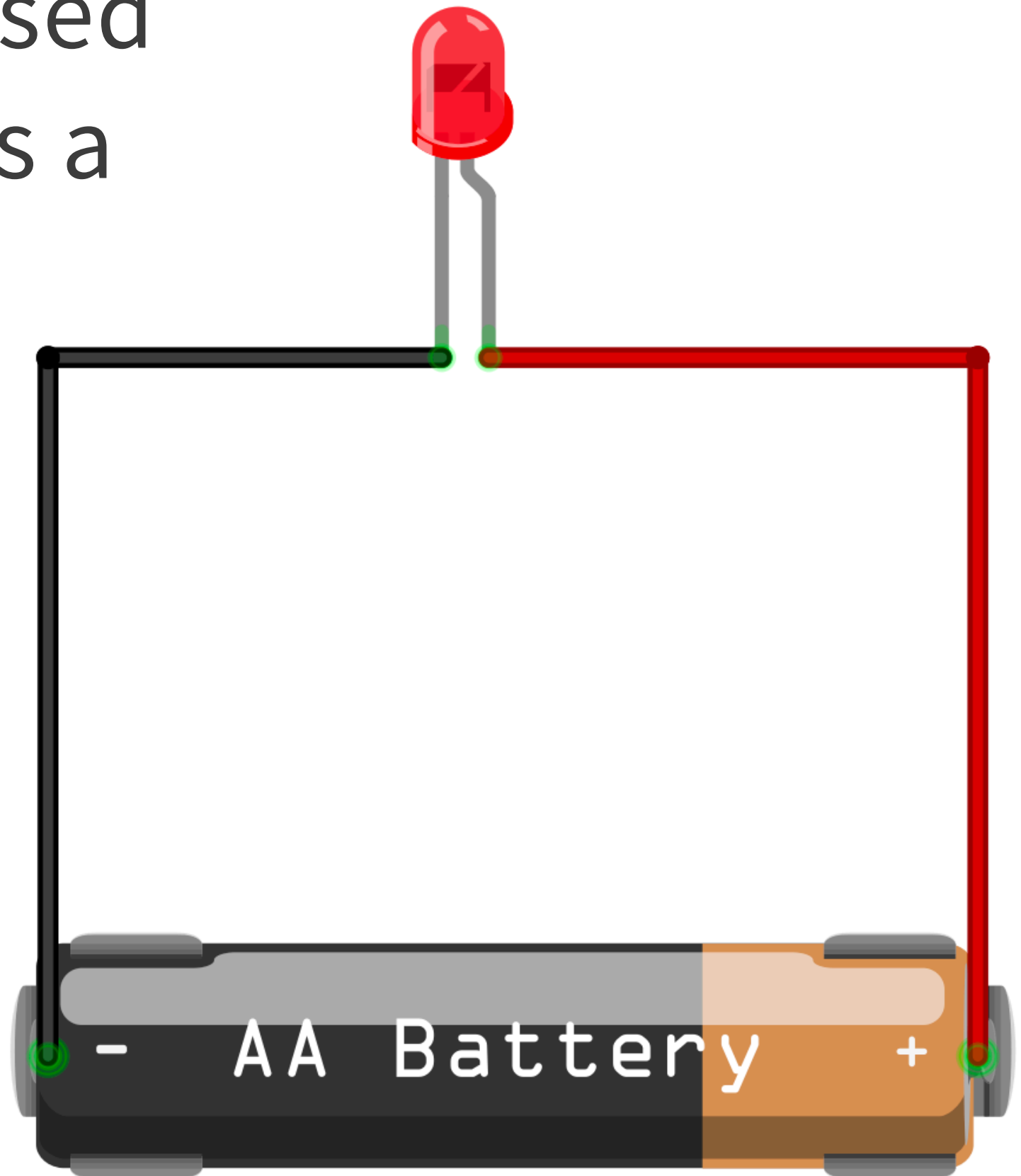


# INTRODUCTION TO CIRCUITS AND ELECTRICITY

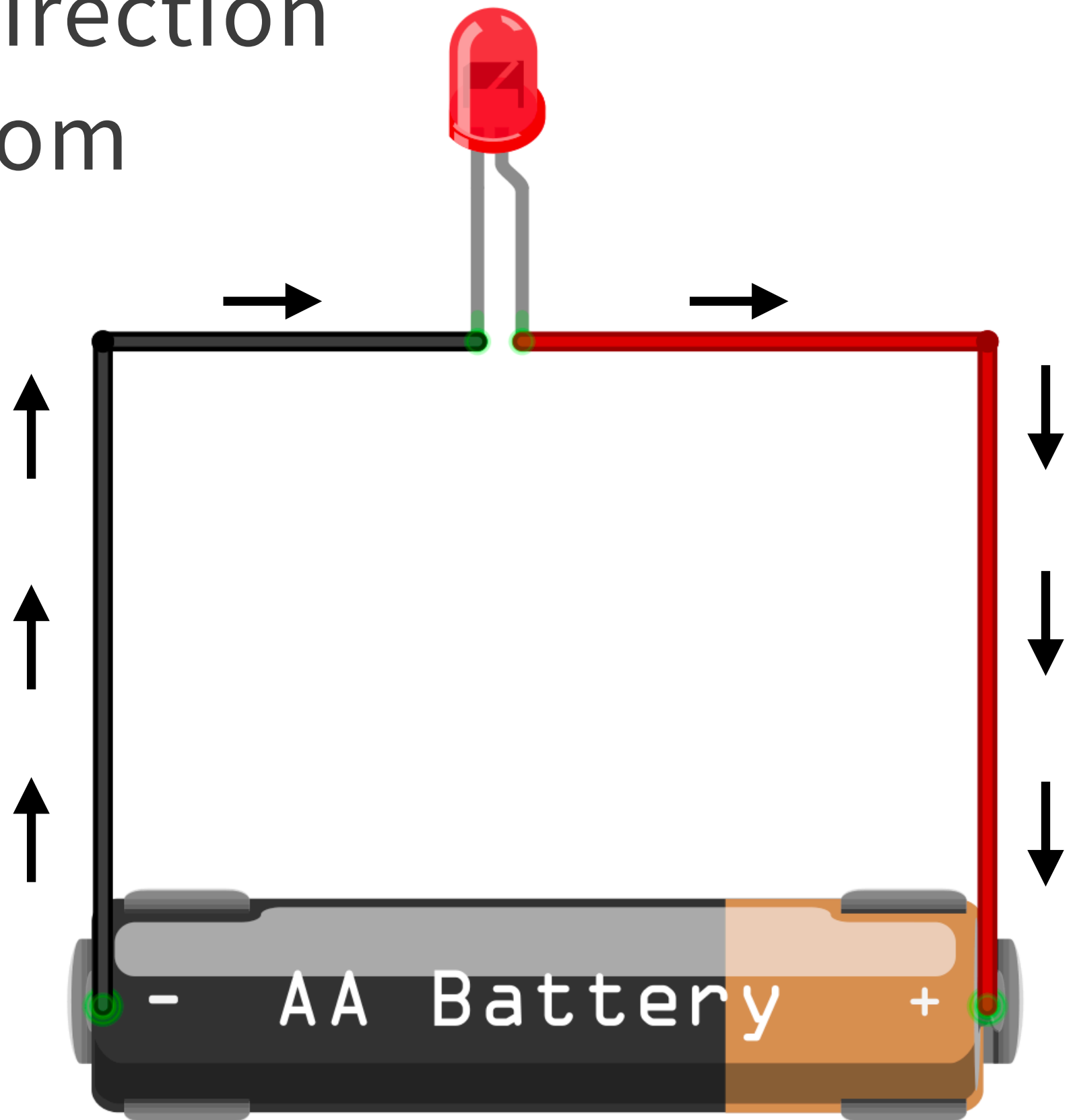
# CIRCUITS & ELECTRICITY

What is a Circuit?

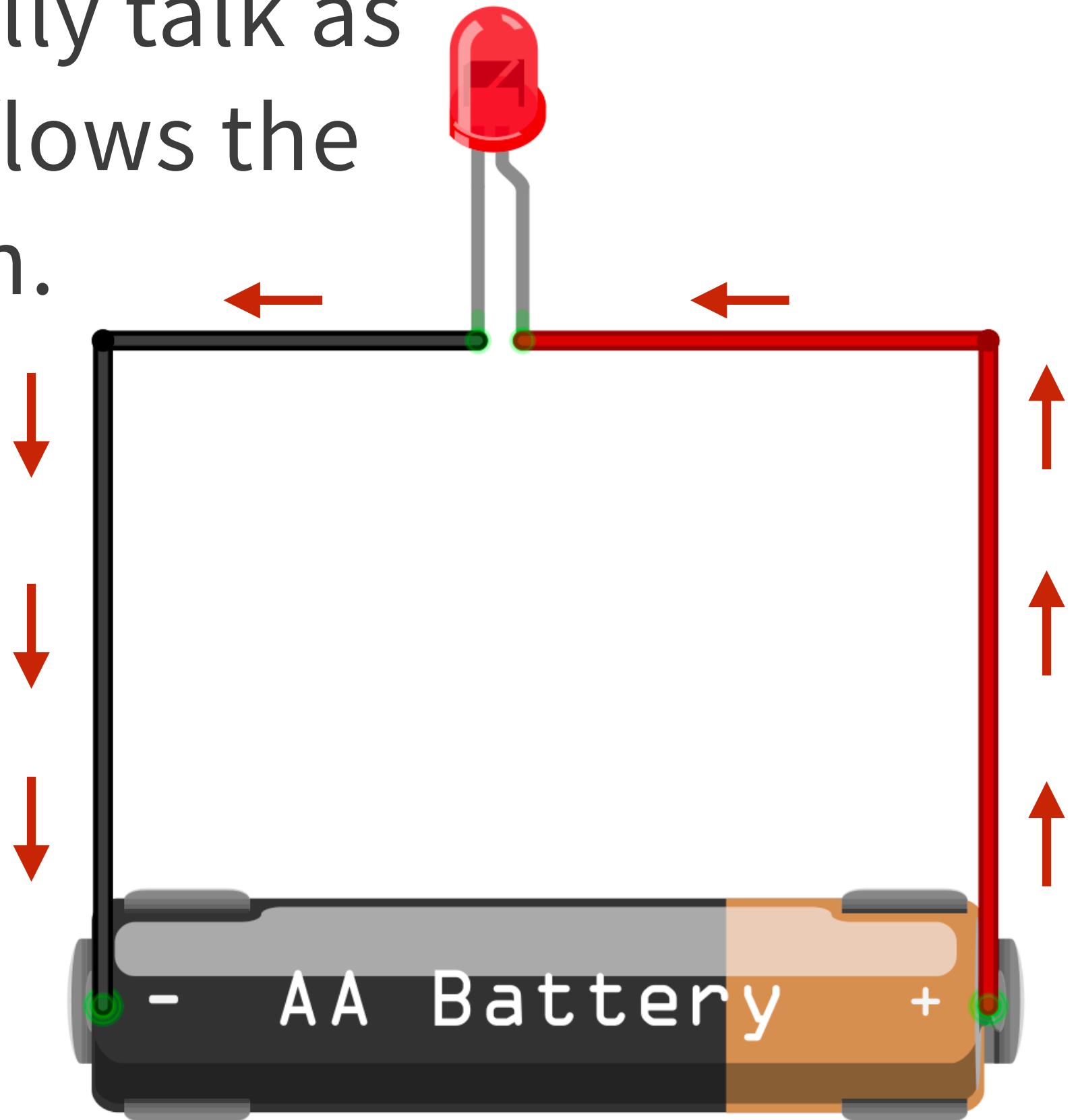
A circuit is a closed loop that carries a current.

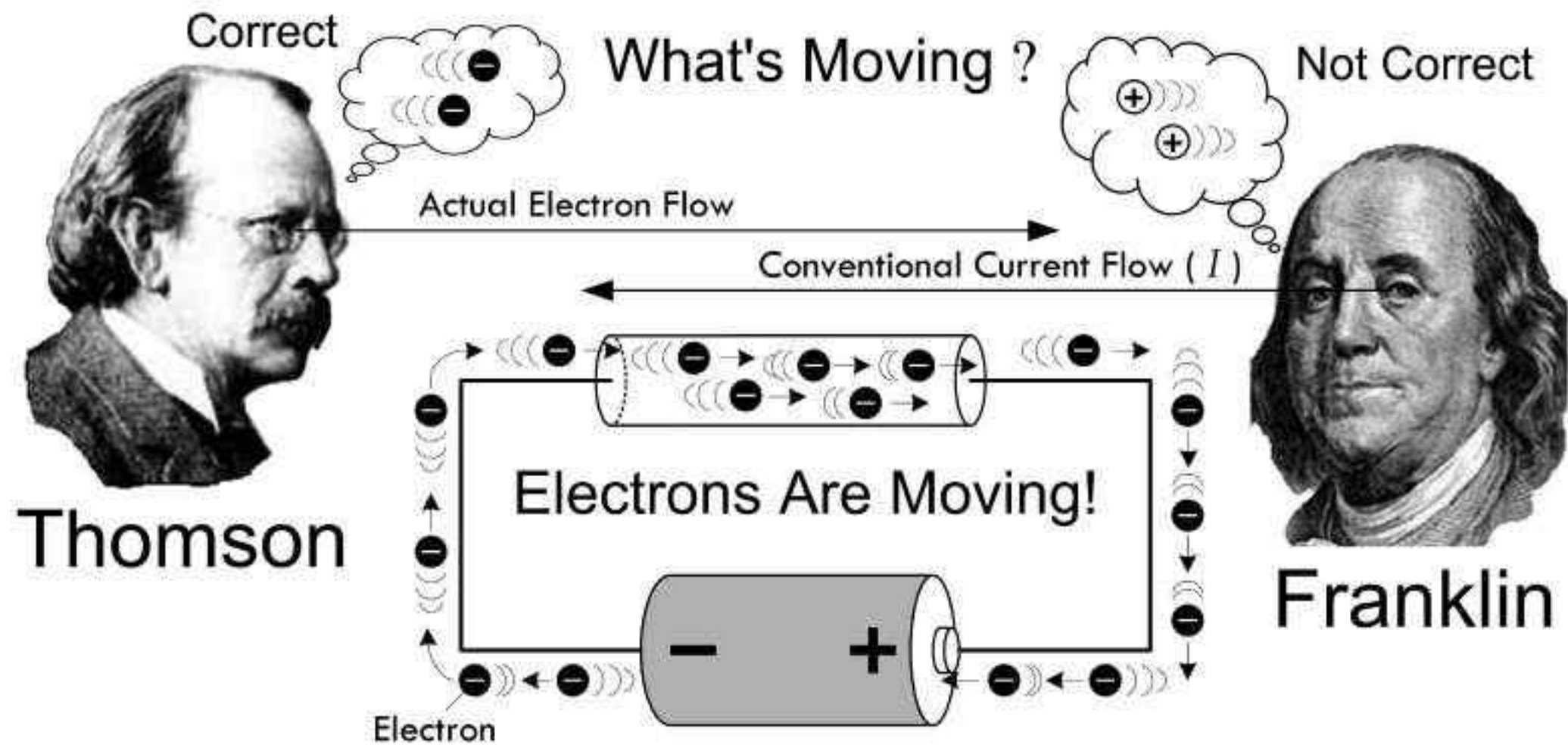


The “actual” direction of current is from negative to positive.



But we generally talk as if the current flows the other direction.





# Three Key Elements of Electricity

1. Current
2. Voltage
3. Resistance



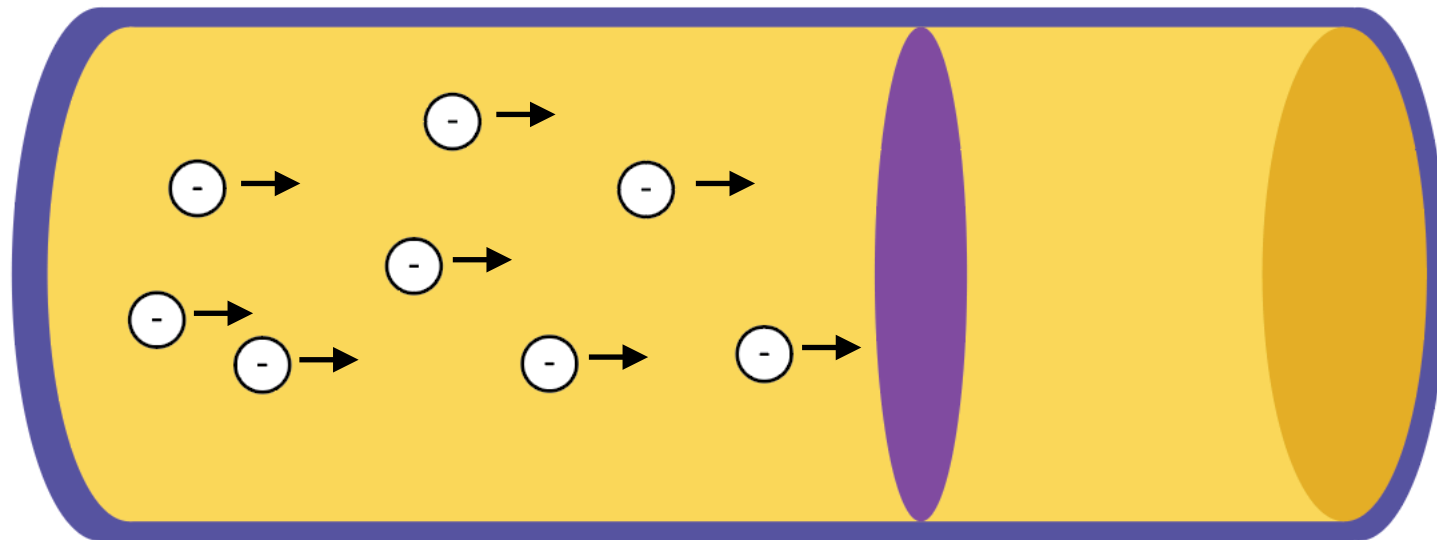
What is Current?

Current is the flow of electrons through a circuit.

Measured in Amperes or Amps.

Amps are symbolized as “A” and current as “I”

An amp is a measure of how many electrons pass through a point in a given amount of time.



What is Voltage?

Voltage is the amount of potential energy between points in a circuit. It is the “push” that causes the electrons to flow.

Measured in Volts and symbolized as “V”

What is Resistance?

Resistance is how much a circuit resists the flow of current.

Measured in Ohms and symbolized with “ $\Omega$ ”

# Ohm's Law



Ohm's law states that the current through a conductor is directly proportional to the voltage across the two points.

$$V = I \times R$$

V is voltage

I is current

R is resistance

$$V = I \times R$$

$$I = V / R$$

$$R = V / I$$

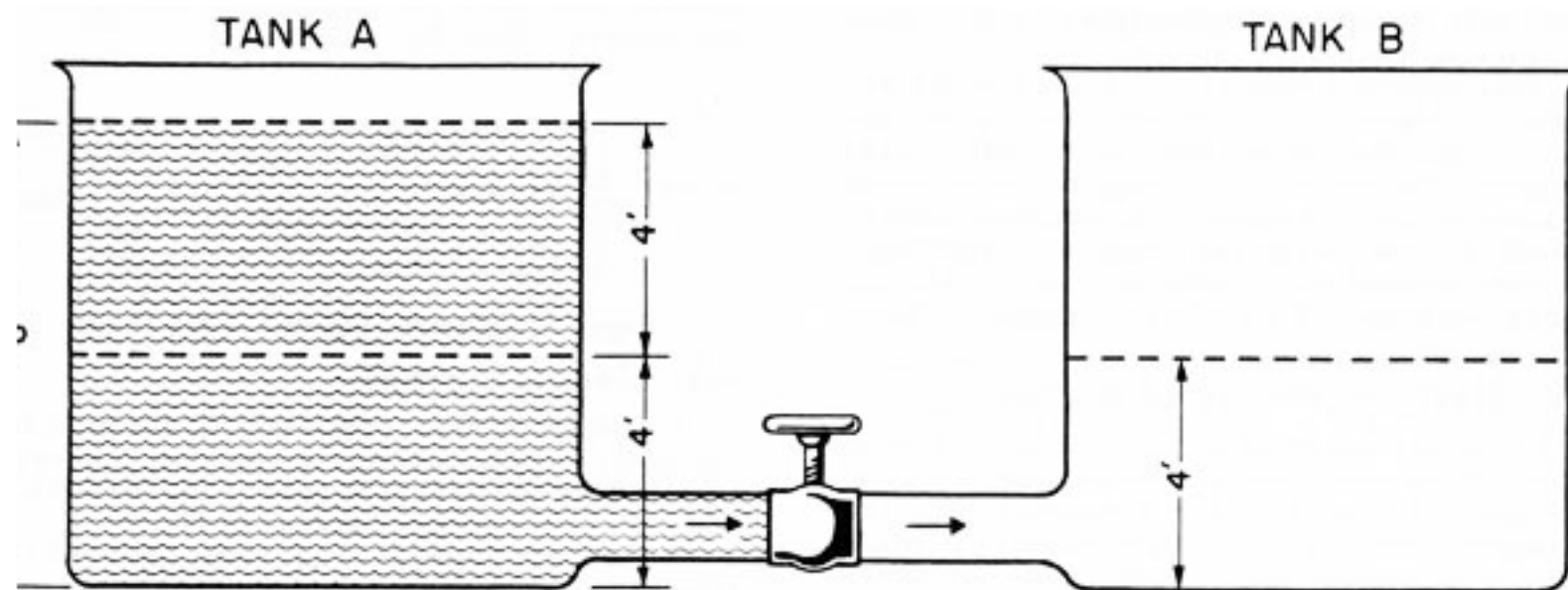
V is voltage

I is current

R is resistance

$$V = I \times R$$

This means that an increase in voltage causes a proportional increase in current.



