ELECTRIC FLUX:-

Definition:

"Number of electric field lines passing through an element of area."

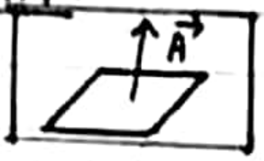
Symbol:

'ϕ_e'

Mathematically:

$\phi_e = \vec{E} \cdot \vec{A} = EA\cos\theta$ (Dot Product).

Vector Area ($\vec{A}$):



" An area normal to the plane area and equal in magnitude to the plane area."

Units:

$\phi_e = \frac{N}{C} m^2 = Nm^2C^{-1}$

$= kgms^{-2} m^2 C^{-1}$

$= kgm^3 s^{-2} A^{-1} S^{-1}$

$\phi_e = kgm^3 s^{-3} A^{-1}$

Dimensions:

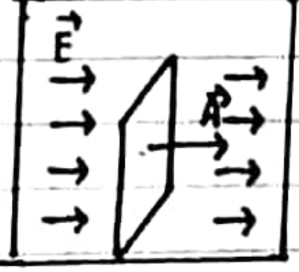
$\phi_e = [ML^3T^{-3}A^{-1}]$

Quantity:

Scalar Quantity.

Explanation:-

Case-I: When surface area is perpendicular to electric field:



Angle between vector area and electric field is zero ($\theta = 0°$)

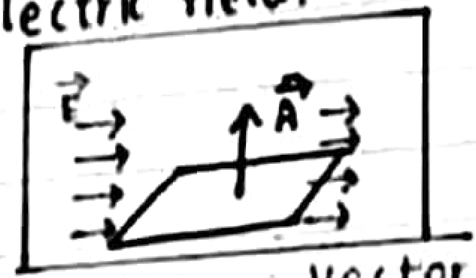
$\phi_e = EA\cos 0°$

$\phi_{max} = EA \perp$

Note:

$\phi_e = \phi_{max} \cos\theta$

Case-II: When surface area is parallel to electric field:



Angle between vector area and electric field is $90°$.

$\phi_e = EA\cos 90°$

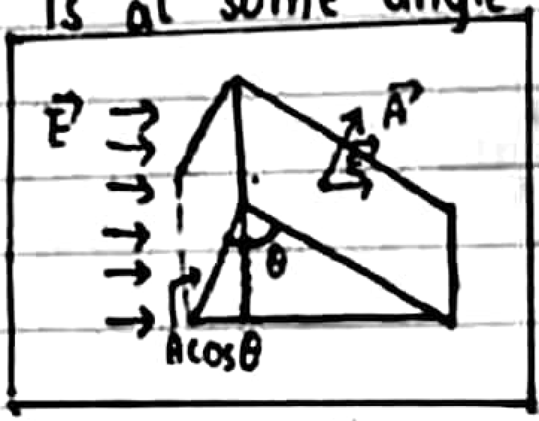
$\phi_e = 0$

$\phi_{min} = 0$

Note:

$\phi_e = \phi_{min} \cos\theta$

Case-III: When electric field intensity is at some angle with surface area:



Projection of $\vec{A}$ is $A\cos\theta$.

Electric flux can be calculated as:

$\phi_e = E(A\cos\theta)$

$\phi_e = EA\cos\theta$

$\phi_e = \vec{E} \cdot \vec{A}$

ELECTRIC FLUX THROUGH A CLOSED SURFACE ENCLOSING A CHARGE:-

- $\phi_e = EA\cos\theta$ is applicable only for flat surfaces
- Imagine the whole sphere is divided into 'n' small patches
- **Surface Area:**

$\Delta A_1, \Delta A_2, \Delta A_3 \cdots \Delta A_n$

- **Vector Area:**

$\vec{\Delta A_1}, \vec{\Delta A_2}, \vec{\Delta A_3}, \cdots \vec{\Delta A_n}$

Electric Intensities:

$\vec{E_1}, \vec{E_2}, \vec{E_3}, \cdots, \vec{E_n}$

Flux through ΔA_1:

$\phi_1 = E_1 \Delta A_1 \cos\theta_1$

$\phi_1 = \vec{E_1} \cdot \vec{\Delta A_1}$

Flux through ΔA_2:

$\phi_2 = \vec{E_2} \cdot \vec{\Delta A_2}$

$\phi_2 = E_2 \Delta A_2 \cos\theta$

Flux through ΔA_n:

$\phi_n = \vec{E_n} \cdot \vec{\Delta A_n}$

$\phi_n = E_n \Delta A_n \cos\theta$

Total flux through sphere:

$\phi = \phi_1 + \phi_2 + \cdots + \phi_n$

$\therefore \phi = E_1 \Delta A_1 \cos\theta_1 + E_2 \Delta A_2 \cos\theta_2 + \cdots + E_n \Delta A_n \cos\theta_n$ —eq 1

As:

$\theta_1 = \theta_2 = \theta_3 = \cdots = \theta_n = 0^\circ$

$\cos\theta_1 = \cos\theta_2 = \cos\theta_3 = \cdots = \cos\theta_n = 1 = \cos 0^\circ$

Due to spherical Symmetry:

$E_1 = E_2 = \cdots = E_n$

Putting in eq 1

$\phi = E\Delta A_1 + E\Delta A_2 + \cdots + E\Delta A_n$

$\phi = E(\Delta A_1 + \Delta A_2 + \cdots \Delta A_n)$

$\phi = E(\text{Surface area of sphere})$ —eq 2