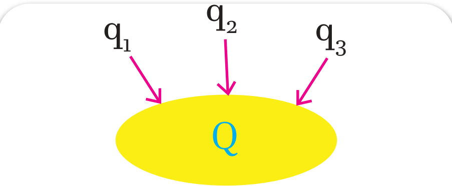
# Electric Charges and Fields Part -1

### Charges are additive in nature.



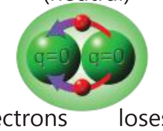

$$Q = q_1 + q_2 + q_3$$

### Electric charge is quantized.

$$Q = n \times e$$

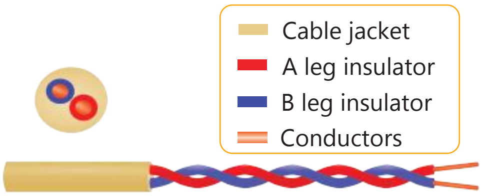
### Charge is a conserved quantity.

Net Charge q=0
(neutral)

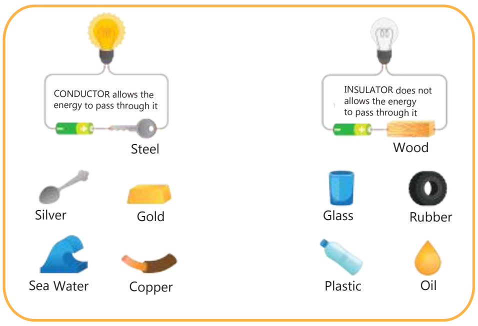



gains 2 electrons loses 2 electrons

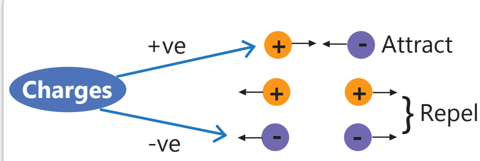
Conductors have free electrons on the surface which allows current to pass through. Insulators don't.




Electrical Conductors | Electrical Insulator




### Like charges repel;Unlike charges attract




### COULOMB'S LAW

$$F_e = \frac{kq_1q_2}{r^2} \qquad k = \frac{1}{4\pi\varepsilon_0}$$

$\varepsilon_0$ = permittivity of vaccum

$=8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$

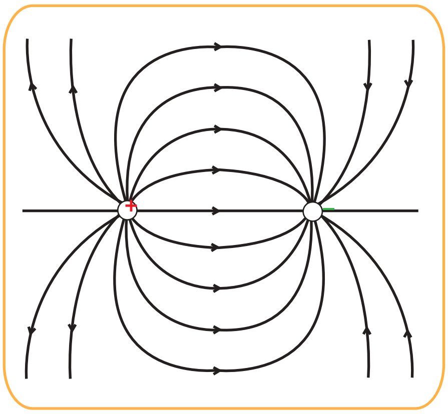
**Vector form of Coulomb's Law**

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{21}^2}\hat{r}_{21} \qquad \vec{r}_{21} = \vec{r}_2 - \vec{r}_1$$

$$\vec{F}_{21} = -\vec{F}_{21}$$

# Electric Field

A region around a charged particle or object within which a force would be exerted on other charged particles or objects.

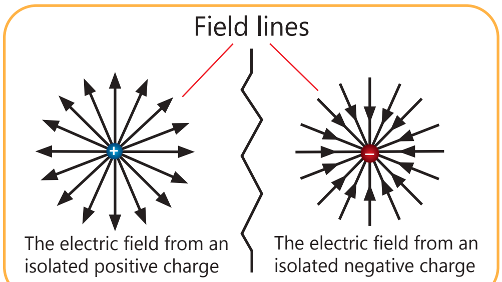


The **electric field intensity** is the measure of the **strength** of an **electric field** at any point.

It is equal to the **electric force per unit charge** experienced by a test charge which is placed at that point

$$E = \frac{F}{q} = \frac{k \cdot q \cdot Q/d^2}{q} = \frac{k \cdot Q}{d^2}$$

$$E = \frac{k \cdot Q}{d^2}$$ Newton / Coulomb ( $NC^{-1}$ )



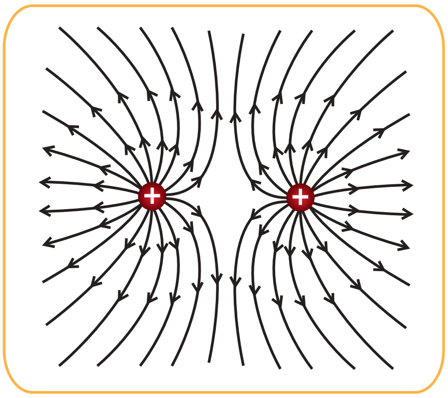

The **electric field intensity** between two points is the vector sum of all the **electric fields** acting at that point.

