Electric-flux (Lecture : 1)

What is Electric flux.

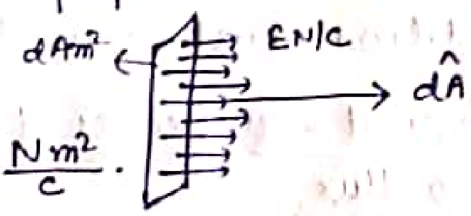
Electric flux is a scalar physical quantity that measures the total quantity of electric lines of forces passes perpendicular through a given surface area $A\ m^2$.

Mathematical Expression of Electric flux:

According to faraday's assumption in electric field region

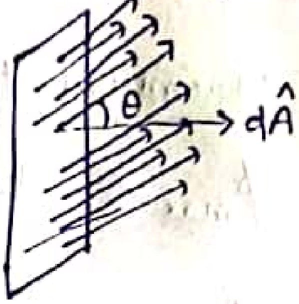
$|E| \propto$ No. of electric field lines passes normally through a surface of unit area.

let an imaginary surface of area 'dA' m^2 in electric field. And at every point on the surface magnitude of field intensity is E N/C, and direction of field is perpendicular to surface i.e. along the normal to plane



then electric flux linked with the surface is equal to $\boxed{d\phi = E\,dA}$ $\frac{Nm^2}{C}$.

If at every point of the given surface magnitude of field Intensity is same i.e. E N/C but it makes an angle 'θ' from normal to plane of surface then we can calculate total electric flux linked with the given surface by formula



$$d\phi = \underbrace{dA}_{\text{Surface Area}}\ \underbrace{(E\cos\theta)}_{\text{Projection of electric field along the normal to plane of surface.}}$$

we can write this formula as:

$$d\phi = E(dA)\cos\theta$$

$$\boxed{d\phi = \vec{E} \cdot \vec{dA}}$$

i.e. Electric flux is measured by "Scalar product of electric field vector and Area vector".

Impartant Points:

(1) If field Intensity is uniform and angle B/w $\hat{E}$ and $\hat{A}$ at everypoint is 'θ' and $|\vec{E}|$ is Constant then:

$$\phi = E\underset{\downarrow}{A}\cos\theta$$

$\hookrightarrow$ ** Effective Area through which field lines passes.

(2) If field Intensity is non-uniform then: flux can be calculated by formula $\int d\phi = \int E\,dA\cos\theta$

(3) If the surface is not plane or. field is not uniform then: divide the surface in different parts $\Delta S_1, \Delta S_2 \cdots \Delta S_n$ and let the electric flux linked with these surfaces are $\Delta\phi_1, \Delta\phi_2, \phi_3 \cdots \Delta\phi_n$ then; Total flux linked in this condition:

$$\phi_T = \phi_1 + \phi_2 + \cdots + \phi_n = \sum_{i=1}^{n} \phi_i$$

Addition must be ~~in~~ done by 'scalar method'

(4) Physical Significance of positive flux, Negative flux and zero flux

Positive flux : field lines are leaving the surface.

Negative flux: field lines are entering the surface.

zero flux : No field lines are passing through the surface.

(5) Maximum flux and Minimum flux.

$\phi_{max} = \pm EA$ where; + means : leaving the surface. − means: Entering the surface.

$\phi_{min} = 0$.

(6) unit of Electric flux is $\dfrac{N-m^2}{C}$

Dimensional formula : $ML^3T^{-3}A^{-1}$.

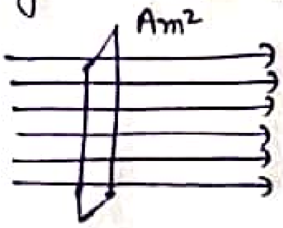
Q: find Electric flux linked with surface given that $\vec{A} = 20\hat{i}$ m^2 and $\vec{E} = \hat{i}+2\hat{j}$ N/C ? $\left(20 \frac{Nm^2}{C}\right)$.

Q: find Electric flux linked with surface given that surface Area is equal to $10 m^2$ and Electric field has magnitude 10 N/C and makes angle 30° from surface? (50 $N\text{-}m^2/C$)

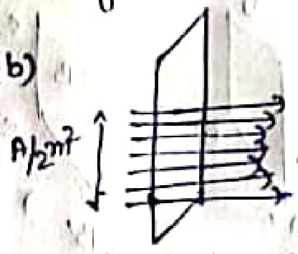
Q: A point charge 'Q' is placed at the ~~centre~~ corner of a square of side 'a' m find flux through the square? (0)

Q: Given uniform Electric field E N/C calculate flux passing through the given surface.

