Module 1

INTRODUCTION TO ELECTRICITY

Learning Outcomes

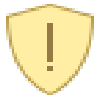
When you have completed this module, you will:

- Understand the concept of electricity
- Understand the concept of a charge
- Know the difference between Static and Current electricity.
- Understand what is meant by EMF(Voltage)
- Understand the concept of fields
- Understand Electromagnetic fields
- Understand the workings of a motor (electric motor)
- Know what a dynamo is and how it’s used to generate electricity

Introduction

Electricity is not in any way a complex term, I mean if you’ve ever seen a lightning bolt in the sky or even movies, you will have an idea of the form of electricity. You see a lot of wired connections in or around your homes, along roads, in your schools and so on, all these mysterious connection of wires are done to be able to transmit and utilize electricity in your homes, schools, your parent’s places of work and more, I mean this list goes on and on. With all said, I believe you can truly see how important electricity is to us in our day to day activities even to do the most basic things like switching on a light, switching on your TV to watch your favourite channels and all.

Electricity, as useful as it may be, it is also very powerful and dangerous, and can cost one his life if tampered with. So I wouldn’t encourage you to go about touching electrical appliances without full knowledge of what it is.

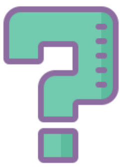


So be sure to ask your parents or your older siblings about an electrical appliance before touching it and you’ll be fine.

Now that we understand the concept of electricity, we'll take a further step into understanding charges.

Fun Facts: Do you know that the energy contained in a single lightning strike can power a 100watt light bulb for 90 days? Awesome right, guess what, this single strike of lightning is 5 times hotter than the surface of the sun.

Charges



What is the first thing that comes to your mind when you hear the word "charge"? I could bet, probably plugging your gadgets like mobile phones to top up your battery life. Well, that assumption isn't wrong, but it's totally different from what we're going to be talking about now.

When watching TV for so long, have you ever noticed the sparks generated from the screen of your TV when you touch it after putting it off? It usually has this tingling feeling on the palm of your hand, notice the sparks in a dark room. Or when rubbing your feet on a carpeted floor for a while then touching a metal object afterwards, you'll get this mild shock on the part of your body that comes in contact with that metal.

All this happens as a result of something called an electric charge which is denoted by ***Q***, and is measured in a unit called ***Columbs*** (C). We can't underestimate the importance of a single charge in electricity, as this charge can become current when a force is applied to it. Charges are either positive (+) or negative (-) which are known as *protons* and *neutrons* respectively.

I do believe you now have a clear idea of what a charge is now, so taking another step forward, we would talk about the types of charge, which are;

1. Static and
2. Current charge.

Static Charge

Static charge, otherwise known as static electricity, simply put is the charge generated through friction. Electrons can pass from one material to the other when two distinct materials come into touch.

Let's perform a simple experiment to demonstrate this;

Before performing an experiment, it is important to give it a proper name just like you have one. So let's get right into it.

Experiment title: Pen and Paper attraction.

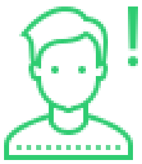
Now that we have a proper descriptive name for our experiment, we shall follow a series of steps to arrive at the desired result.

1. Gather the necessary materials. For this experiment, you'll need;
    - A pen
    - Tiny pieces of paper
2. Now pick up the pen and start rubbing the end (not the sharp part) of the pen on your hair fast. Do this for a minute.
3. Now use the end you just finished rubbing on your hair to pick up one of the pieces of paper.
4. Did it work? If not repeat the process.
5. Viola!!! Experiment completed, congratulations.

An image using a charged pen to pick up a paper.

Moving on quickly, let's look at current charge.

Current Charge



Remember earlier when I said, "charges can become current when a force is applied to it." Well, when a force is applied to it, it flows just like pushing an object basically. Therefore, current charge or in most cases current electricity can be explained as the flow of static charge that builds up, in that, case you get a current. Very straightforward right?

Current can actually be defined as the rate of flow of charge and is measured in ***Amperes*** (A). Notice I used the word *flow,* it is this flow that results in actual electricity we use daily. Mathematically it can be explained as the flow of charge (Q) with respect to time (t), written as;

$$I = \frac{Q}{t}(Amperes)$$

Equation for Current

Let's take a quick example on this;

Example 1

What is the average current in a wire when a charge of 150C passes in 30s?

Answer

First let's list out the values;

Q = 150C, and t = 30s

Applying the Equation for current, we have;

$I = \frac{150}{30}$; Simplifying, we have: $I = 5A$

It is important not to forget your unit of measurement.

Let's look at another one

Example 2

What is the average current in a wire when a charge of 450C passes in 9s?

Answer

First let's list out the values;

Q = 450C, and t = 9s

Applying the Equation for current, we have;

$I = \frac{450}{9}$; Simplifying, we have: $I = 50A$

Voltage

You have probably seen signs like the one on your left with warnings like "Keep Out High Voltage" or heard someone say "the voltage rating of that device is 240 volts" or something quite similar. Well we are all talking about Voltage.

Recall from the last module, when you learned that "charges can become current when a force is applied to it." Well that force we speak up is called voltage or in a more advanced language ***electromotive force.*** Imagine trying to pass water from a hose or pipe through a tight nuzzle, the flow of water is going to be very slow, probably dripping but when adequate pressure to force the water from the hose through the nuzzle is applied you'll discover how rapid the water comes out. An example of this is your Garden Sprinkler. With that said, electrical current requires some force (Voltage) to make it flow.

Voltage can therefore be defined as the driving force in circuit. The greater the voltage, the greater the flow of electrical current through a conductor (wires). Voltage is measured in ***Volts (V)***.

Relationship with Current

As explained above, a charge requires voltage to make it flow which then becomes current. With this we can say voltage is directly proportional to the flow of current. That is, as one increases, the other one also increases.

