Smart Textiles Techniques

Week 1: Basic electronic circuits

Electricity

Electricity is the flow of electrons through a conductor.

Electronics

The control of the flow of electricity.

AC vs DC

Alternating Current vs Direct Current

AC

Electricity flows in waves (cycles)
Flow can reverse
Good for high voltages & long distances
Comes directly from power outlets
Very dangerous! Can kill you.

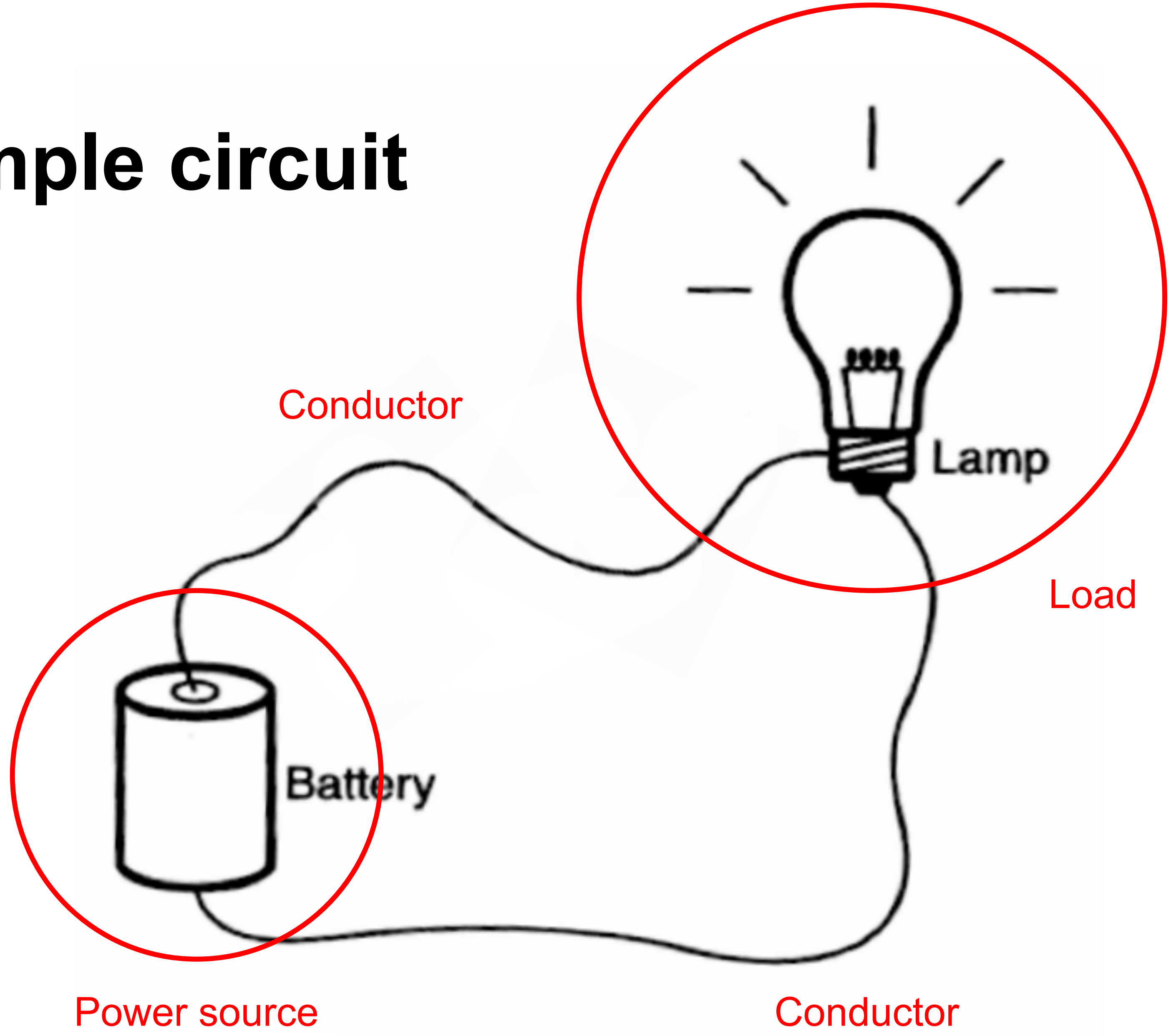
DC

Electricity flows in one direction
Good for low voltages
Used by common electronic devices
Can come from batteries or wall adapters
Typically much safer than AC

Electronic circuit

Interconnected electronic components which manage the flow of electricity.

Simple circuit

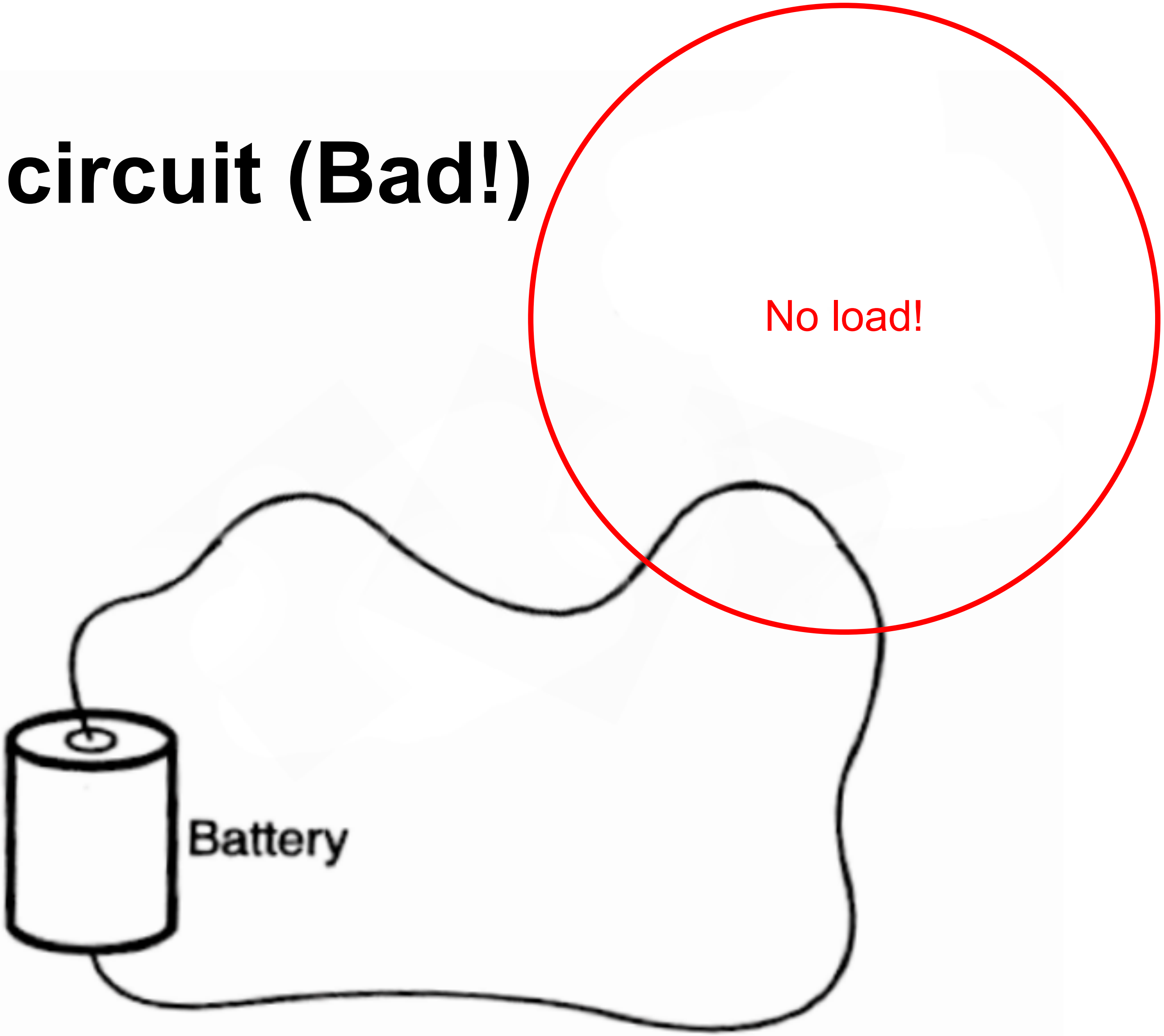


Load

Part of the circuit which does the work.

