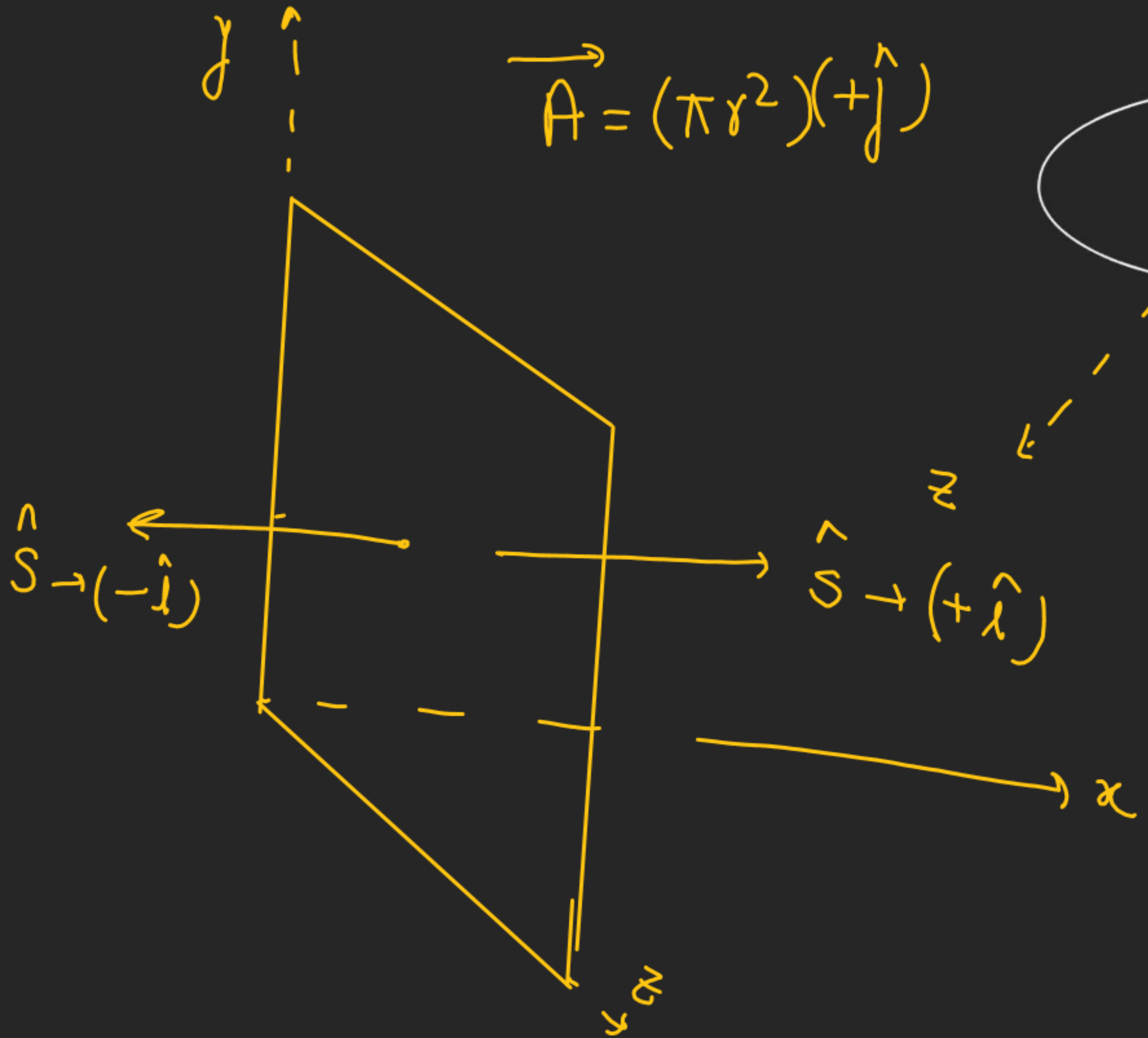
Nishant Jindal

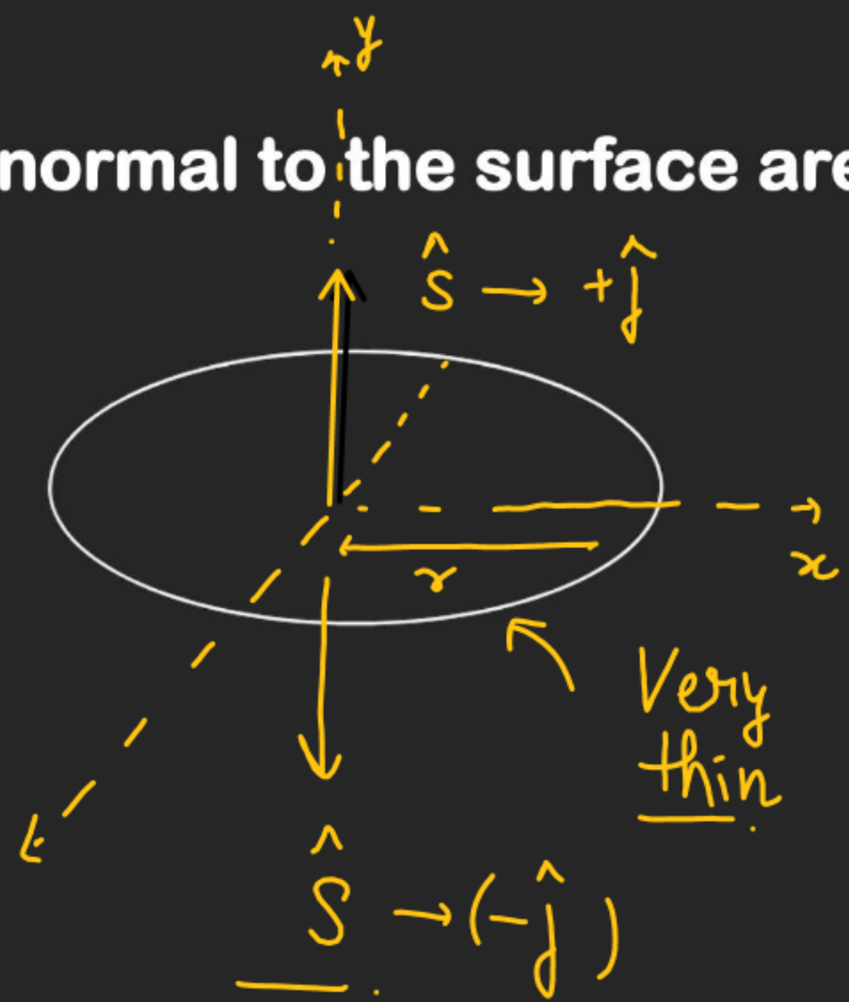
ELECTRIC FLUX

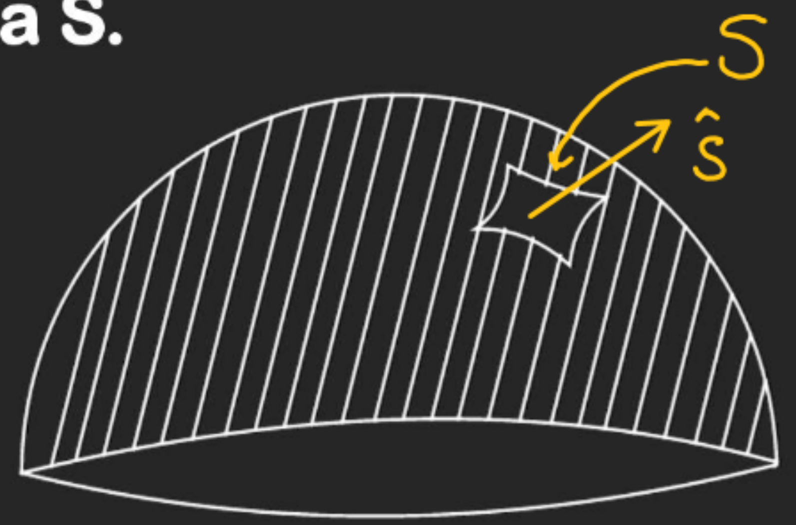
Area Vector

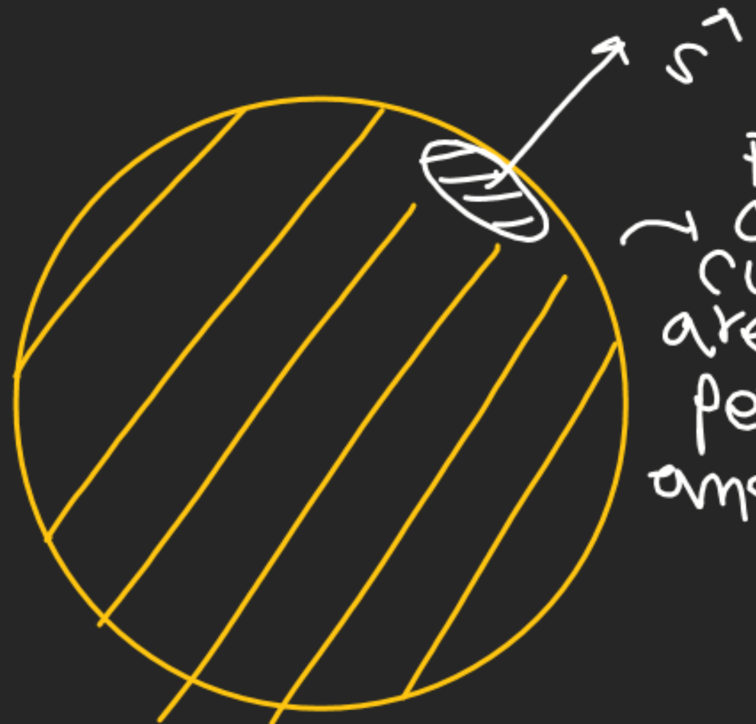
❖ Direction is considered along the normal to the surface area S.

$$\vec{A} = (\pi r^2)(+\hat{j})$$



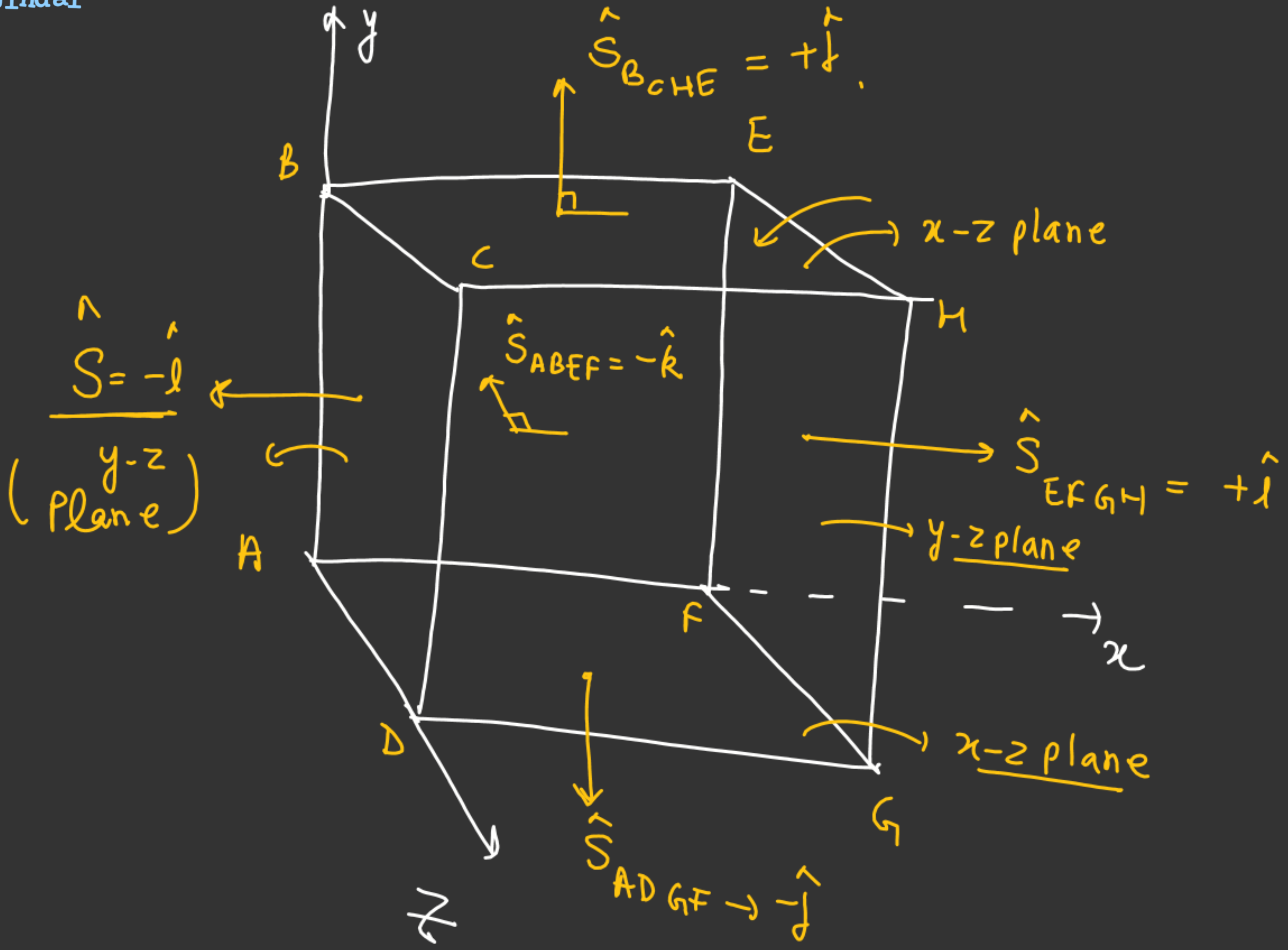






For close curve area vector perpendicular and outward

Nishant Jindal



Nishant Jindal

ELECTRIC FLUX

❖ **Electric lines of forces passing through a given surface contribute towards electric flux.**

$ds \rightarrow$ Area of differential element.