Mathematically this can be expressed as;

$$V \alpha I;$$

But there is a general law governing this relationship. This law, known as **Ohm's law** states that the current flowing through a conductor is directly proportional to the voltage across that conductor and inversely proportional to the resistance of the conductor. Given as;

$$I = \frac{V}{R}$$

Fields

What is a field? We've probably come across this word more than once and may or may not know what it means. Let us perform a simple exercise to understand this. Stretch out your arms, and turn around, the region your arms cover is the field around you, anything your hand touches or is within your reach is in your field, hence can be influenced by you and as you move, it moves also.

Therefore, we can say a field is a region around a body where the influence of that body can be felt. It is important to know that all objects have a field no matter how weak or how small it is.

Field lines: This can be described as an invisible line used to indicate the direction of the force of a field, especially an electric or magnetic field, at various points in space. The strength of a field depends on how far away you are from the body creating the field. The closer you are, the stronger the field and the more powerfully it pushes or pulls other charges around. The farther away you are, the weaker the field.

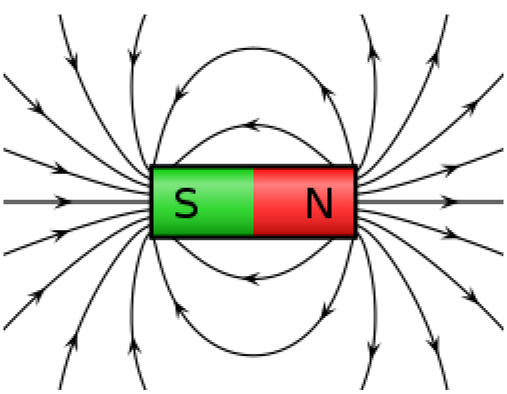
Magnetic field

A magnet is a metal or a material that produces a magnetic field which has the property to attract other metals (ferrous) to itself.

All materials experience magnetism, some stronger than others. Permanent magnets, made of metals such as iron, experience the biggest effects, known as *ferromagnetism*. With an uncommon exception, this is the only type of magnetism powerful enough for people to feel.

Magnets

Magnetic field sources are dipolar (two poles), having a north and south magnetic pole. Opposite poles (N and S) attract, and like poles (N & N, or S & S) repel. This produces a doughnut-shaped field as the direction of the field propagates from the north pole and passes through the south pole as illustrated below.

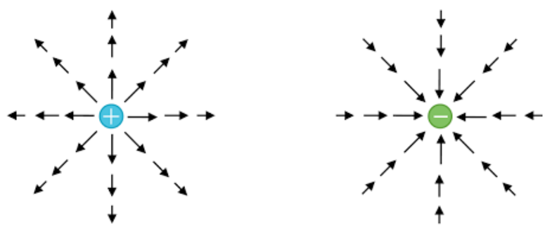


Magnets are found in devices such as speakers, compasses, electric motors, and many other things.

The Electric field

You guessed right! Electric field is the region in which electricity can be experienced. Just like your charges electric fields are either positive or negative depending on the type of charge. The electrical field encircling a positive or negative charge defines how strongly it pushes and pulls other charges, and in what direction.
For instance, if you had a positive charge, then it would push other positive charges away from it in all directions and pull negative charges towards it from all around. Same goes for the negative charge, it pushes all other negative charge away and attracts positive charges.

Notice that this works just like a magnet, in this case attracting unlike charges and repelling like charges and just like your magnetic field, this also produces a doughnut-shaped field as the direction of the field propagates from the positive charge and enters the negative charge as illustrated in Fig B. below.



Field lines of positive and negative charge

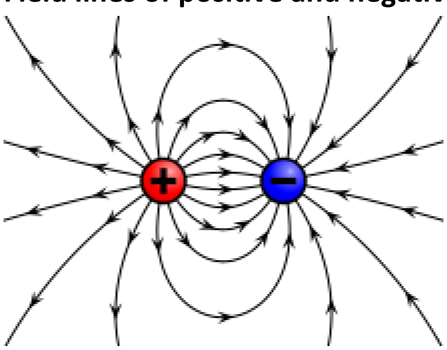


Fig B.

Electromagnetic Field

From the name, it is easy to describe it as the combination of electric and magnetic field to form what is known as electromagnetic field.

An electromagnetic field can be explained as a field created by the motion of an electric charge. A static (stationary) charge will produce only an electric field in the surrounding space. when the charge is moving, a magnetic field is also produced.
An electric field can also be produced by the constant changing magnetic field.

From this explanation, we can derive that;

1. A magnetic field can be produced from a moving charge.
2. Electric fields can be produced from constant changing of magnetic field.

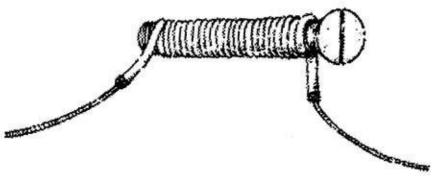
Simply put, electromagnetic field is the mutual interaction of electric and magnetic fields.
Now this is more accurate and even easier to understand.

Let’s perform two simple experiments to demonstrate the two derivations above;

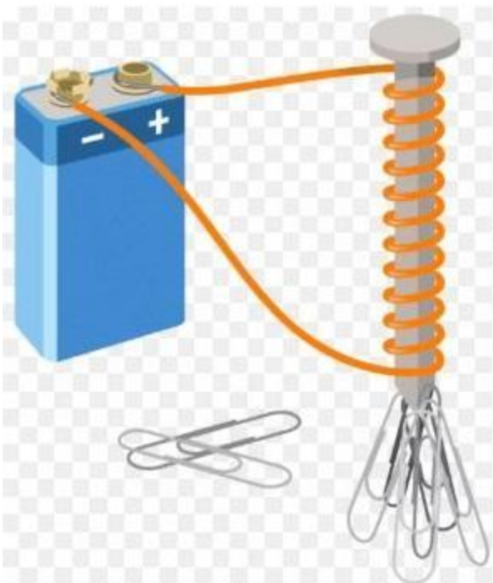
Experiment TWO
Experiment title: Creating an ElectroMagnet.

