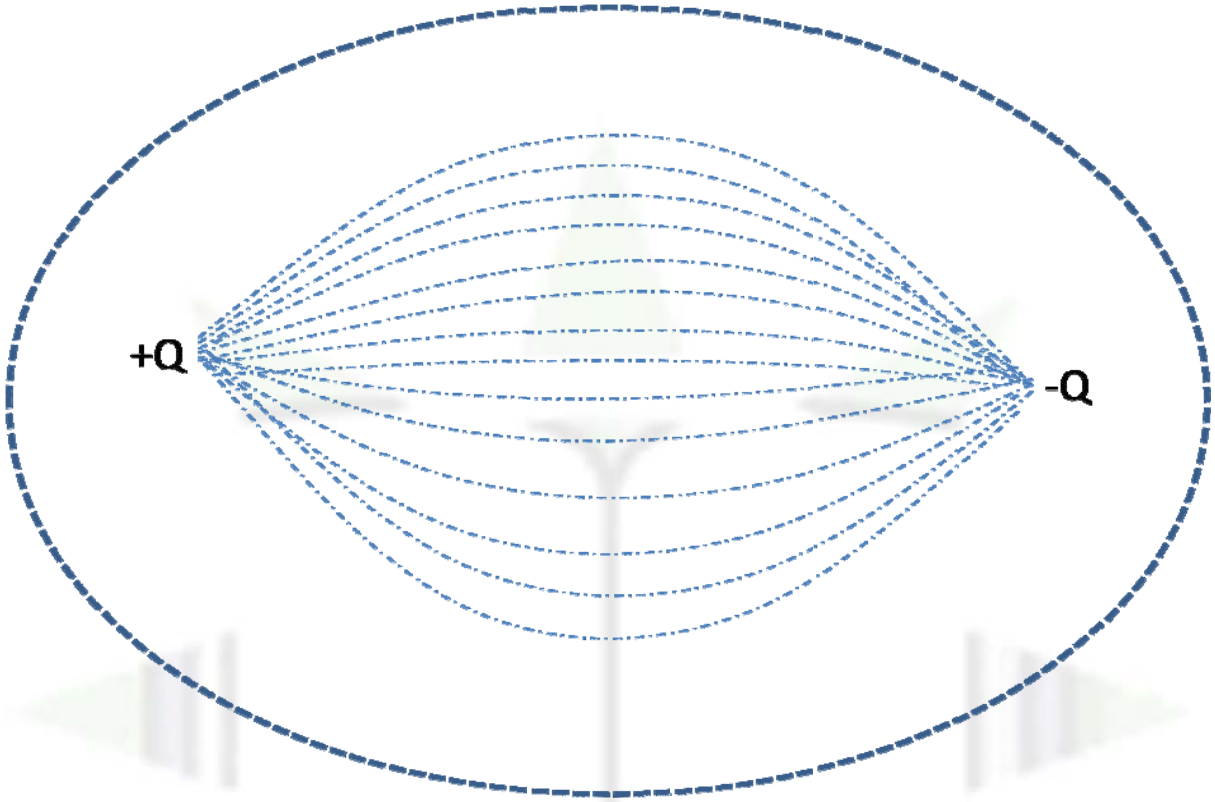
Electric Lines Of Force - Flux

Electric Lines Of Force: The imaginary lines drawn in the electric field to give a pictorial representation of the field are known as electric lines of force. They are the imaginary lines along which a free positive charge moves when left in that field.



Electric lines of force can be defined as the curve the tangent at point to that curve gives the direction of electric intensity at that point.

Properties of lines of force:

(1) Lines of force are emitted from the surface of positively charged bodies and are terminated on the surface of negatively charged body.

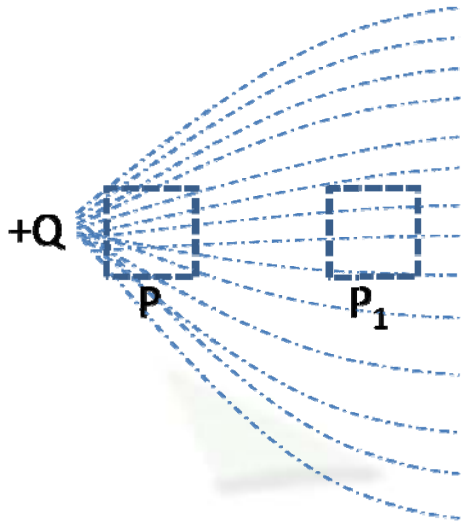
(2) Lines of force leave the surface or enter into the surface perpendicularly.

