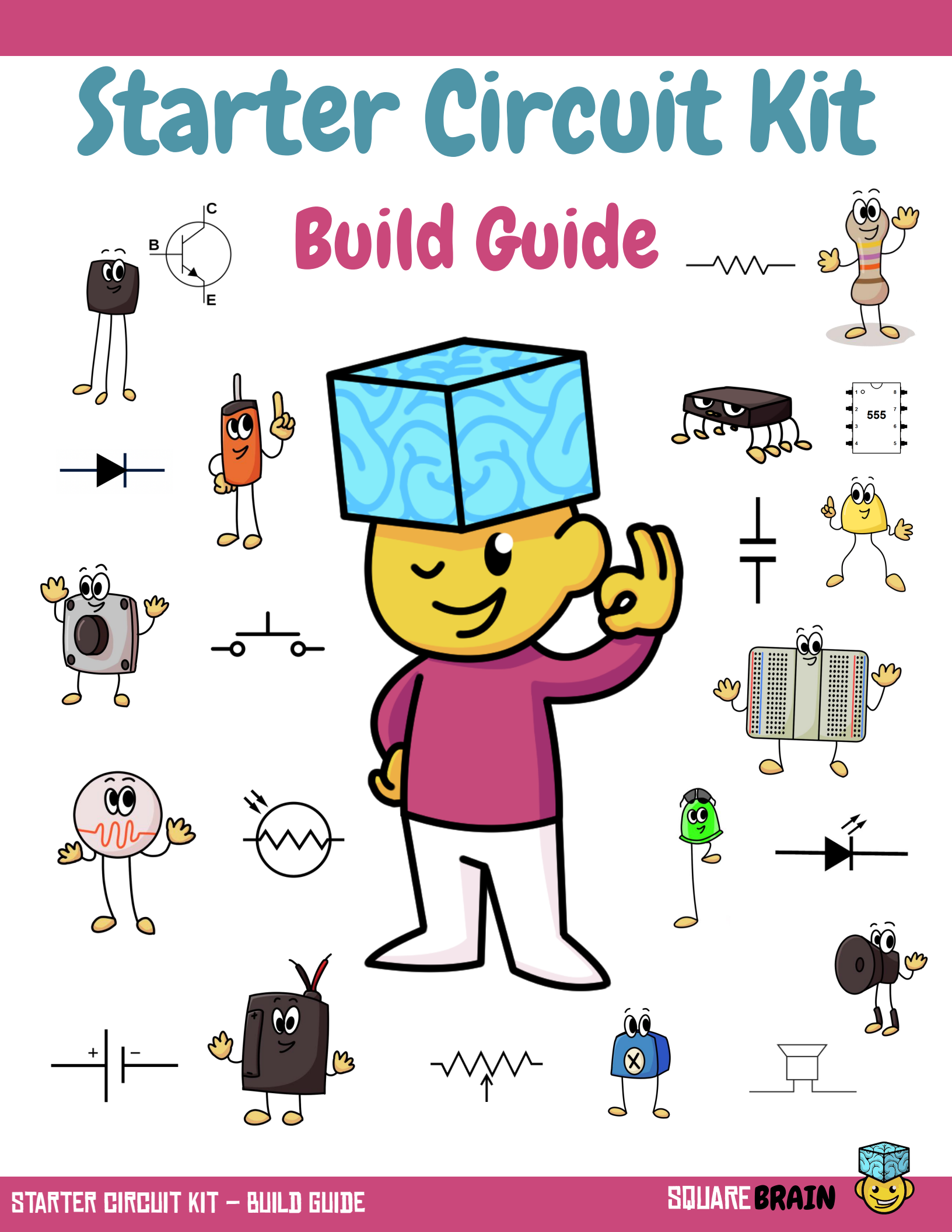
Starter Circuit Kit

Build Guide



Resistors

Value	470 Ω	1 kΩ	10k Ω	100k Ω	270k Ω
Symbol	Yellow Purple Brown Gold	Brown Black Red Gold	Brown Black Orange Gold	Brown Black Yellow Gold	Red Purple Yellow Gold

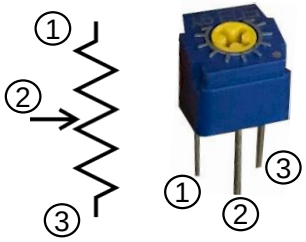
Color 1 – Tens Digit (Yellow = 4)
Color 2 – oNes Digit (Violet = 7)
Color 3 – Multiplier (Brown = 1)
Color 4 – Tolerance (Gold=±5%, Silver=±10%)

Value = TN x 10^M
= 47 x 10^1
= 470 Ω

0 1 2 3 4 5 6 7 8 9

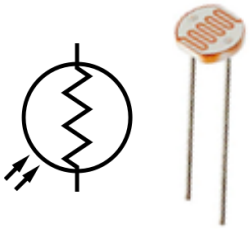
Variable Resistors

Potentiometer (POT)



Change resistance from center (2) to either edge (1 or 3) by turning the top screw (0Ω to 50kΩ).

Photoresistor



Increased darkness increases resistance.
Full Light = 16kΩ
Full Dark = 30kΩ

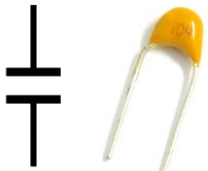
Battery Pack

Provides 4.5 volts to the circuit.

Red wire = (+)
Black wire = (-)

Capacitors

Can absorb energy and store it temporarily. Provides electricity like a battery.



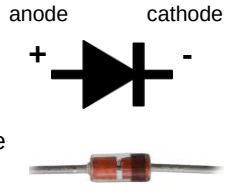
104 → **100 nF**
226 → **22 µF**

Button Switch

Can disconnect or connect the path of electrical flow in a circuit.

Diode

Electricity flows only in the direction of the arrow – from anode (+) to cathode (-). Black line on diode is the cathode.

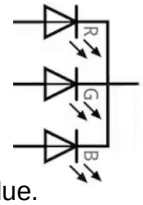


LED

Light Emitting Diode
A diode that emits light when electricity flows through it.

RGB LED

Works just like a normal LED but with three internal colors red, green, and blue.

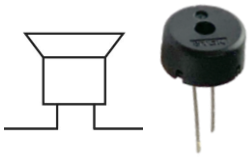


Buzzer

Makes a buzzing sound when a voltage is applied across the leads.

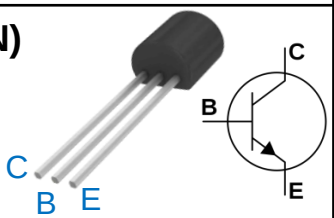
Speaker

Makes a wide variety of sounds based on the electric signals provided to the leads.
Will not buzz with just a voltage.



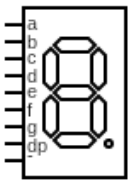
Transistor - (2N3904 NPN)

Allows current to flow from the collector (C) to the emitter (E) when voltage is applied to base (B) driving B → E current.



7 Segment Display

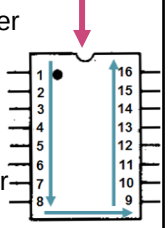
Displays numbers or letters by lighting up a combination of light segments, based on voltage received at the pins.



Chip/IC Labeling

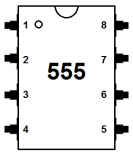
The notch marks the top of the chip.
The dot on the upper left is next to pin 1.

Pins are numbered counterclockwise starting in the upper left-hand corner.



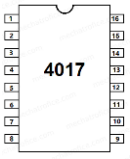
555 Timer

The 555 chip creates repeating pulses of electricity. It is used to flash LEDs, make sounds, run clocks, and more!



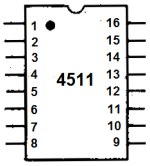
4017 Decade Counter

The 4017 chip allows circuits to count pulses (like from a 555) from 1 to 10 like we do!



4511 BCD - to- 7 Segment Latch Decoder

The 4511 makes the 7 Segment Display (above) show the correct number in response to a 4-bit binary input.

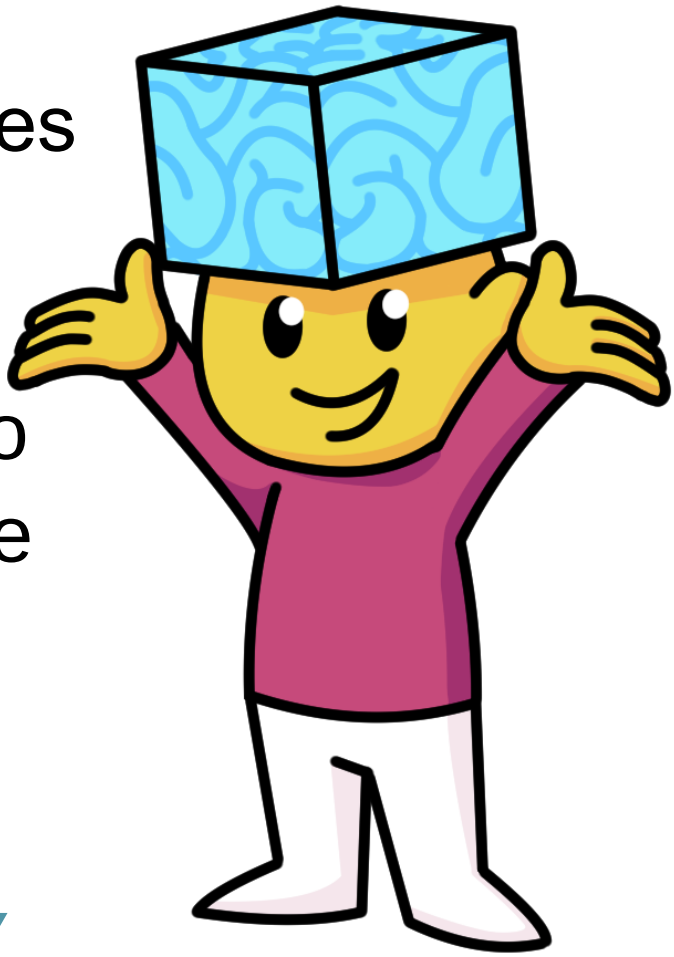


Welcome to your Starter Circuit Kit!

The kit has everything needed (and more!) to build everything described in this manual.

Each circuit builds on what you learn in previous lessons so build them in order.

It's okay to make mistakes and break things! You have lots of extra parts to play with, so go ahead and dream of the possibilities!



Have an electrifyingly great time!

These are ALL the Parts in your Kit!

Line	Part	Kit Quantity
	Capacitors	
1	0.1uF / 100nF Capacitor	6
2	22 µF Capacitor	6
	Resistors	
3	470 Ohm Resistor	20
4	1k Ohm Resistor	20
5	10k Ohm Resistor	20
6	100k Ohm Resistor	20
7	270k Ohm Resistor	20
	Variable Resistors	
8	0-50k Trimmer Potentiometer	6
9	16-33K Ohm Photoresistor (Photocell)	2
	LEDs	
10	LED RGB Clear Common Cathode	4
11	LED RGB Diffused Common Cathode	4
12	LED Blue Clear	24
13	LED Red Diffused	10
	Various Discrete Parts	
14	Diode	20
15	Push Button Switch	8
16	7 Segment LED Display	2
17	NPN Transistor	10
18	Active Buzzer	2
19	Piezo Buzzer Transducer (Speaker)	2
	Integrated Circuits (ICs / Chips)	
20	555 Timer	2
21	4017 Decade Counter	2
22	4511 BCD to 7 Segment Latch Decoder	2
	Main Parts	
23	Breadboard	2
24	AAA Battery Case	2
25	65 piece male to male jumper wires various colors and lengths	1
26	140 piece male to male solid core jumper wires, various colors and lengths, in box	1
	Tools	
27	Phillips Screwdriver	1
28	Flat Head Screwdriver	1
29	4.5-inch Needle nose pliers	1
30	Multi-Meter with 9V 6F22 Li-ion Battery	1
31	Batteries (AAA)	6
32	Box	1

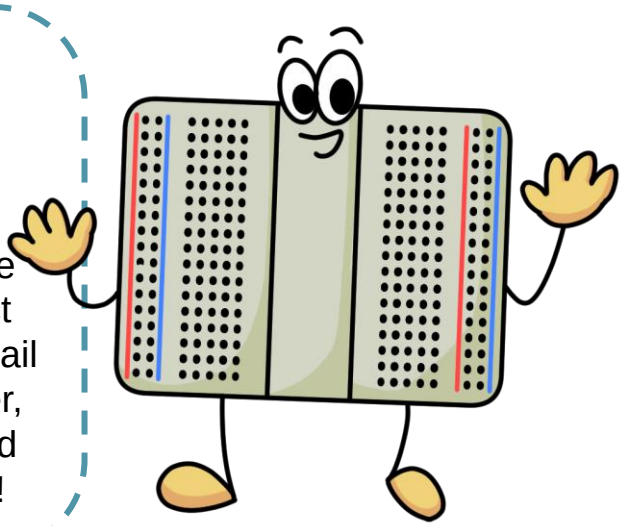
You do not have to purchase our kit to do any of the projects in this manual.

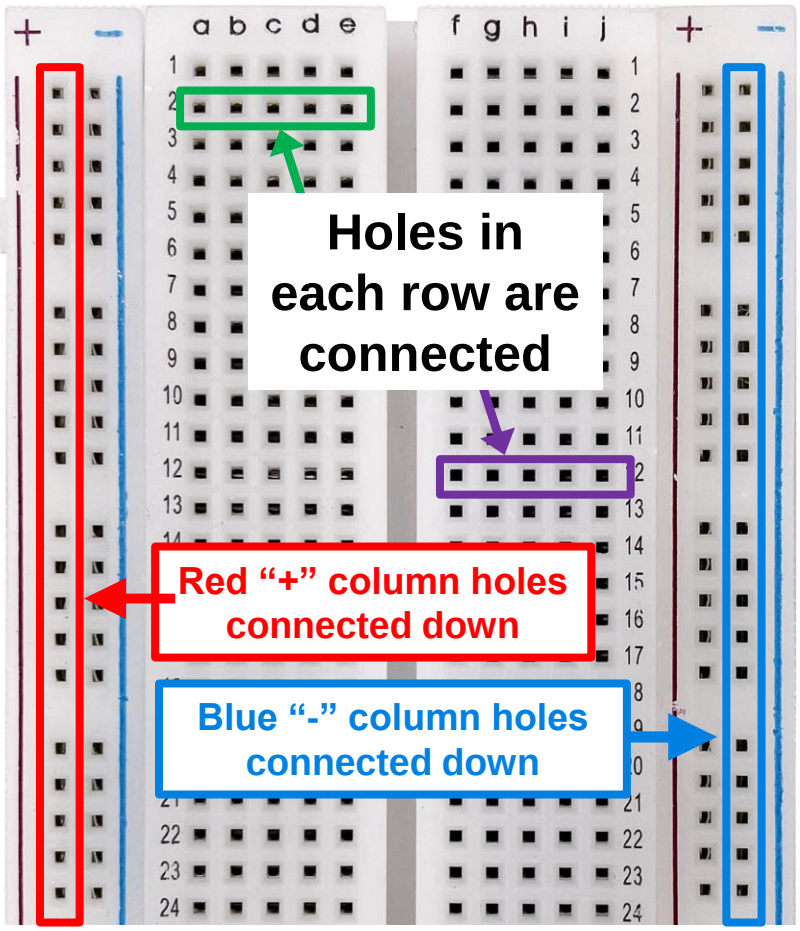
Here is a list of everything we provide in our kit as well as links to the electronic components if you want to buy them on your own.

Table of Contents

Use my 'Power Rails' to make connections on the breadboard

On the breadboard, the holes in the red and blue vertical columns are all connected. These columns are called Power Rails. Use the red Power Rail to connect your circuit to battery power (+) and the blue Power Rail to connect the circuit to the ground (-) end. Remember, the Power Rails on the right and left are not connected together, unless you connect them with a jumper wire!

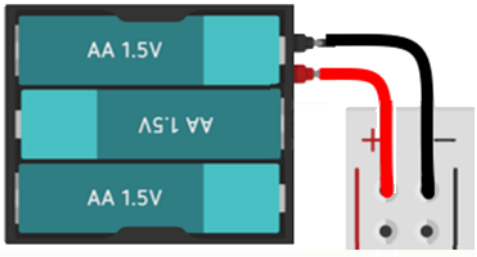




Note: The terms "power" and "ground" are used to describe the positive (+) and negative (-) terminals of the battery. If you use the rails as described, then the red would be power, and the blue would be ground.