$\hat{ds} \rightarrow$ Unit vector pendicular to ds and outward

$$\boxed{d\phi = \vec{E} \cdot \vec{ds}} \quad (*)$$

$\Downarrow$

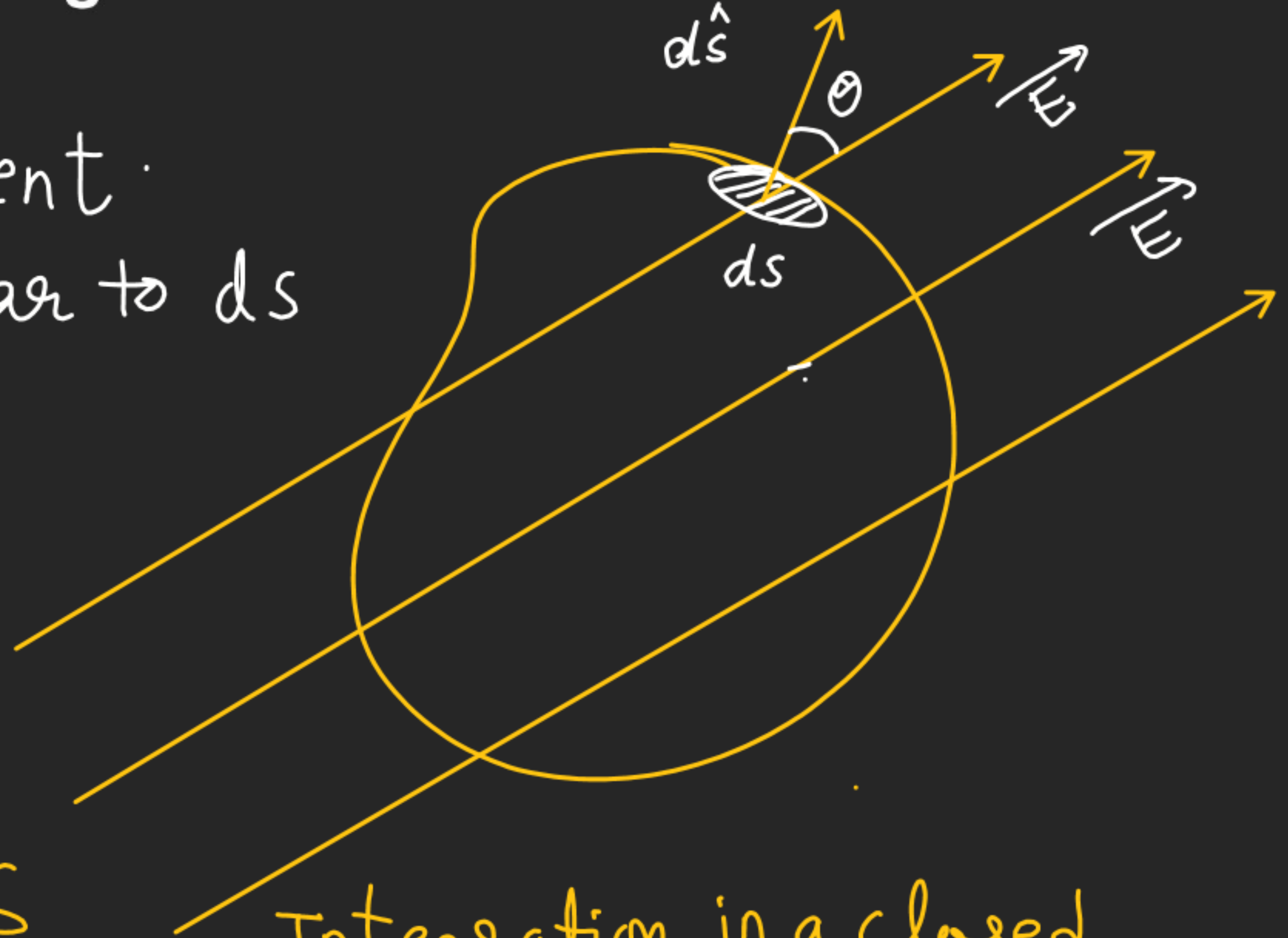
Flux through 'ds' area

$$\boxed{\phi_T = \oint \vec{E} \cdot \vec{ds}} \quad (**)$$

$$\boxed{\phi_T = E\,ds\cos\theta}$$

$\theta \rightarrow$ angle b/w $\vec{E}$ & $\vec{ds}$

$\phi_T \rightarrow$ Flux through whole body.



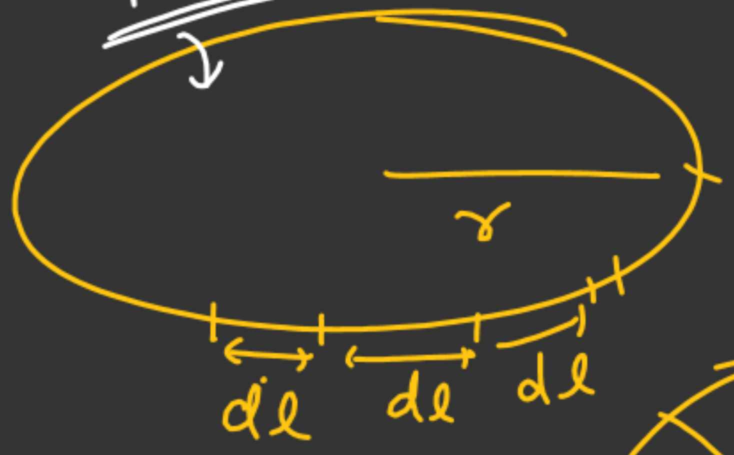
$\oint \rightarrow$ Integration in a closed curve.

Nishant Jindal

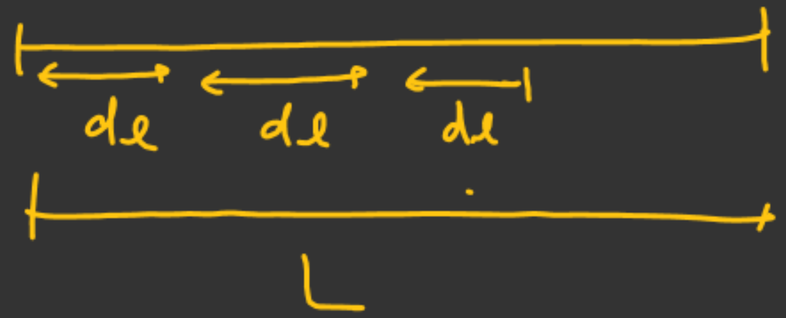
$\oint dl \rightarrow$ Line integral in a close loop

$\oint ds \rightarrow$ Surface integral in a closed loop.

