9- 1 Coulomb's Law:

During the 18th century a French scientist, Charles A. Coulomb, studied fields of force that surround charged bodies. Coulomb discovered that charged bodies attract or repel each other with a force that is directly proportional to the product of the charges, and inversely proportional to the square of the distance between them. Today we call this Coulomb's Law of Charges. Simply put, the force of attraction or repulsion depends on the strength of the charred bodies, and the distance between them.

Experiments show that an electric force has the following properties:

(1) The force is inversely proportional to the square of separation, r^2, between the two charged particles.

$$F \propto \frac{1}{r^2}$$

(2) The force is proportional to the product of charge q_1 and the charge q_2 on the particles.

$$F \propto q_1 q_2$$

(3) The force is attractive if the charges are of opposite sign and repulsive if the charges have the same sign.

We can conclude that:

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

where k: is the coulomb constant = 9×10^9 N.m^2 /C^2

The above equation is called Coulomb's law, which is used to calculate the force between electric charges. In that equation F is measured in Newton (N), q is measured in unit of coulomb (C) and r in meter (m).
The constant k can be written as:

$$k = \frac{1}{4\pi\mathcal{E}_0}$$

where $\mathcal{E}_0$ is known as the Permittivity constant of free space.

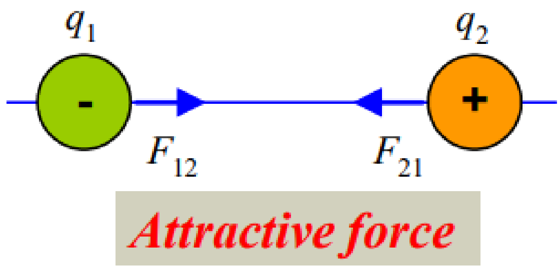
$$\mathcal{E}_0 = 8.85 \text{ x } 10^{-12}\ \text{C}^2/\text{N.m}^2$$

$$k = \frac{1}{4\pi\mathcal{E}_0} = \frac{1}{4\pi 8.85\ x\ r^{-12}} = 9 \times 10^9\ \text{N.m}^2/\text{C}^2$$

The electrostatic force of a charged particle exerts on another is proportional to the product of the charges and inversely proportional to the square of the distance between them.

$F_{12} = -F_{21}$

$F_{12} = F_{21}$



Example 1:

Calculate the value of two equal charges if they repel one another with a force of 0.1N, when situated 50 cm apart in a vacuum.

Solution:

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

$$0.1 = \frac{9\text{x}10^{9}\,q^{2}}{0.5^{2}} \Rightarrow q = 1.7\text{x}10^{-6}\text{C} = 1.7\mu\text{C}$$

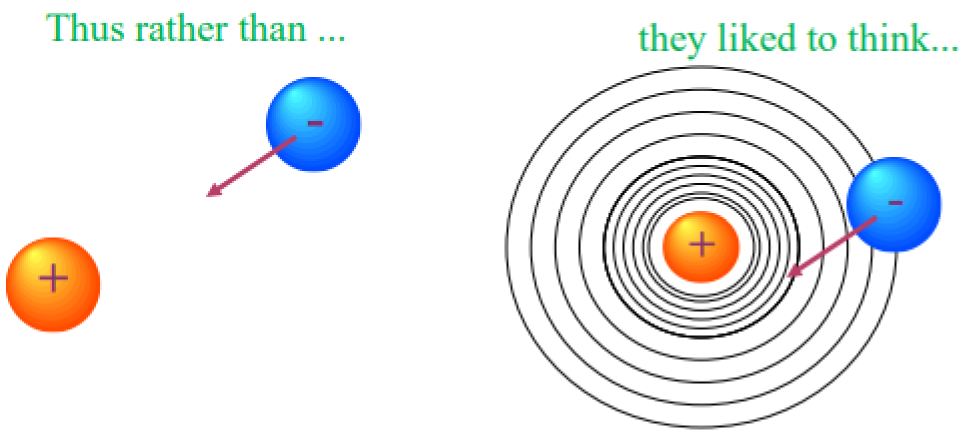
Homework Q1)

One charge of 2.0 C is 1.5m away from a –3.0 C charge. Determine the force they exert on each other.

9-2 Electric Field:

Physicists did not like the concept of "action at a distance" i.e., a force that was "caused" by an object a long distance away.

They preferred to think of an object producing a "field" and other objects interacting with that field.

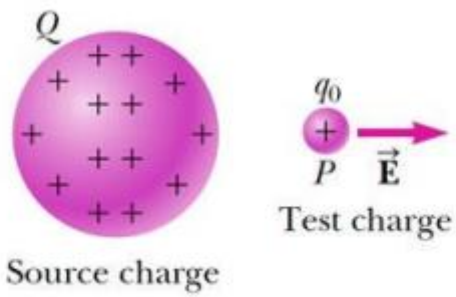


9-2-1 Definition of the Electric Field

Electric Field **E** is defined as the force acting on a test particle divided by the charge of that test particle.

$$\vec{E} = \frac{\vec{F}}{q_o}$$

The direction of the electric field is along ***r*** and points in the direction a positive test charge would move. This idea was proposed by Michael Faraday in the 1830's.



