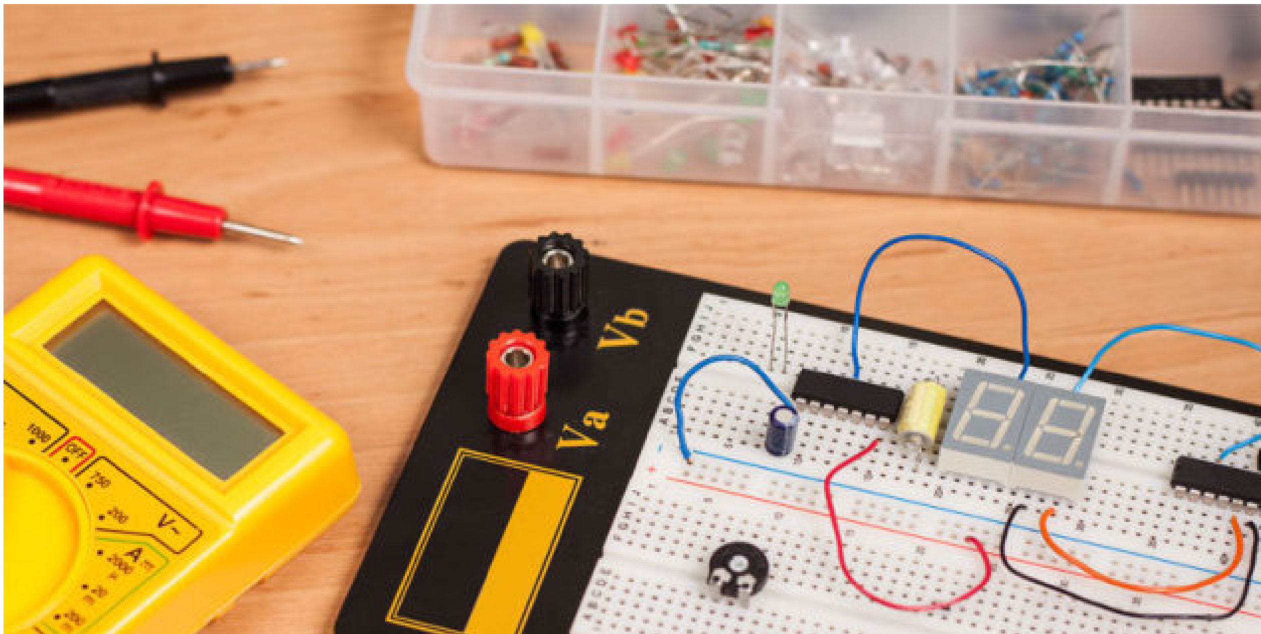
Introduction To Basic Electronics
By Ross Rahman



Learning about basic electronics and creating your own projects is a lot easier than you may think. In this tutorial, I am going to give you a brief overview of common electronic components and explain what their functions are.

You will then learn about schematic diagrams and how they are used to design and build circuits.

For a more advanced explanation click here MP3 Sound File

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Electronic Components

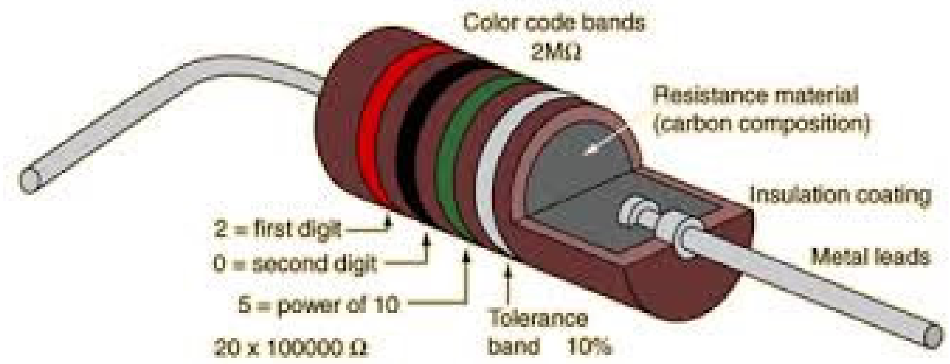
Now its time to talk about the different componen that make your electronic projects come to life. Below is a quick breakdown of the most common components and functions they perform.

Switch

Switches can come in many forms such as pushbutton, rocker, momentary and others. Their basic function is to interrupt electric current by turning a circuit on or off.

Resistor

Resistors are used to resist the flow of current or to control the voltage in a circuit. The amount of resistance that a resistor offers is measured in Ohms. Most resistors have colored stripes on the outside and this code will tell you it's value of resistance.



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Wire Cutter

Wire cutters are essential for stripping stranded and solid copper wire.

Jumper Wire

These wires are used with breadboard and development boards and are generally 22-28 AWG solid core wire. Jumper wires can have male or female ends depending on how they need to be used.

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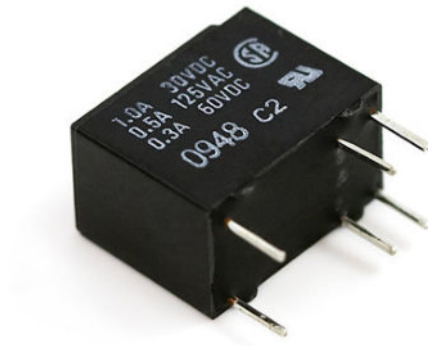
Relay

A relay is an electrically operated switch that opens or closes when power is applied. Inside a relay is an electromagnet which controls a mechanical switch.

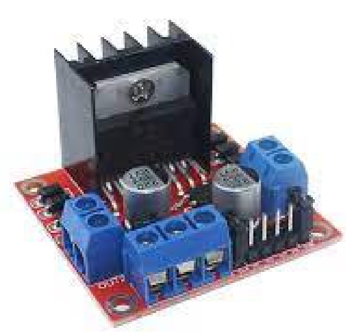


Integrated Circuit (IC)

An integrated circuit is a circuit that's been reduced in size to fit inside a tiny chip. This circuit contains electronic components like resistors and capacitors but on a much smaller scale. Integrated circuits come in different variations such as 555 timers, voltage regulators, micro controllers and many more. Each pin on an IC is unique in terms of it's function.

Motor drivers

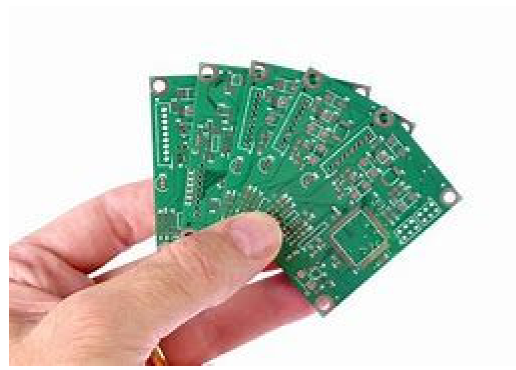
Motor drivers acts as an interface between the motors and the control circuits. Motor require high amount of current whereas the controller circuit works on low current signals. So the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor



Micro controller Boards

An integrated circuit that contains a microprocessor along with memory and associated circuits and that controls some or all of the functions of an electronic device (such as a home appliance) or system. a popular board is Arduino consists of both a physical programmable circuit board (often referred to as a micro controller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board

Printed circuit boards



Printed circuit boards (PCBs) are the foundational building block of most modern electronic devices. Whether simple single layered boards used in your garage door opener, to the six layer board in your smart watch, to a 60 layer, very high density and high-speed circuit boards used in super computers and servers, printed circuit boards are the foundation on which all of the other electronic components are assembled onto.

Semiconductors, connectors, resistors, diodes, capacitors and radio devices are mounted to, and “talk” to one another through the PCB

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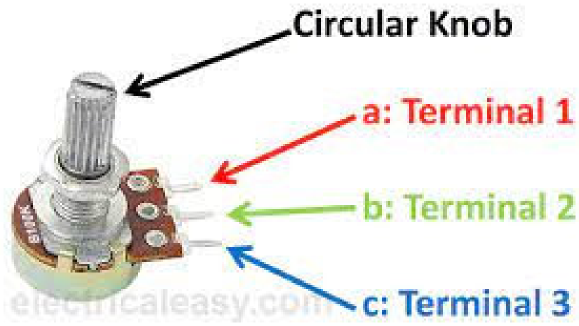
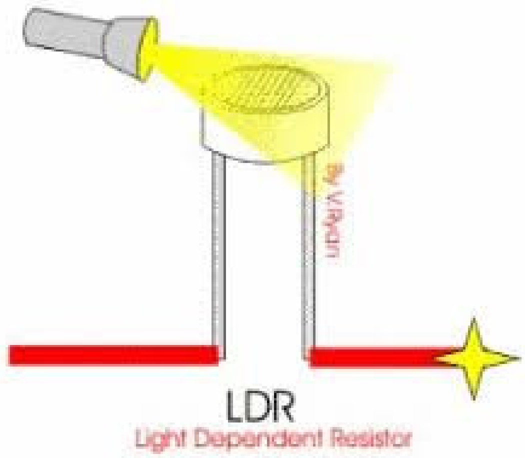
Variable Resistor (Potentiometer)

A variable resistor is also known as a potentiometer. These components can be found in devices such as a light dimmer or volume control for a radio. When you turn the shaft of a potentiometer the resistance changes in the circuit.



Light-Dependent Resistor (LDR)

A light-dependent resistor is also a variable resistor but is controlled by the light versus turning a knob. The resistance in the circuit changes with the intensity of the light. These are often found in exterior lights that automatically turn on at dusk and off at dawn.



Capacitor

Capacitors store electricity and then discharges it back into the circuit when there is a drop in voltage. A capacitor is like a rechargeable battery and can be charged and then discharged. The value is measured in F (Farad), nano Farad (nF) or pico Farad (pF) range.

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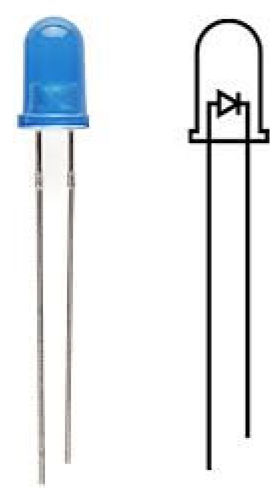
Diode

A diode allows electricity to flow in one direction and blocks it from flowing the opposite way. The diode's primary role is to route electricity from taking an unwanted path within the circuit.

