BRAC UNIVERSITY

Inspiring Excellence

Introduction to Instruments

CSE 250

Circuits And Electronics Lab

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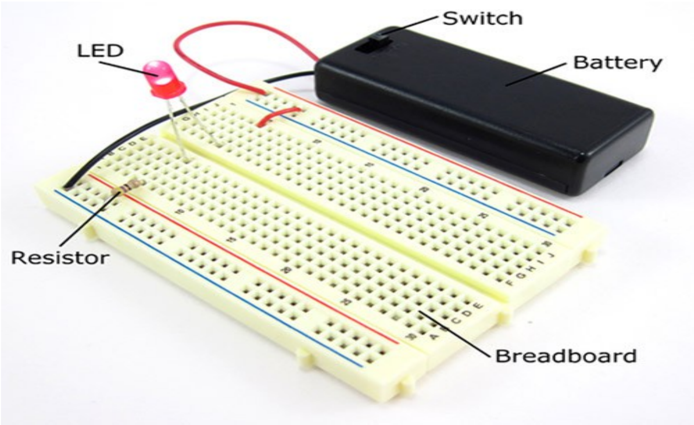
1. Breadboard

Many electronics projects use something called a breadboard. A breadboard is a rectangular plastic board with a bunch of tiny holes in it. These holes let you easily insert electronic components to prototype (meaning to build and test an early version of) an electronic circuit, like this one with a battery, switch, resistor, and an LED (light-emitting diode).



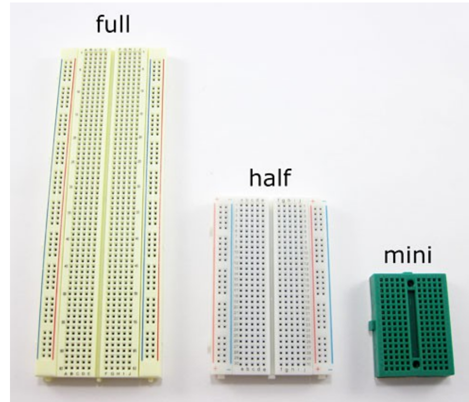
The connections are not permanent, so it is easy to remove a component if you make a mistake, or just start over and do a new project. This makes breadboards great for beginners who are new to electronics.

1.1. Why breadboards are called 'Breadboard'

You might be wondering what any of this has to do with bread. The term breadboard comes from the early days of electronics, when people would literally drive nails or screws into wooden boards on which they cut bread in order to connect their circuits. Luckily, since you probably do not want to ruin all your cutting boards for the sake of an electronics project, today there are better options.

1.2. Sizes of breadboards

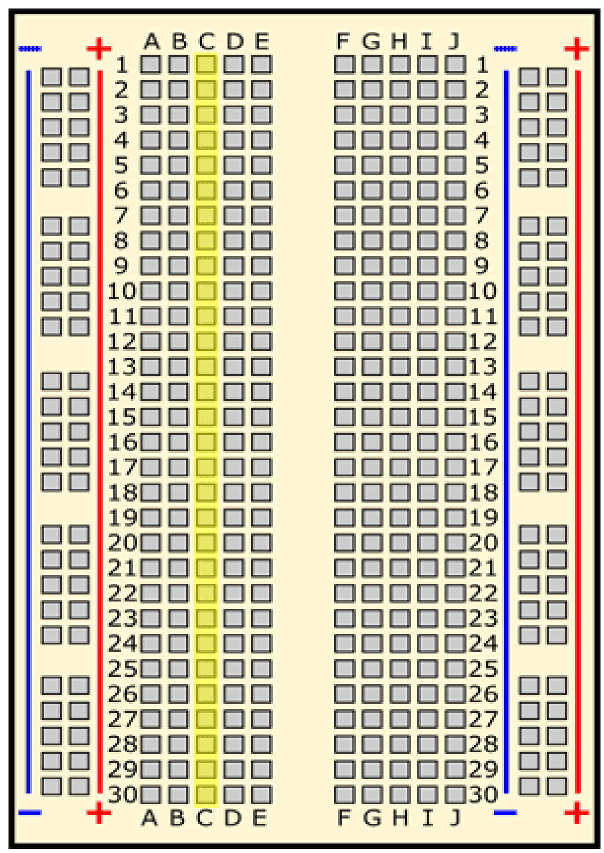
Modern breadboards are made from plastic, and come in all shapes, sizes, and even different colors. While larger and smaller sizes are available, the most common sizes you will probably see are "full-size," "half-size," and "mini" breadboards. Most breadboards also come with tabs and notches on the sides that allow you to snap multiple boards together. However, a single half-sized breadboard is sufficient for many beginner-level projects.