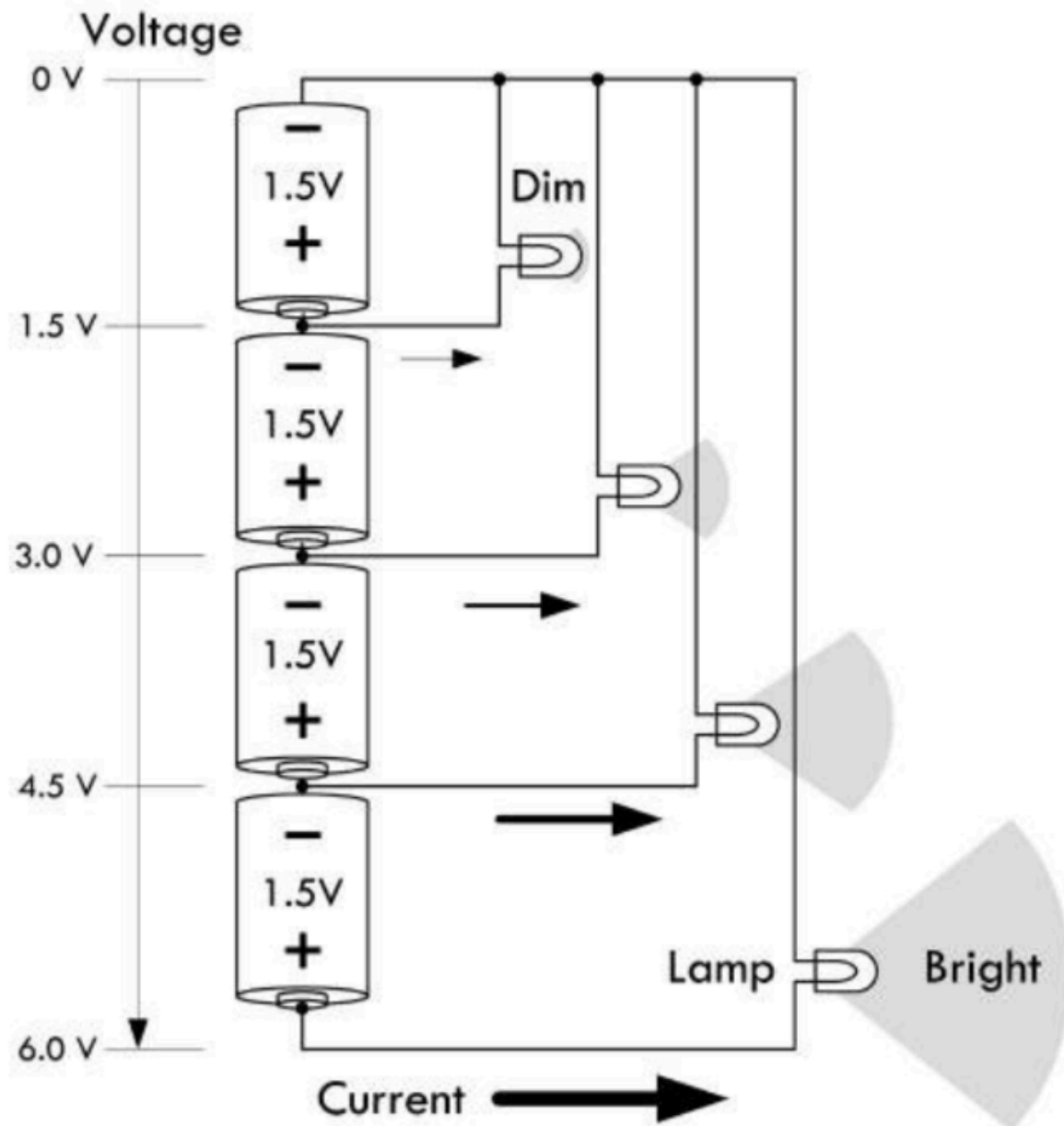
$$R \text{ (resistance)} = V \text{ (voltage)} / I \text{ (current)}$$

$$V = R * I$$

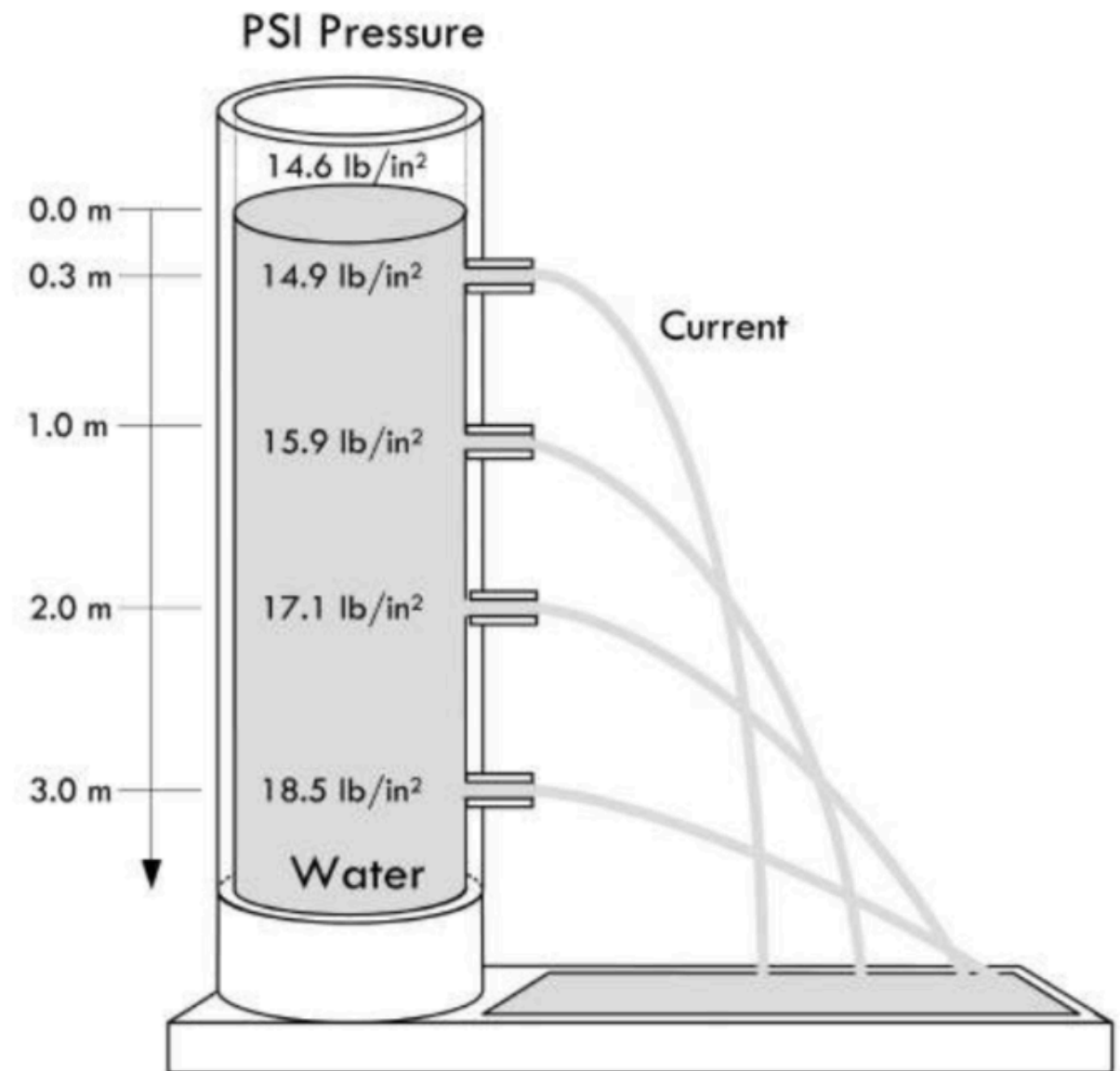
$$I = V / R$$

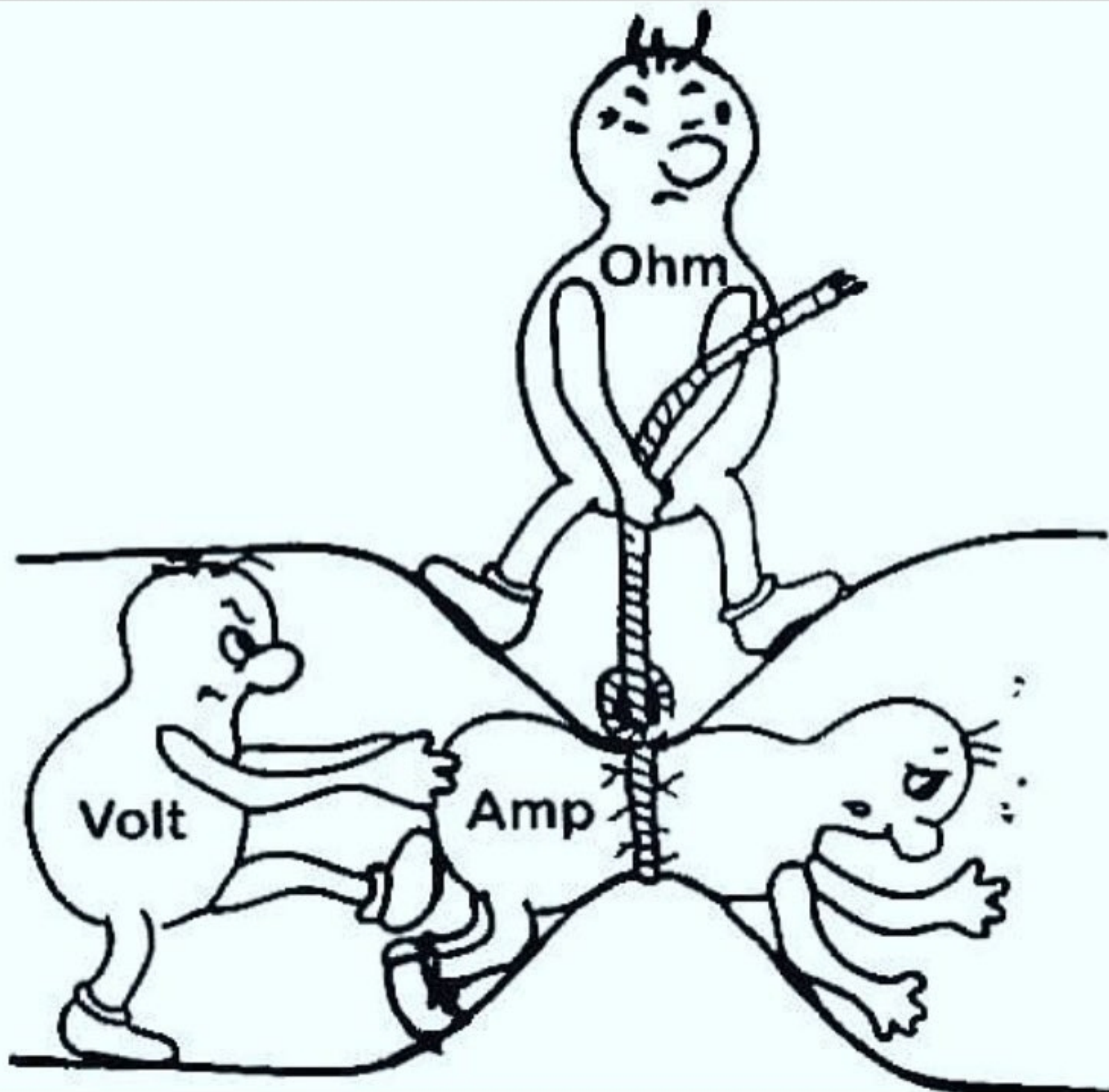
This is the only rule that you really have to memorise and learn to use, because in most of your work, this is the only one that you will really need.

## Electrical System

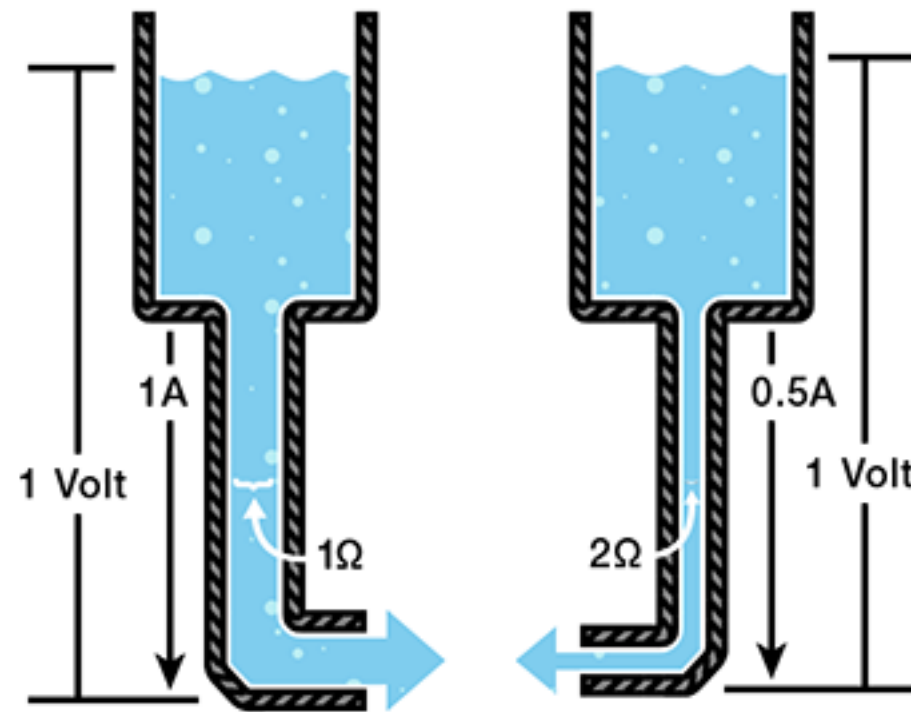


## Water System





$$V = I \cdot R$$



**V = Voltage in volts**

**I = Current in amps**

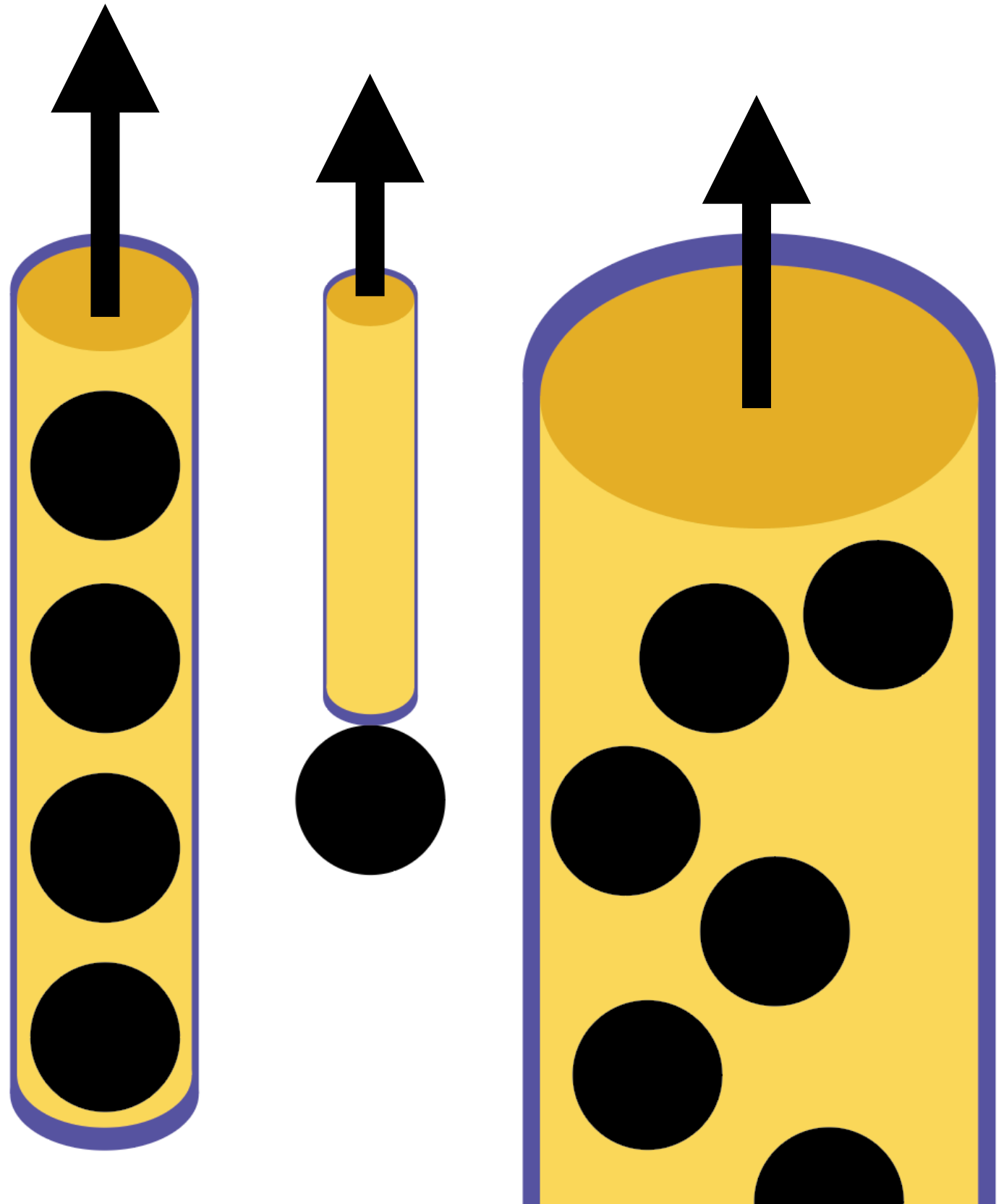
**R = Resistance in ohms**





In the boba analogy,

- the straw size is the resistance,
- the strength of the sucking is the voltage
- and the number of boba per second is the current



**TERMS YOU MAY**  
**HAVE HEARD**

AC and DC

DC - constant current flow in one direction. Think batteries, computer chargers, etc.

AC - Alternating current moves back-and-forth. This is what comes out of a wall socket.

(We mostly care about DC)

Short Circuit

When the positive and negative wires, instead of being put to work, are connected directly together.

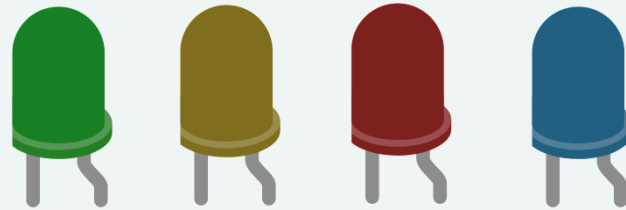
This is bad because the resistance is so low that the current will be very very high which generates heat.

