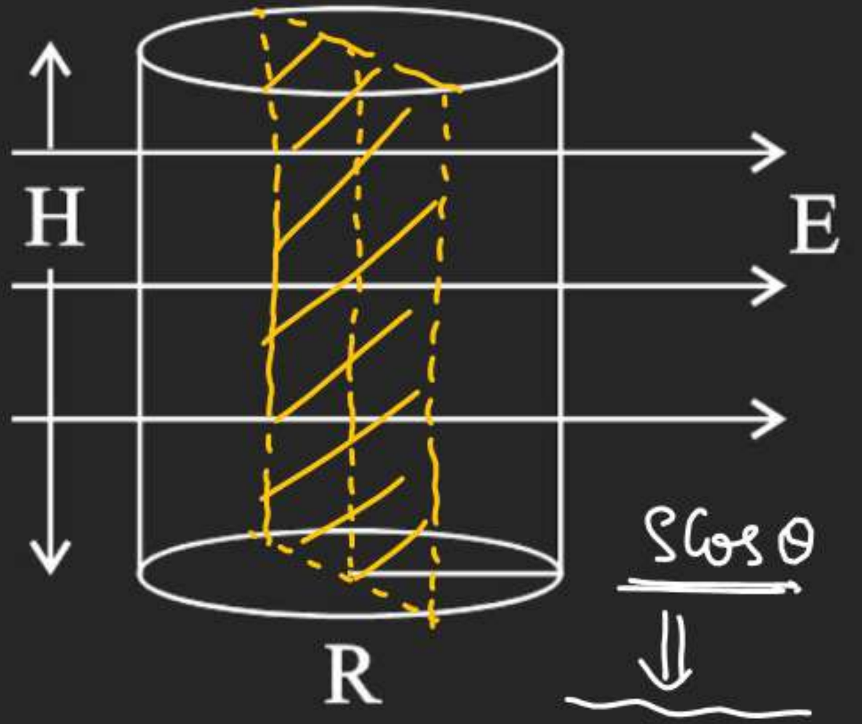
ELECTRIC FLUX

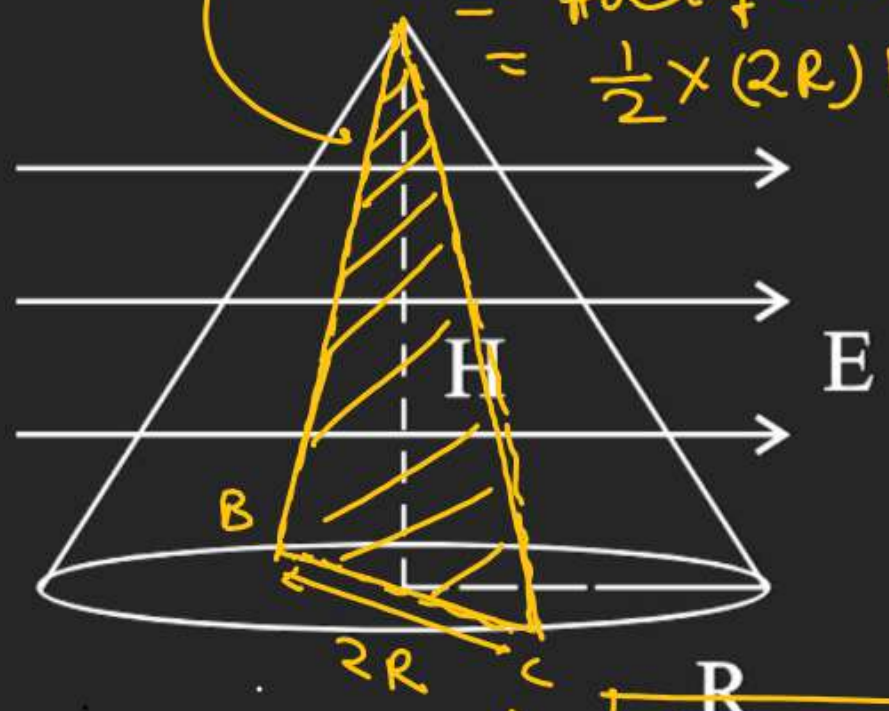
Concept of Effective area

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 = Area of △ABC

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

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

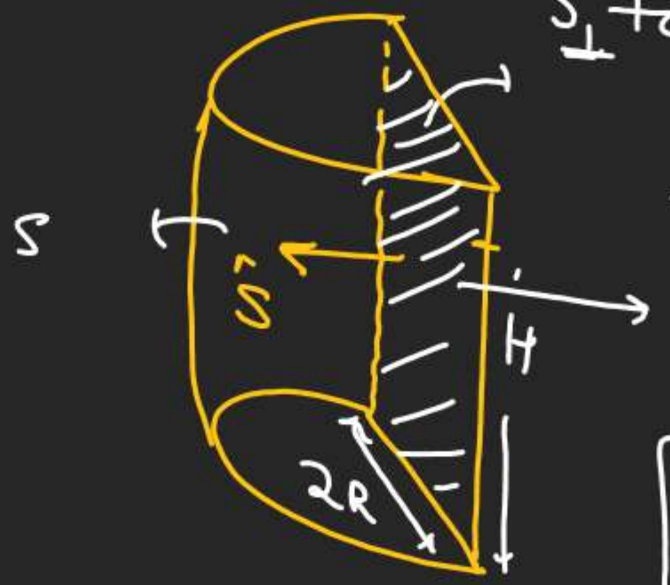
$(\phi_T)_{cone} = 0$

$S\cos\theta$

$\Downarrow$

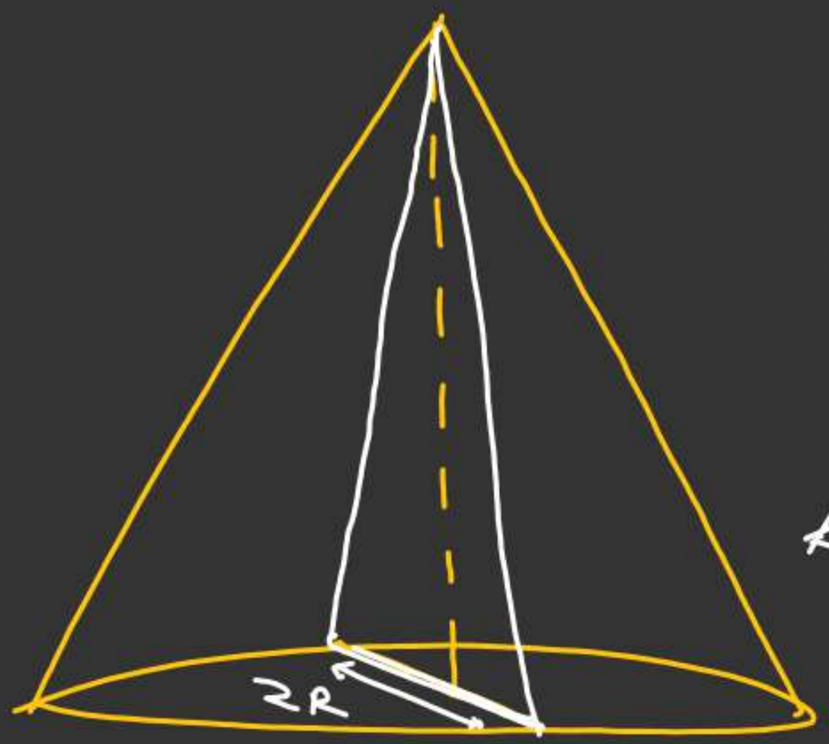
$S_\perp$ to E = Area of Rectangle

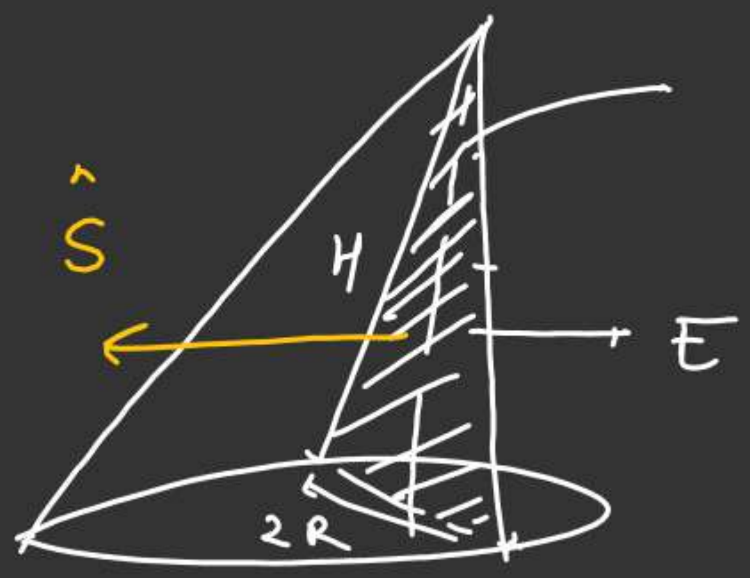
$= 2RH$



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

Left of the curve part





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

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

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

