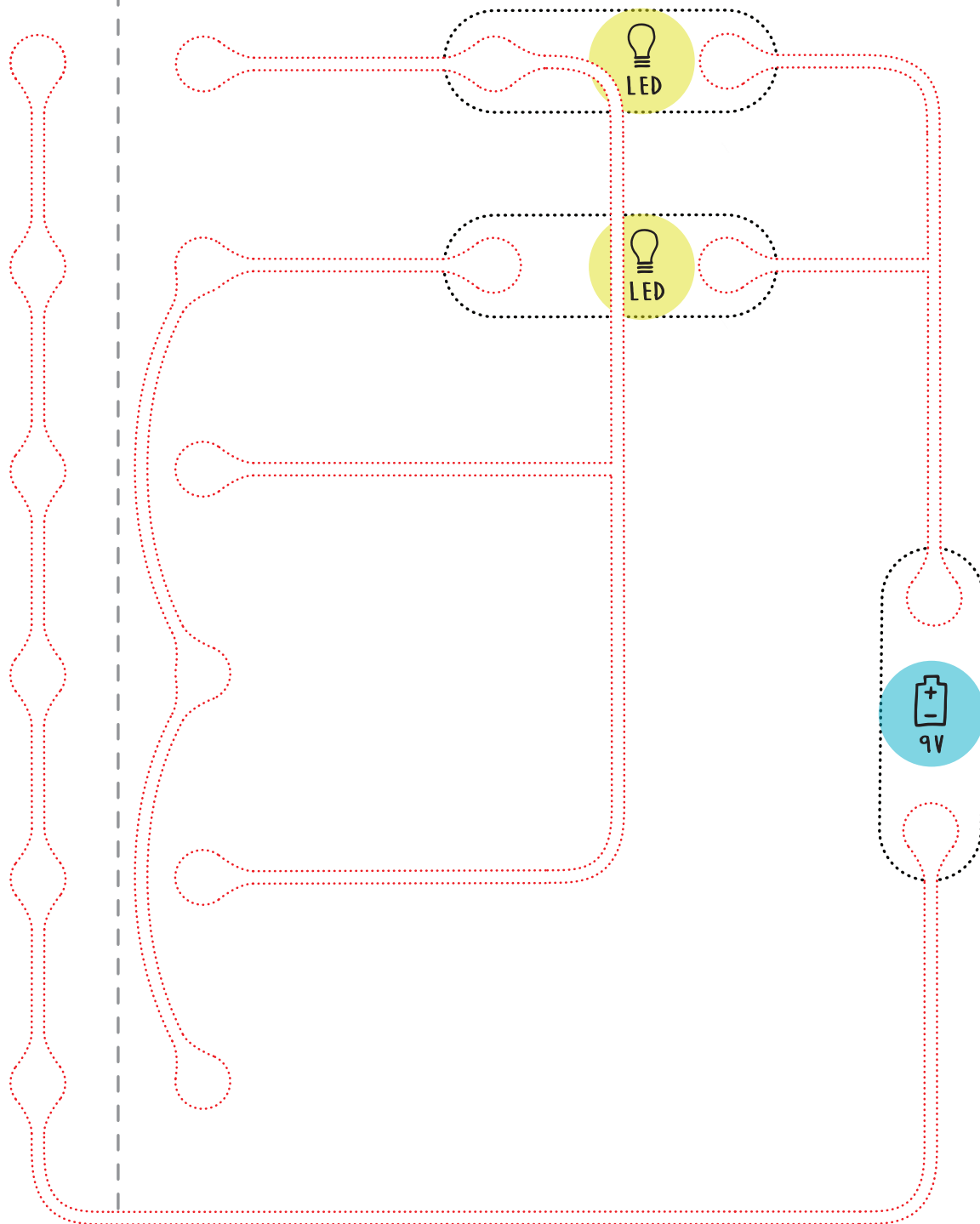
Bottom LED: The LED connected between the Blinker output and GND is in sync with the green flashing light.

Top LED: The LED connected between VCC and the Blinker output alternates with the green light.

Visit [sketch.circuitscribe.com](https://sketch.circuitscribe.com) to learn how to turn your Blinker circuit into a flashing fire truck.

You don't always need to use the Blinker module to create a flashing light effect! In this circuit, we combine several paper push-buttons to create a custom switch.

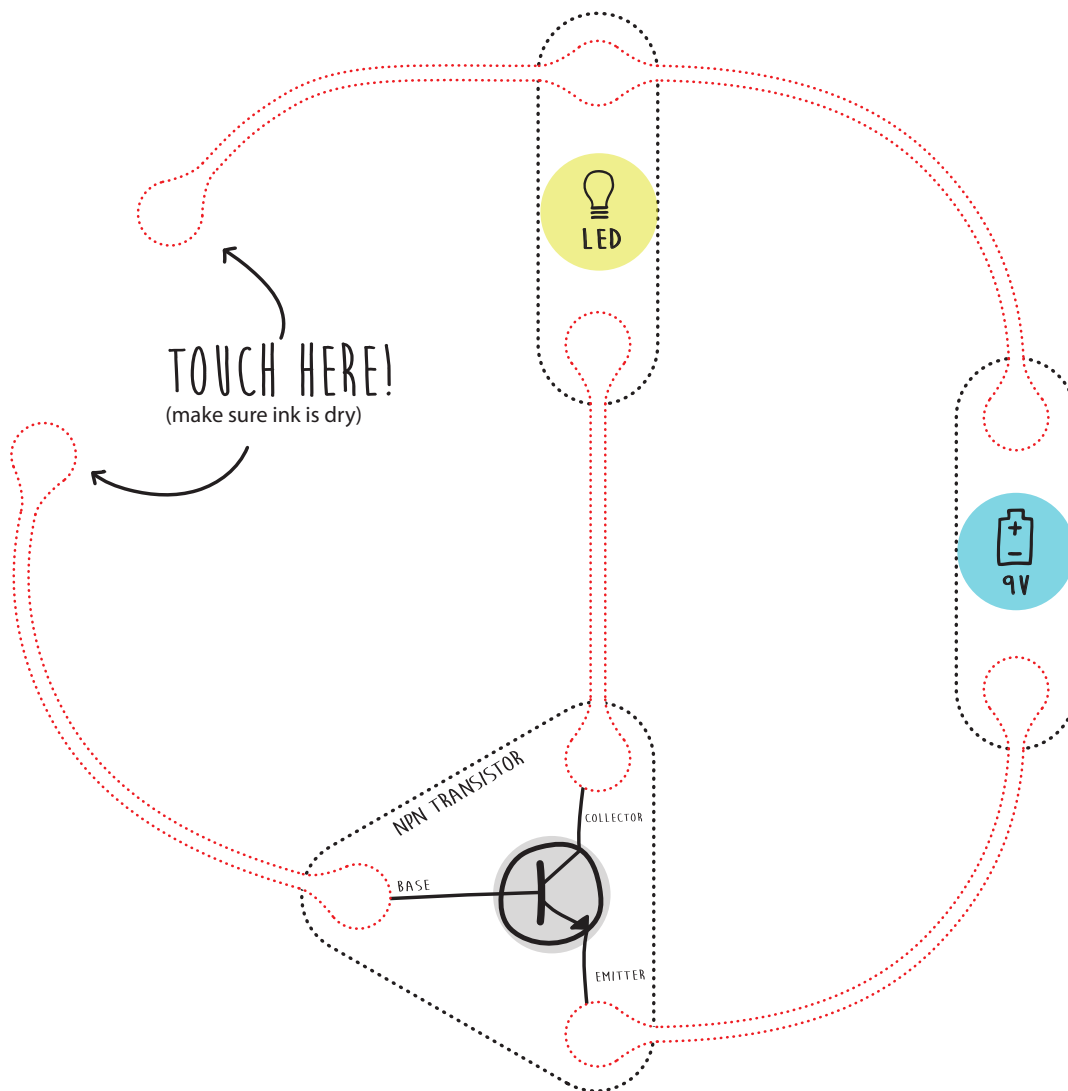
Fold the page along the dotted line, and run your finger up and down the fold to make the lights alternate!



