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GAUSS'S LAW

Some Important points about Gauss's Law:-

→ Applicable only for the closed Surface.

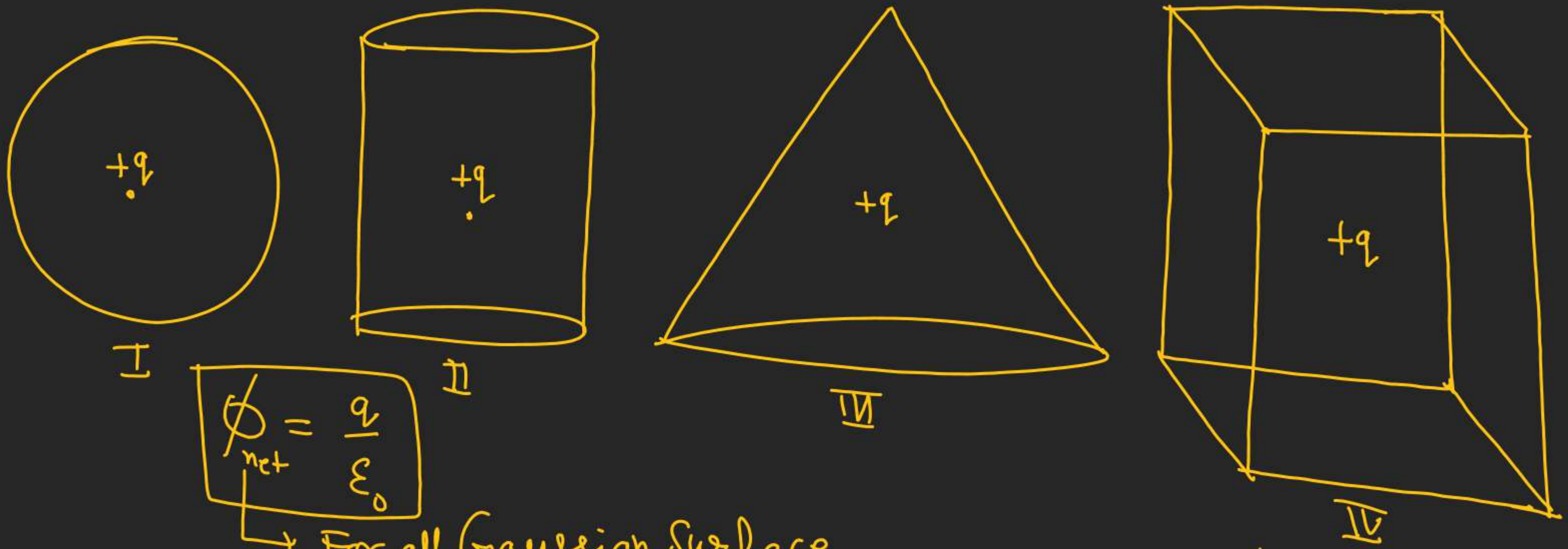
→ It fundamentally gives Electric flux not the electric field intensity

→ 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

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

GAUSS'S LAW

Q. Total flux linked with a closed surface is indpendent of the shape and size of the body and position of charge inside it.



$$\boxed{\phi_{net} = \frac{q}{\varepsilon_0}}$$

→ For all Gaussian Surface.

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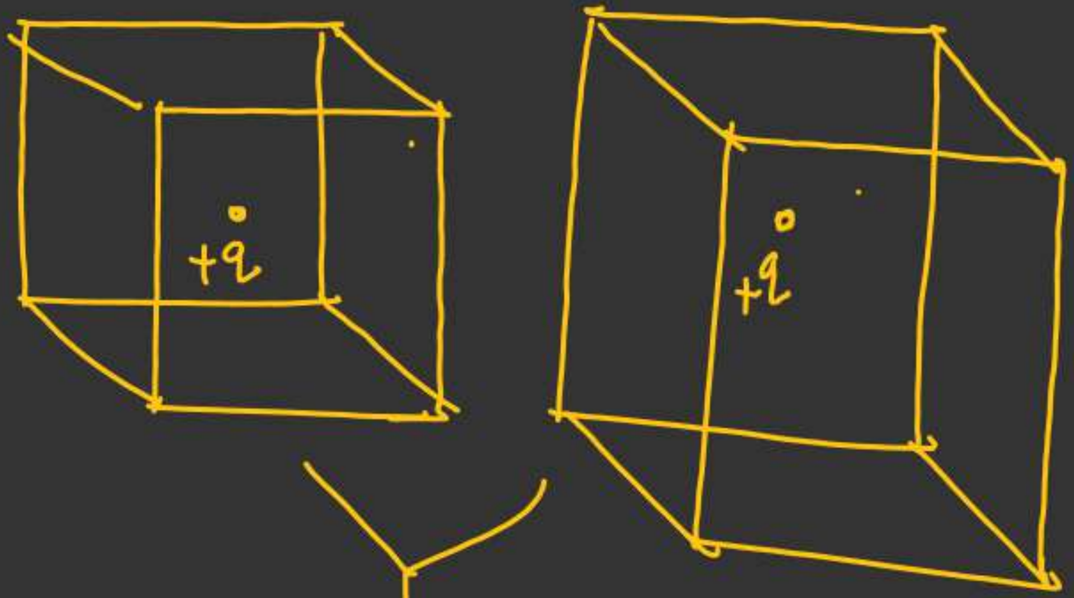
Flux independent of the Location of Charge inside Gaussian surface.

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



$$(\phi_T) = \frac{q}{\varepsilon_0}$$

Total flux through whole cube

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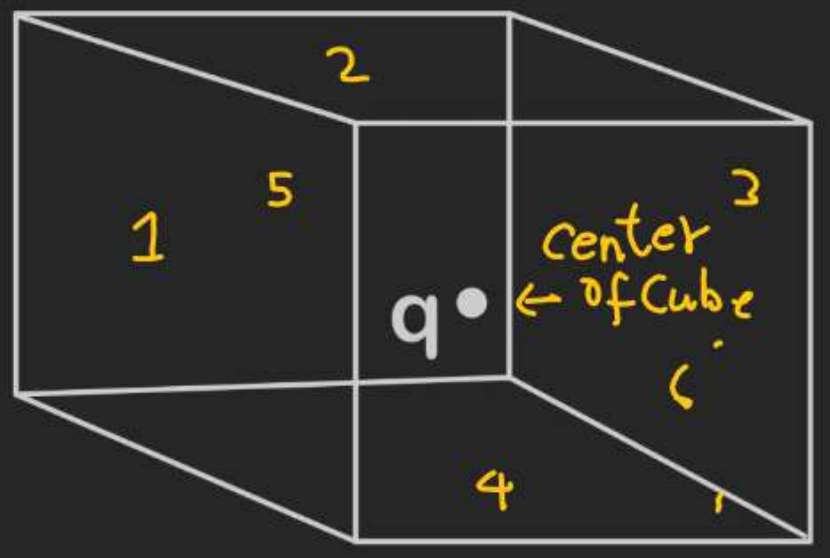
GAUSS'S LAW

Q. If a symmetrical closed body has n-identical faces with point charge at its center. flux linked with each face will be $\frac{1}{n}(\phi_T)$.