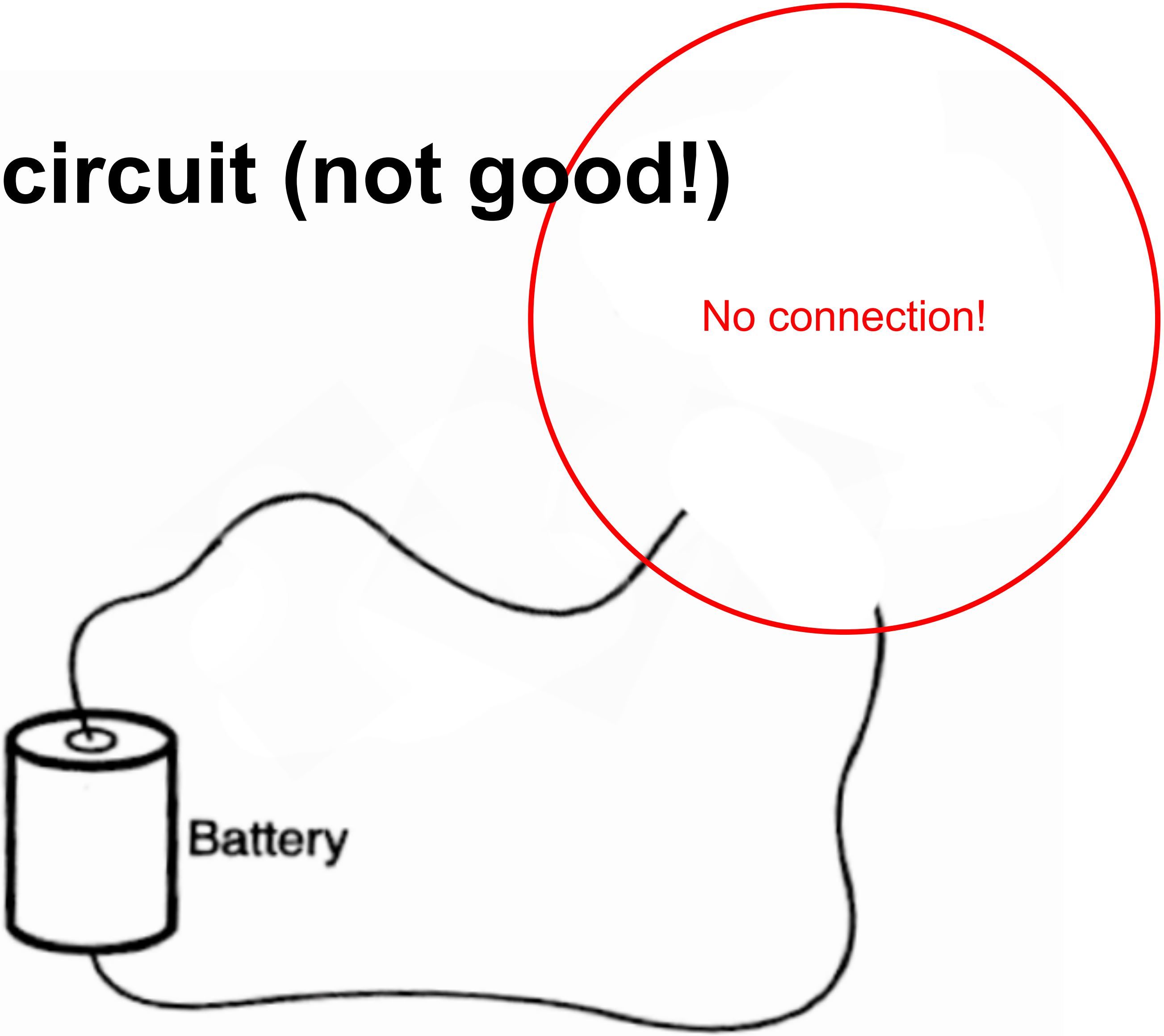
This could be a light, motor, etc.

Short circuit (Bad!)



Results in a rapid buildup of heat!

Open circuit (not good!)



Circuit will not work!

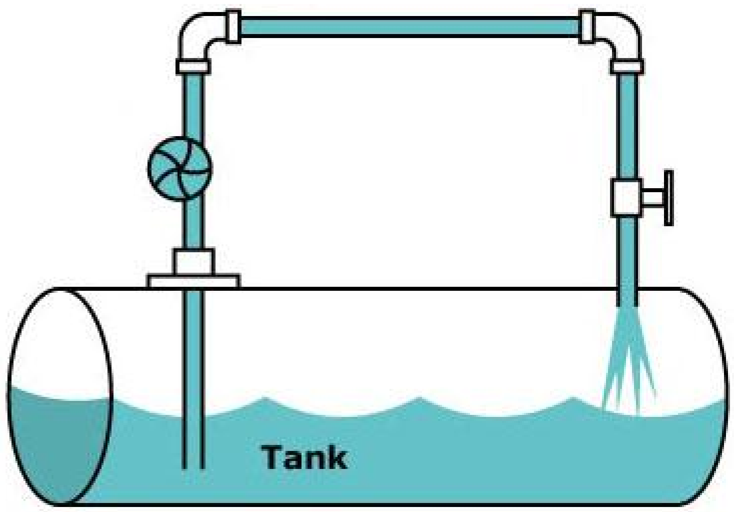
Basic properties of electricity

Voltage, resistance, and current.

All of these properties have mutual influence over one another in a circuit.

Water analogy

We can use a simple analogy to understand the basic electrical properties within a circuit.



Water pump = battery

Pipe = wire

Valve = electronic part

Water = electrons

Voltage

The amount of pressure produced by the pump which drives water through the pipes.

Voltages is measured in volts (V).

The standard Arduino needs 5V of electricity. No more. No less.

Current

The amount of water flowing through a given point in a pipe.

Current is measured in amps (A).

Since we'll often be dealing with very low current, the range will typically be measured in milliamps (mA).

.001A = 1mA or 1A = 1000mA

Resistance

This is the faucet. When we tighten the faucet it reduces the water pressure flowing through.

Resistance is measured in Ohms (Ω).

1 Ohm, 10 ohms, 100 ohms…

1 Kilohm (1KΩ) = 1000 ohms

1 Megohm (1MΩ) = 1 million ohms

Power

This is the water being used to do something (like spin a water wheel, wash your car, water your plants, etc.)

Power is the actual amount work which can be done by a circuit.

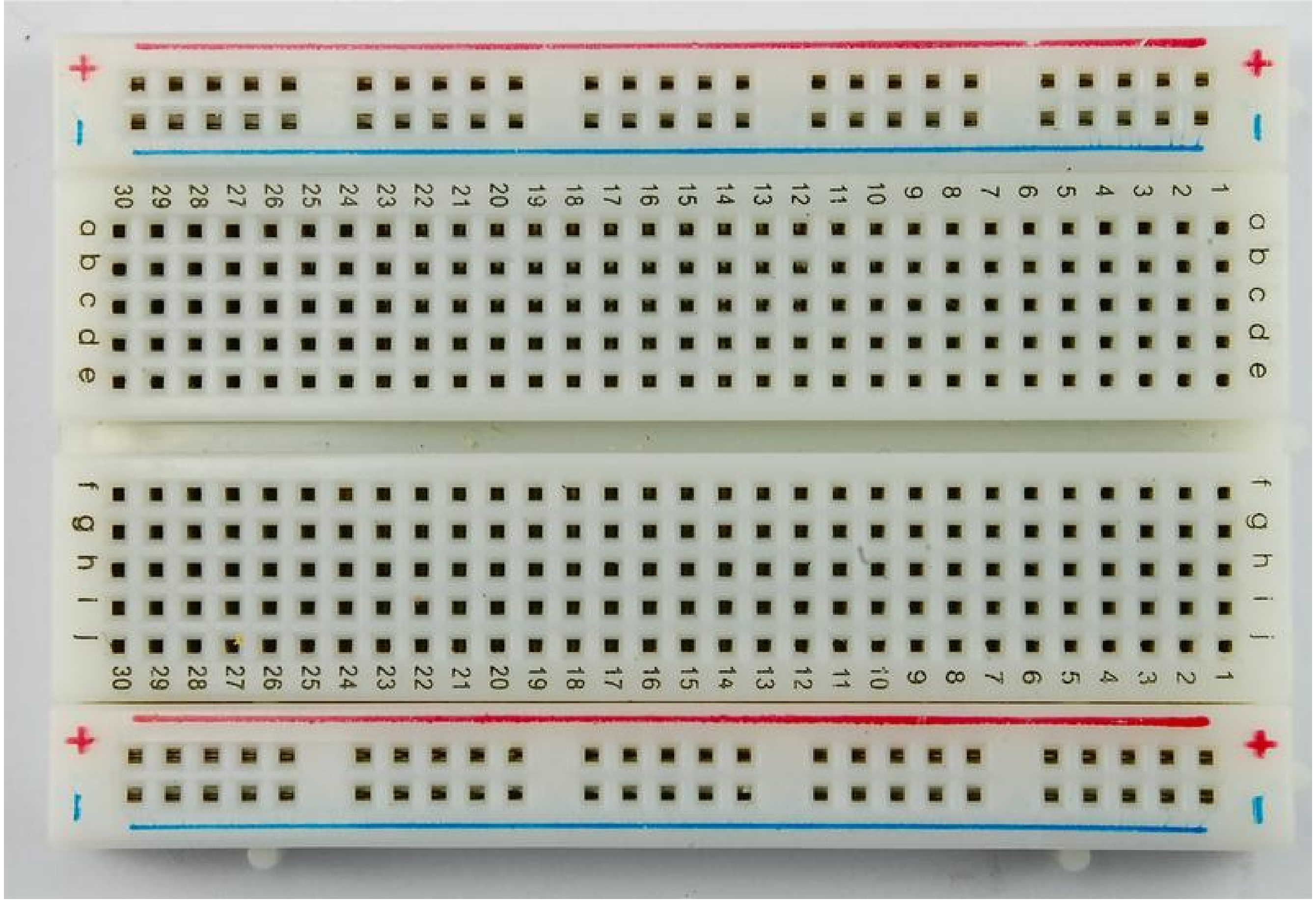
If we were engineers, we'd be much more concerned with this than we will be in here...