The NPN Transistor can be used as an electrical switch. Instead of being activated by a handle, a small current into the **base** controls a large current between the **collector** and **emitter**.

## touch sensor

In this circuit, you'll use your fingers (i.e. a poor conductor or resistor) to activate the transistor. Try touching the circuit with both index fingers. A small amount of current flows through your arms!



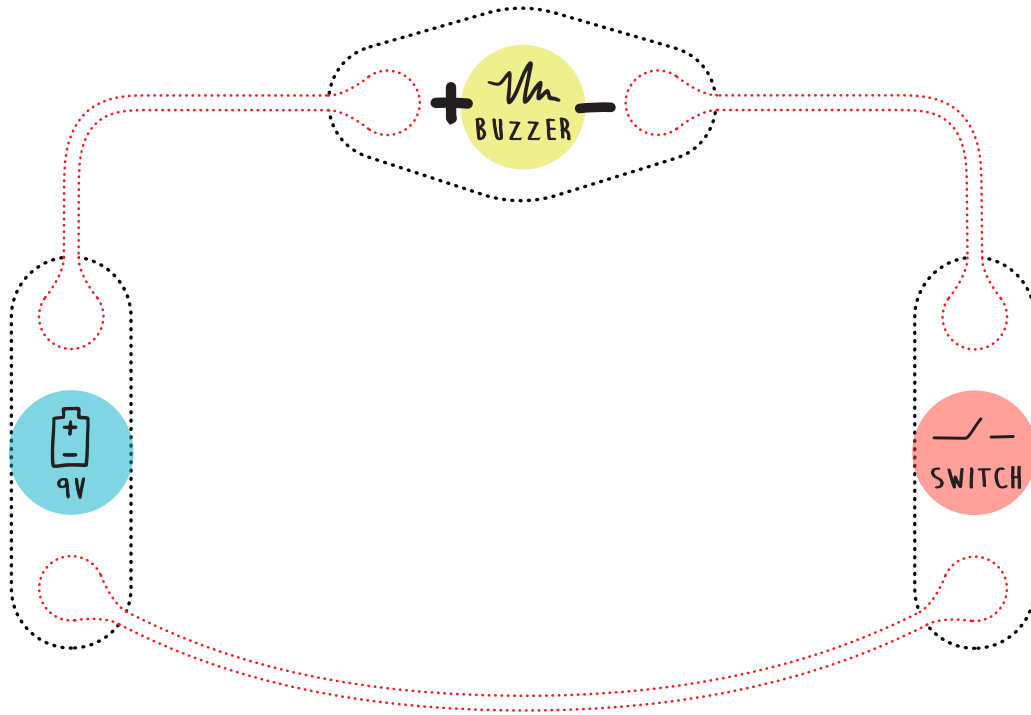
**Tip:** Remove the Transistor and put a Switch where the collector and emitter feet go. Do you see how both modules are a type of switch?

Visit [sketch.circuitscribe.com](http://sketch.circuitscribe.com) to learn more about the Transistor and how to turn this circuit into a high five detector!

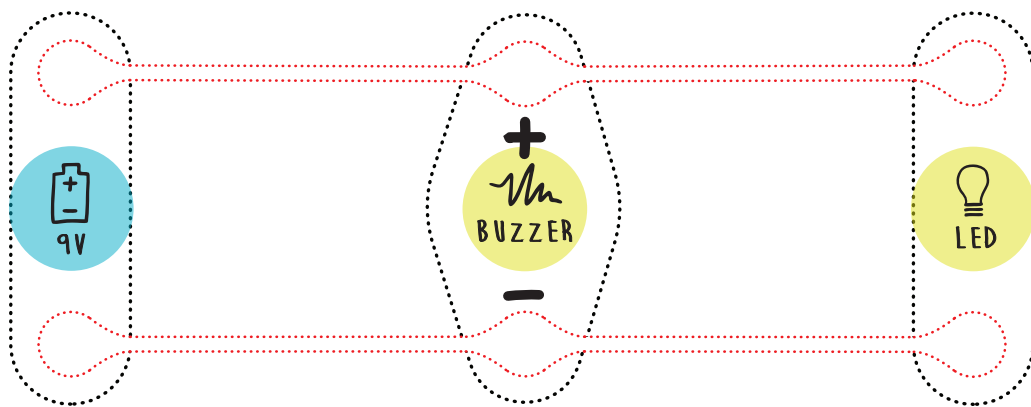
## buzzer module

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The Buzzer contains a film that vibrates in response to an electrical voltage. Notice that the Buzzer has a plus (+) and minus (-) sign. The Buzzer only works in one direction. Does this remind you of anything?