# ELECTRICAL COMPONENTS



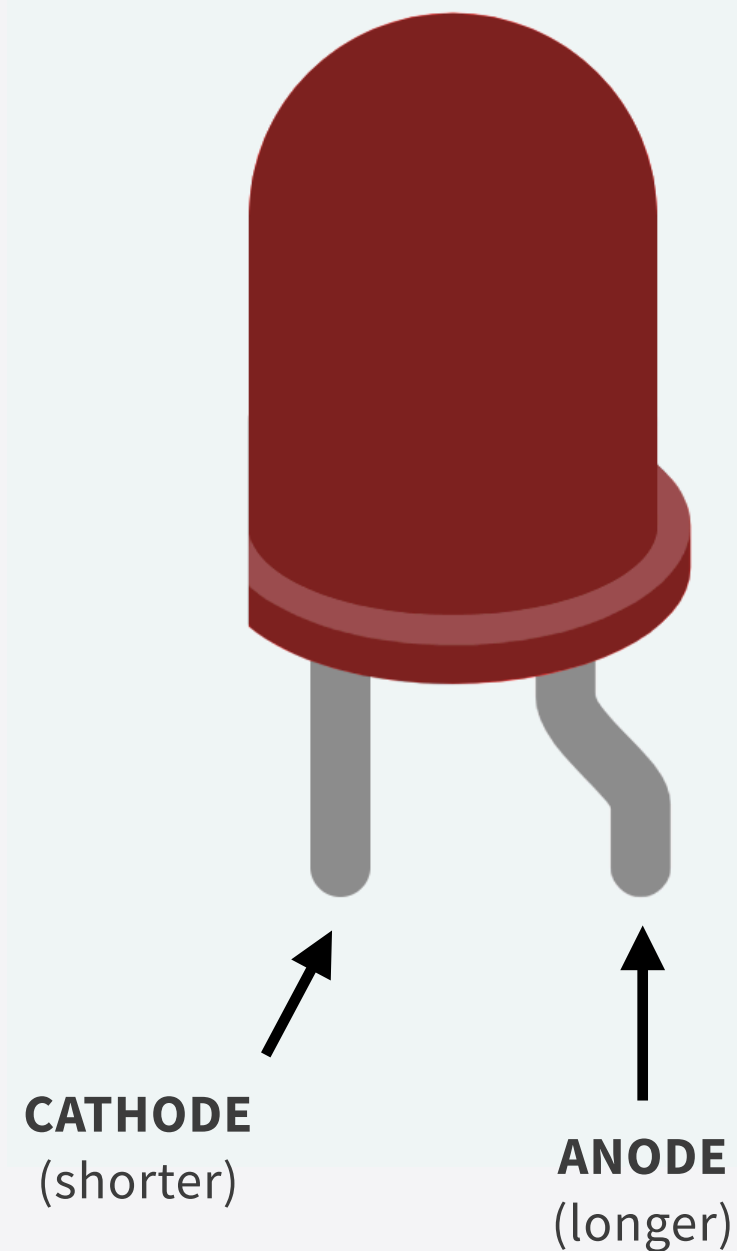
LED

# LED

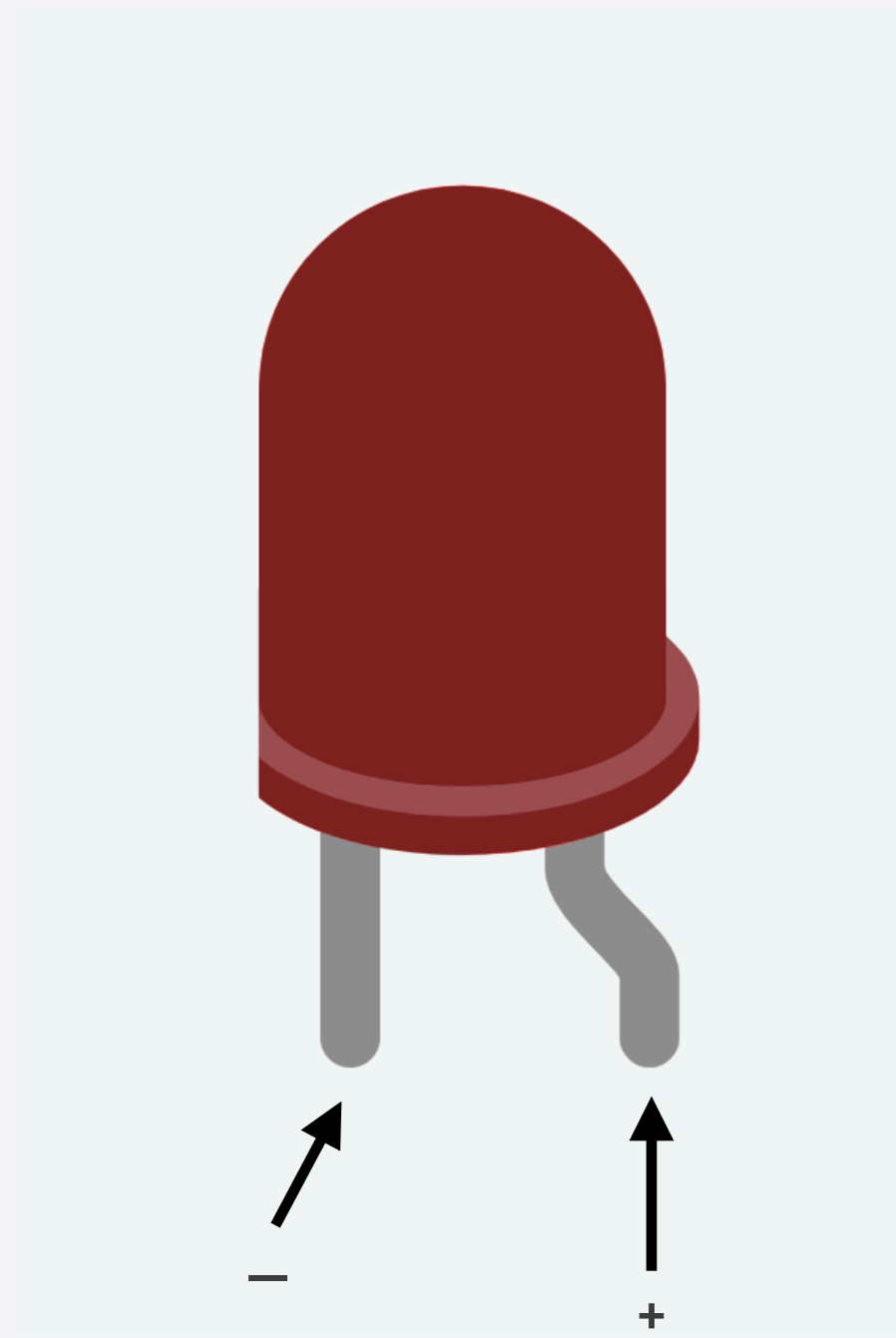


A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it.

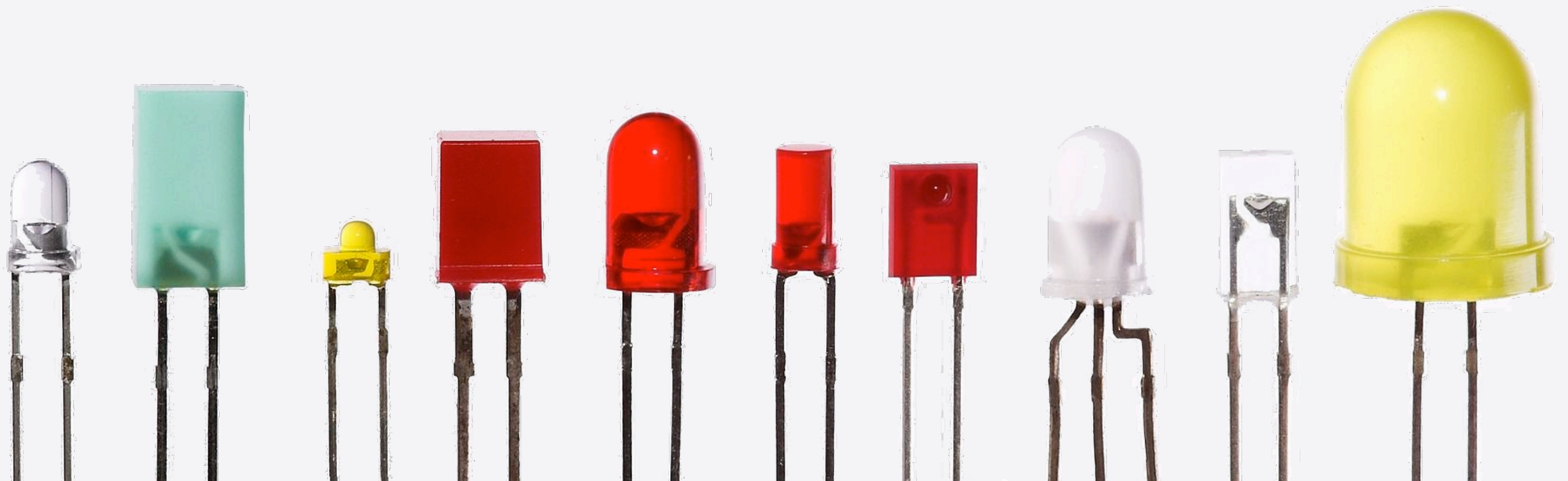
An LED has two legs, a longer one called an anode and a shorter one called a cathode



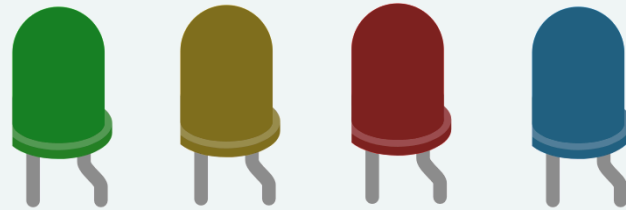
The cathode must be connected to ground, and the anode connected to power



LEDs come in many shapes and sizes. The color is often indicated by the color of the plastic, but not always.



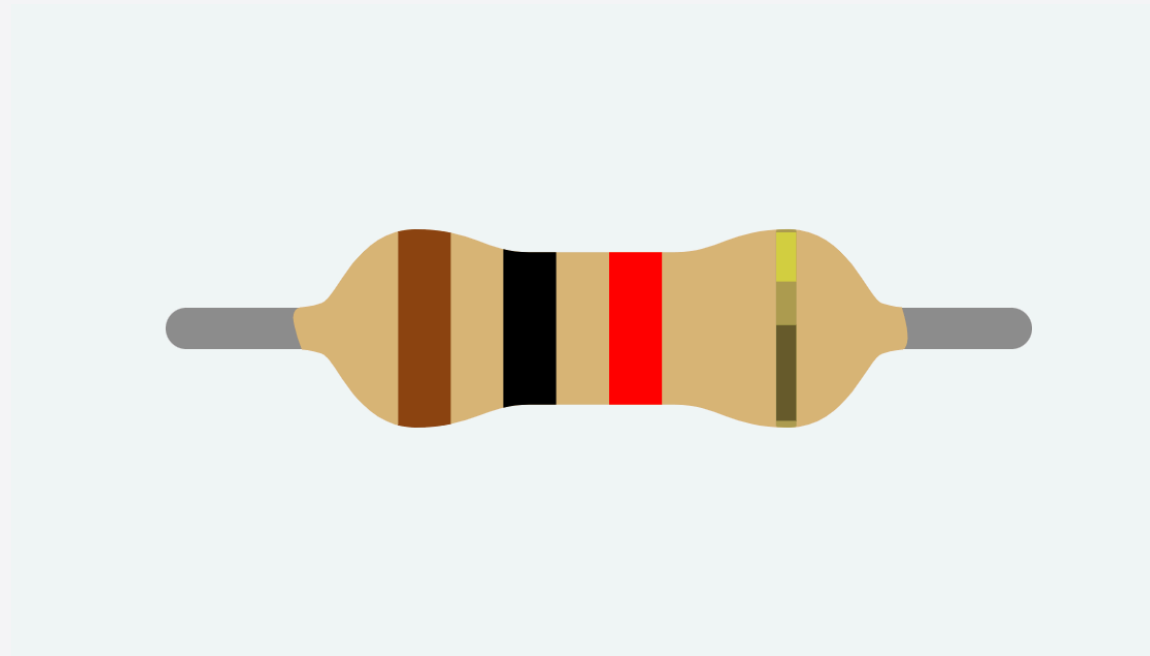
# LED



Every LED has a rating for how much current it can handle, and how much voltage is required for it to work

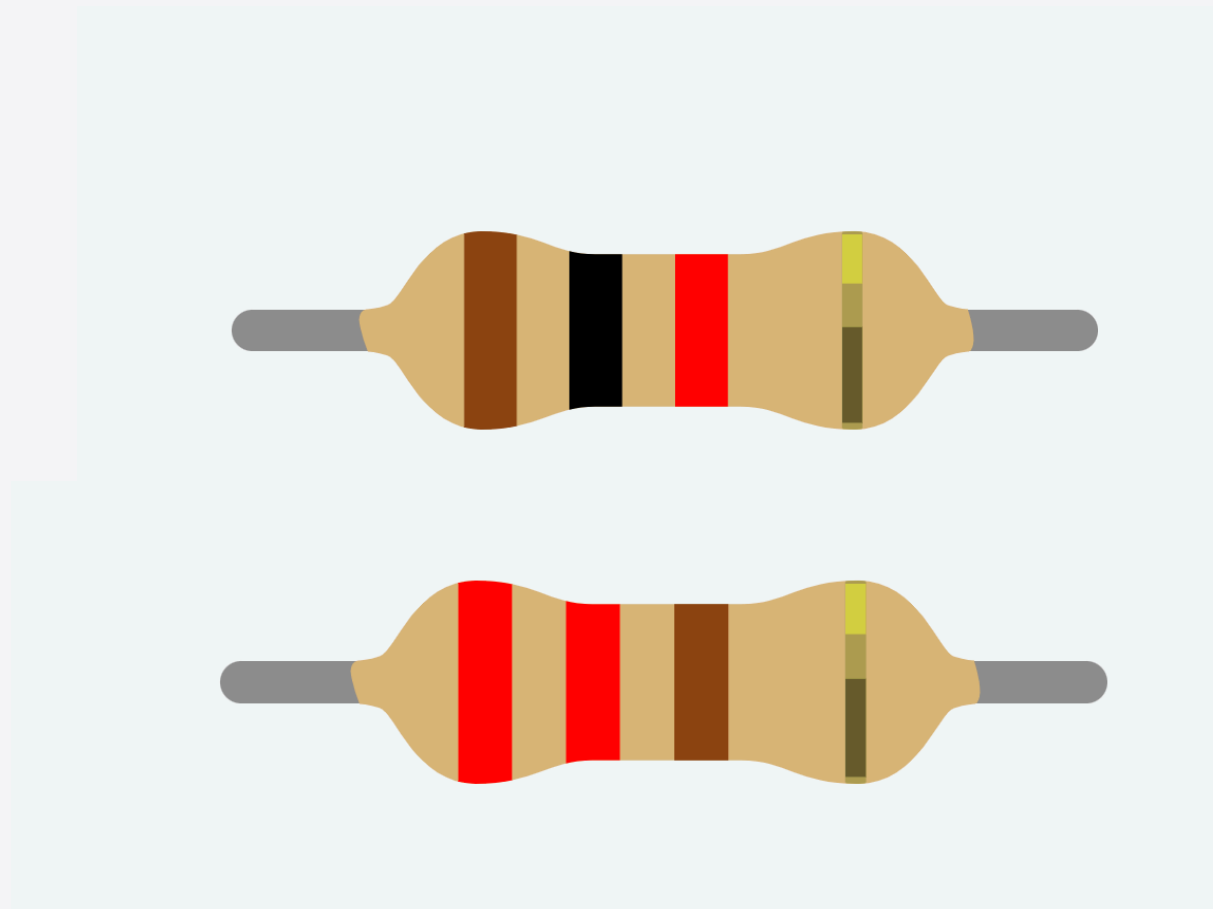
# Resistor

# Resistor



A resistor is a component that creates electrical resistance in a circuit.





The strength of a resistor  
can be found using the  
color bands

**4 BAND**      **1**      **0**       $\times 10^3$        $\pm 5$       = 10,000 $\Omega$  = 10k $\Omega$   $\pm 5\%$



**1<sup>st</sup> DIGIT**

0
1
2
3
4
5
6
7
8
9

**2<sup>nd</sup> DIGIT**

0
1
2
3
4
5
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9

**3<sup>rd</sup> DIGIT**

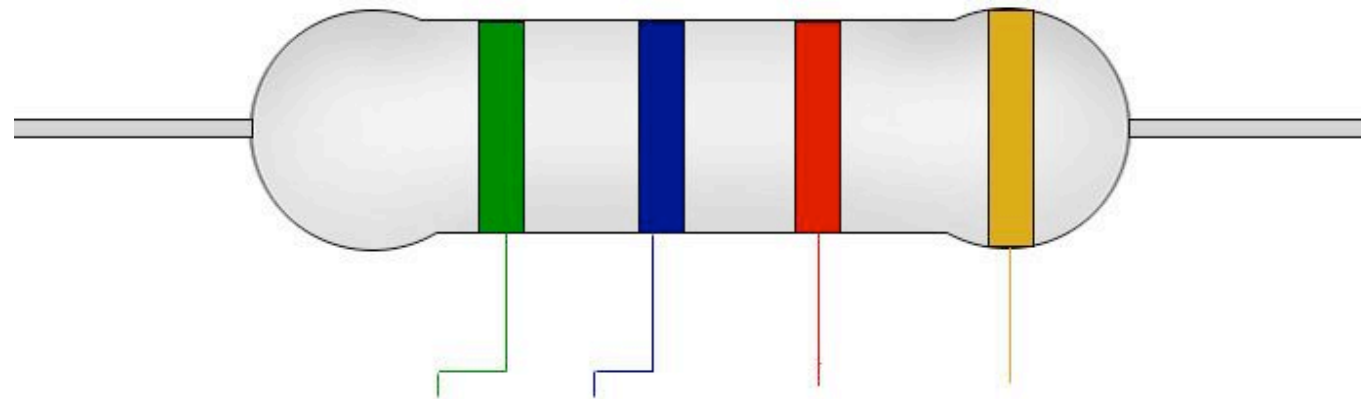
0
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**MULTIPLIER**

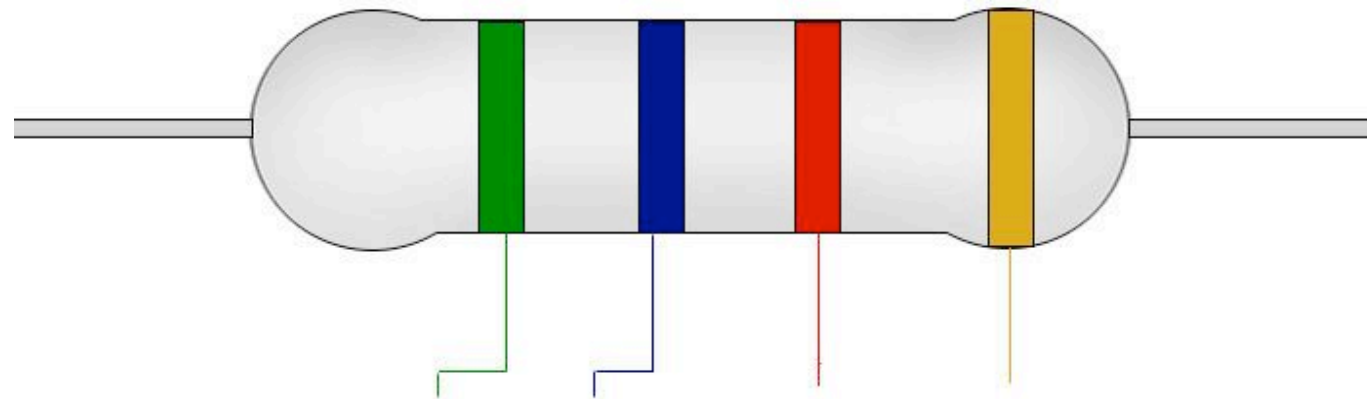
0
1
2
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4
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6

**TOLERANCE**

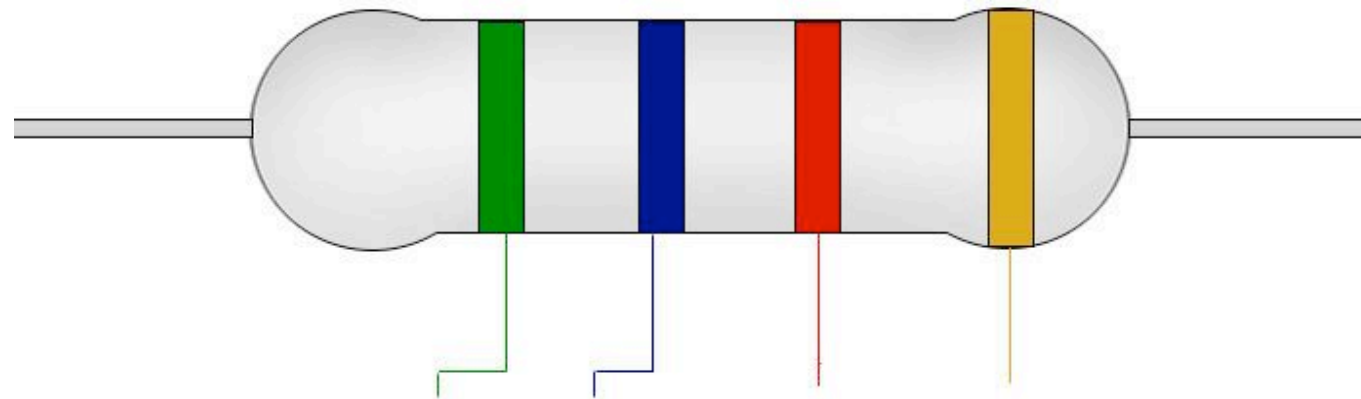
$\pm 1\%$
$\pm 2\%$
$\pm 5\%$ GOLD
$\pm 10\%$ SILVER



