Conductance And Inductance

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CONTENTS THAT WE WILL COVER

- CONDUCTIVITY
- Potential difference and emf of a cell,
- Induction(l)
- Capacitance c

CONDUCTANCE

- **Conductance** is an expression of the ease with which electric current flows through a substance. In equations, **conductance** is symbolized by the uppercase letter G. The standard **unit** of **conductance** is the siemens (abbreviated S), formerly known as the mho.

- Conductance is inversely related to resistance. If *R* is the resistance of a component or device (in ohms), then the conductance *G* (in siemens) is given by:
- *G* = 1/*R=1/RHO* l/a=a/rho*l*
- *1/rho=sigma*
- *Sigma is conductivity of conductor*
- *Unit of conductor siemen or mho*
- *G=1/RHO*a/l*
- *G=SIGMA*a/l   sigma=Gl/a =s/m*

- When a current of one ampere (1 A) passes through a component across which a voltage of one volt (1 V) exists, then the conductance of that component is 1 S. The siemens is, in fact, equivalent to one ampere per volt. If G is the conductance of a component (in siemens), I is the current through the component (in amperes), and E is the voltage across the component (in volts)

What is the Difference Between emf and Potential Difference?

- The emf (electromotive force) is the potential difference between the terminals of a battery when no current is flowing through an external circuit when the circuit is open.
- Potential difference is the voltage across the terminals of the battery when the current is being drawn from it to an external.

Difference between electromotive force and potential difference

Electromotive force (emf)	**Potential Difference (Pd)**
E.m.f is the energy supplied to the unit charge by the cell.	Potential difference is the energy dissipated as the unit charge passes through the components.
E.m.f is the cause.	Potential difference is the effect.
The emf is also present even when no current is drawn through the battery.	Potential difference across the conductor is zero in the absence of current.
Its unit is volt.	Its unit is volt.
It remains constant.	It does not remain constant.
It is always greater than potential difference.	It is always less than emf.
It transmits current both inside and outside of the cell.	Potential difference transfer current between two points in the cell.
Its symbol is E.	Its symbol is V.
Its formula is E = I (R+r) R+r = total external and internal resistance.	Its formula is V = E – Ir
It does not depend on circuit resistance.	It directly depends on the resistance between two points of measurement.
It causes in electric, magnetic and gravitational field.	It induces only in electric field.

Electromotive force

- The electromotive force E of the source is the energy supplied to the unit charge by the cell.
- A charge Δq passed through the circuit in time Δt. This charge enters the cell at its lower potential (negative terminal) and leaves at its positive end (positive terminal), then the source must do work ΔW on the charge Δq in taking it to the positive terminal which is at the higher potential.
  Thus, the emf of the source is defined as" the energy supplied to unit charge by the cell."

E = Energy/unit charge

or

$$E = \Delta W / \Delta q$$

what is Potential Difference

- The potential difference across the two points of a conductor causes the dissipation of electrical energy into other forms of energy as charges flow through the circuit.
  When one end A of a conductor is connected to the positive terminal and its other end B is connected to the negative terminal of the battery, then the potential at A becomes higher than the potential at the B.
  This causes a potential difference between the two points of the conductor. The flow of current continues as long as there is a potential difference.

CONTENTS

- ELECTRICAL CONDUCTIVITY,electro-motive force EMF SOURCES,

Electrical Conductivity

- While both the electrical resistance (R) and resistivity (or specific resistance) ρ, are a function of the physical nature of the material being used, and of its physical shape and size expressed by its length (L), and its sectional area (A), **Conductivity**, or specific conductance relates to the ease at which electric current can flow through a material.

- Conductance (G) is the reciprocal of resistance (1/R) with the unit of conductance being the siemens (S) and is given the upside down ohms symbol mho

- Conductivity, σ (Greek letter sigma), is the reciprocal of the resistivity. That is $1/\rho$ and is measured in siemens per metre (S/m). Since electrical conductivity $\sigma = 1/\rho$, the previous expression for electrical resistance, R can be rewritten as:

Electrical Resistance as a Function of Conductivity

$$R = \rho \frac{L}{A} \quad \text{and} \quad \sigma = \frac{1}{\rho}$$

$$\therefore R = \frac{L}{\sigma A}\ \Omega$$

- **Resistivity Example No2**
- A 20 metre length of cable has a cross-sectional area of $1mm^2$ and a resistance of 5 ohms. Calculate the conductivity of the cable.
- Data given: DC resistance, R = 5 ohms, cable length, L = 20m, and the cross-sectional area of the conductor is $1mm^2$ giving an area of: $A = 1 \times 10^{-6}$ metres^2.