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

$\boxed{\phi_T = 0}$

From the Cone.

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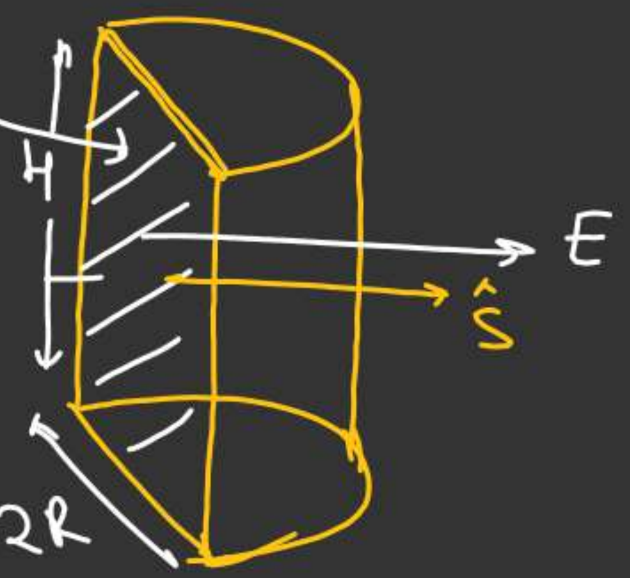
projected area of right half of Cylinder is a rectangle.



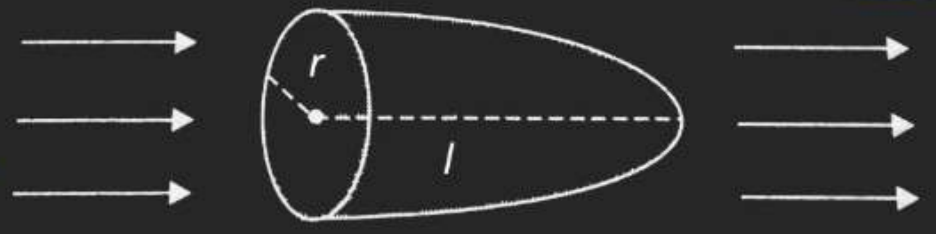
$$\phi_T = (-E\,2RH) + (E \cdot 2RH)$$

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

$$\phi_{\text{right half of the Curved part}} = (+)E\,(2RH)\cos 0$$

ELECTRIC FLUX

Q. Fig. shows a circular surface and a paraboloidal surface. It is placed in a uniform electric field of magnitude E such that the circular surface is oriented at right-angles to the direction of field. Electric flux through the paraboloidal surface is:



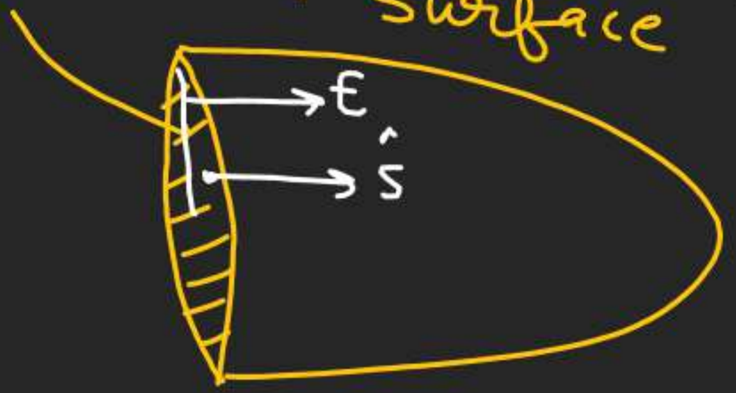
(A) zero

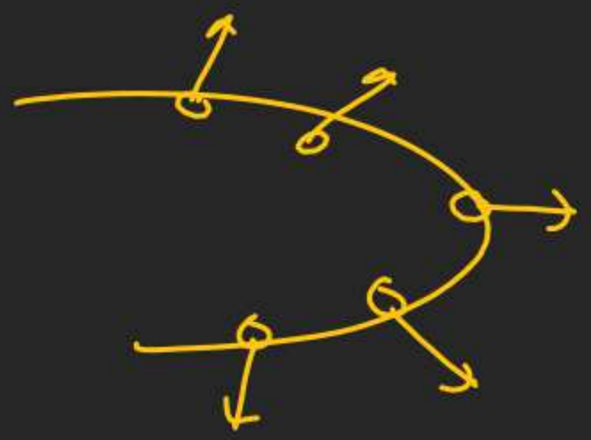
(B) $\pi r^2 l E$

(C) $\frac{1}{2}\pi r^2 E$

(D) $\pi r^2 E$ ✓

projected area of parabolidal surface





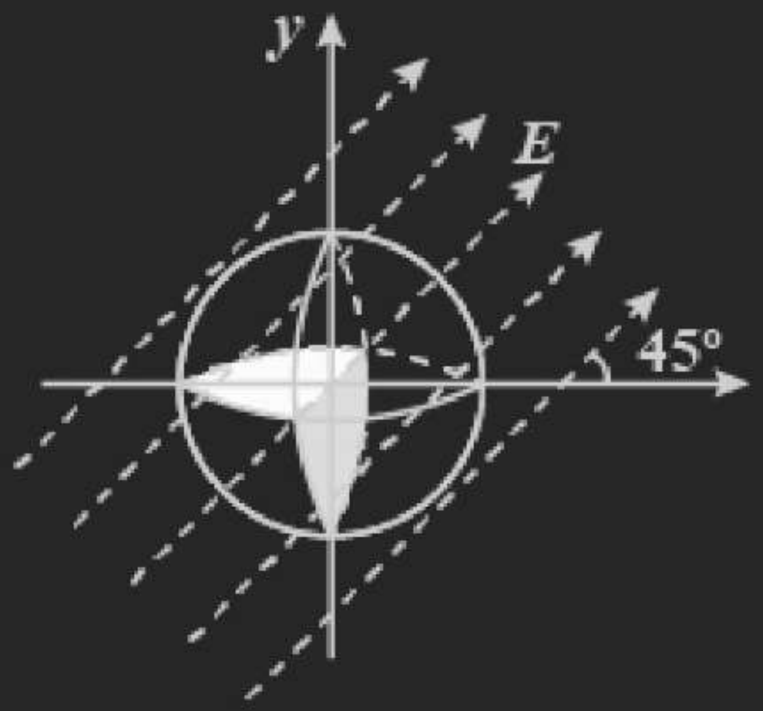
$\phi_{\text{parabolidal Shape}} = E\pi r^2 \cos 0$

$= \underline{E\pi r^2}$ ✓

ELECTRIC FLUX

H.W

Q. One - fourth of a sphere of radius R is removed as shown in Fig. An electric field E exists parallel to the xy plane. Find the flux through the remaining curved part.



(A) $\pi R^2 E$

(B) $\sqrt{2}\pi R^2 E$

(C) $\frac{\pi R^2 E}{\sqrt{2}}$

(D) none of these

ELECTRIC FLUX

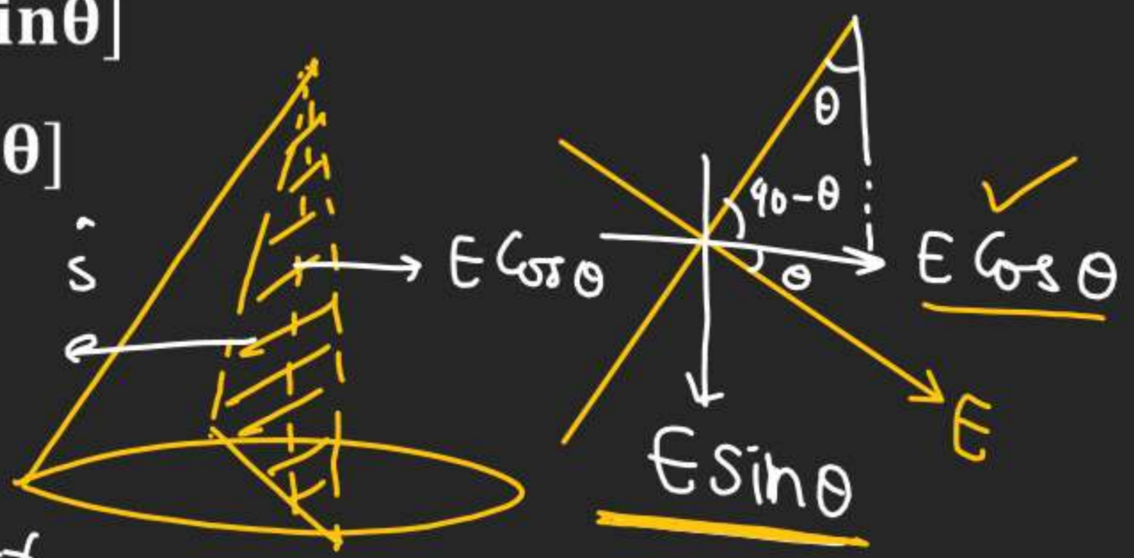
Q. A conic surface is placed in a uniform electric field E as shown in Fig. such that the field is perpendicular to the surface on the side AB. The base of the cone is of radius R, and the height of the cone is h. The angle of the cone is θ. Find the magnitude of the flux that enters the cone's curved surface from the left side. Do not count the outgoing flux $(\theta < 45^\circ)$.

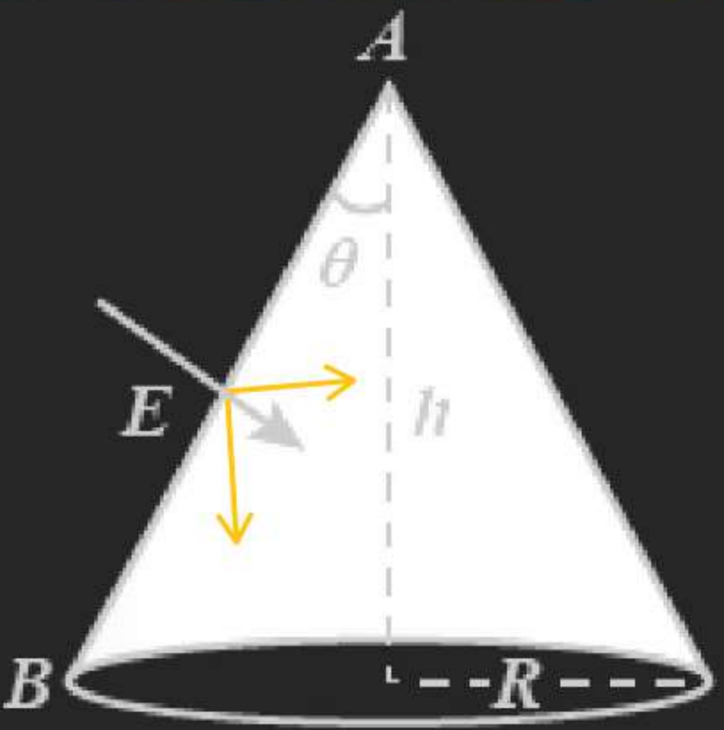
(A) $ER[h\cos\theta + \pi(R/2)\sin\theta]$