Ring



$$\boxed{\oint dl = 2\pi r}$$



$$\boxed{\int dL = L}$$

Sphere

$$\oint ds = 4\pi R^2$$

$\Downarrow$

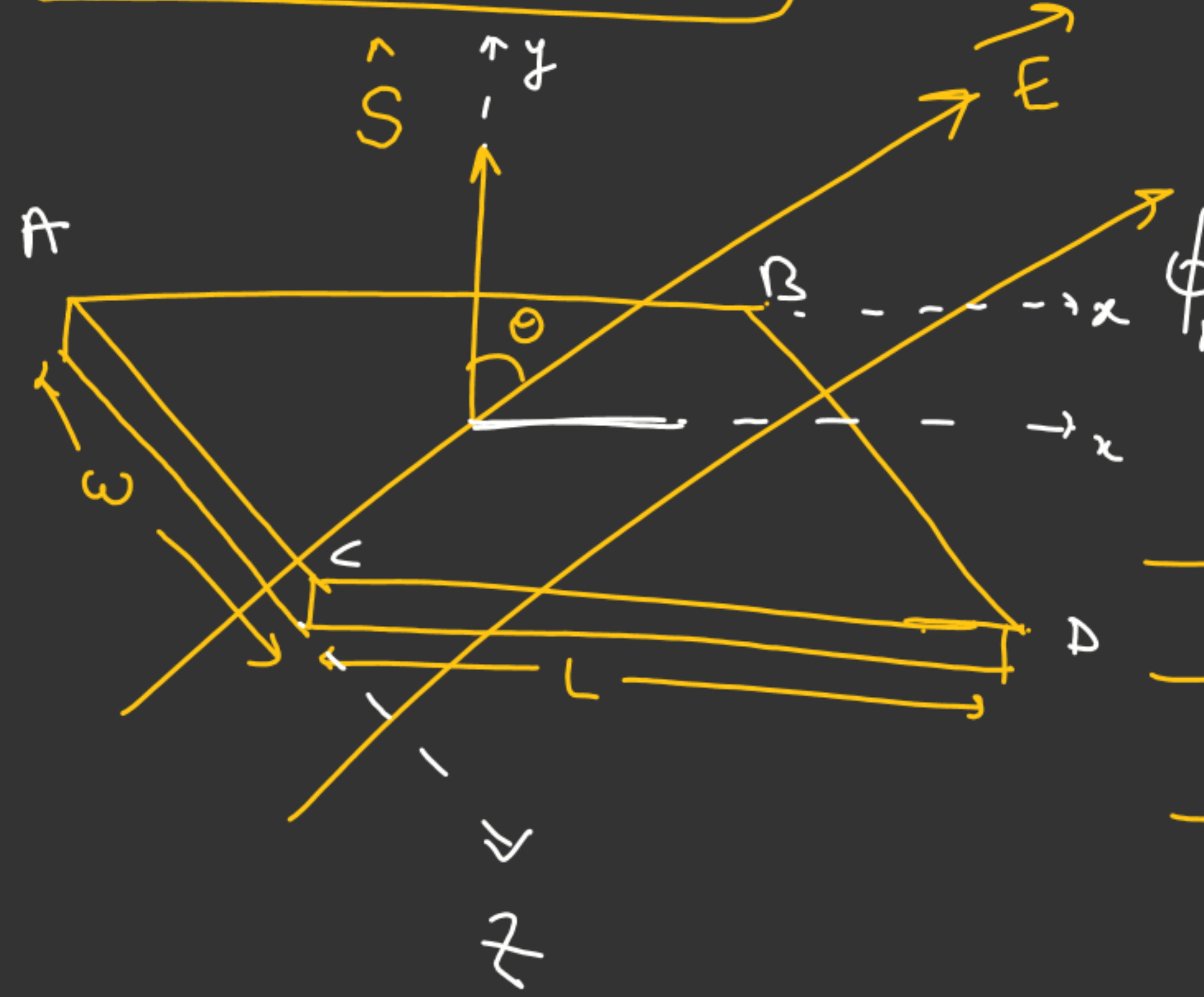
Surface Integral

Nishant Jindal

$\phi = \vec{E}\cdot\vec{S}$ | $d\phi = \vec{E}\cdot d\vec{s}$

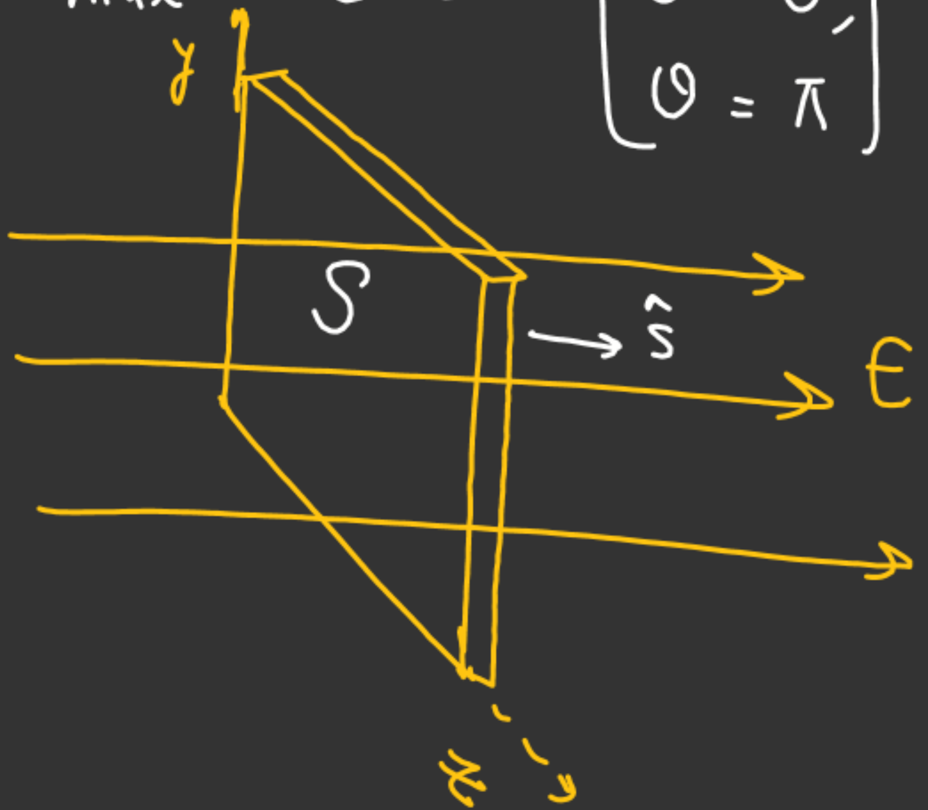
$$\boxed{\phi = ES\cos\theta}$$

$$\phi_{ABCD} = ES\cos\theta$$
$$= [ELW\cos\theta]$$



$\theta \rightarrow$ Angle b/w $\vec{E}$ & $\vec{s}$

$\phi_{max} = ES$ $\begin{bmatrix}\theta = 0, \\ \theta = \pi\end{bmatrix}$ $\cos\theta = \pm 1$