The breadboard connects all the components in the circuit together. The highlighted areas indicate how the rows are connected as well as the Power Rail columns.

Note: More than one breadboard can be connected together to create a larger area to build circuits!

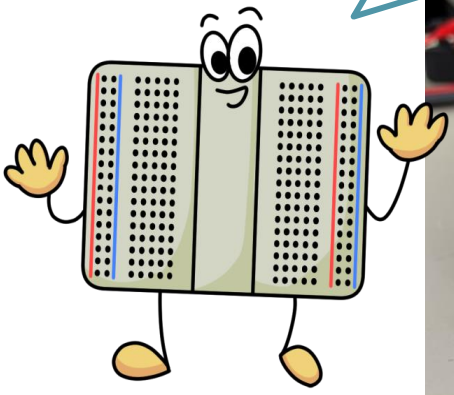


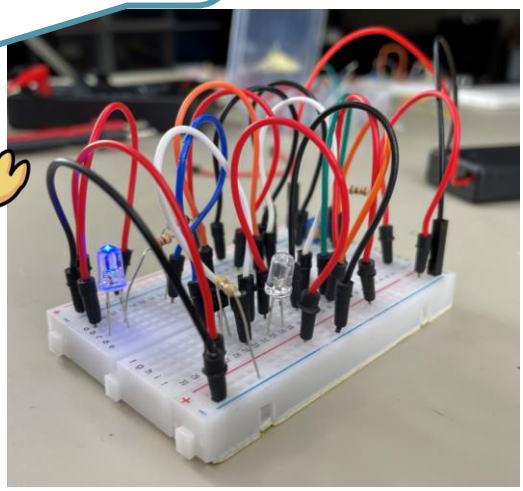
The power rails are not powered until connected to a power source (battery).

The letters and numbers on the breadboard are for reference only.

Jumper Wires vs Solid Core Wires

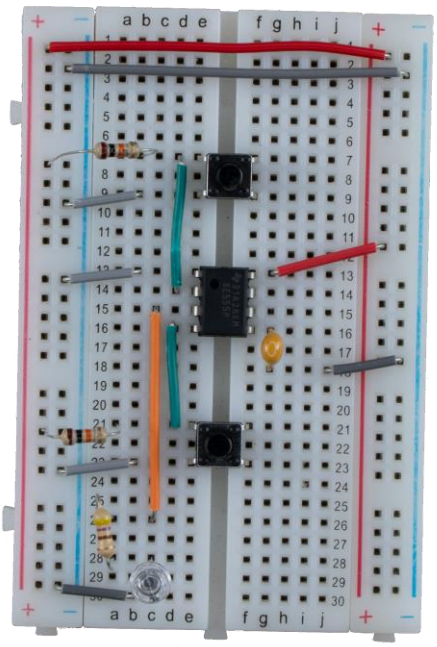
Jumper Wires and the *Solid Core Wires* function the same way!





Jumper wires allow any two points in a circuit to be easily connected. But when there are many connections in a circuit it can sometimes be difficult to see through the tangle of wires to troubleshoot a circuit.

Solid core wires lay flat and can make it easier to see the connections in a circuit when there are many connections. Short wires can be used to connect components located near one another.



A ***multimeter*** is a handheld electronic measuring tool that is used to test and measure various electrical properties, most commonly continuity, resistance, and voltage.

Your digital multimeter consists of five main parts.

1 **Display**

2 **"Face"**

3 **Selection Dial**

4 **Ports**

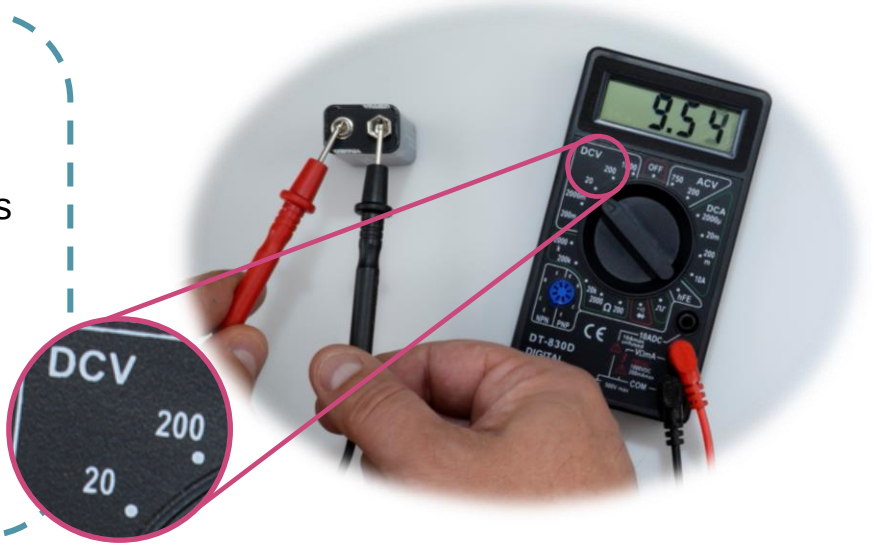
5 **Probes**

Testing Continuity

Continuity means two points have zero or close to zero resistance between them. The multimeter will make an audible beep if two points are “continuous”. If the connection is a broken electrical path or has resistance, the multimeter will not make a sound. This indicates no continuity.

Measuring DC Voltage

DCV stands for ***Direct Current Voltage*** and when the dial is positioned in this area, it allows the measurement of voltage drop across any component, such as a battery, resistor, or LED. To measure DC Voltage, place the leads on the two points to be tested. The voltage difference will be displayed on the multimeter in volts (V).



Measuring Resistance

The ***Ohm*** (Ω) setting on a multimeter is used to determine ***resistance***: the measure of a material's opposition to electrical current flow. To measure resistance on a multimeter, connect the leads of the multimeter across the two points where the resistance is to be measured. The multimeter then calculates the resistance and displays the result in ohms (Ω) on the screen.

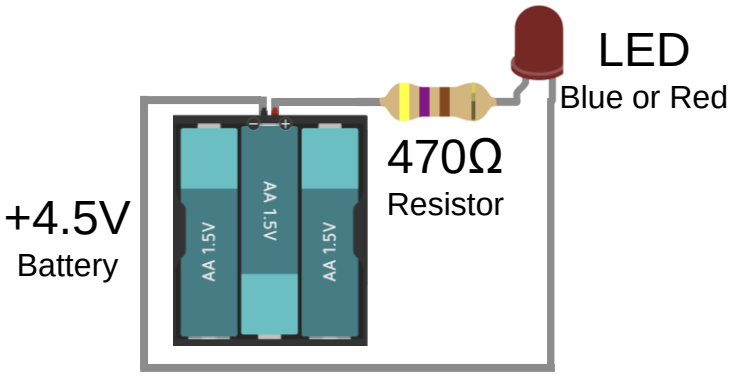
After completing Level 1 students will be able to:

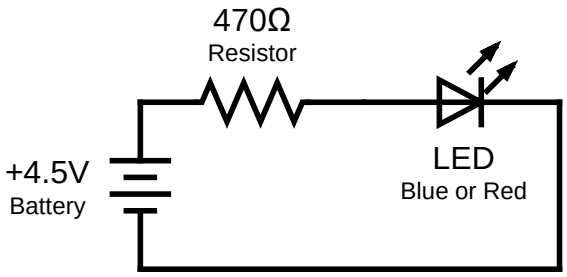
- ❑ Build a circuit with a variety of components.
- ❑ Identify the diagram symbols for a battery, LED, resistor, push button switch, and a potentiometer (POT).
- ❑ Recognize the parts of a breadboard and explain how it works.
- ❑ Correctly connect the plus (+) and minus (-) of a battery pack to a circuit using a breadboard.
- ❑ Visualize how to build the same circuit in multiple ways as long as components and battery pack are connected in the same order.

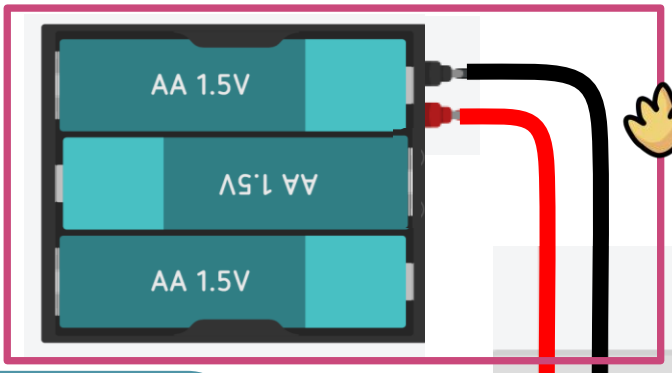
- ❑ Identify which leg of the LED is the anode (+) and which is the cathode (-) as well as which leg should be connected to power.
- ❑ Know how to test if an object is conductive (allows electricity to flow through it).
- ❑ Identify a resistor and how changing the resistance value affects the brightness of an LED circuit.

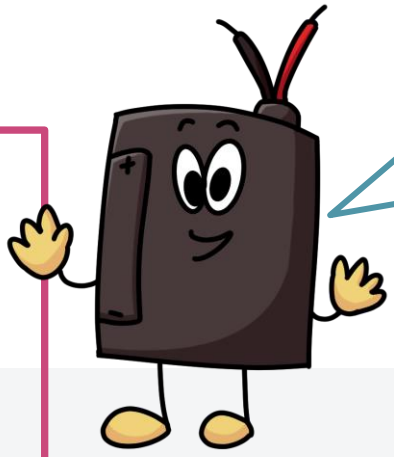
- ❑ Understand how a button switch controls the flow of electricity in a circuit.
- ❑ Combine simple circuits to build more complex circuits.

Turn the battery on to make the LED light up

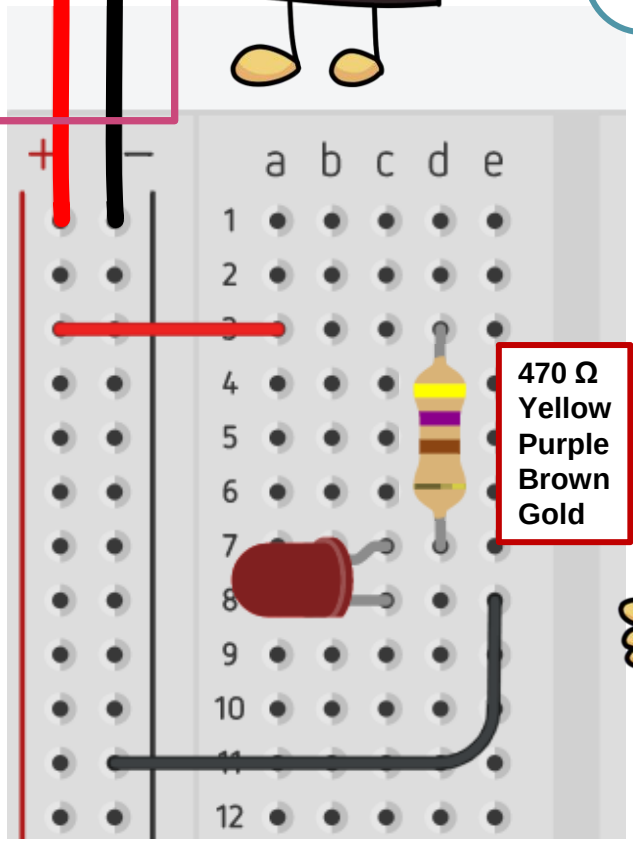






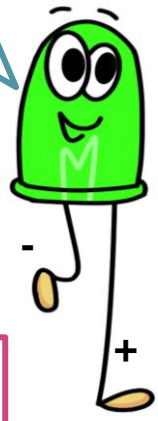


This is where the battery is usually connected. We will only show the red and black battery connections in future builds!



470 Ω
Yellow
Purple
Brown
Gold

If the LED does not light up, check if the LED is in backwards and that the battery is turned on!



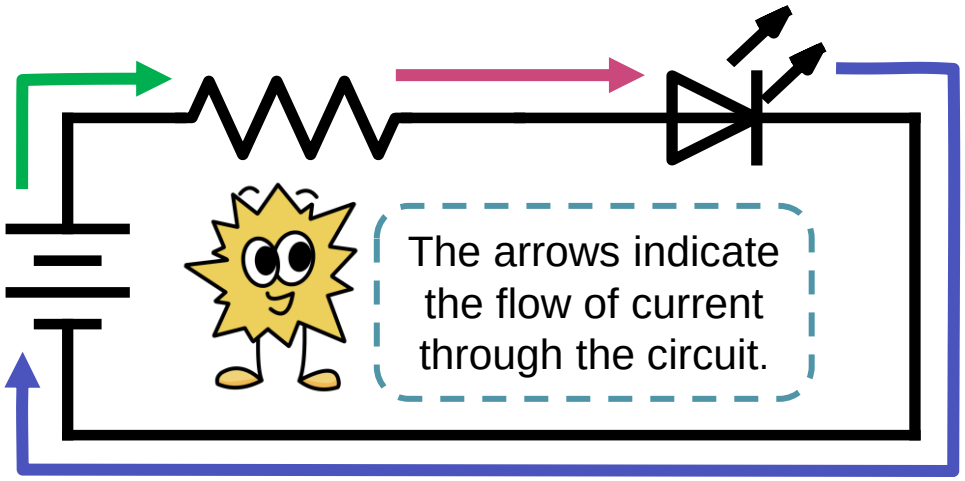
Make sure to use a resistor like me, or you could destroy the LED!

The Short Leg on the LED is called the “cathode” and it connects to ground or (-)

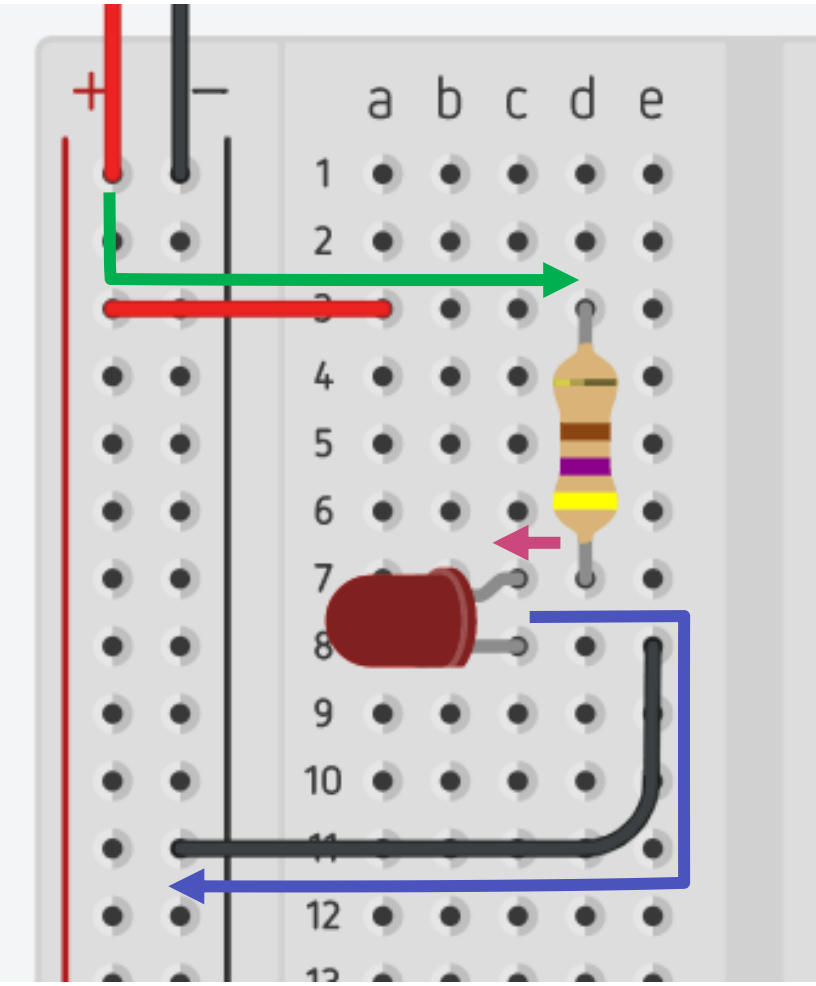
The Long Leg on the LED is called the “anode” and it connects to power or (+)

Try changing the value of the resistor to see what happens!