$$(\phi_T)_{cube} = \frac{q}{\varepsilon_0}$$

$$(\phi)_{\substack{each \\ face}} = \frac{\left(\frac{q}{\varepsilon_0}\right)}{6}$$

$$\boxed{(\phi)_{\substack{each \\ face}} = \frac{q}{6\varepsilon_0}}$$



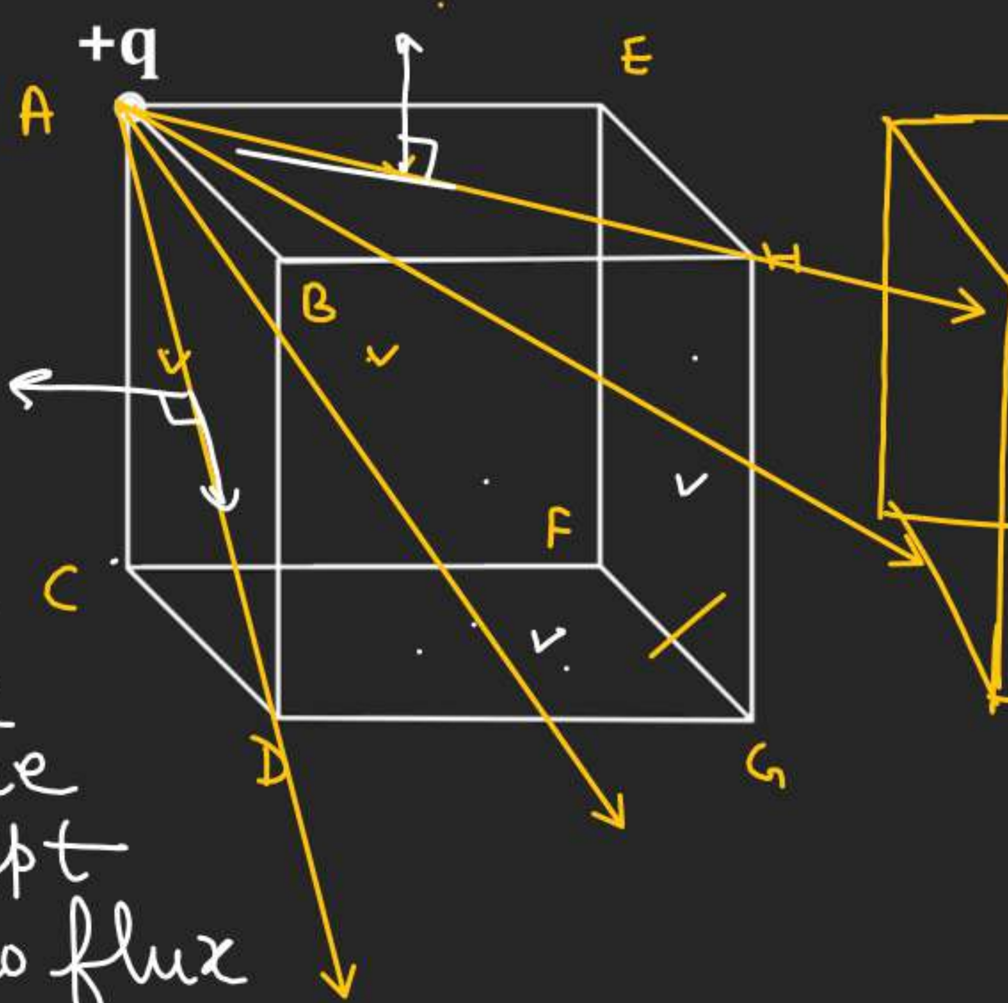
GAUSS'S LAW

At the Corner of the Cube

Flux through each face??

$$\phi_{\text{each face}} = \frac{q}{8\varepsilon_0} \times \frac{1}{3}$$

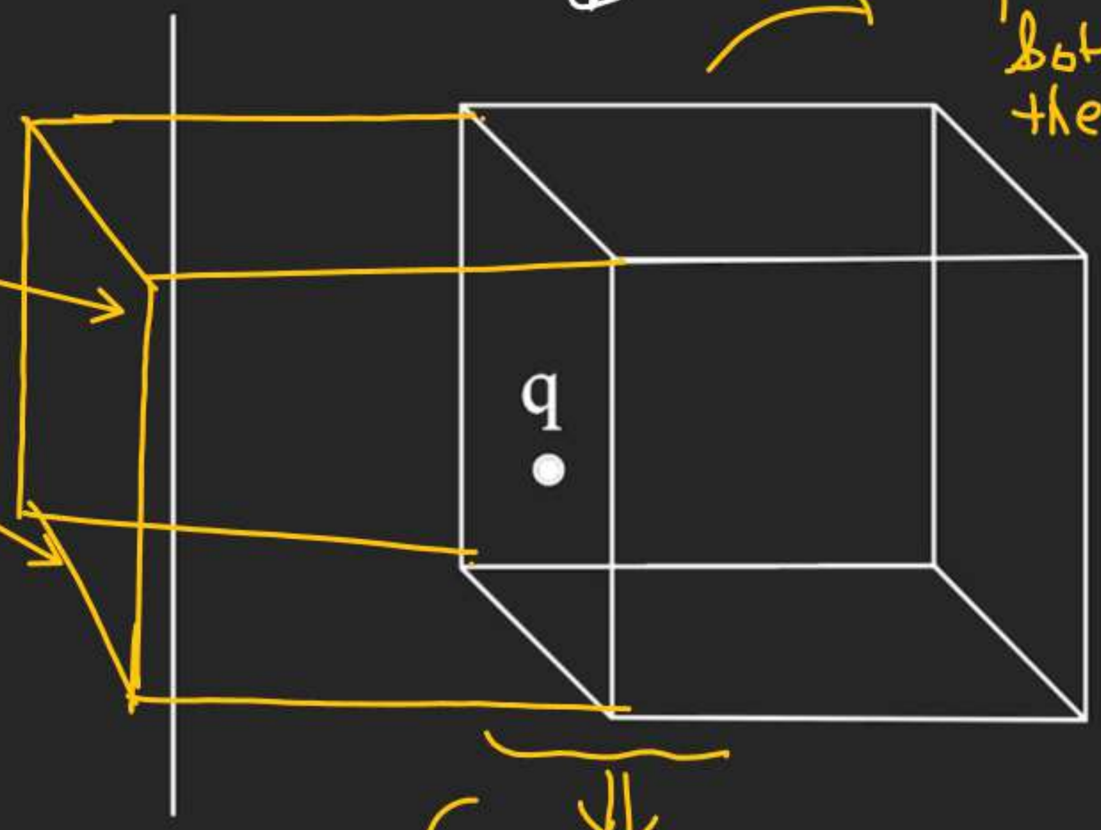
$$\phi_{\text{each face}} = \frac{q}{24\varepsilon_0}$$



Note

(*) Faces contributing towards the corner where charge is kept have zero flux as $\hat{S} \perp E$

Flux through the Cube



$$\phi_{\text{both the cube}} = \frac{q}{\varepsilon_0}$$

$$\phi_{\text{each cube}} = \frac{1}{2} \times \frac{q}{\varepsilon_0} = \frac{q}{2\varepsilon_0}$$