Now that we have a proper descriptive name for our experiment, we shall follow a series of steps to arrive at a desired result.

1. Gather necessary materials. For this experiment, you would need;
    a. A 9V Battery
    b. Copper wire
    c. A long screw or nail
    d. Metal paper clips
2. Wind the copper wire around the screw/nail like this.



3. Now pick both ends and connect one to the negative terminal of the battery and the other to the positive terminal.
4. Place the metal paper clips at a close distance, notice the attraction.



5. Viola! Experiment completed, we can see the presence of magnetic field here.

Experiment THREE
Experiment title: Creating electricity with magnets.

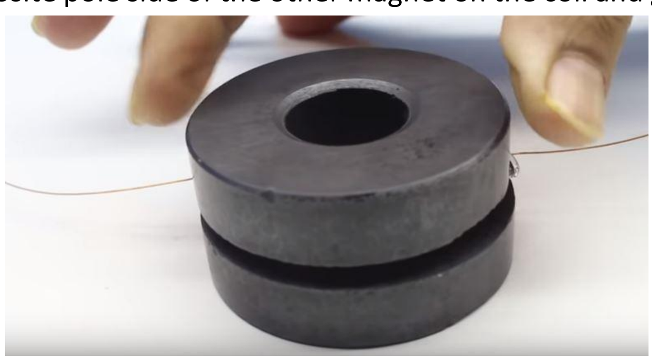
Now that we have a proper descriptive name for our experiment, we shall follow a series of steps to arrive at a desired result.

1. Gather necessary materials. For this experiment, you would need;
   a. Two Magnets. You can get this from your spoilt speakers
   b. Copper wire
   c. An LED lamp/bulb
   d. Hot glue
2. Wind the copper wire around a cylindrical material of a bigger diameter like this;

3. Coil two separate wires opposite each other on it like this;

4. Now place the coil on one side of the magnet and glue it, like this;

5. Now place the opposite pole side of the other magnet on the coil and glue them, like this;



6. Connect both ends of the coil to the two terminals on your lamp, like this;

7. Did it light up? No? Check your connection, Use a smaller lamp. Yes? Awesome!!
8. Viola! Experiment completed.

The Electric Motor

An electric motor popularly known as Rotors is an electrical device that changes electrical energy into mechanical movement. Electric motors work by using the force of magnetism. They are found in Toy Cars, Radios, DVD players and so on.

An Electric Motor

How it works

A conductor with flowing current creates a magnetic field, as explained earlier. When a coil like the last one we made in the previous experiment is powered, will have a magnetic field with north and south poles, just like any other magnet. And we now know that *like poles repel each other and opposite poles attract each other*. So, if you put a magnetized coil of wire over a regular magnet with the same poles close to each other, the coil will try to twist itself around.

With that said, let us perform a simple experiment.

Experiment FOUR

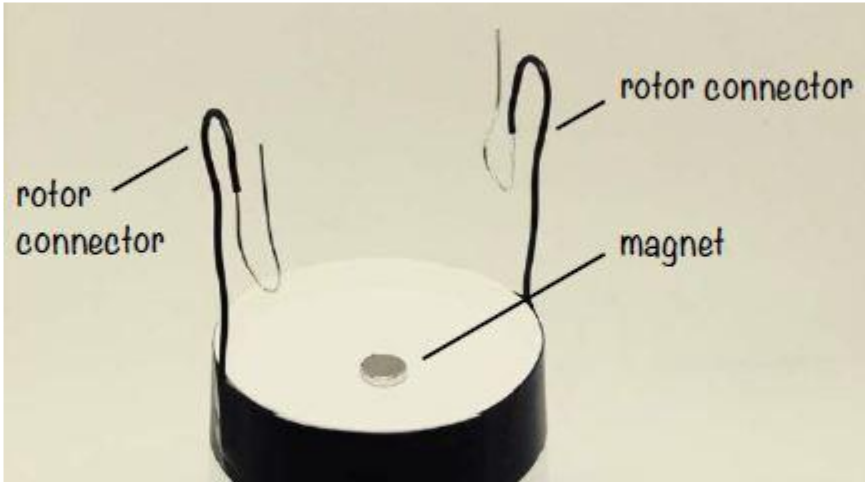
Experiment title: Making an Electric Motor.

Now that we have a proper descriptive name for our experiment, we shall follow a series of steps to arrive at a desired result.

1. Gather necessary materials. For this experiment, you'll need;
   a. A 9V Battery
   b. Copper wire for coil
   c. A thicker copper wire
   d. Magnets
2. Wind the copper wire around a cylindrical material of a bigger diameter like this;

3. Coil two separate wires opposite each other on it like this;

4. Now fold your thicker copper wire and erect them like this to serve as your connector;



5. Place the magnet under as shown above.
6. Now place the two ends of the coil on the rotor connection and connect your battery.

7. With no doubt it should spin. If it doesn't check your connection and try again.
8. Viola!!! Experiment completed.

Electricity Generation

Electricity generation is a process of converting primary sources of energy into electricity. Some examples of primary sources of energy include energy from the sun (Solar Energy), Water (hydroelectricity), Gas etc. Electricity, is popularly generated by a device known as an electric generator, also called a *Dynamo*. These generators function to convert mechanical energy into electrical energy, just like your generators at home does. The process is based on the relationship between magnetism and electricity known as electromagnetic induction as explained earlier (the electric motor). Electromagnetic induction can simply be explained as generating voltage due to change in magnetic field.