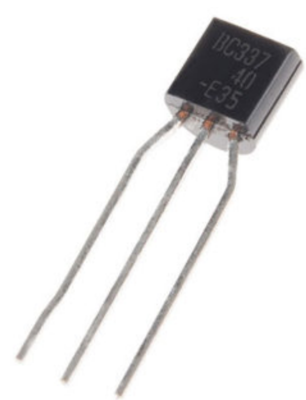
Light-Emitting Diode (LED)

A light-emitting diode is like a standard diode in the fact that electrical current only flows in one direction. The main difference is an LED will emit light when electricity flows through it. Inside an LED there is an anode and cathode. Current always flows from the anode (+) to the cathode (-) and never in the opposite direction. The longer leg of the LED is the positive (anode) side.



Transistor

Transistor are tiny switches that turn a current on or off when triggered by an electric signal. In addition to being a switch, it can also be used to amplify electronic signals. A transistor is similar to a relay except with no moving parts.



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Servo Motors

Servo motors or “servos”, as they are known, are electronic devices and rotary or linear actuators that rotate and push parts of a machine with precision. Servos are mainly used on angular or linear position and for specific velocity, and acceleration.

Click Here for in depth details

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SERVOS IN DEPTH DETAILS

Servo motors (or servos) are self-contained electric devices that rotate or push parts of a machine with great precision. Servos are found in many places: from toys to home electronics to cars and airplanes. If you have a radio-controlled model car, airplane, or helicopter, you are using at least a few servos. In a model car or aircraft, servos move levers back and forth to control steering or adjust wing surfaces.

And of course, robots might not exist without servos. You see servo-controlled robots in almost every movie (those complex animatronic puppets have dozens of servos), and you have probably seen a number of robotic animal toys for sale. Smaller laboratory robots also use servos to move their joints. Hobby servos come in a variety of shapes and sizes for different applications. You may want a large, powerful one for moving the arm of a big robot, or a tiny one to make a robot's eyebrows go up and down. Figure 1 below shows two sizes you can find in a hobby store— an inexpensive common size and a more expensive miniature one.

Fig 1

Two common servo sizes. The standard servo on the left can range in power or speed to move something quickly, or it can accommodate a heavier load, such as steering a big radio-controlled monster truck or lifting the blade on a radio-controlled earthmover toy. The miniature servo is about the size of a U.S. quarter and is intended for applications where smallness is a critical factor but a lot of power is not.

How does a servo motor work?

The simplicity of a servo is among the features that make them so reliable. The heart of a servo is a small direct current (DC) motor, similar to what you might find in an inexpensive toy. These motors run on electricity from a battery and spin at high RPM (rotations per minute) but put out very low torque (a twisting force used to do work— you apply torque when you open a jar). An arrangement of gears takes the high speed of the motor and slows it down while at the same time increasing the torque. (Basic law of physics: work = force x distance.) A tiny electric motor does not have much torque, but it can spin really fast (small force, big distance).

The gear design inside the servo case converts the output to a much slower rotation speed but with more torque (big force, little distance). The amount of actual work is the same, just more useful. Gears in an inexpensive servo motor are generally made of plastic to keep it lighter and less costly (see Figure 2 below). On a servo designed to provide more torque for heavier work, the gears are made of metal (see Figure 3 below) and are harder to damage.

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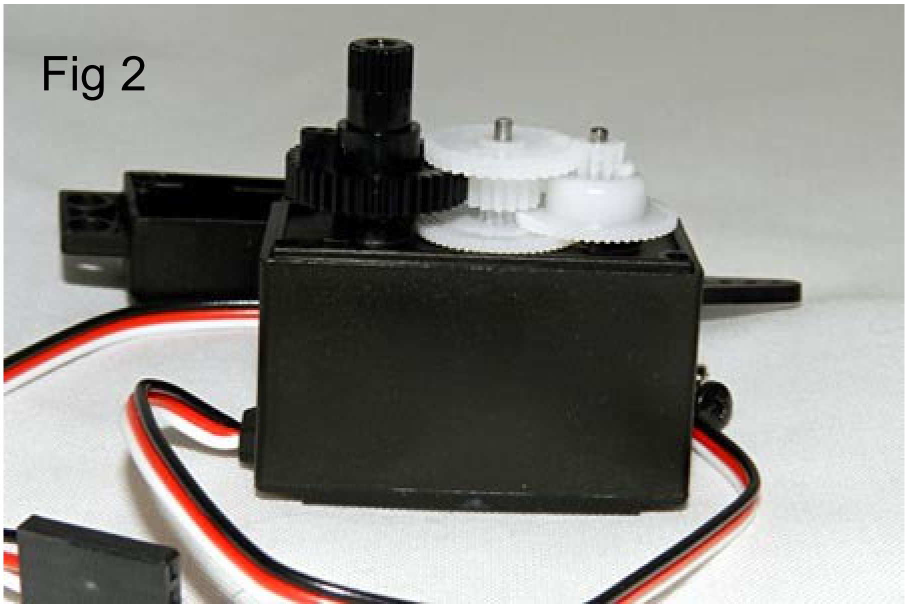

Fig 2

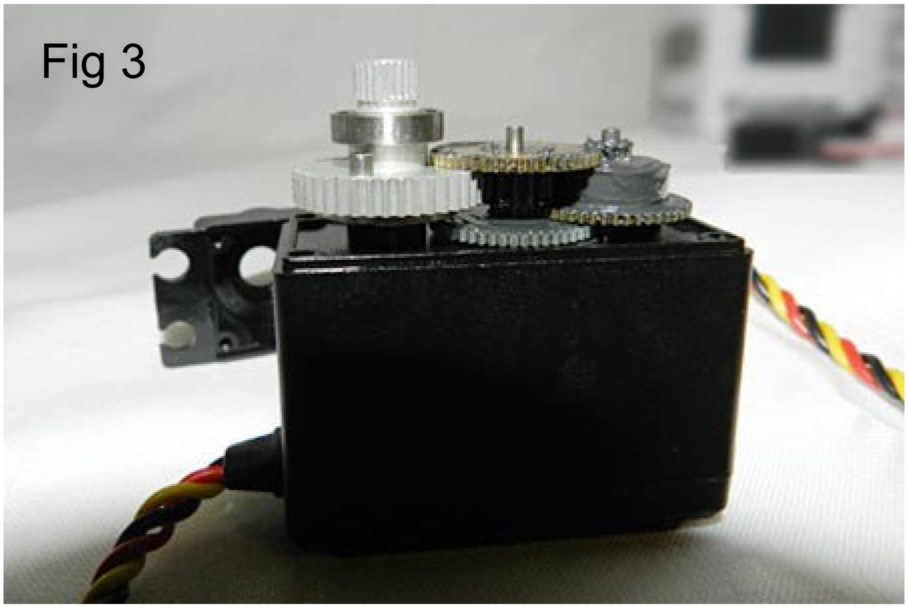

Fig 3

In a high-power servo, the plastic gears are replaced by metal ones for strength. The motor is usually more powerful than in a low-cost servo and the overall output torque can be as much as 20 times higher than a cheaper plastic one. Better quality is more expensive, and high-output servos can cost two or three times as much as standard ones.

With a small DC motor, you apply power from a battery, and the motor spins. Unlike a simple DC motor, however, a servo's spinning motor shaft is slowed way down with gears. A positional sensor on the final gear is connected to a small circuit board (see Figure 4 below). The sensor tells this circuit board how far the servo output shaft has rotated. The electronic input signal from the computer or the radio in a remote-controlled vehicle also feeds into that circuit board. The electronics on the circuit board decode the signals to determine how far the user wants the servo to rotate. It then compares the desired position to the actual position and decides which direction to rotate the shaft so it gets to the desired position.

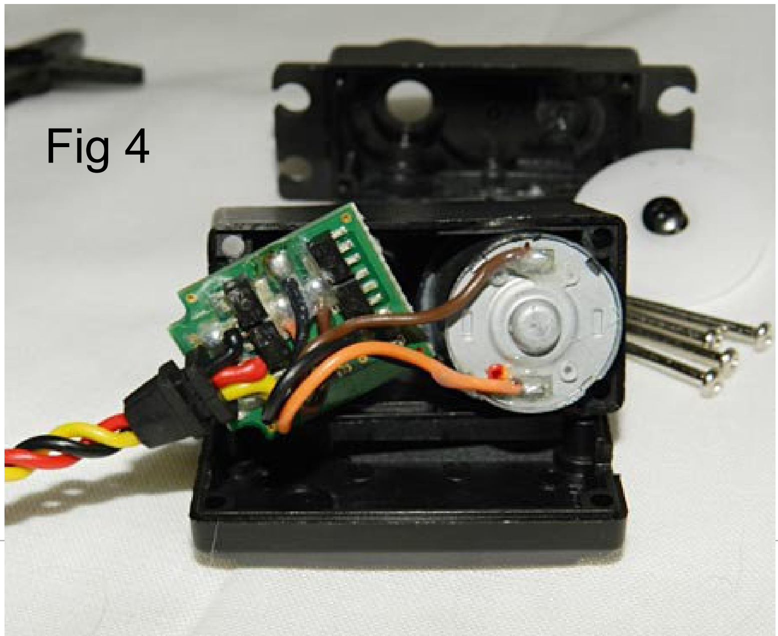
Fig 4

Types of servo motors
Servos come in many sizes and in three basic types: positional rotation, continuous rotation, and linear.

Positional rotation servo: This is the most common type of servo motor. The output shaft rotates in about half of a circle, or 180 degrees. It has physical stops placed in the gear mechanism to prevent turning beyond these limits to protect the rotational sensor. These common servos are found in radio-controlled cars and water- and aircraft, toys, robots, and many other applications.

Continuous rotation servo: This is quite similar to the common positional rotation servo motor, except it can turn in either direction indefinitely. The control signal, rather than setting the static position of the servo, is interpreted as the direction and speed of rotation. The range of possible commands causes the servo to rotate clockwise or counterclockwise as desired, at varying speed, depending on the command signal. You might use a servo of this type on a radar dish if you mounted one on a robot. Or you could use one as a drive motor on a mobile robot.