Prototyping circuits

Let’s do this together!

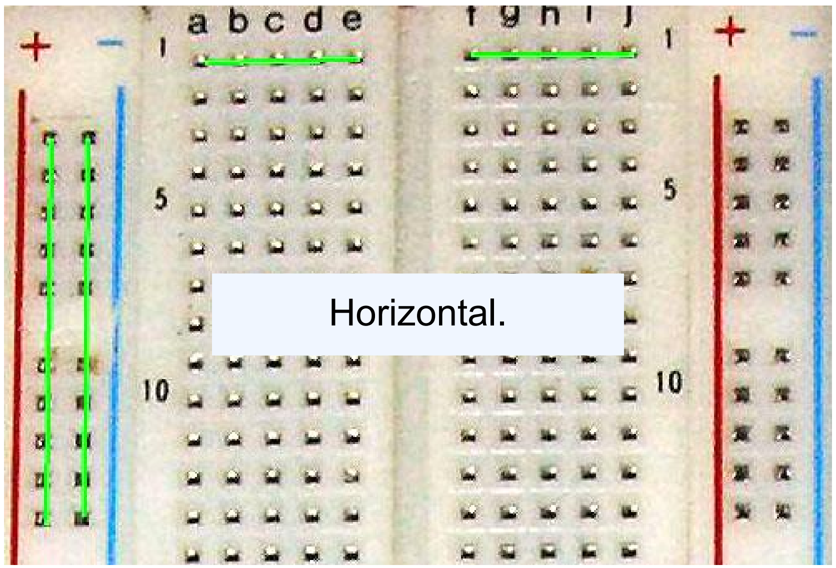
Prototype some basic circuits using common tools and materials.

Breadboard

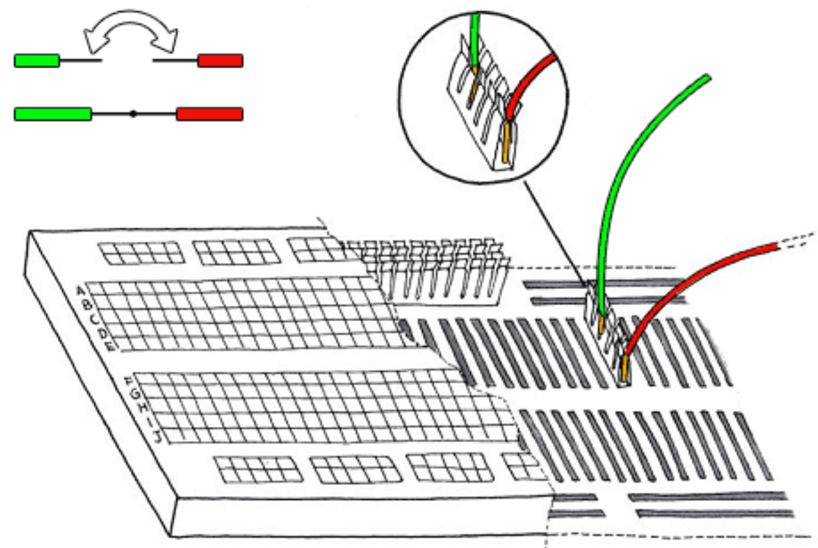


+
-
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
a b c d e
f g h i j
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
+
-

Breadboard connections



Horizontal.



Vertical

Wire

Wire strippers & wire cutters

Battery & battery snap

Battery polarity

A battery is a polarized component.

Sometimes this is referred to as…

POSITIVE & NEGATIVE (+ & -)
POWER & GROUND (9V & GND)

By convention, the color RED is associated with POWER, and BLACK/BLUE with GROUND.

This is only a convention!

This is not a hard rule!

Be sure to double check all connections

Multimeter

An instrument which can be used to test properties of an electronic circuit.

Multimeters are also useful for testing connections (continuity) within a circuit.

Use multimeter to check battery!

Turn dial to smallest DC voltage range (V with 2 straight lines).

If the display says just 1 or 0L, choose the next highest range.

How much voltage is *actually* being provided by your battery?

Adding power to a breadboard

Let’s do this together!

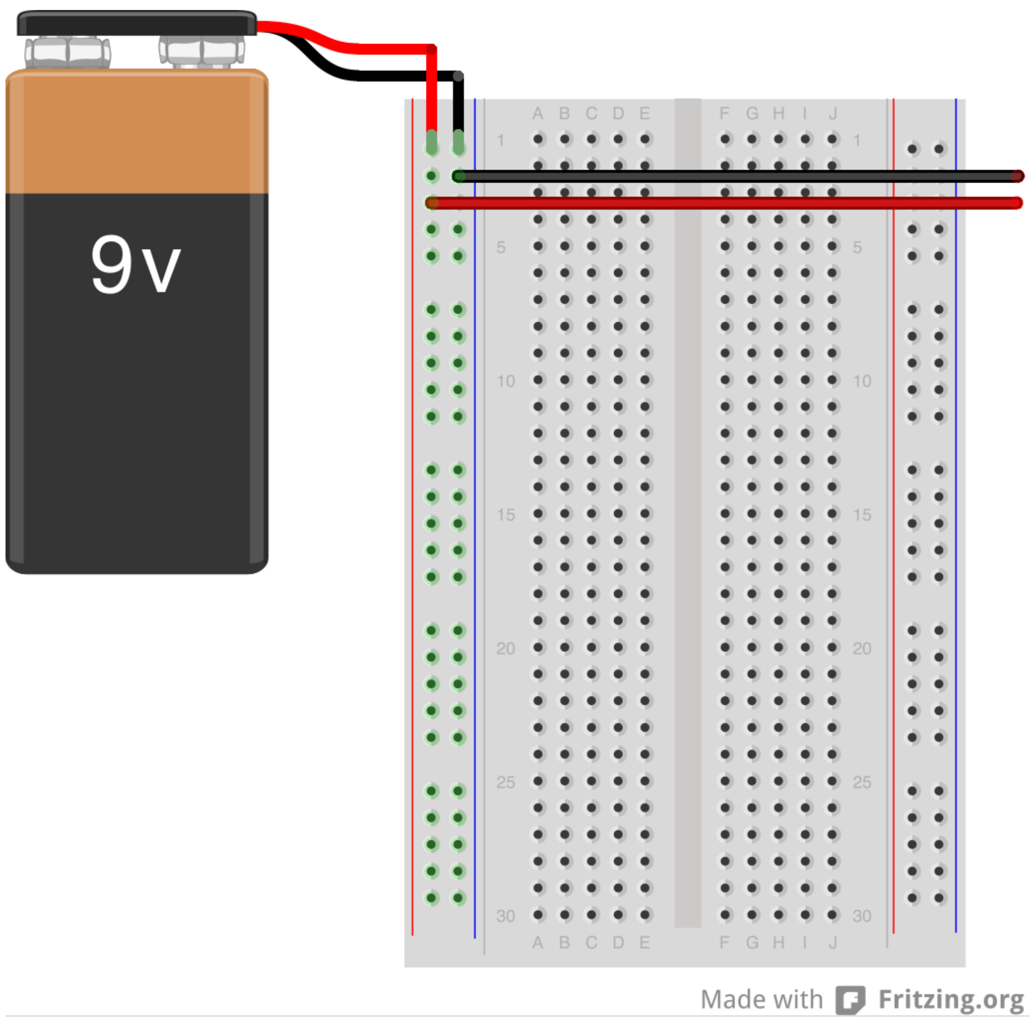
Connect battery to battery snap.

Connect battery snap to breadboard.

Connect wires to our + and - busses.

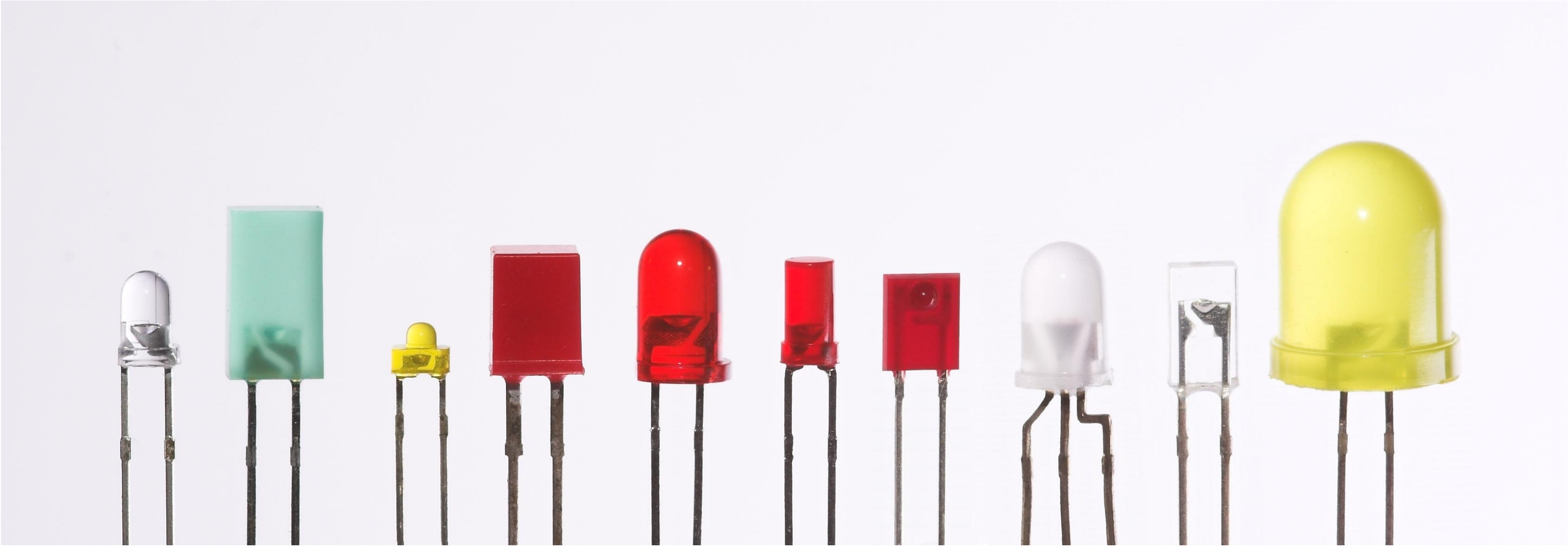
Use multimeter to check voltage.