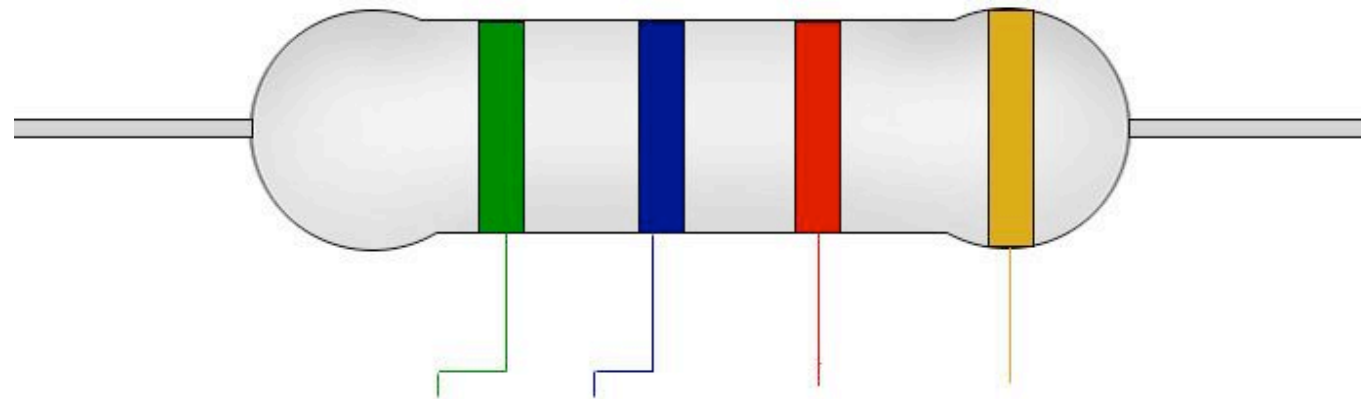
	First Digit	Second Digit	Multiplier	Tolerance
Black	Nil	0	1	Nil
Brown	1	1	10	±1%
Red	2	2	100	±2%
Orange	3	3	1000	±3%
Yellow	4	4	10000	±4%
Green	5	5	100000	±0.5%
Blue	6	6	1M	±0.25%
Violet	7	7	10M	±0.10%
Grey	8	8	100M	±0.05%
White	9	9	1G	Nil
Gold	Nil	Nil	÷10	±5%
Silver	Nil	Nil	÷100	±10%



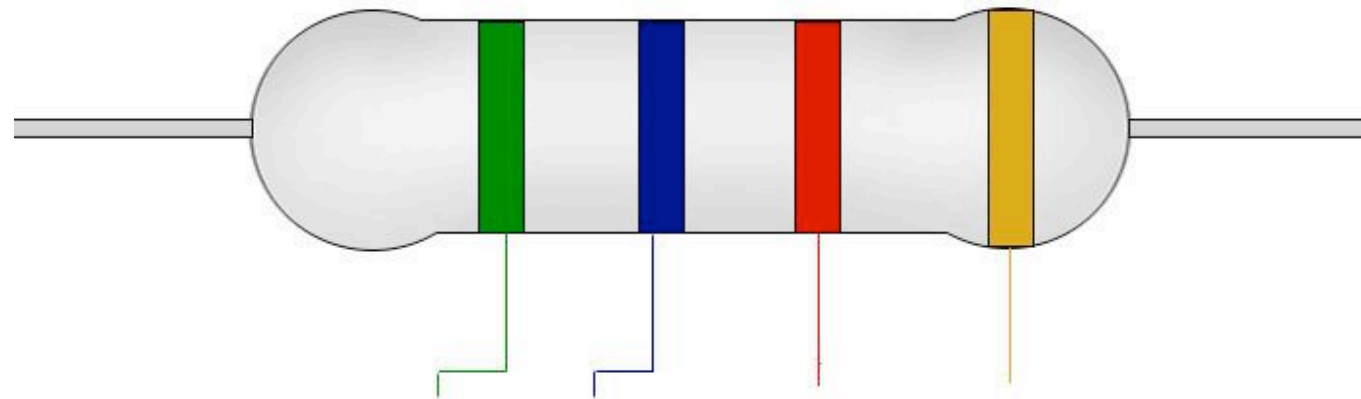
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Grey	8	8	100M	±0.05%
White	9	9	1G	Nil
Gold	Nil	Nil	÷10	±5%
Silver	Nil	Nil	÷100	±10%



	First Digit	Second Digit	Multiplier	Tolerance
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Orange	3	3	1000	±3%
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Green	5	5	100000	±0.5%
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White	9	9	1G	Nil
Gold	Nil	Nil	÷10	±5%
Silver	Nil	Nil	÷100	±10%

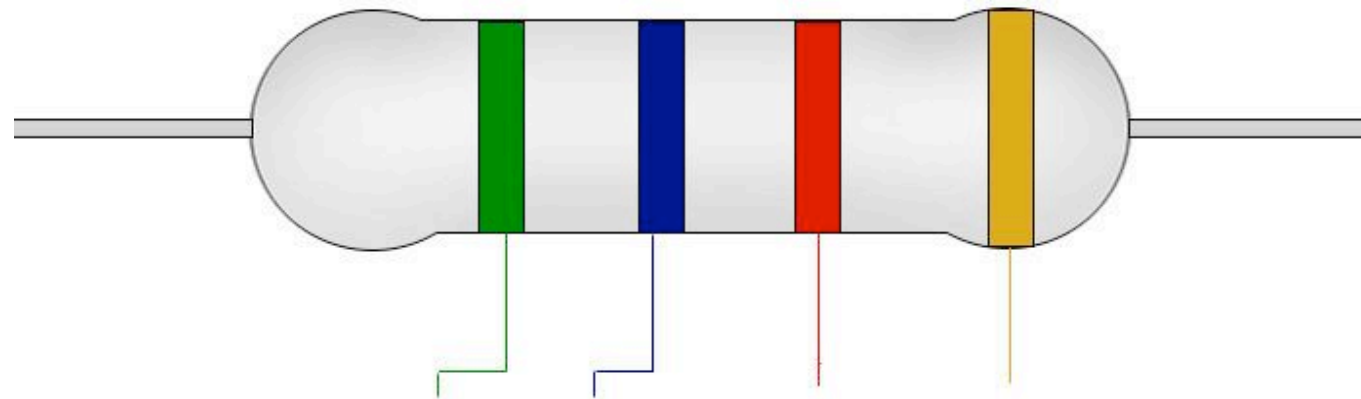


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Grey	8	8	100M	±0.05%
White	9	9	1G	Nil
Gold	Nil	Nil	÷10	±5%
Silver	Nil	Nil	÷100	±10%



	First Digit	Second Digit	Multiplier	Tolerance
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Brown	1	1	10	±1%
Red	2	2	100	±2%
Orange	3	3	1000	±3%
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Green	5	5	100000	±0.5%
Blue	6	6	1M	±0.25%
Violet	7	7	10M	±0.10%
Grey	8	8	100M	±0.05%
White	9	9	1G	Nil
Gold	Nil	Nil	÷10	±5%
Silver	Nil	Nil	÷100	±10%

5600 = 5.6K



	First Digit	Second Digit	Multiplier	Tolerance
Black	Nil	0	1	Nil
Brown	1	1	10	±1%
Red	2	2	100	±2%
Orange	3	3	1000	±3%
Yellow	4	4	10000	±4%
Green	5	5	100000	±0.5%
Blue	6	6	1M	±0.25%
Violet	7	7	10M	±0.10%
Grey	8	8	100M	±0.05%
White	9	9	1G	Nil
Gold	Nil	Nil	÷10	±5%
Silver	Nil	Nil	÷100	±10%

5.6K  $\Omega$



We will use resistors to create the right amount of current for LEDs and to create and calibrate sensors.



# Breadboard

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g

h

i

j

+

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a

b

c

d

e

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3

4

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16

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18

19

20

21

22

23

24

25

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27

28

29

30

a

b

c

d

e

+

-

f

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h

i

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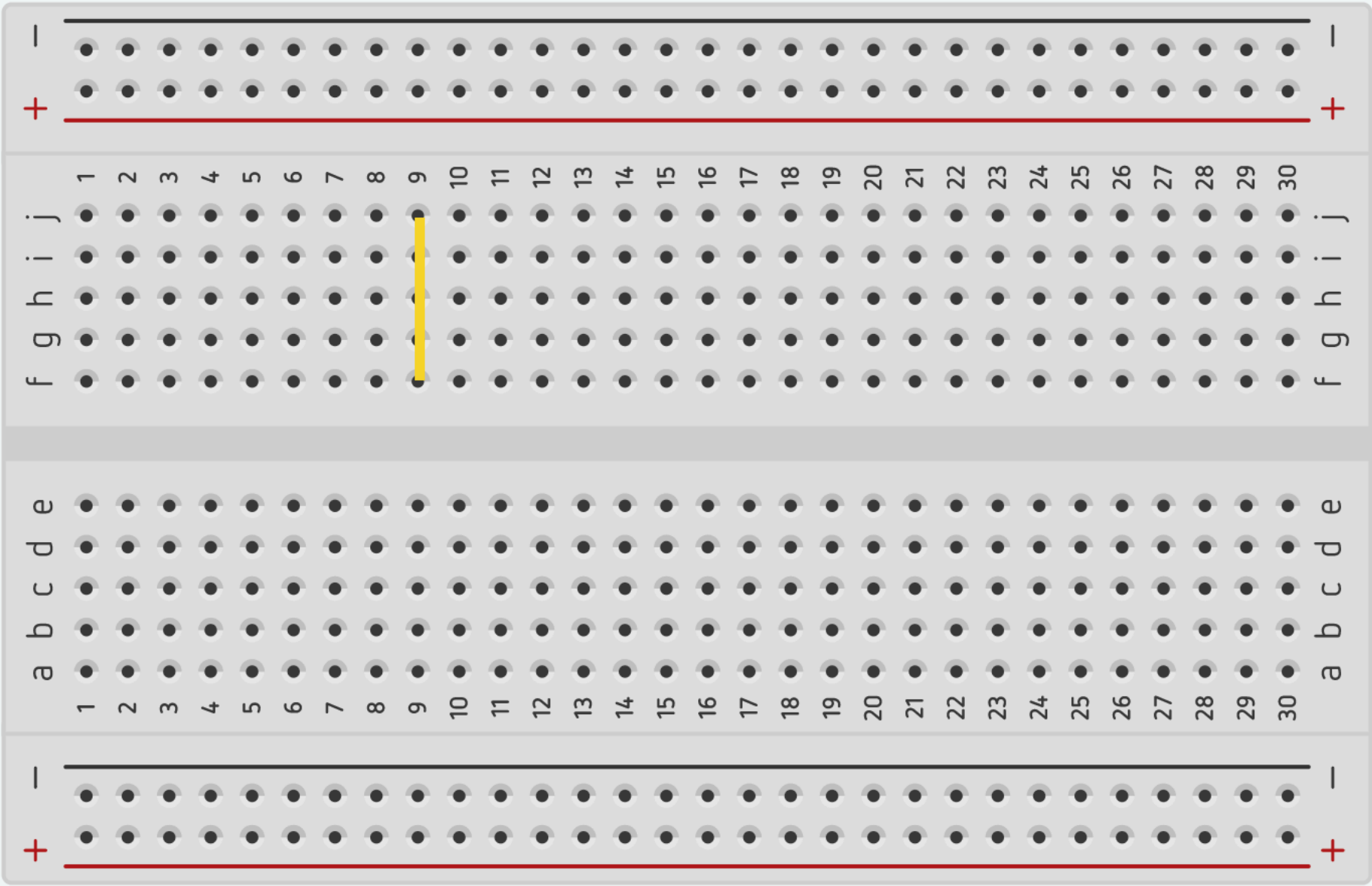
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g

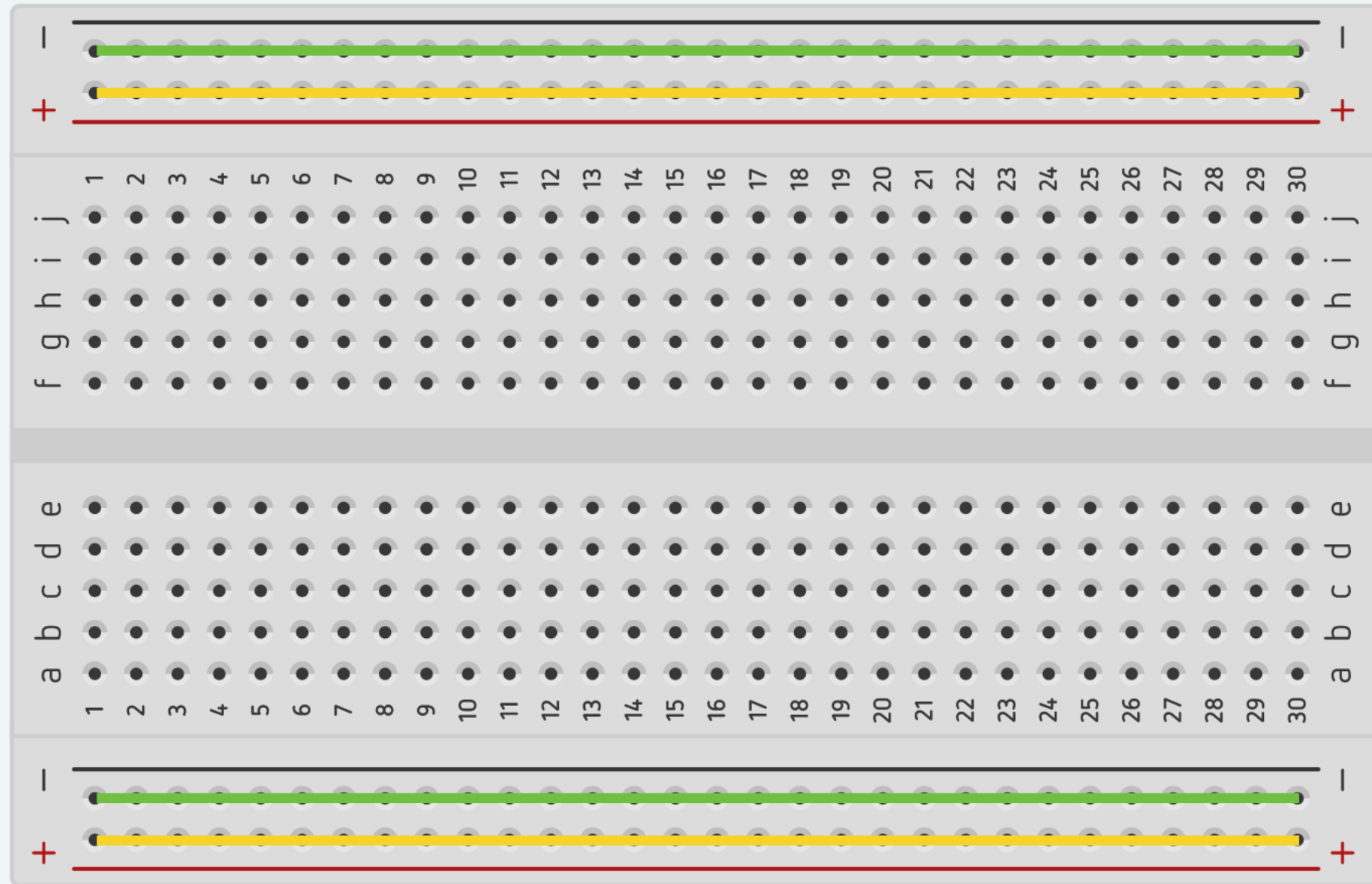
h

i

j



**RAILS**  
(typically for  
connecting  
power)



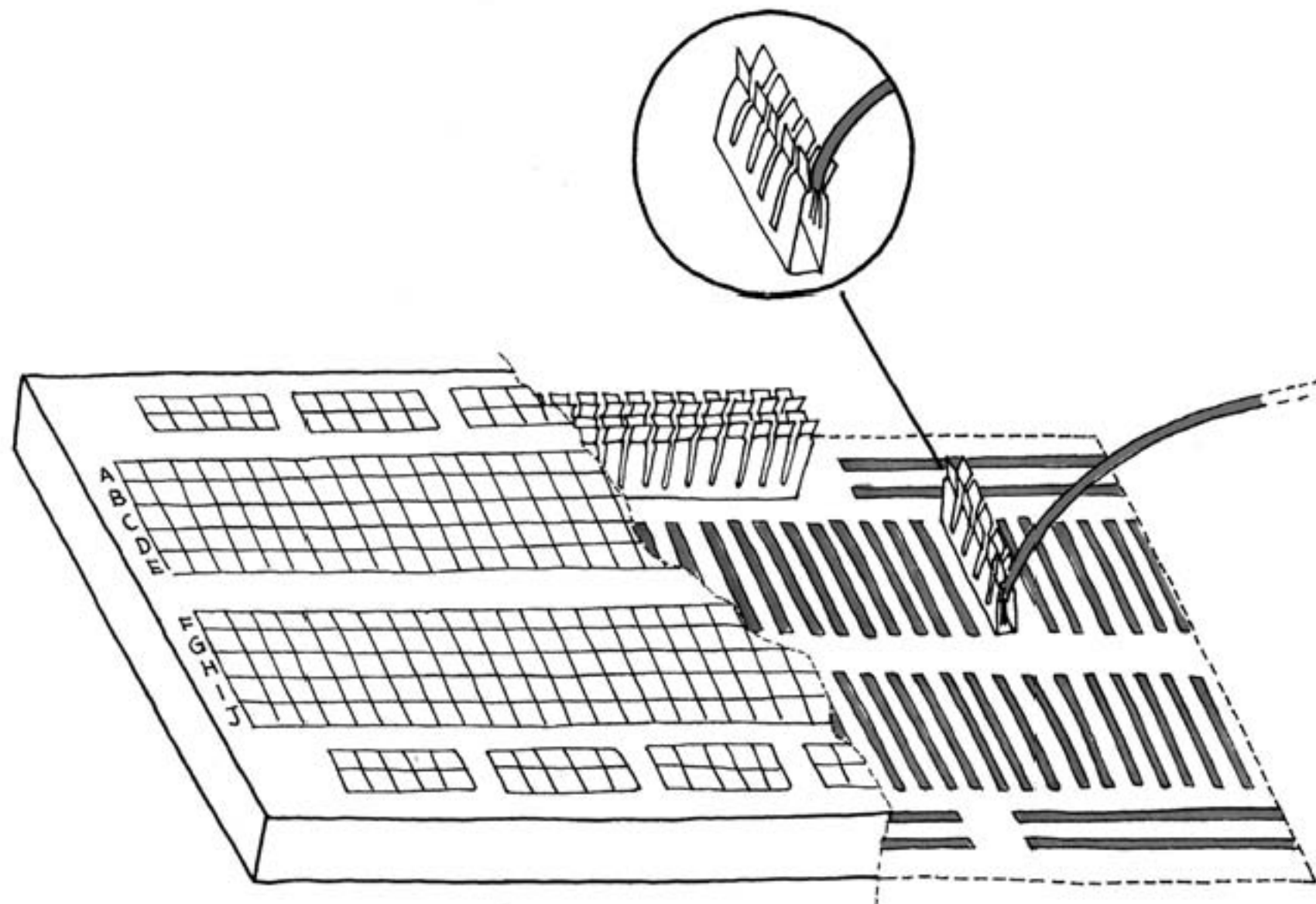
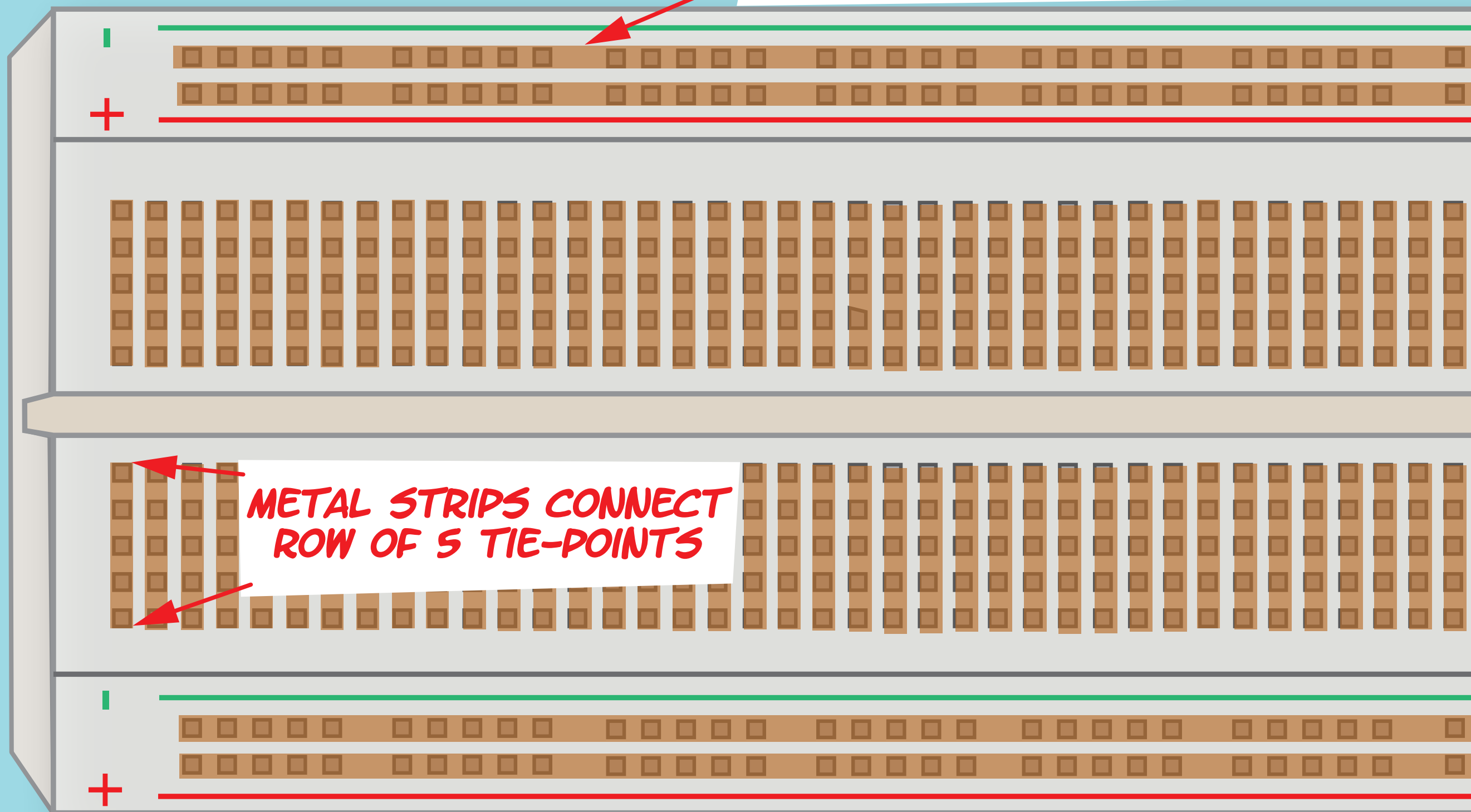