Linear servo: This is also like the positional rotation servo motor described above, but with additional gears (usually a rack and pinion mechanism) to change the output from circular to back-and-forth. These servos are not easy to find, but you can sometimes find them at hobby stores where they are used as actuators in larger model airplanes

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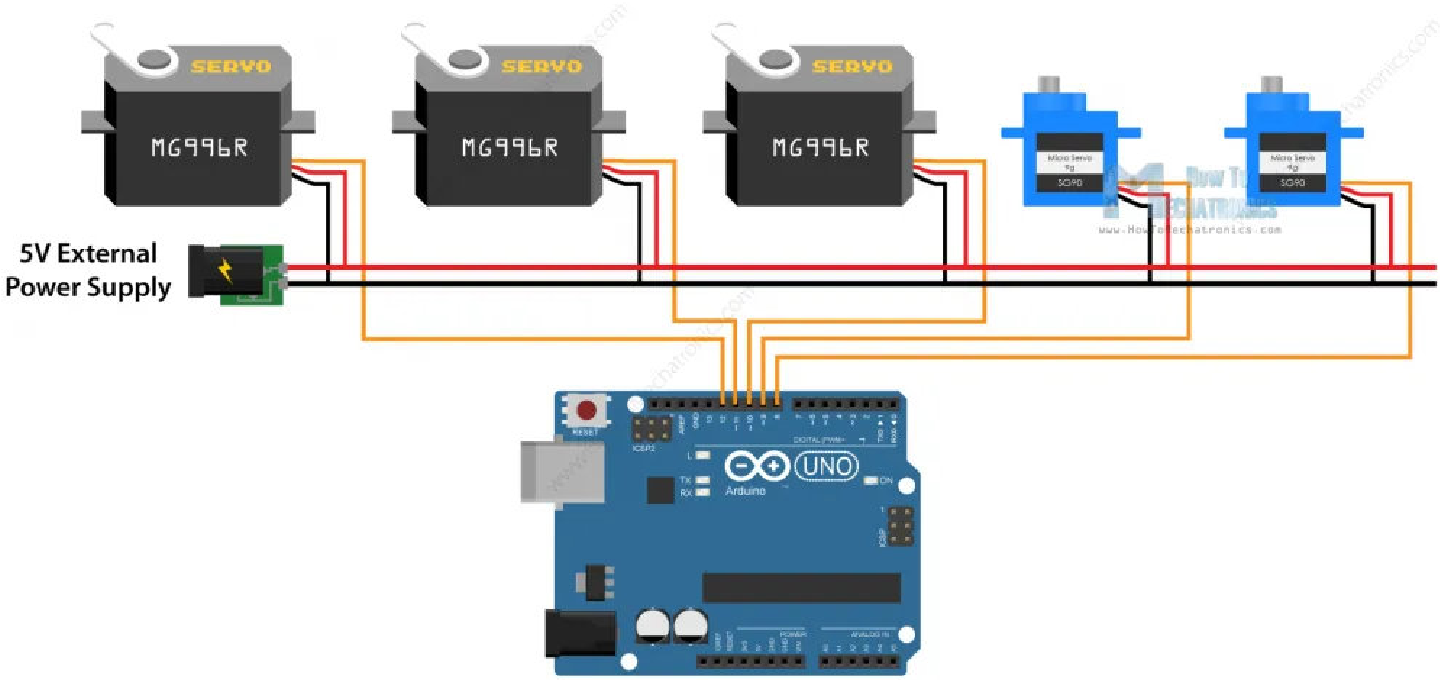
Controlling Multiple Servo Motors with Arduino

The Arduino servo library supports controlling of up to 12 servos at the same time with most the Arduino boards, and 48 servos using the Arduino Mega board. On top of that, controlling multiple servo motors with Arduino is as easy as controlling just a single one.



Program your servos using the **Enigma coding consul**, This is a very easy way to pre program servos to operate a animated sequence, enabling you to pre program a robotic arm to perform a series of moves. These moves are triggered by a time line giving complete control of the sequence of movements

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Controlling Servo Motors with Arduino

Servo motors are extremely useful in so many different applications; it'd be good to learn how to control them! Solenoid and DC motor control have been shown already; for the most part, they are both pretty straightforward (only power and ground connections) methods of motor control. We'll be controlling our servo using PWM on an Arduino.

A servo motor is a little different, using 3 connections (Power, Ground, and Signal) to move the motor to a certain rotary position. This position is dictated by what is sent on the signal wire. Once the motor reaches the position specified by the signal, it will hold its position and resist any forces that try to move it from that position. This resistance is known as the Torque Rating of the servo and will be found on the datasheet.

There are a couple of types of servo you can get:

Fixed Rotation Servos – These servos have fixed limitations in their rotation, so you can't turn it past its limitations. Great for robotic arms, pulling/pushing levers etc.

Continuous Rotation Servos- These servos allow you to continually turn either clockwise or counter-clockwise indefinitely.

Linear Servo – Allows you to have linear motion with servo motor control.

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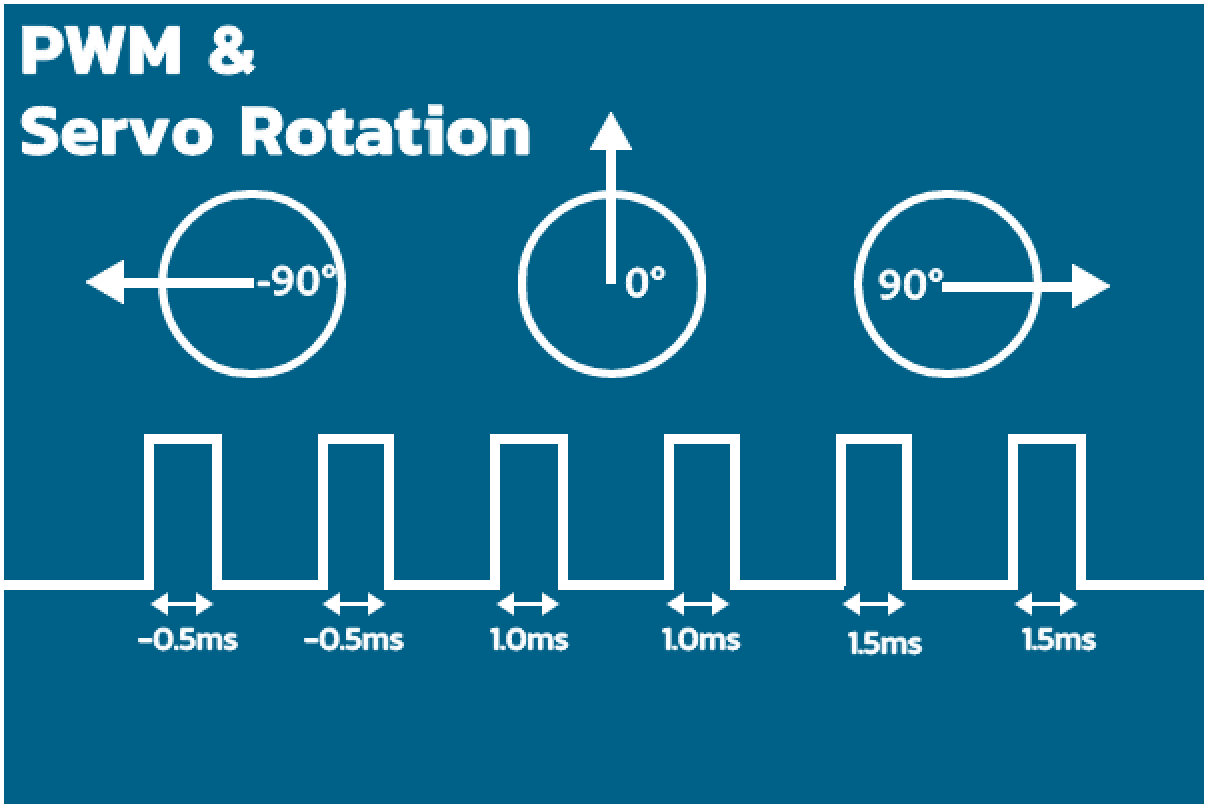

Pulse Width Modulation timing and servo rotation angles diagram

Pulse Width Modulation Servo motors tend to work from the 0-6V range, especially the hobby servos we are used to seeing in the Makersphere.

In order to control the rotation, we send a pulse of a variable width on the signal wire (the power and ground wires used as references for the signal). If you aren't familiar with it, a pulse is simply a square waveform that goes from 0V to another voltage for a set period of time, before returning to 0V. The servo will turn left or right according to the width of this pulse.

The idea of using pulses to control a servo's position can seem a little backward at first, take a look at this diagram to get a more intuitive understanding of how it all works. Essentially there is a neutral position that the servo motor's circuitry will hold at, this will be defined by a pulse width (let's call it 1ms for this example).

Hypothetically, imagine the 1ms pulse that holds our servo at neutral will hold that position indefinitely. If we send a pulse that is shorter than the 1ms neutral pulse (<1ms) the motor will fractionally turn toward zero degrees. The opposite happens on the other side (> 1ms) and the motor will turn fractionally toward maximum rotation (180 degrees). The circuitry that calculates this fractional amount of rotation either side of neutral is a lot more complicated than this simplification. That should give you a good idea of the way it works, though.

This theory behind the servo isn't too relevant when we are programming with the Arduino either. There is a library that we import that takes care of most of this PWM talk behind the scenes. The library is known as the Servo library and you can see Arduino's reference page for all the different functions of that library.

The basics of using the servo library includes the following steps:

1 Name our servo motor as a servo, this is done using the Servo [servo name]; function.

2 Attach our servo to a pin, this pin will be the signal pin for our servo and uses the [servo name].attach([PinNumber])

3 Create a variable for the position of the servo (or just use an integer value)

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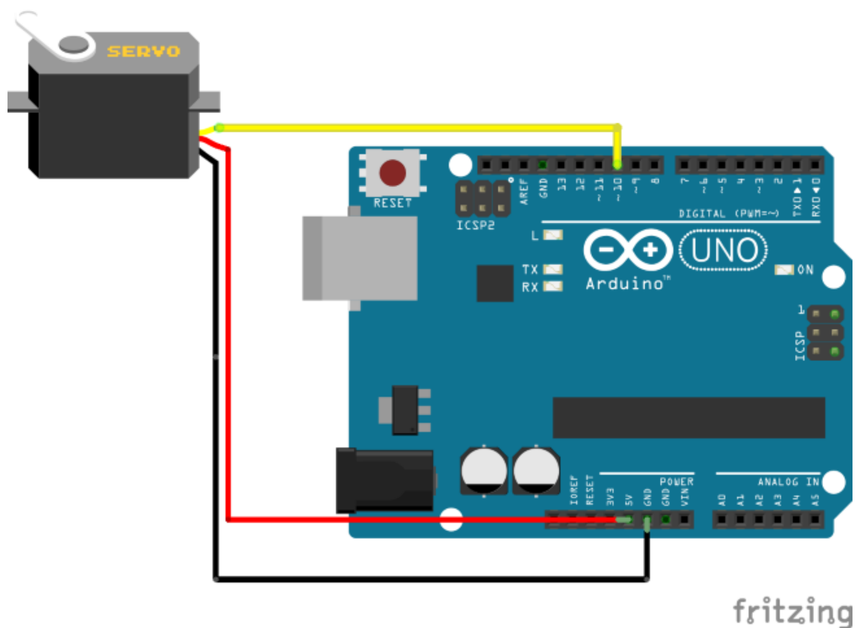
4 We can now write a position to the servo using [servo name].write([position integer]).