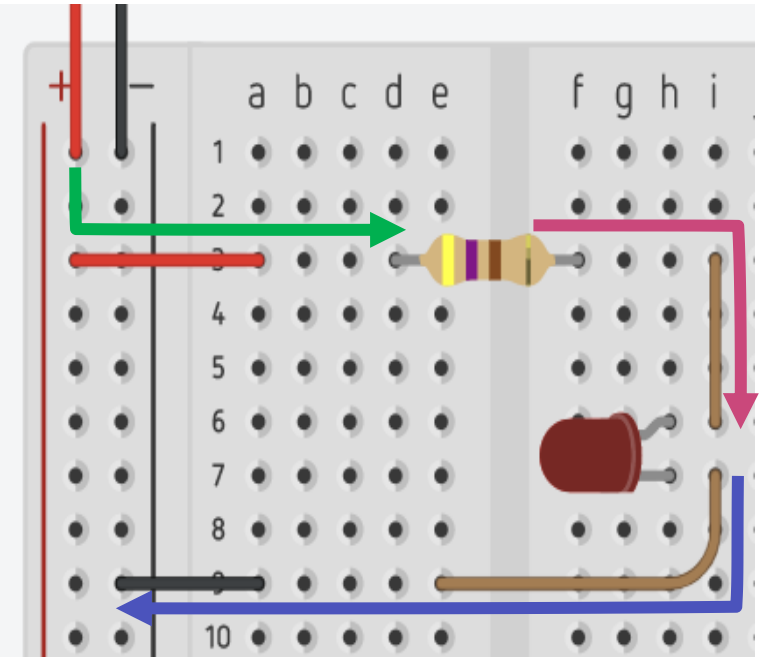
How Current Flows Through the Circuit



Play around with making up your own way to connect this circuit! You can use as many extra jumpers as you want. The resistor can go before or after the LED. And remember, the Anode (+) side of the LED has to be closer to the power side of the battery.



Both circuit drawings have the current flowing though the components in the same order even though the components are in different places on the breadboard.

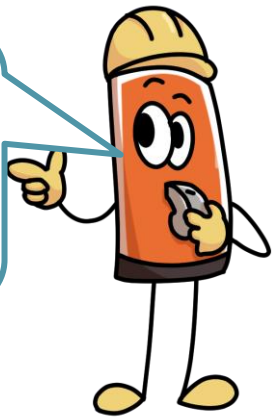


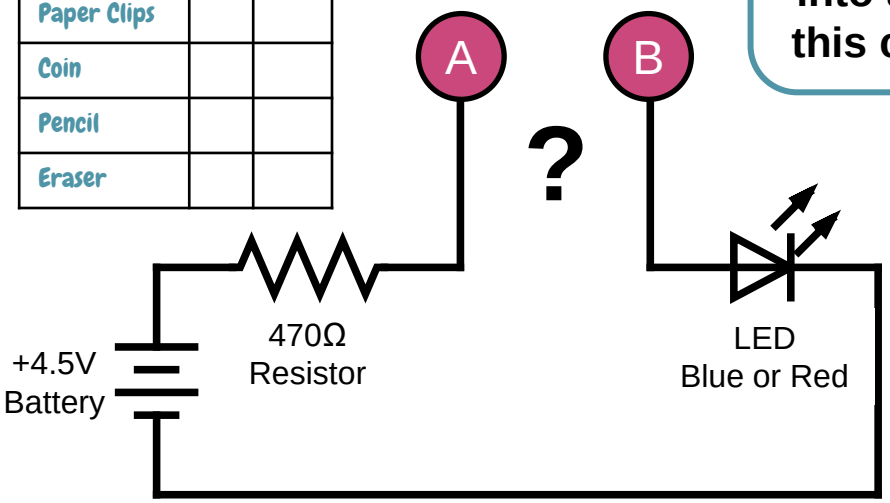
Touch the wire ends to different items to see if the LED lights up

OBJECTS TO TRY	Conductive	Non-Conductive
Paper Clips		
Coin		
Pencil		
Eraser		

Connect objects between points A and B for testing

WARNING!
Never plug anything into a wall socket as this could be deadly!

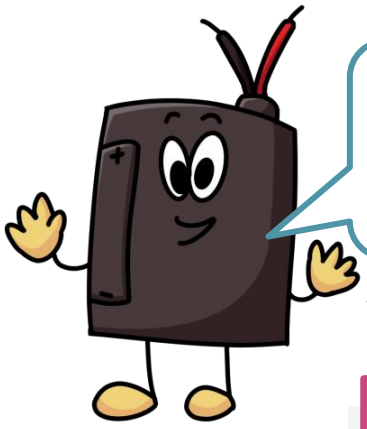




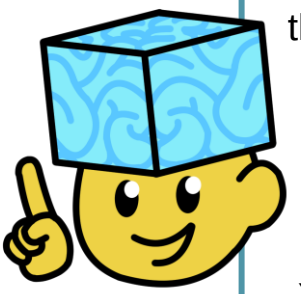
Try connecting different objects you have around the house between points A and B. If the LED lights up, the object is conductive!

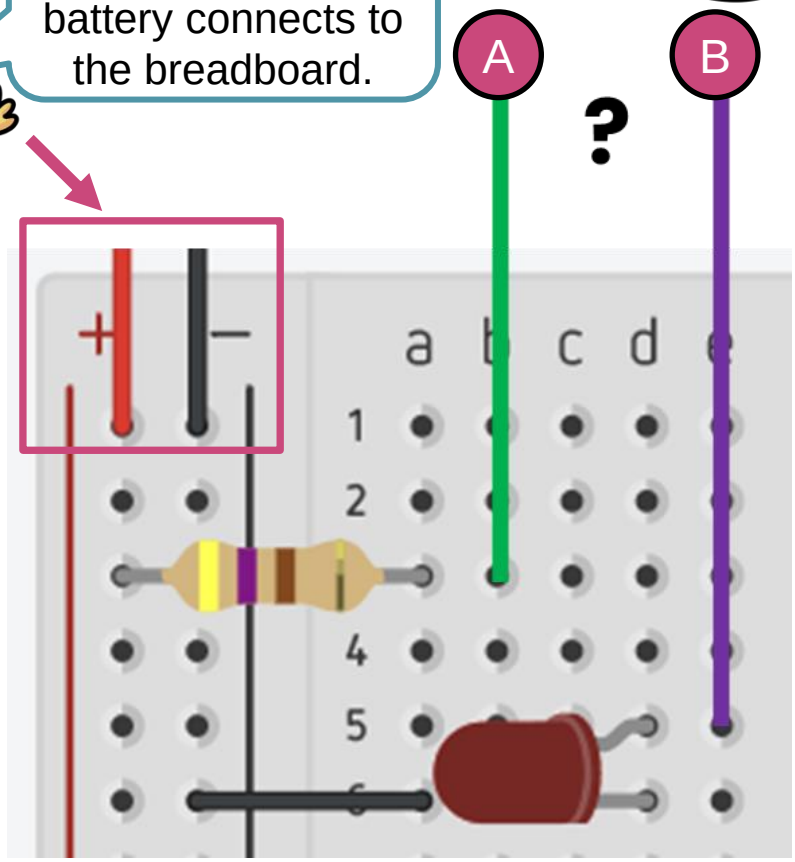
You might also try another resistor, jumper wire, or a diode. Be sure to try the diode both ways.

Create a data table to record which items light the LED.



Remember that this is where the battery connects to the breadboard.



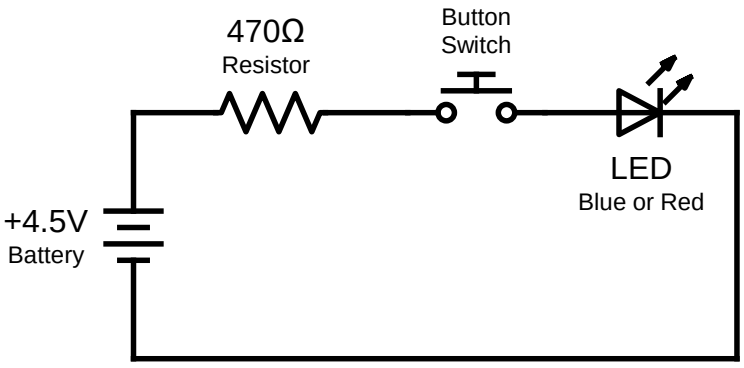


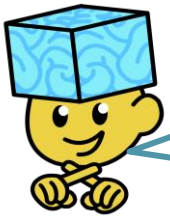
Pay attention to color bands on the side of the resistor to confirm you have the right resistor value.

LEDs light up only when current is flowing from the long pin (+) to the short pin (-)

Turn an LED on and off using a push button switch

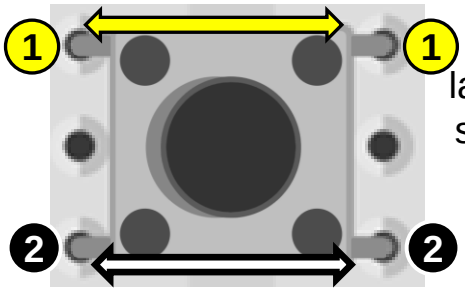
Remember, my long leg is called the anode (+) and my short leg is called the cathode (-)



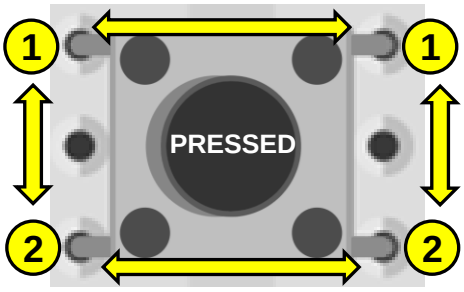


1 is not connected to 2

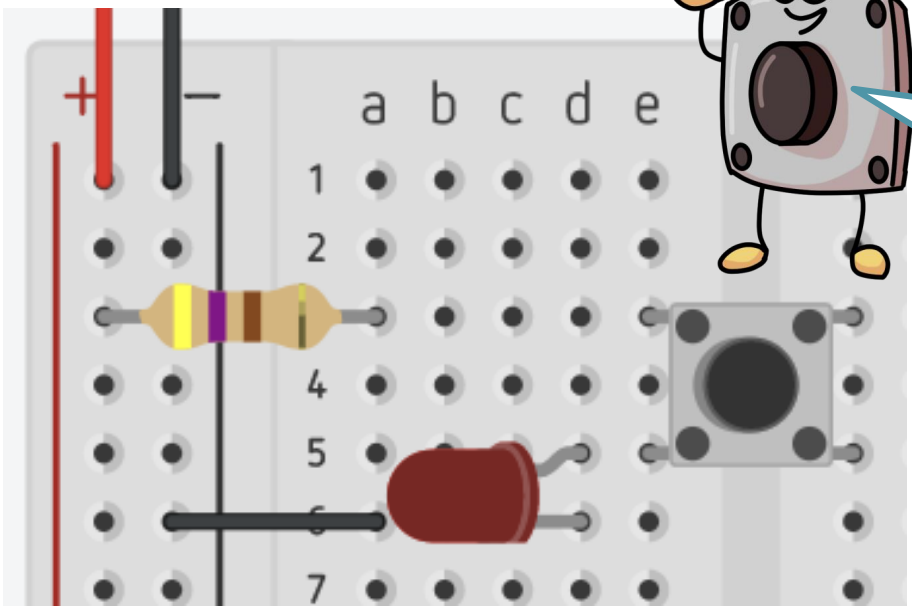
All 1 pins connect to all 2 pins



The pins labeled with the same numbers are **always** connected to each other.



When the button is pressed all pins are connected together!



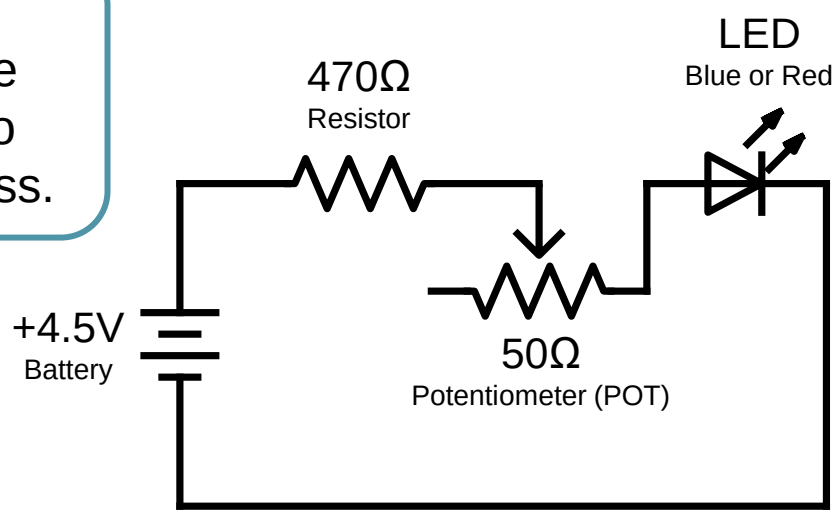
Check the orientation of the pushbutton switch to make sure connection is made between the same side pins.

What would happen if you change the order of the components?

Does it work?

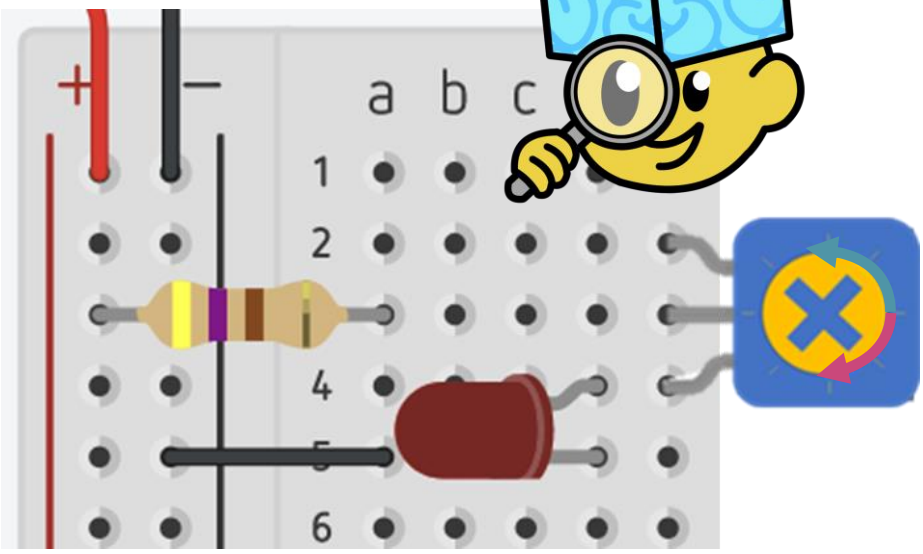
Use the potentiometer (POT) to adjust the brightness of LED

Use your Phillips head screwdriver to adjust the resistance of the POT to change the LED brightness.



In your kit you will find a Phillips screwdriver that has a plus-shaped end to adjust the POT.

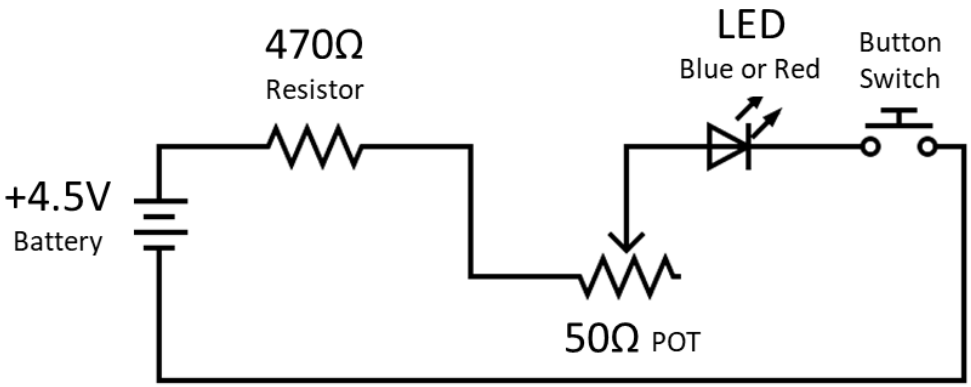
Make sure one of your connections is to the middle pin of the POT.



The POT is just like a resistor that lets you change the resistance value! They are sometimes called variable resistors!