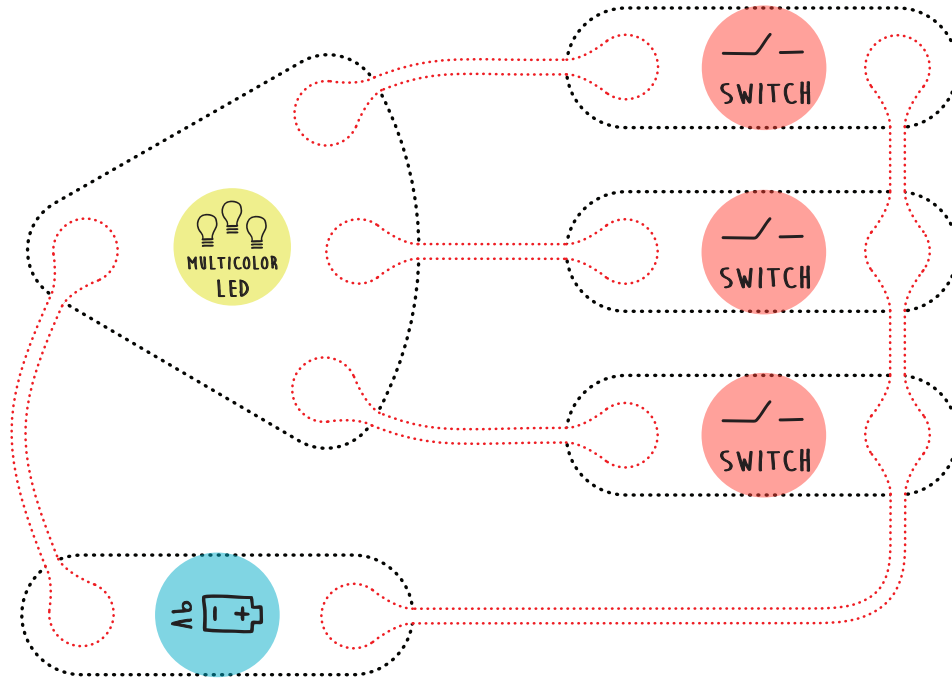
Now try combining the Buzzer and LED in **parallel**. Similar to the parallel switches project from page 9, if you remove one output module the other will stay on!



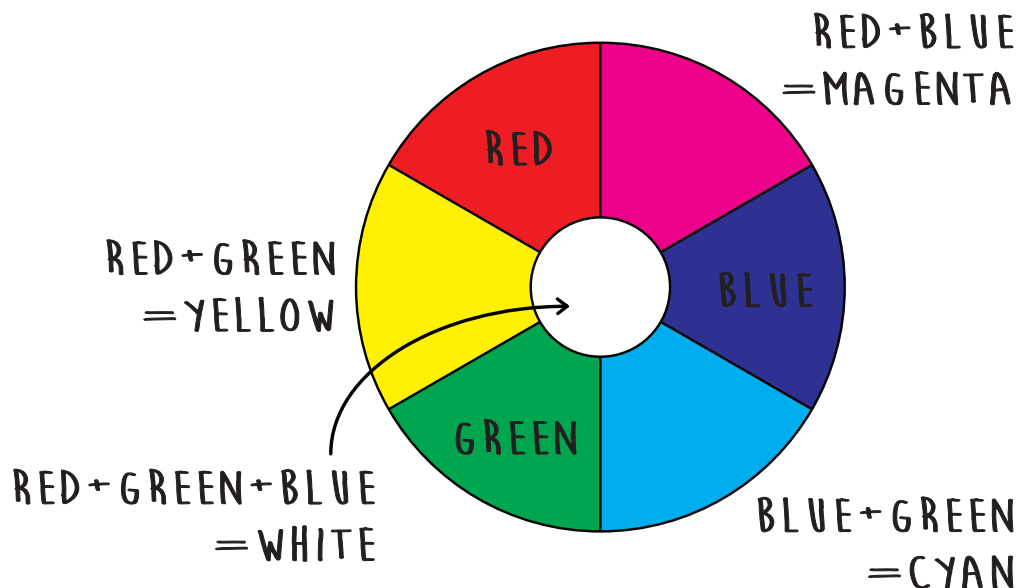
Try reversing the direction of the battery. What changes do you expect to see (or hear) in the Buzzer and LED?

The Multi-Colored LED has 3 LEDs on one module: red, green, and blue. Each LED shares its negative (-) terminal, which always connects to the (-) foot of the battery.

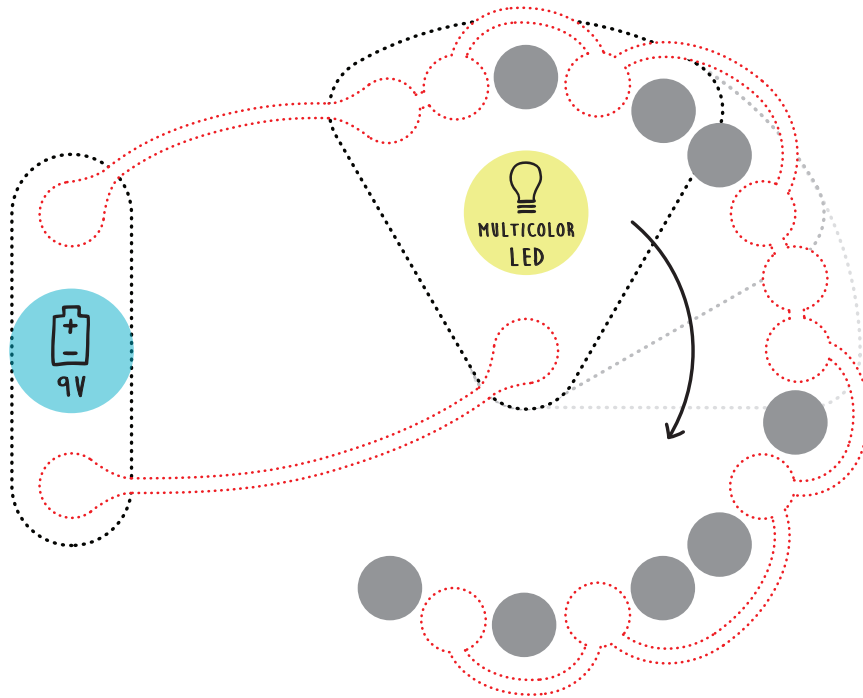
In the circuit below you will control each color with its own switch. **If you have the Super Kit, try using your single switch on each of the switch icons, one at a time.**