Gaussian Surface

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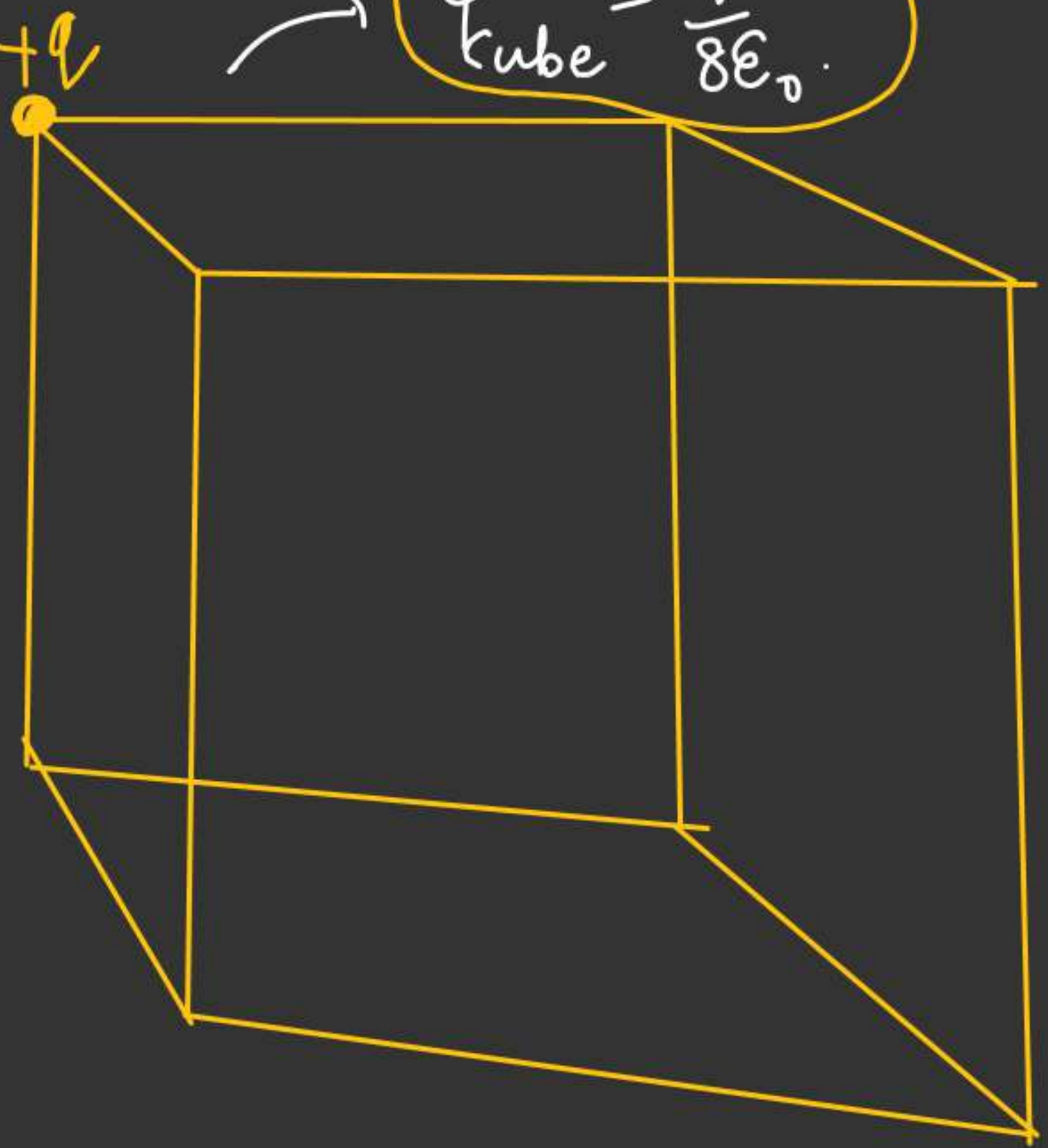
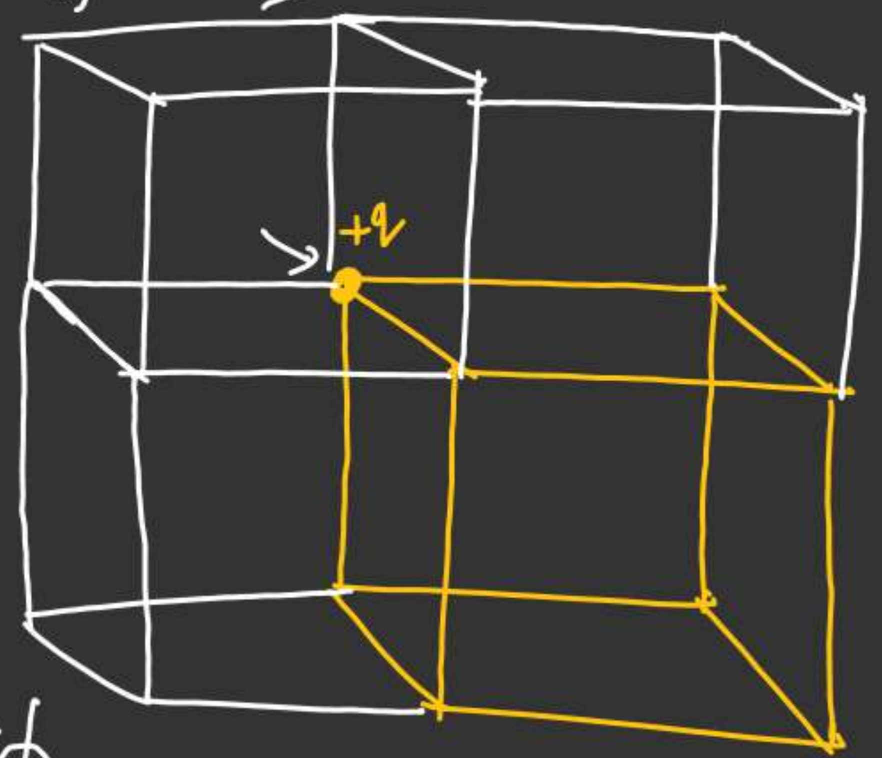
#



$$\phi_{cube} = \frac{q}{8\varepsilon_0}.$$

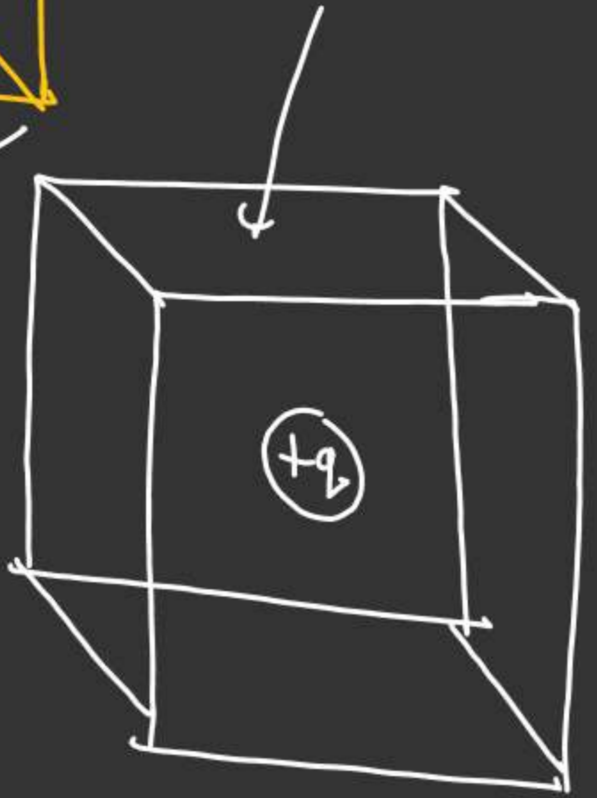
4 → back sides



$$\phi_{eight\ cubes} = \left(\frac{q}{\varepsilon_0}\right)$$

All the Eight Cubes are identically located w.r.t q.