(3) Two lines of force can never intersect each other otherwise at the point of intersection we can draw two tangents to the two curves giving two directions of intensity at the same point which is not possible.

(4) Lines of force do not exist inside a conductor.

(5) A uniform electric field is represented by drawing parallel lines of force.

Electric Intensity in terms of lines of force:



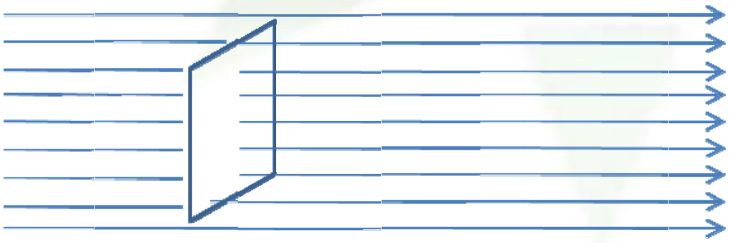
From the figure we find that if the point is close to the charge particle the no. Of lines of force passing through the unit area at that point is more.

According to the definition of intensity, intensity is greater at a point closer to the charge. Thus intensity at a point can also be defined as the number of electric lines of force passing through unit area at right angles to the direction of lines of force.

Flux: The total no. Of lines of force passing through a given surface normally is known as flux through the surface.

Relation between intensity and flux:

Case I: The field is uniform and the surface is held at right angle to the field.



When area $= 1$ then no. Of lines $= E$

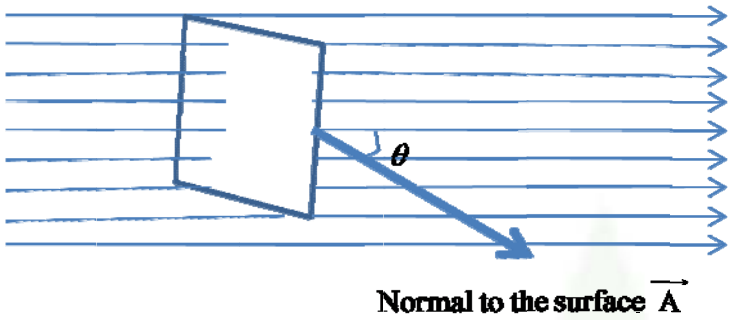
When area $= A$ then no. Of lines $= EA$

$\phi = EA \rightarrow (1)$

Where $E =$ Intensity

$A =$ Area

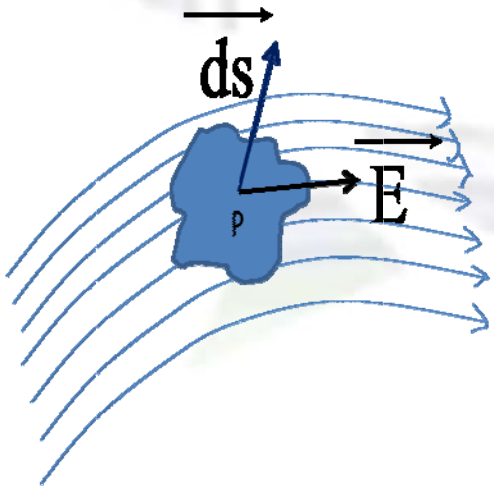
Case II: The field is uniform but the surface is not at right angles to the field.



Let θ be the angle between the direction of the field and the normal drawn to the surface of area A.
The component of electric intensity in the direction of normal = E cosθ
The no. of lines of force passing through the unit area of the surface normally

$$\phi = (E\cos\theta)A = \vec{E}.\vec{A}$$

Case III: When the field is non uniform



Let us consider any point P in the field.
Let $\vec{E}$ = Intensity of the field at the point P
Let us consideran element of the surface area ds.
Then flux through the elementry surface
$d\phi = \vec{E}.\vec{ds}$
Hence flux through the total surface can be obtained by integrating above equation

$$\phi = \int d\phi = \int \vec{E}.\vec{ds}$$