(B) $ER[h\sin\theta + \pi R/2\cos\theta]$

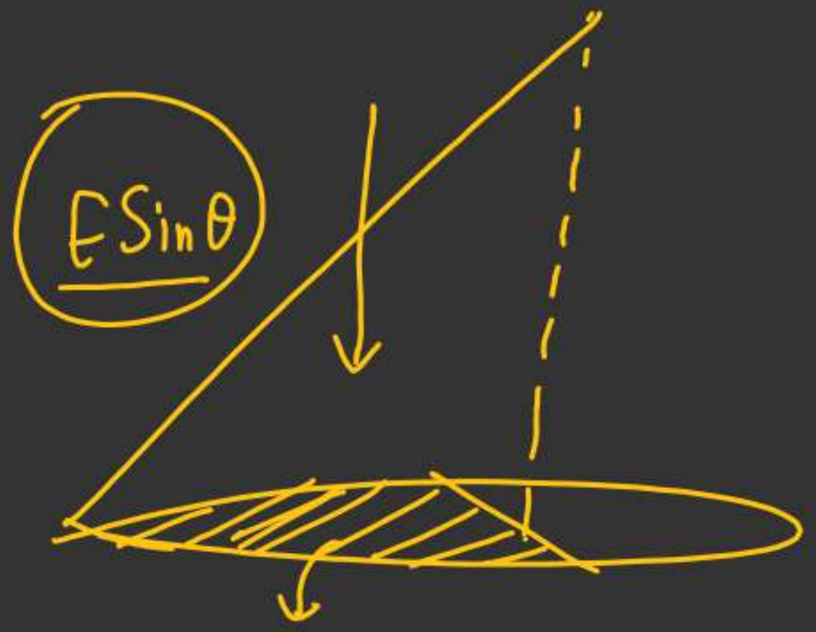
(C) $ER[h\cos\theta + \pi R\sin\theta]$

(D) none of these





$$\left|\phi_{E\cos\theta}\right| = (E\cos\theta)\frac{1}{2}\times 2R\times h = ERh\cos\theta$$



$$|\phi_T| = \phi_{E\cos\theta} + \phi_{E\sin\theta}$$
$$= ERh\cos\theta + E\sin\theta\left(\frac{\pi R^2}{2}\right)$$
$$= ER\left[h\cos\theta + \frac{\pi R\sin\theta}{2}\right]$$

projected area perpendicular to $E\sin\theta$ = Area of Semi Circle

$$= \frac{\pi R^2}{2}$$

$$|\phi_{E\sin\theta}| = \frac{E\sin\theta \times \pi R^2}{2} \checkmark$$

ELECTRIC FLUX

A cube of side a is placed such that the nearest face, which is parallel to the yz plane, is at a distance a from the origin. The electric field components are

$\boxed{E_x = \alpha x^{1/2}}$ $E_y = E_z = 0$

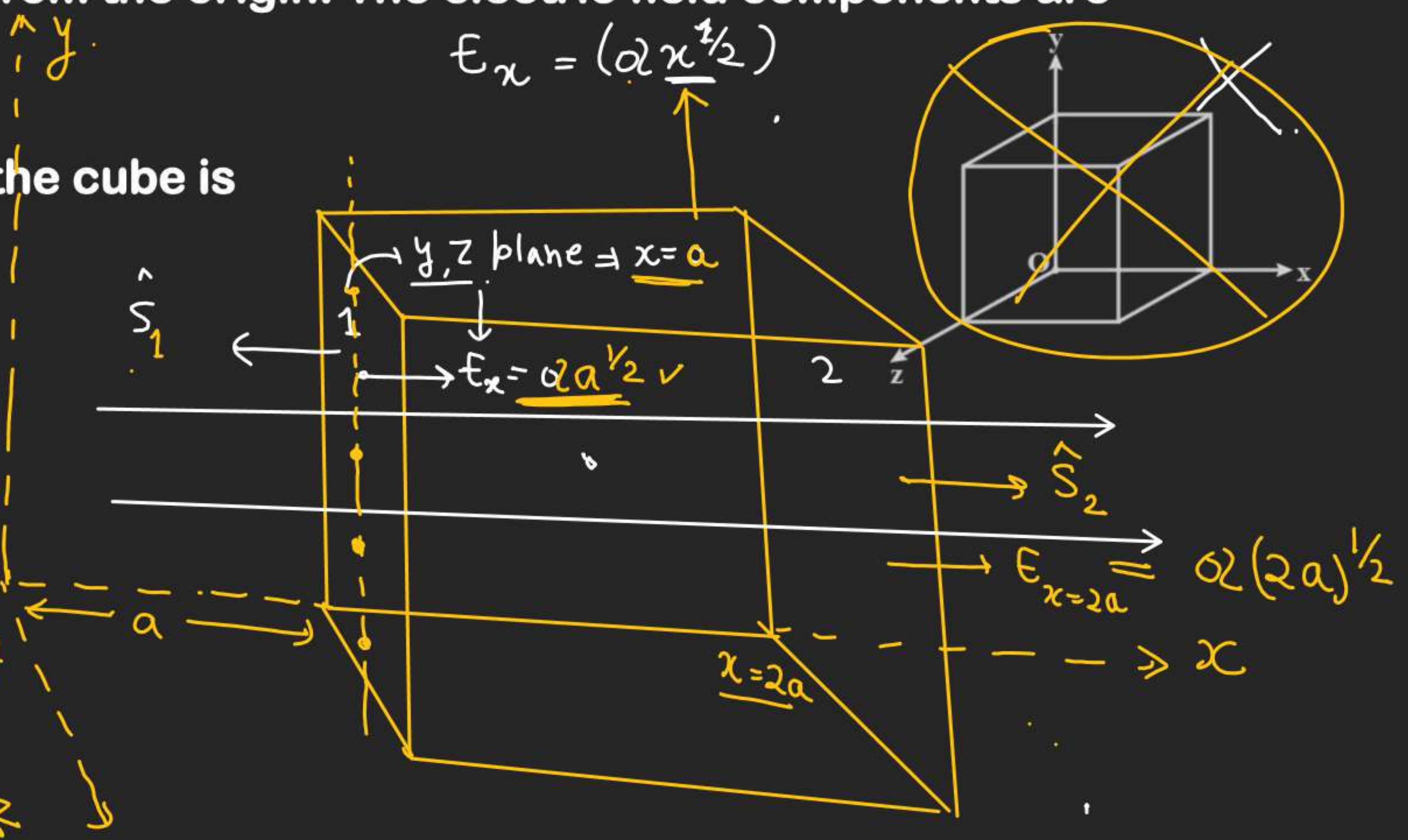
Q. The flux ϕ_E through the cube is

(A) $2\sqrt{2}\alpha a^{5/2}$

(B) $-\alpha a^{5/2}$

(C) $(\sqrt{2}-1)\alpha a^{5/2}$

(D) zero



$$\phi_{net} = [\alpha a^{1/2}(\sqrt{2}-1)]a^2$$
$$= \alpha a^{5/2}(\sqrt{2}-1)$$

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ELECTRIC FLUX

(Unit vector along x-axis) ($\hat{x} \to \hat{i}$)

