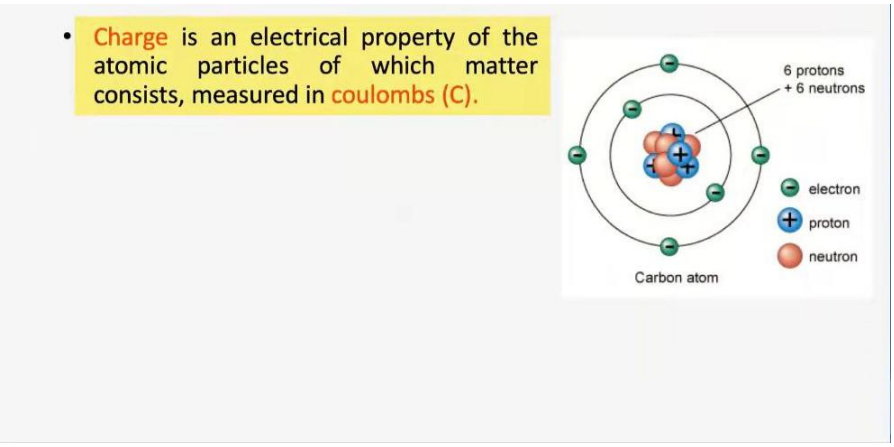
Introduction

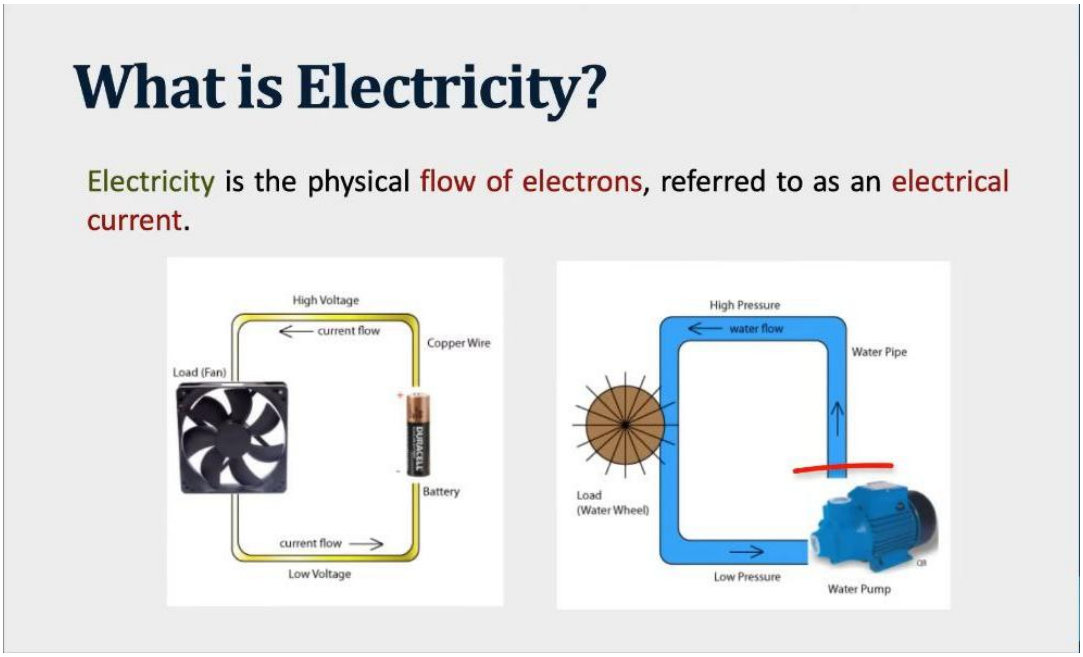
All materials are made up from atoms, and all atoms consist of protons, neutrons and electrons. Protons, have a positive electrical charge. Neutrons have no electrical charge (that is they are Neutral), while Electrons have a negative electrical charge. Atoms are bound together by powerful forces of attraction existing between the atoms nucleus and the electrons in its outer shell.

When these protons, neutrons and electrons are together within the atom they are happy and stable. But if we separate them from each other they want to reform and start to exert a potential of attraction called a ***potential difference.***



Now if we create a closed circuit these loose electrons will start to move and drift back to the protons due to their attraction creating a flow of electrons. This flow of electrons is called an ***electrical current***. The electrons do not flow freely through the circuit as the material they move through creates a restriction

to the electron flow. This restriction is called ***resistance***.



