What exactly *is* electricity?

- Electricity is a class of physical phenomena associated with stationary and moving charges and is anything that happens as a result of charge.

Conductors and Insulators

- A conductor is a material, such as a metal or an ionic solution, in which some charges are relatively free to move about.

Semiconductors and Superconductors

- Semiconductors, such as silicon and germanium, are materials that are intermediate between conductors and insulators, they present no resistance to the movement of electric charge through a material.

Electric charge

- The symbol for electric charge is written q, -q or Q.
- The unit of electric charge is coulomb "C".
- The charge of one electron is equal to the charge of one proton, which is $1.6 \bullet 10^{-19}$C. This number is given a symbol "e".

Coulomb's Law

Like charges repel

Unlike charges attract

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

F - is the force between the two particles,

q_1 - is the net charge on particle A,

q_2 - is the net charge on particle B,

r - is the distance between the particles,

Coulomb's Law

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

k - is a proportionality constant which is $8.99 \cdot 10^9$ Nm^2/C^2.

$$k = \frac{1}{4\pi\varepsilon_0}$$

ε_0 - is a is the permittivity of space which is $8.85 \cdot 10^{-12}$ C^2/Nm^2.

- The magnitude of force that a particle exerts on another particle is directly proportional to the product of their charges and inversely proportional to the square of the distance between them.

Electric field

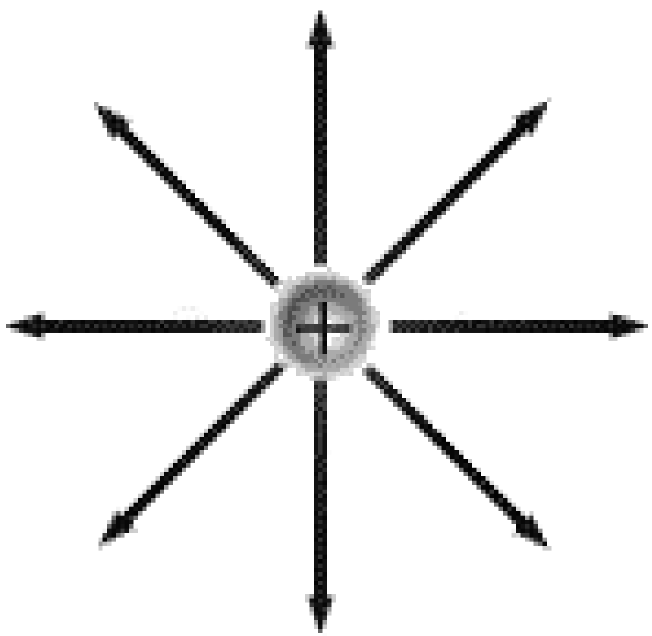
- Electric field is defined as the electric force per unit charge.

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

- The units of the electric field are: $[E] = \frac{N}{C}$

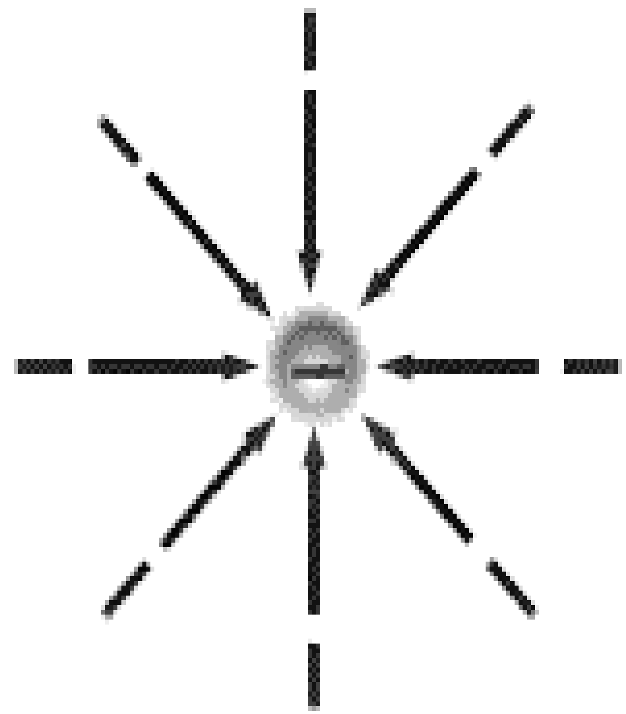
Electric field lines

The field lines for a positive point charge.



The lines flow out from the positive charge

The field lines for a negative point charge.