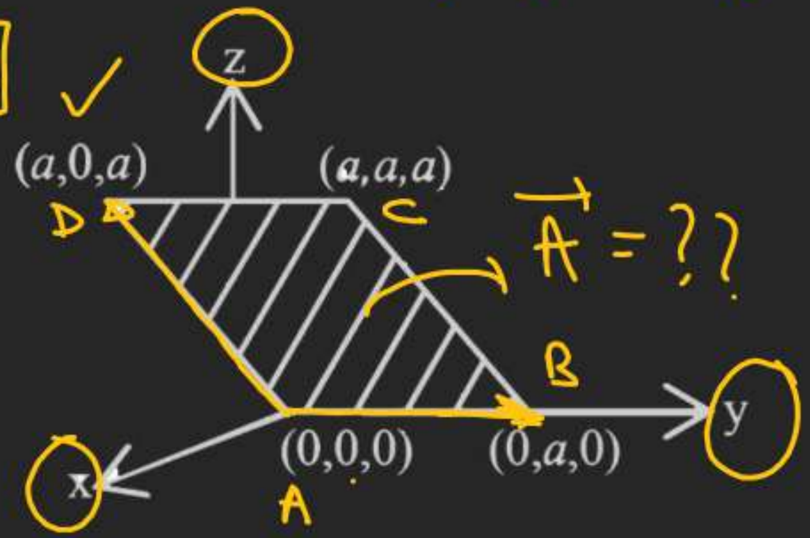
Q. Consider an electric field $\vec{E} = E_0\hat{x}$, where E_0 is a constant. The flux through the shaded area (as shown in the figure) due to this field is

Cross product

[IIT-JEE-2011 (Paper-1)]

$|\vec{A} \times \vec{B}| = $ [Area of parallelogram]

($\vec{A}$ and $\vec{B}$ adjacent sides)



(A) $2E_0a^2$

(B) $\sqrt{2}E_0a^2$

(C) E_0a^2

(D) $\frac{E_0a^2}{\sqrt{2}}$

$\vec{AB} = a\hat{j}$

$\vec{AD} = a\hat{i} + a\hat{k}$

$(\vec{AB} \times \vec{AD}) = a\hat{j} \times (a\hat{i} + a\hat{k})$

$\vec{A} = a^2(-\hat{k}) + a^2\hat{i}$

$\vec{E} = (E_0\hat{i})$

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

$= E_0\hat{i} \cdot (a^2(-\hat{k}) + a^2\hat{i})$

$= \boxed{E_0a^2}$ Ans

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ELECTRIC FLUX

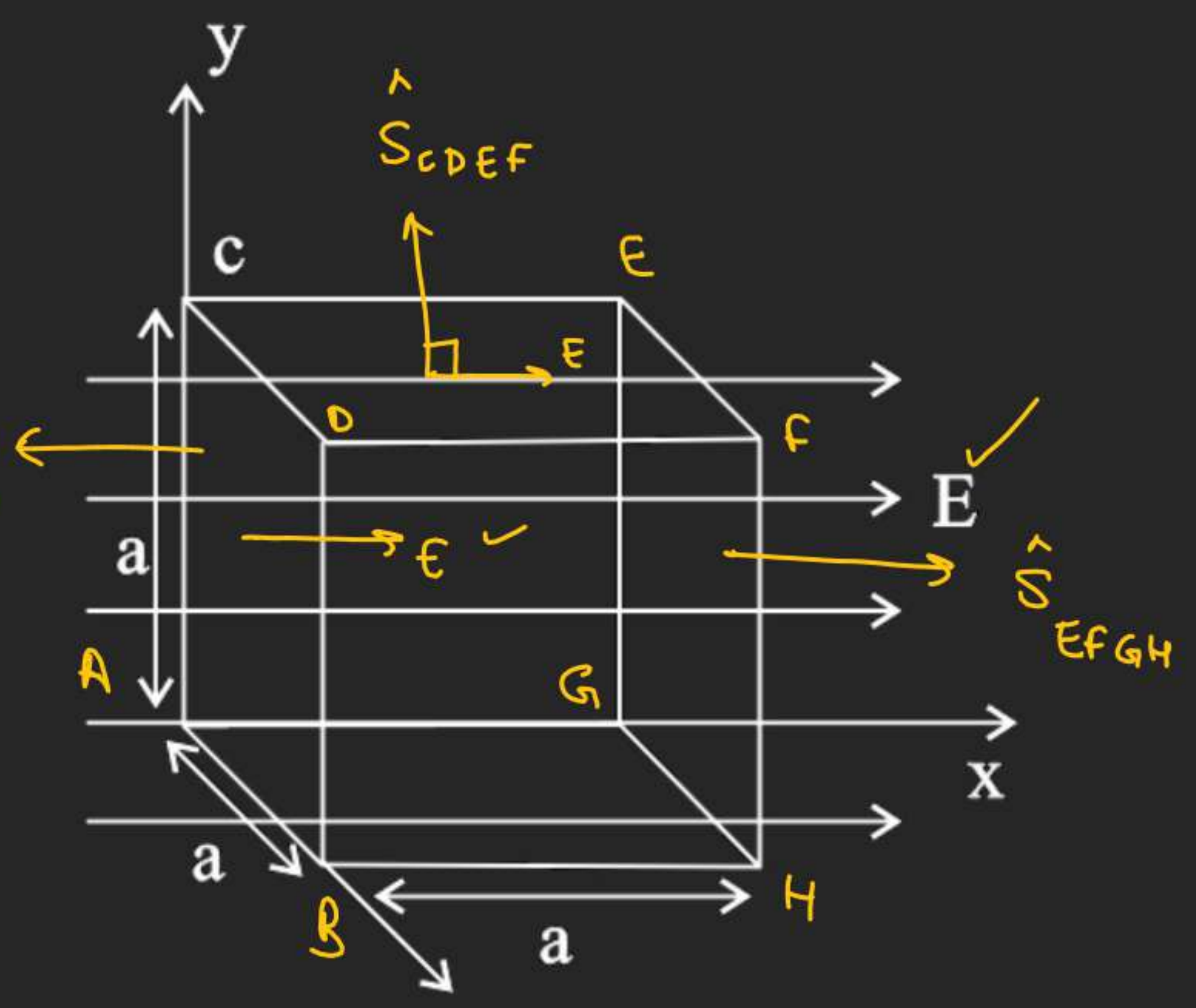
Find ϕ_{cube} = ??