Then all basic electrical or electronic circuits consist of three separate but very much related electrical quantities called: **Voltage**, (v), **Current**, (i) and **Resistance**, (Ω)

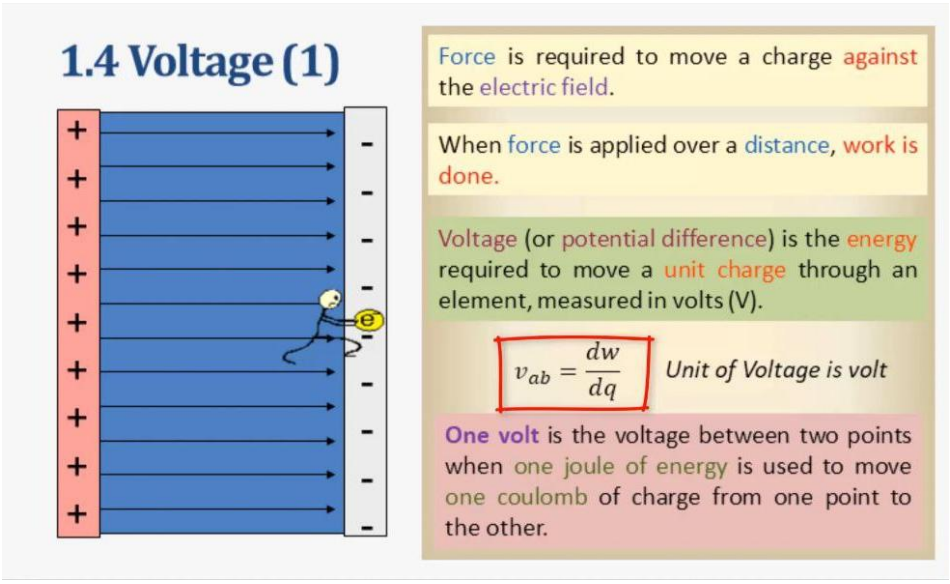
Electrical Voltage

In **Dc** circuit theory, **voltage**, (V) is the potential energy of an electrical supply stored in the form of an electrical charge. Voltage can be thought of as the force that pushes electrons through a conductor and the greater the voltage the greater is its ability to "push" the electrons through a given circuit.

As energy has the ability to do work this potential energy can be described as the work required in joules to move electrons in the form of an electrical current around a circuit from one point or node to another.

Then the difference in voltage between any two points, connections or junctions (called nodes) in a circuit is known as the **Potential Difference, (p.d.)** commonly called the **Voltage Drop**.

The Potential difference between two points is measured in **Volts** with the circuit symbol V, or lowercase "v", although **Energy**, E lowercase "e" is sometimes used to indicate a generated emf (electromotive force). Then the greater the voltage, the greater is the pressure (or pushing force) and the greater is the capacity to do work.

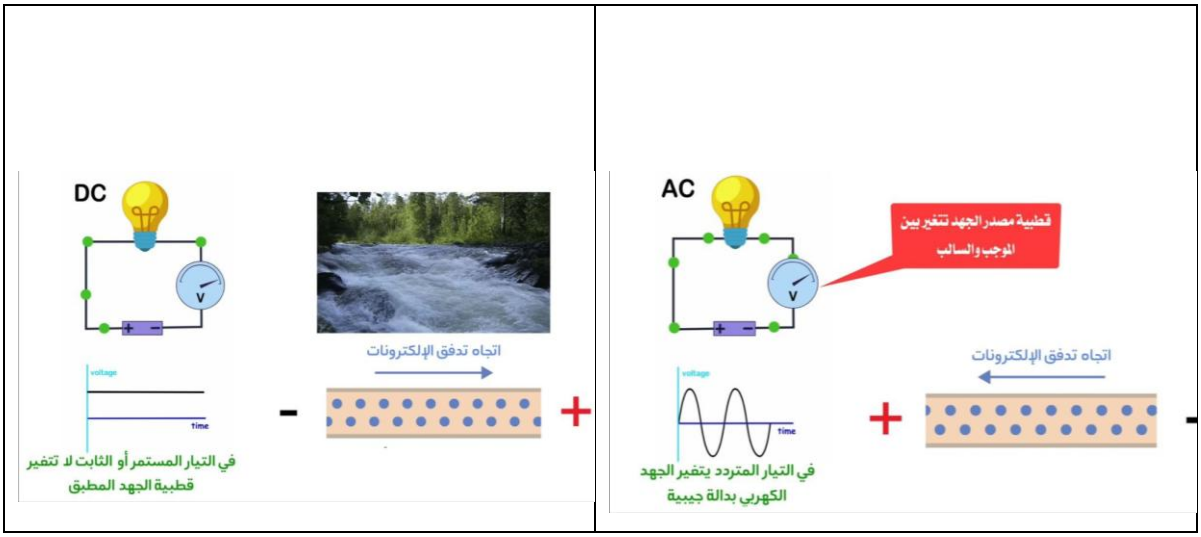


A voltage source that is unchanging and constant over time is called a **DC Voltage**. While a voltage source that varies periodically in amplitude over time is called an **AC voltage**. Whether an AC or DC supply, voltage is measured in volts, with one volt being defined as the electrical pressure required to force an electrical current of one ampere through a resistance of one Ohm.