Connecting battery

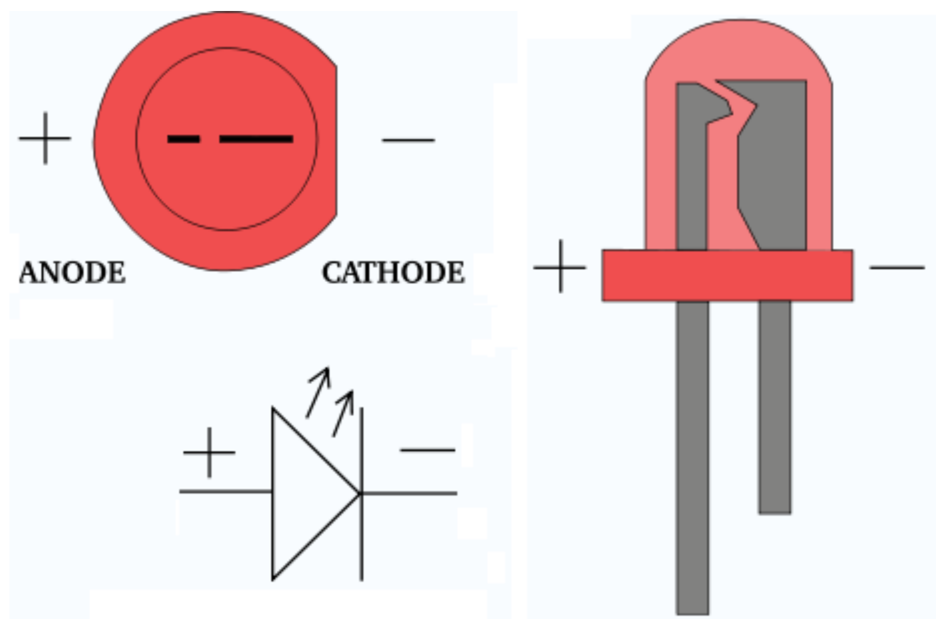


Use the multimeter to check the voltage coming from the two wires.

Light Emitting Diode (LED)

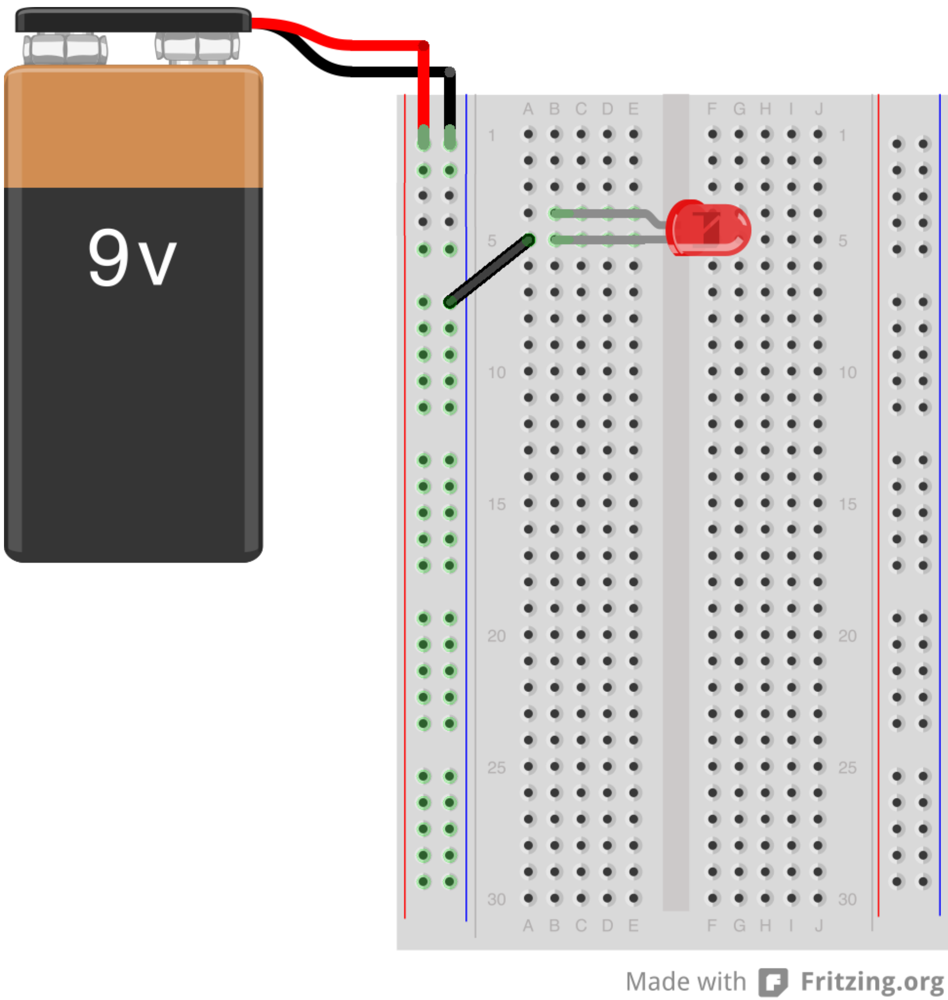


LED polarity



Always orient the LED so that cathode is closer to GROUND/-

Adding LED to breadboard

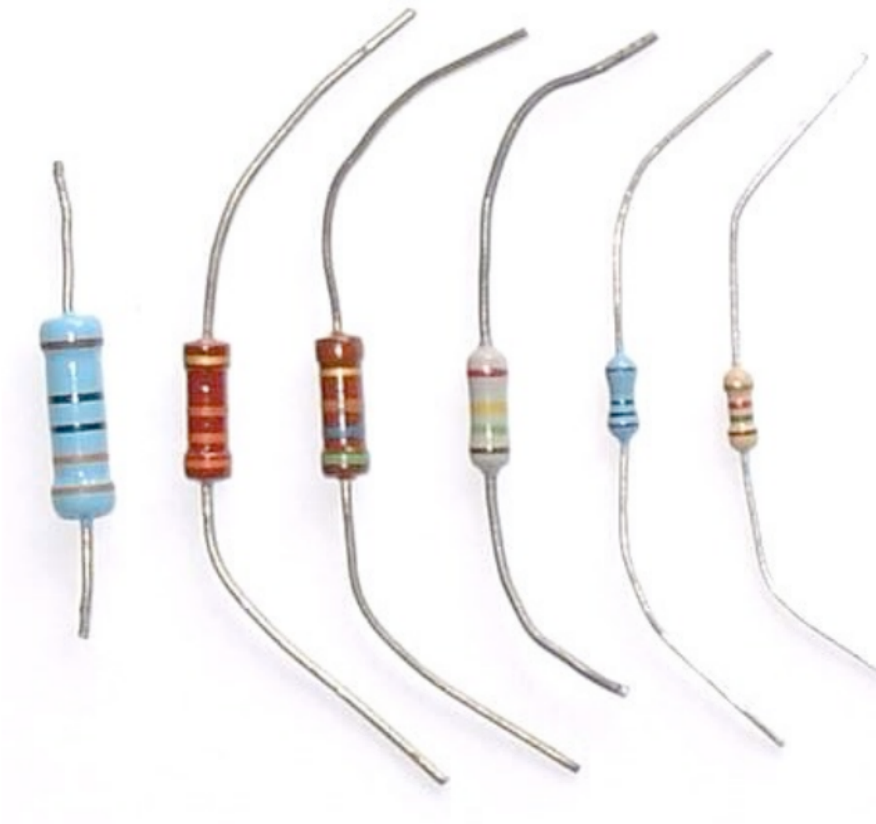


Important!

Notice that only one leg is connected to the power bus.

Do not connect the second leg… yet!