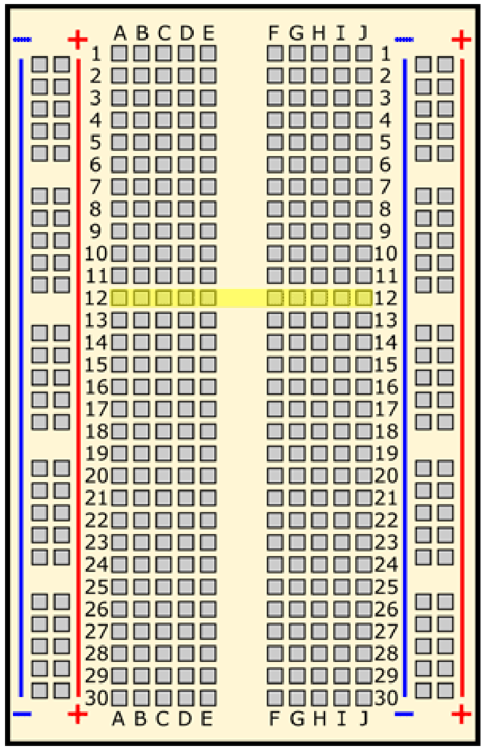
1.3. Breadboard labels: rows, columns, and buses

What do the letters and numbers on a breadboard mean?

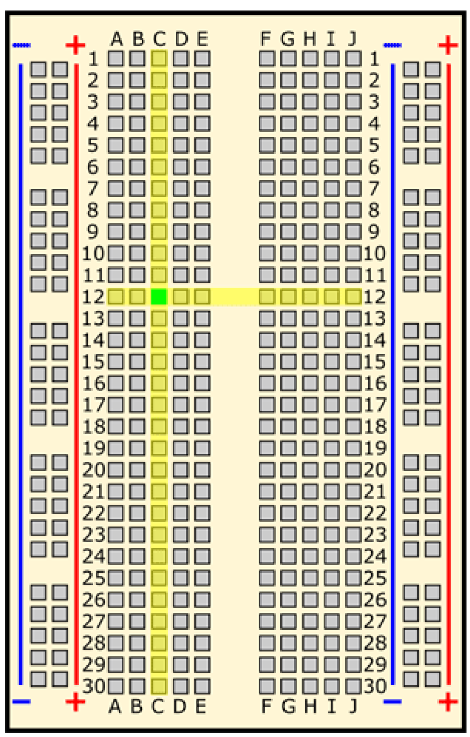
Most breadboards have some numbers, letters, and plus and minus signs written on them. What does all that mean? While their exact appearance might vary from breadboard to breadboard, the general purpose is always the same. These labels help you locate certain holes on the breadboard so you can follow directions when building a circuit. If you have ever used a spreadsheet program like Microsoft Excel® or Google Sheets™, the concept is exactly the same. Row numbers and column letters help you identify individual holes in the breadboard, just like cells in a spreadsheet.



For example, all of the highlighted holes are in "column C."



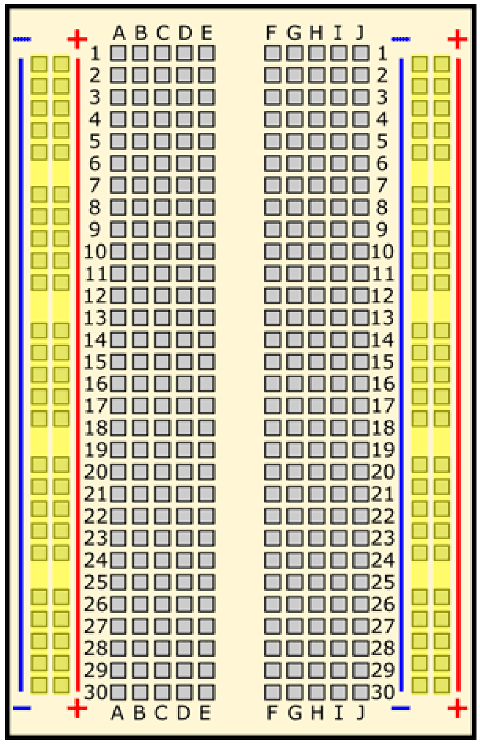
All of the highlighted holes are in "row 12."