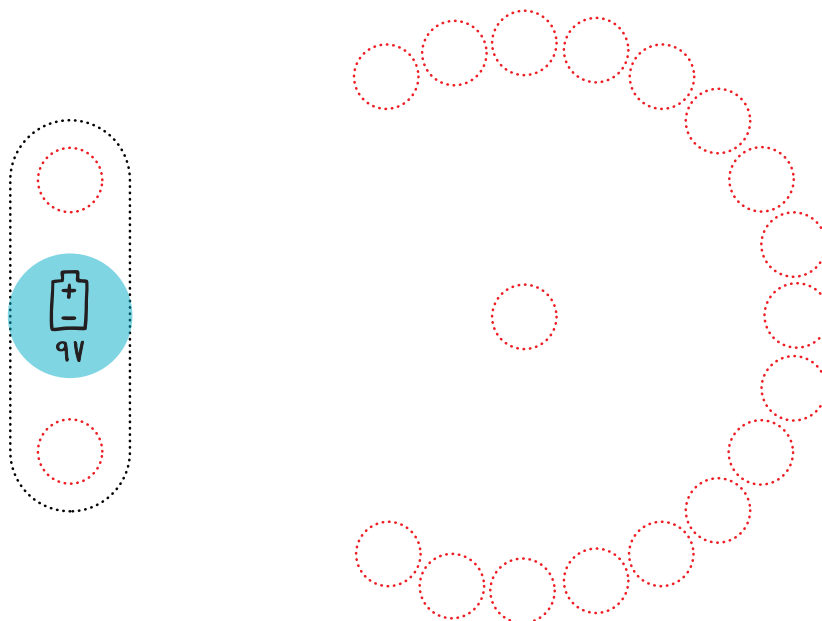
What happens when you turn on two switches at a time? Or all three? The guide below shows you how our eyes interpret mixing of colored light.



Fill in the template with Circuit Scribe; you can leave dark pads empty. Keep the (-) terminal of the Multi-Colored LED on the center pad, then rotate it around the circuit.



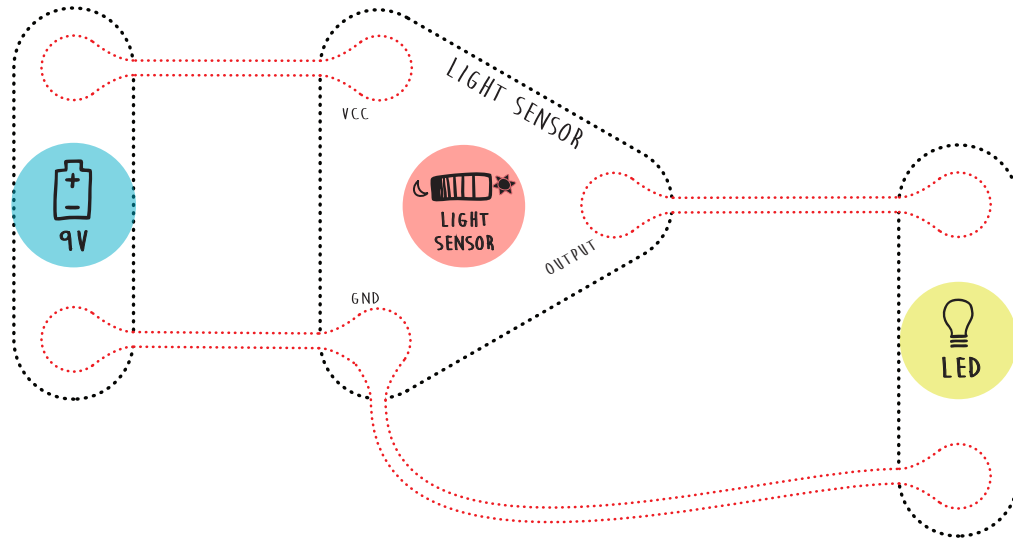
Use the template below to design your own color palette. Decide which pads on the outer ring to connect with Circuit Scribe.



Visit [sketch.circuitscribe.com](https://sketch.circuitscribe.com) to learn more about the visible light spectrum.

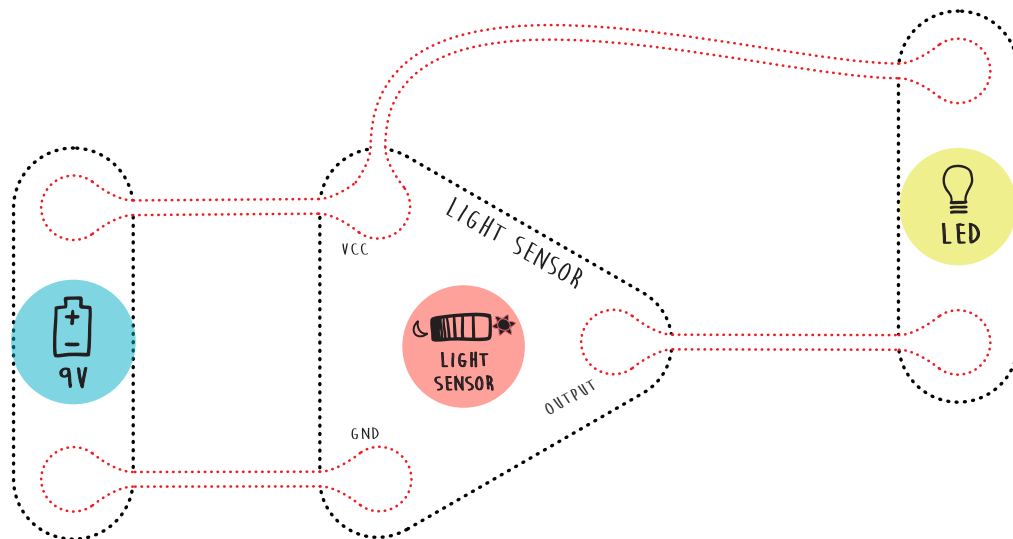


In the circuit below, supply power to the Light Sensor module. Shine light on it from a mobile phone flashlight or other source to increase the voltage at the output foot. The LED will shine more brightly as your light gets closer!



## reverse light sensor

Now try hooking up an LED between VCC and the output. How does the LED respond to the flashlight now? The voltage actually decreases as you shine the light.