Figure A-1.  
The solderless breadboard

STRIPS OF METAL CONNECT  
TIE-POINTS ON DISTRIBUTION BUS



METAL STRIPS CONNECT  
ROW OF 5 TIE-POINTS

+

-

1

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3

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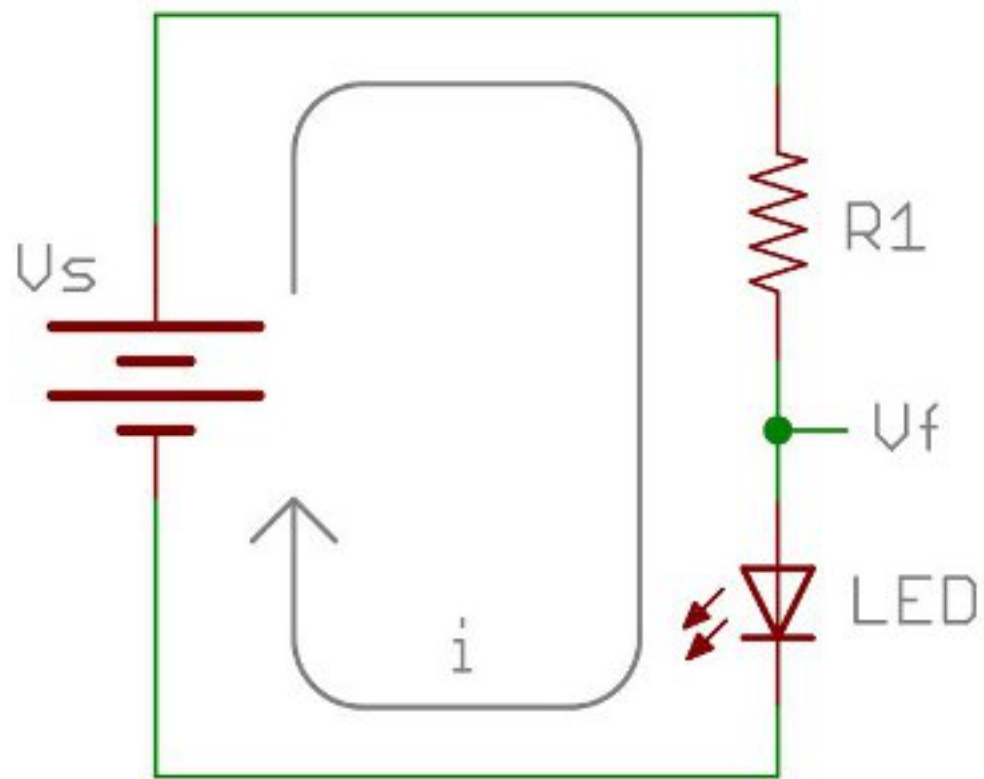
h

i

j



Using LEDs



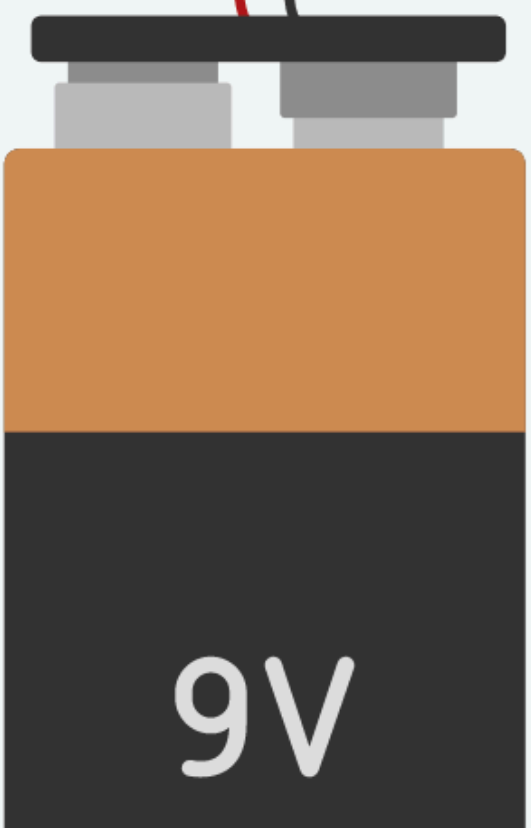
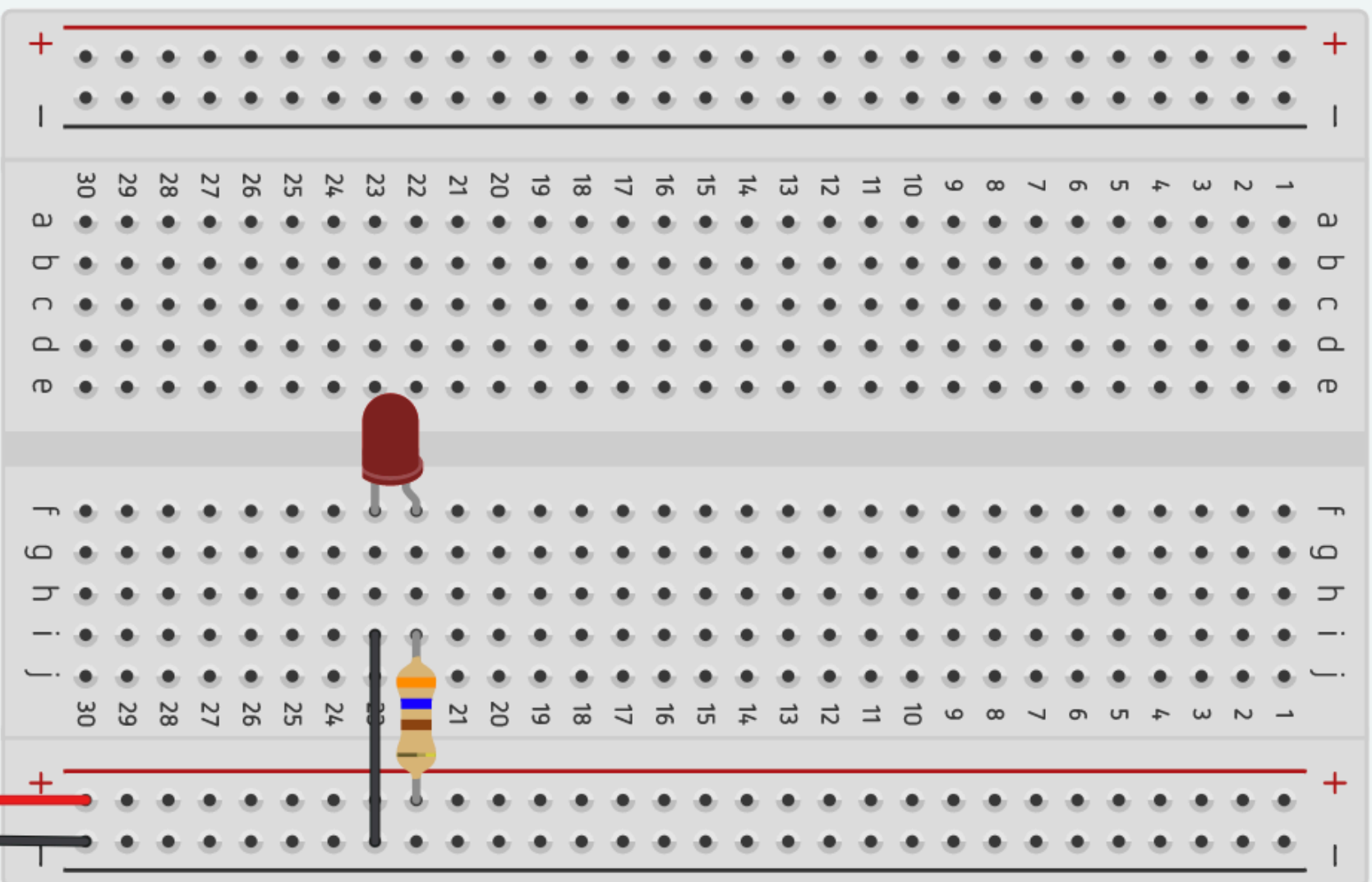
$i$  = LED forward current in Amps  
(found in the LED datasheet)

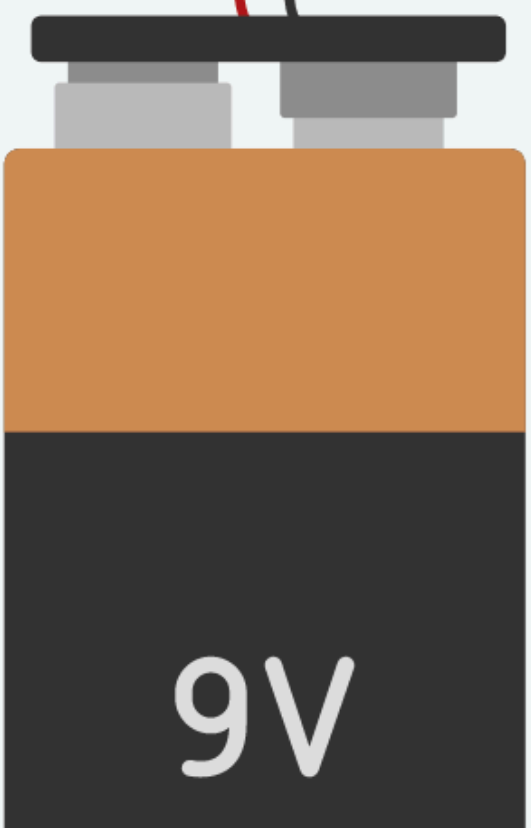
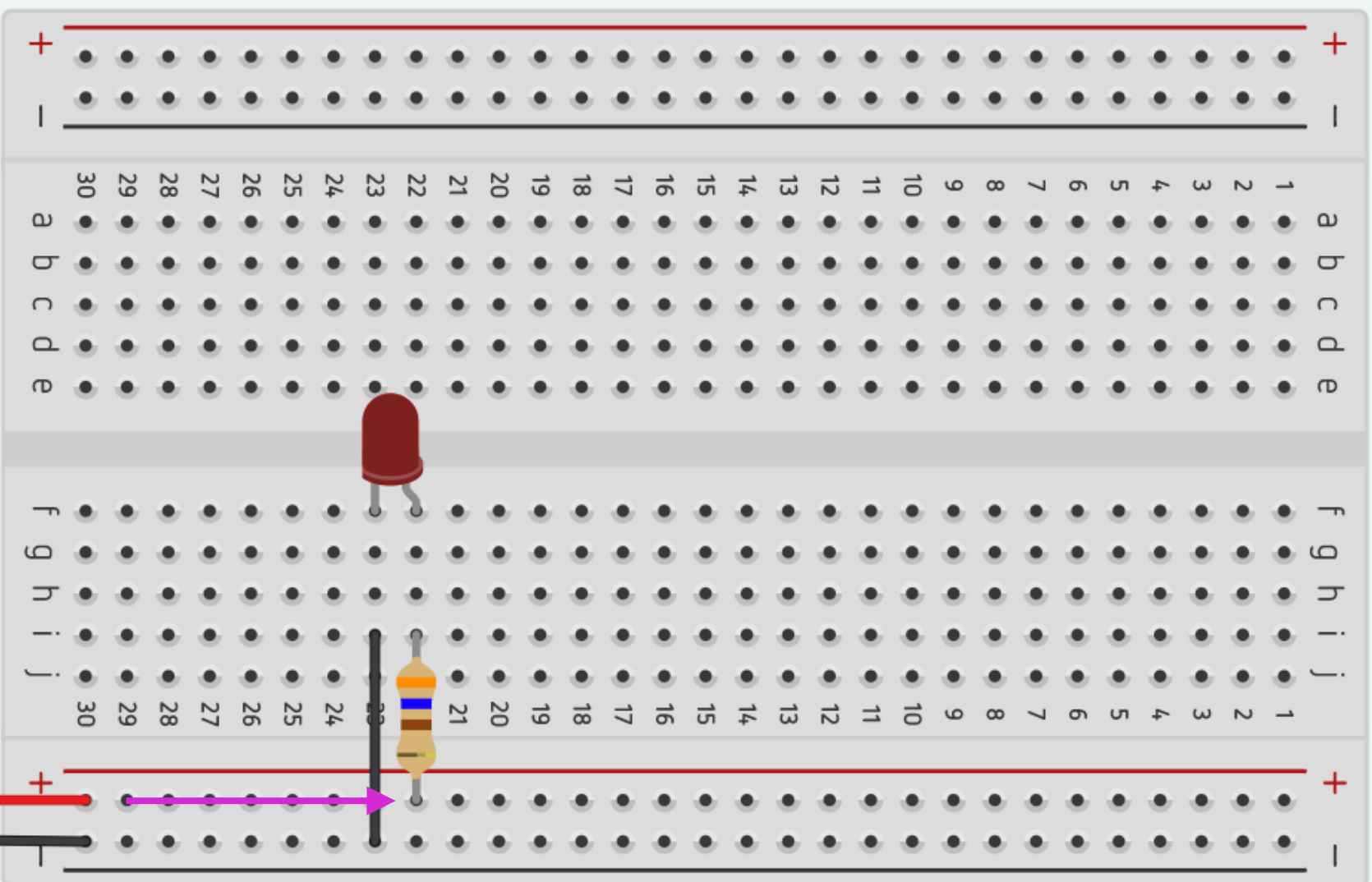
$V_f$  = LED forward voltage drop in Volts  
(found in the LED datasheet)

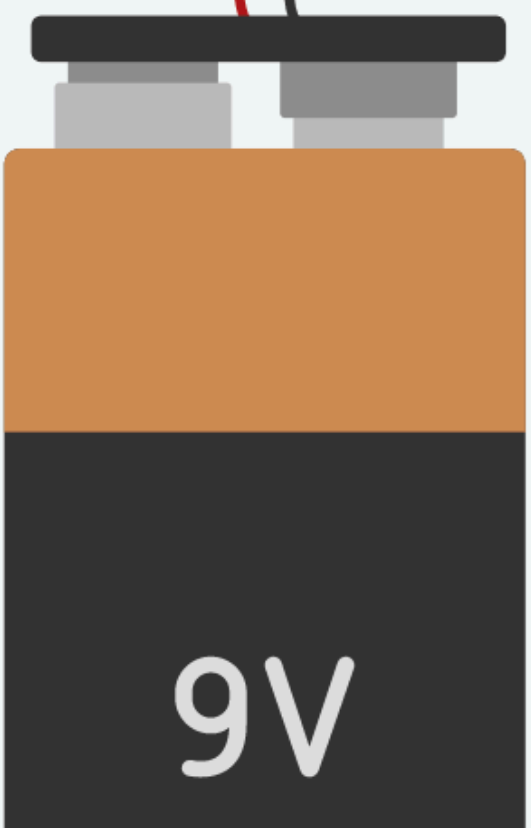
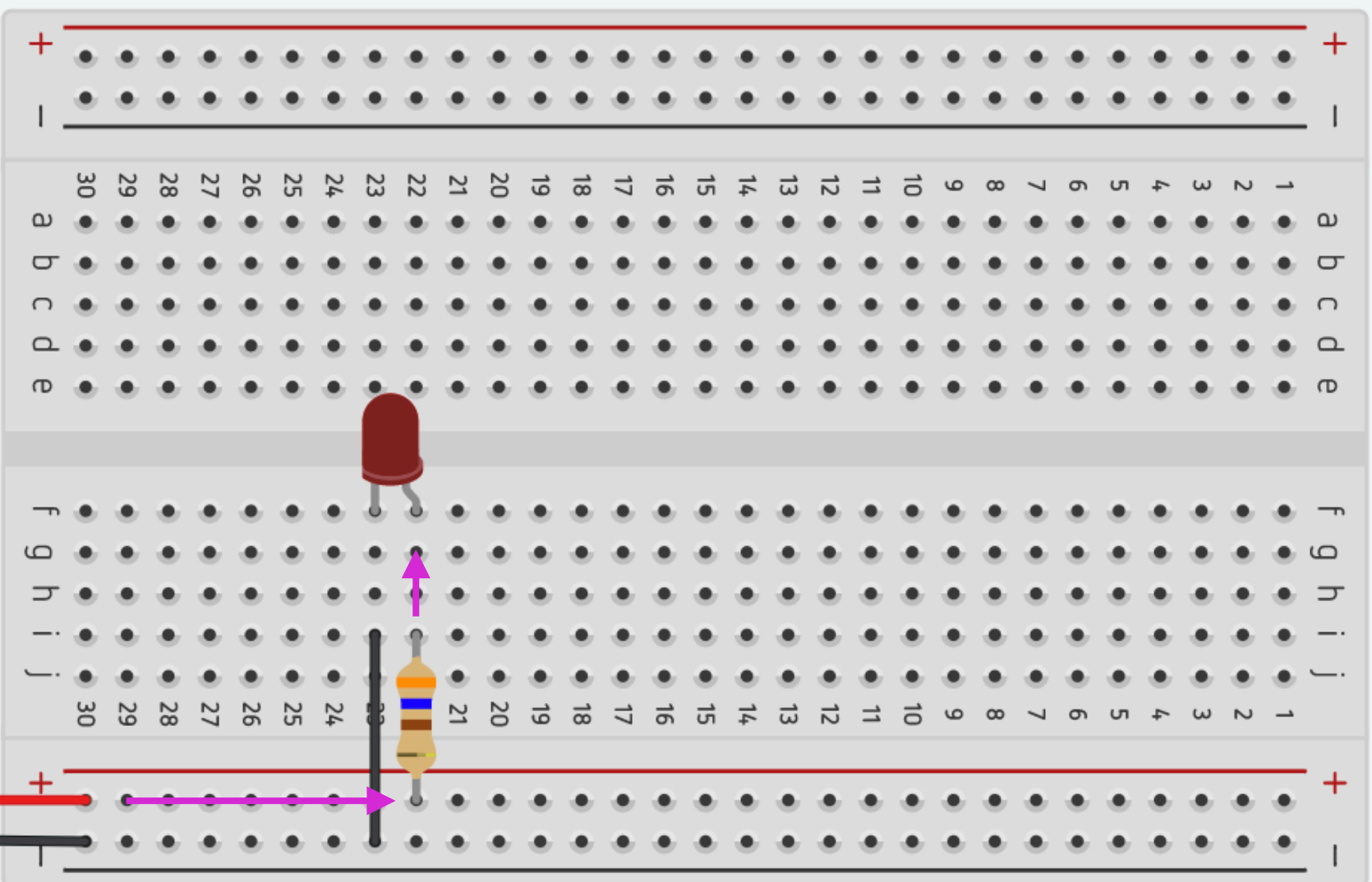
$V_s$  = supply voltage