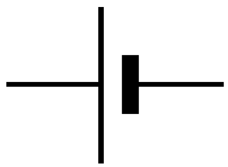
$$R = \frac{L}{\sigma A} \qquad \therefore \sigma = \frac{L}{RA}$$

$$\sigma = \frac{L}{RA} = \frac{20}{5 \times 1 \times 10^{-6}} = 4MS/m$$

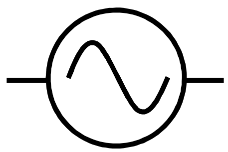
source of electromotive force

A device that, by doing work on charge carriers, maintains a potential difference between its terminals is called a source of electromotive force (emf).

Other form of energy is converted into electricity in a source of electromotive force:



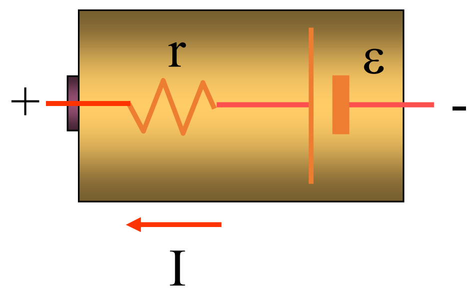
battery	-	*chemical energy*
electric generator	-	*mechanical energy*
solar cell	-	*electromagnetic radiation*
thermopile	-	*internal energy*
living cell	-	*chemical energy*



electromotive force

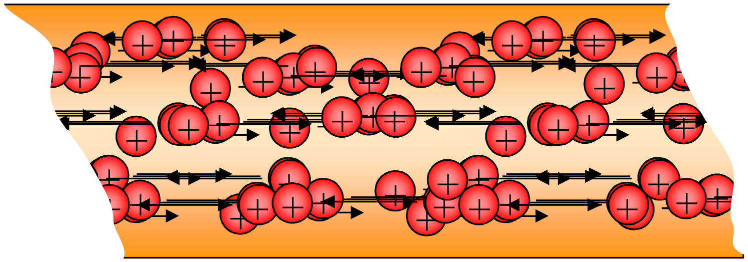
The maximum electric potential difference that can exist between the terminals of the voltage source is called the electromotive force of that source.

Voltage produced by a real source of electromotive force:



The **emf** is equal to the work done on the charge per unit charge (ϵ=dWdq) when there is no current flowing. Since the unit for work is the joule and the unit for charge is the coulomb, the unit for **emf** is the volt (1V=1J/C).

direct and alternating current

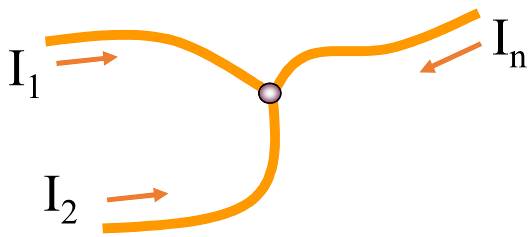


If the charge moves in a circuit in the same direction at all times, the current is said to be ***direct current*** (DC). Constant current (independent of time) is a special case of direct current.

If the charges move (across a surface) changing their direction of motion, the current is said to be ***alternating current*** (AC).

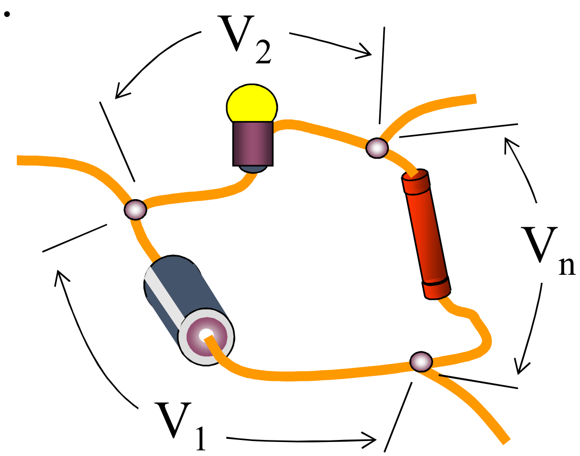
circuit analysis

Kirchhoff's Junction Rule:
The sum of all the currents entering a junction is zero.



$$\sum_i I_i = 0$$

Kirchhoff's Loop Rule:
Around any closed circuit loop the sum of potential differences is zero.