$$\phi_{cube} = \phi_{ABCD} + \phi_{EFGH}$$

$$= Ea^2 \cos\pi + Ea^2 \cos 0$$

$$= -Ea^2 + Ea^2$$

$$\boxed{\phi_{net} = 0}$$



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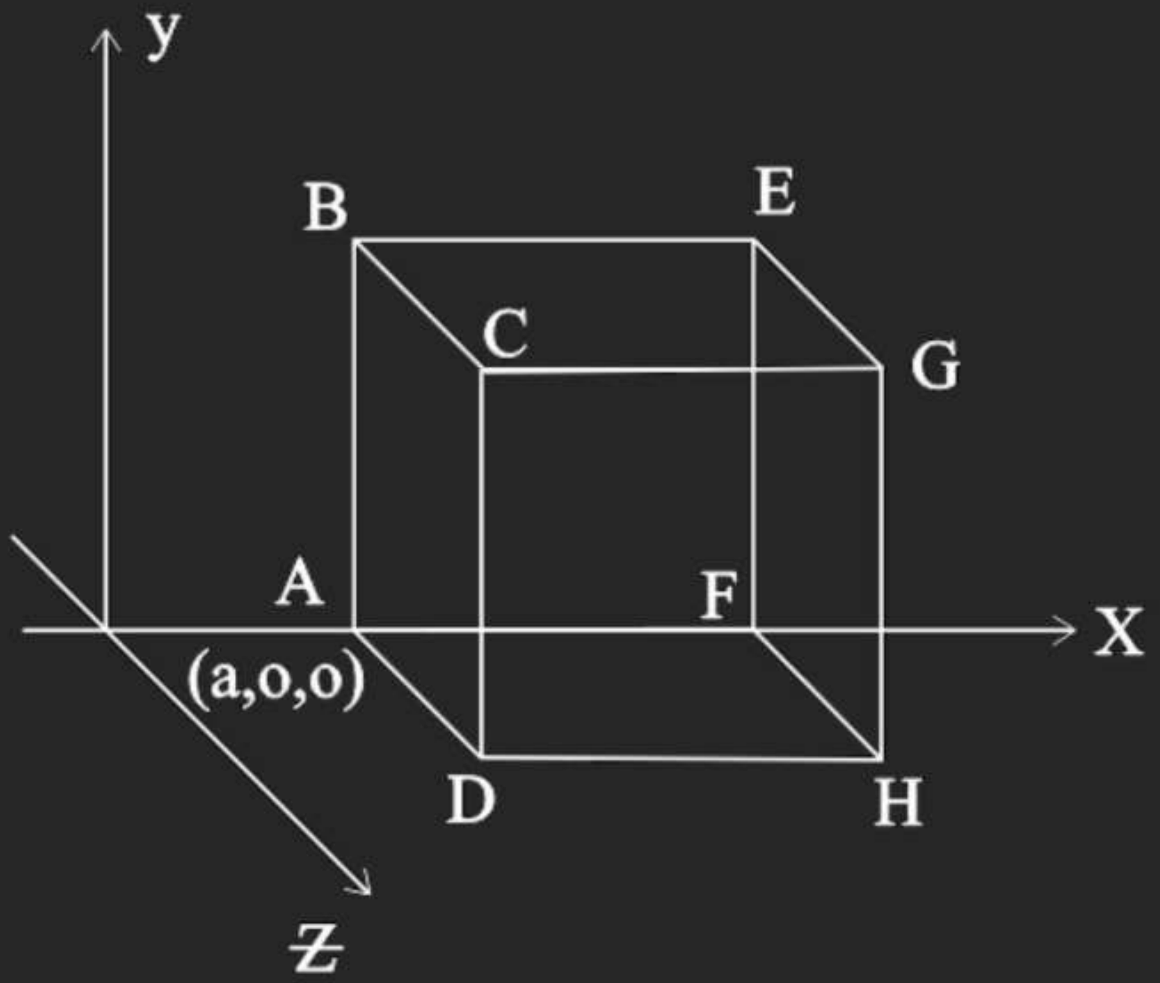
H.W :

$\vec{E} = E_0 x^2 \hat{i}$

Find net flux through the Cube of side a.

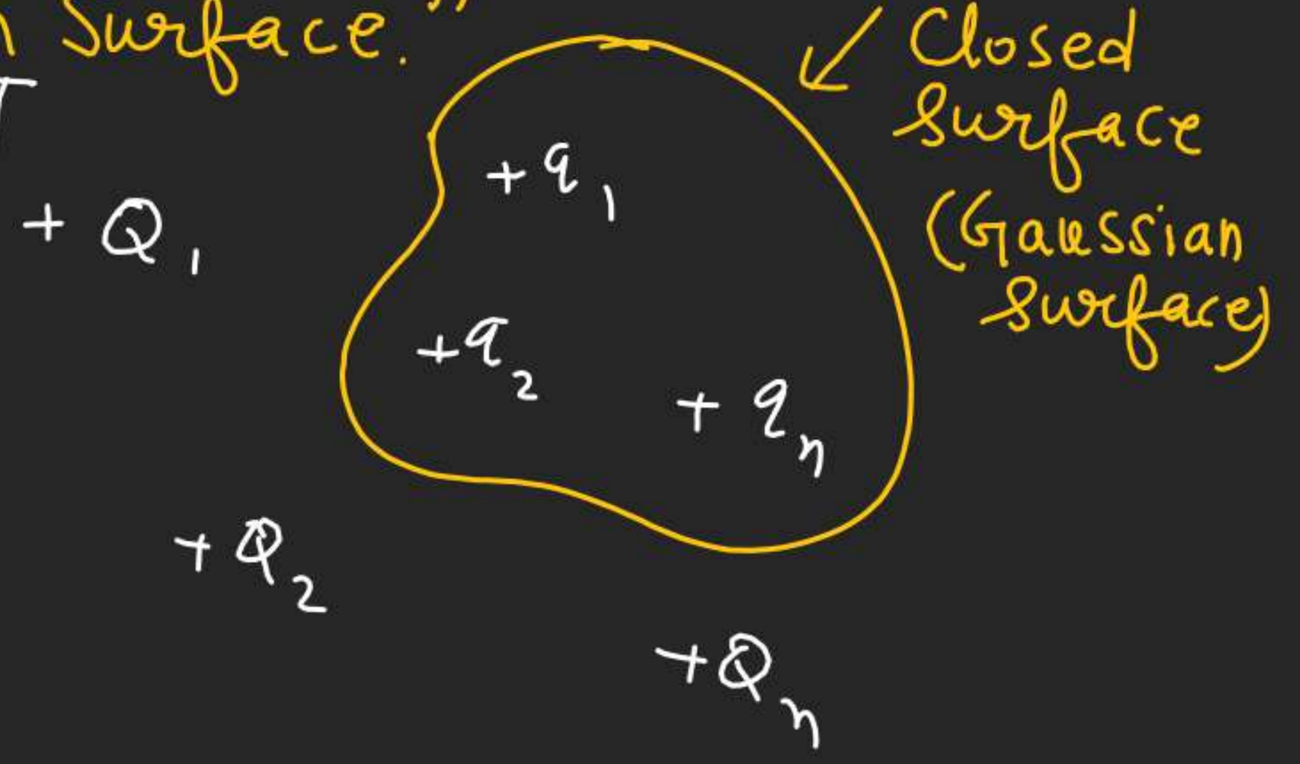


GAUSS'S LAW

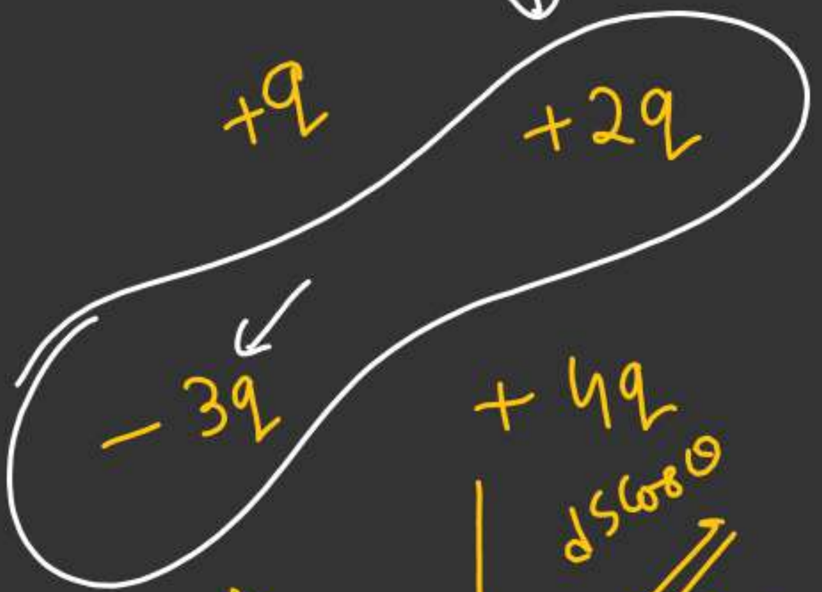
Statement :-

↳ "The net flux passing through any Close Surface (Gaussian Surface) is equal to $\frac{1}{\varepsilon_0}$ times total Charge enclosed within the Gaussian Surface."