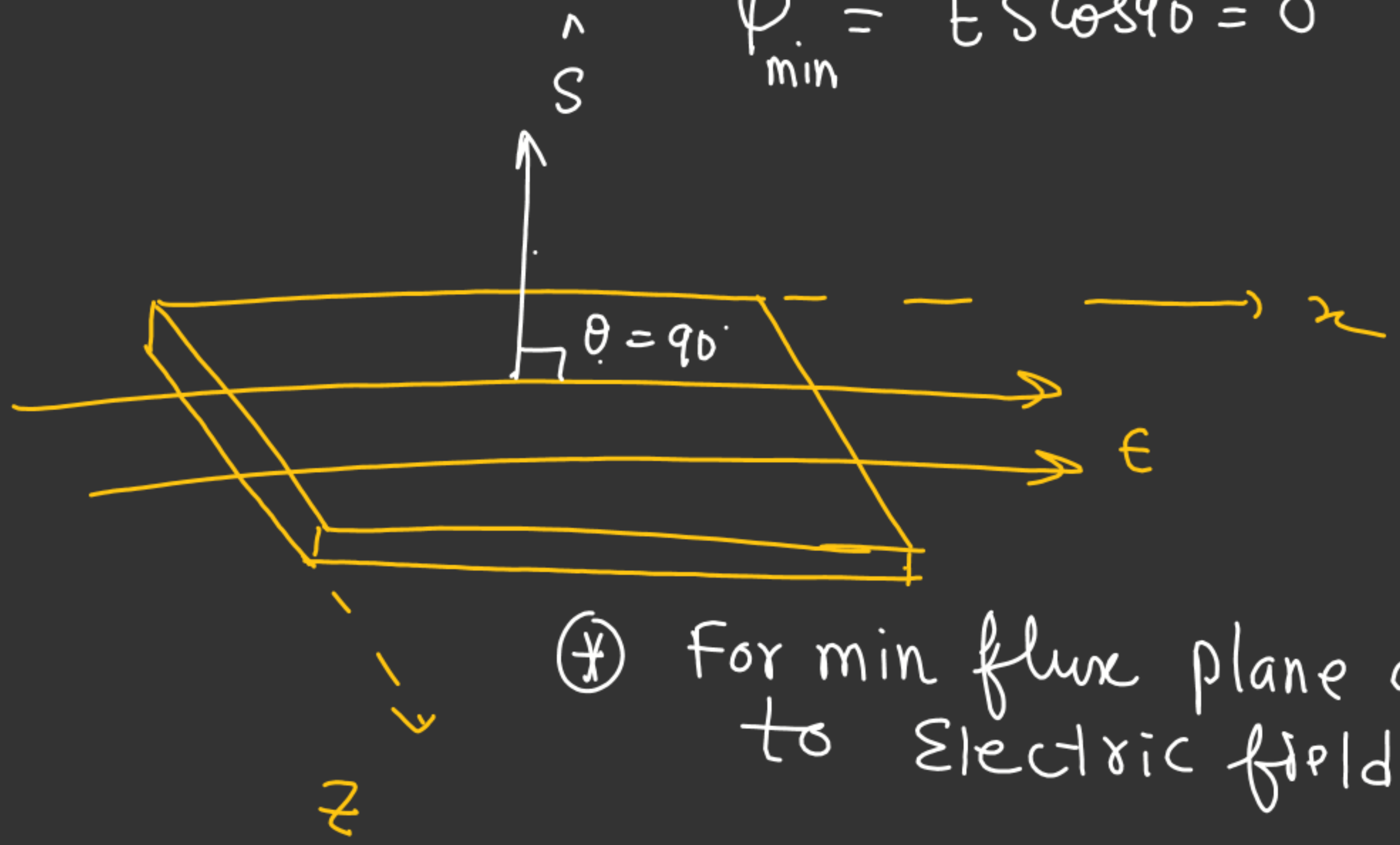
$\hat{s} \rightarrow +\hat{i}$

$E \rightarrow +\hat{i}$

$$\boxed{\phi_{max} = ES}$$

Nishant Jindal

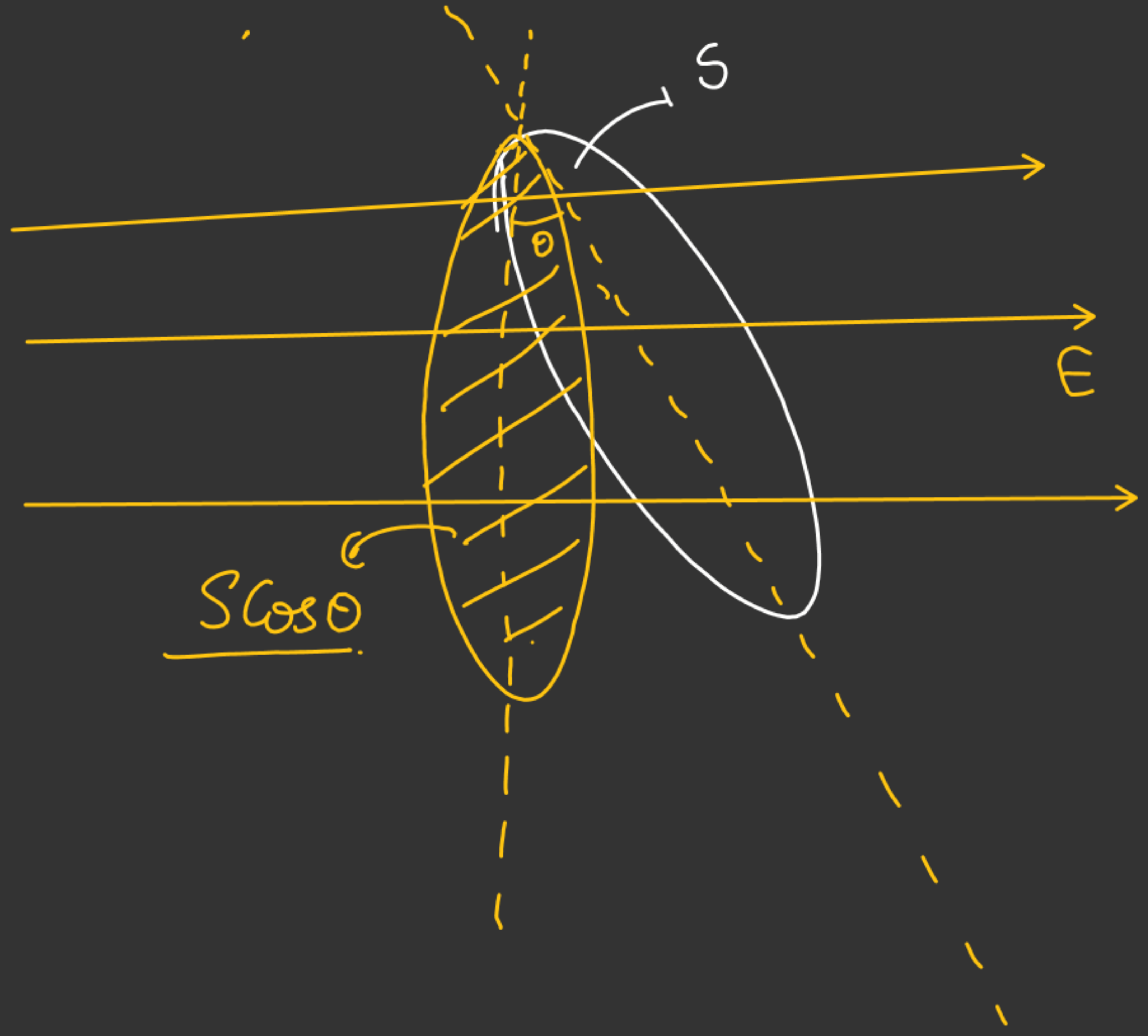
$$\phi_{min} = ES\cos 90^\circ = 0$$

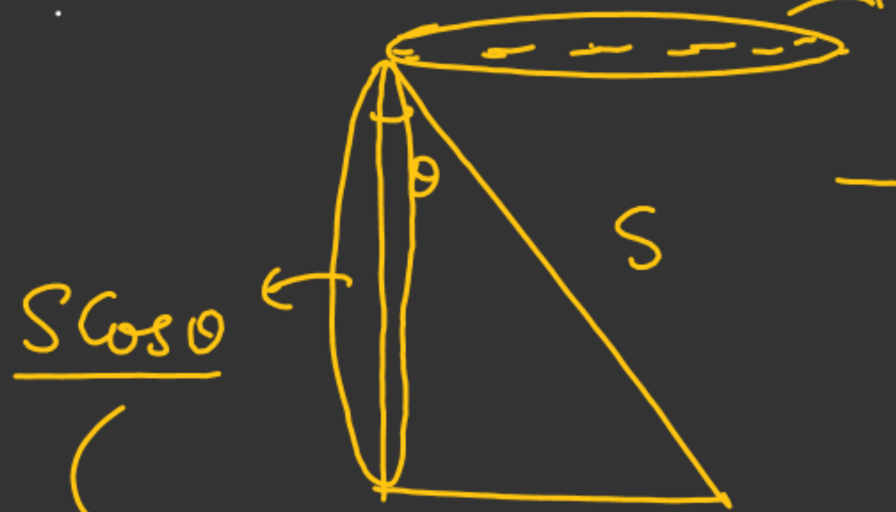


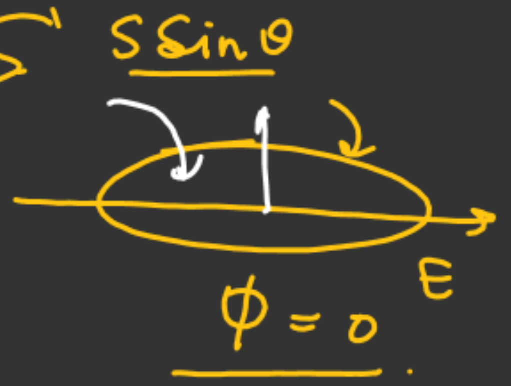
(*) For min flux plane of the Surface is parallel to Electric field