8 → Cubes



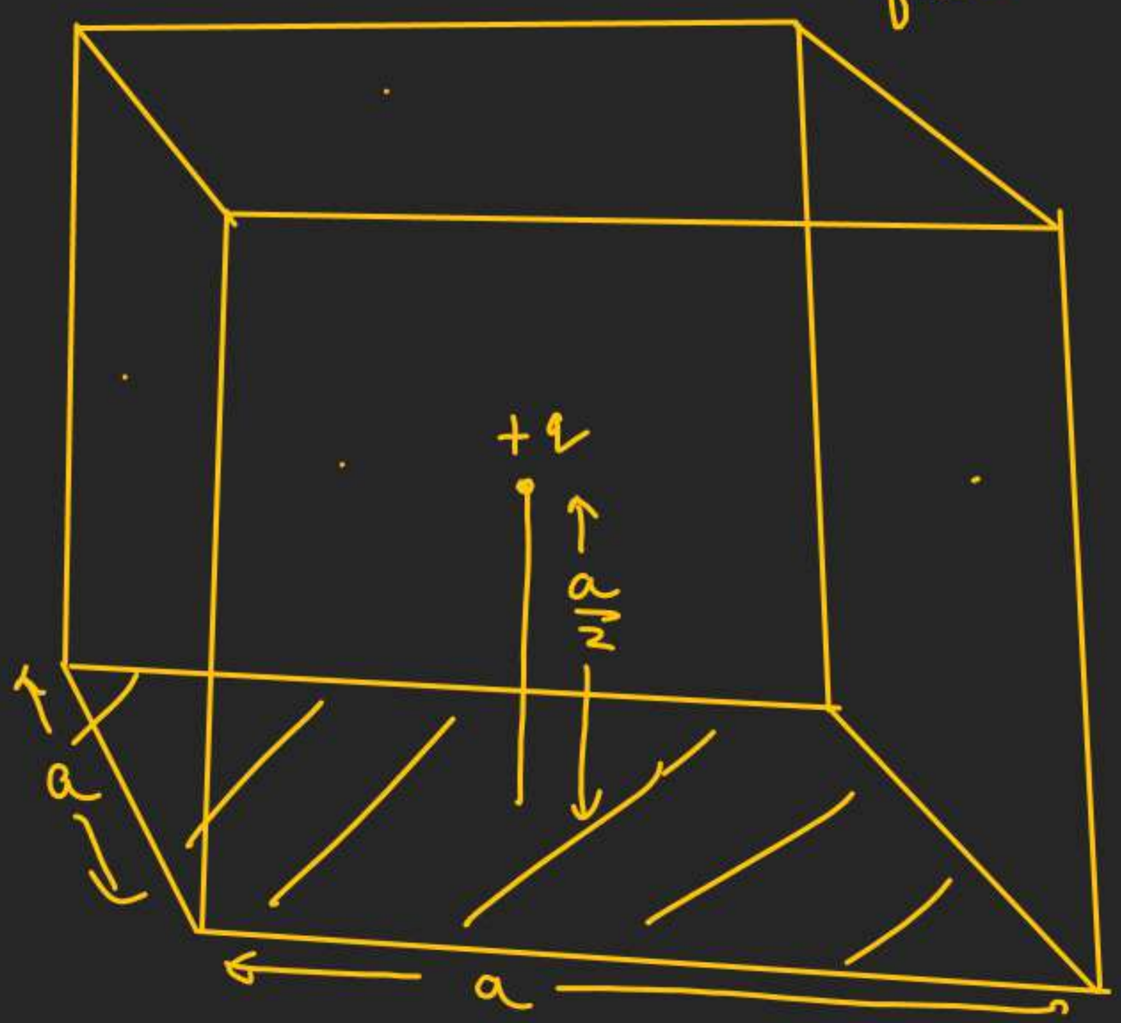
$$\phi_{each\ cube} = \left(\frac{q}{\varepsilon_0} \times \frac{1}{8}\right)$$

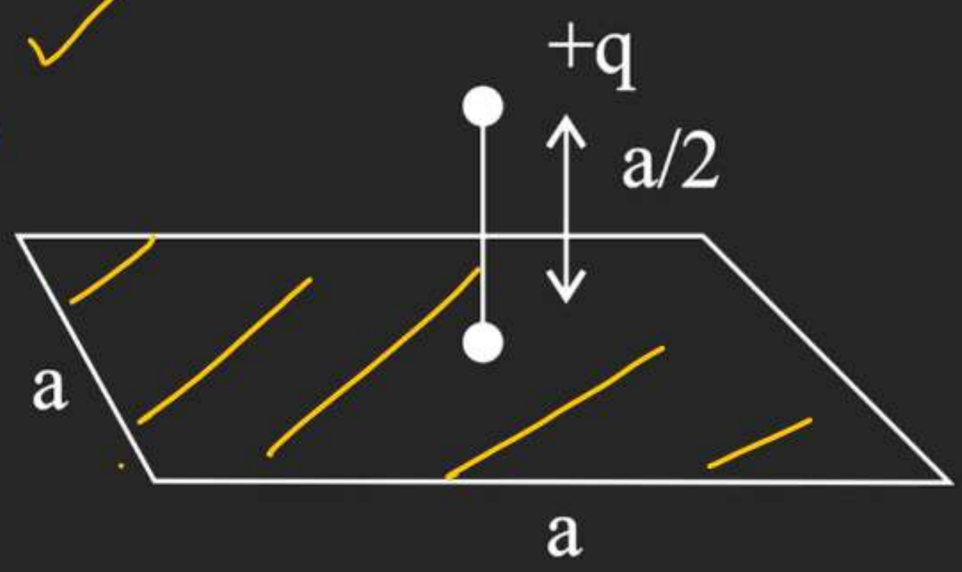
$$= \frac{q}{8\varepsilon_0}.$$

GAUSS'S LAW

$\Phi_{face} = ?$

$\phi_{cube} = \frac{q}{\varepsilon_0}$, $\phi_{\substack{each\\face}} = \frac{q}{6\varepsilon_0}$ ✓





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GAUSS'S LAW

Fig. shows an imaginary cube of side a. A uniformly charged rod of length a moves towards right at a constant speed v. At $t = 0$, the right end of the rod just touches the left face of the cube. Plot a graph between electric flux passing through the cube versus time. Cube