Resistors



Various materials, sizes, and colors of resistors

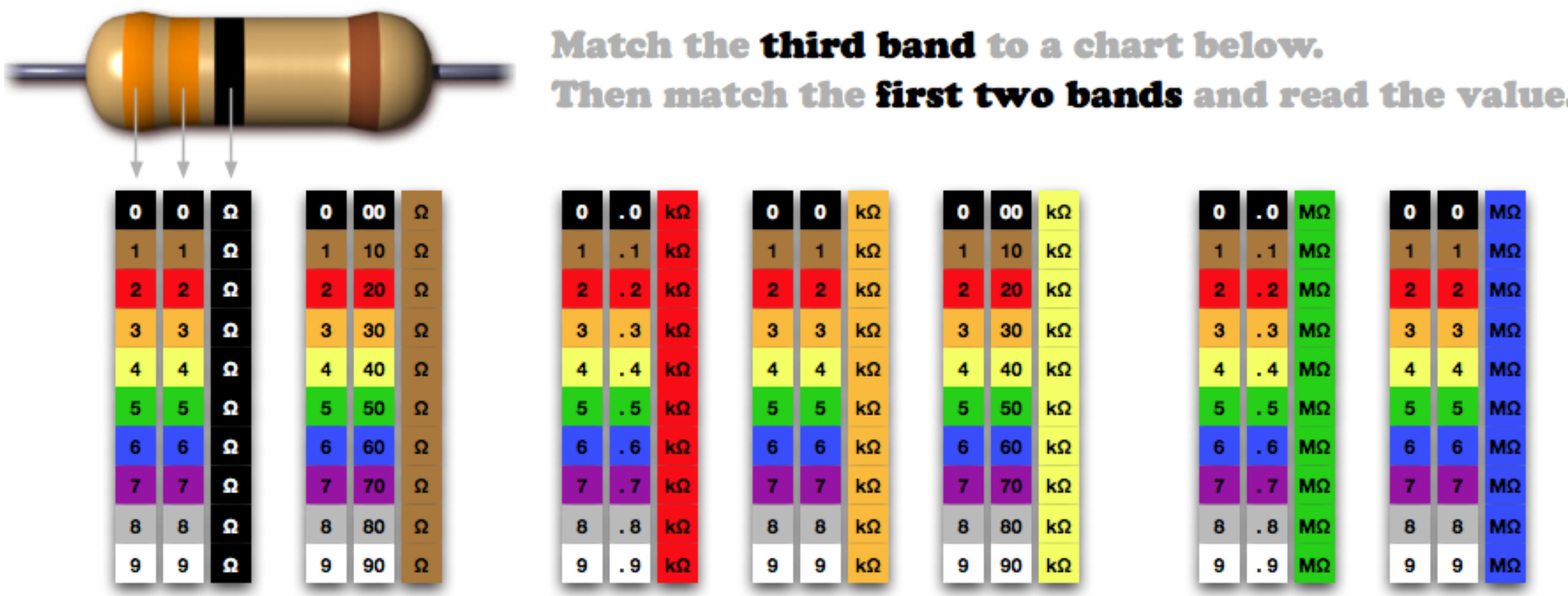
Test resistance with multimeter

Choose a resistor.

Turn dial to the lowest resistance range (Ω).

If the display says just 1 or 0L, choose the next highest range.

Resistor codes



No multiplication necessary!
PDF available from Bret Victor (http://worrydream.com/ResistorDecoder/)

Simple LED circuit

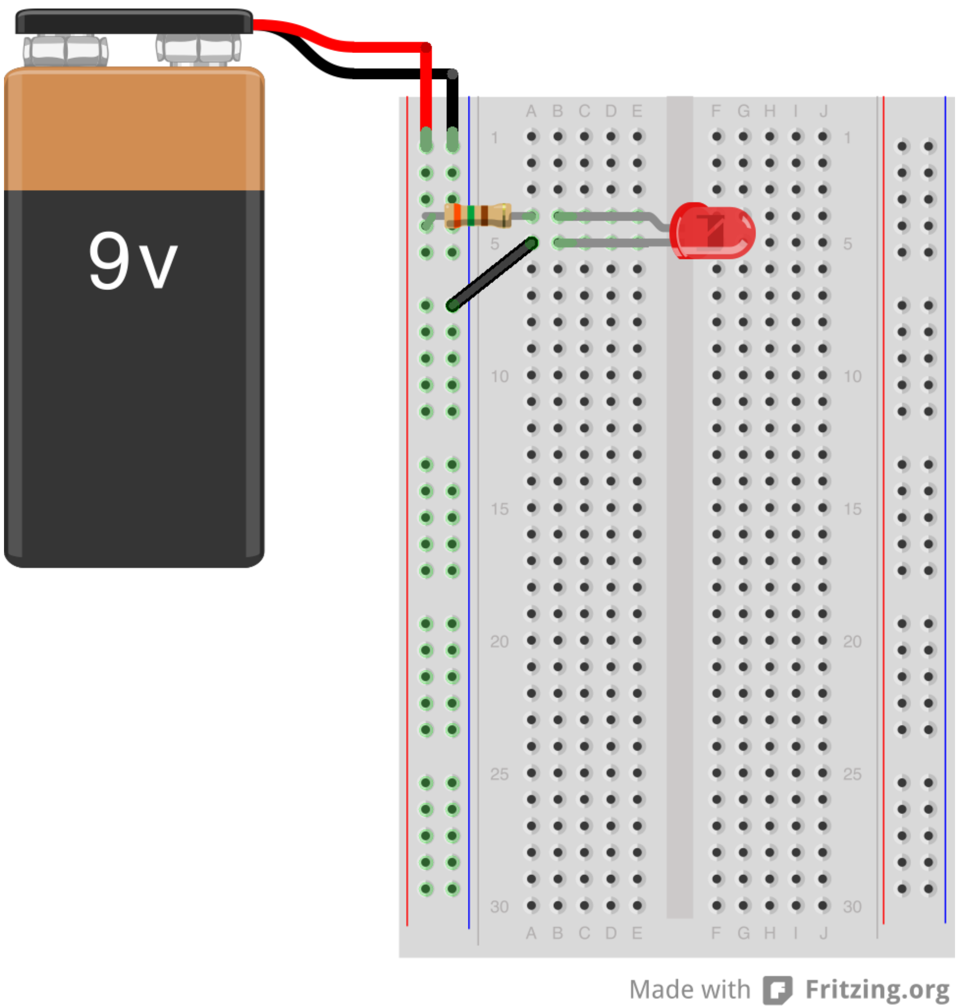
Let’s do this together:

What does the resistor do?

What happens if replace the resistor with a larger (resistance) one?

How is the LED oriented in the circuit?

Basic LED circuit



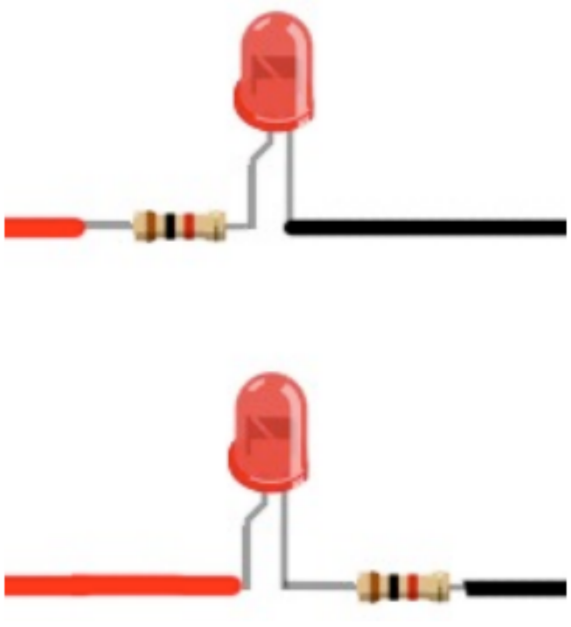
What is the resistor used for?

LEDs need only a small amount of current to work.

A resistor is used to limit the current to an LED.

The amount of resistance is determined by the needs of the LED and the amount of voltage your power supply can provide.

Limiting LED current with resistors



The resistor can go on either side of the LED in the circuit

Choosing resistors

How did we know to use that particular resistor?

Basic LED characteristics

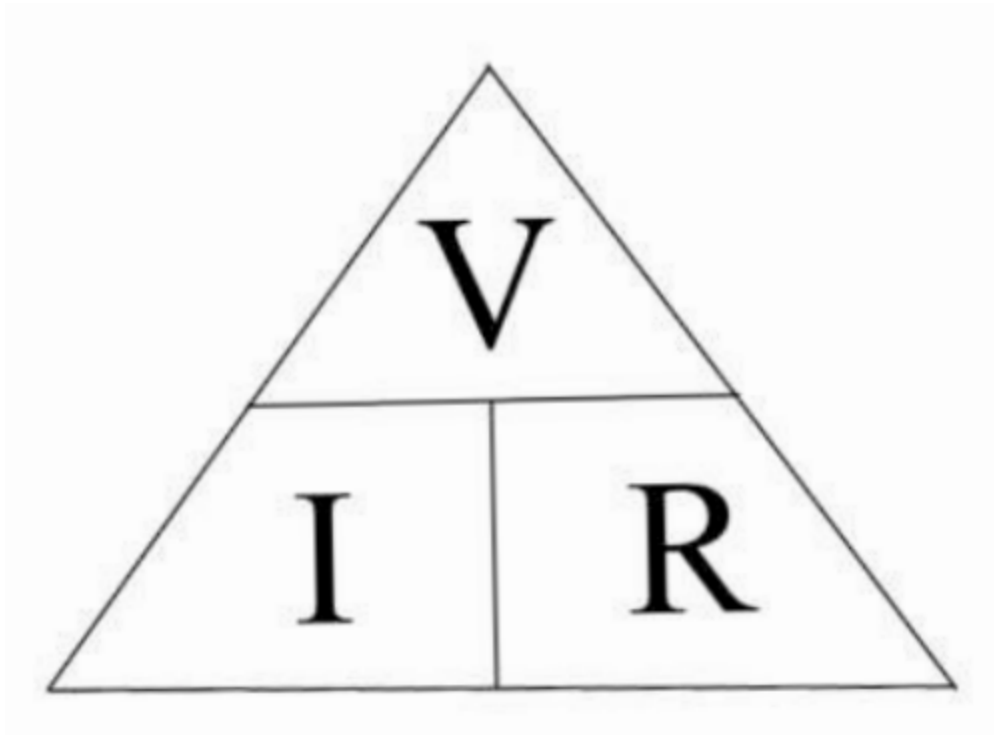
A basic LED needs…

Voltage: roughly 2V

Current: 20-30 mA

Resistance? This is determined by your circuit.

