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ELECTRIC CHARGE AND ELECTRIC FIELD

FRICTIONAL ELECTRICITY

The word electric comes from Greek word for amber meaning electron

If you run a comb through your dry hair, you will note that the comb begins to attract small pieces of paper

like charges repel and unlike charges attract each other.

Once a body is charged by friction, it can be used to charge other conducting bodies by conduction, i.e., by touching the charged body with an uncharged body; and induction, i.e., by bringing the charged body close to an uncharged conductor and earthing it

Conservation of Charge

It is neither created nor destroyed. It is only transferred from one body of the system to the other

Quantisation of Charge

if Q is the charge on an object, it can be written as Q = Ne, where N is an integer and e is charge on an electron.

COULOMB'S LAW

The electrical force between Magnetism two static point charges q1 and q2 placed some distance apart is – directly proportional to their product ; – inversely proportional to the square of the distance r between them; – directed along the line joining the two charged particles ; and – repulsive for same kind of charges and attractive for opposite charges

$$F = k\frac{Q1 \times Q2}{r^2}$$

$$F = \frac{1}{4\pi\varepsilon}\frac{Q1Q2}{r^2}$$

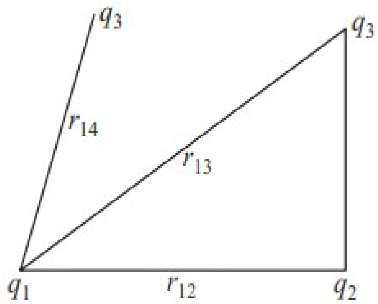
Where ε is the permittivity of the medium

If two equal charges separated by one metre experience a force of 9×10^9 N, each charge has a magnitude of one coulomb

The ratio of forces between two point charges q1 and q2 separated by a distance r, when kept in free space (vacuum) and material medium, is equal to ε/ε0 :

where ε_r is known as relative permittivity or dielectric constant

Principle of Superposition



F = F12 + F13 + F14 + …

$$F = k\frac{Q1\times Q2}{r^2} + k\frac{Q1\times Q3}{r^2} + k\frac{Q1\times Q4}{r^2}$$

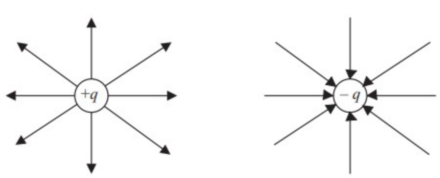
ELECTRIC FIELD

Faraday introduced the concept of electric field.

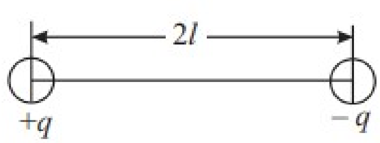
The electric field E at a point is defined as the electric force F experienced by a positive test charge q0 placed at that point divided by the magnitude of the test charge.

$$E = \frac{F}{q_0}$$

the action of electric force is mediated through electric field



Electric Field due to a Dipole

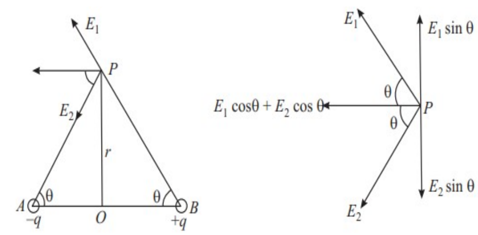


two equal and opposite charges are separated by a small distance, the system is said to form a dipole.

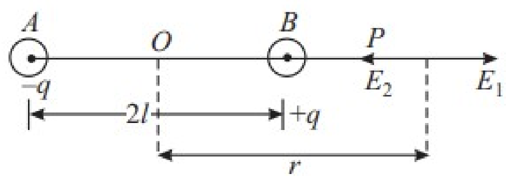
The product of the magnitude of charge and separation between the charges is called dipole moment

p = q × 2l

Electric field due to a dipole at an axial point : End–on position

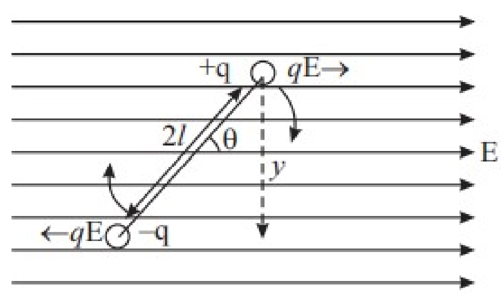


$$E = \frac{2P}{4\pi\varepsilon r^3}$$



$$\mathbf{E} = \frac{2\mathbf{p}}{4\pi\varepsilon_0} \times \frac{r}{r^4\,(1 - l^2/r^2)^2}$$

Electric Dipole in a Uniform Field



τ = p × E

Electric Lines of Force (Field Lines)

The number of field lines passing through a unit area of a plane placed perpendicular the direction of the field is proportional to the strength of the field.

The field lines start from a positive charge radially outward in all directions and terminate at infinity.

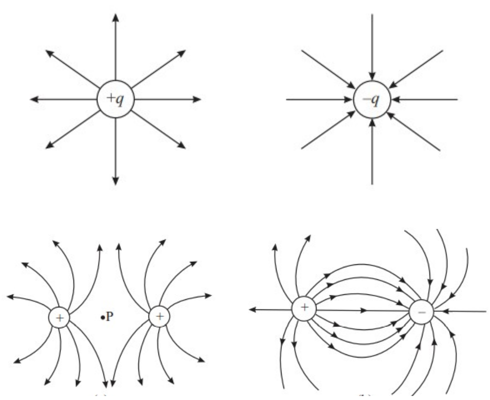
The field lines start from infinity and terminate radially on a negative charge.

