PHYSICS 133-PMB

- 8 Credit course
- 24 lectures, 6 tutorials and 6 practicals

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Electricity and Magnetism

Electricity: are any physical phenomena that involve moving and stationary **electric charges**.

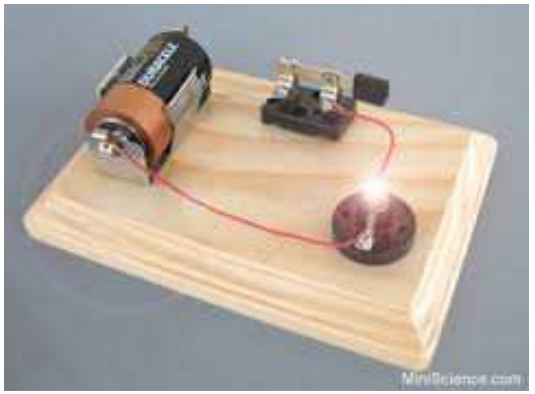
Magnetism: are any physical phenomena that are mediated by **magnetic field.** The magnetic field is a region in space near a magnet, electric current or moving charged particle.

Electromagnetism: is a study that involves an **interaction between electricity and magnetism**. We will very briefly touch on this section towards the end of this section.

Electricity

Electrostatics: is a branch of physics that deals with the phenomena and properties of **stationary or slow moving** electric charges.

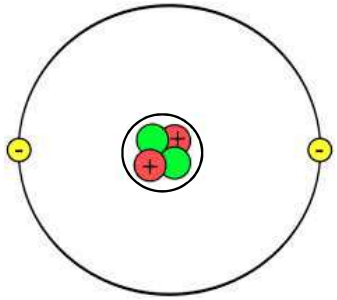
Electric current: is a branch of physics that deals with the phenomena and properties of **moving** electric charges.



Electrostatic

The origin of electricity

Atom: is a basic unit (particle) of matter. It is made up of electron, protons and neutron, which are collectively termed subatomic particles.



Proton: is a subatomic particle that is situated in a nucleus positively charged (Red).

Neutron: is a subatomic particle that is situated in a nucleus neutral (Green)

Electron: is a subatomic particle, orbiting around the nucleus negatively charged (Yellow).

Electric Charge: is an intrinsic property of protons and electrons that causes matter to attract/repel each other.

Experiments have shown that:

1. There exist **two types of electric charge** which we now call positive and negative.

2. The charge on the **proton** is exactly **equal and opposite** to the charge on the **electron**.

3. **Like charges repel and unlike charges attract.**

The magnitude of the charge on the proton or electron is denoted by the symbol e. The SI unit of charge is the coulomb (C) and is found experimentally to have the value of $e = 1.6\times10^{-19}$ C

Electrostatic cont.

By convention, the charge of the **proton is given as +1.6×10^{-19} C** and the charge of the **electron is -1.6×10^{-19} C**. The charge e is the smallest amount of free charge that has been discovered. Any charge represented as q is therefore an integer multiple of e. Thus if N is an integer then

