

# Electrostatics

Every substance contains protons (positive charges) and electrons (negative charges).

	charge (C)	mass (kg)
electron	$-1.60 \times 10^{-19}$	$9.11 \times 10^{-31}$
proton	$+1.60 \times 10^{-19}$	$1.67 \times 10^{-27}$
neutron	0	$1.67 \times 10^{-27}$

When the natural balance in an object (same number of negative and positive charges) is upset (either by adding or subtracting electrons), the object gains a net (overall) charge.

The fundamental rule of electrostatics is that like charges repel and unlike charges attract.

When two objects with different affinity for electrons are rubbed together, the contact causes electrons to jump to the object with the greater affinity.

Charge can never be created or lost. If something becomes positively charged, something else must become negatively charged, so that charge is always conserved.

## Coulomb's Law

Charles-Augustin deCoulomb discovered the relationship between two charged objects and the force they experience.

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

where  $q_1$  and  $q_2$  are the charges on each body,

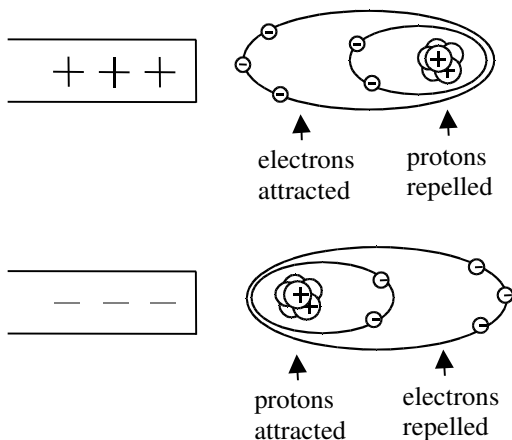
$r$  is the distance between them,

and  $k$  is the Coulomb force constant (also known as the electrostatic constant)

which has a value of  $k = 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2}$

## Dipoles

When a charged object is brought close to a neutral object, the atoms (or molecules) will polarise – part of each atom/molecule will be attracted to the charged object, and part repelled.

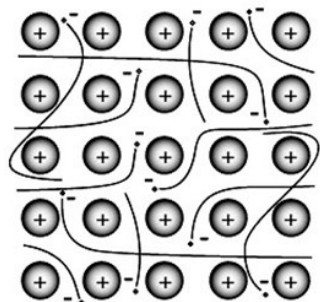


We say that the atoms or molecules have formed electric dipoles. That is, they now have two poles with opposite charge.

The attracting part is now closer than the repelling part, so the attractive force will be greater and the two objects will experience an overall attraction.

## Conductors and Insulators

The atoms in every solid are fixed in position. In metals, some of the electrons are allowed to move around from atom to atom, forming a 'sea' of electrons. Charge can therefore move along metals, and they are called conductors.



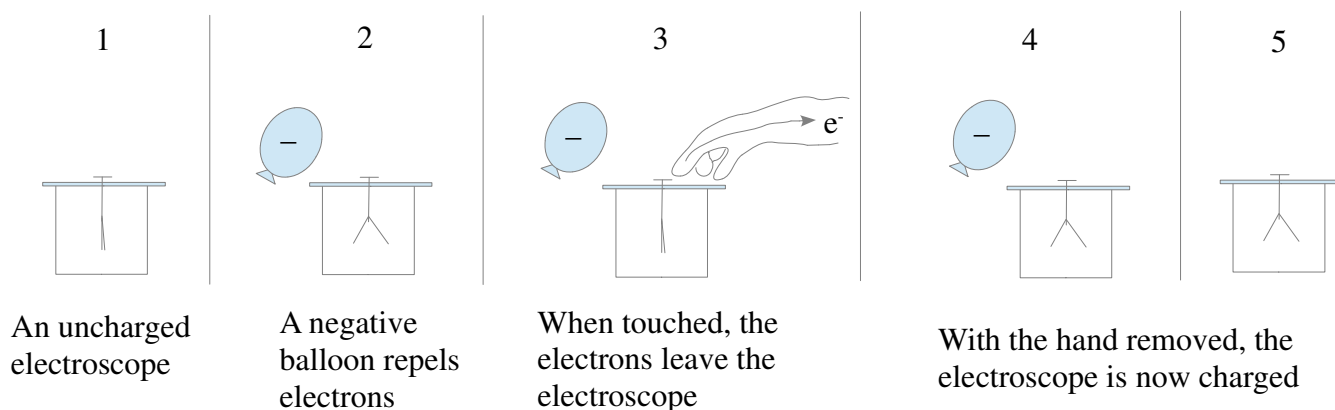
The delocalised electrons are free to move around. Applying a voltage would cause the electrons to move in one direction, acting as a current.

Materials that do not allow the movement of charge along them are called insulators.

## Charging by Induction

Charging objects by friction is just one of the ways of charging by contact. That is, by touching the objects. It is possible however to use a charged object to charge a conductor without touching the two objects together.

When a charged object is brought near (even without touching) a conductor, some of the electrons in the conductor will be attracted to the charged object if it is positive or repelled away from it if it is negative. If the conductor is grounded (connected to a source of effectively infinite charge such as the Earth) then electrons will move from or to the conductor. If the grounding is then removed, the conductor is left with an overall charge.



An uncharged electroscope

A negative balloon repels electrons

When touched, the electrons leave the electroscope

With the hand removed, the electroscope is now charged