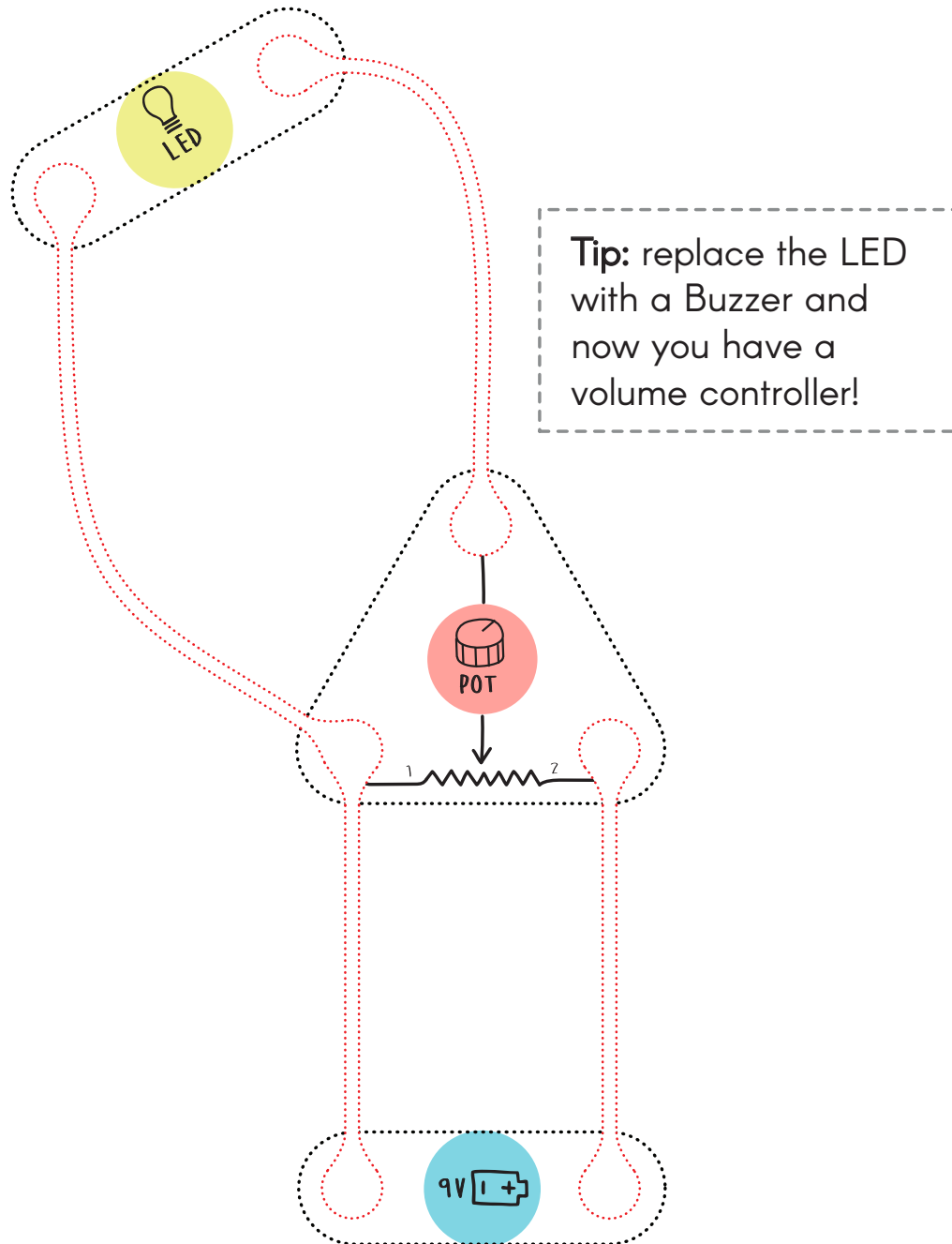


**Tip:** The Light Sensor is a "photo transistor." Instead of responding to a small electrical current, it amplifies or switches in response to light. [Learn more about the Light Sensor at sketch.circuitscribe.com](http://sketch.circuitscribe.com).

## voltage divider

One of the most common circuit configurations you'll see is called a voltage divider. Below you will use the Potentiometer (or "pot") to adjust voltage across the LED with a knob.

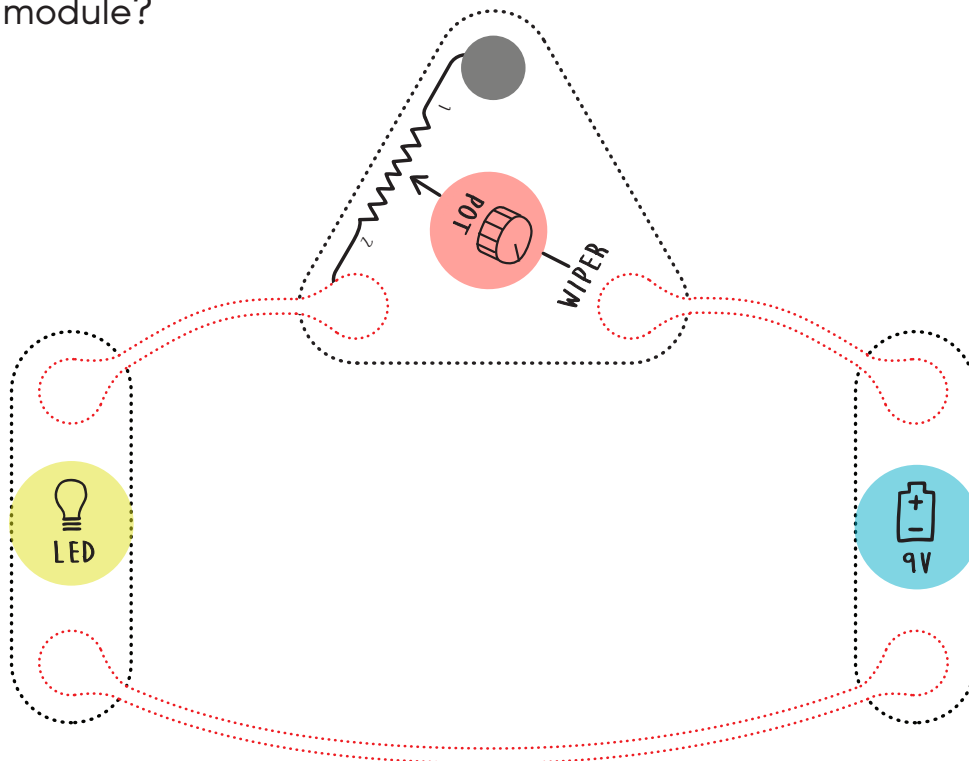
Apply power from the battery between terminals 1 and 2 of the Potentiometer to get a sweeping voltage out of the dial between 0 and 9 volts (the max that the battery can provide).



Visit [sketch.circuitscribe.com](https://sketch.circuitscribe.com) to learn how to add a paper-craft gauge and arrow to this project.