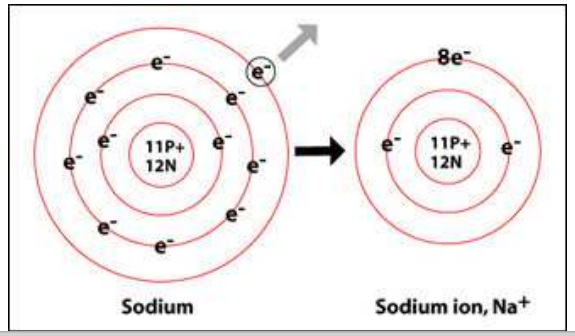
$$q = Ne$$

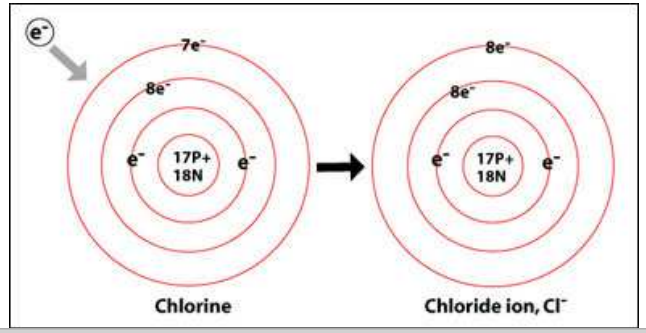
N here gives the number of protons in a charge.
Because any electrical charge q can be expressed as a multiple of an elementary charge e, electric charge is said to be **quantized**.

Example 1.1: The number of electrons in a charge
Determine the number of electrons required to produce a charge of 1 coulomb.

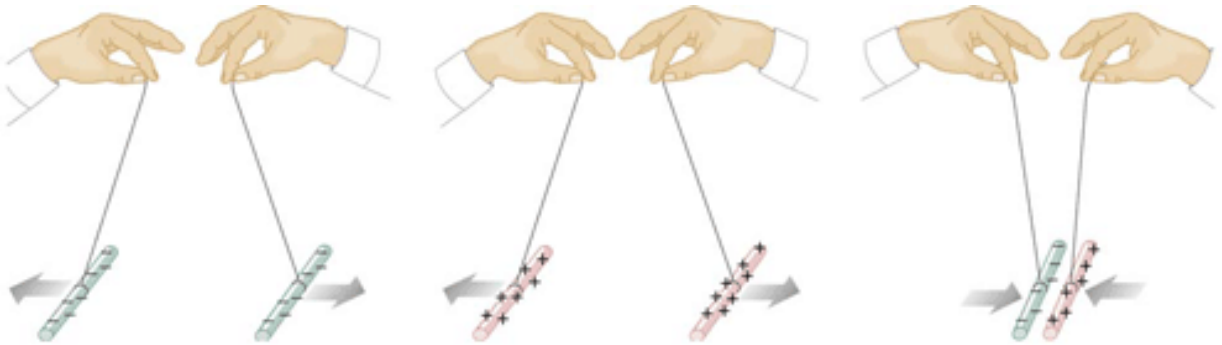
Electrostatic cont.

Atoms normally have an equal number of protons and electrons and therefore have no net charge since the algebraic sum of the charges of all the protons and electrons is zero. An atom that carries no net charge is said to be **electrically neutral**. An atom that has a net electrical charge (because it has lost or gained one or more electrons) is called an **ion**.