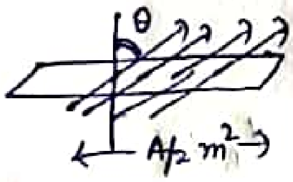
(a)



(b)

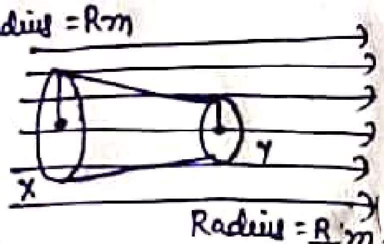


(c)



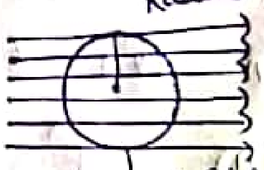
(d)

(e)



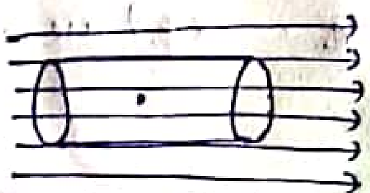
find flux linked with
(i) Surface 'x' (ii) Surface 'y'
(iii) Curved Surface.

(f)



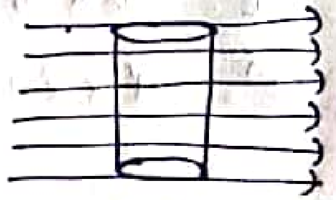
No. of field lines entering in sphere?

(g)



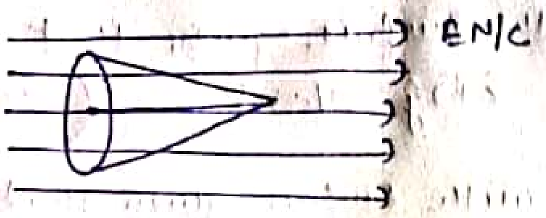
(a) Electric flux entries in cylinder
(b) " " leaving the cylinder
(c) ϕ_{plane} (d) ϕ_{curved}
(e) ϕ_{Total}

(h)



# height = h m
radius = R m

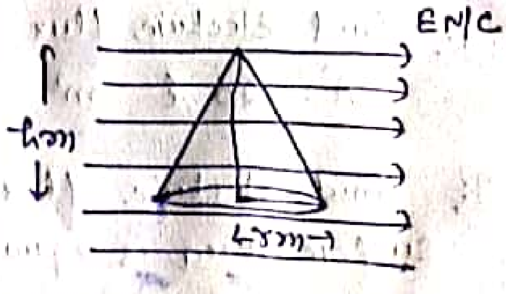
(i) $\phi_{entries}$ (ii) $\phi_{leaving\ out}$
(iii) ϕ_{curved} (iv) ϕ_{plane} (v) ϕ_{Total}

(g) 

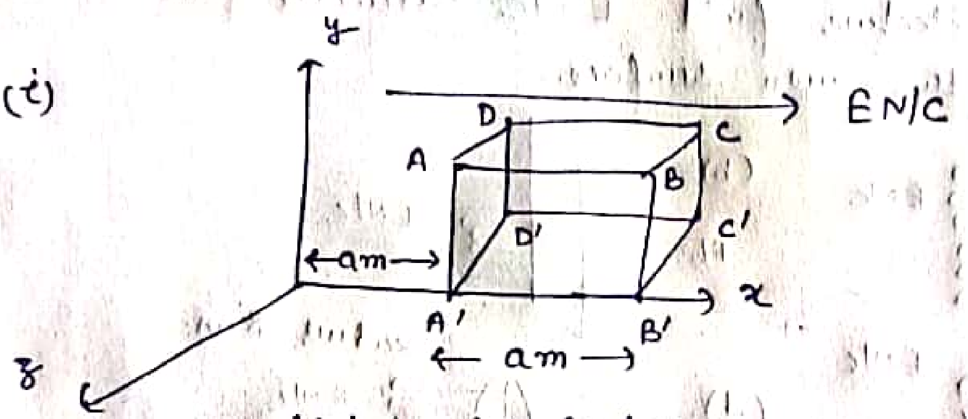
Cone: radius = R m
height = h m

$\phi_{(entering)}$ in cone.

ϕ_E (linked with curved surface)

(h) 

· Total flux entering in through curved surface.

(i) 

Electric flux linked with surface

(i) ϕ_{ABCD} (ii) $\phi_{A'B'C'D'}$ (iii) $\phi_{ADD'A'}$ (iv) $\phi_{BCC'B'}$

(v) $\phi_{A'B'BA}$ (vi) $\phi_{D'C'CD}$.

given: (a) $\vec{E} = +2\hat{i}$ N/C

(b) $\vec{E} = +2\hat{i} + 3\hat{j}$ N/C

(c) $\vec{E} = +2\hat{i} + 3\hat{j} - 4\hat{k}$ N/C

(d) $\vec{E} = \alpha x\, \hat{i}$ N/C where, 'α' is arbitrary constant

(e) $\vec{E} = \alpha x\, \hat{i} + \beta y\, \hat{j}$ N/C --- 'α' & 'β' are constant.

(f) $\vec{E} = \alpha x\, \hat{i} + \beta y\, \hat{j} + \gamma z\, \hat{k}$ N/C -- α, β, γ are const.