The Dynamo

A dynamo is the direct opposite of a motor in terms of functionality. That is, takes in mechanical energy and converts it to electrical energy. When an electric motor is turned from its shaft (the extruding rod) with speed, it generates electricity which can then be used to power up an electrical lamp. An application of this is in your bicycle.

Not all bicycle has this, but for those with them, it’s usually located by the side of either tyres.

Picture of a dynamo on a bicycle

This works on the simple electromagnetic induction principle as stated above. The dynamo is usually connected to the headlamp of the bicycle to help give light when riding in a dark area. You’ll notice when riding your bicycle, the faster you go the more your head lamp brightens.

This shows the basic generation of electricity, and it’s also used on a larger scale as an electric generator in dams (hydroelectricity) where water subjected from a higher place (higher reservoir) flows down the penstock (pipes/paths) and pushes the blades of a turbine to cause a massive rotation which is connected to the electric generator and in turn rotates very quickly to generate electricity on a very large scale. another application of an electric generator is in wind turbines.

And with this we’ve come to the end of this module. I believe you learnt a lot of new things here and enjoyed it as well.

Module~~Chapter~~ 2

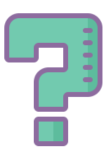
INTRODUCTION TO ELECTRONICS

Learning Objectives

When you have completed this module, you will:

- Have a basic understanding of electronics
- Identify tools used in electronics
- Identify and know the functions of basic electronic components
- Understand what is meant by a circuit and circuit configuration
- Know the different types of boards used in electronics
- Know the configuration of a Breadboard
- Perform an LED lamp project with a breadboard.

Introduction



What does the word electronics mean to you? Let me give you an idea, your TV, your Radio, your Mobile devices, your Computers in school or at home and so on. They are all electronic devices.
Why are they called electronic devices? On a much lower level, they are called electronic devices because they are made up of electronic components. And on a higher level, they are called electronic device because they control the flow of electrons for performing the particular task. This definitely sounds too complex at this stage, but as we move on it will become simpler to you.

Before wee delve deeper, it is important you get familiar with safety rules when working with these tools.

Electronics Safety Rules

Safety, while working on any project in electronics or electricity is very important. With that said, safety rules can be explained as a principle or regulation governing actions and procedures of use of devices, components and machines to lower the occurrence or risk of injury, loss and danger to persons, property or the environment. Some major safety rules while working on an electronic/electrical projects are;

- Never work on a circuit while power is applied.

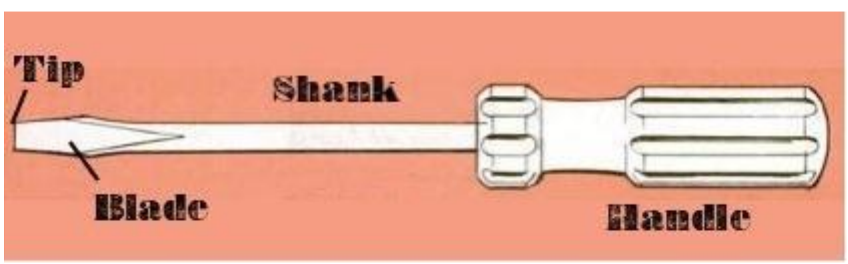
- Do not connect power to a circuit until the circuit is finished and you have checked your work.
- If you smell something burning, immediately disconnect the power and examine your circuit to find out what went wrong.
- Keep your work area dry.
- Always wear safety goggles
- Be careful around large capacitors; they can continue to hold voltage long after they are disconnected from power.
- Be especially careful when you solder because a hot soldering iron can easily burn you.
- Always work in a well-ventilated space.
- Have safety equipment such as fire extinguishers and first-aid kit, nearby in case of an emergency.

Electronic Tools

Every kind of work requires one or more particular tool to ensure precision and neatness on that job. For instance, just like writing in your notebook, you'd either use a pen or a pencil but definitely not a stone or a spoon.

Below are the major tools used in electronics and their functions;

1. Screwdrivers: Screwdrivers are hand operated tools used for turning (tightening and loosening screws). They are of two types Flat mouth (Tip) and star mouth (Tip).



A screwdriver

There's also the special screwdriver kit which has a lot of screwdrivers with different mouth

2. Pliers: These are hand tools used to hold objects firmly, twist wires, peel and cut wires.
    A. Combination pliers: This is a general purpose plier

B. Needle Nose: Needle nose or long nose pliers are used to reach deep in a circuit, also used for twisting.

C. Cutters: Cutters as its name implies is used for cutting and peeling wires.

3. Soldering iron: This is heated up and used to melt solder lead on a joint. It is used in soldering and desoldering process.

4. Multimeter: A multimeter is a multipurpose device used to measure voltage, current, resistance, and connectivity. There range from simple ones to complex ones.

5. Solder Lead: A solder lead is a metal or alloy that melts at a low temperature. It is melted with a soldering iron to strengthen a joint.

6. Google: this is used for eye protection because the fumes from the melting of the lead are dangerous to the eyes.

7. Solder sucker: This is used to suck solder from a joint during desoldering process.

Electronic components

Electronic components can simply be explained as any element that makes up an electronic circuit. Electronic components/elements are charged with their own specific function in an electronic circuit. Electronic components are divided into two the passive and active components.

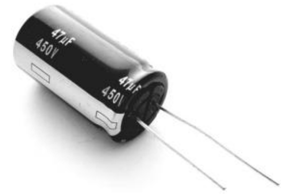
Passive components are basically components do not generate energy, but can store it or dissipate it they do not require energy to perform their intended functions. There are mostly two terminal components, examples of passive components are your resistors, capacitors.

Active components are the opposite of passive components; they can inject power into the circuit such as amplifying a signal. They require sources of energy to perform their intended task. Common examples of active components are transistors, diodes, IC (integrated circuits).