While voltages are generally expressed in Volts, prefixes are used to denote sub-multiples of the voltage present, such as **microvolts** (μV =

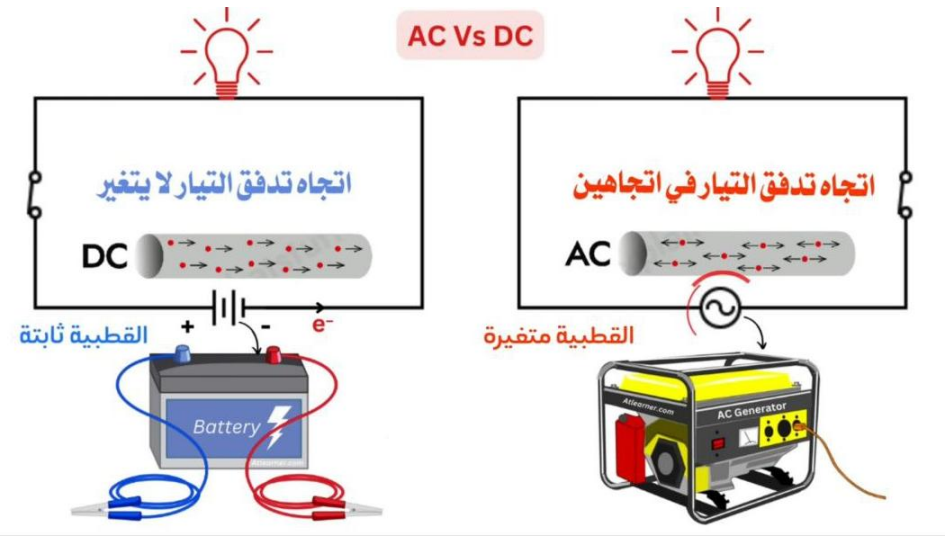
10^{-6} V), **millivolts** (mV = 10^{-3} V) or **kilovolts** (kV = 10^{3} V). Note that voltage can be either positive or negative in amplitude.

Batteries, power supplies or solar cells produce a **D.C. (direct current)** voltage source of a fixed value and polarity. For example, 5v, 12v, -9v, etc. **A.C. (alternating current)** voltage sources on the other hand such as those available for homes, offices and industrial applications have a value relating to the power they supply. The voltage and frequency of mains alternating current (AC) electricity used in homes is typically 230 volts AC (230V) in the United kingdom and 110 volts AC (110V) in the USA.



General electronic circuits operate on low voltage DC battery supplies of between 1.5V and 24V dc The circuit symbol for a constant voltage source usually given as a battery symbol with a positive, + and negative, – sign indicating the direction of the polarity. The circuit symbol for an alternating voltage source is a circle with a sine wave inside.

Voltage Symbols



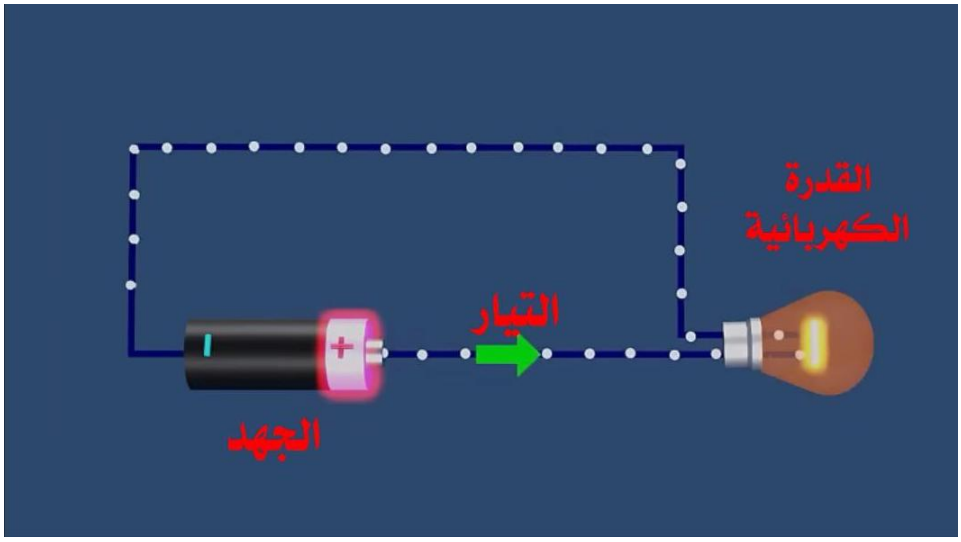
A simple relationship can be made between a tank of water and a voltage supply. The higher the water tank above the outlet the greater the pressure of the water as more energy is released, the higher the voltage the greater the potential energy as more electrons are released.