"Hole C12" is where column C intersects row 12.

What do the colored lines and plus and minus signs mean?

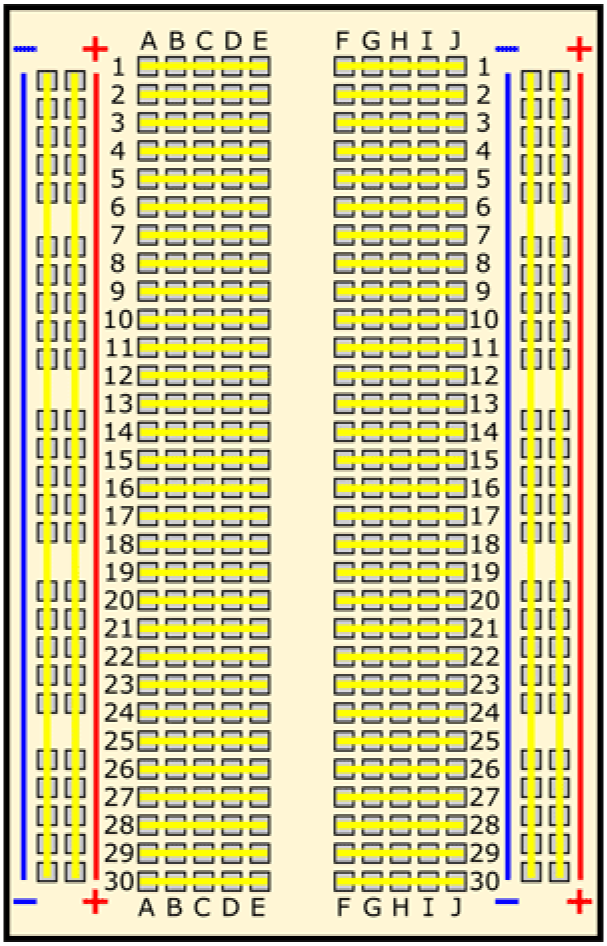
What about the long strips on the side of the breadboard, highlighted in yellow here?



These strips are typically marked by red and blue (or red and black) lines, with plus (+) and minus (-) signs, respectively. They are called the buses, also referred to as rails, and are typically used to supply electrical power to your circuit when you connect them to a battery pack or other external power supply. You may hear the buses referred to by different names; for example, power bus, positive bus, and voltage bus all refer to the one next to the red line with the plus (+) sign. Similarly, negative bus and ground bus both refer to one next to the blue (or black) line with the minus (-) sign. Sound confusing? Use this table to help you remember—there are different ways to refer to the buses, but they all mean the same thing. Do not worry if you see them referred to by different names in different places (for example, in different Science Buddies projects or other places on the internet). Sometimes you might hear "power buses" (or rails) used to refer to both of the buses (or rails) together, not just the positive one.

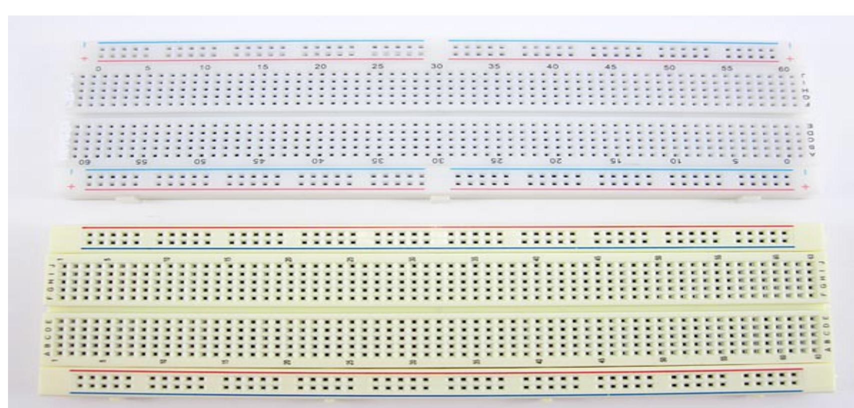
How are the holes connected?