We are going to use an Arduino Uno and a small hobby servo in this tutorial. Generally, servos draw more current than what the Arduino pins can supply (20mA per pin), always check the power specs of a device before connecting it to your Arduino.

As we know this hobby servo is within the specs, it will be fine to use directly connected to the Arduino for this tutorial. If your servo motor is larger, look into connecting via a servo shield or similar external supply device.

Your setup should look like this, note we are using the Pin 10 with PWM but any of the PWM pins will do!



Arduino Uno connected to Servo circuit diagram

Writing the code is as simple as following the process above for using the Servo library. We will write a sketch that can move our servo backward and/or forward. You can see our code below but feel free to write your own and use ours as a checklist of sorts.

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```
#include <Servo.h>//import the servo library

Servo coreservo; //Name the Servo

void setup() {  coreservo.attach(10);   /*Attach the named servo object to
Digital IO 13, use following syntax:
  servoname.attach(Pin#, minimum Pulse width (ms), maximum pulse width
(ms));

  if you want to define the pulse widths for your motor*/}void loop() {
  coreservo.write(0);
  delay(200);
  coreservo.write(90);
  delay(200);
  coreservo.write(180);
  delay(200);
  /* If you wanted to read the angle of your servo at any given time, use
servoname.read();
   * If you wanted to write a pulse of a certain width use
servoname.writemicroseconds(value in microseconds);  */
}
```

If you are wanting to build a robot or something that uses a whole bunch of servos take a look at this great servo shield from Adafruit, It allows you to have 16 Servos connected up at any given time!

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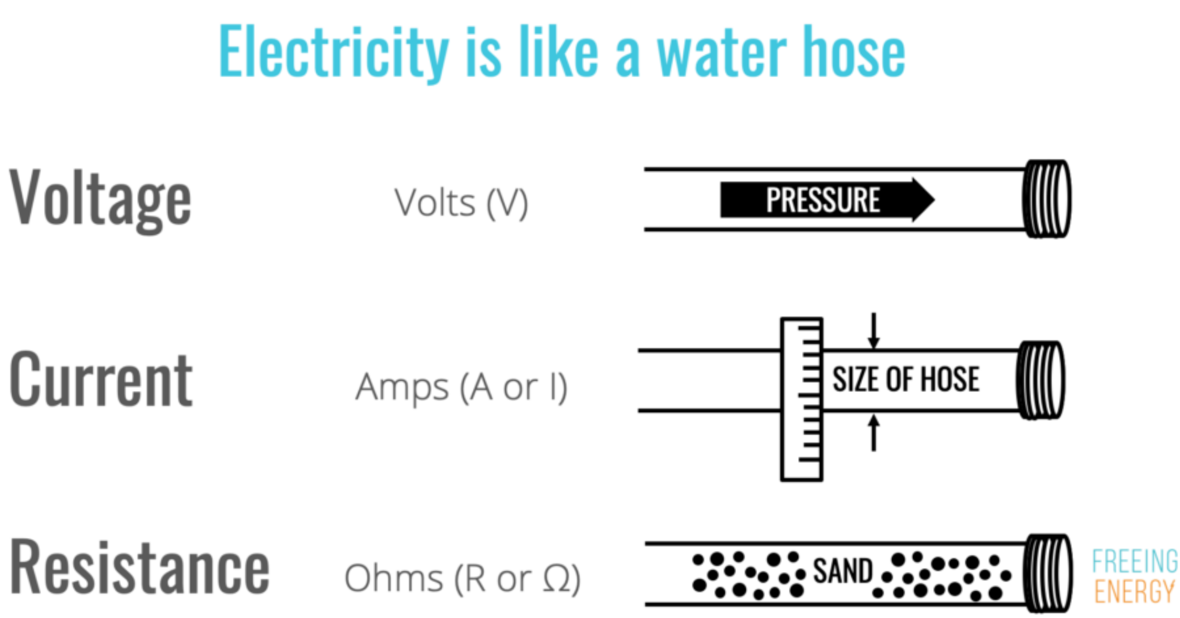
Basic Electricity

The fundamental laws of electricity are mathematically complex. But using water as an analogy offers an easy way to gain a basic understanding.

Electricity 101 – Voltage, Current, and Resistance
The three most basic components of electricity are voltage, current, and resistance.

VOLTAGE is like the pressure that pushes water through the hose. It is measured in volts (V).
CURRENT is like the diameter of the hose. The wider it is, the more water will flow through. It is measured in amps (I or A).
RESISTANCE is like sand in the hose that slows down the water flow. It is measured in ohms (R or Ω).