The lines flow in towards the charge

Electric field due to single point charge

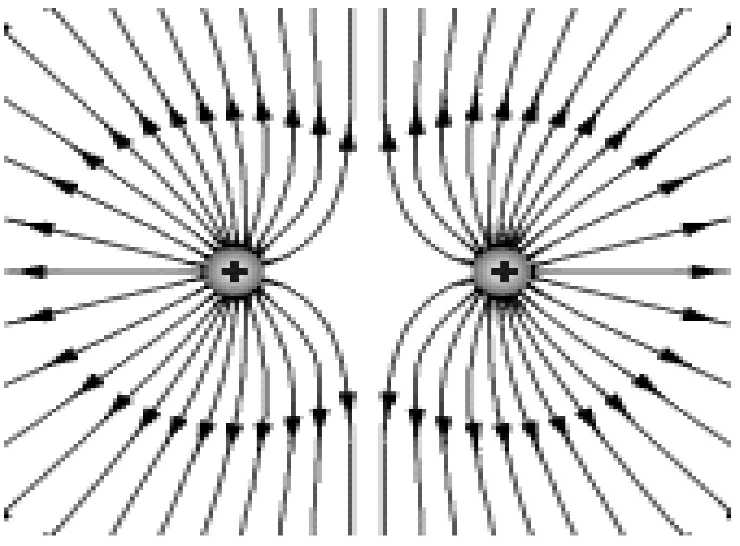
$$F = k\frac{qQ}{r^2} \quad \text{or} \quad F = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{r^2}$$

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

$$E = k\frac{Q}{r^2} \quad \text{or} \quad E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

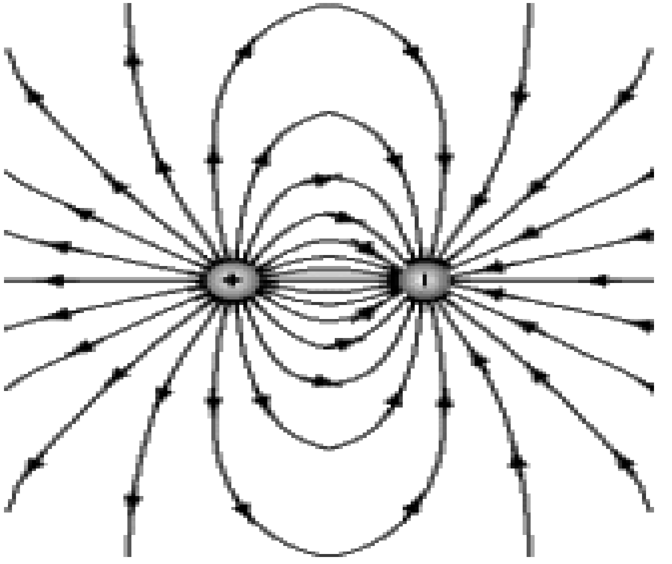
Electric field lines

The field lines for two positive point charges .



The lines flow away from both charges.

The field lines for one positive point charge and one negative point charge.



The lines flow out of the positive charge and into the negative charge

Electric field of an electric dipole

A pair of equal but opposite charges, +q and –q, is called an electric dipole.