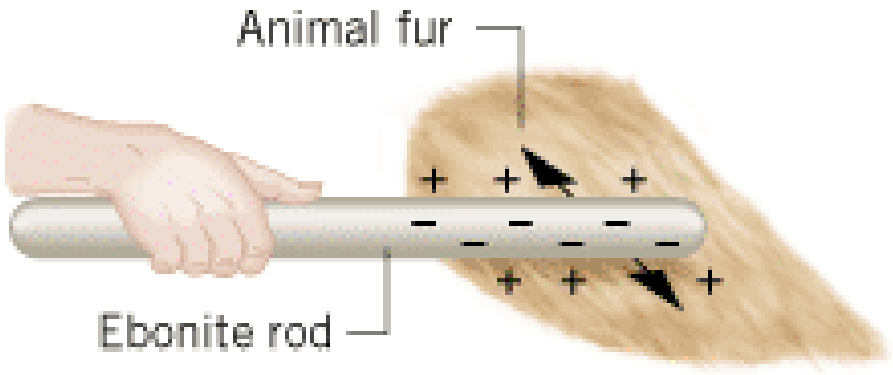
Implication of ionization



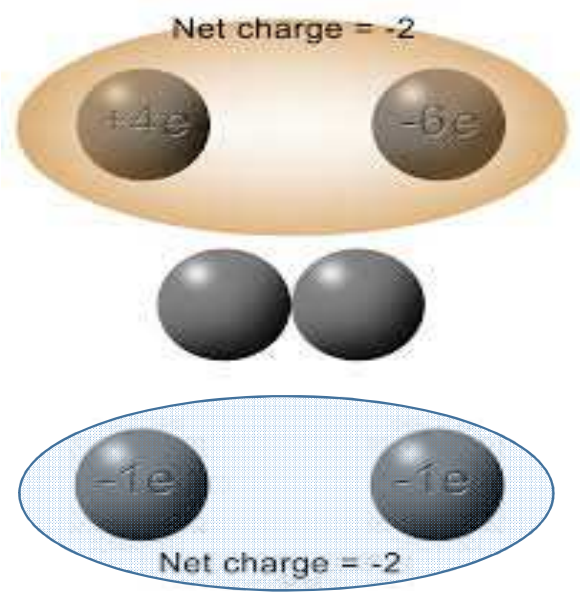
Conservation of electric charge

The law of conservation of electric charge

The algebraic sum of all electric charges in an isolated system remains constant.



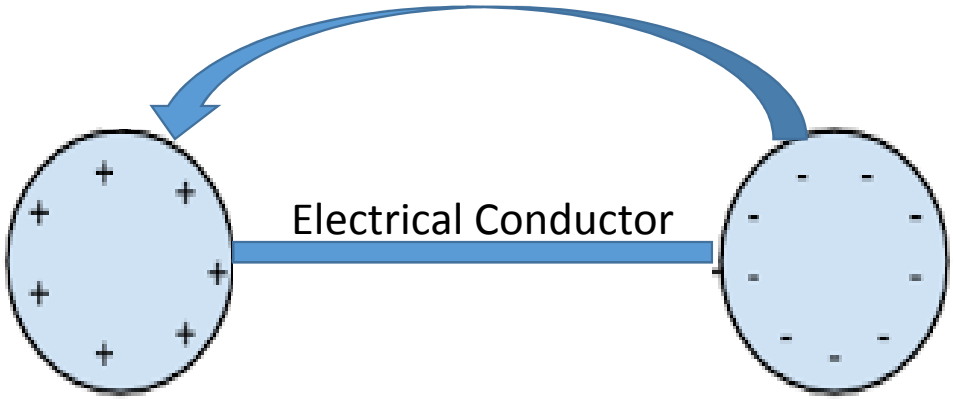
Rubbing an ebonite rod against an animal fur result in the transfer of electrons from atoms of the fur are transferred to the rod. This transfer gives the rod a negative charge (–) and leaves a positive charge (+) on the fur. However, the net charge is constant.

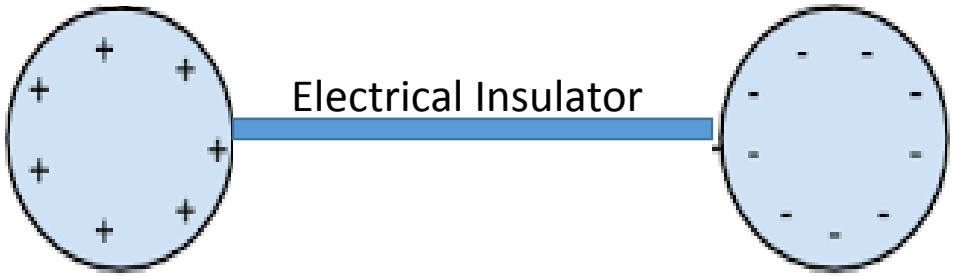


The net charge of the -6e and +4e object is -2e. Here electrons are transferred front the -6e object to the +4e object until the charge on both objects is the same. However the net charge is constant

Conservation of electric charge cont.

An electric charge can not only be transferred to and from different objects, it can also move through materials.