Ohm's Law



Resistance (R) = Voltage (V) / Current (I)

Ohm’s Law

The resistance needed by the LED can be determined using this formula:

Resistance (R) = Voltage (V) / Current (I)

or...

Resistance = (Supply Voltage - Voltage needed by LED) / LED Current

or...

Ohm's Law

Resistance = (Supply Voltage - Voltage needed by LED) / LED Current

350 ohms = (9V-2V)/.02A*

*20 mA is .02A

Add another LED!

Make another LED circuit, just like the one you made before!

Use a different resistor and see what happens to your LED… is it as bright as before?

Types of circuits

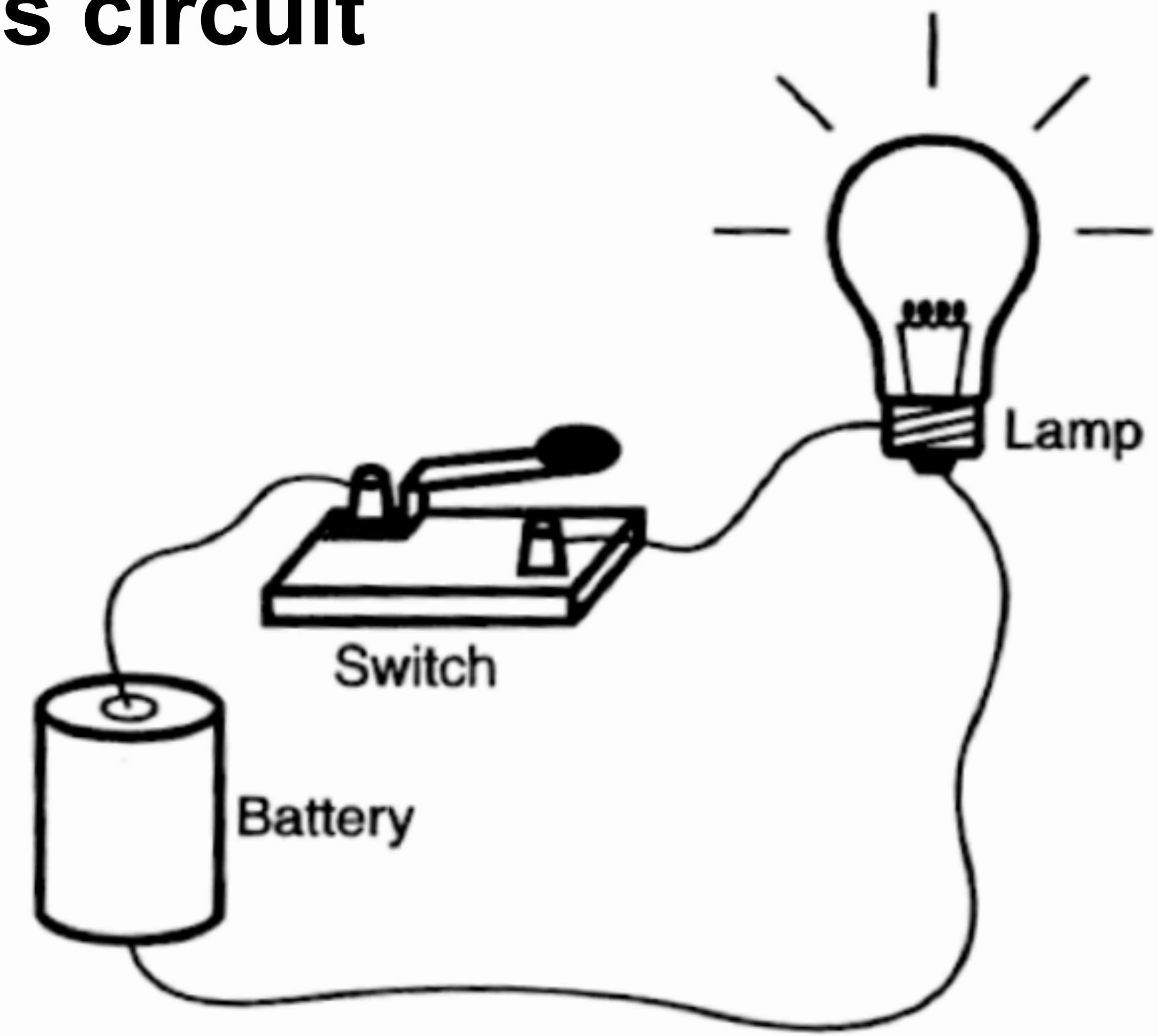
There are two basic types of circuits:

Series circuits

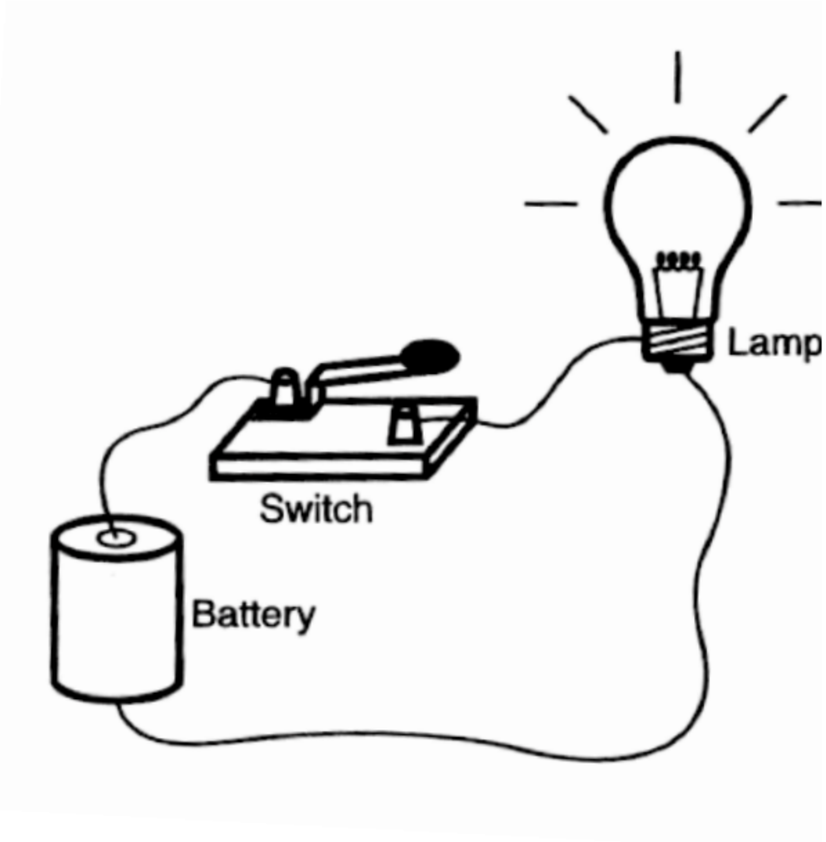
Parallel circuits

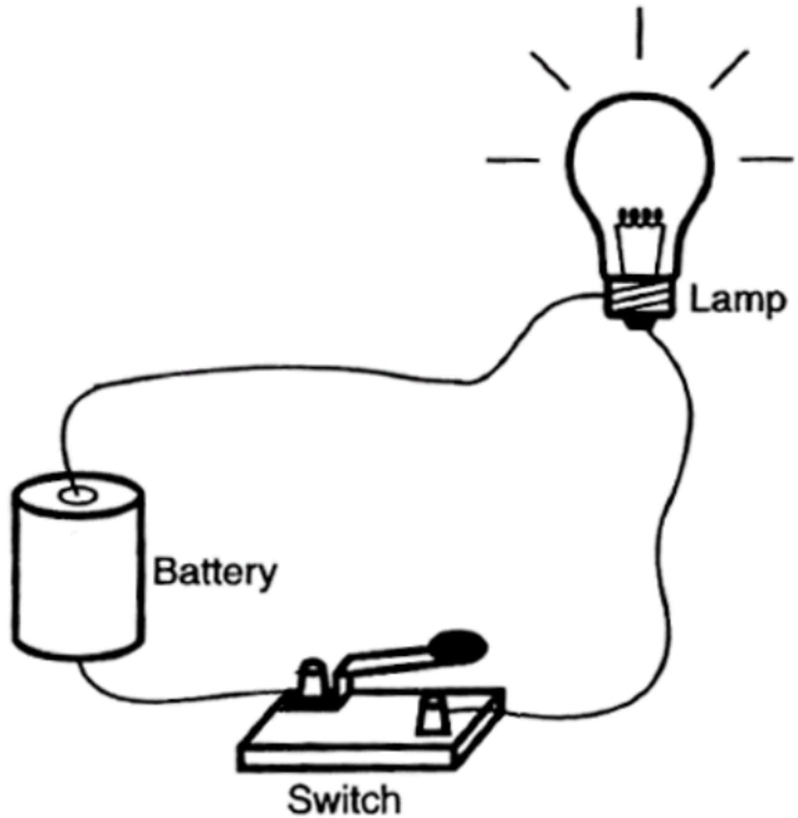
These can be combined to make complex circuits!