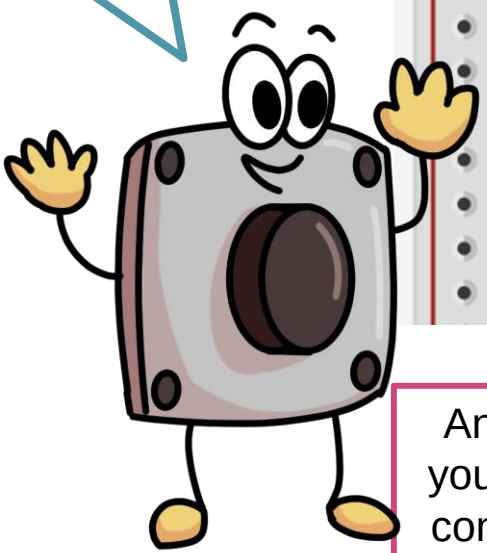
Turning the POT one direction will brighten LED. The other direction will dim the LED. The direction will depend on how you put the POT into the circuit.

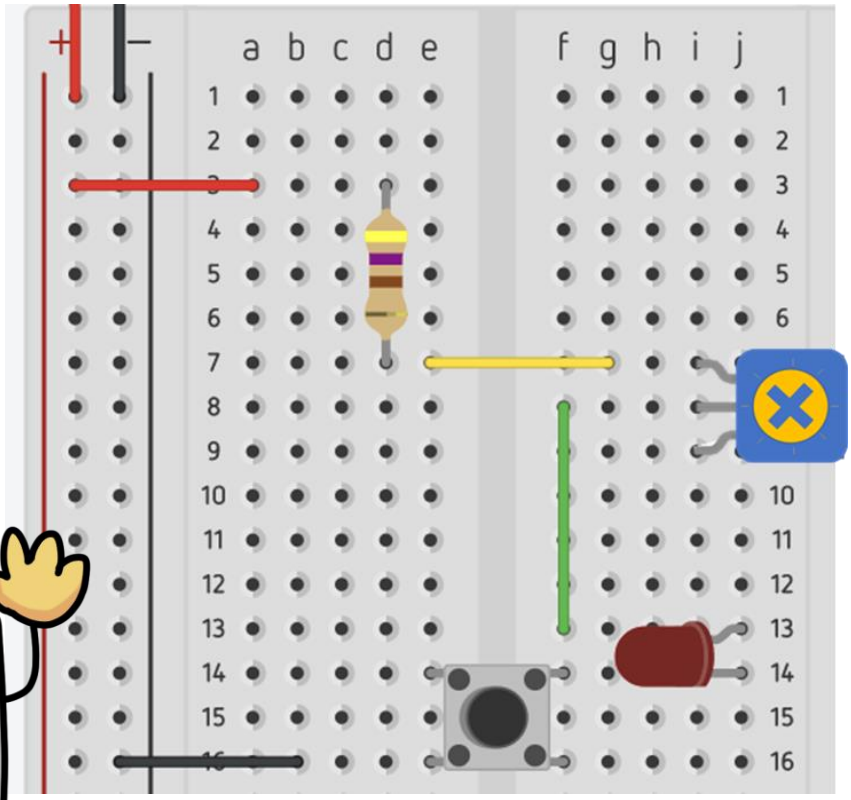
Light up LED when button switch is pressed and use the POT to adjust the brightness of LED



This circuit combines the previous two circuits. Simple circuits can be combined to create more complex circuits!

In this circuit, we are using the button switch to connect diagonally, instead of just on the same side.



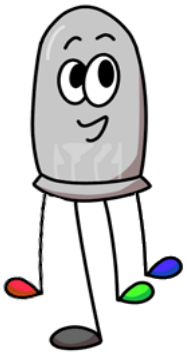


Notice that the long leg of the LED is connected to the middle leg of the POT.

Any color wires can be used to connect your circuits. Red wires are often used to connect to the power (+) and black wires to indicate ground (-). This makes it easier to see what is connected in a circuit.

After completing Level 2, students will be able to:

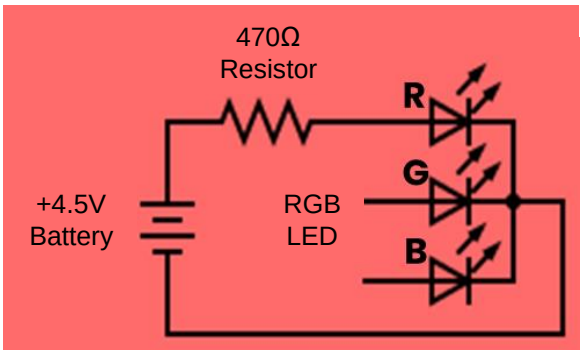
- ❑ Identify the diagram symbols for an RGB LED, a transistor, a photoresistor, and a buzzer.
- ❑ Identify the legs of a common cathode RGB LED, specifically the red anode (+), green anode (+), blue anode (+), and the common cathode (-).
- ❑ Specify which legs of the RGB LED should be connected to power to light up each color.

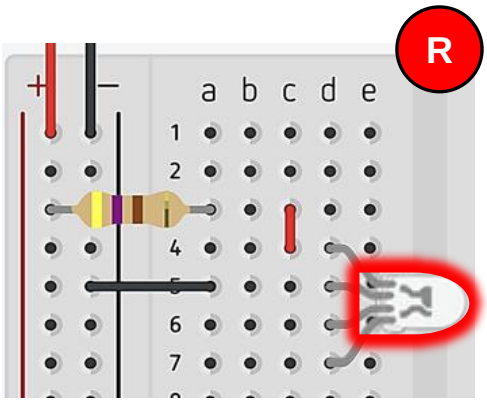


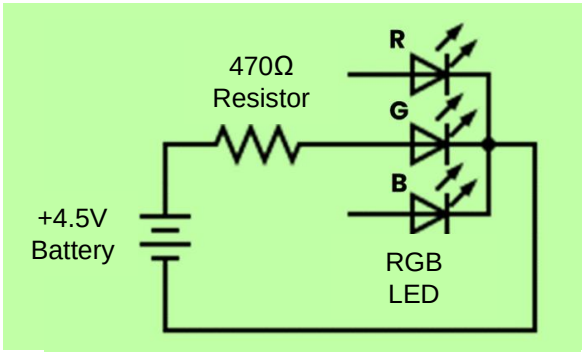
- ❑ Blend red, green, and blue colors from the RGB LED using POTs to create different colors.
- ❑ Recognize different ways to connect a button switch in a circuit so it works.
- ❑ Explain what a transistor is and how it works.
- ❑ Understand how the amount of light changes the resistance value in a photoresistors.
- ❑ Explain how to use a buzzer.

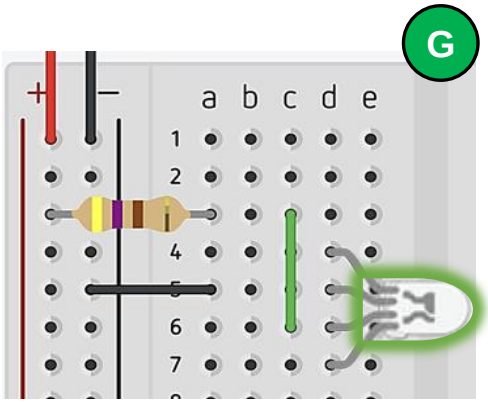
Connect different legs of the RGB LED to make the colors red, green or blue

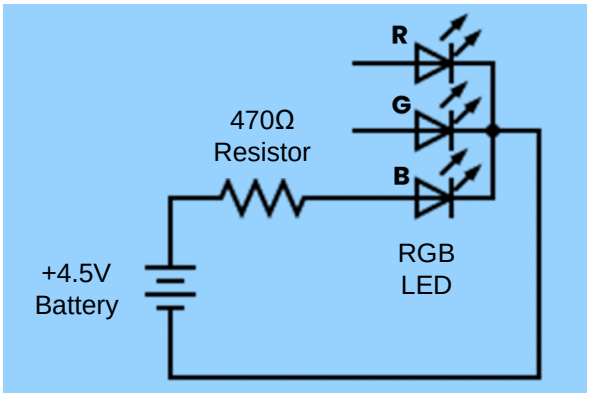
Each of the circuits R, G and B are the same except for which leg of the RGB LED is connected to the resistor.

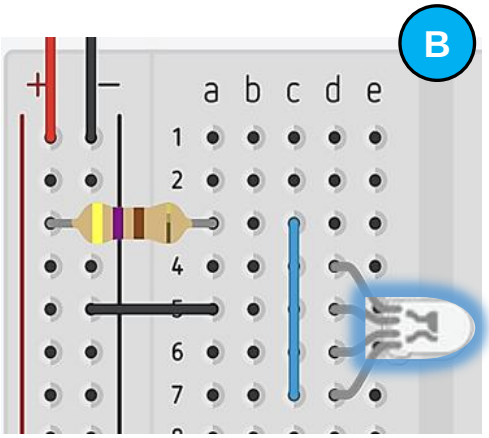


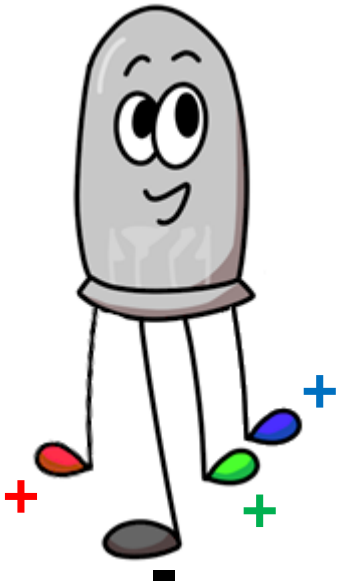










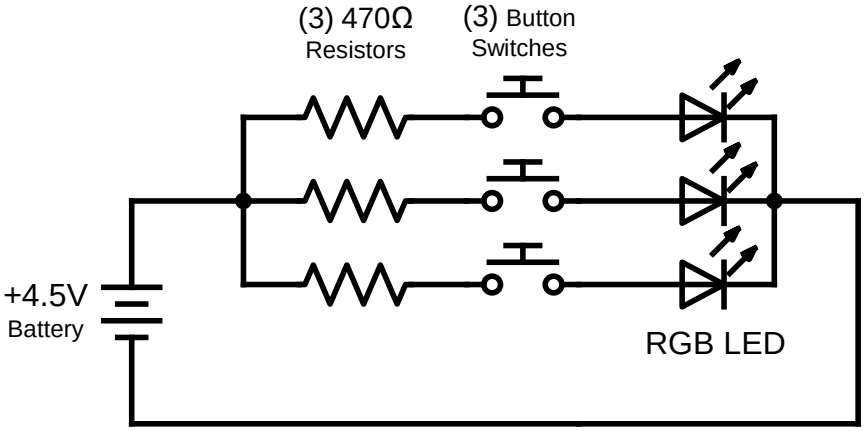


The RGB LEDs provided in the kit are called common cathode (-) LEDs.

This means the longest leg of the RGB LED should be connected to ground (-).

The Red pin is by itself to one side of the ground pin, and Blue and Green pins are together on the other side of the longest pin.

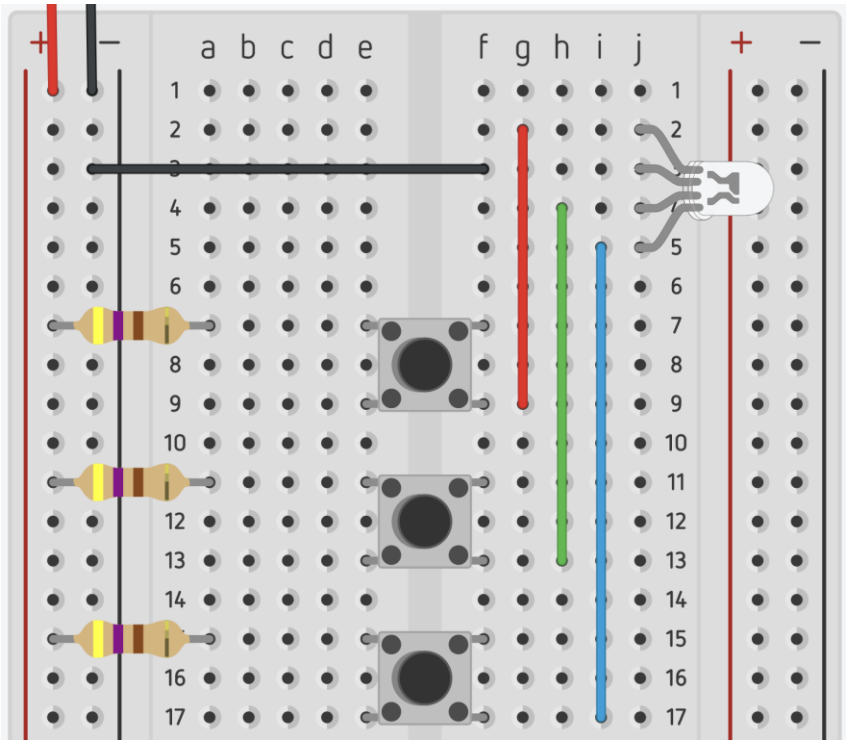
Push the button switches one at a time to make the RGB LED light up red, green and/or blue



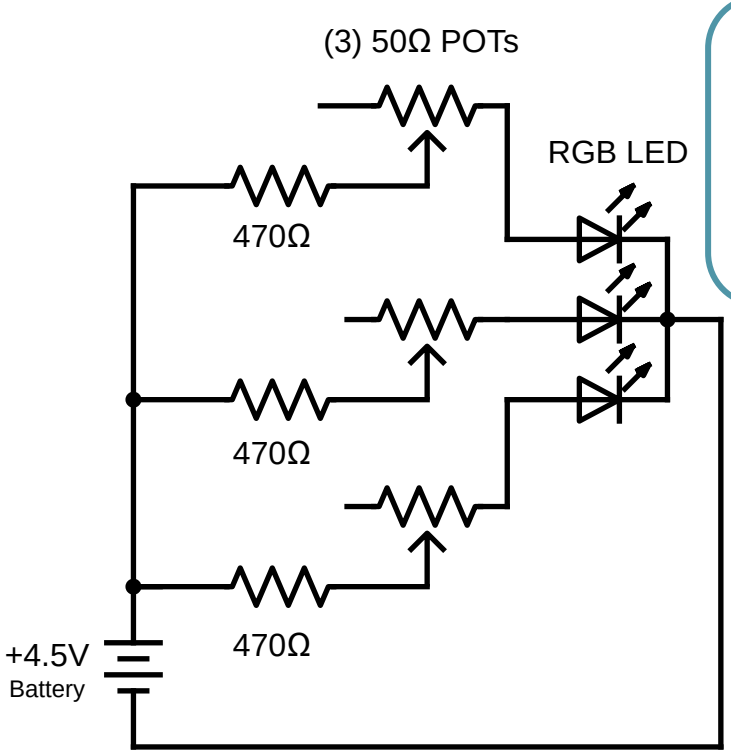
RGB LEDs can have power (+) attached to multiple anode pins (red, green, blue) at the same time.

This circuit combines the three simple RGB LED circuits from before into one circuit. The button switches turn on and off the flow of electricity to each of the different legs of the RGB LED.

Check the orientation of the pushbutton switches. It is OK to connect the pins that are diagonal from one another or on the same side, but not across from each other.



Adjust the three POTs connected to the RGB LED to make new colors

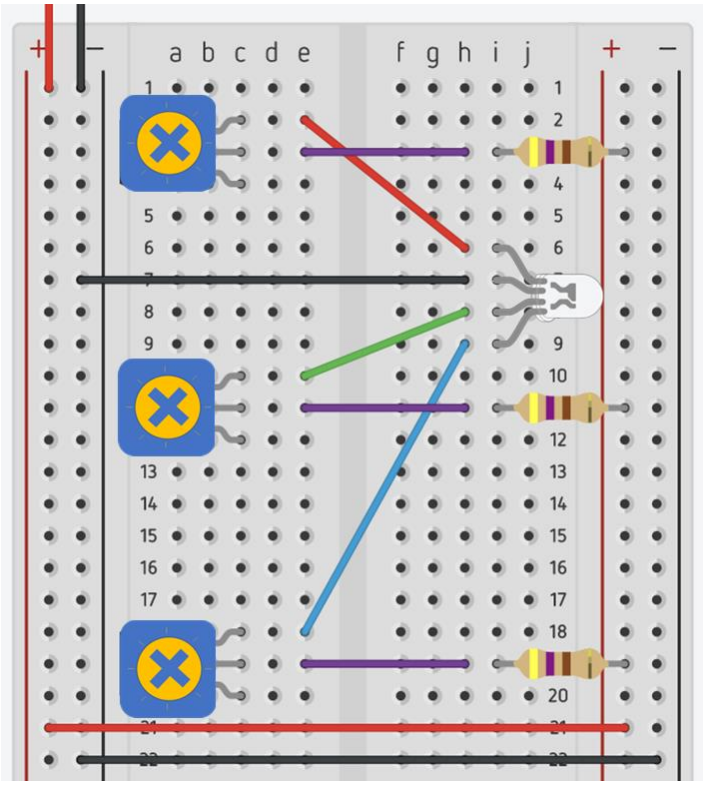


How many different colors can you get?