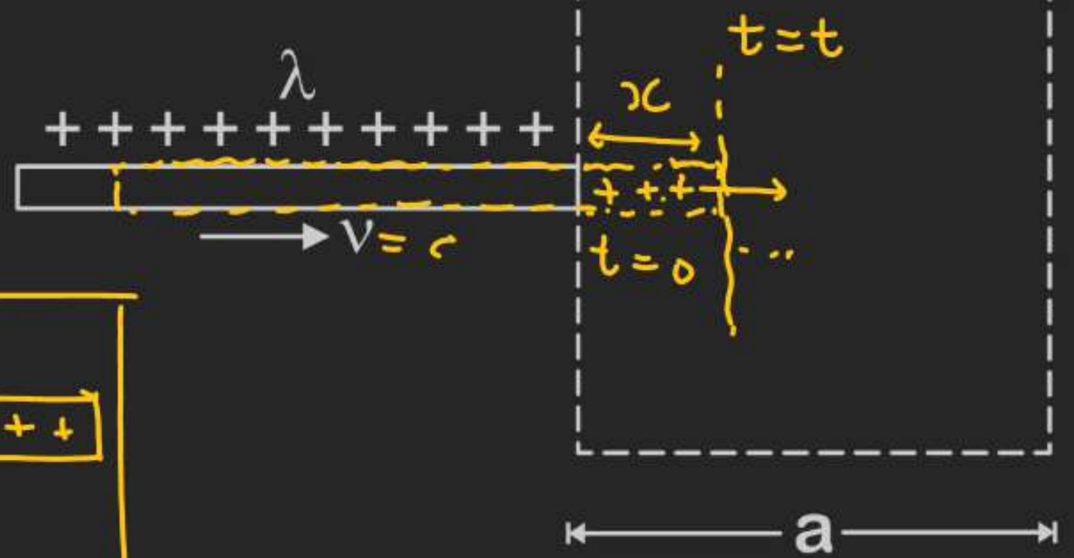
[ϕ Vs t]

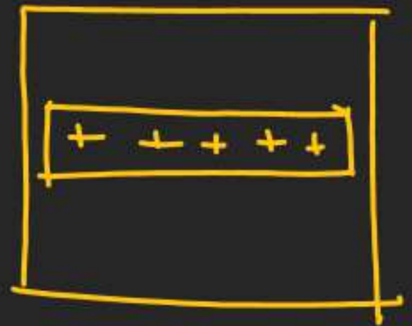
$$x = vt$$

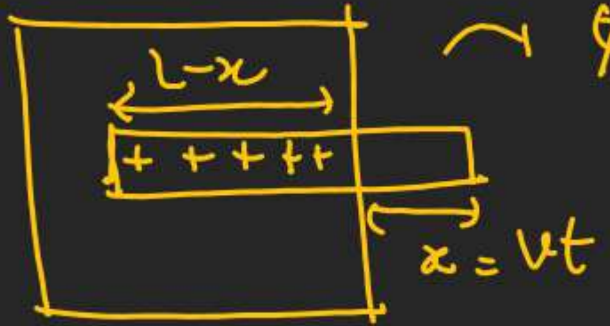
$$(q_{enc})_{t=t} = \lambda \cdot x = \lambda v t$$

$$\phi_{cube} = \frac{(q_{enc})_{t=t}}{\varepsilon_0} = \left(\frac{\lambda v}{\varepsilon_0} \times t\right)$$

$$\boxed{\begin{aligned} \phi_{cube} &= \left(\frac{\lambda v}{\varepsilon_0}\right) t \\ y &= m x \end{aligned}}$$







$$\phi = \lambda(L - x)$$
$$= \lambda(L - vt)$$

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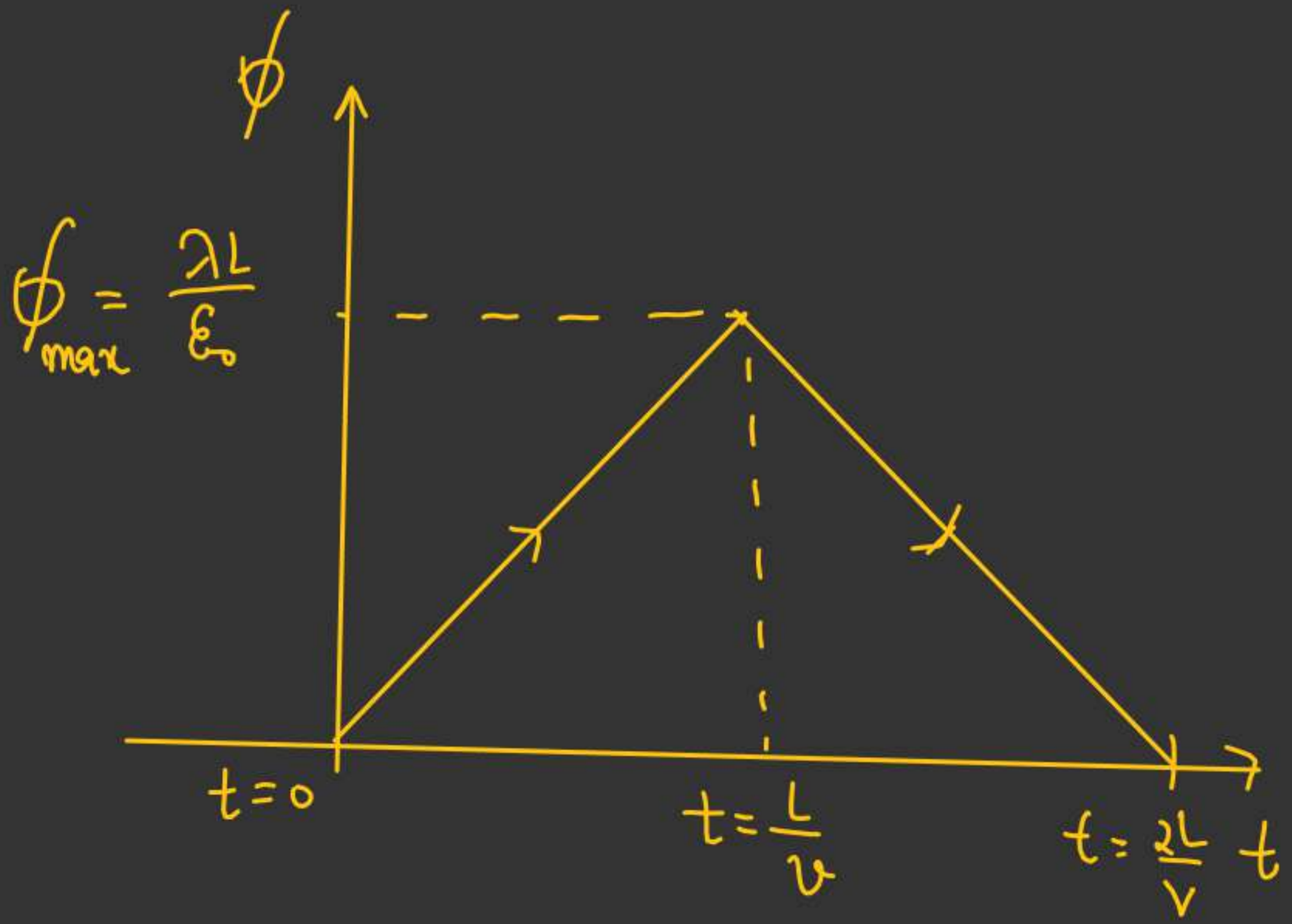

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GAUSS'S LAW

H.W.