**Example 1:** The knob is in the center and  $R1 = R2 = 5000$  ohms

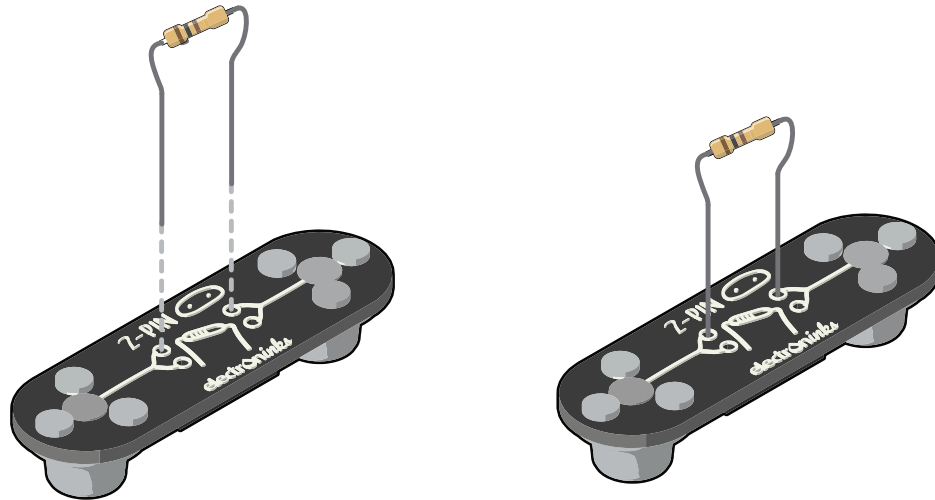
The circuit below uses just the wiper and terminal 2 to control the brightness of an LED. Does this remind you of the Dimmer module?



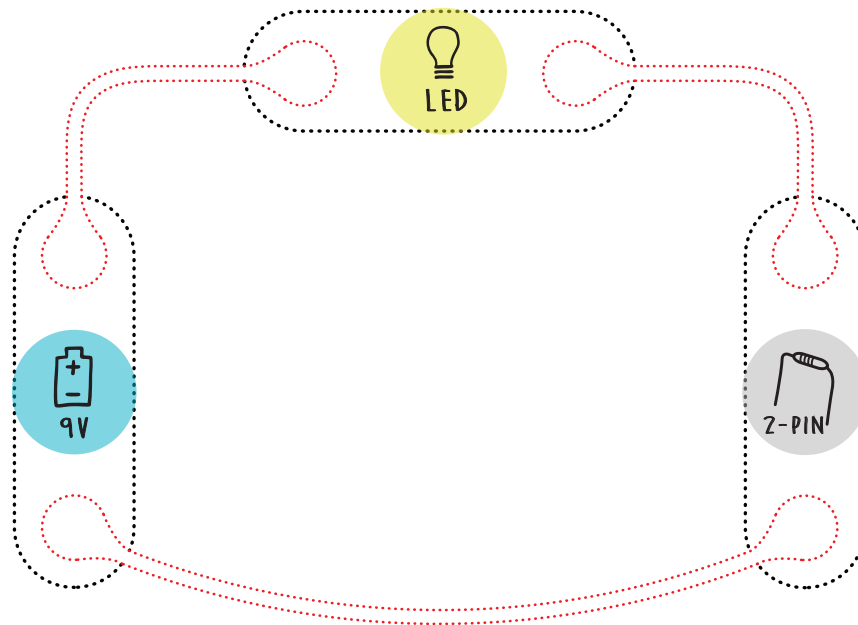
Visit [sketch.circuitscribe.com](https://www.sketch.circuitscribe.com) and use the Potentiometer to turn a Multi-Colored LED into a red-yellow-green traffic light.

## resistors and 2-pin connector

Resistors restrict or slow down current. To explore how they work, use a 2-Pin Connector module and the bag of 2-pin components (not included in Super Kit). Insert resistors into the module as shown.



After drawing the circuit, swap in different resistors and watch the change in LED brightness. See if you can line up the resistors based on their conductivity!



Resistance is measured in **ohms**. Higher resistance = lower current and a dimmer LED.


The resistor colors indicate its value in ohms. Flip to the next page to learn how to read the colored bands.

# resistor color code

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A resistor restricts or slows the flow of current through a circuit. Resistors are used to control the brightness of an LED, the volume of a buzzer, or the speed of a motor.

The electrical component called a resistor has a resistance value measured in ohms. The colored stripes on the resistor are a code that indicates its value. This chart explains how to read the code:



COLOR	1st BAND	2nd BAND	multiplier
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	
WHITE	9	9	

## Example resistor:

The first two bands are the first two digits  
(**brown** and **red** = 12).

Multiply by the third band (**blue** = 1,000,000).

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**Resistors in your kit:** match the resistor with its value