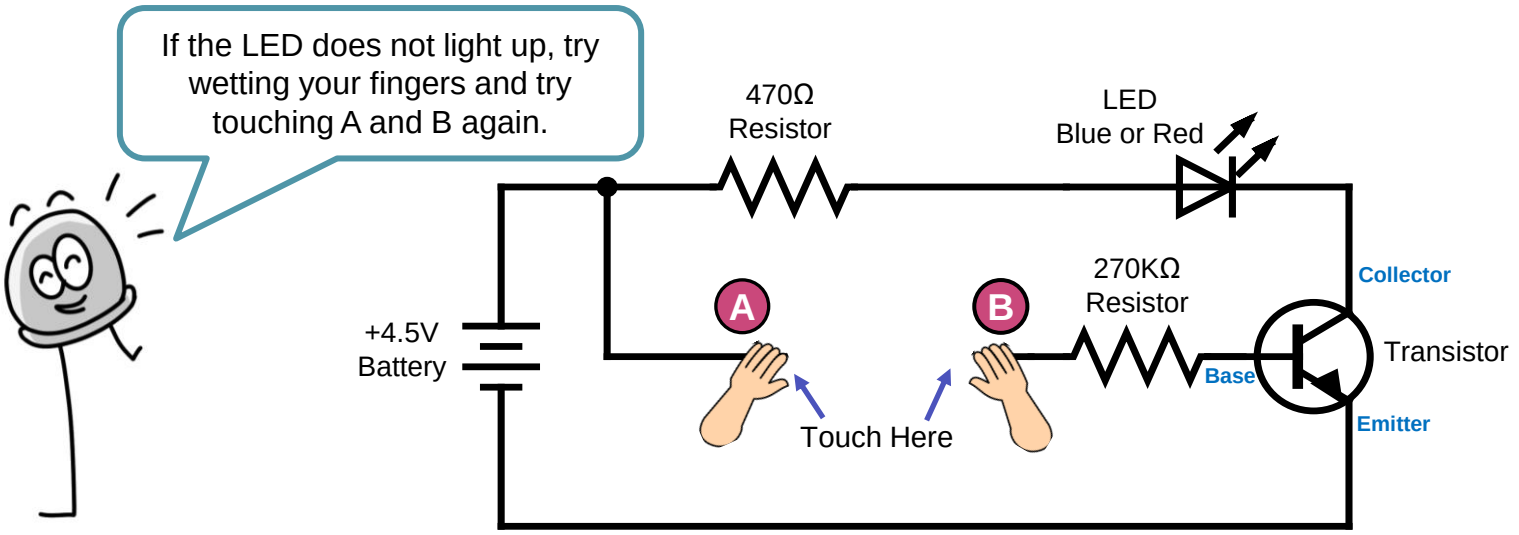
Adjust the resistance of each POT to change the individual red, green, and blue colors of the RGB LED.

What colors can you make?

- ❑ Purple
- ❑ Yellow
- ❑ Orange
- ❑ Magenta
- ❑ Cyan
- ❑ _____?



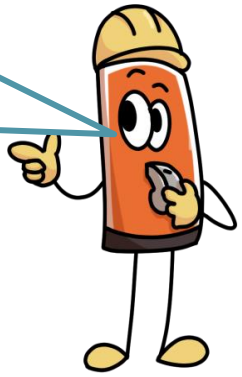
Touch each of the two wires to light the LED

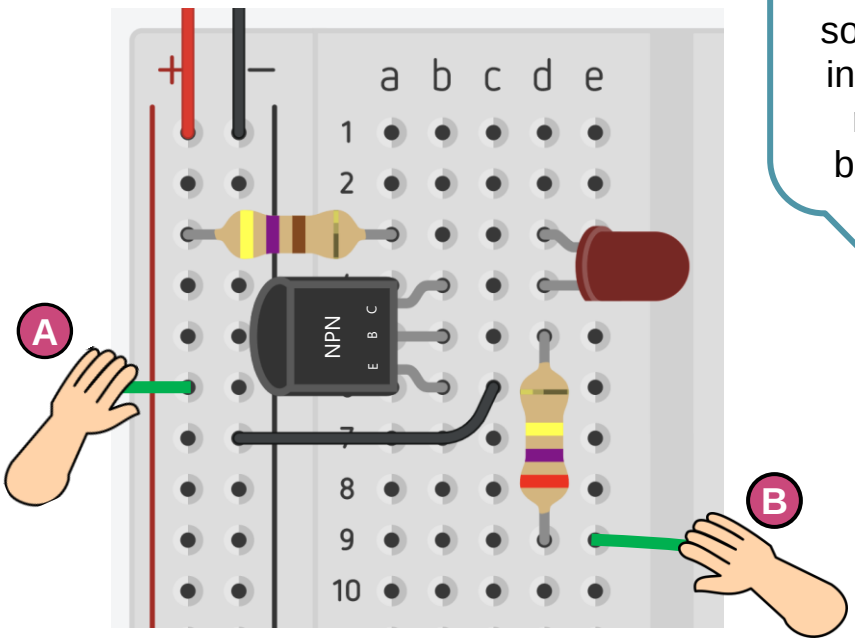


Touching the circuit at points (A) and (B) with your fingers will send a very small amount of current to the base of the transistor. The more current that the base receives, the more current will flow through the transistor.

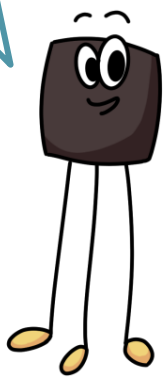
For our circuit, touching the ends of the wires with your fingers makes the transistor act like a switch to light up the LED part of the circuit. If you wet your fingers, the LED will shine brighter.

CAUTION!
Do not touch wire (A) to wire (B) because it could overload the transistor and cause it to burn out!



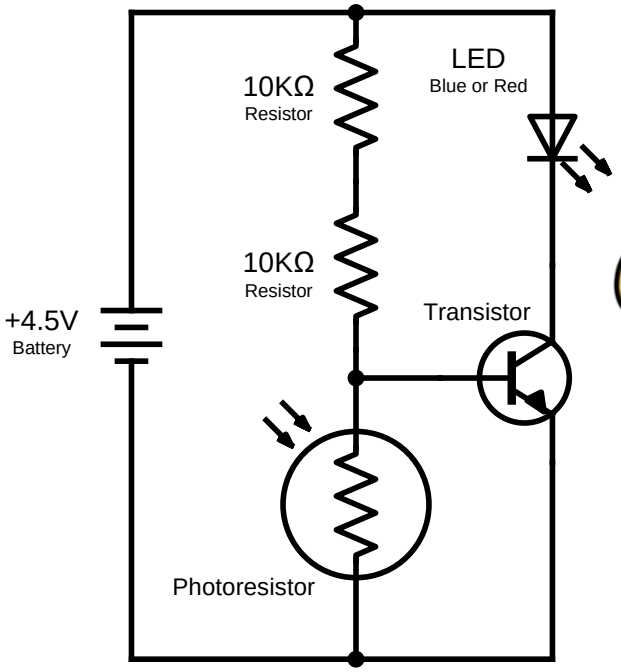


Be sure to plug the transistor in so each pin is in a separate row of the breadboard.



Touching the circuit at points (A) and (B) with your fingers sends a little bit of current through the human body triggering the transistor to open.

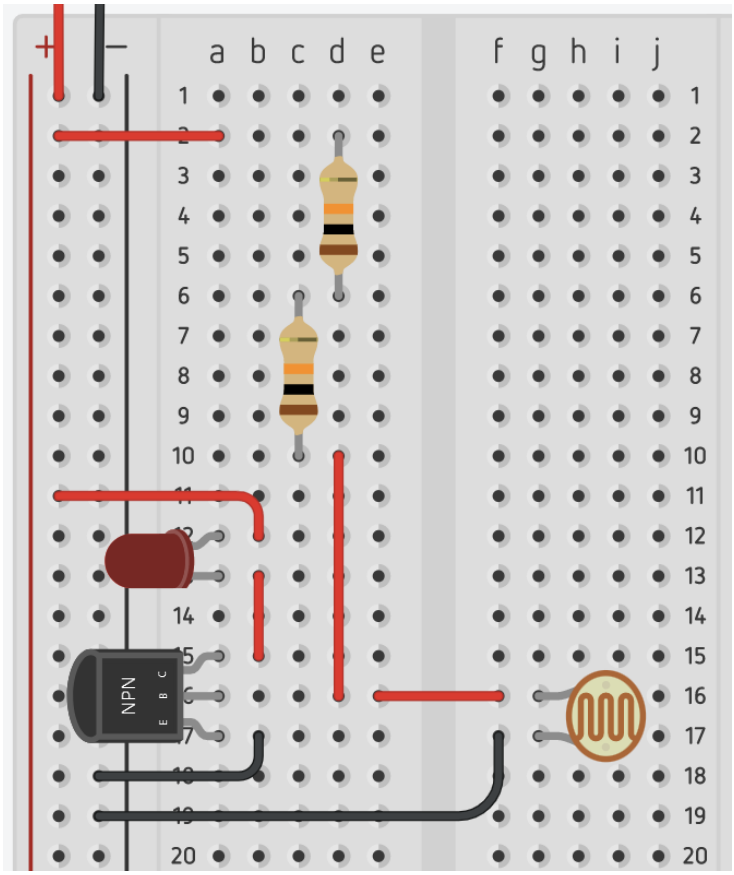
When the lights go out, the LED turns on



The two 10KΩ resistors in this circuit are in series (lined up), which means together they act the same as a 20KΩ resistor.

The amount of light present changes the photoresistor's resistance! Our photoresistor has more resistance with no light.

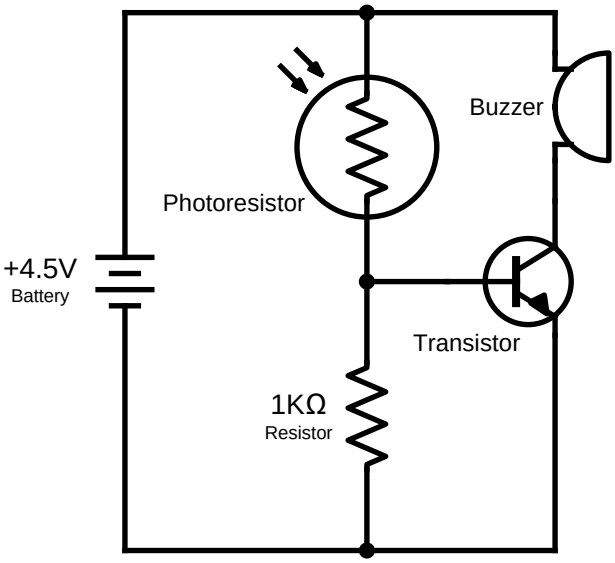
With the flat end of the transistor facing you, the emitter is to the left and the collector is to the right.



If you have a nightlight at your home, you will find a similar circuit to this one inside it!

Cover the Photoresistor with your finger to light up the LED!

When the lights go on, the buzzer turns on

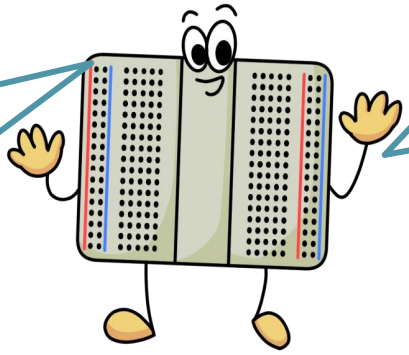


Double check the colors on your resistor to make sure you have the right value.

1KΩ Resistor
Brown
Black
Red
Gold

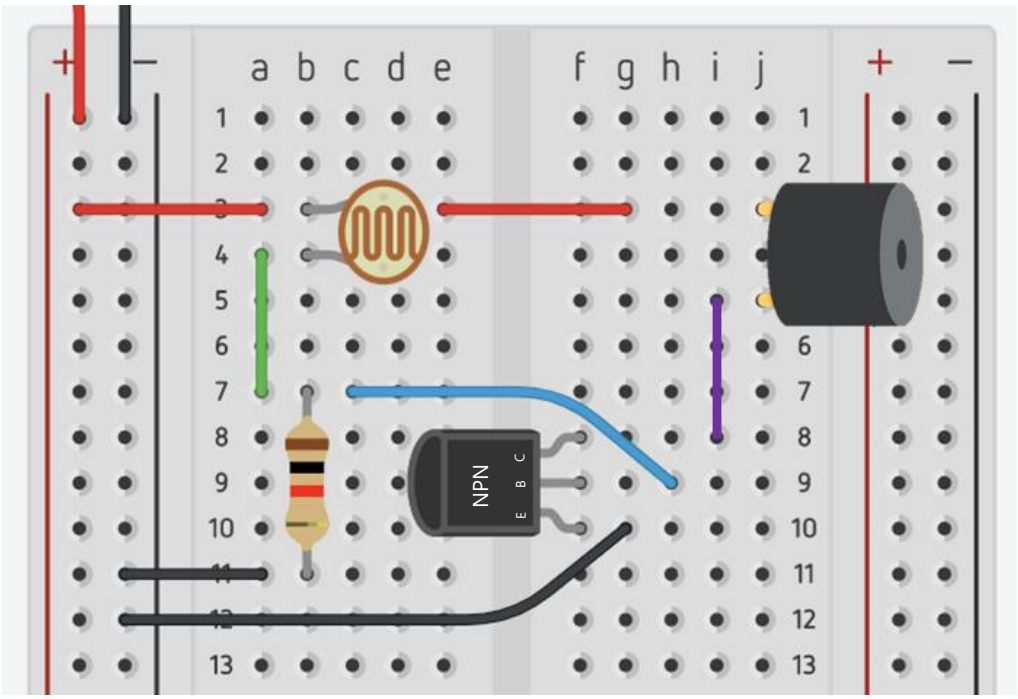
Make sure the transistor is connected the right way.

If you want to make the circuit *less sensitive* to light, replace the resistor with a *lower* resistance value.



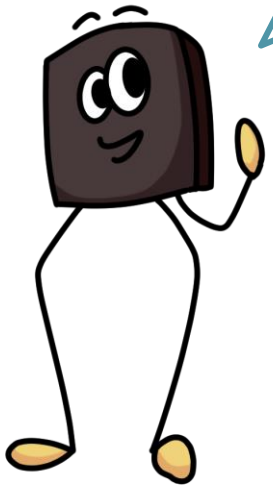
If you want to make the circuit *more sensitive* to light, replace the resistor with a *higher* resistance value.

Buzzer pins have (+) and (-) pins.