$$\boxed{(\phi_T)_{\text{Closed Surface}} = \frac{1}{\varepsilon_0}(q_1 + q_2 \dots + q_n)}$$

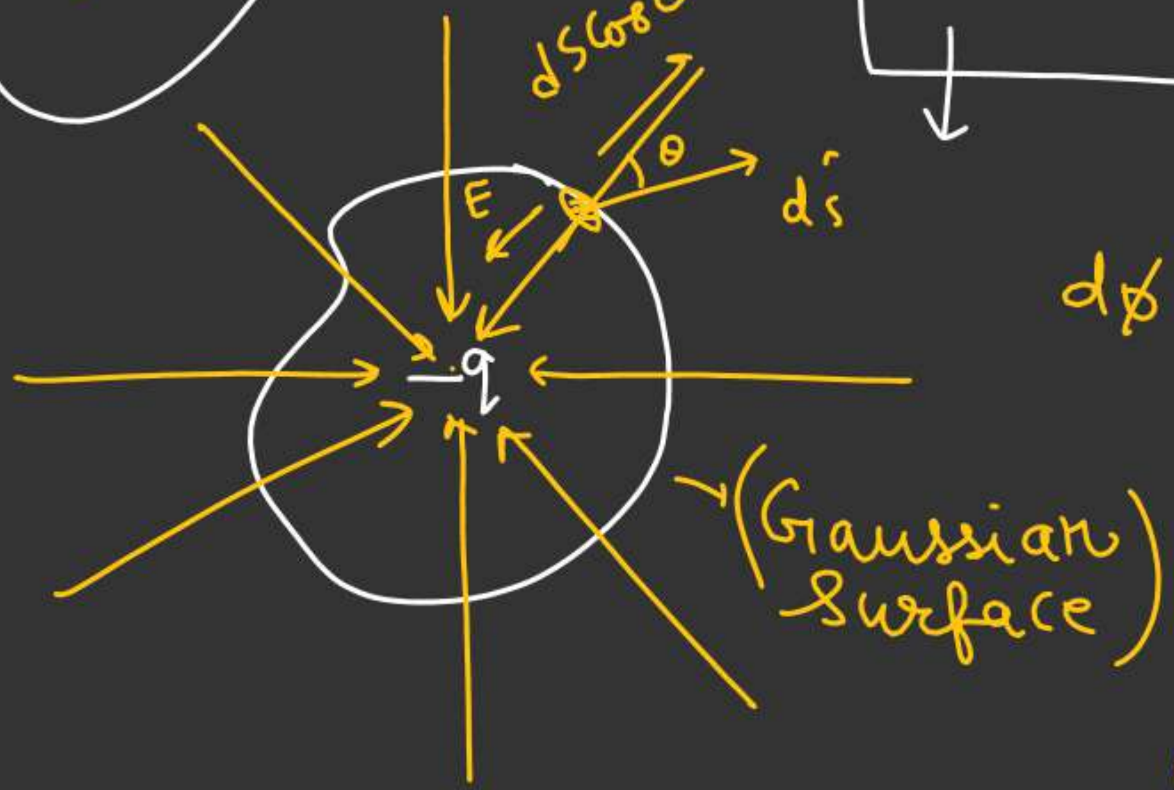


Gaussian Surface



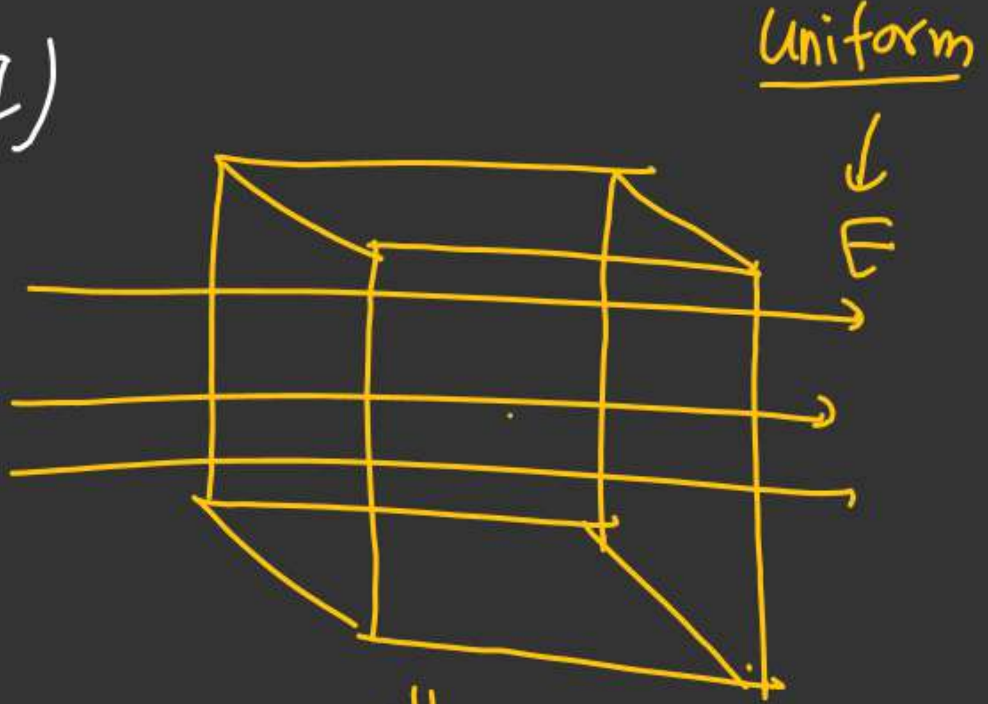
$$\phi_T = \frac{1}{\varepsilon_0}(2q - 3q)$$