Series circuit



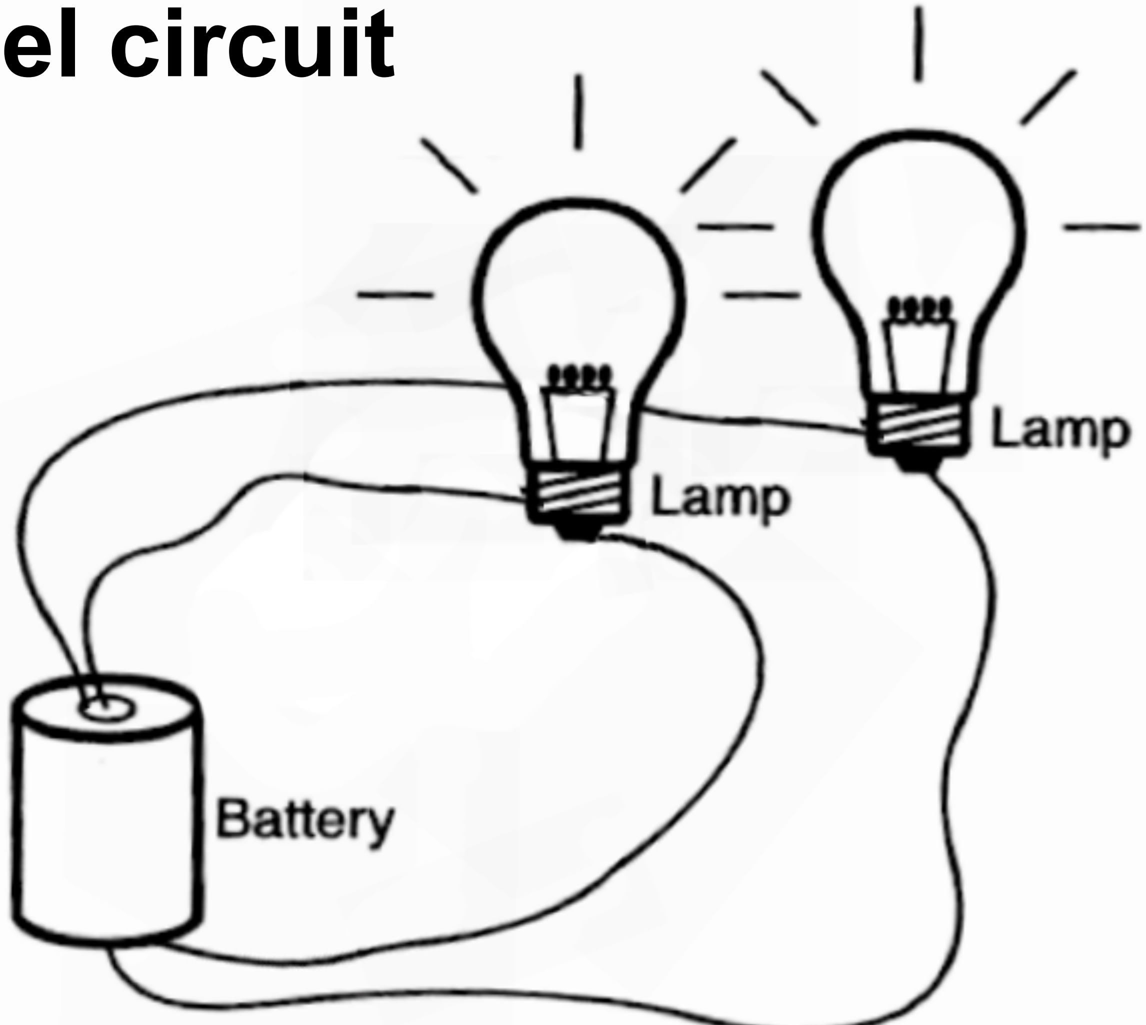
Series circuits





The order of the switch and lamp in this circuit is not important

Parallel circuit



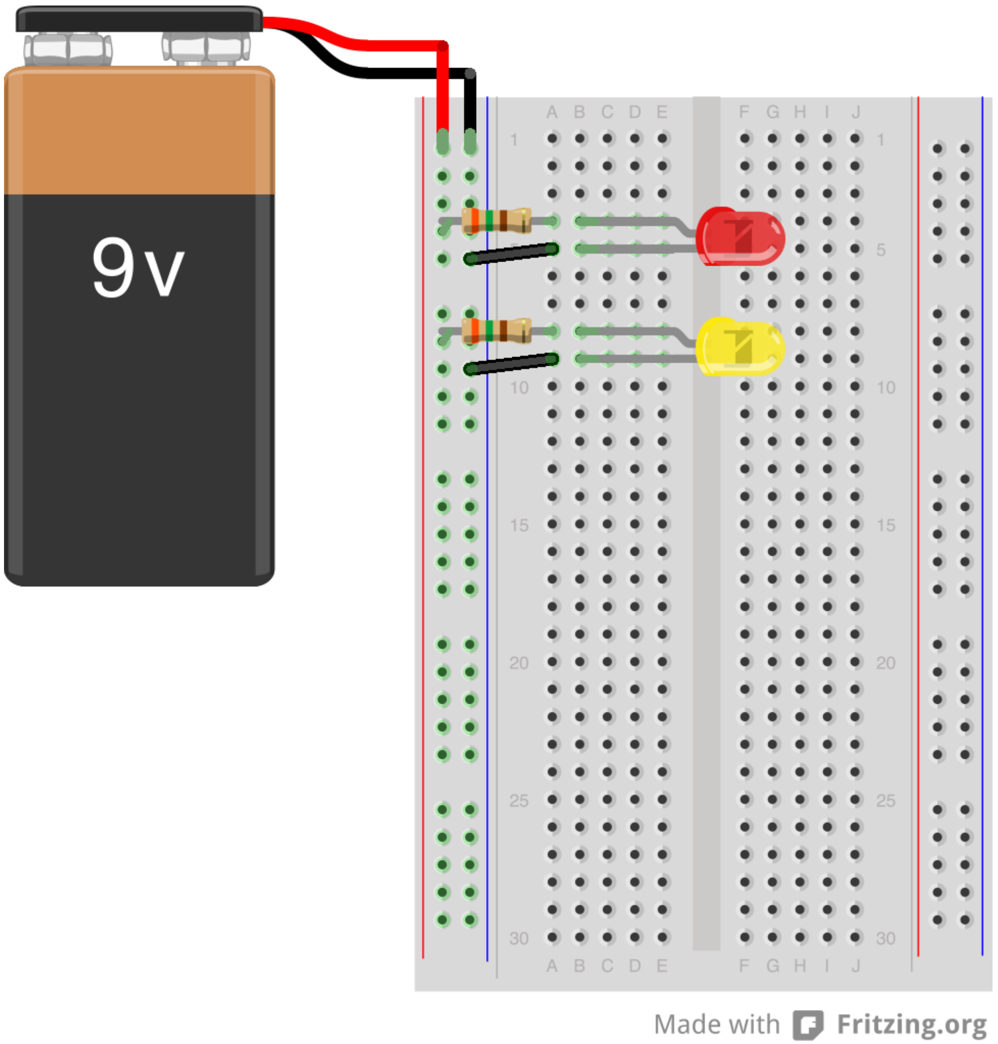
Adding even more LEDs

Two basic options…

Parallel circuit: All LEDs need resistors.

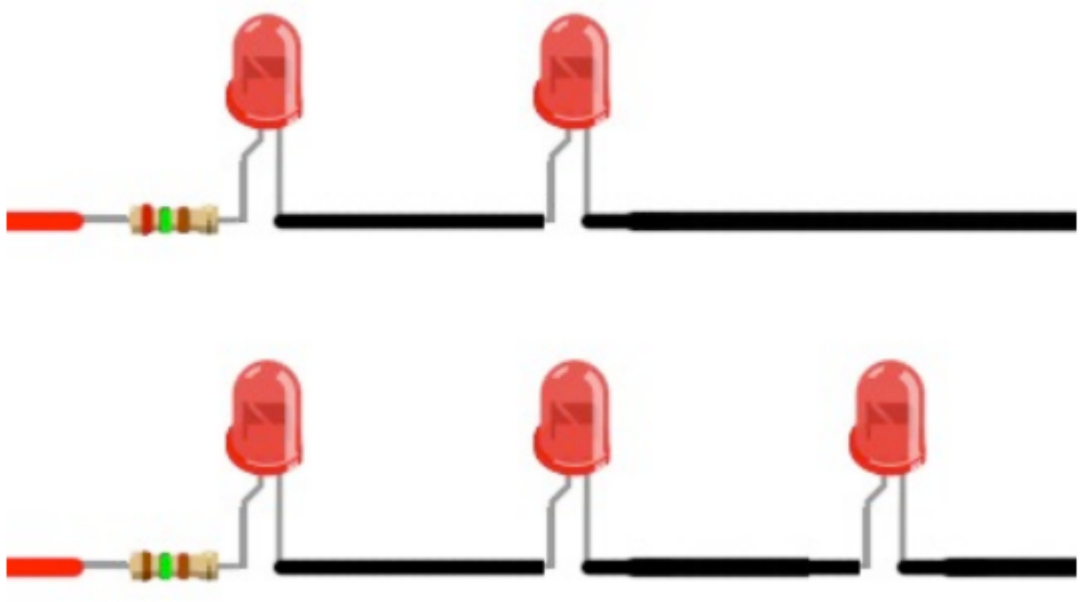
Series circuit: All LEDs share one resistor.