Remember that the inside of the breadboard is made up of sets of five metal clips. This means that each set of five holes forming a half-row (columns A–E or columns F–J) is electrically connected. For example, that means hole A1 is electrically connected to holes B1, C1, D1, and E1. It is not connected to hole A2, because that hole is in a different row, with a separate set of metal clips. It is also not connected to holes F1, G1, H1, I1, or J1, because they are on the other "half" of the breadboard—the clips are not connected across the gap in the middle. Unlike all the main breadboard rows, which are connected in sets of five holes, the buses typically run the entire length of the breadboard (but there are some exceptions). This image shows which holes are electrically connected in a typical half-sized breadboard, highlighted in yellow lines.



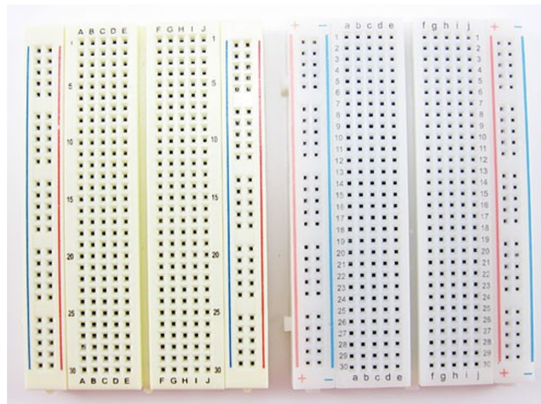
Buses on opposite sides of the breadboard are not connected to each other. Typically, to make power and ground available on both sides of the breadboard, you would connect the buses with jumper wires, like this. Make sure to connect positive to positive and negative to negative.

Are all breadboards labeled the same way?



Note that exact configurations might vary from breadboard to breadboard. For example, some breadboards have the labels printed in "landscape" orientation instead of "portrait" orientation. Some breadboards have the buses broken in half along the length of the breadboard (useful if you need to supply your circuit with two different voltage levels). Most "mini" breadboards do not have buses or labels printed on them at all.

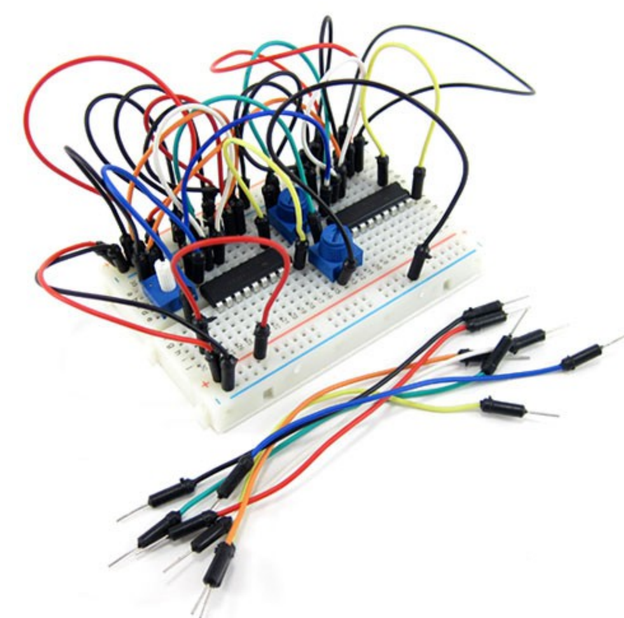
There may be small differences in how the buses are labeled from breadboard to breadboard. Some breadboards only have the colored lines and no plus (+) or minus (-) signs. Some breadboards have the positive buses on the left and the negative buses on the right, and on other breadboards, this is reversed. Regardless of how they are labeled and the left/right positions, the function of the buses remains the same.