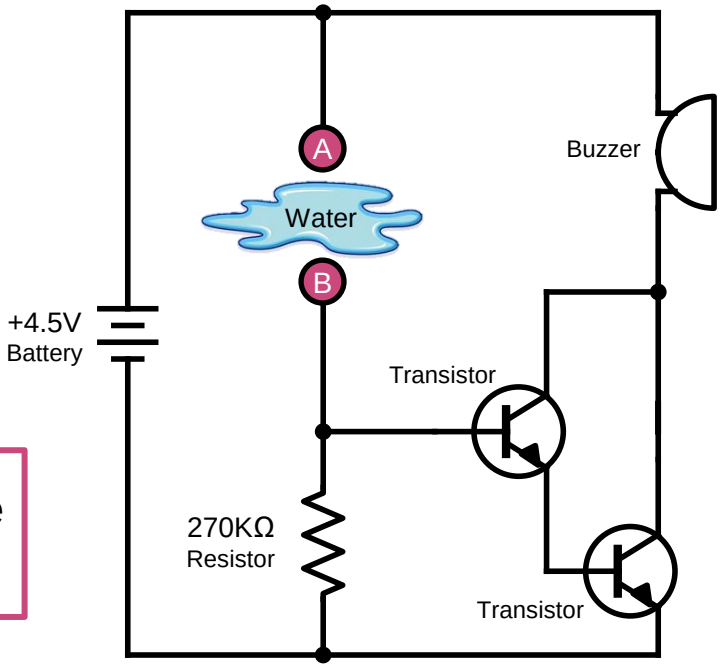


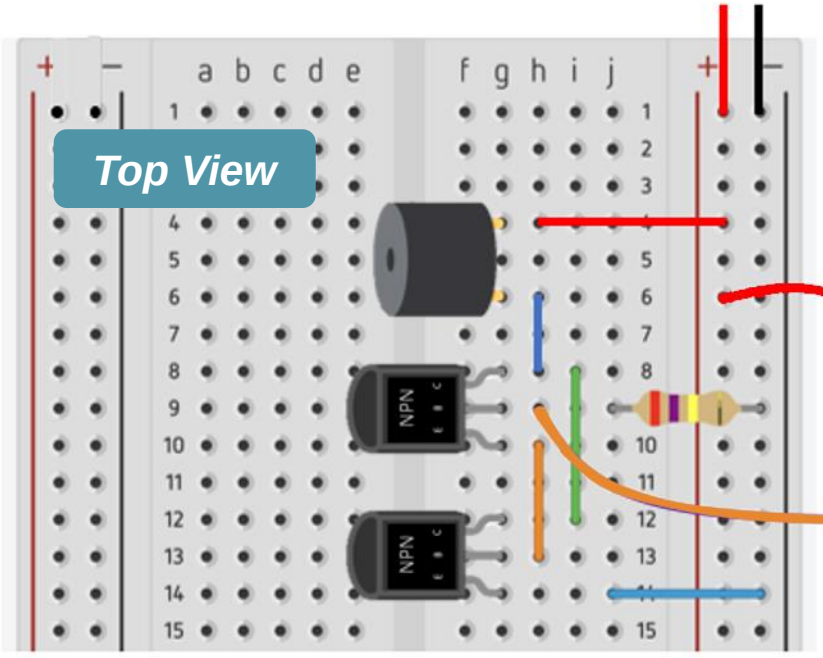
This circuit detects water leaks

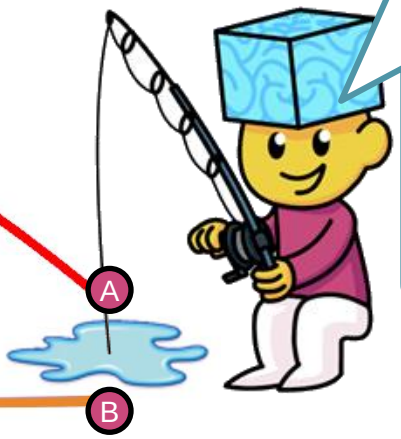
Make sure that the transistors are connected correctly to each other and to the other components.



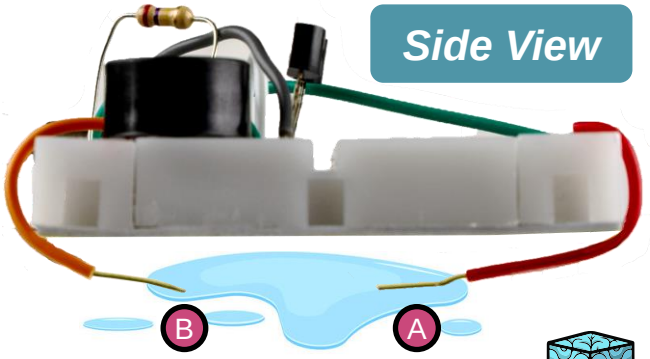
Buzzers produce only one tone.





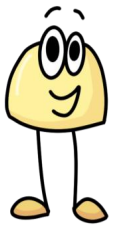


How much water does it take to sound the alarm?



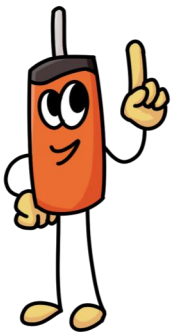
If you build it like this, with the two leads mounted under the breadboard, it can be used under a sink as a leak detector!

After completing Level 3, students will be able to:



- ❑ Identify the diagram symbols for capacitor, speaker, diode, 555 Timer, 4017 Decade Counter, 4511 BCD-to-7 Segment Decoder, and 7 Segment Display.
- ❑ Understand how to find pin 1 on an integrated circuit (IC) by locating the notch or the dot on the top of the chip.
- ❑ Find any pin number on any chip.
- ❑ Connect chips on the breadboard to ensure all pins are plugged into their own rows (are isolated).
- ❑ Differentiate between schematic diagrams and pictures of chips/ICs.

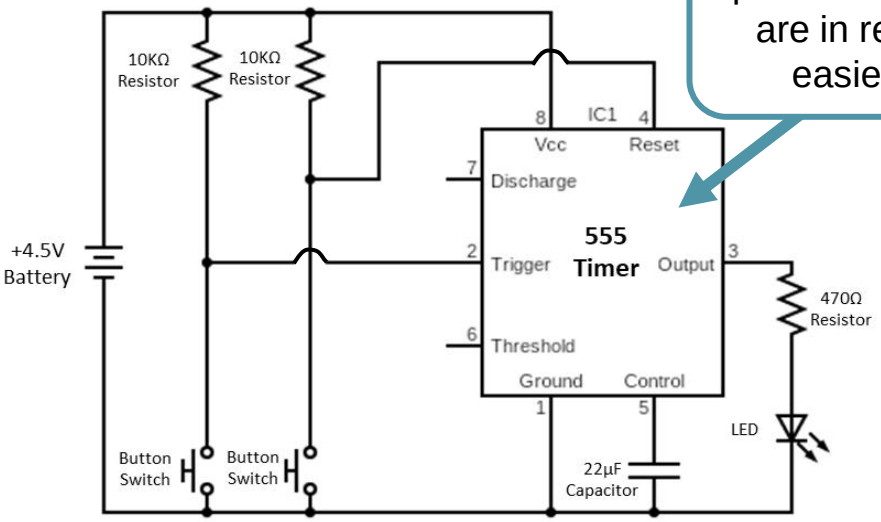
- ❑ Tell the difference between the two similar looking capacitors in the kit.
- ❑ Describe the basic functions of the following ICs:
  - ❑ 555 Timer
  - ❑ 4017 Decade Counter
  - ❑ 4511 BCD to 7 Segment Display
- ❑ Explain the differences between a speaker and buzzer.

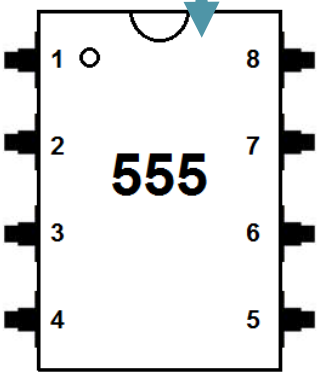


- ❑ Flash an LED using a 555 Timer circuit.
- ❑ Utilize a 4017 chip to turn on and off 10 LEDs.
- ❑ Turn 4-bit inputs into decimal output (0-9 digits on display) using a 4511 chip.

One switch triggers the LED to light up and the second switch triggers the LED to turn off

The 555 Timer on the schematic has the pin numbers in a different order than they are in reality. This was done to make it easier to draw the circuit diagram.

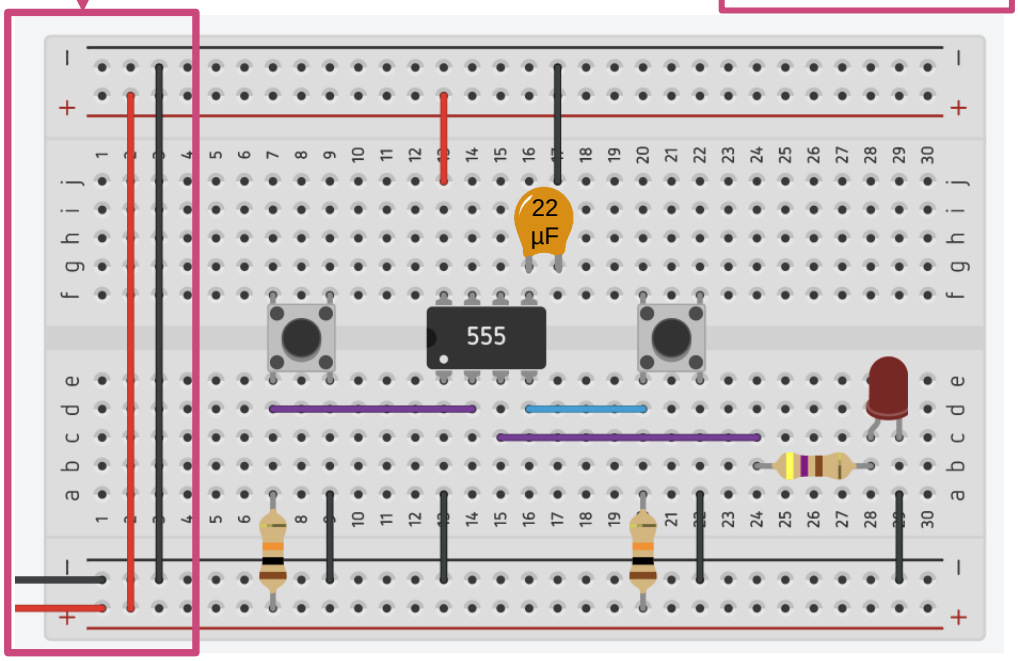




The #1 pin on the 555 timer is always next to the dot on the chip and to the left of the notch.

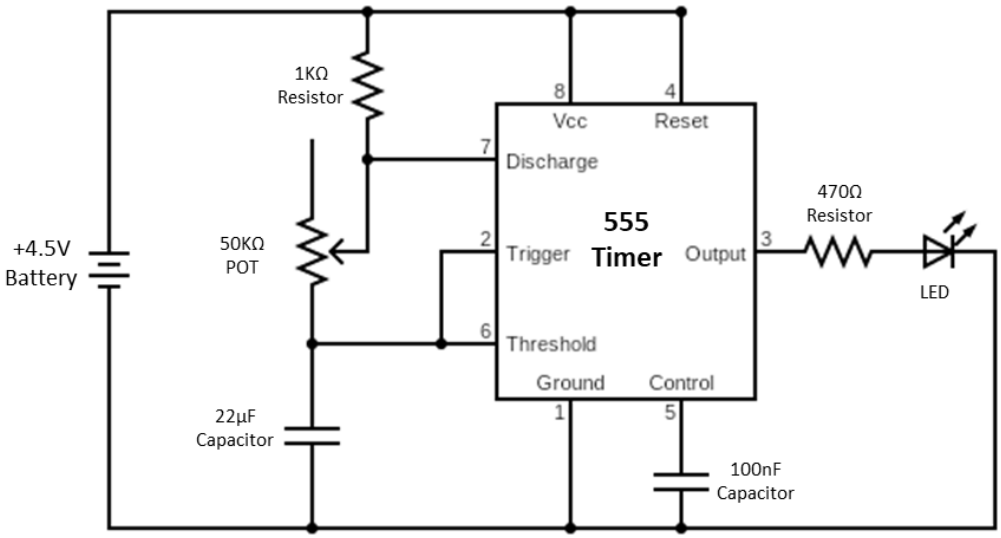
The 555 Timer should be inserted across the center divider of the breadboard to avoid connecting the pins across from one another on the chip.

In this circuit, the power rails on either side of the breadboard are connected with red and black jumper wires.

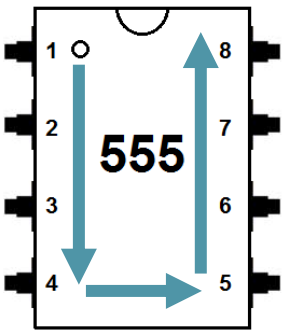


Check the wiring and orientation of the 555 Timer on the breadboard.

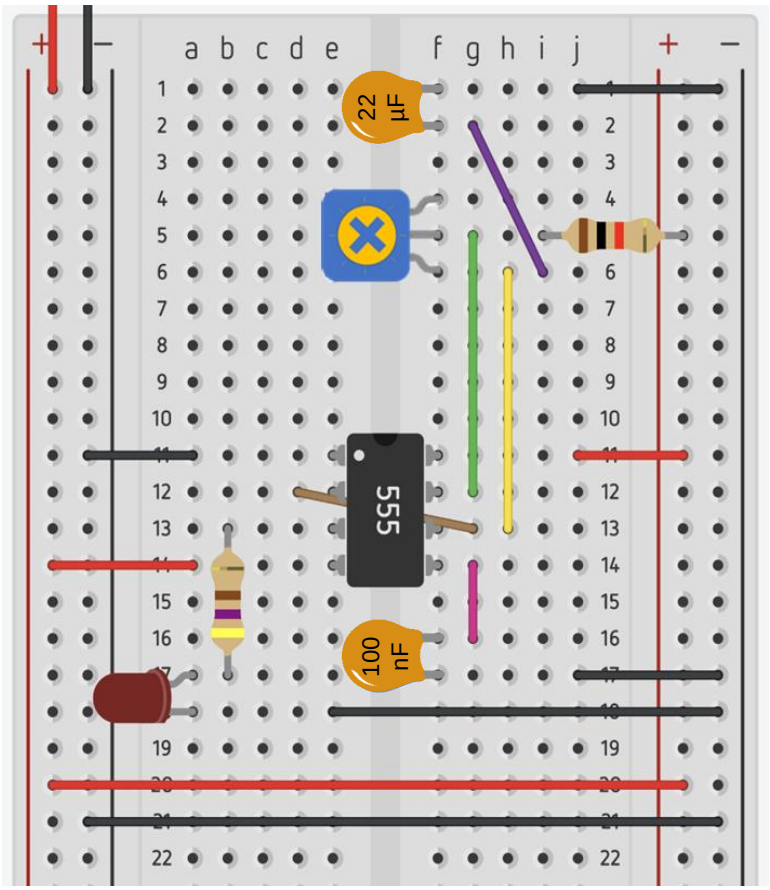
Control how quickly the LED blinks by adjusting the Potentiometer



The notch on the chip identifies the top of the chip to help you find pin 1.

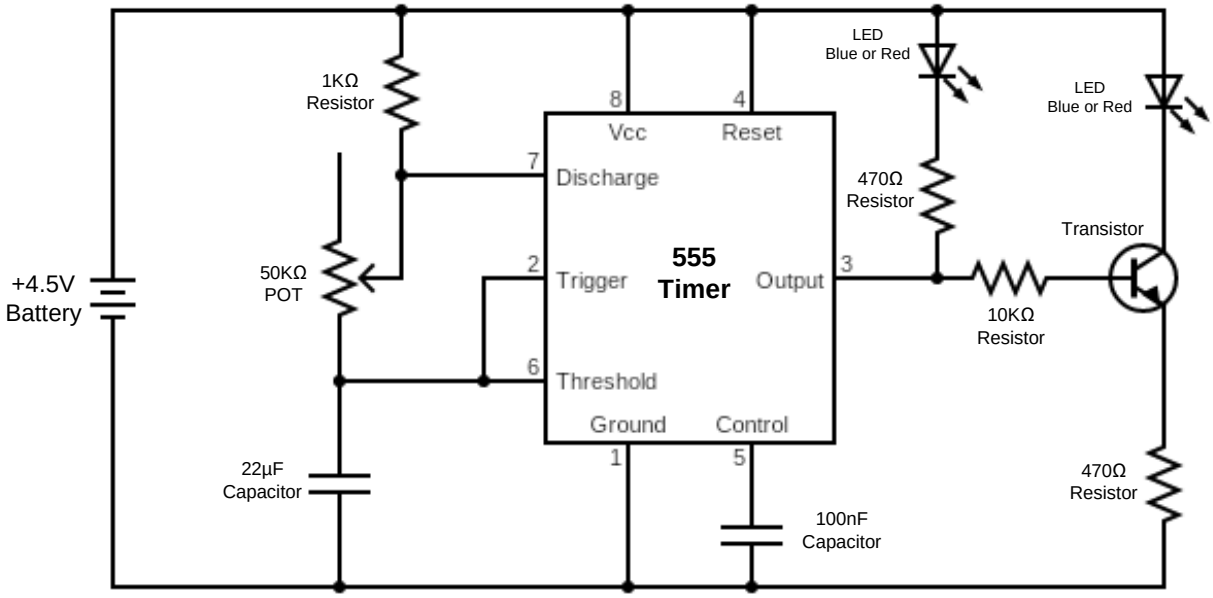


The pins are numerically arranged counterclockwise from the top left pin.



The 555 Timer puts out pulses that blink the LED.
The POT controls the frequency of the pulses making the LED blink faster or slower.