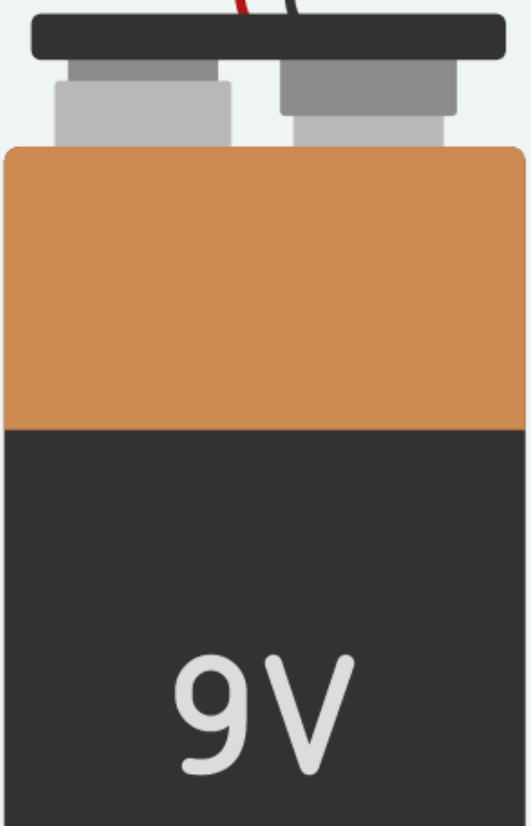
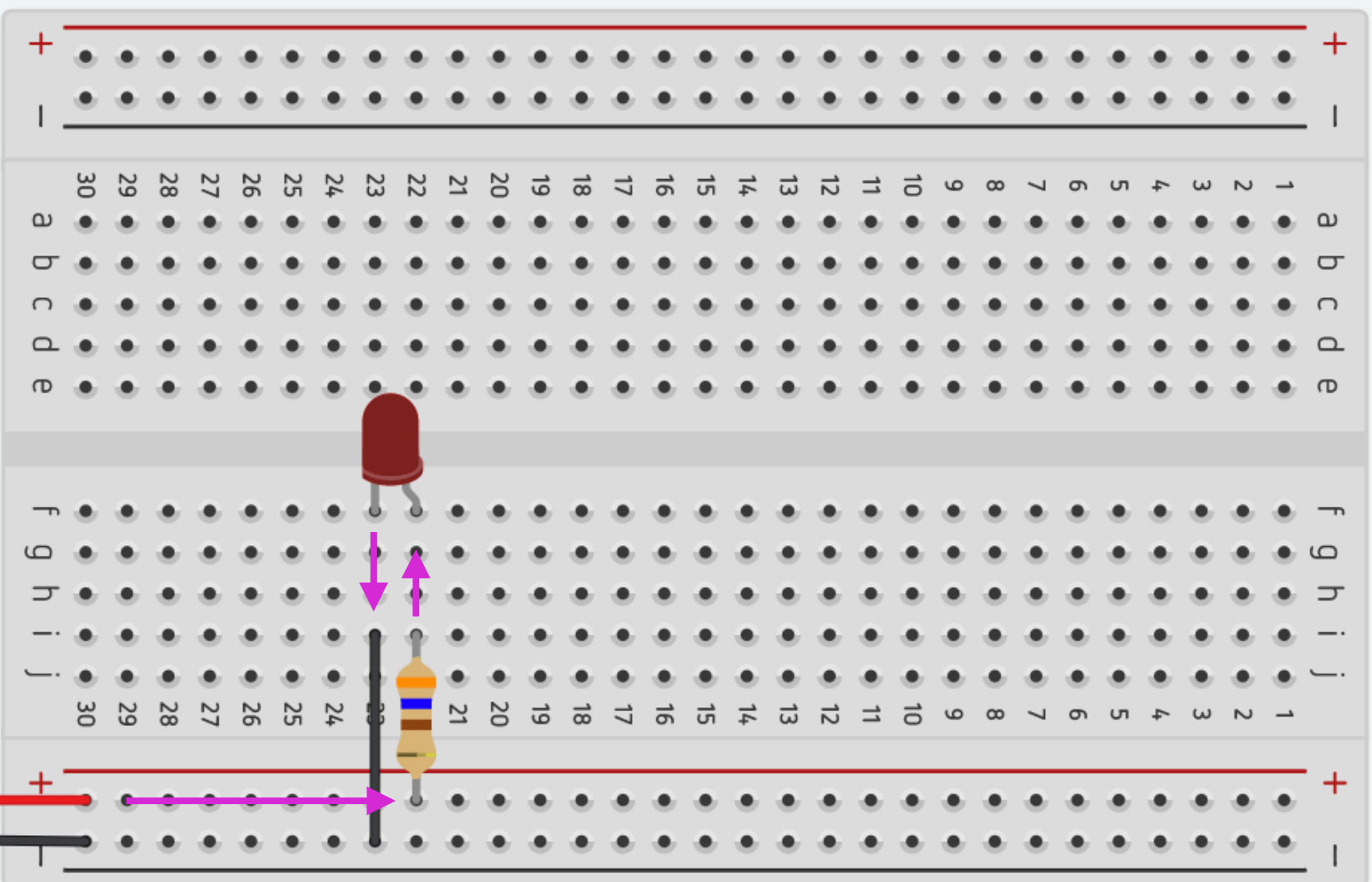
$$R = \frac{V_s - V_f}{i}$$

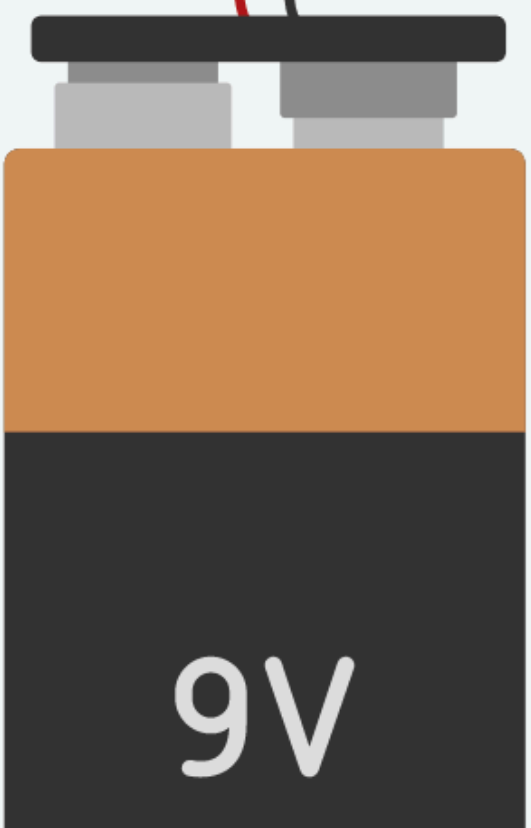
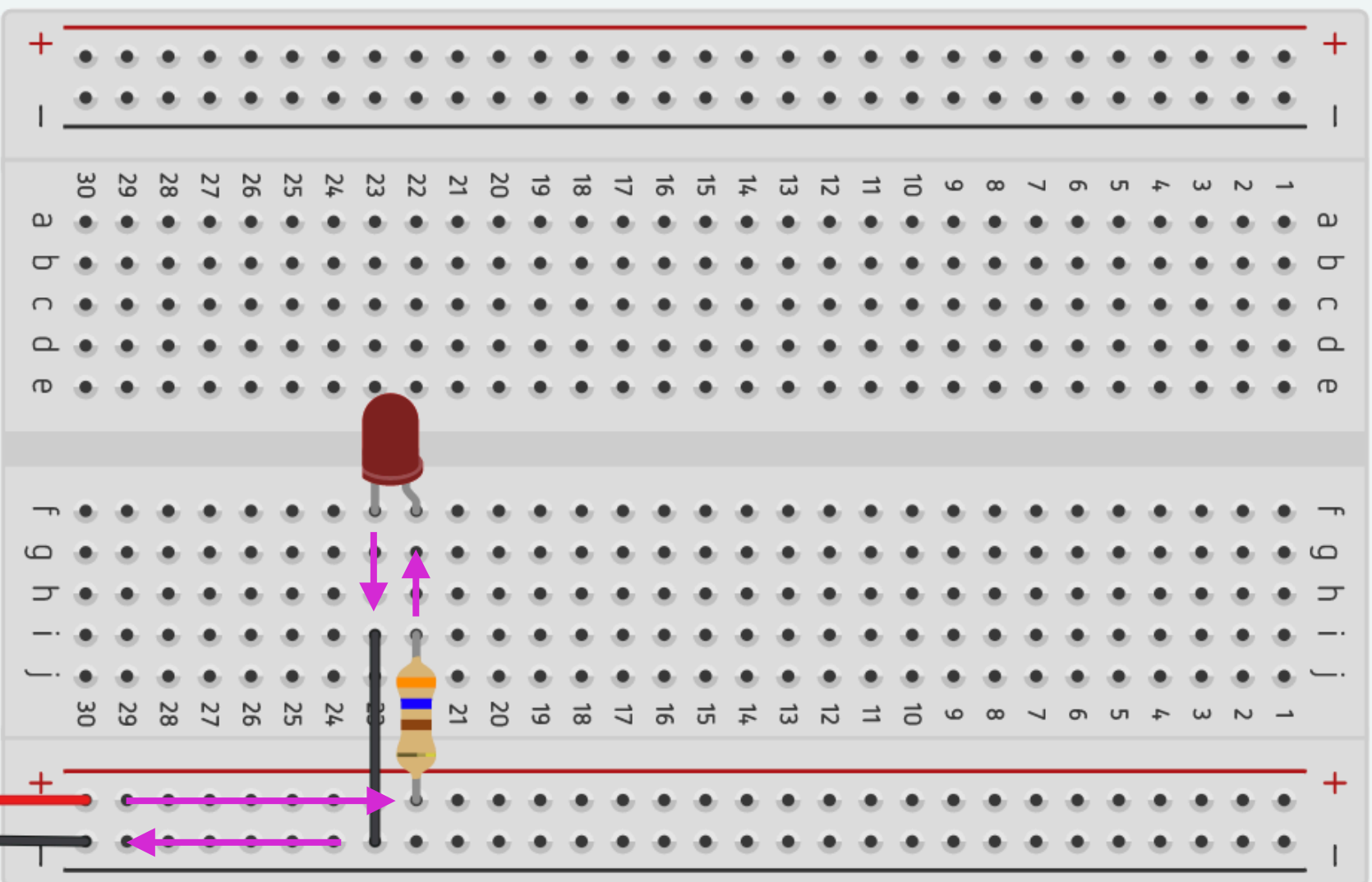
<https://ledcalculator.net/>