Some major electronics components and their short description are;

- Resistors: Passive components used to limit the flow of current in a circuit.

- Capacitors: passive components used to store charges and filter signals.



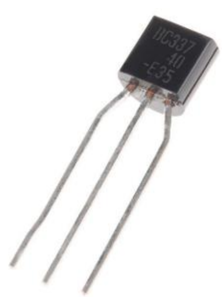
- Inductors: Passive component, its major use is to store electrical energy in the form of magnetic field.

- Battery: Active component used to supply power to a circuit.

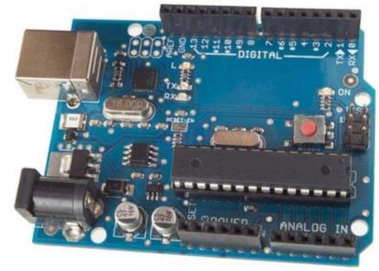
- Diodes: Passive component, diodes are very important components as it has a lot of uses; as rectifier (converting AC signals to DC signals), Voltage regulator etc.

- LED: Passive components, emits light when voltage is passed through it.

- Transistors: An Active component used to amplify or switch electronic signals.



- Microcontrollers: Microcontrollers are primarily used in embedded systems.



- Transformers: Passive component, used to either raise or lower voltages and currents in an electrical circuit.

- Fuse: This is a protective element used to protect electronic circuits from overcurrent (excessive current).

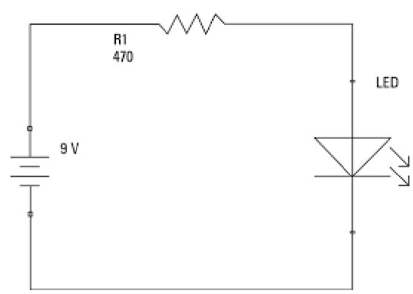
- Switches: This is used for opening (breaking) and closing (continuing) a circuit.

- Jumper Wires: These are wires used in connecting different components or different points in an electronic circuit together.

Constructing a Simple Circuit

A circuit is a closed path that allows electricity to flow from one point to another. It usually include various electrical/electronic components, such as transistors, resistors, and capacitors, but the flow is unimpeded by a gap or break in the circuit.

A basic electronic circuit has a power source, wires connecting components, and components. An example of a basic electronic is shown below;



Example of a simple Circuit

This circuit is composed of a resistor;

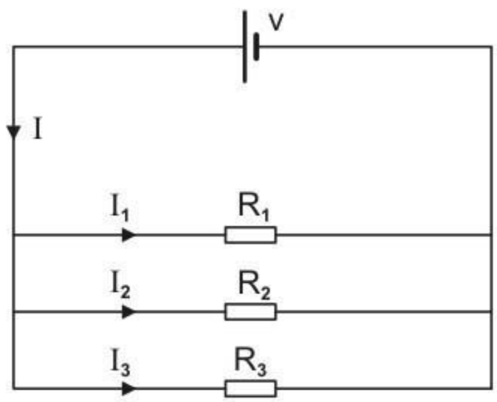
1. The power source for this circuit is 9V.
2. The components used in this circuit are LED and Resistors.

Circuit Configuration

There are two different configurations of a resistor in a circuit which are;

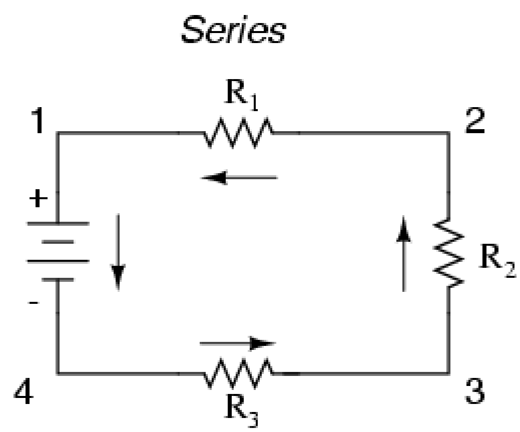
1. The parallel configuration and
2. The series configuration

Parallel Configuration: A Parallel configuration/circuit can be explained as a circuit have multiple branching pathways for electrical current. An example of parallel configuration.



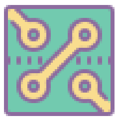
Straightforward right? Great! let's ride on then.

! **Series Configuration**: A Series configuration/circuit can be explained as a circuit that has a single pathway for electrical current. An example of parallel configuration. Below is an example of a series configuration.



You can see from the direction of the current (Arrows), that there's just a single path. You'll agree with me that this isn't in any way complex right?

Circuit Boards

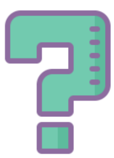


Circuit boards! Think of them as a foundation (ground) for building your circuits, just like foundation for building houses. Basically a circuit board can be explained as a platform on which circuits are built on. Advances in circuit boards have led to new engineering and manufacturing methods for these types of devices. There are several types of circuit boards some more complicated than the other.

Common Circuit Boards

1. Breadboard
2. Vero/strip board
3. PCB (Printed Circuit Boards)
4. Donut board

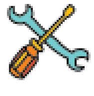
Breadboard



Breadboard? What does that even mean? A board made out of bread? What is it used for? Does it relate to electricity?
I know a lot of questions must be running through your mind right now but do not worry I'll work you through this.
Now what is a breadboard? This can be described as a thin plastic board with a lot of holes used to connect and hold electronic components for temporary connection.

