# Electric Fields

To be able to calculate the force between two charges
To be able to explain what electric field strength is
To be able to calculate the electric field strength at a distance r from the centre

Coulomb's Law (Electric Force)

The electrostatic force acts between all charged particles and can be attractive or repulsive. It is the charges themselves that cause the force to exist. The force that acts between two charges, Q_1 and Q_2, whose centres are separated by a distance of r is given by:

$$F \propto \frac{Q_1 Q_2}{r^2}$$

Like charges   *Opposite charges*   *Like charges*
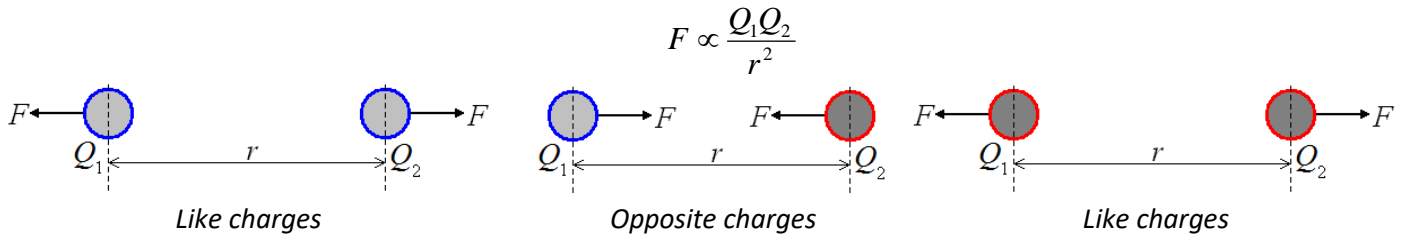
The proportional constant was found and the equation becomes:

$$F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2}$$

ε_0 is the Permittivity of Free Space, ε_0 = 8.854 x 10^{-12} F m^{-1}

When one of the charges is large, Q, the force between it and a test charge, q, whose centres are separated by a distance of r is given by:

$$F = \frac{Qq}{4\pi\varepsilon_0 r^2}$$

If the two charges are positive, $(+Q)(+q) = + Qq$ A positive force means the charges repel.
If the two charges are negative, $(-Q)(-q) = + Qq$ A positive force means the charges repel.
If one is negative and one is positive, $(-Q)(+q) = - Qq$ A negative force means the charges attract.

Electric Fields

An electric field is the area around a charge where any other charge will experience a force. We can model a field with field lines or lines of force.

Radial Fields

For a positive charge the field lines start at the charge and go out to infinity. For a negative charge the field lines end at the centre of a mass and tail back from infinity. We can see that they become more spread out the further from the charge we go.
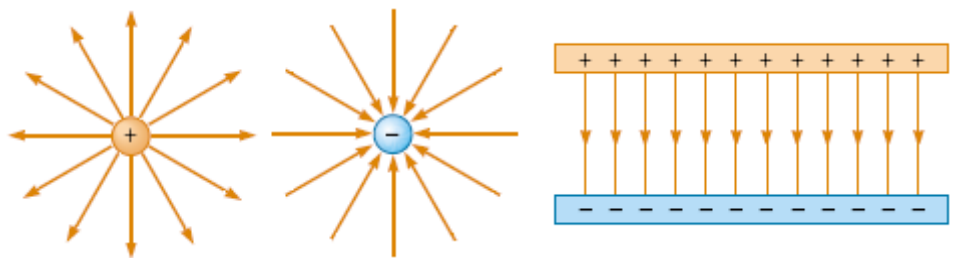
Uniform Fields

The field lines are parallel in a uniform field. Between two conducting plates the field lines leave the positive plate and enter the negative plate.

Electric Field Strength, E

We can think of electric field strength as the concentration of the field lines at that point. We can see from the diagrams above that the field strength is constant in a uniform field but drops quickly as we move further out in a radial field.

The electric field strength at a point is a vector quantity and is defined as:

The force per unit charge acting on a small charge placed at that point in the field

We can represent this with the equation:

$$E = \frac{F}{q}$$

If we use our equation for the electric force at a distance r and substitute this in for F we get:

$E = \dfrac{Qq}{4\pi\varepsilon_0 r^2 q}$ which simplifies to:

$$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$$ **(RADIAL FIELDS)**

Electric Field Strength is measured in Newtons per Coulomb, N C^{-1}