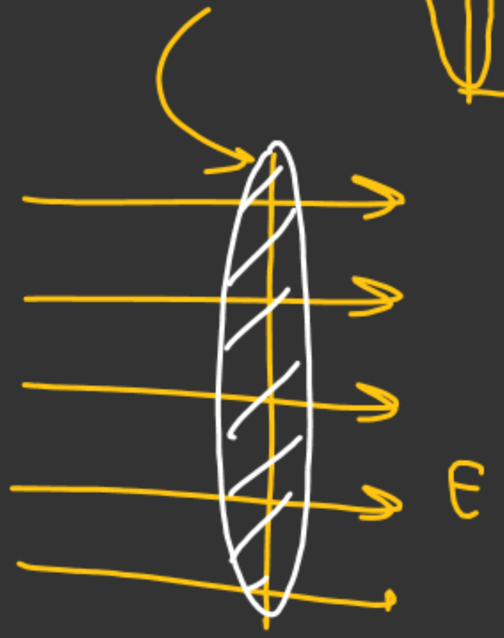
Nishant Jindal

$$\phi = E\,\underline{S\cos\theta} \qquad \vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$$









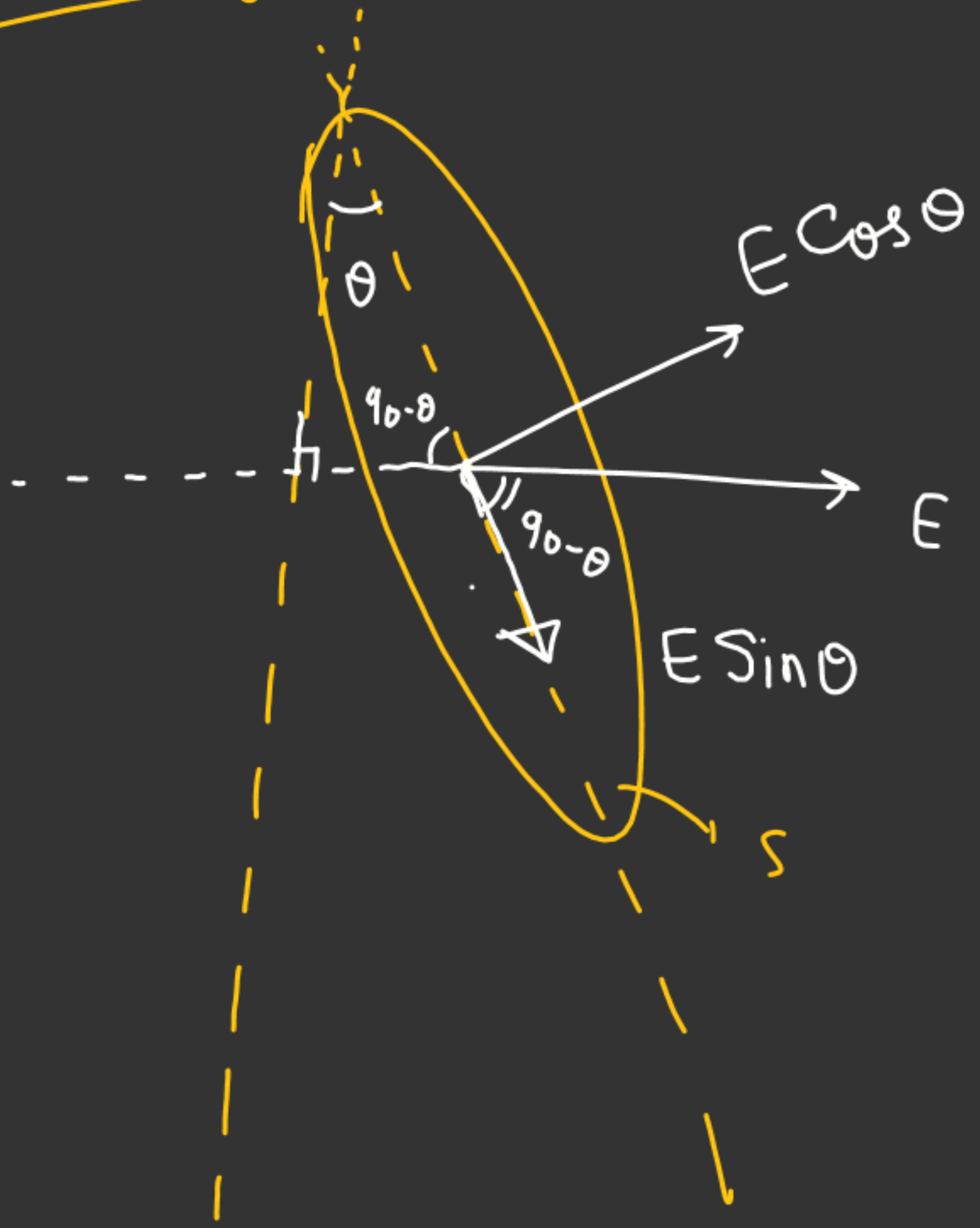
$$\phi = E\,\underline{S\cos\theta}$$

$\Downarrow$

Effective area which is perpendicular to Electric field lines.