$$\boxed{\phi_T = \frac{-q}{\varepsilon_0}}$$



$$d\phi = (E\,ds\cos\theta)\cos\pi$$

$$= -E\,ds\cos\theta$$



$$\phi_T = 0$$

$$\frac{q_{enc}}{\varepsilon_0} = 0 \Rightarrow \boxed{q_{enc} = 0}$$

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According to Gauss's Law

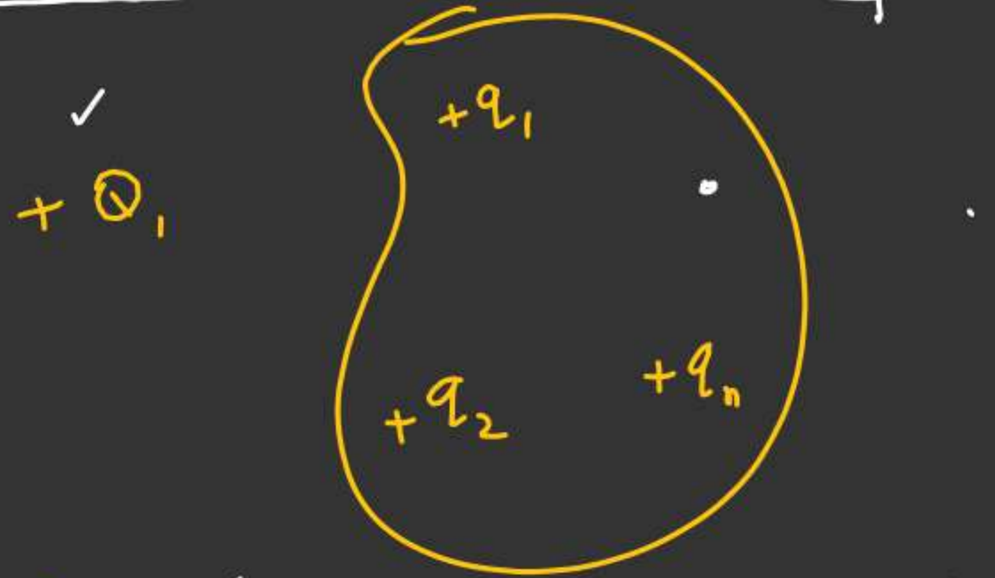
$$\phi_{net} = \frac{(q_{enc})}{\varepsilon_0}$$

$$\Downarrow$$

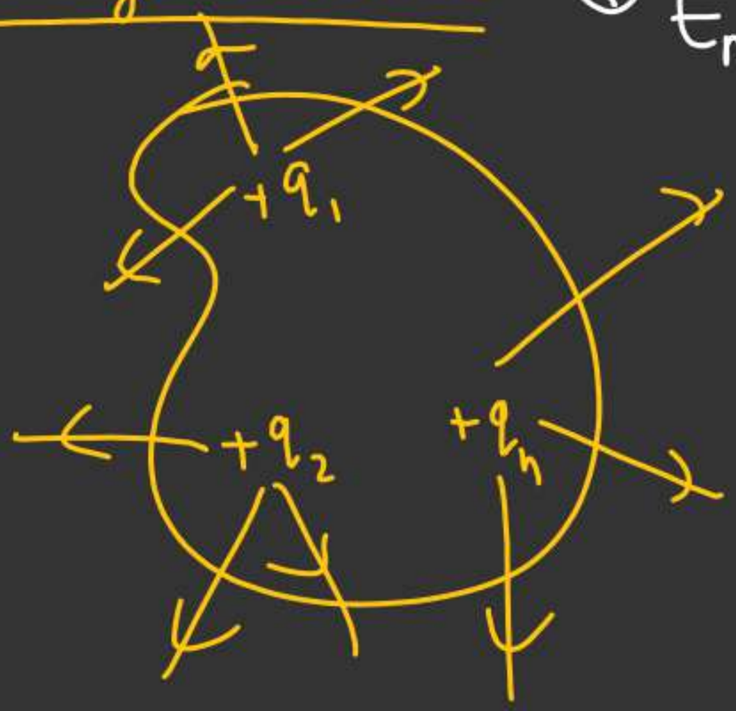
$$\boxed{\oint \vec{E} \cdot d\vec{s} = \left(\frac{q_{enc}}{\varepsilon_0}\right)}$$

$\vec{E}_{net}$

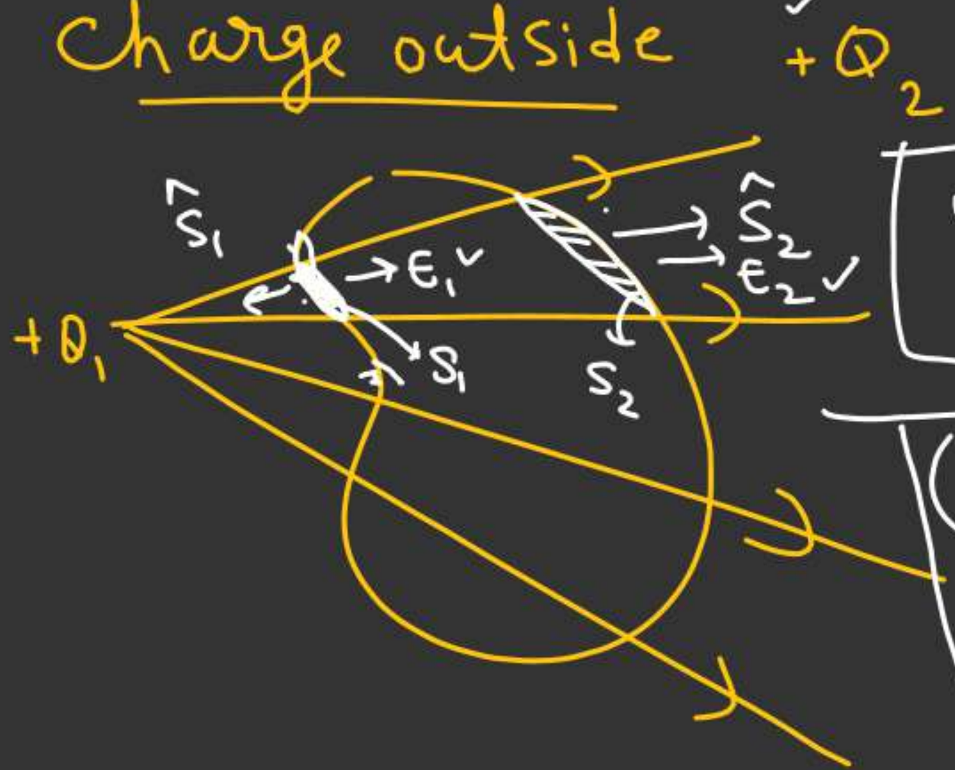
$$\boxed{\vec{E}_{net} = \left(\vec{E}_{Inside} + \vec{E}_{outside}\right)}$$



Charge Inside



Charge outside



$$\boxed{\phi_{s_2} = -\phi_{s_1}}$$ (due to Solid angle)

$$\Downarrow$$

$$\boxed{(\phi_T)_{\text{outside charge}} = 0}$$

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GAUSS'S LAW

Some Important points about Gauss's Law:-

→ Applicable only for the closed Surface. ✓

→ It fundamentally gives Electric flux not the electric field intensity

→ If relates the total flux linked with a closed surface to the charge enclosed by the closed surface. If a closed surface doesn't enclose any Charge then

$$\boxed{\oint \vec{E} \cdot d\vec{S} = 0}$$

$\Rightarrow q_{enc} = 0$