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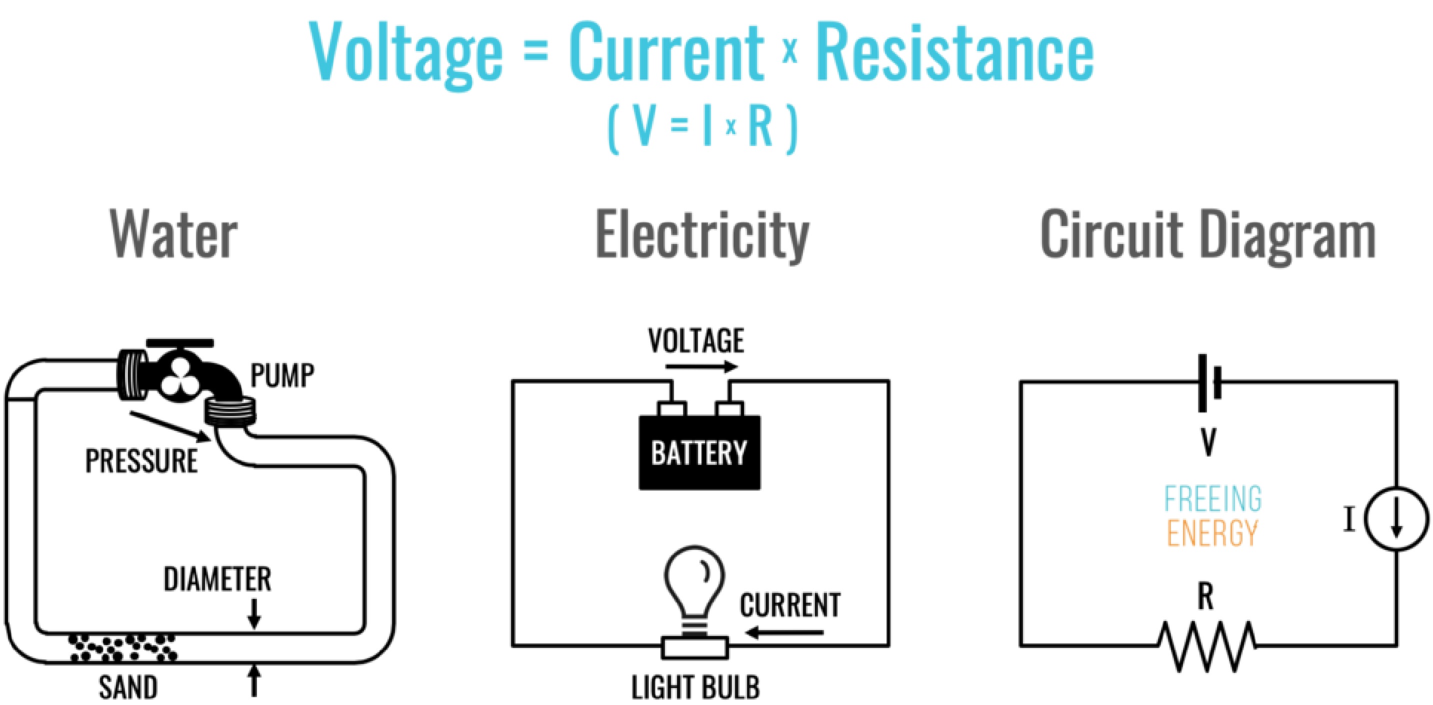
Voltage, current, and resistance are all related. If you change one of them in a circuit, the others will change, too. Specifically, voltage is equal to current multiplied by resistance (V = I x R). Thinking about water, if you add sand into the hose and keep the pressure the same, it's like reducing the diameter of the hose… less water will flow.



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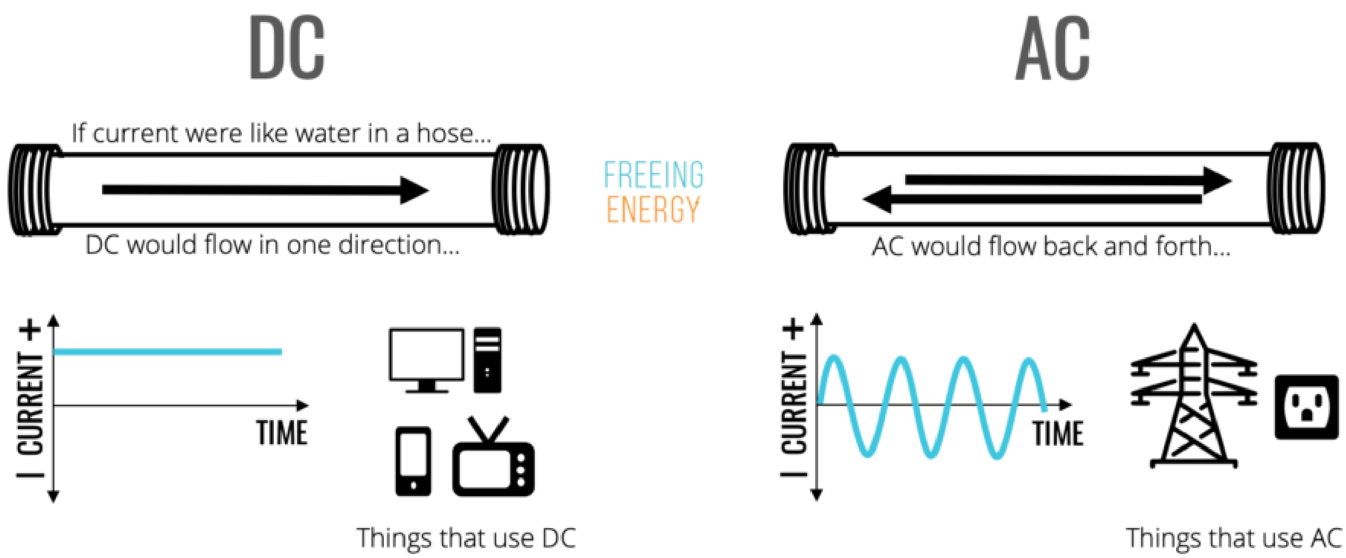
Alternating Current vs Direct Current



BATTERIES can be thought of as water pumps that circulate water through a hose that travels in a closed loop back to the battery. There are many metrics used for the capacity of batteries and not all are immediately logical. They include amp-hours and kilowatt hours. Batteries can only generate DC power.

TRANSFORMERS are like holding your thumb partially over the end of the hose to get the water to spray farther. The water volume (power) remains the same but the pressure (voltage) increases as the diameter (current) decreases. This is exactly what transformers do for overhead powerlines. The electricity can travel farther with fewer losses because the resistance (sand) doesn't impede the electricity (water) when the current is lower (smaller diameter hose). Transformers only work with AC. The ability to move electricity over long distances is the main reason AC beat out DC a century ago.

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Now, let's keep using the hose analogy to dive into the murkier waters of circuits (pun intended, sorry).

POWER is like the volume of water that is flowing from the hose, given a specific pressure and diameter. Electric power is measured in watts (W). And larger systems are measured in kilowatts (1 KW = 1000 watts) or megawatts (1 MW = 1,000,000 watts). -

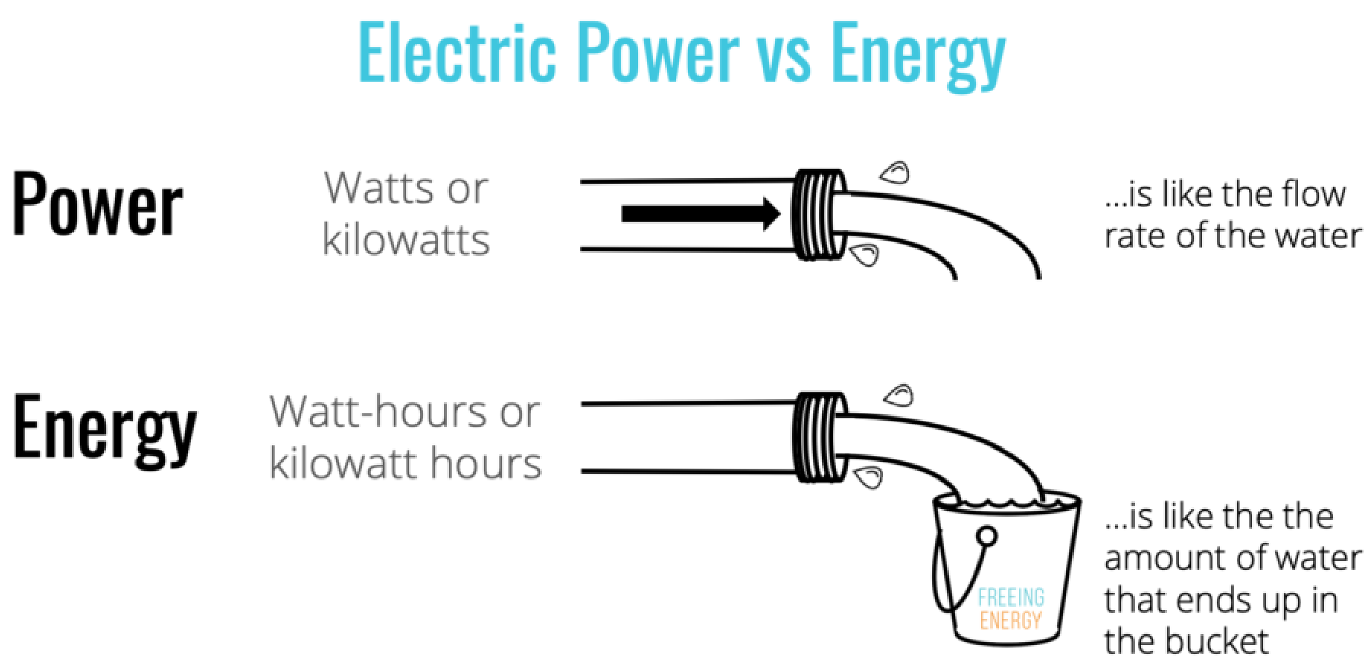
The- three most basic units in electricity are voltage (V), current (I, uppercase "i") and resistance (R). Voltage is measured in volts, current is measured in amps and resistance is measured in ohms.

What Are Watts? A watt describes the rate of power flow. When one amp flows through an electrical difference of one volt, its result is expressed in terms of watts. "W" is the symbol for watt or watts. Watts are derived from the formula V x A = W.

ENERGY is like measuring the volume of water that has flowed through the hose over a period of time, like filling a 5 gallon bucket in a minute.