The intensity of an electric field depends only on the coordinates x and y as follows,

$$\vec{E} = \frac{a(x\hat{i} + y\hat{j})}{x^2 + y^2}$$

where, a is a constant and $\hat{i}$ and $\hat{j}$ are the unit vectors of the ax and ix axes.

Find the charge within a sphere of radius R with the centre at the origin.

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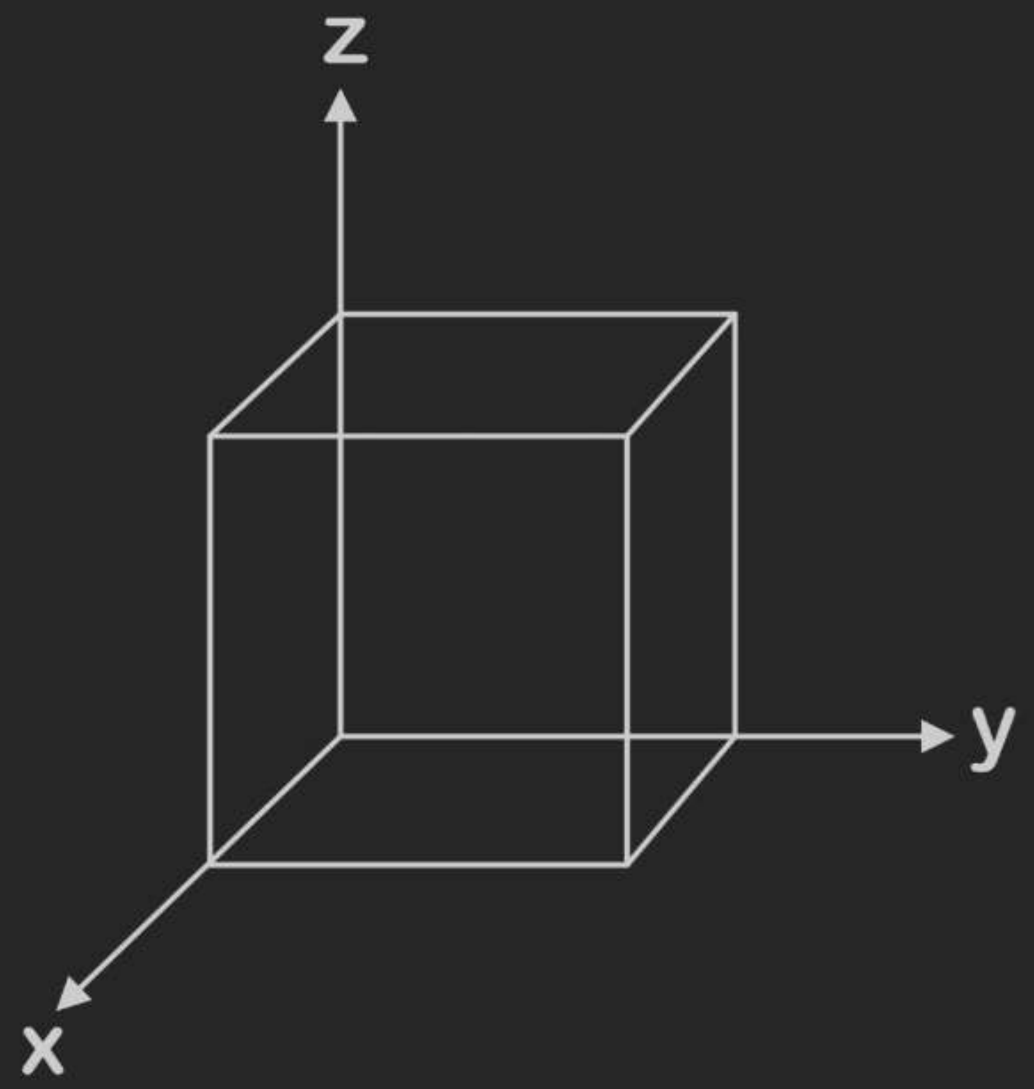
GAUSS'S LAW

H.W.

Electric field in a region is given by $\vec{E} = -4x\hat{i} + 6y\hat{j}$. Find charge enclosed in the cube of side $1\ \mathrm{m}$ as shown in the diagram.