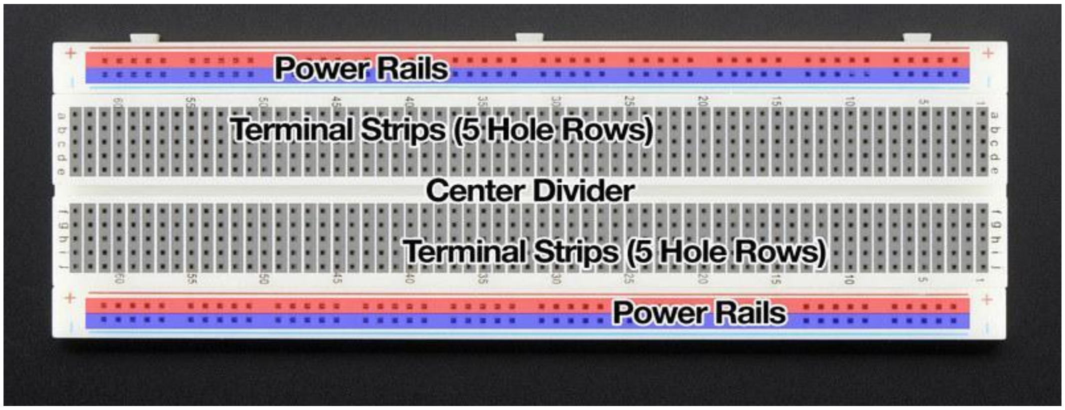
Why do we use it?

We use breadboard to majorly to learn how to connect circuits and to temporarily construct a circuit for testing purposes before transferring it to a permanent board.



Testing is really required to point out the defects and errors that were made during the circuit construction. Some examples of errors are; *shorts, open, resistance and capacitance also.*

Configuration of Breadboard



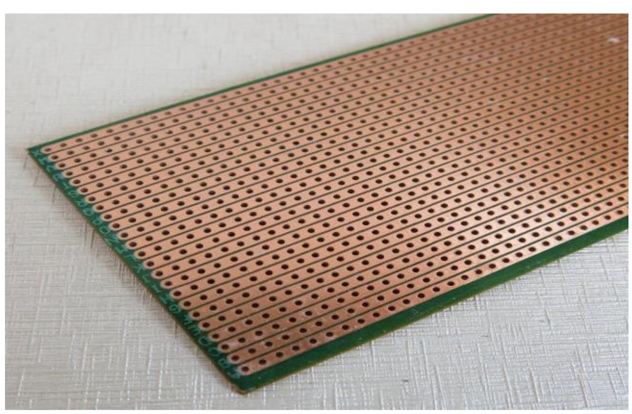
Picture of a breadboard

From the picture shown above, we would be talking about what each label means.

- Power Rails: This, as the name implies, is used to supply voltage to power the connected electronic components. It has a negative and positive conducting line as indicated by blue and red respectively. They are straight each connected in conducting lines.
- Terminal Strips: The terminal strips labelled from a-e (horizontally/rows) and f-j (also horizontally/rows) are straight conducting lines.

Vero/strip board

Vero or strip board, this is a kind of circuit board different from the breadboard, this is used for a more permanent circuit connection. The vero or strip board is a thin semi-fragile board with a smooth surface and visible strips of conducting lines at the back. Below is a clear image of a vero/strip board.

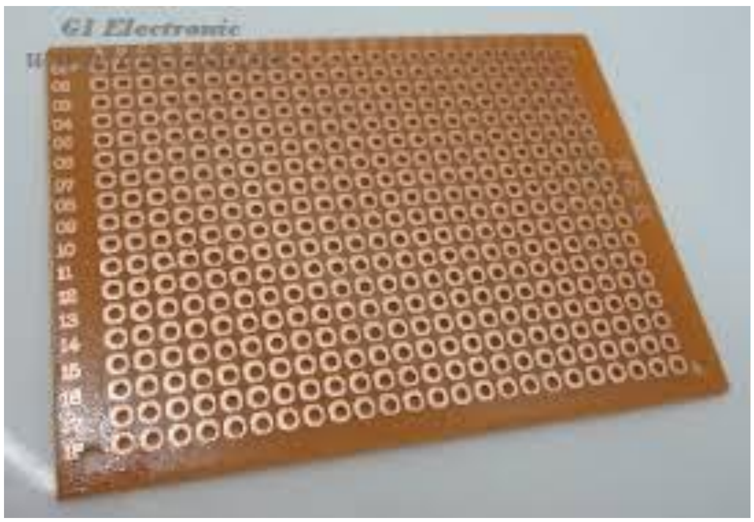


Vero/Strip board

The image above shows the visible strip of conducting lines. These lines run parallel to each other, that is an isolated strip per line. When the need arises to discontinue a conducting line, it is easily done by scratching or slightly engraving a line at that point.

Donut Board

Donut board! Did you just imagine a board that looks like an actual donut?? 😁 Well jokes on you! This board looks exactly like your vero board, but it differs from it because of the “conducting dots”. Below is a clear image of a donut board.

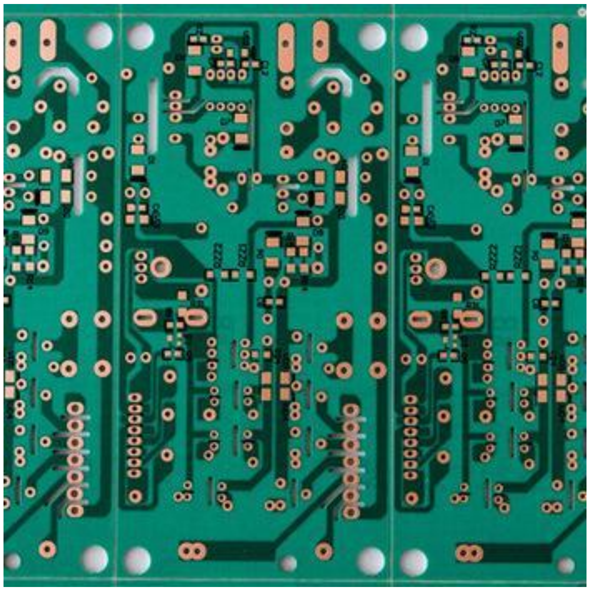


Donut board

Notice the conducting Dots and go back to look at the vero board. Notice the differnces? Yes? That’s it. To connect two “donuts” together they have to be joined by a wire.