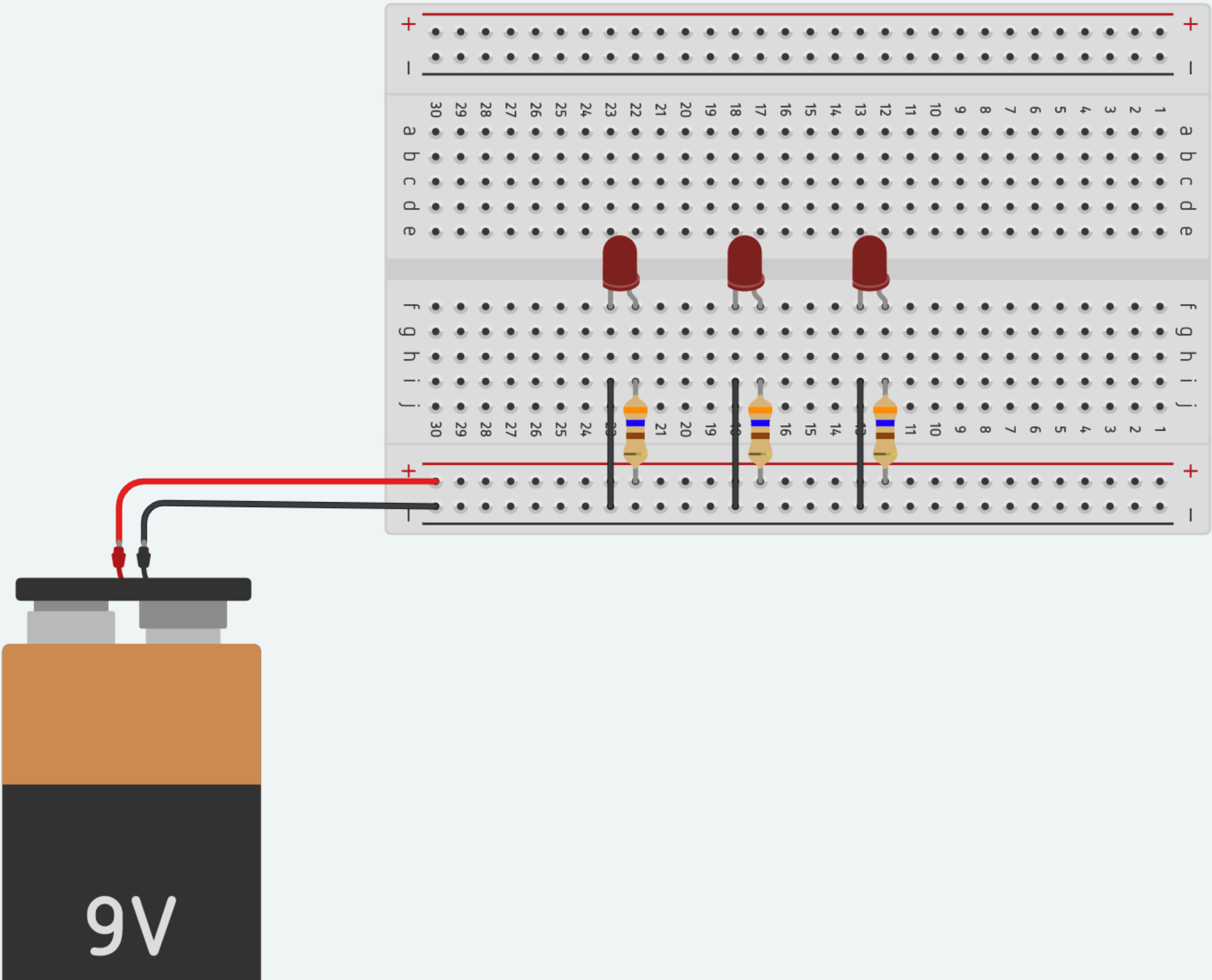




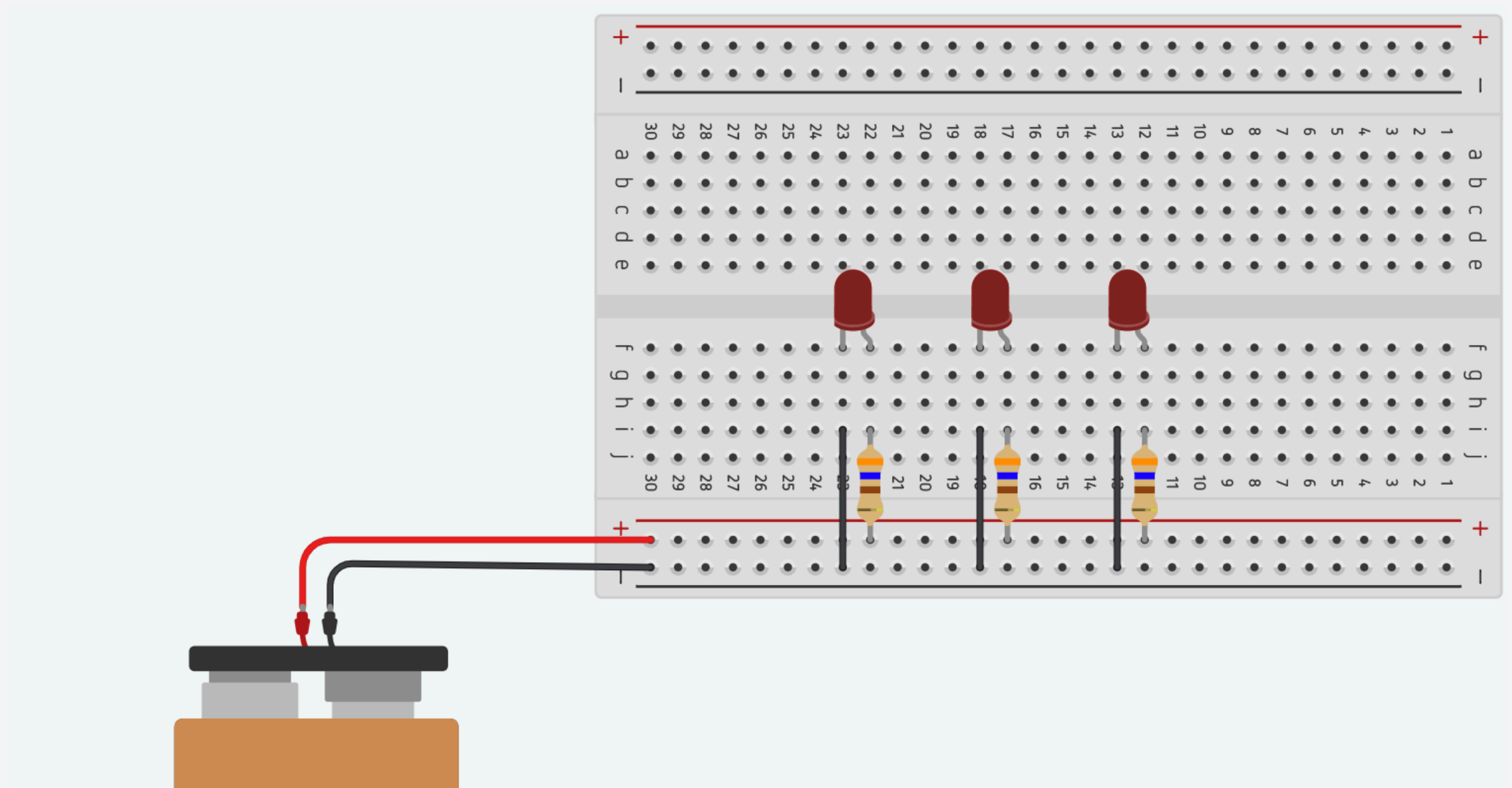


Try adding more LEDs

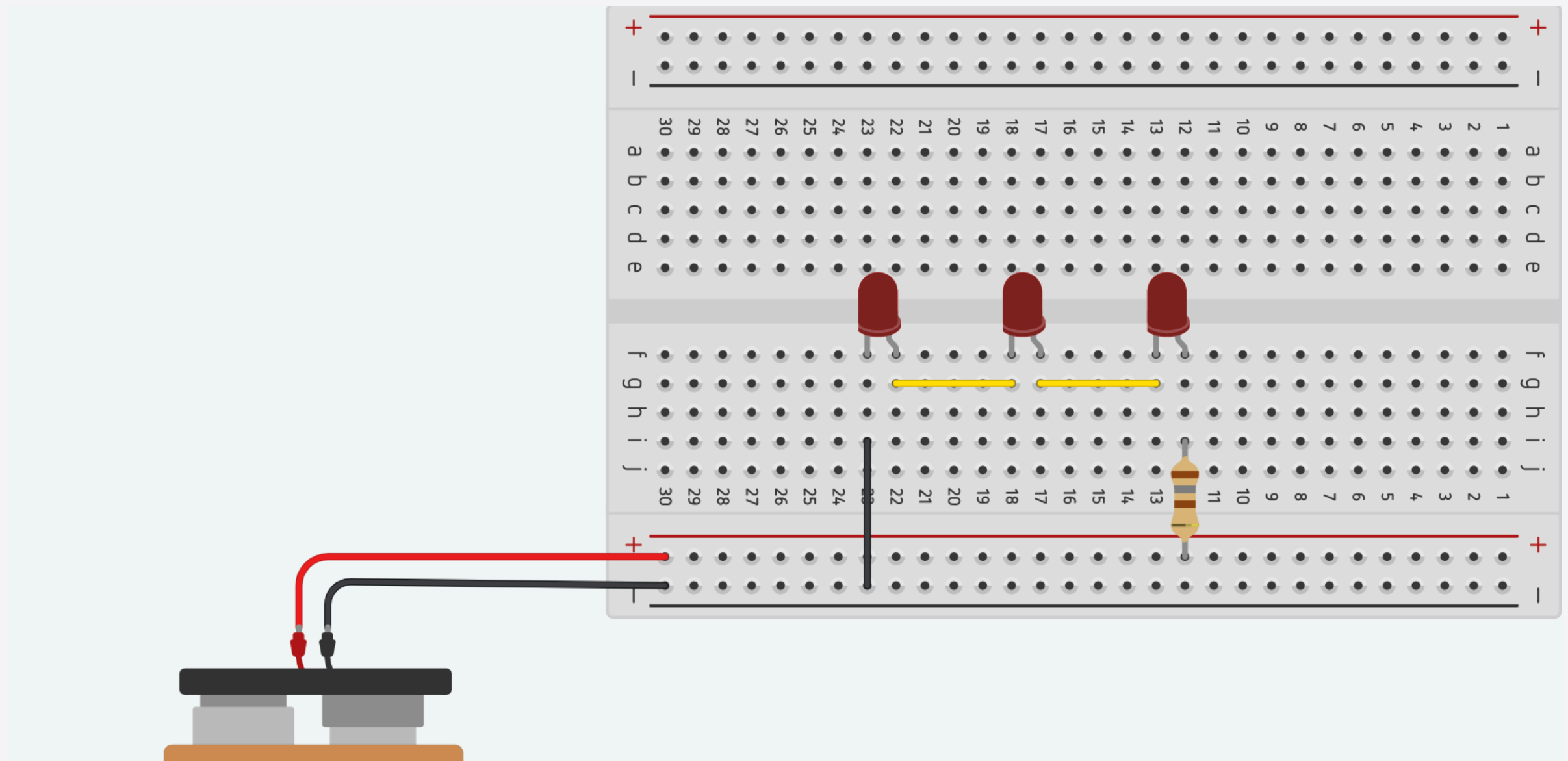




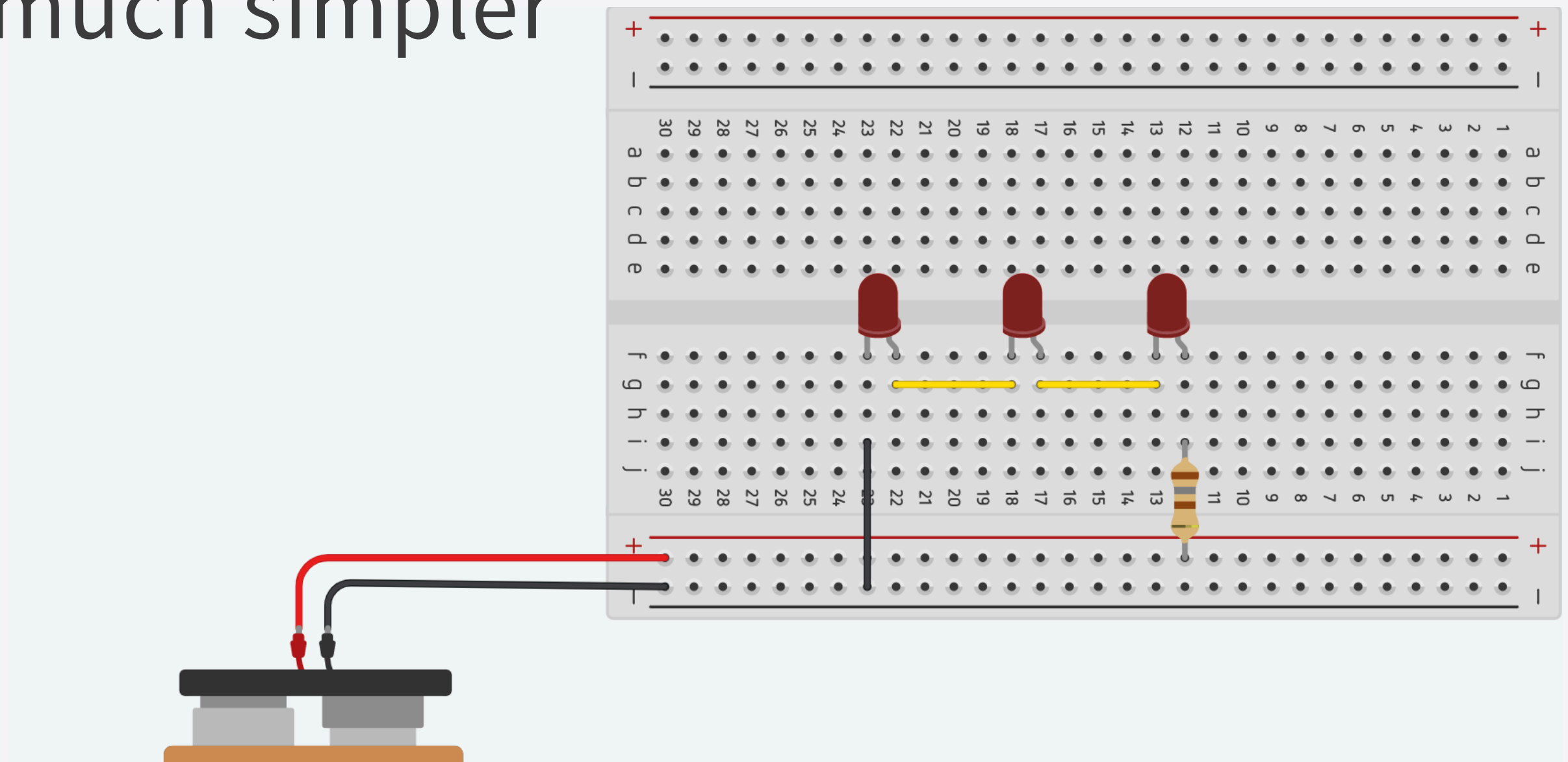
This layout is called parallel because it is as-if there are 3 separate circuits, one for each LED



You can also connect them in series, with each LED connected to the next, and a smaller resistor.

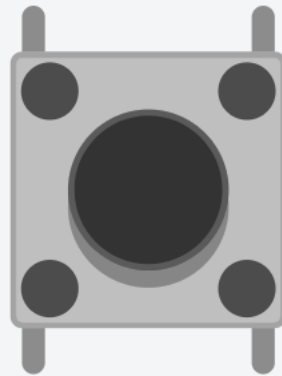


Connecting them in series is more likely to fail because if one component breaks, they all stop working, however it uses less components and the wiring is much simpler



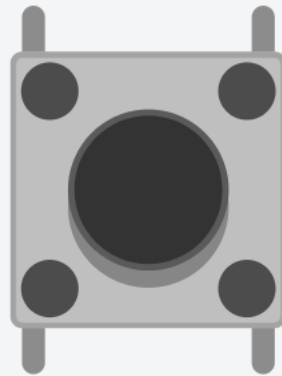
# Buttons

# Buttons



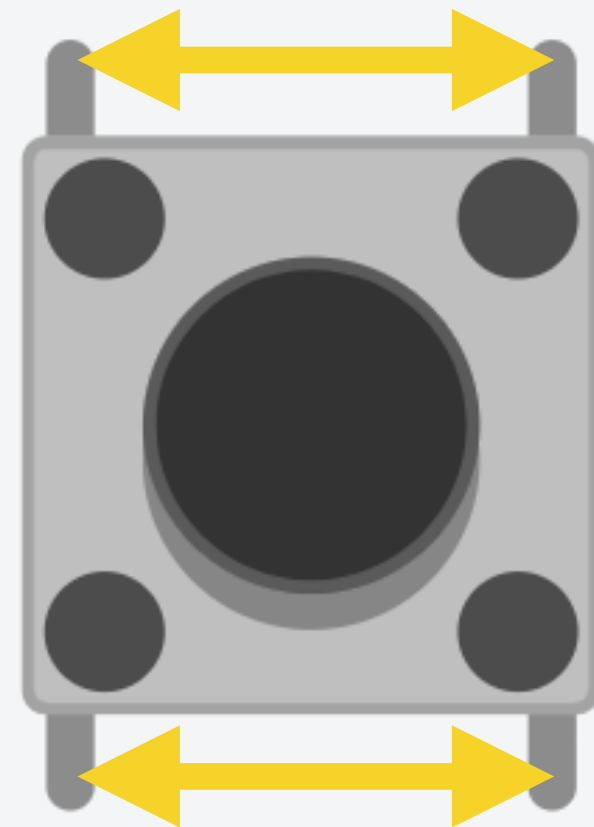
A button is a simple switch mechanism that completes or breaks a circuit when pushed.

# Buttons



Buttons typically come in two types normally closed (NC) and normally open (NO). NO buttons complete the circuit when pressed, NC buttons break the circuit when pressed.

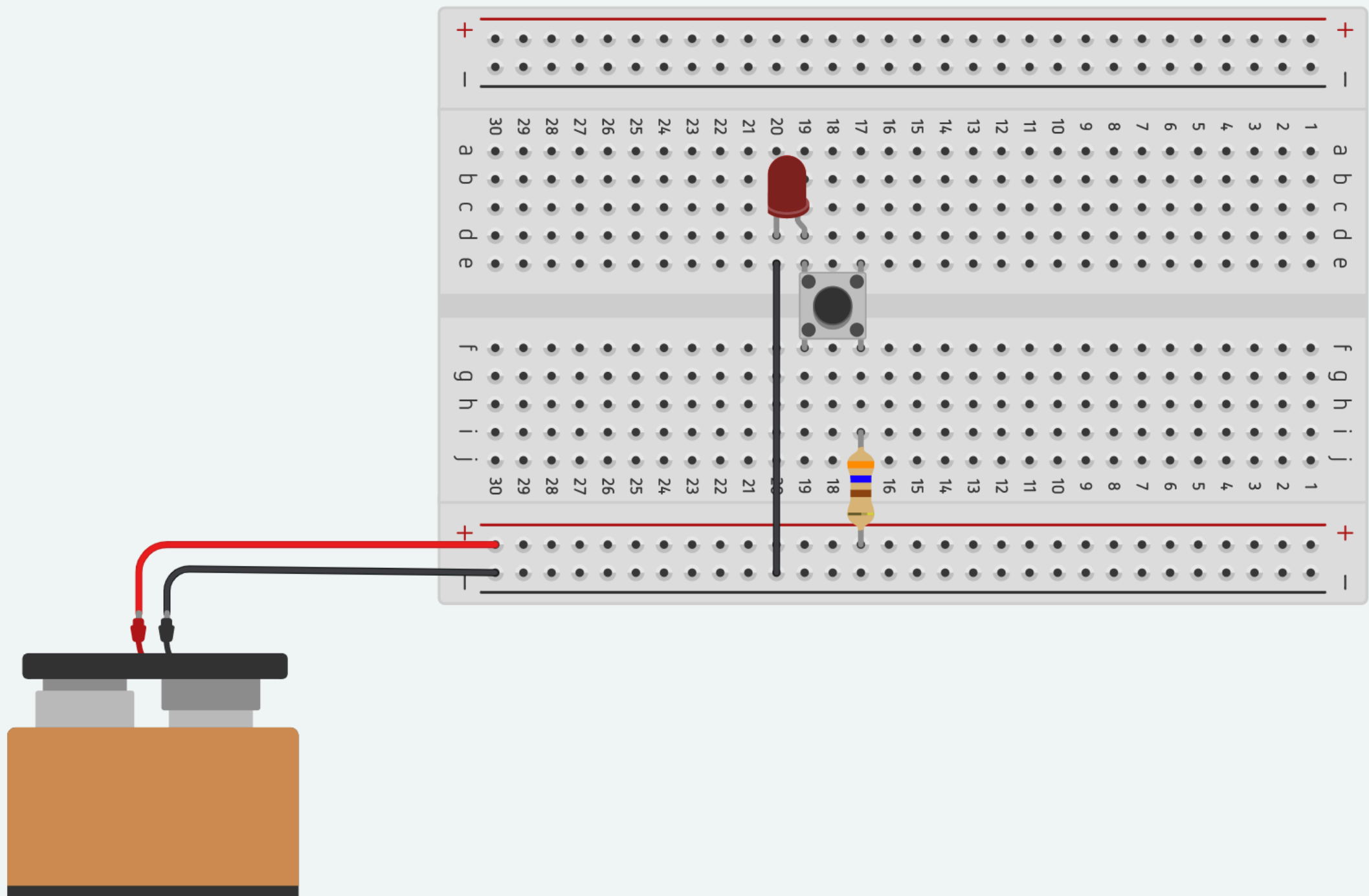
When pressed, a NO button connects the legs from one side to those on the other side. Most of the buttons we will use are NO



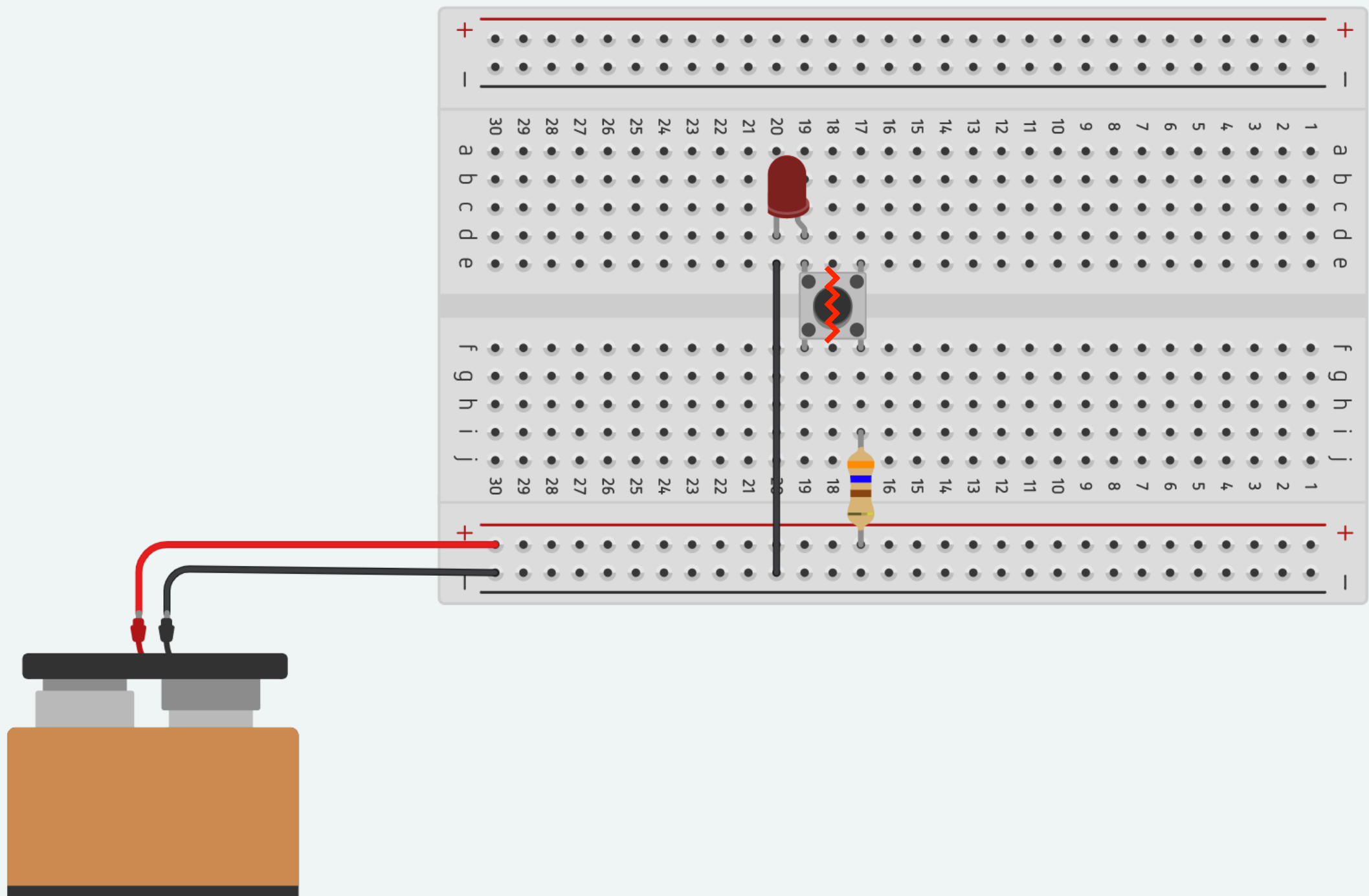


# Using Buttons (with LEDs)

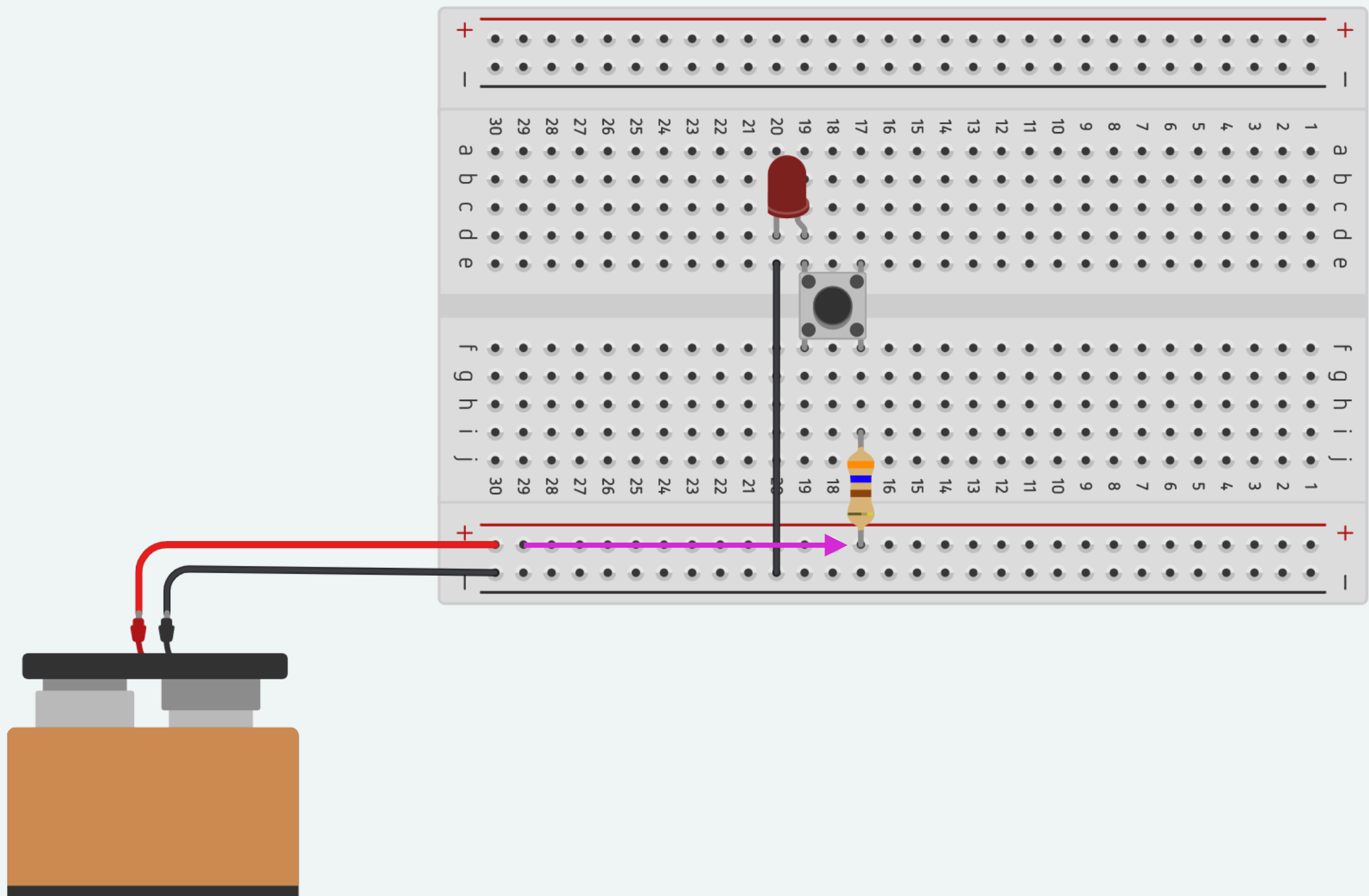
Our first LED circuit with a button.  
The LED will light when the button  
is pressed.