1.4. What are jumper wires and what kind should I use?

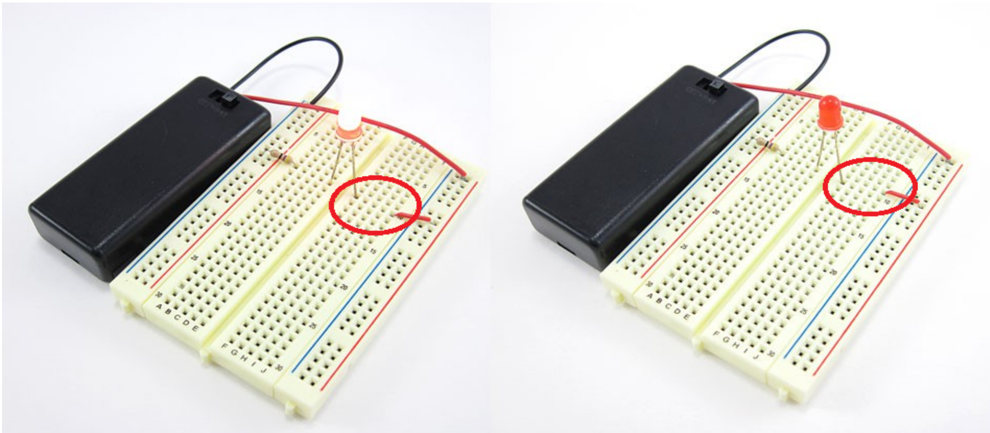
Jumper wires are wires that are used to make connections on a breadboard. They have stiff ends that are easy to push into the breadboard holes. There are several different options available when purchasing jumper wires.

Flexible jumper wires are made of a flexible wire with a rigid pin attached to both ends. These wires usually come in packs of varying colors. This makes it easy to color-code your circuit. While these wires are easy to use for beginner circuits, they can get very messy for more complicated circuits; because they are so long, you will wind up with a tangled nest of wires that are hard to trace (sometimes called a "rat's nest" or "spaghetti").