PCB (Printed Circuit Boards)

Ever seen circuit boards from spoilt gadgets like TVs, radios, rechargeable lamps etc. Yes, those are Printed Circuit Boards (PCB). This kind of boards are customized for the particular circuits to be designed by a special machine.



PCB (printed circuit board) are used to connect electronic components into a working circuit. This is permanent compared to the Vero/Strip board and the Donut board. In this type of circuit board, the "wires" connecting the components are built right into the board.

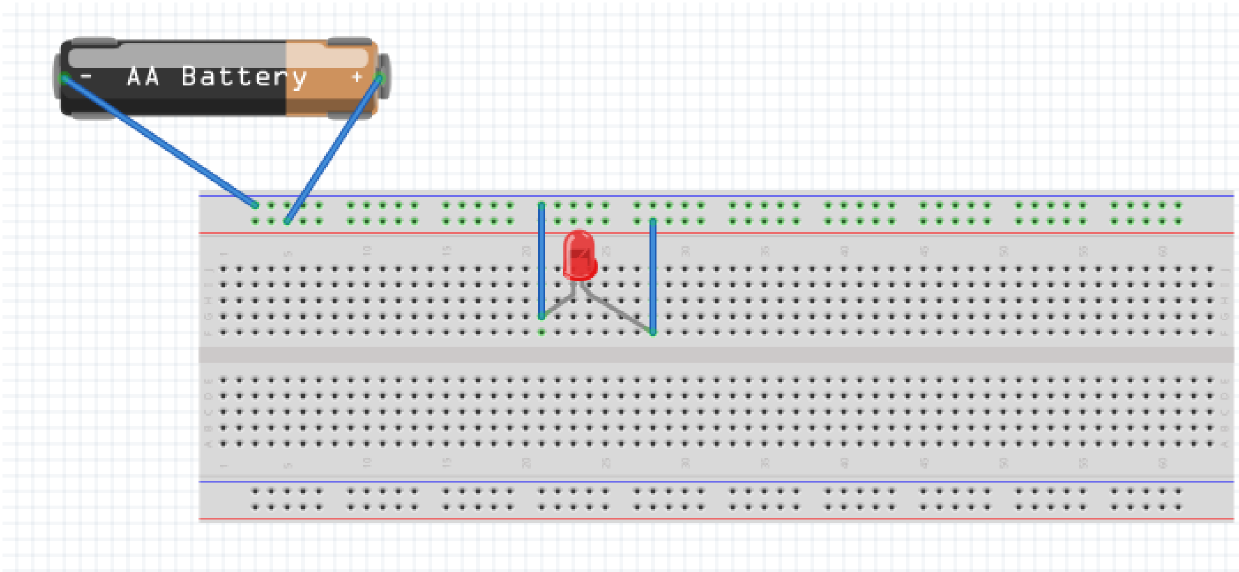
Let’s perform a simple experiment shall we?

In this experiment we shall be connecting an LED to a breadboard

Experiment title: Connecting an LED lamp with a breadboard.

Now that we have a proper descriptive name for our experiment, we shall follow a series of steps to arrive at a desired result.

1. Gather necessary materials. For this experiment, you’ll need;
    - An LED
    - A Breadboard
    - 1 AA battery
    - Jumper wires
2. Now connect your circuit as shown in the image below
   Take note:



- Connect the shorter leg to the negative terminal of the battery
- Observe the battery is connected to the power rail terminals. Note doesn’t mean this wouldn't work if they were connected directly to the terminal strips, but as we move further into more complex circuit you’ll see the need.

3. Did the LED light up? If No, check the circuit to ensure proper connection, if it persists, change the battery or change the LED it may be bad, one after the other.
4. Did it light up now? Yes, Viola!! Experiment completed.

Module~~Chapter~~ 3

RESISTORS

Learning Outcomes

When you have completed this module, you will be able to:

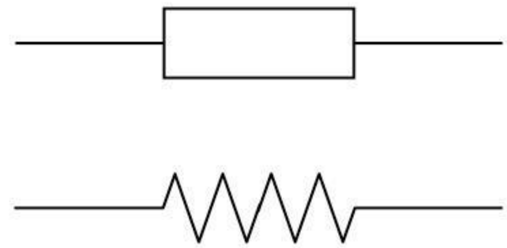
- Understand the function of a resistor
- Know the different configuration of a resistor
- Determine the total resistance according to the implemented configuration
- Determine the rating of a resistor

Introduction

What are resistors? The very first electronic component you should know about is the resistor and that's exactly what we are going to be discussing in this module. It's relatively normal to assume that a resistor, as it's called, will try to prevent or block the passage of something, and you'd also be right with that hypothesis! A resistor is basically an electronic component that limits the flow of current in an electronic circuit. The measurement unit for resistance is in *Ohms (Ω).*

A resistor acts as a guard especially in your electronic circuit to protect delicate components. Popular types of resistors include; adjustable/variable resistors (found in the control for ceiling fan, radios etc.), and the fixed resistor which is the most widely used resistor.

Stay with me, this is about to become really interesting, so fasten your seatbelts.