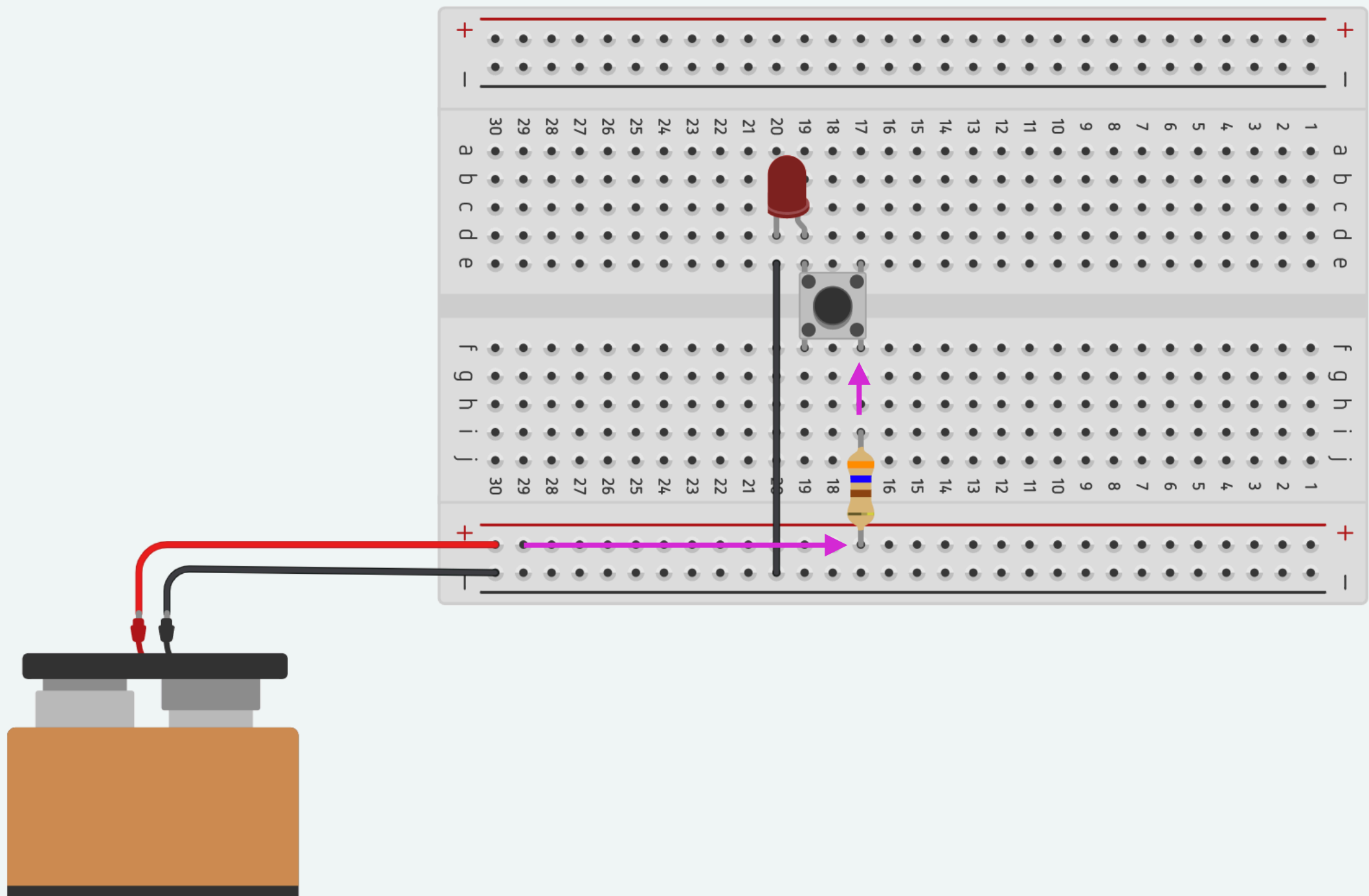
Our first LED circuit with a button.  
The LED will light when the button  
is pressed.



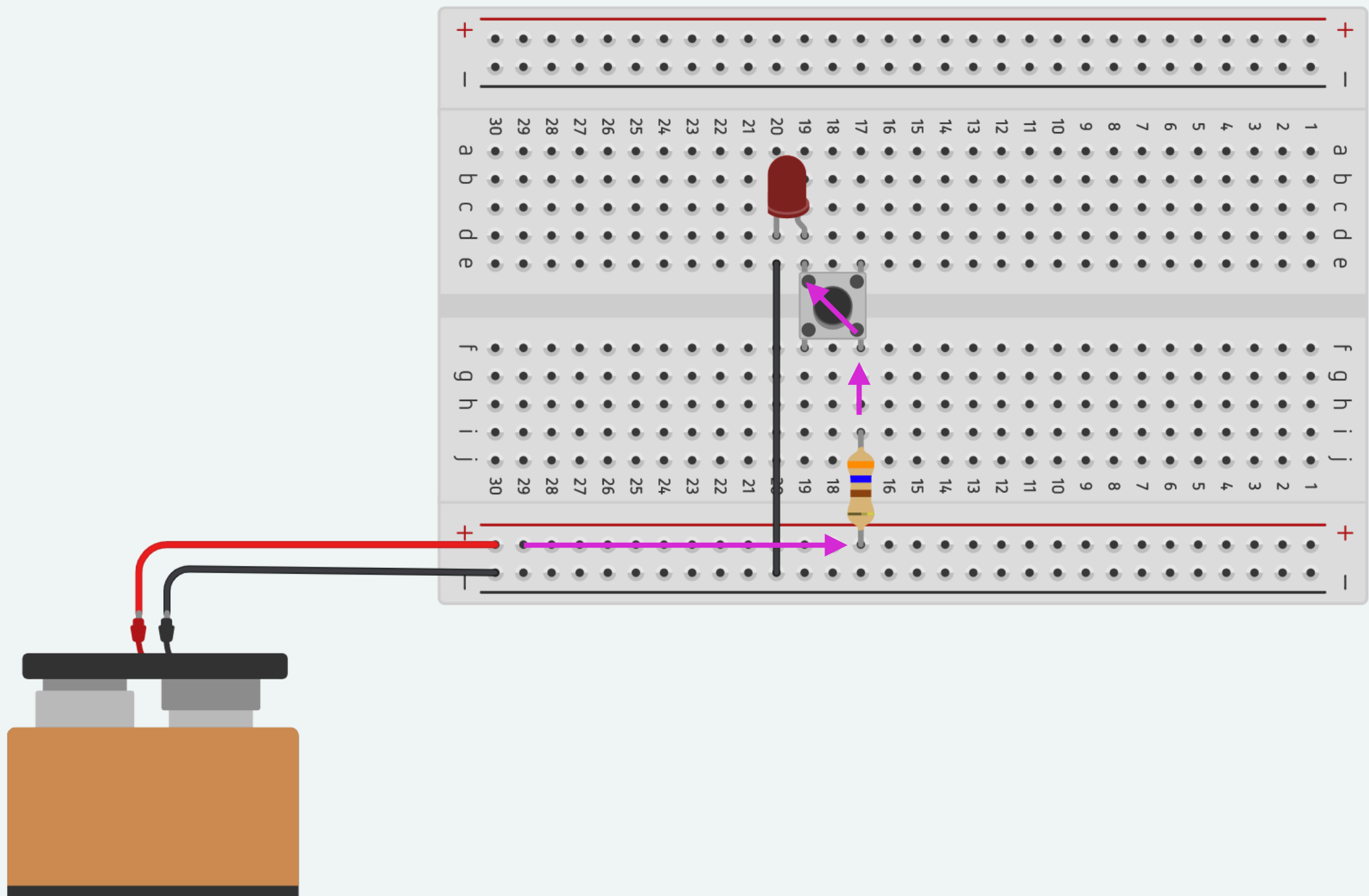
Our first LED circuit with a button.  
The LED will light when the button  
is pressed.



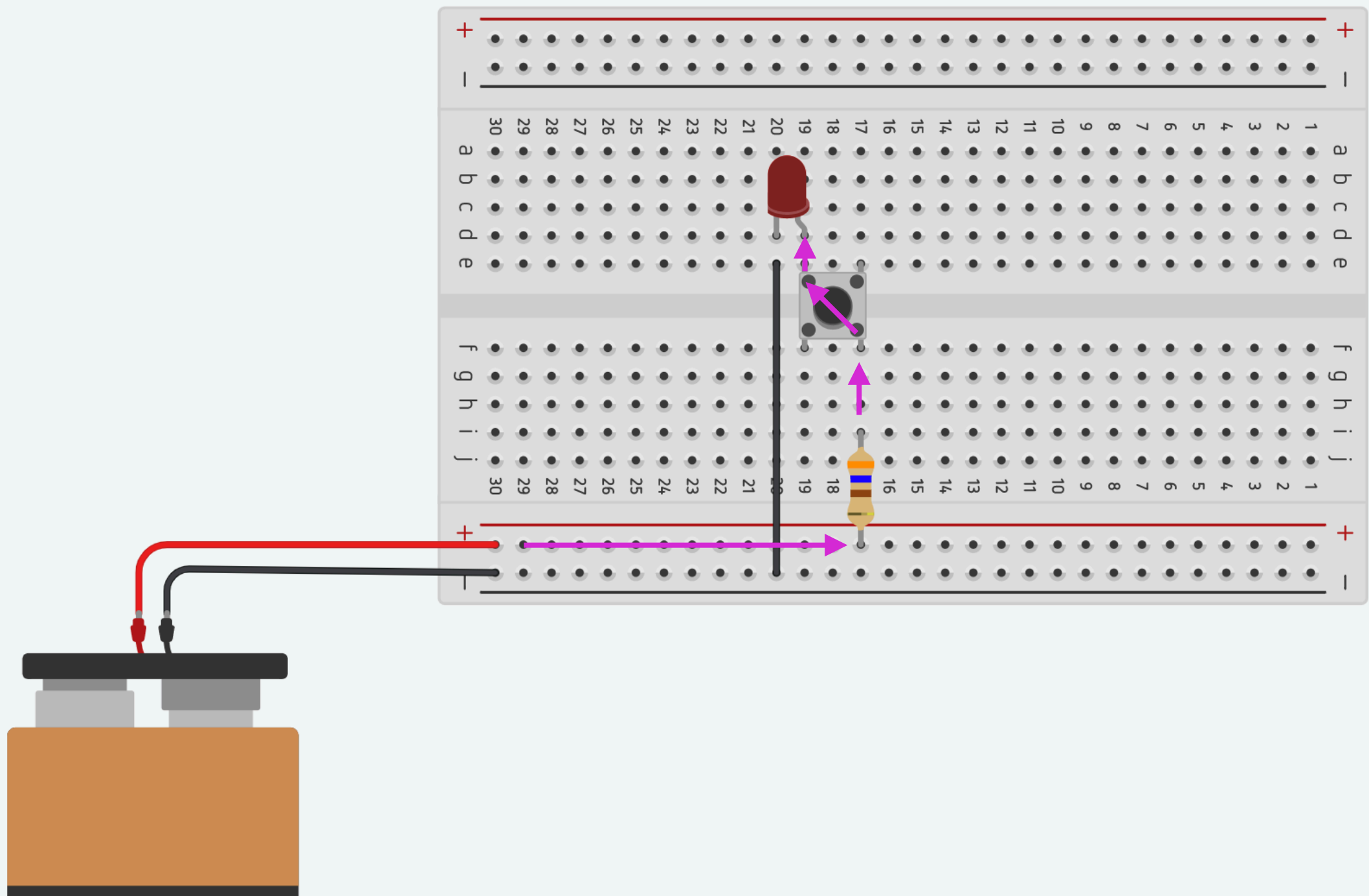
Our first LED circuit with a button.  
The LED will light when the button  
is pressed.



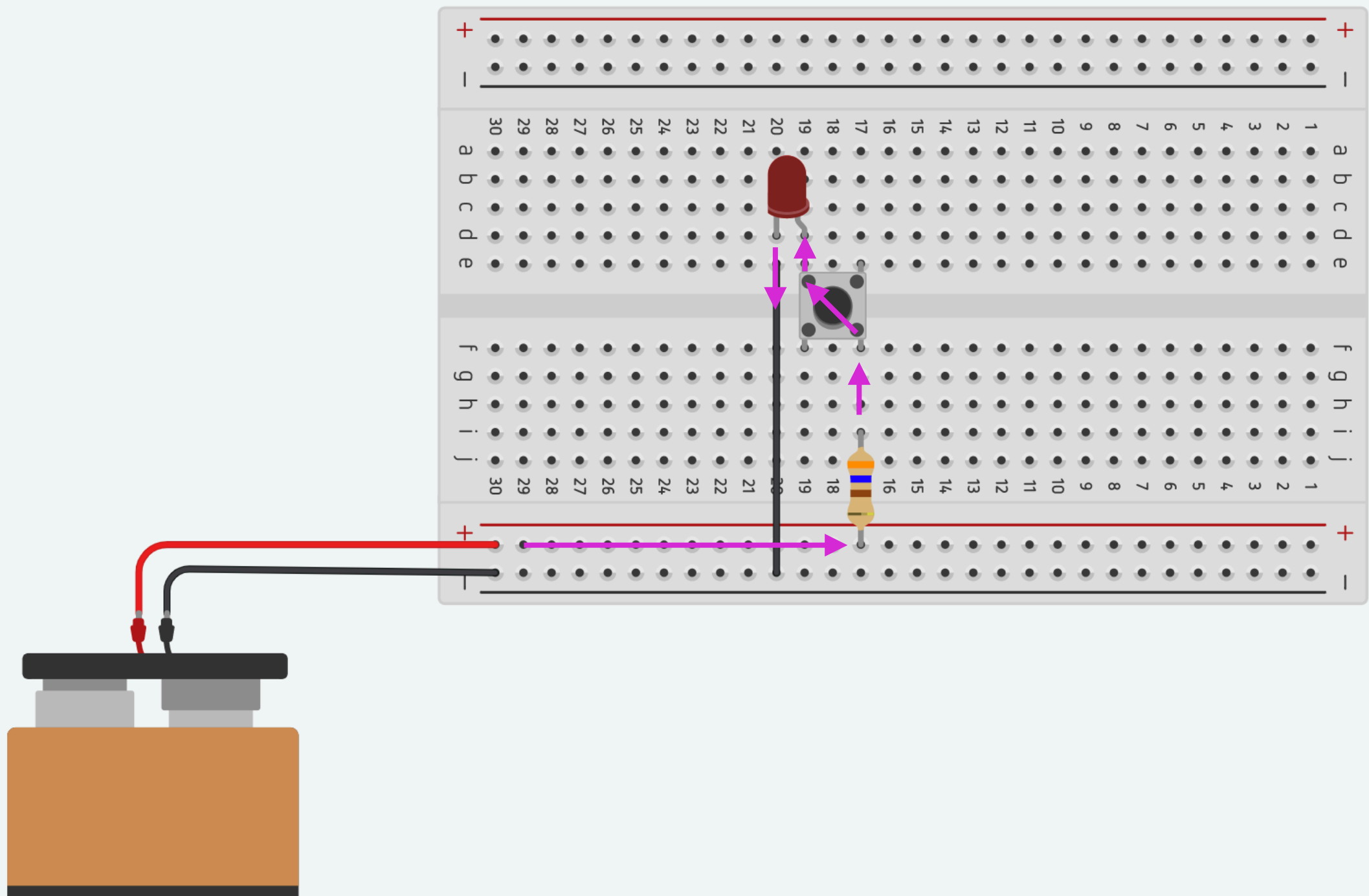
Our first LED circuit with a button.  
The LED will light when the button  
is pressed.



Our first LED circuit with a button.  
The LED will light when the button  
is pressed.

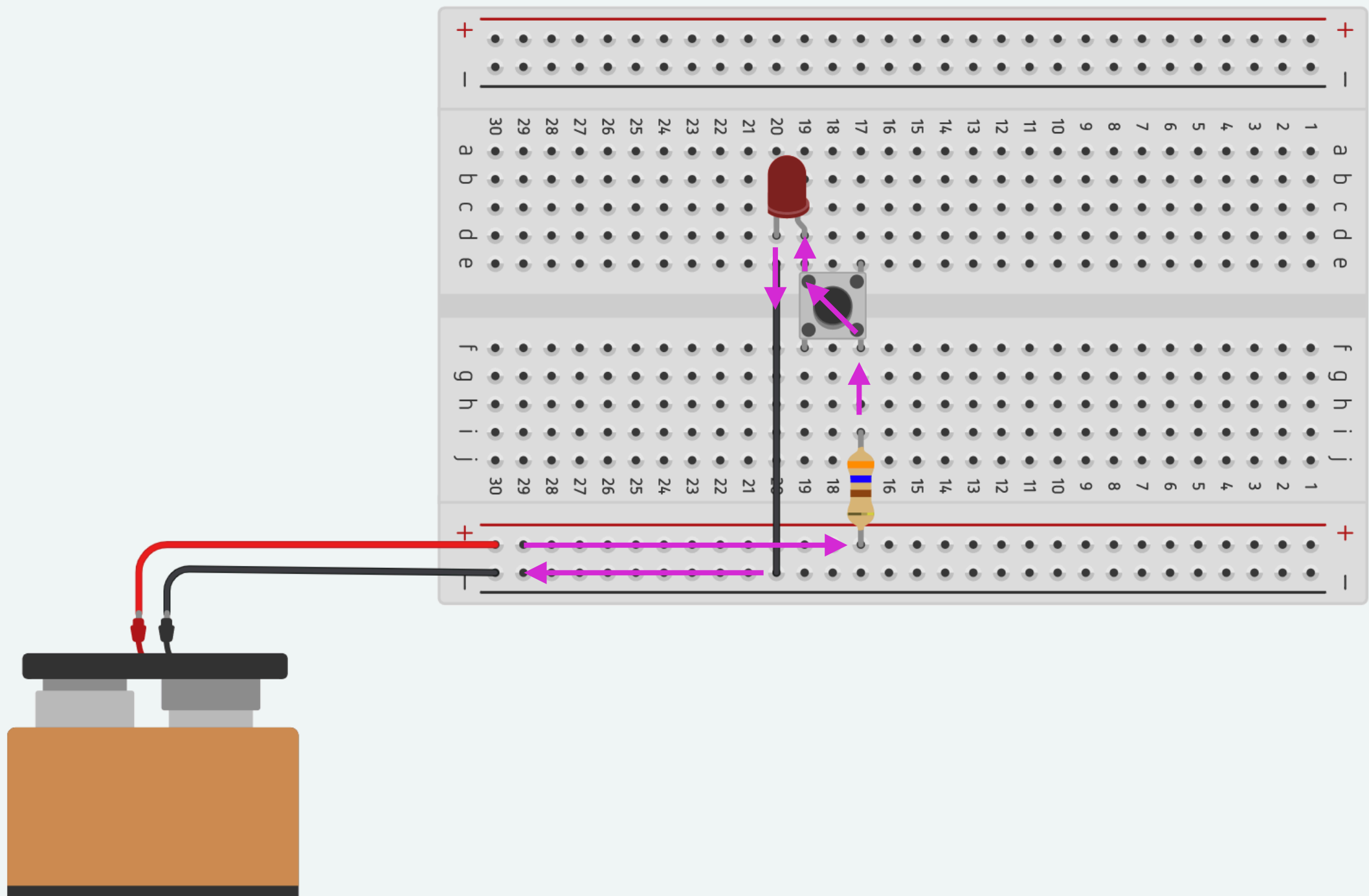


Our first LED circuit with a button.  
The LED will light when the button  
is pressed.





Our first LED circuit with a button.  
The LED will light when the button  
is pressed.



For Wednesday, try duplicating the button circuit to add more buttons and LEDs. Experiment with controlling multiple LEDs with one button, or using different buttons to control different colors or patterns.