Nishant Jindal

Another approach for calculating ϕ



$$\phi = E\cos\theta \times S$$

$E\cos\theta$ → Effective Component of Electric field perpendicular to area

Nishant Jindal

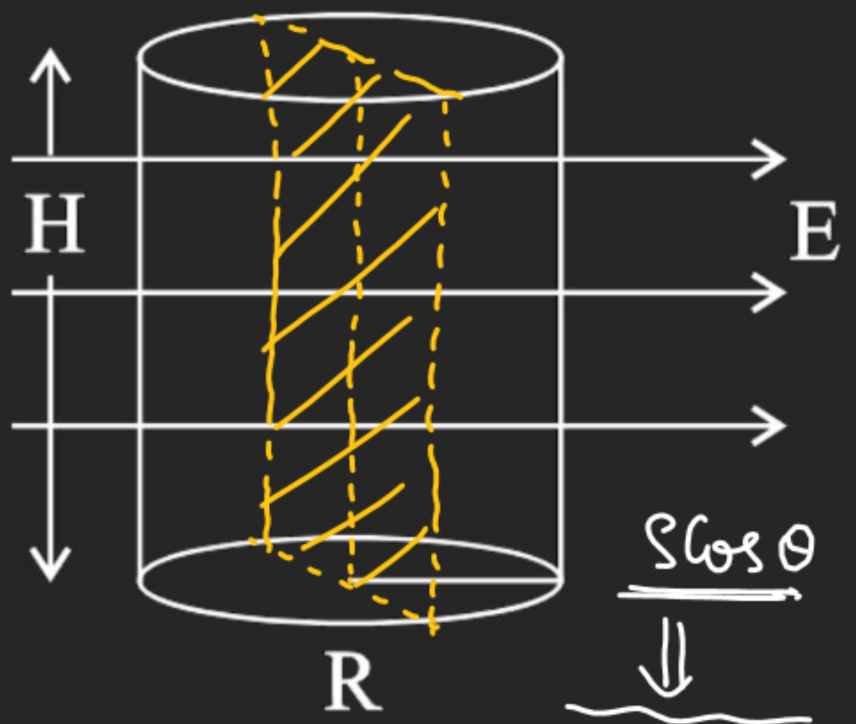
ELECTRIC FLUX

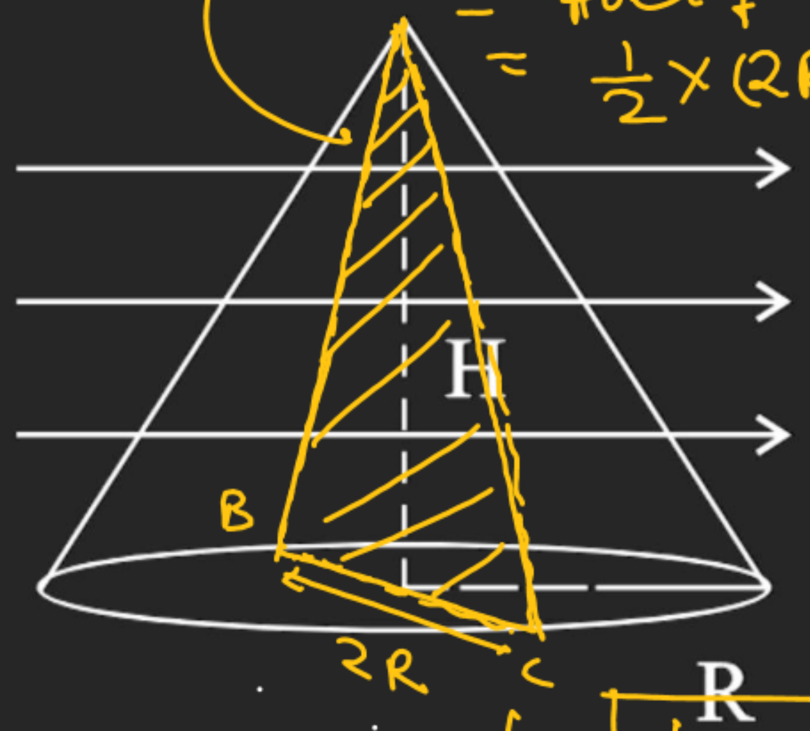
Concept of Effective area

Find flux

a) Total flux through half of the curved part of the cylinder and cone.

b) Total flux through the cylinder and cone.