Picture of a Resistor

circuit symbol of a Resistor

Resistor Configurations

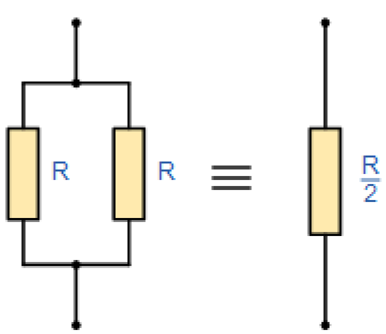
Remember, from the last module, we have two different configurations for electronic components which are;

1. The parallel configuration and
2. The series configuration

Parallel Configuration

With prior knowledge from circuit configurations, you'd understand that it is possible to connect resistors so that they branch out from a single point (known as a node) and catch up somewhere else in the circuit. *In this configuration, the voltage across them is the same* but they do *not carry the same current.*

This configuration usually looks like this;



Resistors in parallel

What connecting resistors in parallel does is it reduces the total resistance by creating more paths for current to flow through. As we can see from the picture above the total resistance is halved if both resistors are of the same value.

Mathematically, the formula for calculating resistors in parallel is given as;

$$\frac{1}{RT} = \frac{1}{R1} + \frac{1}{R2} + \ldots + \frac{1}{Rn}$$

Where “n” is the number of resistors and
RT is the total resistor value.

Example:

If three resistors of values 4Ω, 2Ω, and 6Ω are connected in parallel, calculate the total resistance.

Solution:

In order to calculate this, we have to follow a couple of steps

1. First step is listing out the values of the given resistors

   R1=4Ω, R2=2Ω, and R3=6Ω

2. Second step is applying the appropriate formula and simplifying

$$\frac{1}{RT} = \frac{1}{4} + \frac{1}{2} + \frac{1}{6}$$

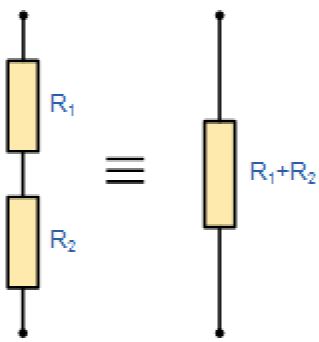
3. Find the L.C.M and simplify

$$\frac{1}{RT} = \frac{3+6+2}{12}; \ \frac{1}{RT} = \frac{11}{12}\Omega \ or \ 0.9166\Omega;$$

Easy peasy!! Good Job

Series Configuration

The series can be explained as connecting two or more resistors end to end. *In this configuration, resistors carry the same current, but the voltage drop across them is not the same.*



Resistors in Series

What connecting resistors in series does is it combines to act as one hence, causes a voltage drop across each resistor by creating a single path for current to flow through. As we can see from the picture above the total resistance is doubled if both resistors are of the same value.

Mathematically, the formula for calculating resistors in parallel is given as;

$$RT = R1 + R2 + \ldots + Rn$$

Where “n” is the number of resistors and
RT is the total resistor value.

Example:

If three resistors of values 4Ω, 2Ω, and 6Ω are connected in series, calculate the total resistance

In order to calculate this, we have to follow a couple of steps

1. First step is listing out the values of the given resistors

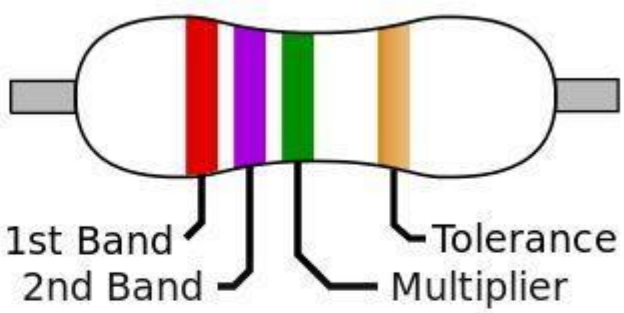
   R1=4Ω, R2=2Ω, and R3=6Ω

2. Second step is applying the appropriate formula and simplifying

$$RT = 4 + 2 + 6; RT = 12\Omega$$

Colour Code

Colour code, Colour combination, colour strips etc. In this case they all mean the same thing. Think of it as an identity for the resistors just like you have a name you're being called for easy identification. Depending on the circuit or function you are implementing, different values of resistors are usually needed. From the image below, notice the colors on the body of the resistor. Those colours, called colour bands are used to calculate the value of a resistor, I will show you how.



There are different types of resistor based on the colour band. Shown above is a 4 band resistor. There are also 5 and 6 bands resistor. To calculate the value of this type of resistor, there is a standard resistor colour band table to read from.

Resistor Colour Code

Colour	Digit	Multiplier	Tolerance (%)

Black	0	$10^{0}(1)$	
Brown	1	10^{1}	1
Red	2	10^{2}	2
Orange	3	10^{3}	
Yellow	4	10^{4}	
Green	5	10^{5}	0.5
Blue	6	10^{6}	0.25
Violet	7	10^{7}	0.1
Grey	8	10^{8}	
White	9	10^{9}	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

Seems complex already right? Do not panic, i promise it isn't as complex as it looks, let's take some examples and see.

Example 1

A 4 band resistor with the colour code green-violet-orange-gold will be 57kΩ with a tolerance of +/- 5%

Calculated from the table above;

- The first two bands are digits: green and violet equivalent to 5 and 7 respectively
- The third band, Orange is the multiplier and is equivalent to 10^{3}
- And the tolerance which is always written as +/- (plus or minus), is gold which is equivalent to 5. So therefore +/- 5

You see, it isn't as hard and complex as it looks. Let's try some more examples.

Example 2

A 4 band resistor with the colour code white-violet-black would be 97Ω with a tolerance of +/- 20%.
In this case, when you see only three color bands on a resistor, it is actually a 4-band code with a blank (20%) tolerance band.
So calculated from the table above;

- The first two bands which are white and violet equivalent to 9 and 7 respectively
- The third band is black, we can see from the table that it's given as $10^{0}(1)$ which is also equivalent to 1
- And finally remember, a 3 band with a blank (4 bands) has a tolerance of +/- 20%

Try:

1. A resistor with colour codes brown-red-gold-silver
2. A resistor with colour codes yellow-grey-white

Do this and compare your answers with your colleague