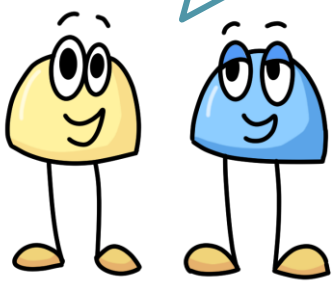
Two LEDs take turns blinking one at a time



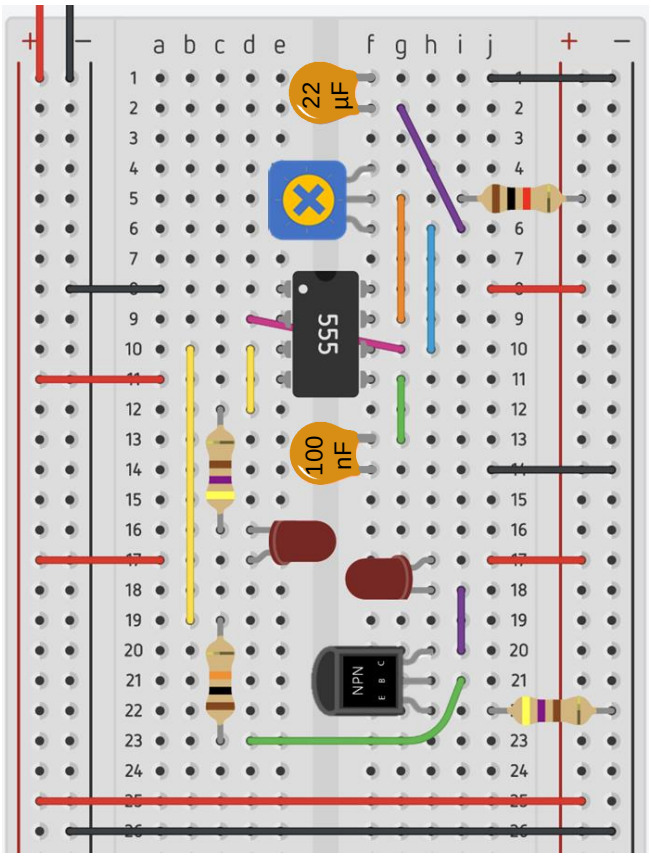
This circuit is almost the same as the blinking LED circuit but with a few additional components.

The values printed on each capacitor in the kit are **104** and **226.**

104 = 100nF
226 = 22µF

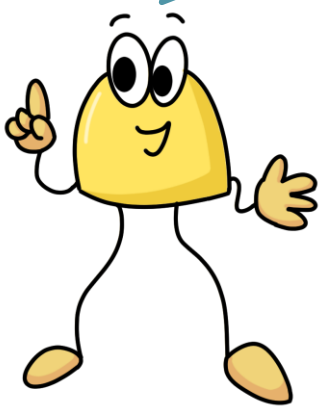


Pay attention to the orientation of components and how they get connected to other components.

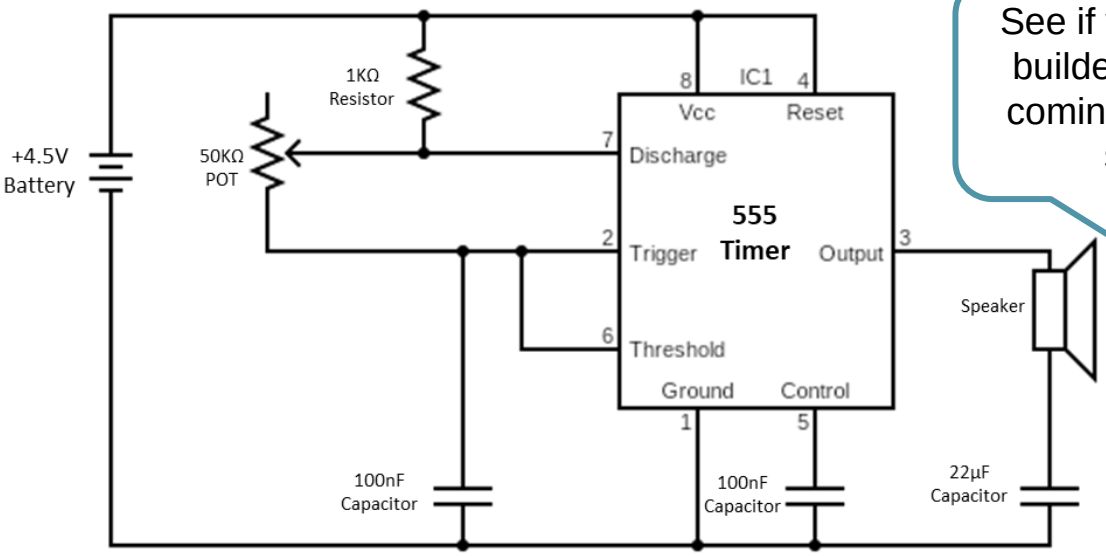


In our kit we have two different capacitor values, but they look almost the same.

Double check the printing on each capacitor to check its value!

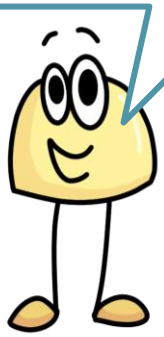


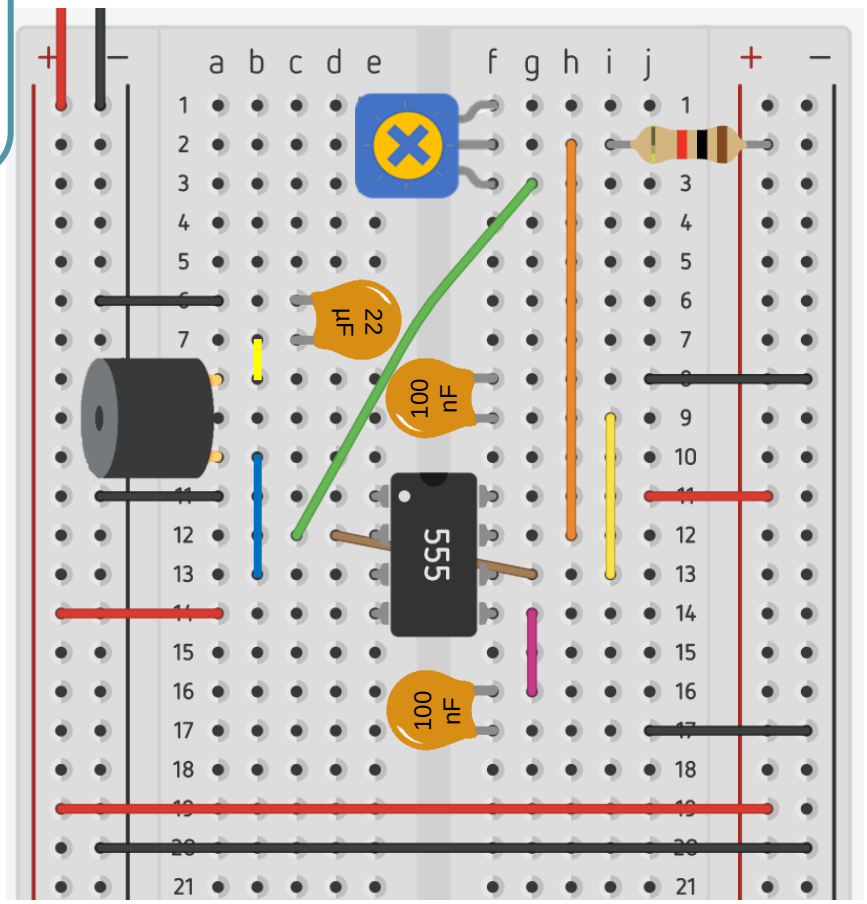
The Potentiometer controls the tone of the sound coming out of the speaker



See if you and another circuit builder can tune the sounds coming out of the speaker to sound the same!

These capacitors do not have (-) or (+) pins, but some capacitors do have polarity!

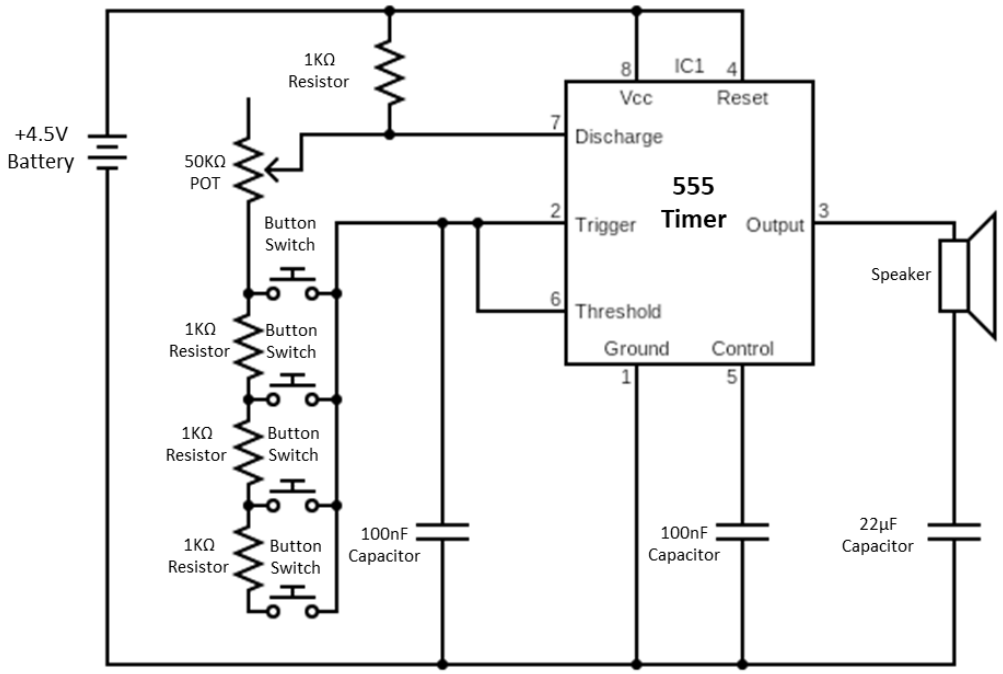




The 555 Timer puts out a signal that can be varied by the POT. This changes the sound tone coming from the speaker.

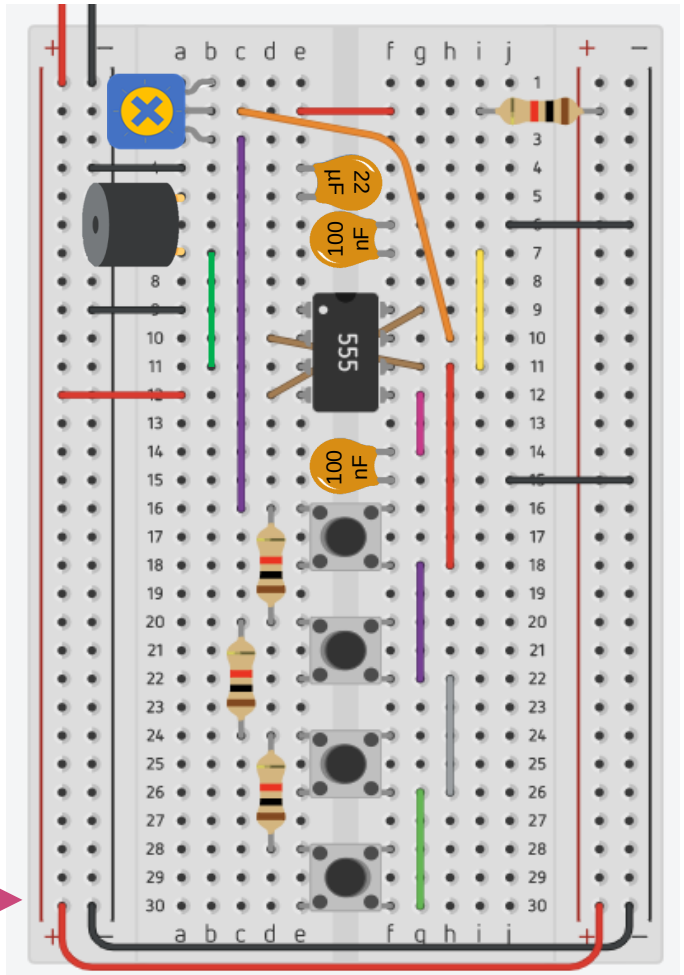
Speakers can make a wide variety of tones and do not have (-) or (+) pins.

Each push button switch makes its own note



This is the same circuit as the ***Variable Tone Generator Circuit*** you built before with the addition of button switches.

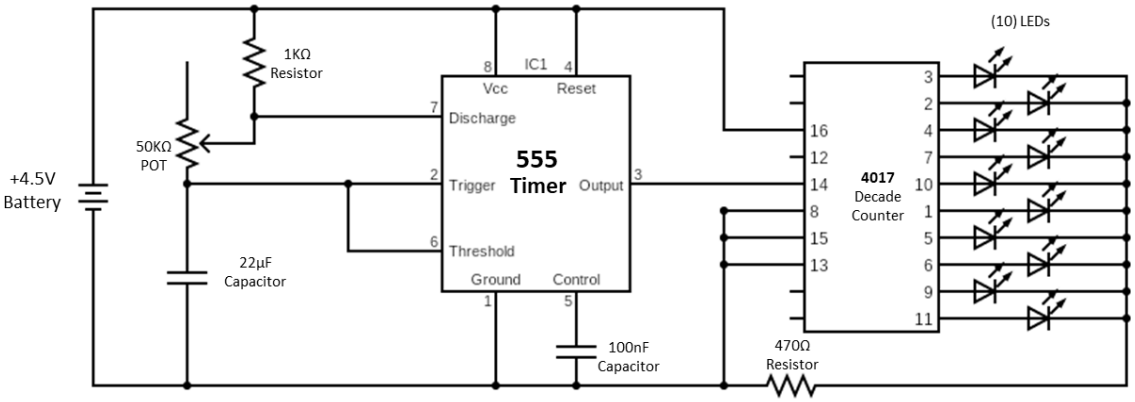
Can you create a song with your musical instrument circuit?



Notice that both power rails are connected.

Ten LEDs will light up one right after each other and then repeat from the beginning

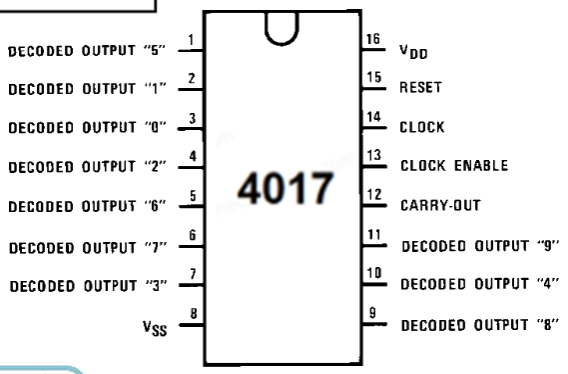
Remember!
The schematics (line drawings) of the 555 and 4017 chips do not have the pin numbers in the same order as physical chips.



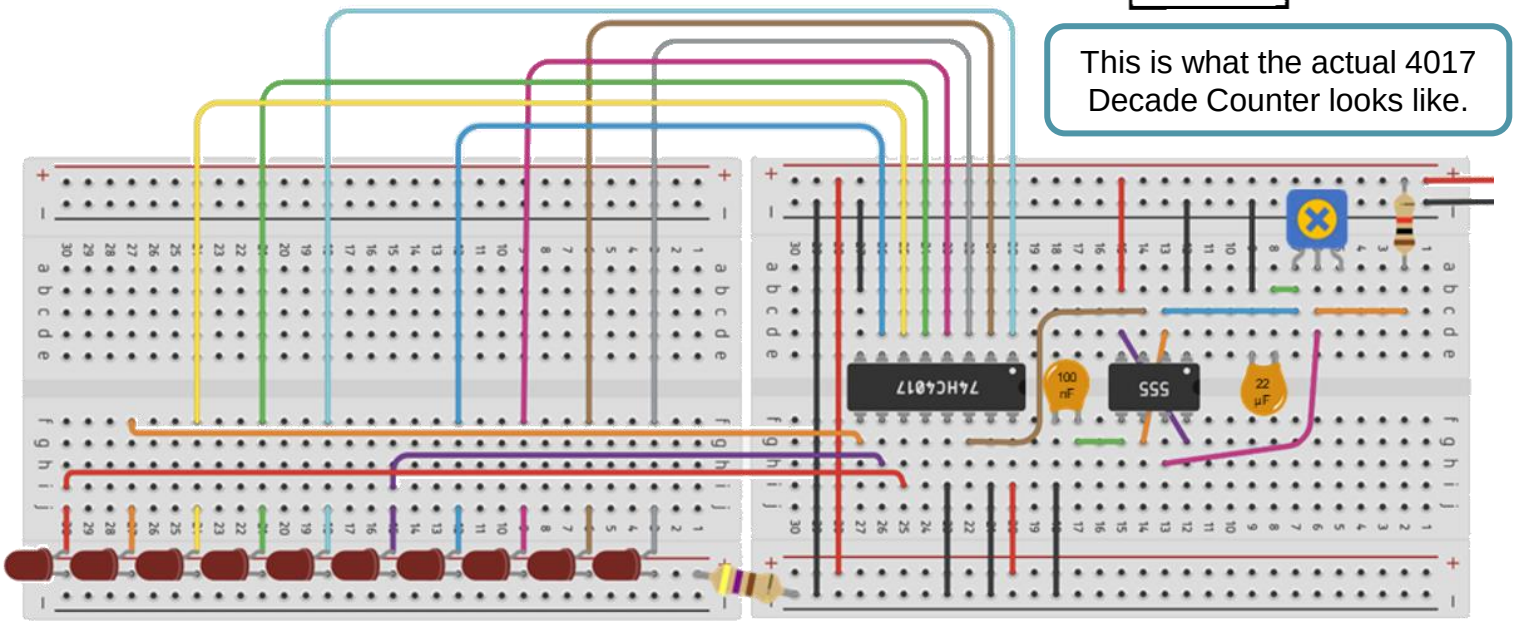
The 555 sends out pulses at a speed determined by the POT. The 4017 counts pulses, turning on the "0" to "9" pins that light up the LEDs in order.