Voltage is always measured as the difference between any two points in a circuit and the voltage between these two points is generally referred to as the "**Voltage drop**".

Note that voltage can exist across a circuit without current, but current cannot exist without voltage and as such any voltage source whether DC or AC likes an open or semi-open circuit condition but hates any short circuit condition as this can destroy it.

Electrical Current

In DC circuit theory, **electrical Current**, (I) is the movement or flow of electrical charge and is measured in **Amperes**, symbol **i**, for *intensity*). It is the continuous and uniform flow (called a drift) of electrons (the negative particles of an atom) around a circuit that are being "pushed" by the voltage source. In reality, electrons flow from the negative (–ve) terminal to the positive (+ve) terminal of the supply and for ease of circuit understanding conventional current flow assumes that the current flows from the positive to the negative terminal.



Current is measured in **Amps** and an amp or ampere is defined as the number of electrons or charge (Q in Coulombs) passing a certain point in the circuit in one second, (t in Seconds).

Electrical current is generally expressed in Amps with prefixes used to denote **micro amps** ($\mu A = 10^{-6} A$) or **milliamps** ($mA = 10^{-3} A$). Note that electrical current can be either positive in value or negative in value depending

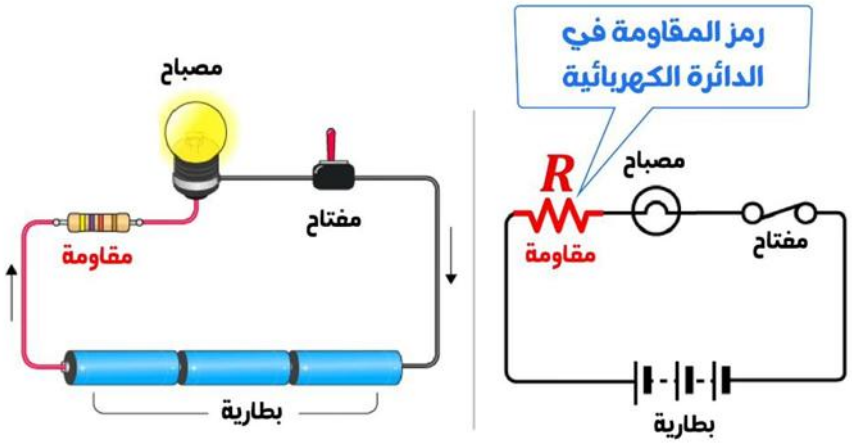
upon its direction of flow around the circuit.

Current that flows in a single direction is called **Direct Current**, or **D.C.** and current that alternates back and forth through the circuit is known as **Alternating Current**, or **A.C.**. Whether AC or DC current only flows through a circuit when a voltage source is connected to it with its "flow" being limited to both the resistance of the circuit and the voltage source pushing it.

DC Circuit Theory of Resistance

Resistance, (R) is the capacity of a material to resist or prevent the flow of current or, more specifically, the flow of electric charge within a circuit. The circuit element which does this perfectly is called the "Resistor"