Electric energy is often confused with electric power but they are two different things – power measures capacity and energy measures delivery.

Electric energy is measured in watt hours (wh) but most people are more familiar with the measurement on their electric bills, kilowatt hours (1 kWh = 1,000 watt hours). Electric utilities work at a larger scale and will commonly use megawatt hours (1 MWh = 1,000 kWh).

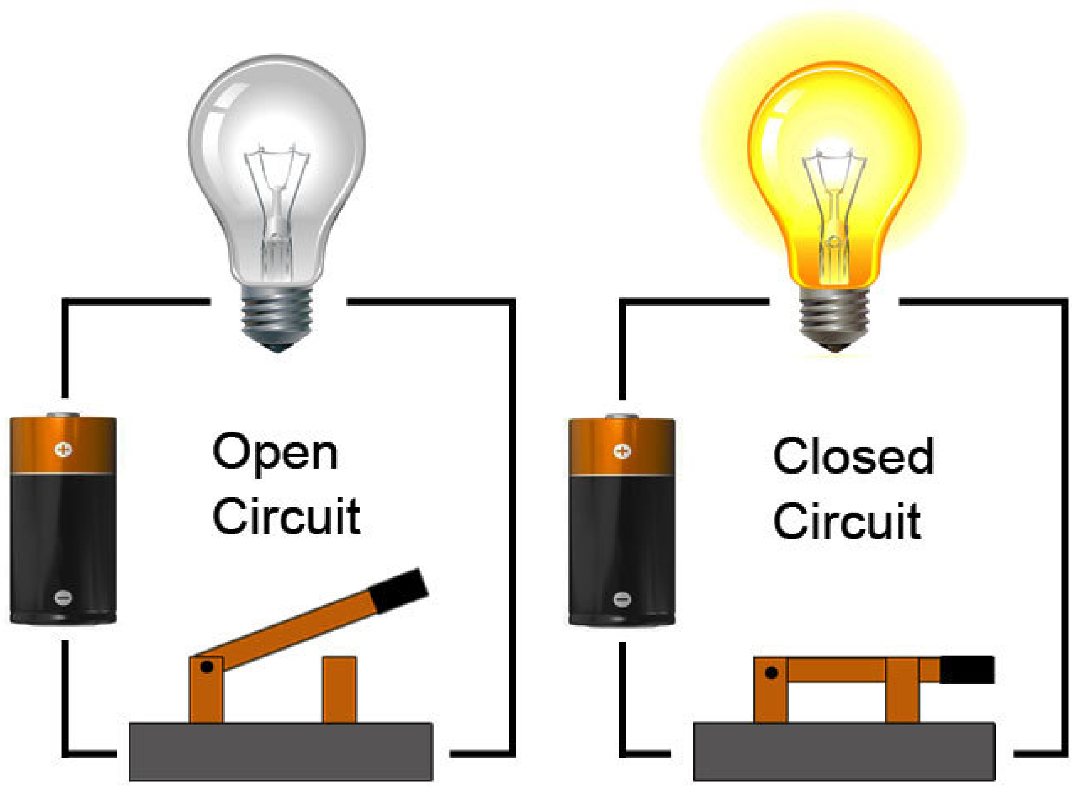


What Is A Circuit?

Before you design an electronic project, you need to know what a circuit is and how to create one properly.

An electronic circuit is a circular path of conductors by which electric current can flow. A closed circuit is like a circle because it starts and ends at the same point forming a complete loop. Furthermore, a closed circuit allows electricity to flow from the (+) power to the (-) ground uninterrupted.

In contrast, if there is any break in the flow of electricity, this is known as an open circuit. As shown below, a switch in a circuit can cause it to be open or closed depending on it's position.



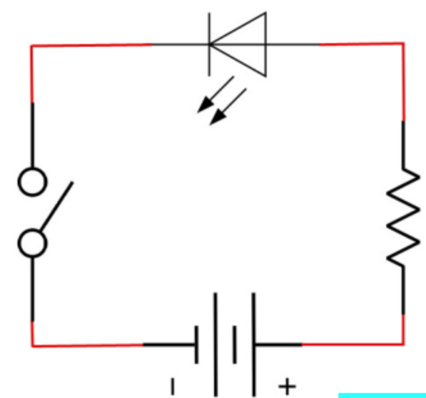
All circuits need to have three basic elements. These elements are a voltage source, conductive path and a load.

The voltage source, such as a battery, is needed in order to cause the current to flow through the circuit. In addition, there needs to be a conductive path that provides a route for the electricity to flow. Finally, a proper circuit needs a load that consumes the power. The load in the above circuit is the light bulb.

Schematic Diagram

When working with circuits, you will often find something called a schematic diagram. These diagrams use symbols to illustrate what electronic components are used and where they're placed in the circuit. These symbols are graphic representations of the actual electronic components.

Below is an example of a schematic that depicts an LED circuit that is controlled by a switch. It contains symbols for an LED, resistor, battery and a switch. By following a schematic diagram, you are able to know which components to use and where to put them. These schematics are extremely helpful for beginners when first learning circuits.



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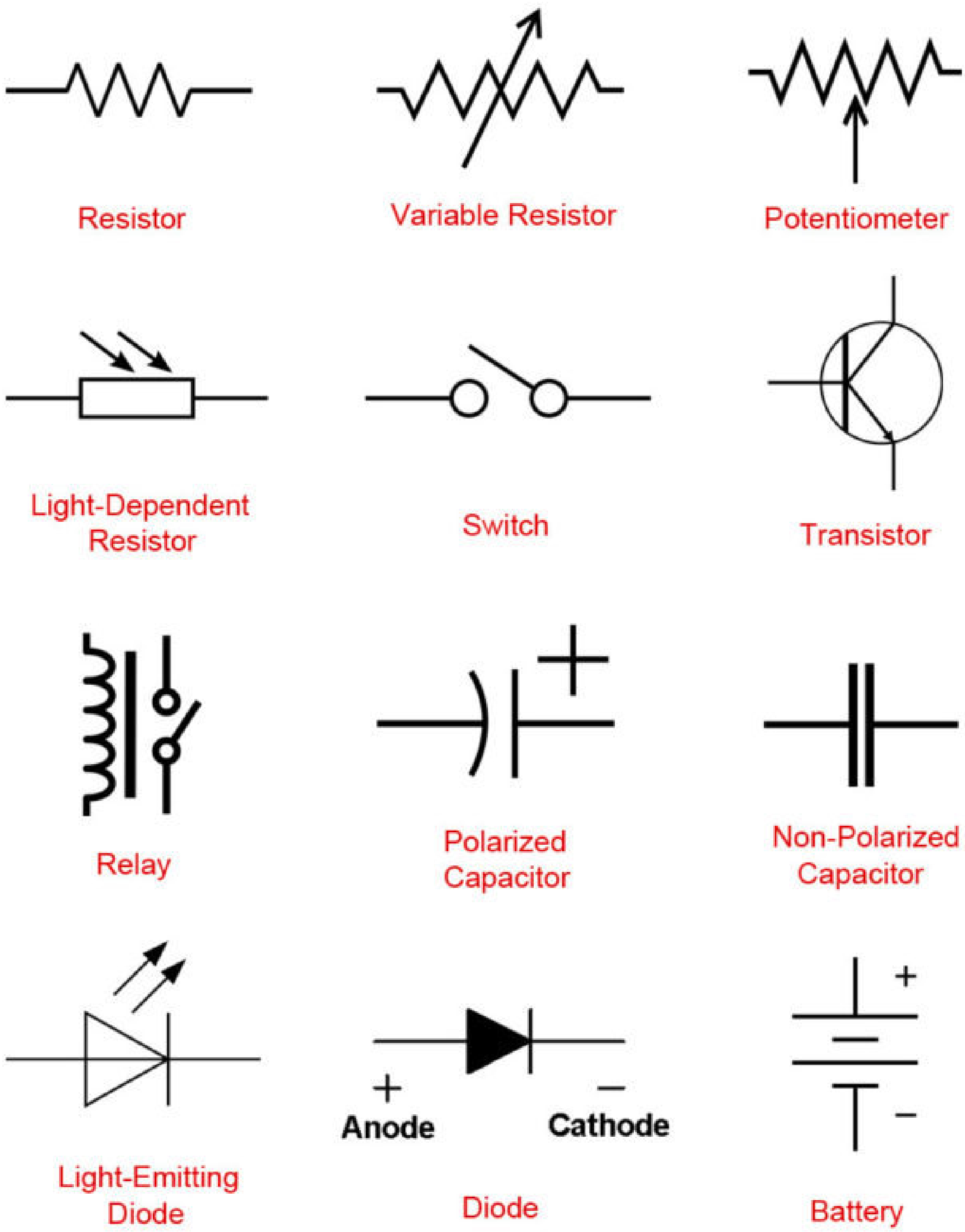
Schematic Diagram For LED Circuit

There are many types of electronic symbols and they vary slightly between countries. Below are a few of the most commonly used electronic symbols in the US.



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How To Determine A Resistor Size