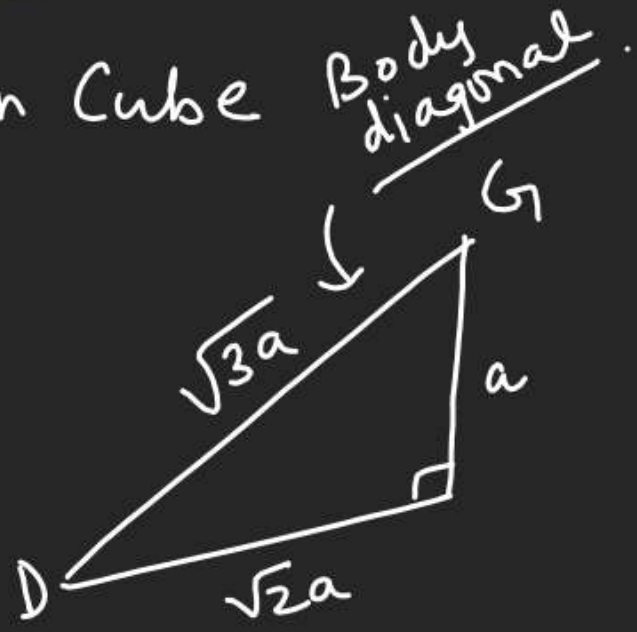
GAUSS'S LAW

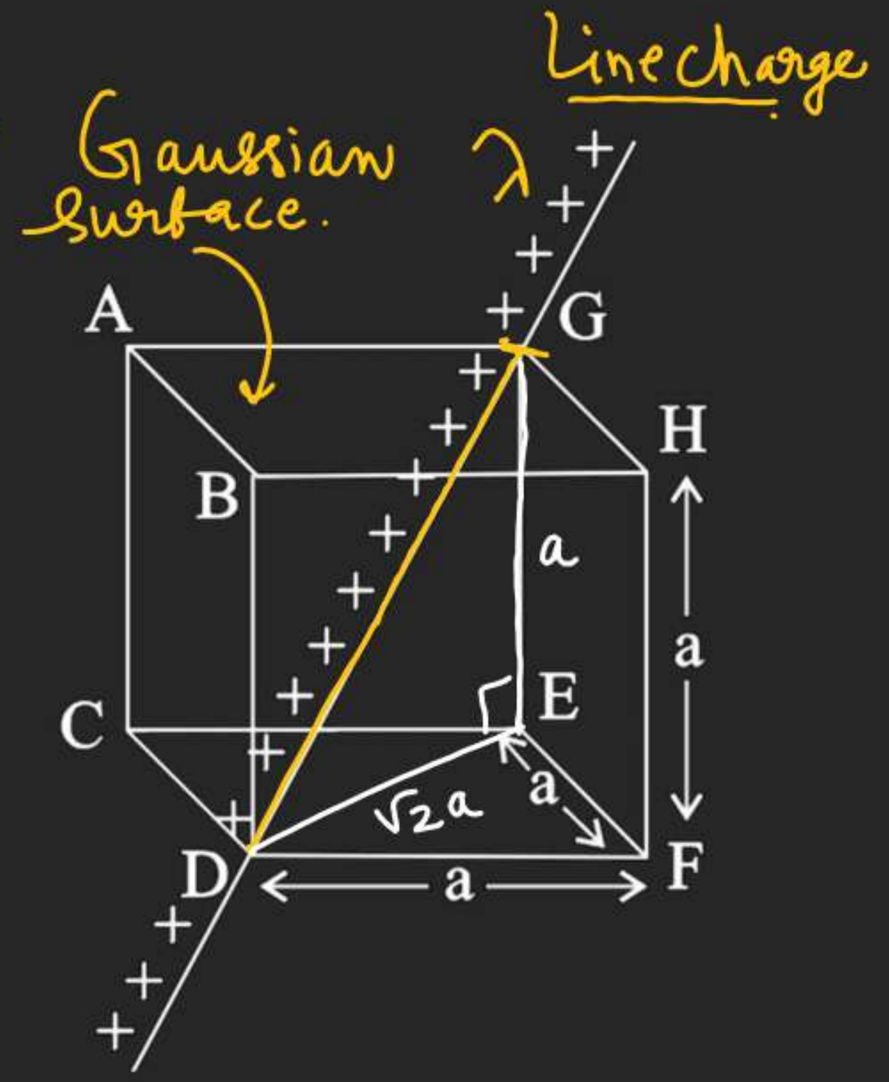
\# Find flux through the Cube if line Charge is along body diagonal.

$\Phi_{cube} = ?$

Sol^n Charge enclosed within Cube $= \lambda\sqrt{3}a$

$$\boxed{\phi_{cube} = \frac{\lambda\sqrt{3}a}{\varepsilon_0}}$$





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GAUSS'S LAW

A point charge q is placed at the centre of the cubical box.

Find, (a) total flux associated with the box ✓ → $\left(q/\varepsilon_0\right)$

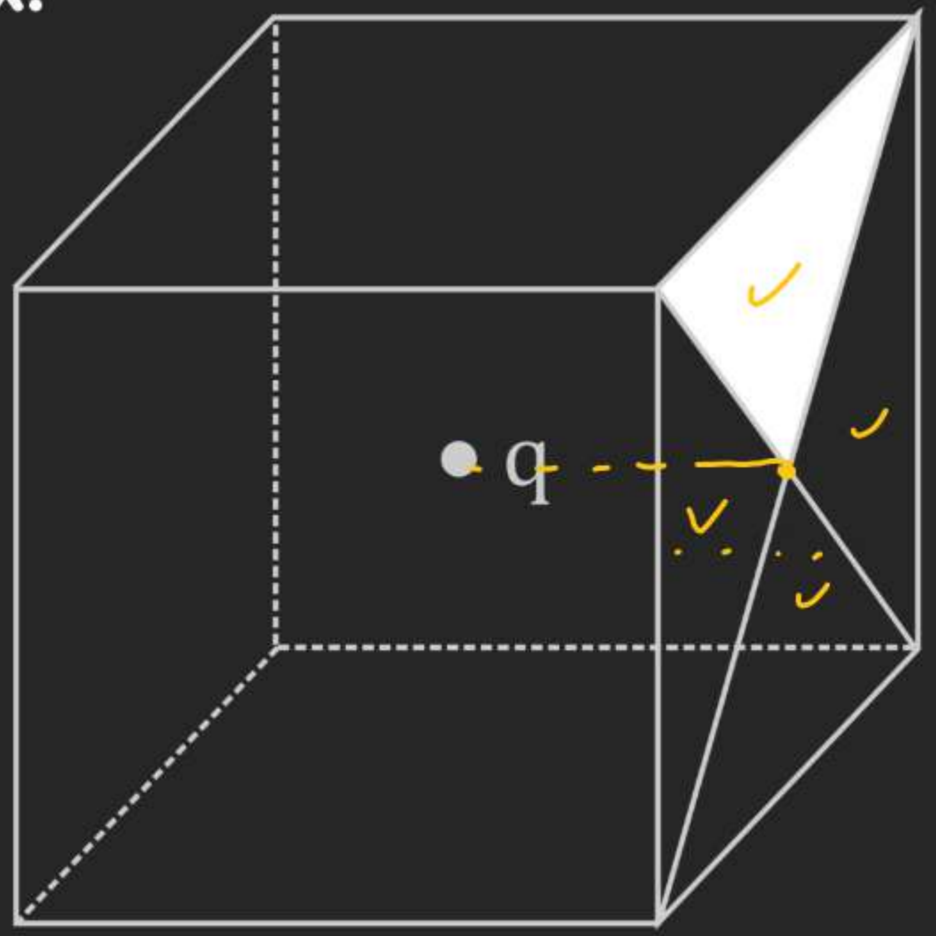
(b) flux emerging through each face of the box

$4\left(\frac{q}{6\varepsilon_0}\right)$

(c) flux through shaded area of surface.

$\hookrightarrow \phi = \frac{\text{Flux through each face}}{4}$

$= \frac{q}{24\varepsilon_0}$ ✓



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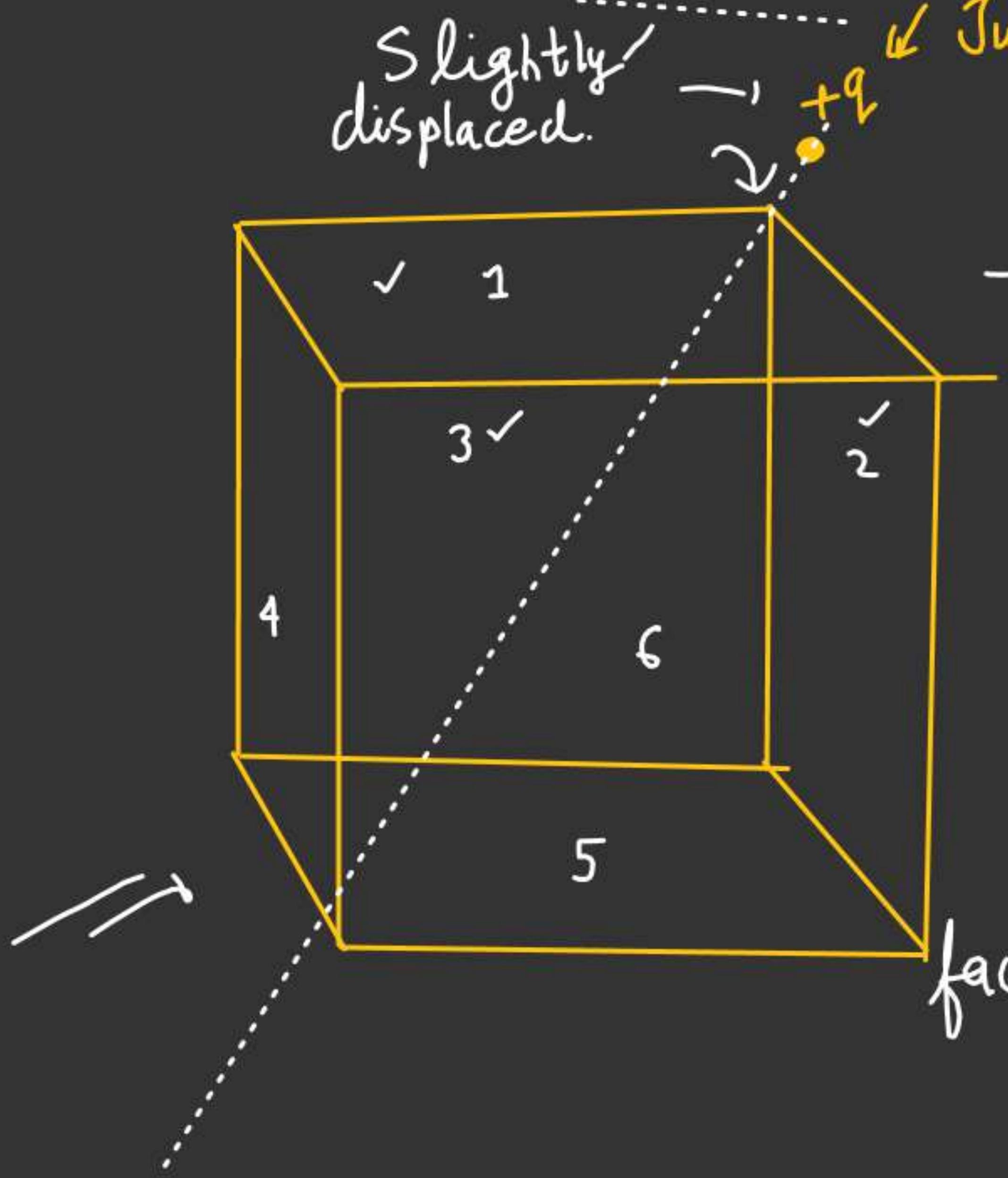