100 ohms



1000 ohms



10,000 ohms

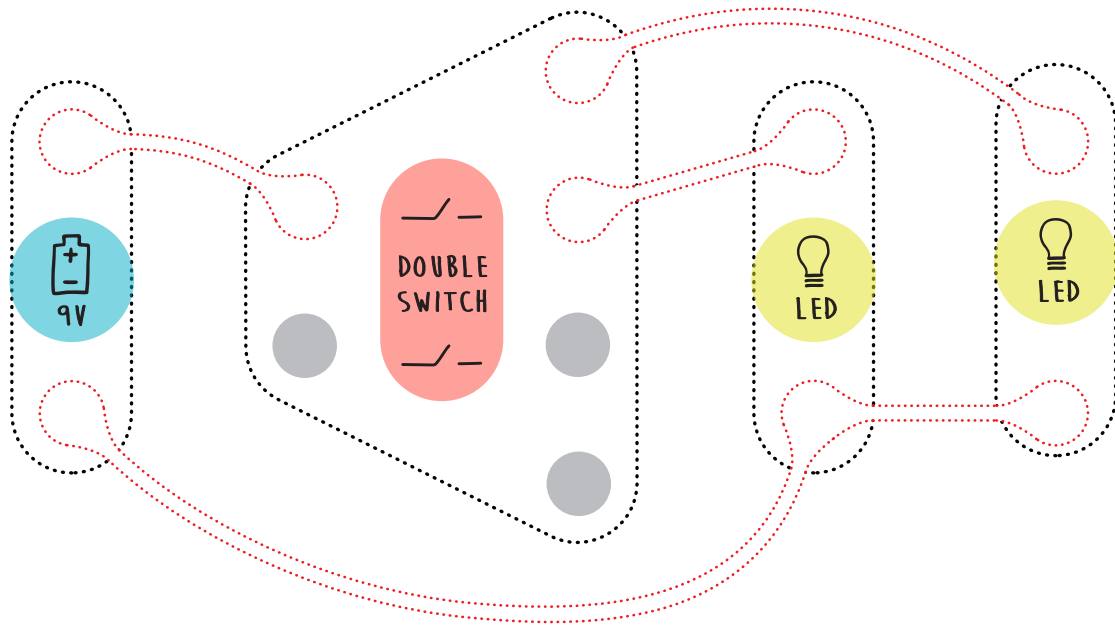


100,000 ohms

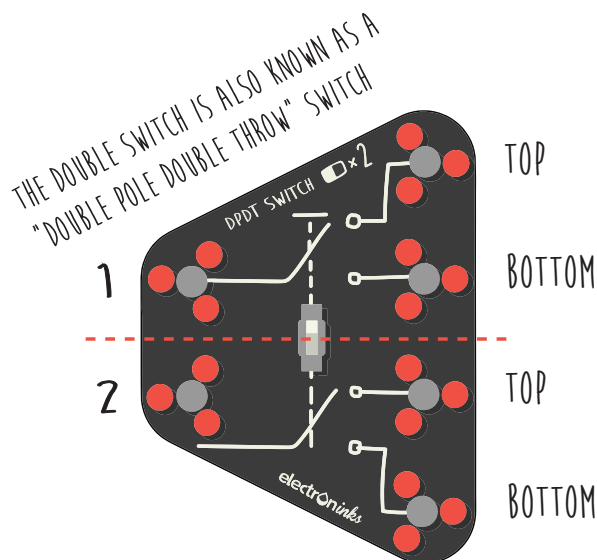


1,000,000 ohms

The larger switch (Ultra Kit only) is more than an on/off switch. By toggling this switch you are changing the current's path. Try it below! See if you can draw arrows to show the two different paths that current can take.



The circuit above only uses the top of the Double Switch. This switch is actually two separate toggle switches controlled by one lever. It can control not just one, but two circuits!

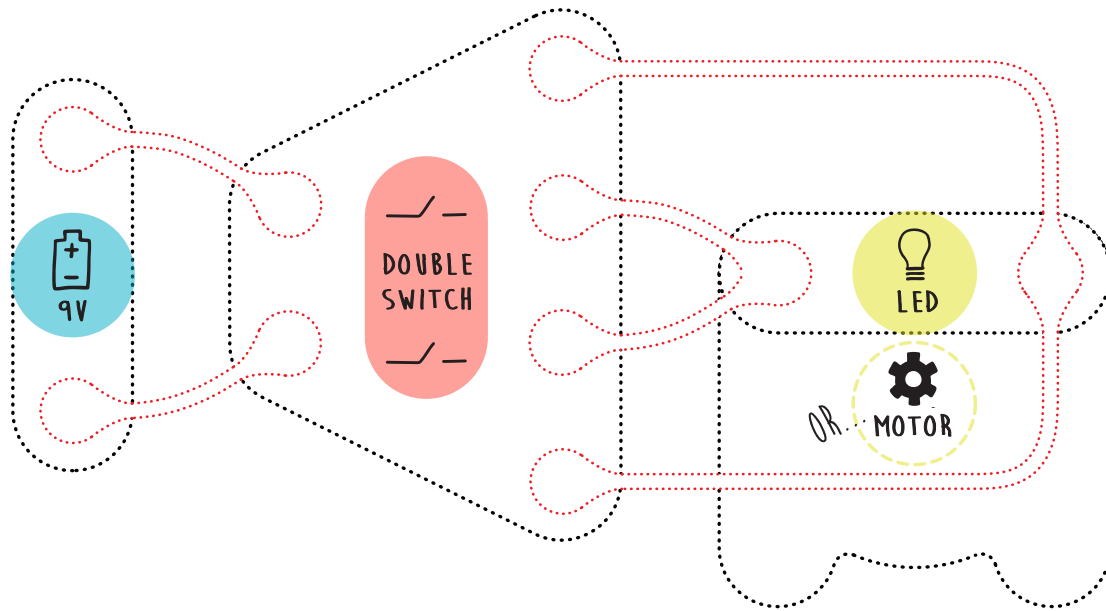


**Switch up:** 1 is connected to TOP 1 and 2 is connected to TOP 2

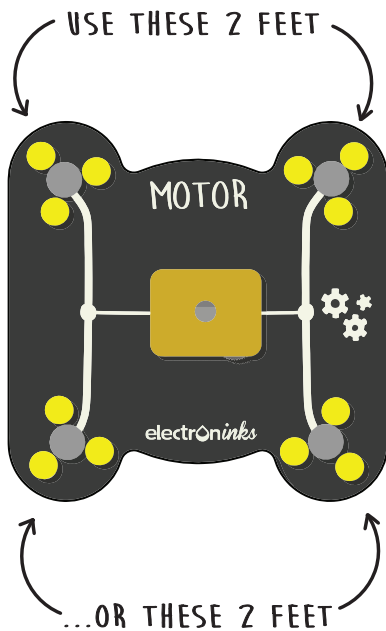
**Switch down:** 1 is connected to BOTTOM 1 and 2 is connected to BOTTOM 2

Visit [sketch.circuitscribe.com](https://sketch.circuitscribe.com) for projects using the Ultra Kit's Double Switch module.

Now use the Double Switch (Ultra Kit only) to change the color on an LED module. The switch is used to flip the direction of current flow through the LED.



## motor module



**Or try the motor!** Replace the LED above with the Motor Module. Flip the switch to change the direction that the motor spins.

The Motor (Ultra Kit only) converts electrical energy from the battery into rotational motion.