Parallel LED circuits



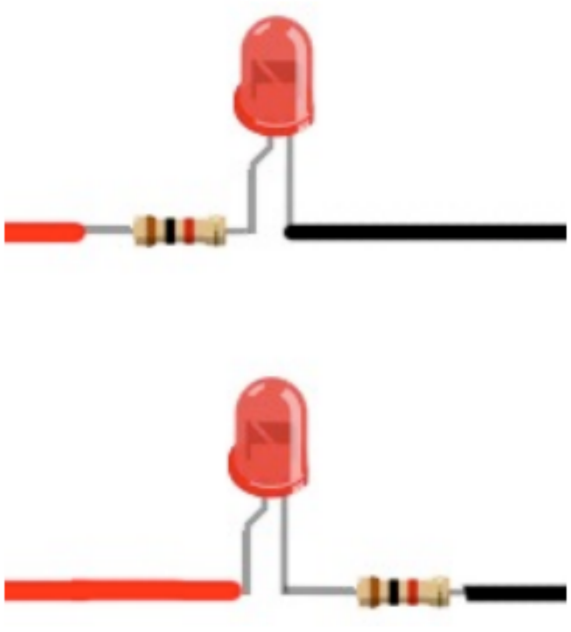
LEDs connected in series

250 ohms = (9V-(2V+2V))/20mA



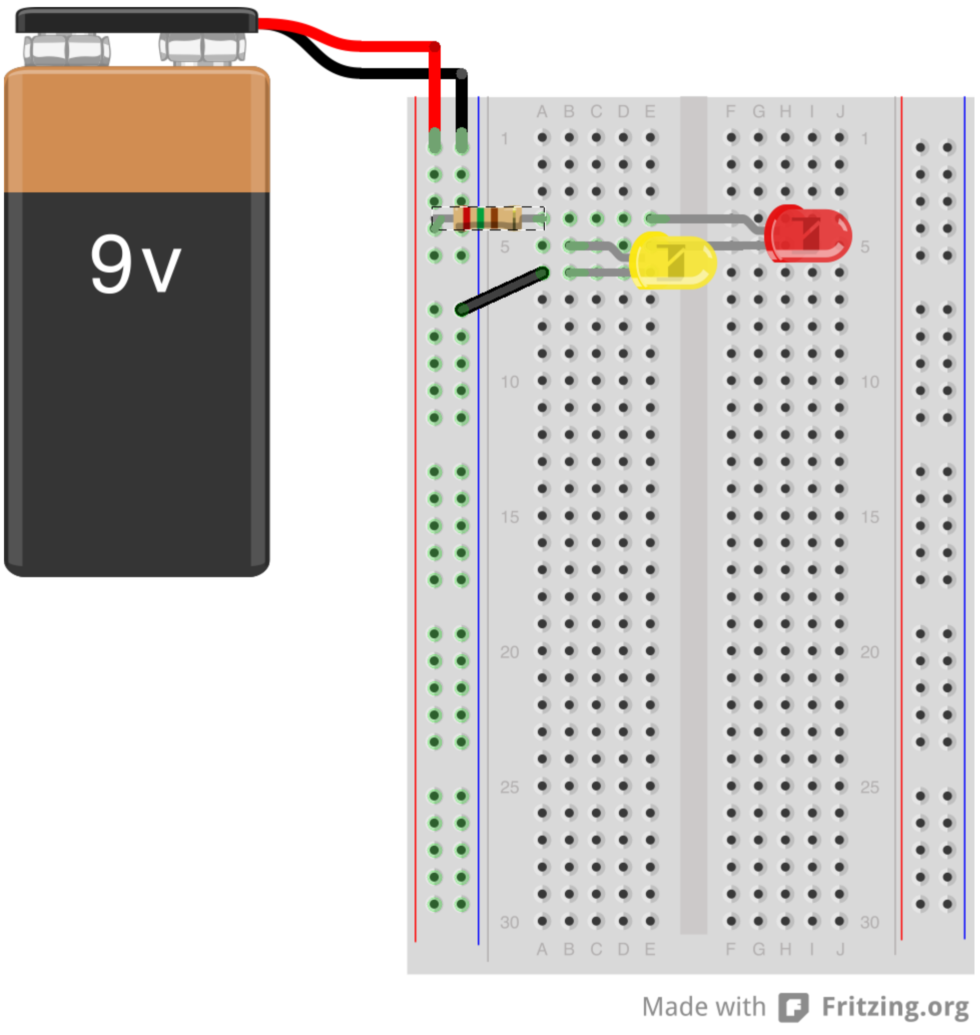
150 ohms = (9V-(2V+2V+2V))/20mA

Limiting LED current with resistors



The resistor can still go on either side of the LED in the circuit

LED series circuit



Add some LEDs in series

Let’s do this:

Add as many LEDs in series as your power supply will allow and limit the current with a single resistor.

Use Ohm’s Law to determine the resistance needed.

Switches/buttons

Switches/buttons

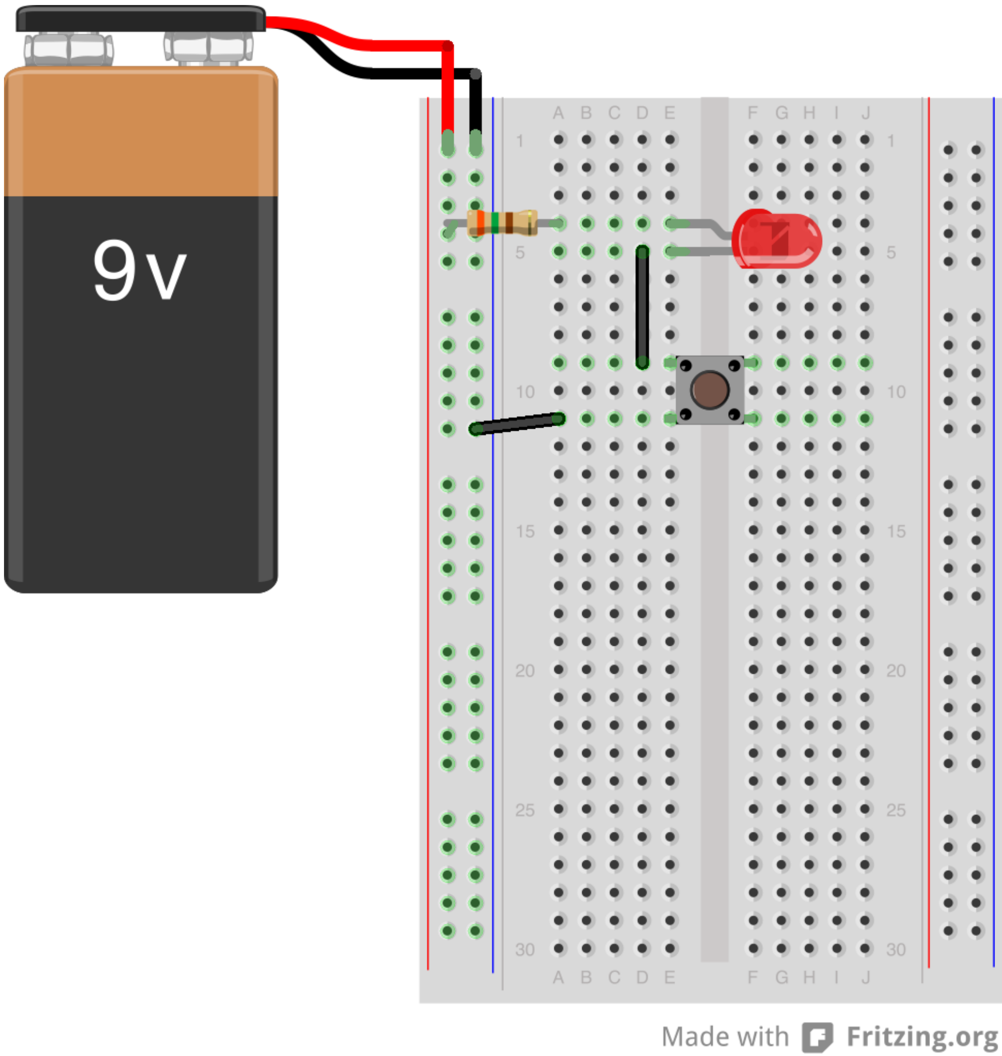
Work by interrupting the flow of electricity.

Add a button

Let's do this:

Add a button in series with your LED circuit to turn it on and off.

Pushbutton LED circuit



Is the button in series or parallel with the LED?

Can you modify the circuit so that is turns off many LEDs at once?