Just outside the Cube but location is along body diagonal.

→ Find flux through the Cube. → 0

→ Find flux through the faces which Contribute to the Corner.

$$\phi_4 = \phi_5 = \phi_6 = \phi = \underline{\frac{q}{24\varepsilon_0}}$$

$$\underbrace{\phi_1 = \phi_2 = \phi_3}_{\Downarrow} = \phi' = ??$$

faces which Contribute the Corner

$$3(\phi + \phi') = 0$$

$$\phi_{cube} = 0$$

$$-\phi + \phi' = 0$$

$$\boxed{\phi' = -\phi = \frac{-q}{24\varepsilon_0}}$$

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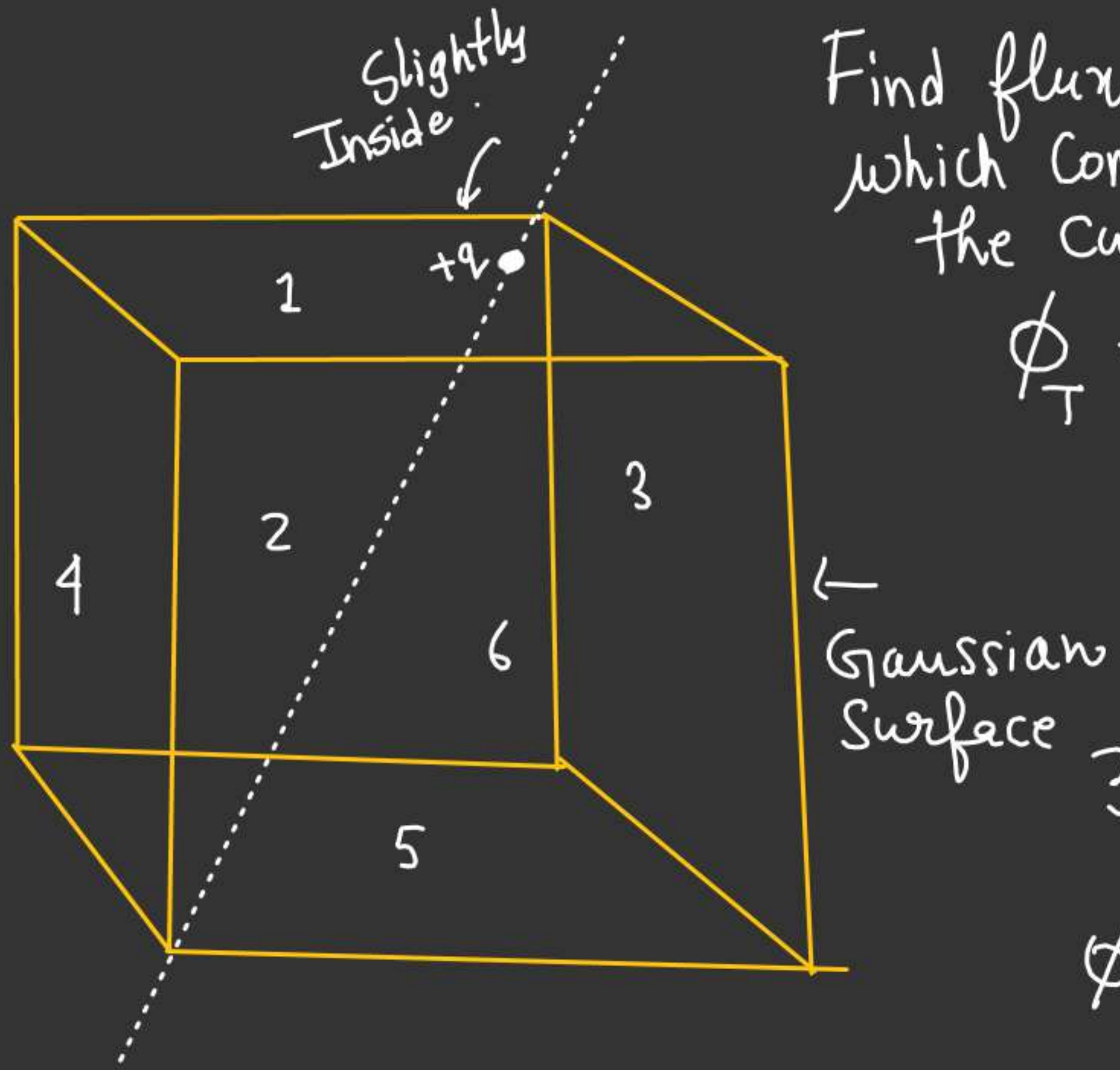

Find flux through each faces which Contributing towards the Corner of the Cube.

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

$$\phi_1 = \phi_2 = \phi_3 = \phi'$$

$$\phi_4 = \phi_5 = \phi_6 = \phi = \frac{q}{24\varepsilon_0}$$

$$\phi' + \phi = \phi_T$$

$$3\left[\phi' + \frac{q}{24\varepsilon_0}\right] = \frac{q}{\varepsilon_0}$$

$$\phi' + \frac{q}{24\varepsilon_0} = \frac{q}{3\varepsilon_0}$$

$$\phi' = \frac{q}{3\varepsilon_0} - \frac{q}{24\varepsilon_0} = \frac{8q - q}{24\varepsilon_0} = \frac{7q}{24\varepsilon_0}$$