We put two breadboards together from the starter circuit kit to help spread out the components to make it easier to build.

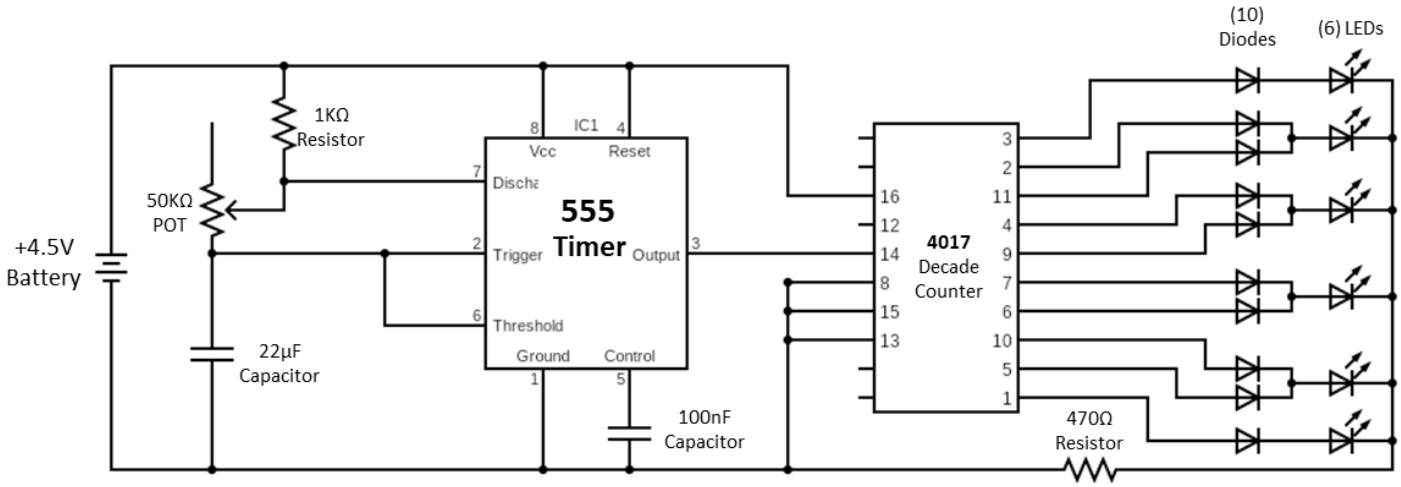
Can you make this circuit on a single breadboard?



This is what the actual 4017 Decade Counter looks like.

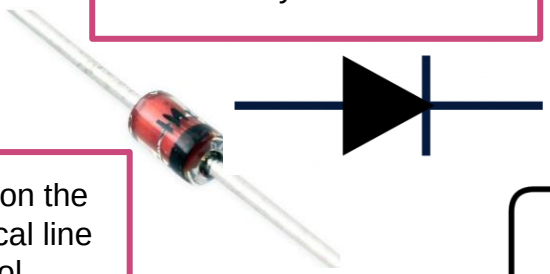


LEDs will light up sequentially forward then bounce back at each end



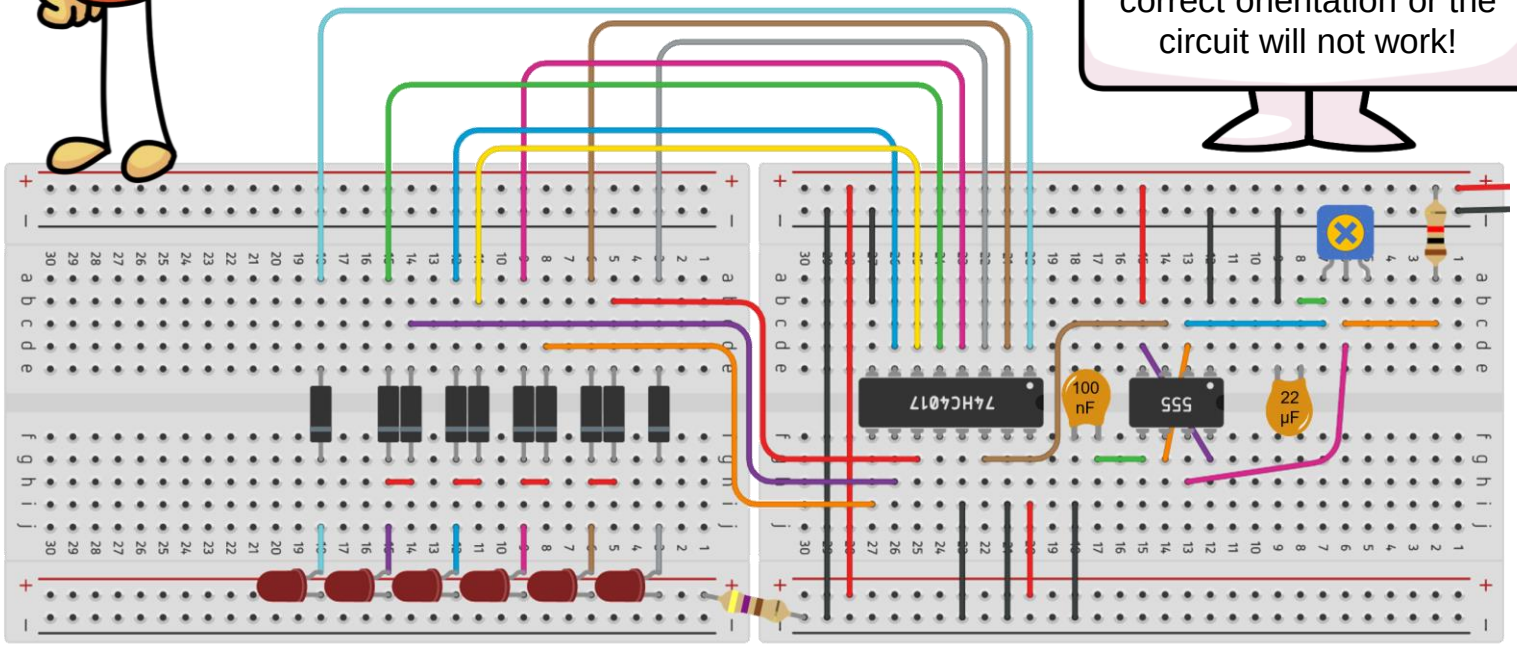
There are two diodes for each LED except for the 1st LED and the 6th LED.

Diodes allow electricity to flow in only one direction.



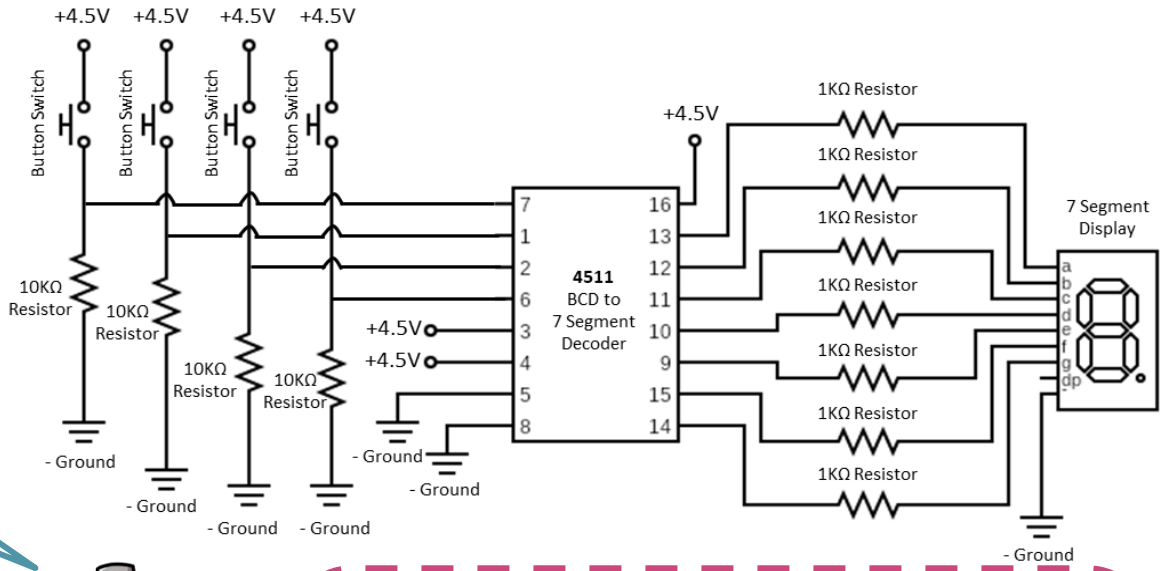
The black stripe on the diode is the vertical line on the symbol.

Make sure all the diodes and LEDs are in the correct orientation or the circuit will not work!



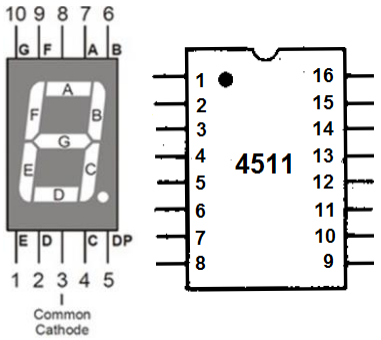
Use four push buttons to create digits 1-9 on the display

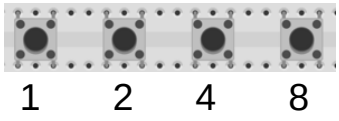
Anywhere in the schematic that +4.5V appears, the component is connected to the power (+) of battery and everywhere the symbol (⏚) appears, the component is connected to the battery ground (-).



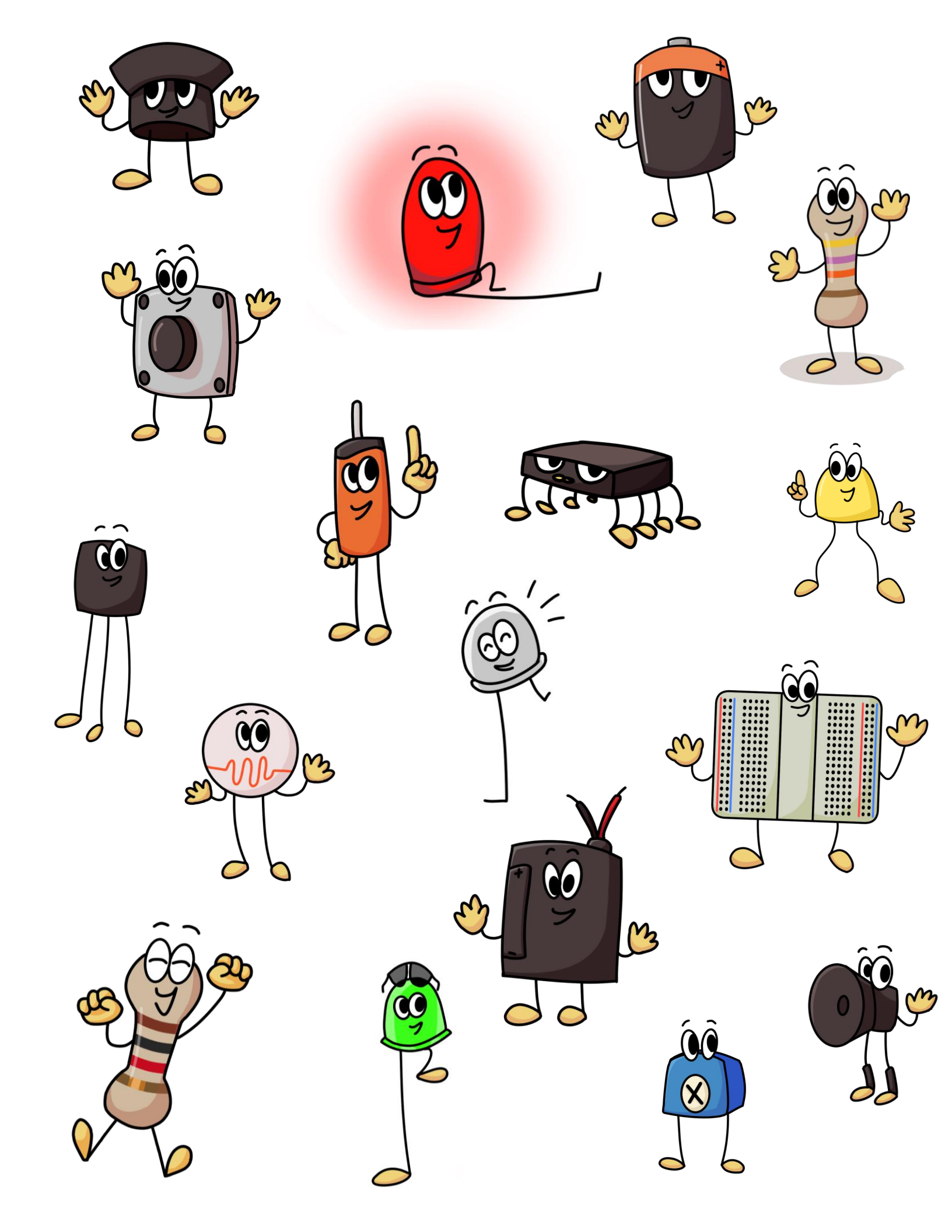
The 4511 IC will add the number below each switch to display the value on the 7-segment display.

In reality, the connections of the seven segment display and the 4511 timer look like this. Pins are rearranged on schematics to make them simpler to draw.

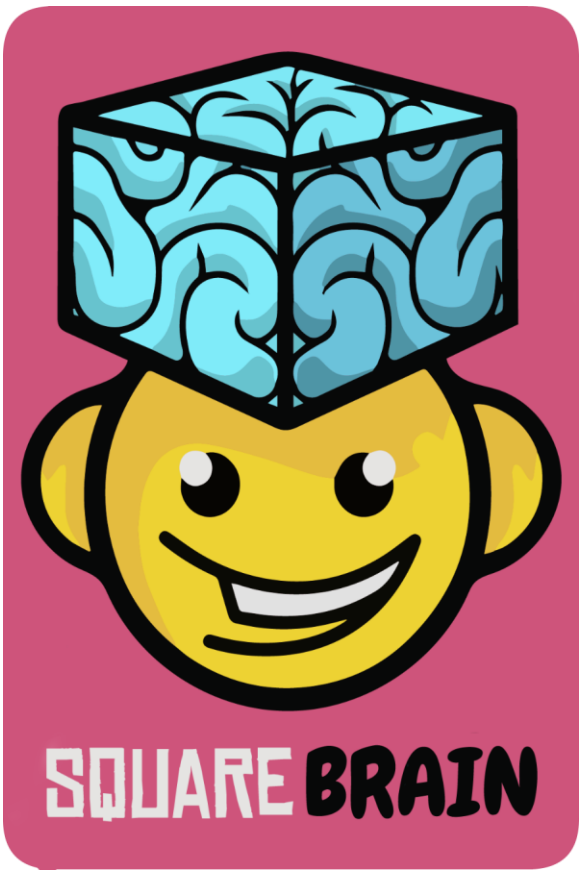




How many wires are in this circuit?!?!




You've
reached
THE END


SQUARE BRAIN