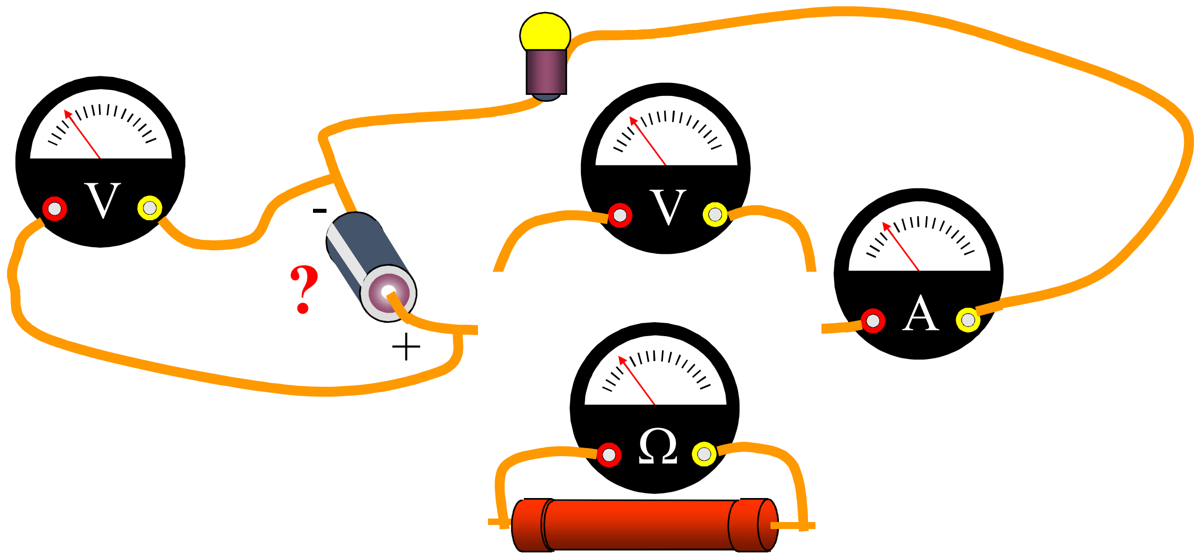
$$\sum_i V_i = 0$$

electrical measurements

Current is measured with an ***ammeter***, which must be inserted into the circuit in series with the element in which the current is measured.

Voltage is measured with a ***voltmeter***, which must be inserted into the circuit in parallel to the elements across which the voltage is measured.

The resistance of passive elements can be measured with an ***ohmmeter***.



electric current & the human body

Currents of **200 mA** can be fatal. A current that strong can affect the proper operation of the heart.

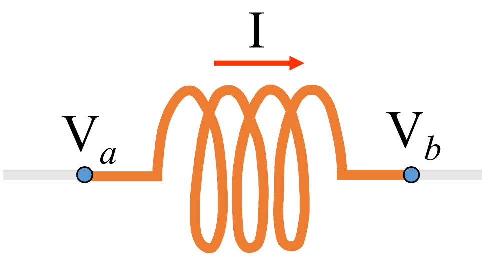
A current above **100 mA** can cause muscle spasm.

A person can sense an AC with a current of **1mA**.

NEVER TOUCH AN OPERATING CIRCUIT WITH BOTH HANDS !!!

Inductors (L)

An inductor is an element of a circuit with two sides for which (at any instant) the potential difference V between its terminals is proportional to the rate of change in current I passing through this element.



$$V_a - V_b = L\frac{dI}{dt}$$

The proportionality coefficient L is called the inductance of the inductor.

In SI the henry is the unit of inductance $H = \frac{Vs}{A}$

While the capacitor stores energy in an electrical field, the inductor stores energy in a magnetic field. Inductance is the inductor's capacity to resist variation of electric current and is measured in henries (H). The inductor is nothing more than a rolled wire in spirals which can have a nucleus inside to increase the magnetic field and the inductance. Here are various types of inductors. Sometimes inductors are called solenoids.

- **Capacitance**
- Capacitance is the ability of a device to store electric charge, and as such, the electronic component that stores electric charge is called a capacitor. The earliest example of a capacitor is the Leyden jar. This device was invented to store a static electric charge on conducting foil that lined the inside and outside of a glass jar.
- The simplest capacitor consists of two flat conducting plates separated by a small gap. The potential difference, or voltage, between the plates is proportional to the difference in the amount of the charge on the plates. This is expressed as $Q = CV$, where Q is charge, V is voltage and C is capacitance.

Combination of cells in series and in parallel.

- We know that electrical current is the flow of charged particles. It is the flow of electrons through a circuit.
- A collection of two or more cells which are connected in series is called **A Battery**. A battery is an energy source that converts chemical energy to electrical energy. It is otherwise known as **Electrochemical Cell**.

- The energy is stored in the form of chemical energy inside a battery
- Batteries give us a convenient source of energy for energizing devices without cables and wires.
- When it is connected to a circuit it produces electrical energy. A battery consists of two terminals – A Positive and Negative Terminal. The positive terminal is called **Cathode** and the negative terminal is called **Anode**. They are also called as **Electrodes of a Cell**. These electrodes will be dipped in a solution called **Electrolyte**. It is liquid which is ionic and conducts electricity.

- There are two simplest ways for cell connectivity are as follows:
- ***Series Connection:*** Series connection is the connectivity of the components in a sequential array of components.
- ***Parallel Connection:*** Parallel connection is the connectivity of the components alongside to other components.