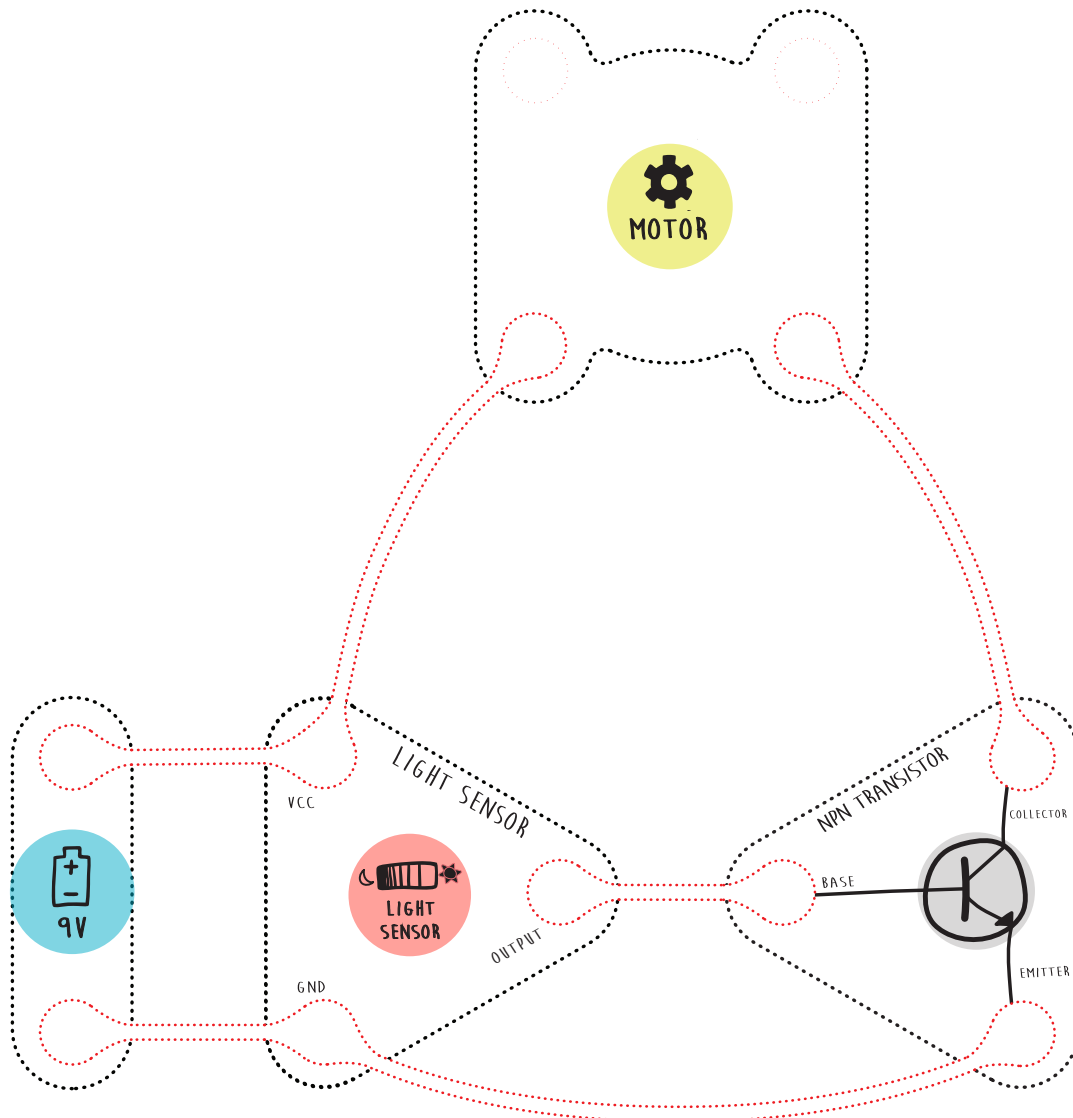
On the module, there are four feet for stability. You only need to use two for the motor to work.

If your motor is not spinning, try rotating the module 90 degrees.

Now you will use the Light Sensor to control the Motor (Ultra Kit only). Before trying out this project, go back to [page 17](#) and replace the LED module with the Motor. Does the circuit work?

It was probably hard to get the Motor started using the Light Sensor. That's because not enough current was running through the output foot of the Light Sensor module.

This is the perfect time to use the **NPN Transistor** as an amplifier! Small current into the Transistor's base results in a large current through the collector, emitter, and Motor.

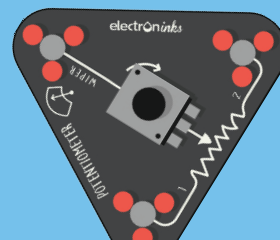


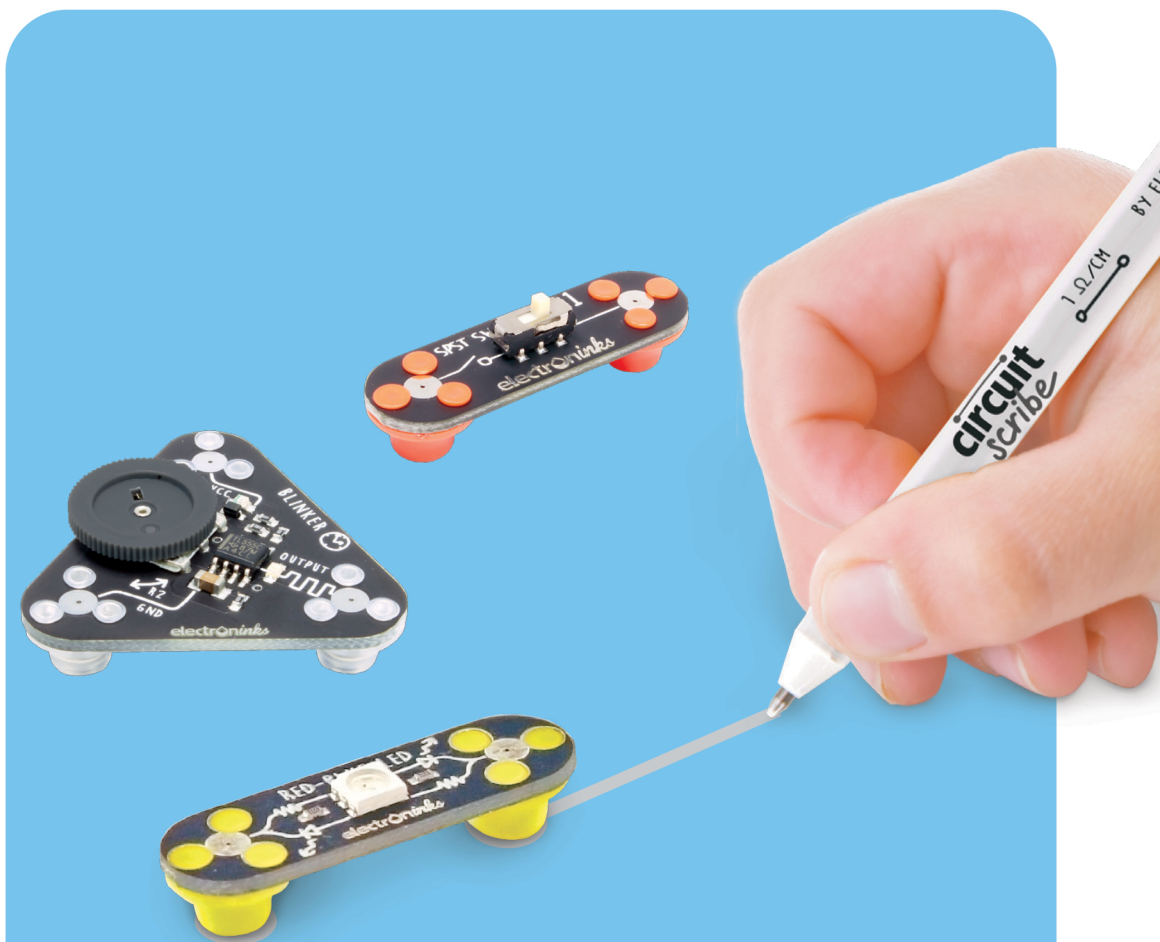


## CIRCUIT DRAWING KITS

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- BUZZER
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