projected area perpendicular to E

$= \text{Area of } \Delta ABC$

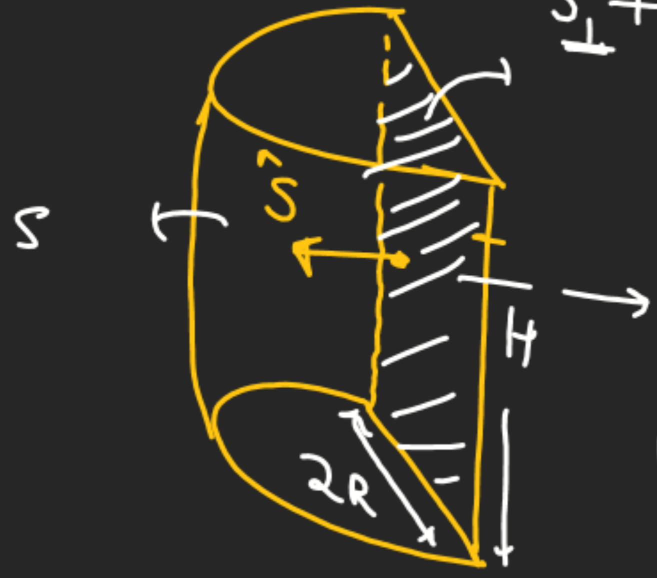
$= \frac{1}{2} \times (2R) H = RH$

$S\cos\theta$

$\Downarrow$

$S_\perp \text{ to } E = \text{Area of Rectangle}$

$= 2RH$

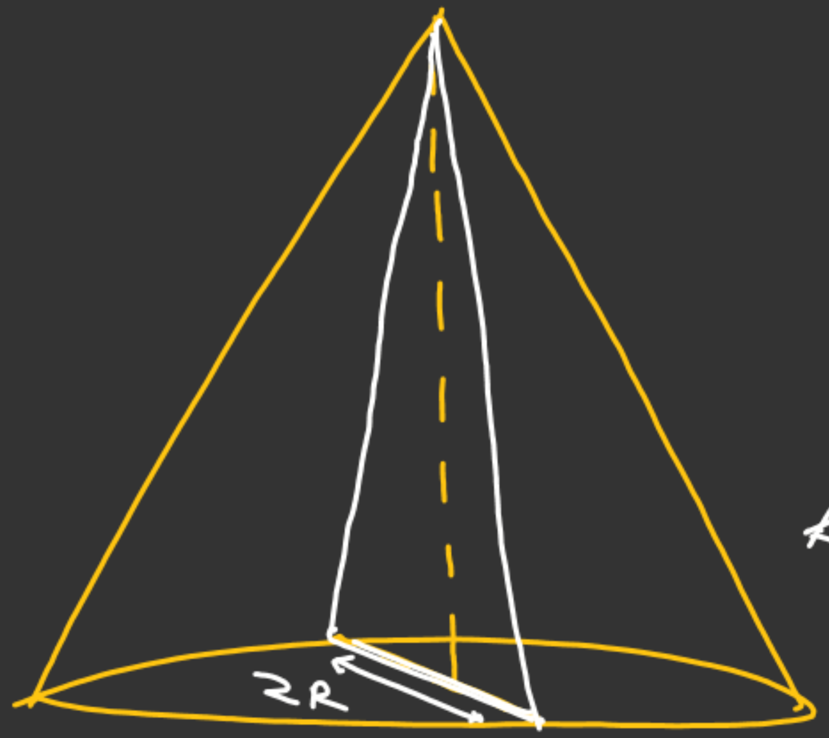


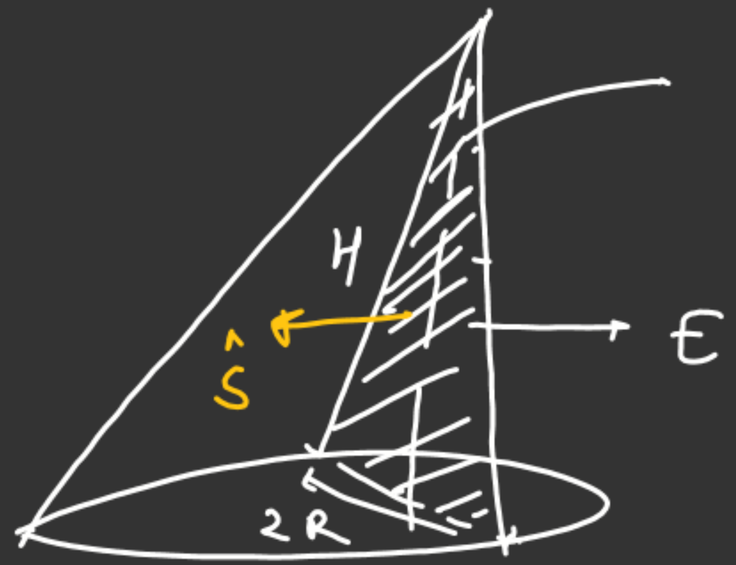
$\phi_{\text{half of curve part of cylinder}} = -E\,2RH$

Left of the curve part

$\phi_{\text{half of curve part of the cone}} = ERH$

$(\phi_T)_{\text{cone}} = 0$





Area $= \frac{1}{\cancel{2}} \times \cancel{2}R \times H$

$S\cos\theta$ = Effective area perpendicular to Electric field lines

$\phi_{\text{left half of Curve part}} = -E(\cancel{2}R \cdot H) \times \frac{1}{\cancel{2}} = -(ERH)$

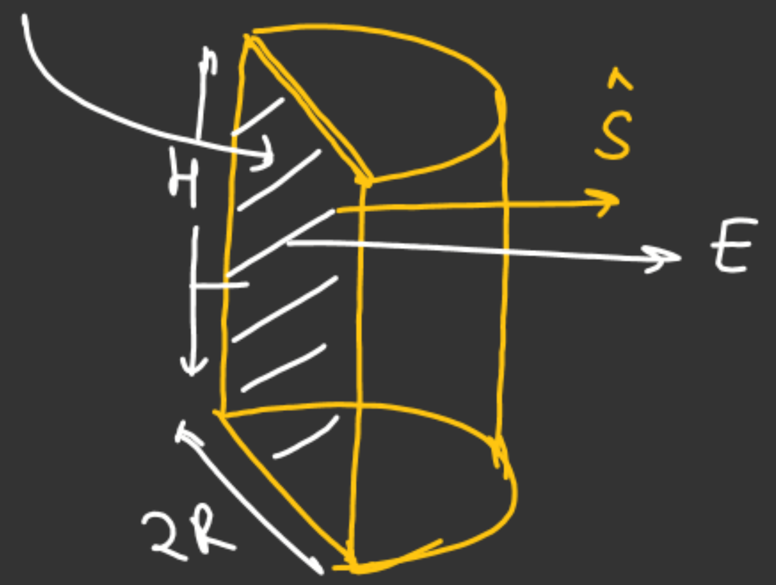
$\phi_{\text{Right half of Curve part}} = +(E\,2RH) \times \frac{1}{2} = +(ERH)$

$\boxed{\phi_T = 0}$

Frome the Cone.

Nishant Jindal

projected area of right half of cylinder is a rectangle.