For a dipole, field lines start from the positive charge and terminate on the Magnetism negative charge.

z A tangent at any point on field line gives the direction of electric field at that point.

z The number of field lines passing through unit area of a surface drawn perpendicular to the field lines is proportional to the field strength on this surface.

z Two field lines never cross each other.



ELECTRIC FLUX AND GAUSS' LAW

It states that the net electric flux through a closed gaussian surface is equal to the total charge q inside the surface divided by ε0 .

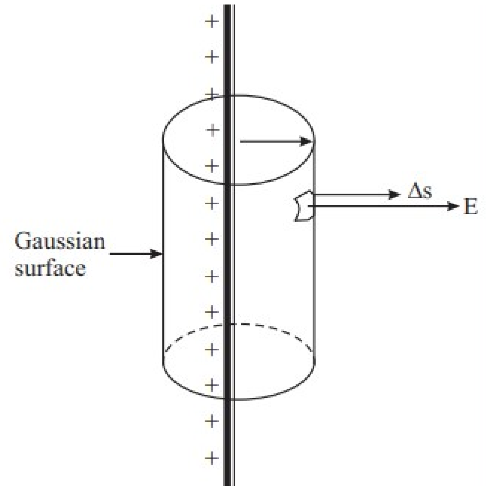
$$\boldsymbol{\varphi_e = \frac{q}{\varepsilon_0}}$$

$$E = \frac{2P}{4\pi\varepsilon r^2}$$

Electric Field due to a Point Charge

$$E = \frac{q}{4\pi\varepsilon_0 r^2}$$

Electric Field due to a Long Line Charge



$$E \times 2\pi rl = q/\varepsilon_0 = \sigma_l l/\varepsilon_0$$

$$E = \frac{\sigma_l}{2\pi\varepsilon_0 r}$$

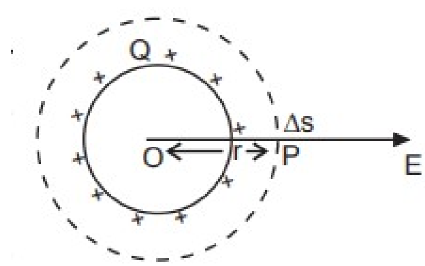
Electric Field due to a Uniformly Charged Spherical Shell

Field at an external point

$$\Sigma E \Delta s \cos 0° = \frac{Q}{\varepsilon_0}$$

$$\Delta E \cdot 4\pi r^2 = \frac{Q}{\varepsilon_0}$$

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

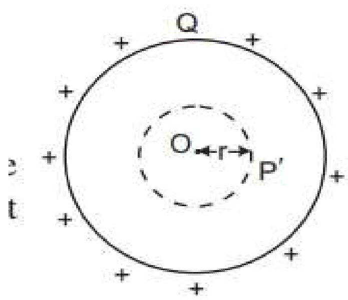


Field at an Internal Point

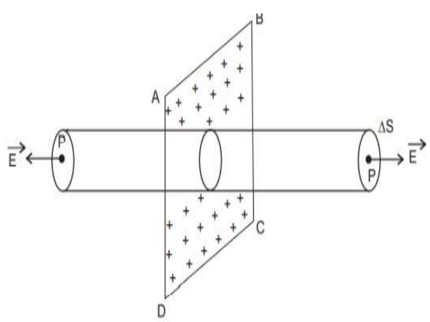
$$\Sigma E \Delta s \cos 0° = \frac{Q}{\varepsilon_0}$$

$$E \cdot 4\pi r^2 = \frac{Q}{\varepsilon_0}$$

$$E = 0 \text{ as } Q = 0$$



Electric Field due to a Plane Sheet of Charge



$$E = \frac{\sigma}{2\varepsilon_0}$$

Check Your Self

1 A charged object has q= $4.8*10^{-16}$ C. Number of fundamental charge are there on object is

a) $3*10^{3}$
b) $3*10^{-3}$
c) $2*10^{3}$
d) $2*10^{-3}$

2 SI unit of permittivity of free space

a) $C^2N^{-1}m^{-2}$
b) $C^1N^{-1}m^{-2}$
c) $C^2N^{-2}m^{-2}$
d) $C^2N^{-1}m^{-1}$

3 The Value of dielectric constant or relative permitivity

a) $\varepsilon_r=1$
b) $\varepsilon_r>1$
c) $\varepsilon_r<1$
d) All the above

4 Two charge of ,each of $6.0*10^{-10}$ C are separated bya distance of 2.0 m.Magnitude of coulomb force between them

a) $8.1*10^{-8}$ N
b) $80*10^{-11}$ N
c) $90*10^{-12}$N
d) $81*10^{-11}$N

5 If charge q is taken positive than diection of electric field E is

a) Toward charge
b) away from charge
c) no changes
d) none of the above

Stretch Your Self

1 When the electric field lines are parallel to each other

2 The electric force at some point due to a point charge 3.5 c is $8.5*10^{-4}$ N calculate the strength of electric field at that point.

3 A proton is placed in a uniform electric field E $8*10^{14}$ Nc^{-1} calculate the acceleration of the proton.

4 Drive an expression for electric field due to a dipole.