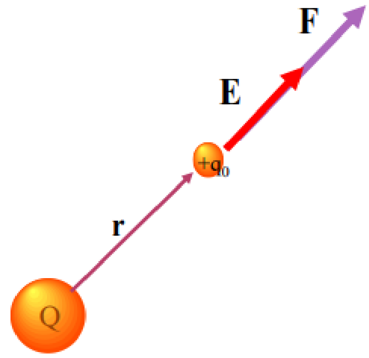
The Coulomb force is $F = K\frac{Qq_0}{r^2}$

The force per unit charge is $E = \dfrac{F}{q_0}$ and then the electric field at ***r*** is

$$\boxed{E = K\frac{Q}{r^2}}$$

due to the point charge q_0. The units are N/C

Thus, Electric Field from a single charge is $E = \dfrac{1}{4\pi\mathcal{E}_0}\dfrac{Q}{r^2}$

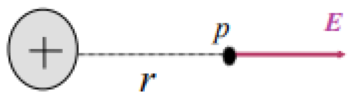


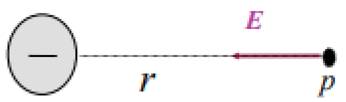
How do we find the direction.? The direction is the direction a unit positive test charge would move. أي ان اتجاه المجال الكهربائي هو في اتجاه شحنة اختبار موجبة

9-2-2 The Direction of the Electric Field:

If Q is **+ve** the electric field at point ***p*** in space is radially **outward** from **Q.**

If Q is **-ve** the electric field at point ***p*** in space is radially **inward** toward **Q.**





9-2-3 Representation of the Electric Field:

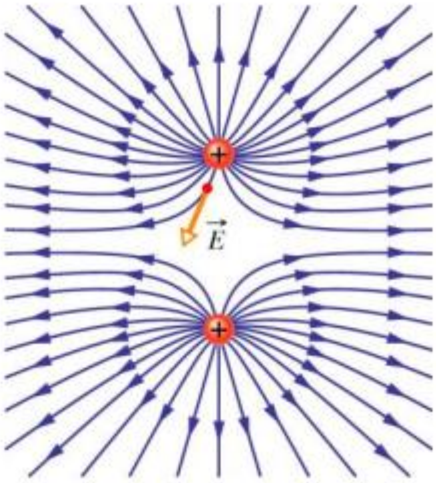
We represent the electric field with lines whose direction indicates the direction of the field.

- The lines must begin on positive charges (or infinity).
- The lines must end on negative charges (or infinity).
- The number of lines leaving a +ve charge (or approaching a -ve charge) is proportional to the magnitude of the charge
- Electric field lines cannot cross.

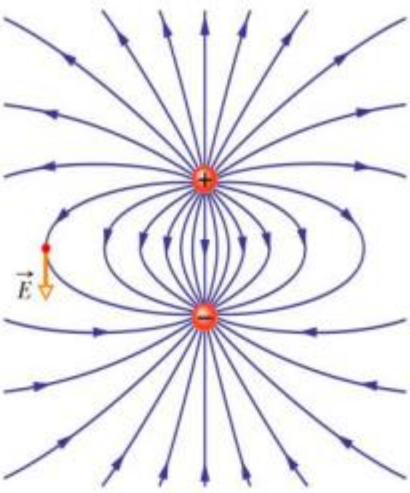
Notice that as we move away from the charge, the density of lines decreases.

9-2-4 Electric field lines for different charge distributions

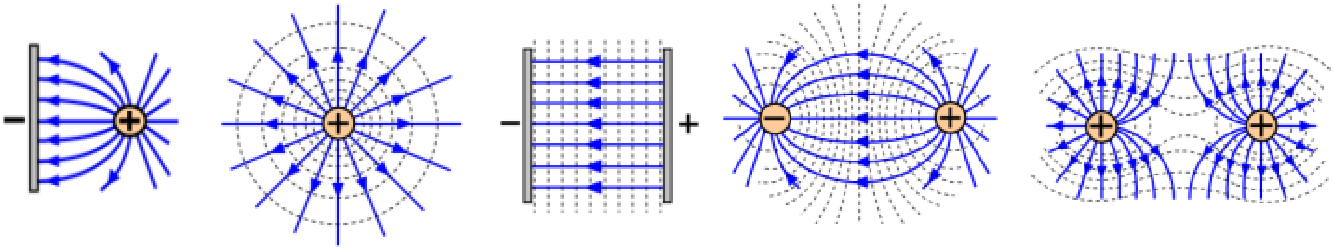
Electric Field Lines like Charges (+ +)



Opposite Charges (+ -)



- The electric field vector, E, is at a tangent to the electric field lines at each point along the lines.
- The number of lines per unit area through a surface perpendicular to the field is proportional to the strength of the electric field in that region.



These are called Electric Field Lines

Charge Particles in Electric Field

Using the Field to determine the force.