Resistors are commonly used in electronics projects and it's important to know which size to use. To find the resistor value, you need to know the voltage and the amps for your LED and battery.

A standard LED generally needs a voltage of around 2V and a current of 20mA or .02A to operate correctly. Next, you need to find out what voltage your battery is. In this example, we will be using a 9V battery. In order to determine the resistor size, we need to use a formula known as Ohm's law as shown below.

Ohm's Law – Resistance (R) = Voltage (V) / Current (I)

$$R = \frac{V_{Bat} - V_{LED}}{I_{LED}}$$

Resistance is measured in Ohms (Ω)
Voltage is measured in volts (V)
Current is measured in amps (A)

$$350 = \frac{9V - 2V}{.02A}$$

Using Ohm's law, you need to subtract the LED voltage from the battery voltage. This will give you a voltage of 7 which needs to be divided by .02 amps from the LED. This formula shows that you will need a 350 Ω resistor.

As a note, standard resistors don't come in 350 Ω but are available in 330 Ω which will work fine.

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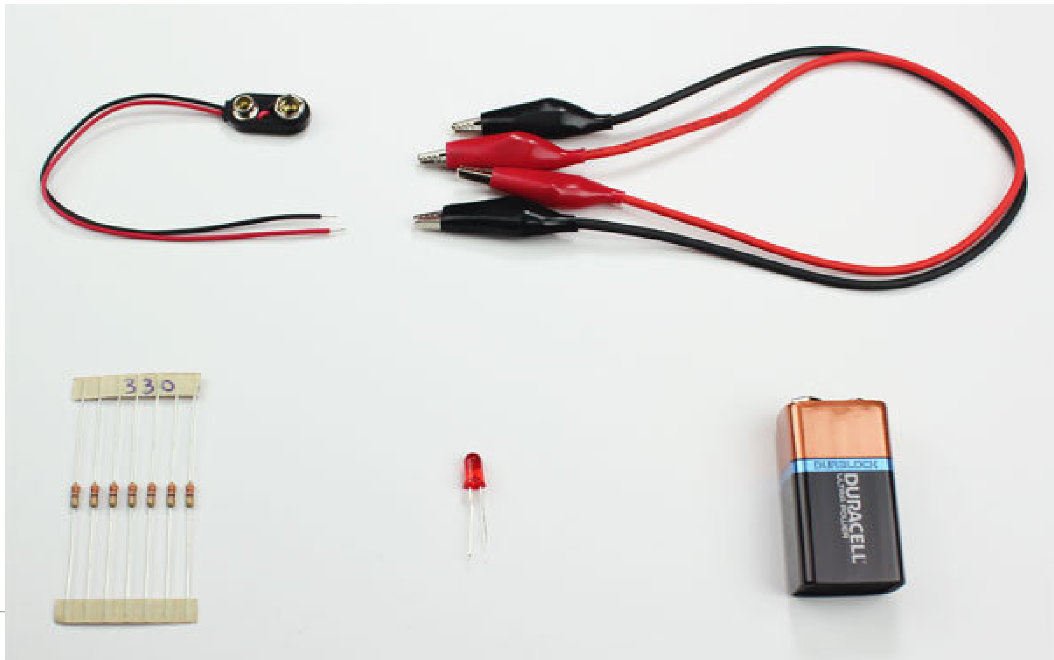
Electronics Project

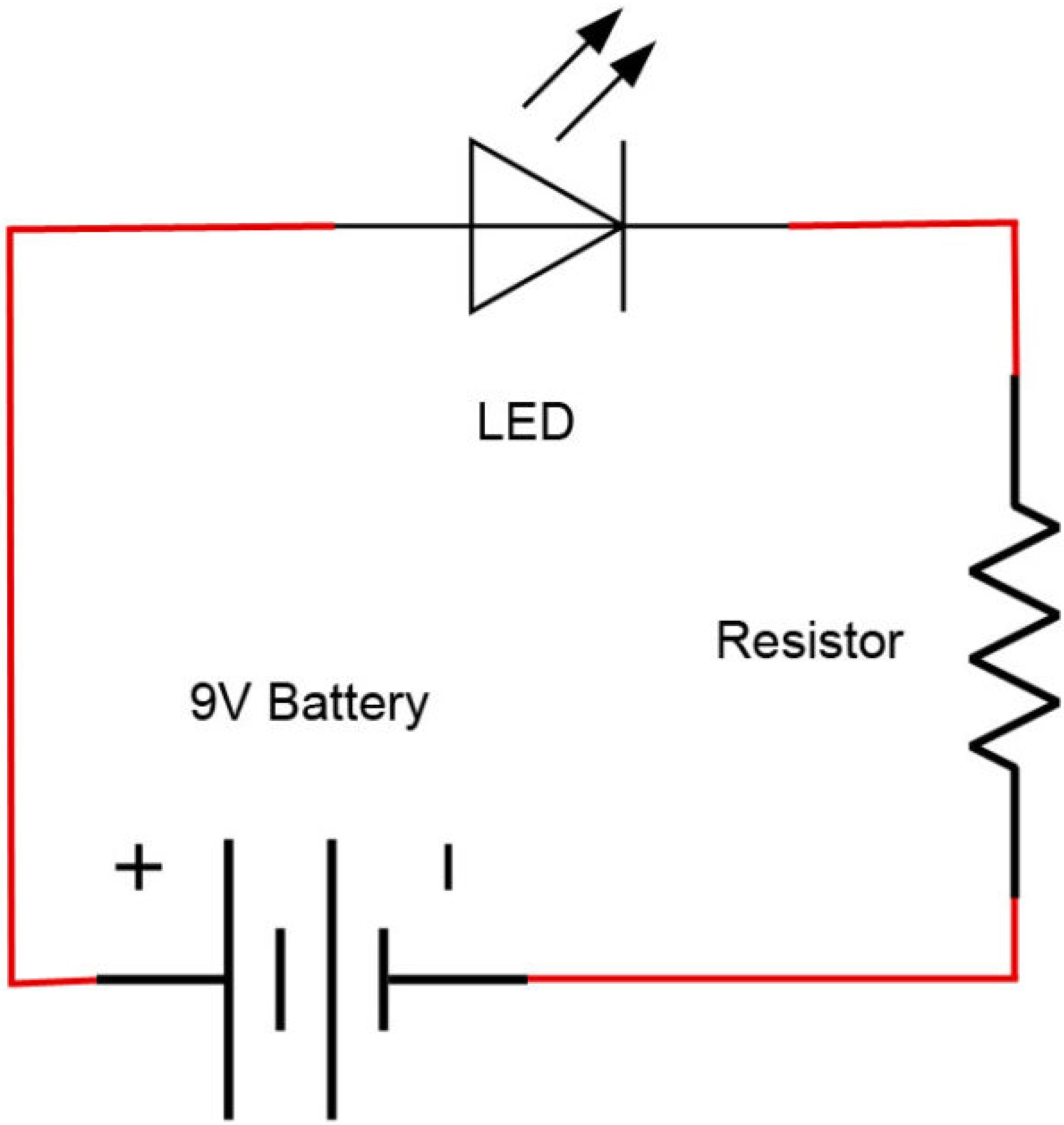
Now it's time to combine everything you've learned and create a basic circuit. This project is a great starter project for beginners. We will be using test leads to create a temporary circuit without having to solder it together.

Parts Needed:

9V Battery
Battery Snap-on Connector
Test Leads w/ Alligator Clips
330 Ohm Resistor
LED – Basic Red 5mm



Schematic Diagram



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Project Steps

1 Attach the battery clip to the top of the 9V battery.

2 Red wire from the battery clip is connected to one alligator clip on the red test lead.

3 The other end of the red test lead is connected to the long leg (+) of the LED.

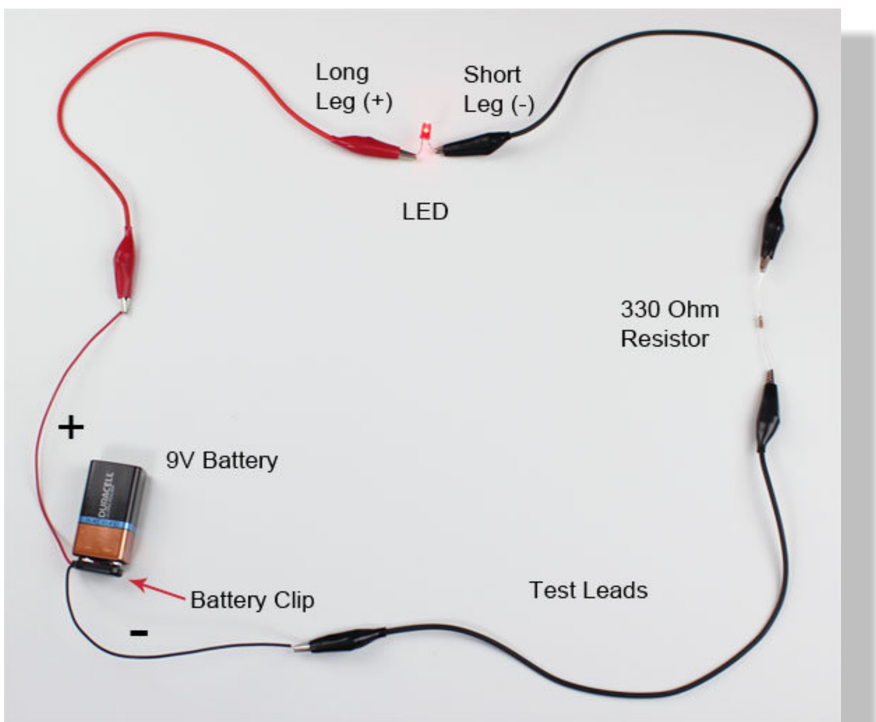
4 Connect one alligator clip from black test lead to the short leg (-) of the LED.

5 The other end of the black test lead is clipped to one leg of the 330 Ω resistor

.

6 Clip one side of the other black test lead to the other leg of the 330 Ω resistor.

7 The opposite end of the black test lead is connected to the black battery wire. IMPORTANT – Never connect an LED directly to a 9V battery without a resistor in the circuit. Doing so with damage/destroy the LED. You can however connect an LED to a 3V or smaller battery without a resistor.