$$\phi_T = (-E\,2RH) + (E \cdot 2RH)$$

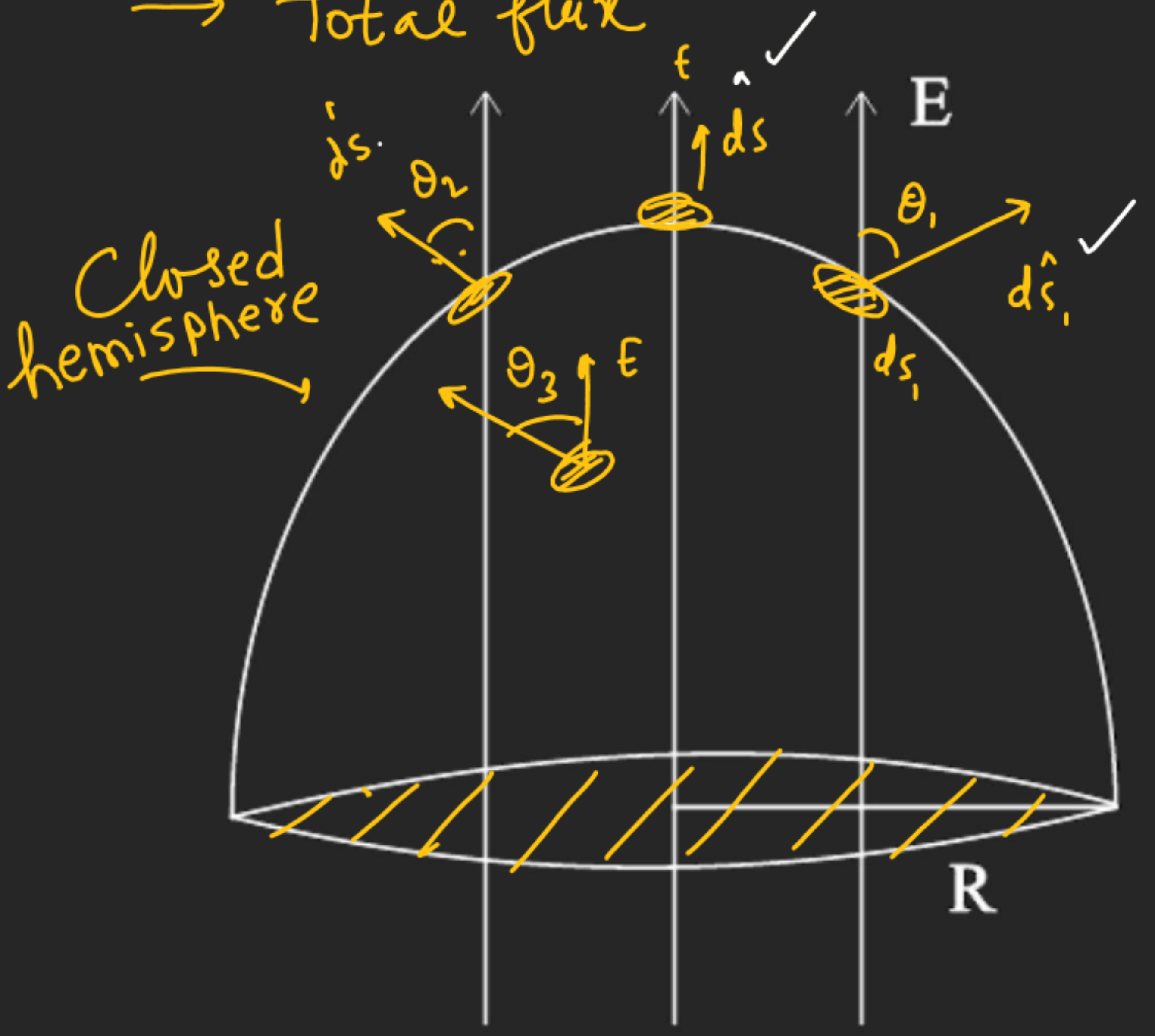
$$\boxed{(\phi_T)_{cylinder} = 0}$$

$$\phi_{\substack{\text{right half of} \\ \text{the curved part}}} = +E\,(2RH)$$

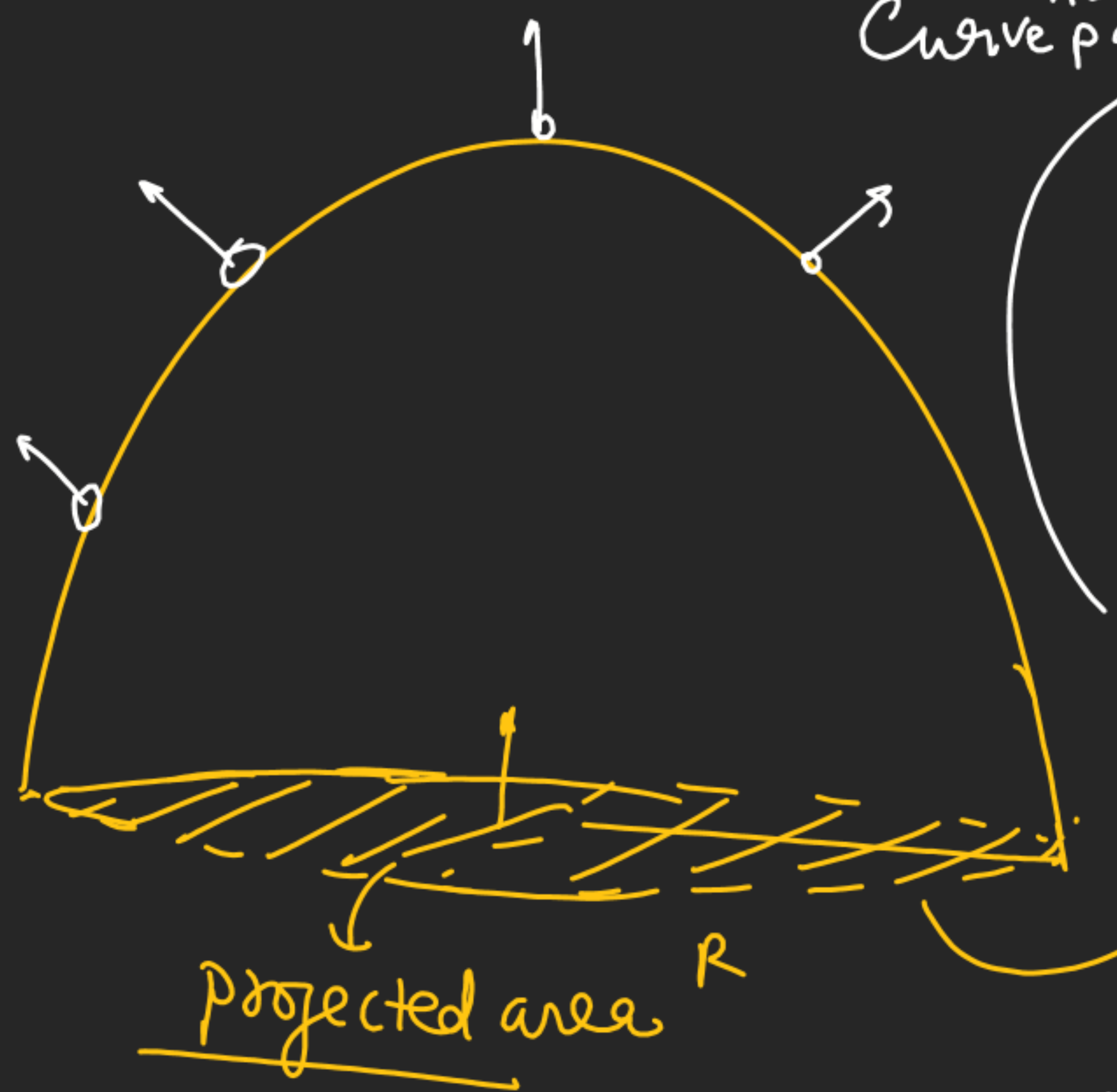
Nishant Jindal

ELECTRIC FLUX

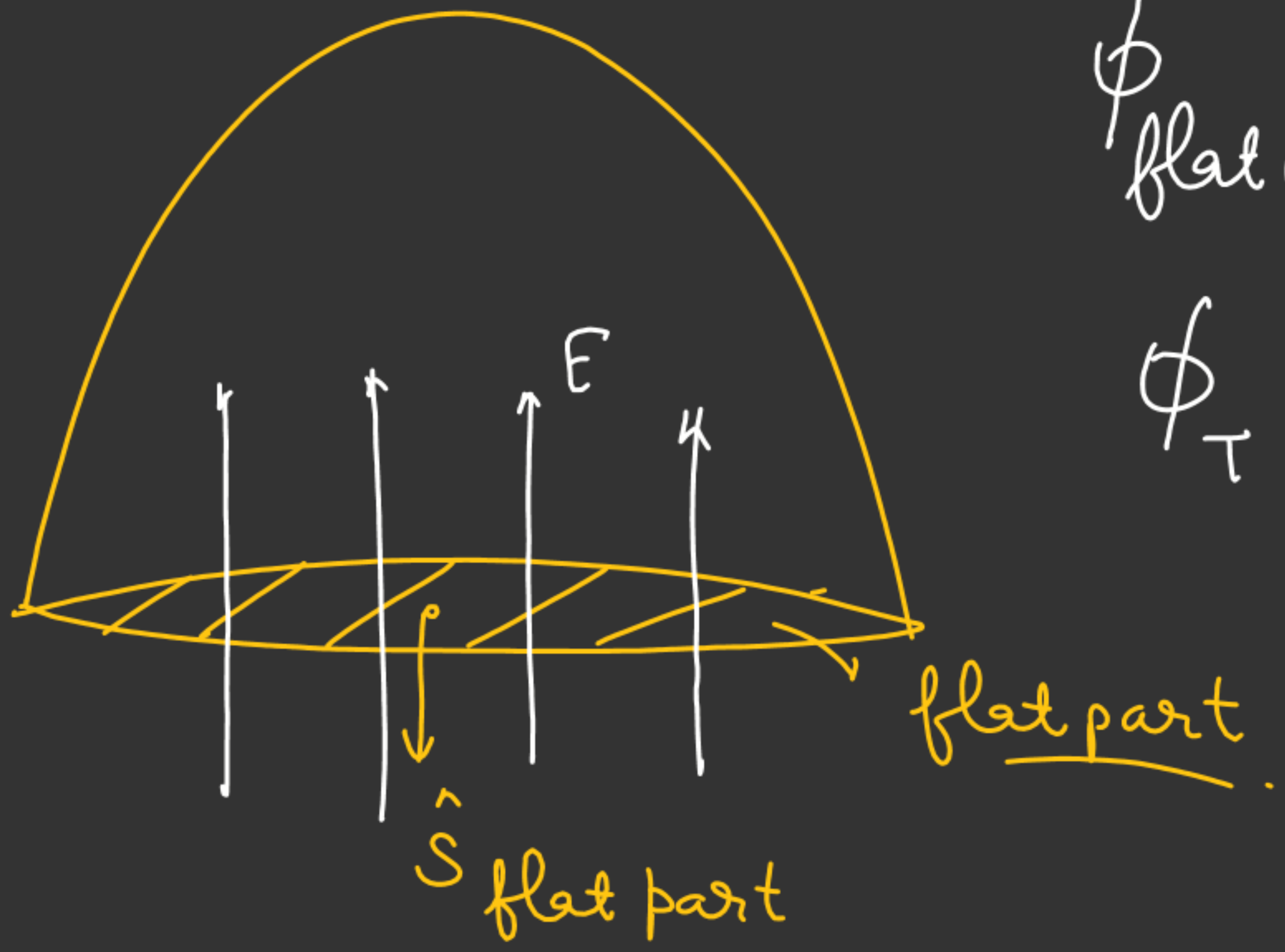
Find flux
→ Through the Curve part of the hemisphere.
→ Total flux



$$\phi_{\substack{\text{hemisphere}\\ \text{Curve part}}} = E\pi R^2 \cos 0 = +E\pi R^2$$



projected area of hemi Sphere



$$\phi_{\text{flat part}} = E\,\pi R^2 \cos \pi$$
$$= -E\pi R^2$$

$$\phi_T = \phi_{\text{flat part}} + \phi_{\text{curve part}}$$
$$= 0 \checkmark$$