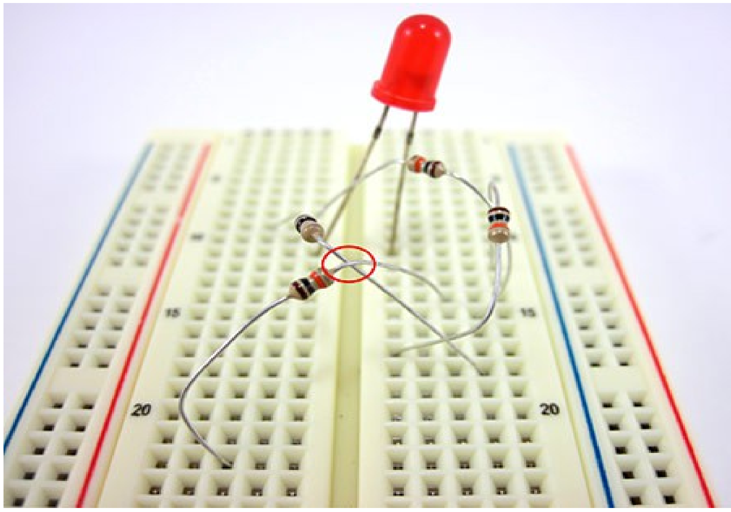


1.5. Common mistakes

1. Getting row numbers wrong

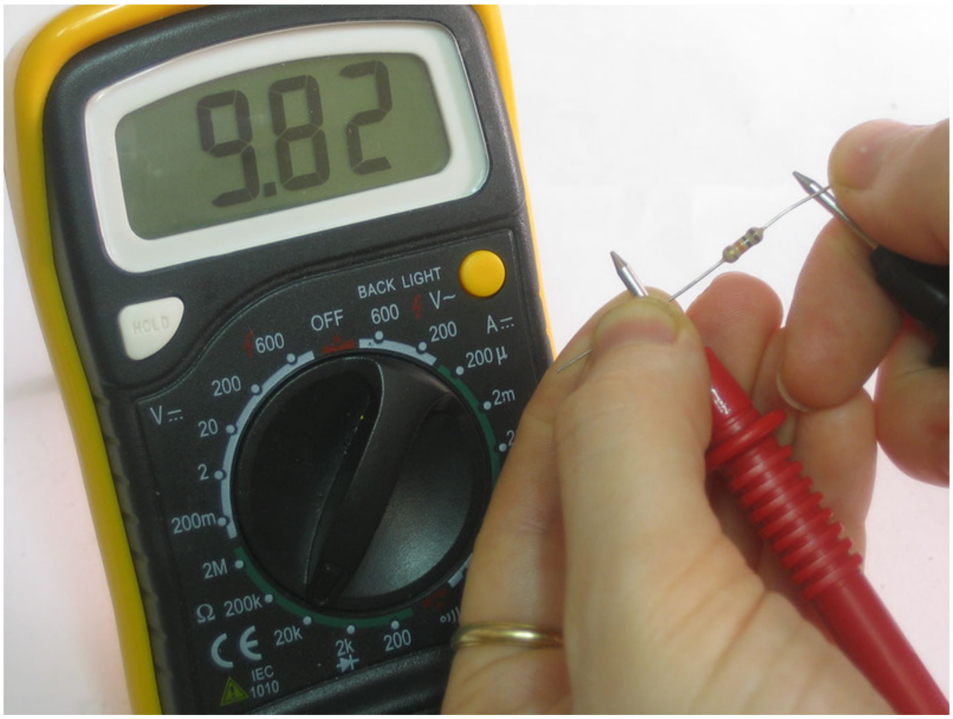


2. Getting power and ground mixed up
3. Not pushing leads and wires in all the way
4. Short circuits



2. Multimeter

A Multimeter is known as a multitester or VOM (Volt-Ohm Milliammeter). It is an all-in-one electronic measuring instrument that combines several measurement functions. Thus, it'll be able to troubleshoot issues with your circuit or electronic designs!
There are two types of multimeter, but a typical multimeter is capable of measuring voltage, current and resistance. We will go into more detail in the latter part of this guide.
A typical multimeter nowadays looks like this,



2.1. Measuring Voltage

Turn the multimeter dial to 'Voltage'. Then connect the two probes of the multimeter to the two points between which the voltage difference is being measured. The numerical value will be shown on the monitor of the multimeter. The value might be positive or negative, depending on the orientation of the connected probes. Consider the sign of the measured value carefully.
If AC voltage (or current) is to be measured, one must use the multimeter in AC mode. The multimeter can be switched between DC and AC mode by pressing a special button (A BLUE COLORED BUTTON in the top right corner under the monitor).

2.2. Measuring Current

The current flowing through any branch/component of a circuit can be measured with a multimeter by using it as an ammeter. But a more convenient method is used to measure the current; which is to first measure the voltage across the component (resistor(s)), then divide this value by the value of the measured resistance of that component (resistor(s)).

Why don't we measure current with a multimeter in ammeter mode?

- We have to break the main circuit whenever we want to measure the current as the ammeter has to be connected in series with the component of which we want to measure the current.
- There is a chance of flowing a large current through the multimeter if there is any error in the circuit and this may cause damage to the multimeter.
- The multimeter (as an ammeter) may not be able to measure currents precisely for some complex configuration of circuits.