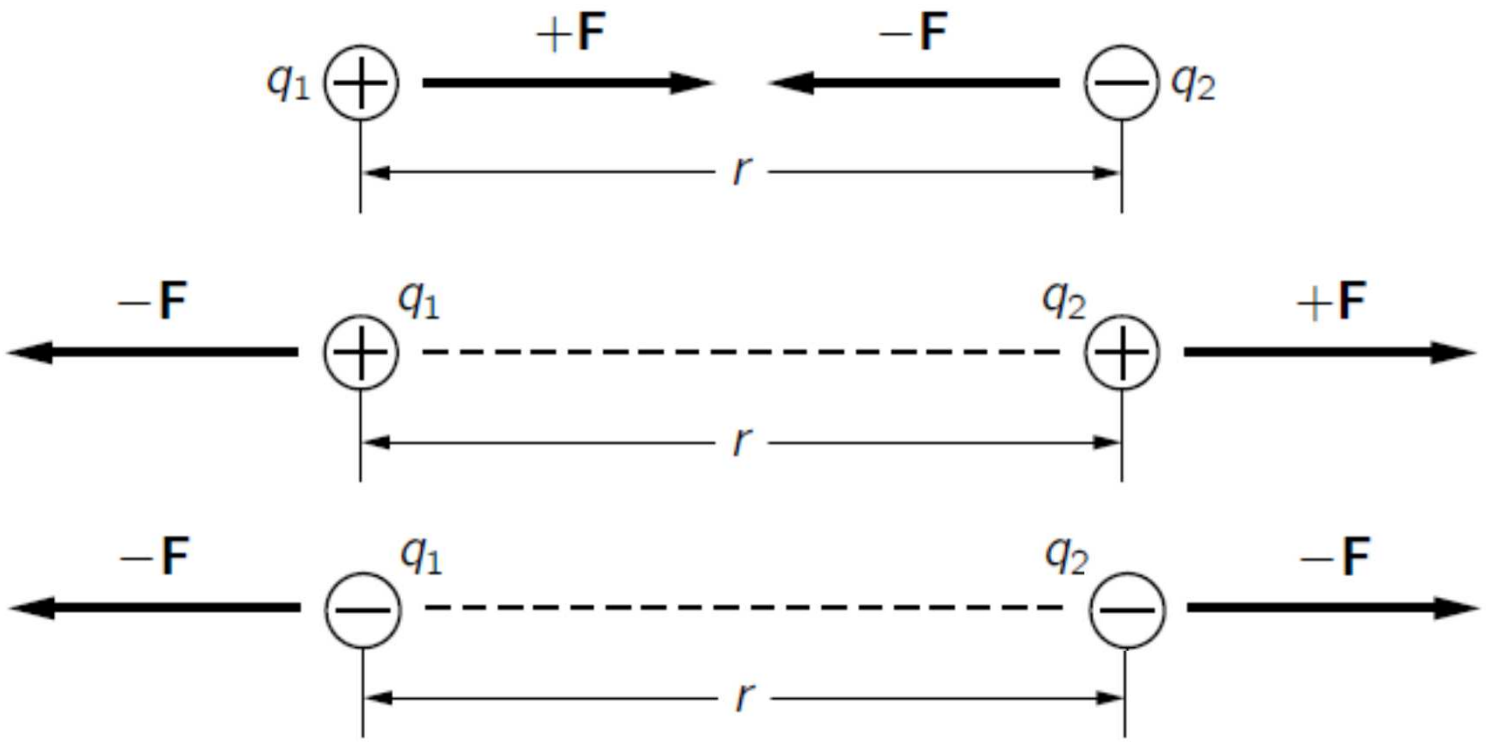
Examples of Electrical conductors

- Metals e.g. Copper wire
- Electrolyte e.g. Table salt

Examples of Electrical insulators

- Glass
- Rubber
- Plastic
- Wood

Coulomb's law



The magnitude of the force is given by

$$F = k\frac{q_1 q_2}{r^2}$$

where

$$k = \frac{1}{4\pi\varepsilon_0} = 9.0 \times 10^9\ Nm^2C^{-2}$$

and q_1 and q_2 are magnitudes (without the signs)