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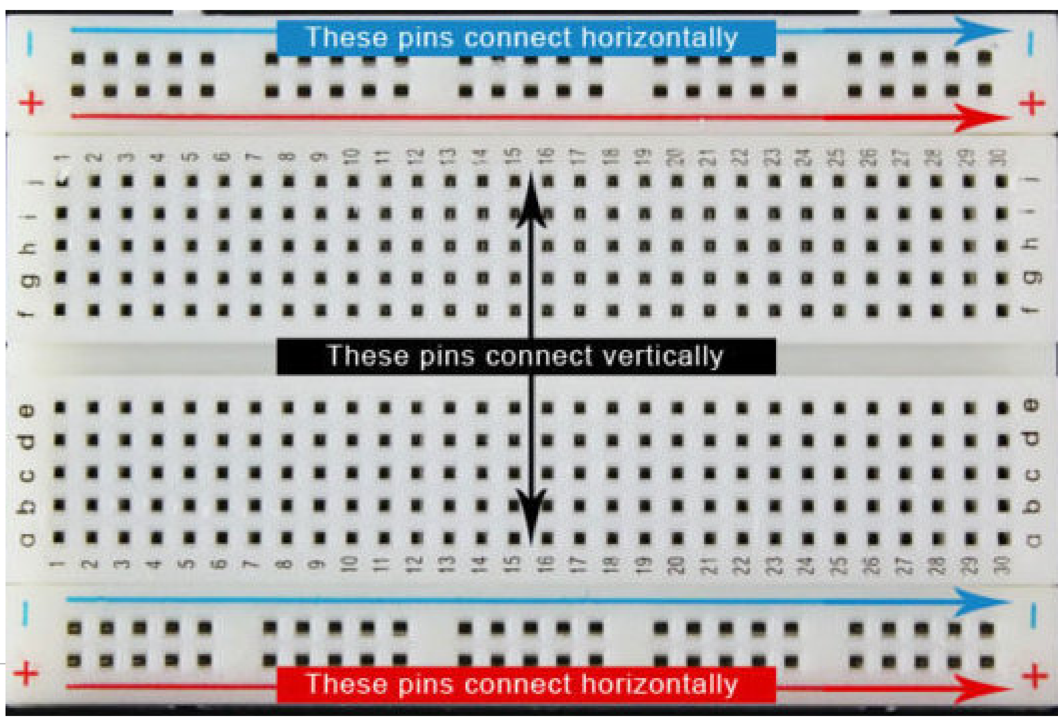
How To Use A Breadboard

Another way to create and test a circuit is to build it on a breadboard. These boards are essential for testing and prototyping circuits because no soldering is needed. Components and wires are pushed into the holes to form a temporary circuit. Because it's not permanent, you can experiment and make changes until the desired outcome is reached.

Below the holes of each row are metal clips that connect the holes to each other. The middle rows run vertically as shown while the exterior columns are connected horizontally. These exterior columns are called power rails and are used to receive and provide power to the board.



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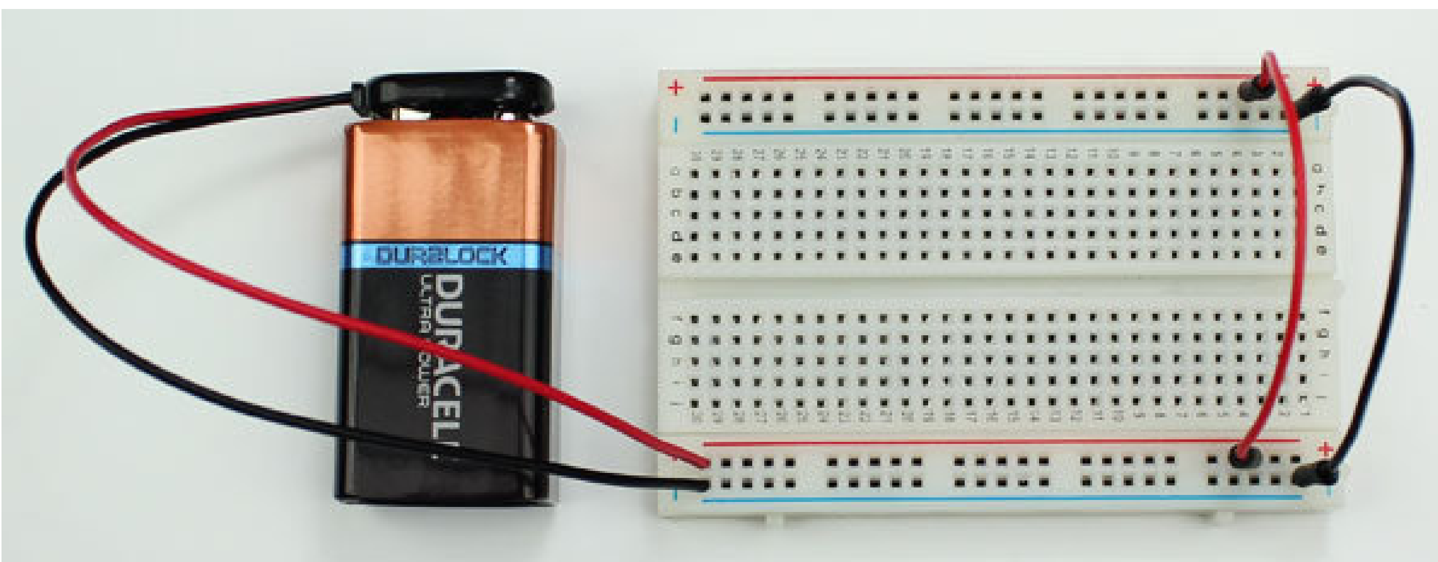
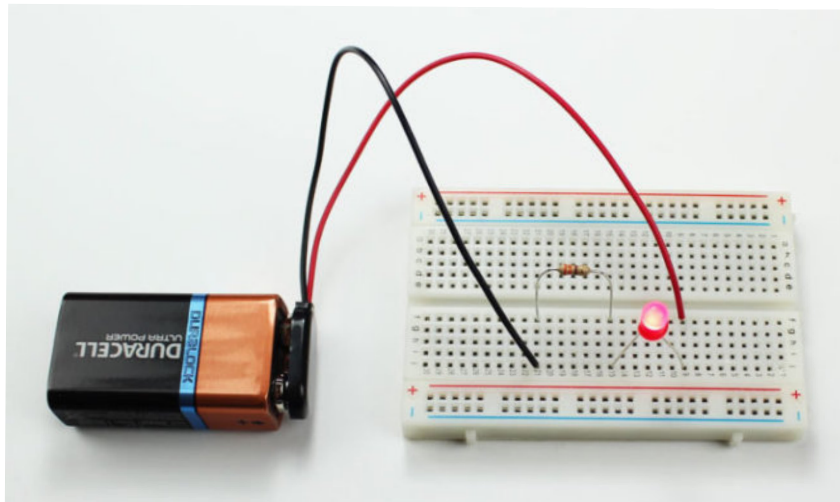
Breadboards will need to have power supplied to them and this can be done in a few ways. One of the easiest way is to plug the wires from a battery holder into the power rails. This will supply voltage to the rail it's plugged into only.

To power both rails, you will need to use a jumper wire from the (+) and (-) to the rail on the opposite side.

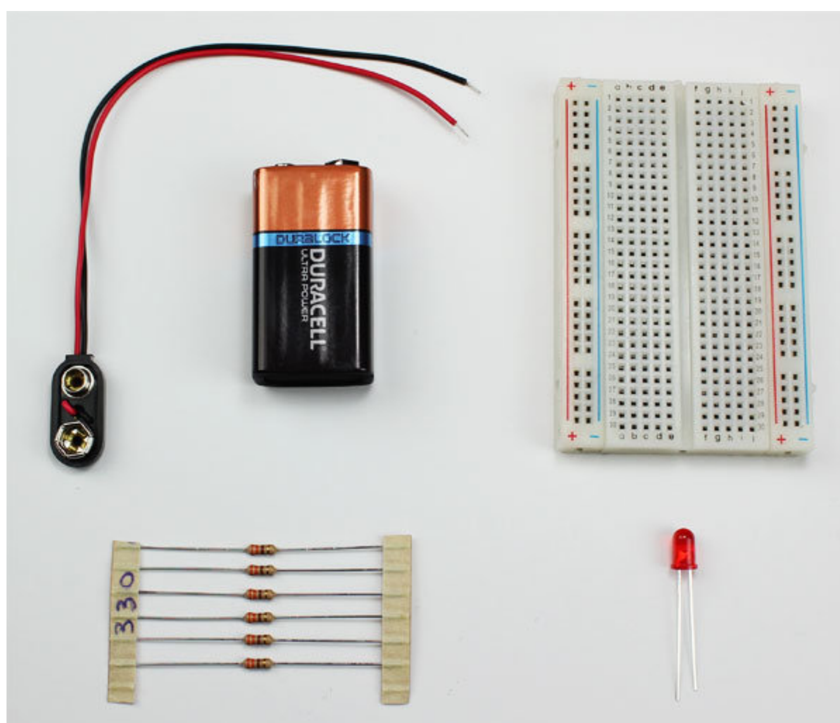


Now we're going to learn how to create a circuit on a breadboard. This circuit is the exact same one we did earlier but we won't be using the test leads.

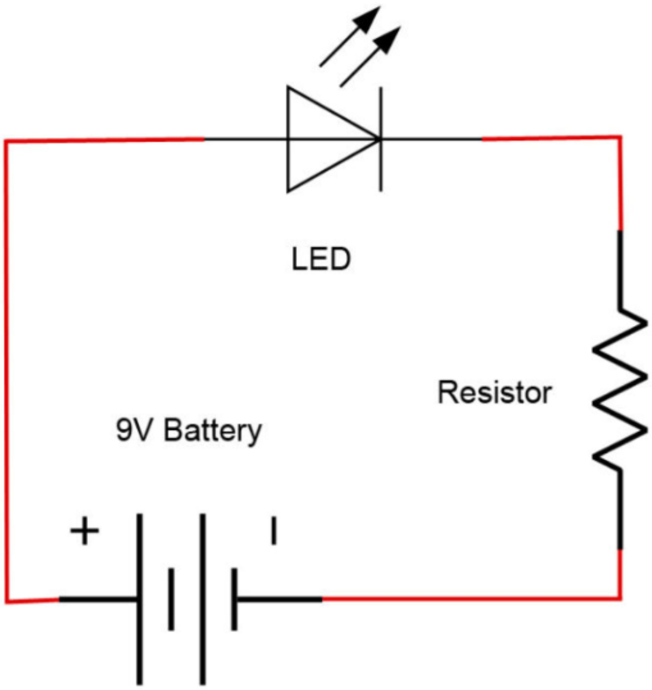


Parts Needed:

9V Battery
Battery Snap-on Connector
330 Ohm Resistor
LED – Basic Red 5mm
Breadboard- Half Size

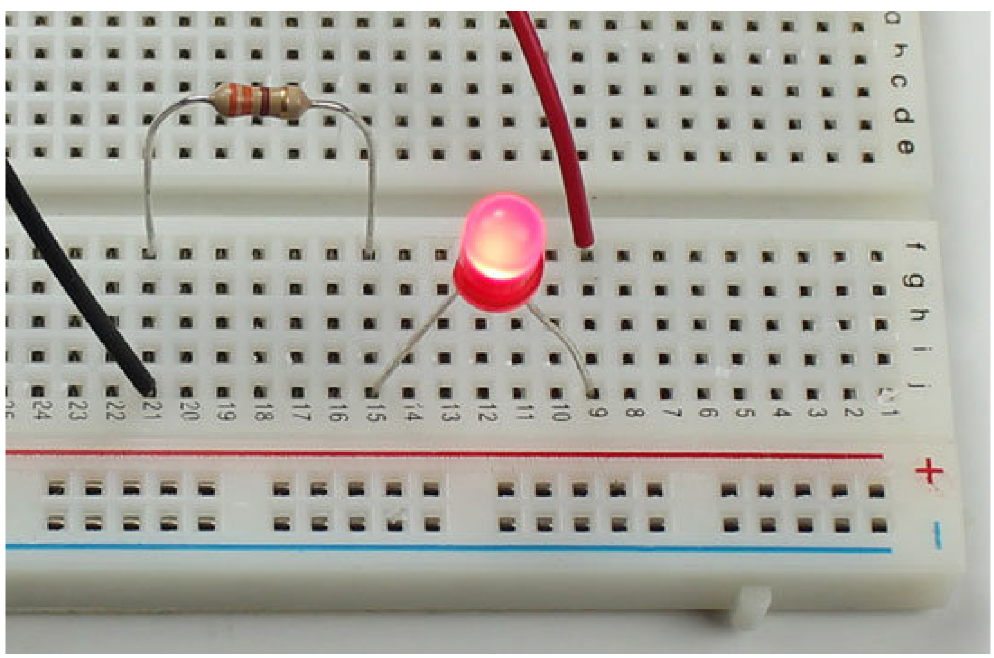


Schematic Diagram



Project Steps

- **Attach the battery clip to the top of the 9V battery.**
- **Place the red wire from the battery clip into F9 of the breadboard.**
- **Insert the black wire from the battery clip into J21 of the breadboard.**
- **Bend the legs of the 330 Ω resistor and place one leg into F21.**
- **Place the other leg of the resistor into F15.**
- **Insert the short leg of the LED into J15 and the long leg into J9.**



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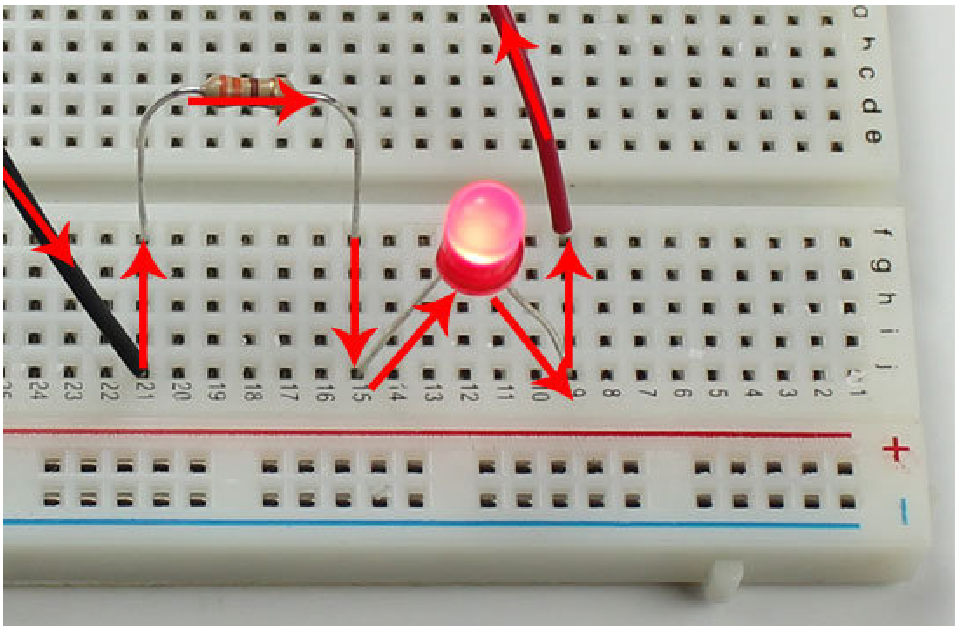
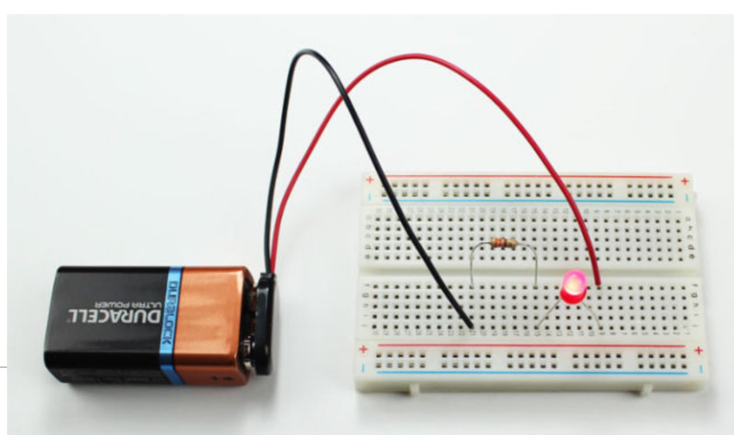
The red arrows in the image below help to show how electricity is flowing in this circuit. All components are connected to each other in a circle just like when we used the test leads.



IMPORTANT – Never connect an LED directly to a 9V battery without a resistor in the circuit. Doing so will damage/destroy the LED.



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