3. Resistors

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

3.1. Measuring Resistance

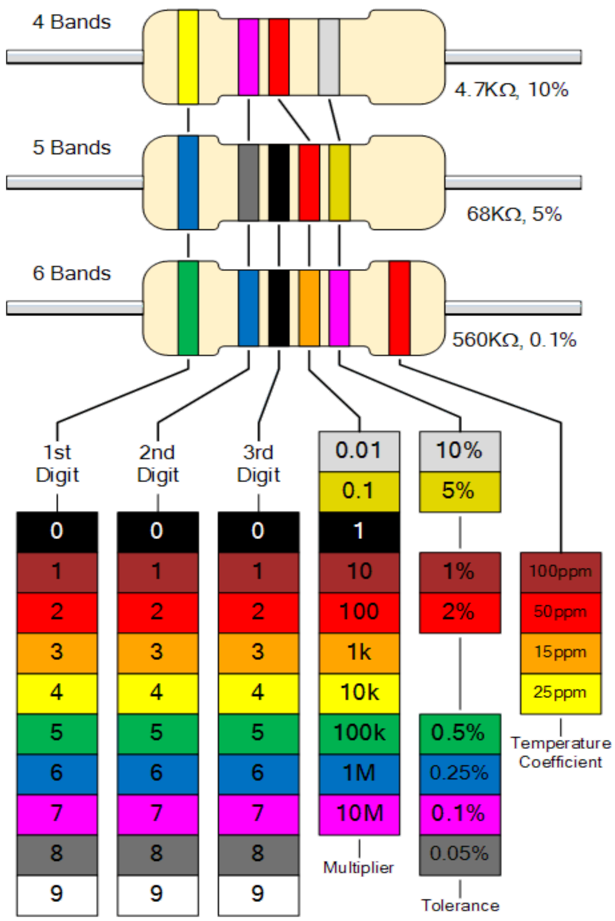
Using multimeter

Turn digital multimeter dial to 'Resistance', or 'Ohms'. Then connect the two probes to two terminals of the resistance. A numerical value with appropriate unit will be displayed in the multimeter. **Do not measure the resistance while it is connected to a circuit with other**

components specially connected to a active power supply as it may cause to show a wrong value for the resistance.

Using Resistor Color Code

As there are many different types of Resistor available we need to form of resistor colour code system to be able to identify them.



The Resistor Colour Code Table

Colour	Digit	Multiplier	Tolerance
Black	0	1	
Brown	1	10	± 1%
Red	2	100	± 2%
Orange	3	1,000	
Yellow	4	10,000	
Green	5	100,000	± 0.5%
Blue	6	1,000,000	± 0.25%
Violet	7	10,000,000	± 0.1%
Grey	8		± 0.05%
White	9		
Gold		0.1	± 5%
Silver		0.01	± 10%
None			± 20%

Calculating Resistor Colour Code Values

The Resistor Colour Code system is all well and good but we need to understand how to apply it in order to get the correct value of the resistor. The "left-hand" or the most significant coloured band is the band which is nearest to a connecting lead with the colour coded bands being read from left-to-right as follows:

Digit, Digit, Multiplier = Colour, Colour x 10 colour in Ohm's (Ω)

For example, a resistor has the following coloured markings;
Yellow Violet Red = 4 7 2 = 4 7 x 10^2 = 4700Ω or 4k7 Ohm.
The fourth and fifth bands are used to determine the percentage tolerance of the resistor. Resistor tolerance is a measure of the resistors variation from the specified resistive value and is a consequence of the manufacturing process and is expressed as a percentage of its “nominal” or preferred value.
Typical resistor tolerances for film resistors range from 1% to 10% while carbon resistors have tolerances up to 20%. Resistors with tolerances lower than 2% are called precision resistors with the or lower tolerance resistors being more expensive.
Most five band resistors are precision resistors with tolerances of either 1% or 2% while most of the four band resistors have tolerances of 5%, 10% and 20%. The colour code used to denote the tolerance rating of a resistor is given as:
Brown = 1%, Red = 2%, Gold = 5%, Silver = 10 %
If resistor has no fourth tolerance band then the default tolerance would be at 20%.

4. DC Power Source

A DC power source is a device that produces steady and controlled DC voltage to power up a circuit under test, such as a breadboard circuit, a printed circuit board, or an electronic product.

There are four channels in two different groups on this device (Ch1 and Ch3 together and Ch2 and Ch4 together) to supply DC power to an external circuit. At the same time, we can observe any one channel from a group (i.e., any one of the channels 1-3 and channels 2-4). The buttons on the top right and top left corners of the device's monitor are used to switch between the channels. The two push buttons are used to operate the two groups in independent, series, or parallel mode (for our lab experiments, we will use them in "independent" mode).

To supply power to the circuit under test,

1. First, push the power button (on the bottom left corner of the device).
2. Set the current limit using the current knob(s) (around 0.5 A). Then, set the desired value(s) of voltage using the voltage knob(s). Remember that channels 1-3 are in the same group and channels 2-4 are in the same group, and use the current knobs accordingly to set the current for the desired voltage knob/channel.
3. Once you set the voltage to your desired value push the "Output" button top right corner of the knob panel. The power will not be supplied to the external circuit until you push the "Output" button.