$$E = E_1 + E_2 + \ldots + E_n$$

$$= kq_1/r_1^2 + kq_2/r_2^2 + \ldots + kq_n/r_n^2$$

# Electric Field Lines: Properties

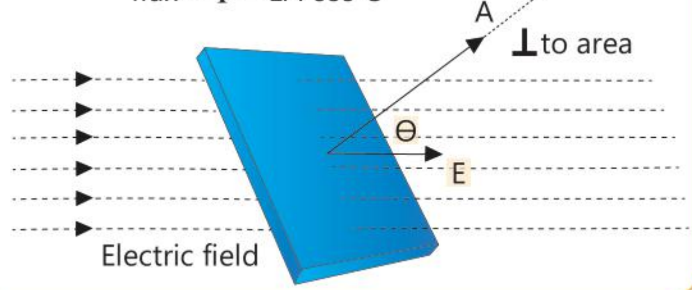
- Electric field lines start from a positive charge and end at a negative charge.
- In case of a single charge, electric field lines end at infinity.
- In a charge-free region, electric field lines are continuous and smooth.
- Two electric field lines never intersect or cross each other.
- Electric field lines never form a closed loop because electric field is conservative in nature.



# Electric Charges and Fields Part -2

**Electric flux** is the rate of flow of the **electric** field through a given area. Electric flux in an area is the **Electric field** multiplied by the **area** of the surface projected in a plane **perpendicular** to the field.

flux = $\Phi = EA\cos\Theta$



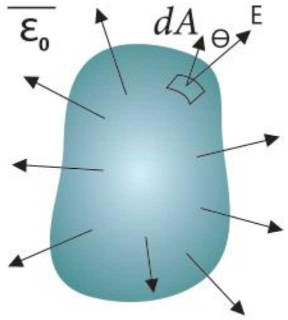

**Gauss law** states the total flux linked with a closed surface is $1/\varepsilon_0$ times the charge enclosed by the closed surface.

## Gauss'Law

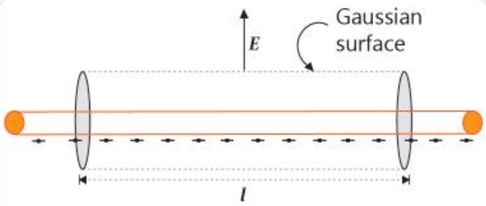
$$\Phi = \frac{Q}{\varepsilon_0}$$

- electric flux, $Nm^2/C$ ($\Phi$)
- enclosed charge, C ($Q$)
- permitivity of free space ($8.85\times10^{-12}$) ($\varepsilon_0$)

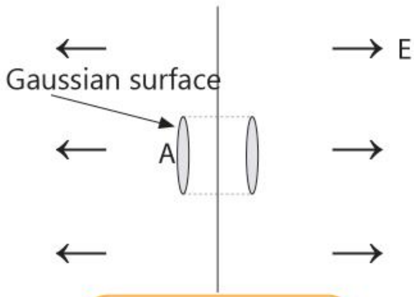
$$\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\varepsilon_0}$$



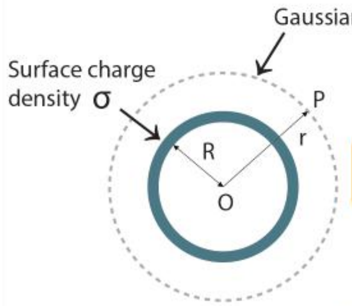

## Application of Gauss Law




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




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



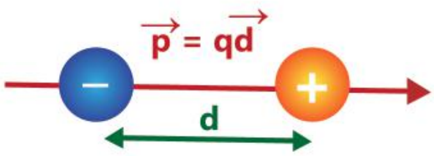

Outside shell

$$E = \frac{\sigma R^2}{\varepsilon_0 r^2}$$

Inside shell

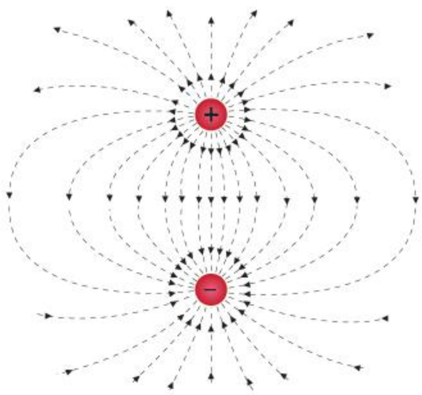
$$E = 0$$

Any two point charges which are equal in magnitude but of opposite signs, separated by a small distance consists an **"electric dipole".**



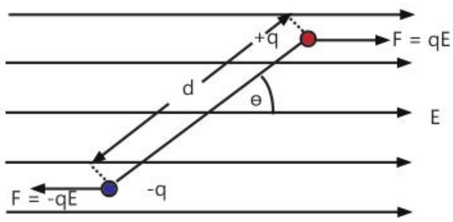

Magnitude of dipole moment **(p)** is the product of either of the charges **(q)** and the separation distance **(d)** between them.

## Electric Dipole



## Torque

$$\tau = Eqd\sin\Theta = \vec{p}\times\vec{E}$$




## Potential energy

$$U_E = -\vec{p}\cdot\vec{E}$$