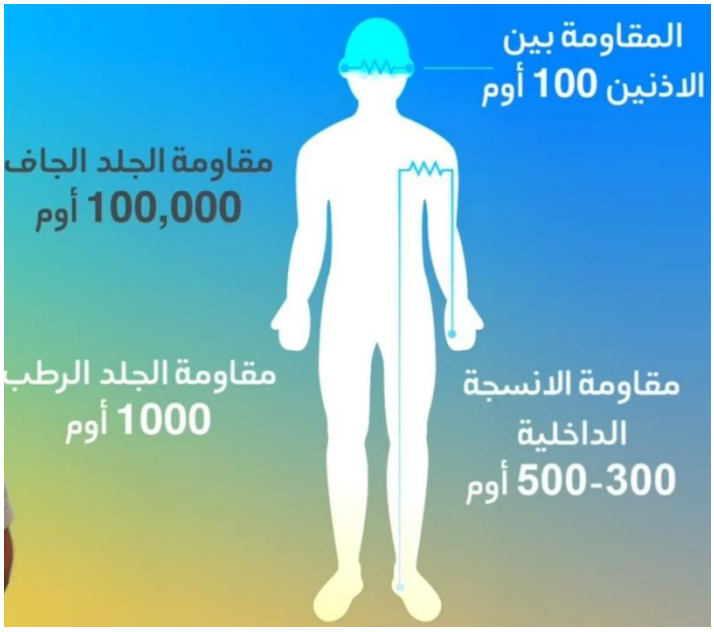
Resistance is a circuit element measured in **Ohms**, Greek symbol (**Ω**, Omega) with prefixes used to denote **Kilo-ohms** ($k\Omega = 10^3\Omega$) and **Mega-ohms** ($M\Omega = 10^6\Omega$). Note that resistance cannot be negative in value only positive.



DC Circuit Theory for Resistor Symbols

The amount of resistance a resistor has is determined by the relationship of the current through it to the voltage across it which determines whether the circuit element is a "good conductor" – low resistance, or a "bad conductor" – high resistance. Low resistance, for example 1Ω or less implies that the circuit is a good conductor made from materials such as copper, aluminium or carbon while a high resistance, 1MΩ or more implies the circuit is a bad conductor made from insulating materials such as glass, porcelain or plastic.

A "semiconductor" on the other hand such as silicon or germanium, is a material whose resistance is half way between that of a good conductor and a good insulator. Hence the name "semi-conductor". Semiconductors are used to make Diodes and Transistors etc.



DC Circuit Theory Summary

Hopefully by now you should have some idea about DC circuit theory and how electrical Voltage, Current and Resistance are closely related together. The relationship between **Voltage**, **Current** and **Resistance** forms the basis of Ohm's law. In a linear circuit of fixed resistance, if we increase the voltage, the current goes up, and similarly, if we decrease the voltage, the current goes down. This means that if the voltage is high the current is high, and if the voltage is low the current is low.

Likewise, if we increase the resistance, the current goes down for a given voltage and if we decrease the resistance the current goes up. Which means that if resistance is high current is low and if resistance is low current is high.

A basic summary of the three units is given below.

- Voltage or potential difference is the measure of potential energy between two points in a circuit and is commonly referred to as its " **volt drop** ".
- When a voltage source is connected to a closed loop circuit the voltage will produce a current flowing around the circuit.
- Voltage is measured in **Volts** and has the symbol V for voltage or E for electrical energy.
- Current flow is a combination of electron flow and hole flow through a circuit.
- Current is the continuous and uniform flow of charge around the circuit and is measured in **Amperes** or **Amps** and has the symbol I.
- Current is Directly Proportional to Voltage ($I \propto V$)
- Resistance is the opposition to current flowing around a circuit.
- Low values of resistance implies a conductor and high values of resistance implies an insulator.
- Current is Inversely Proportional to Resistance ($I\ 1/\propto R$)
- Resistance is measured in **Ohms** and has the Greek symbol Ω or the letter R.

Email: zahraa.hashim@uomus.edu.iq

Quantity	Symbol	Unit of Measure	Abbreviation
Voltage	V or E	Volt	V
Current	I	Ampere	A
Resistance	R	Ohms	Ω

Text Book

Fundamentals of Electric Circuits

Alexander and Sadiku

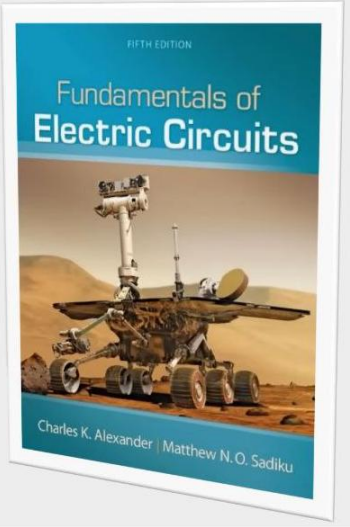
Fifth edition

Link

https://drive.google.com/open?id=1s03OpuGKtxLAXcjEtBTFbHOxS5KRt6rn

or

https://bit.ly/2mt8jtb



In the next tutorial about DC Circuit Theory we will look at Ohms Law which is a mathematical equation explaining the relationship between Voltage, Current, and Resistance within electrical circuits and is the foundation of electronics and electrical engineering.

Email: zahraa.hashim@uomus.edu.iq