$$E_+ = k\frac{q}{(r-a)^2} \qquad E_- = k\frac{-q}{(r+a)^2}$$

$$E = E_+ + E_- = kq[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}]$$

Electric field of an electric dipole

$$E = k\frac{4aqr}{(r^2 - a^2)^2}$$

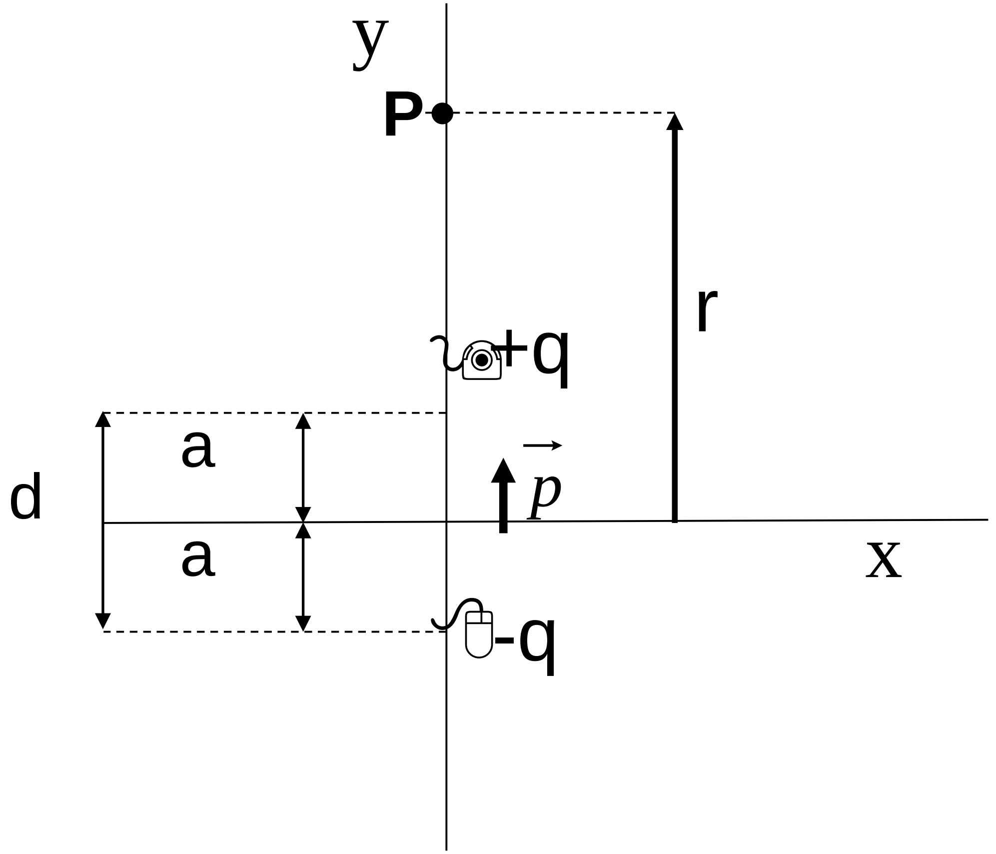
$$E = k\frac{4aq}{r^3}$$

Electric dipole

$$d = 2a$$

$$\vec{p} = qd$$

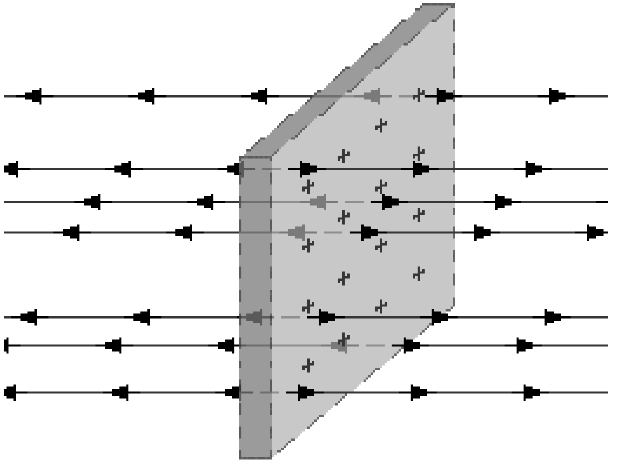
$$k = \frac{1}{4\pi\varepsilon_0}$$



$$E = k\frac{4aq}{r^3} \qquad E = k\frac{2dq}{r^3} \qquad E = k\frac{2p}{r^3} \qquad E = \frac{1}{2\pi\varepsilon_0}\frac{p}{r^3}$$

Electric field of a uniformly charged plate

The field lines for a large positively charged plate.



The field lines flow away from the plate on both sides.

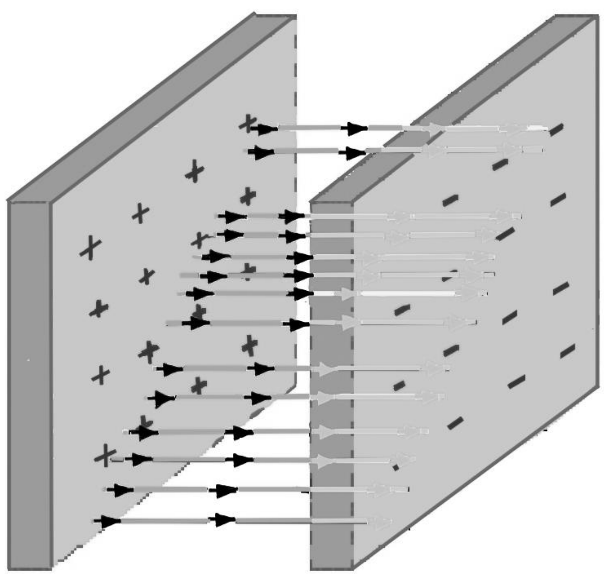
$$E = 2\pi k \frac{Q}{A}$$

or

$$E = \frac{1}{2\varepsilon_0}\frac{Q}{A}$$

Electric field between charged plates

The field lines due to the two plates bearing equal but opposite charges.



The field lines add between the plates and cancel elsewhere.

$$E = 4\pi k \frac{Q}{A}$$

or

$$E = \frac{1}{\varepsilon_0} \frac{Q}{A}$$