LAKSHYA JEE

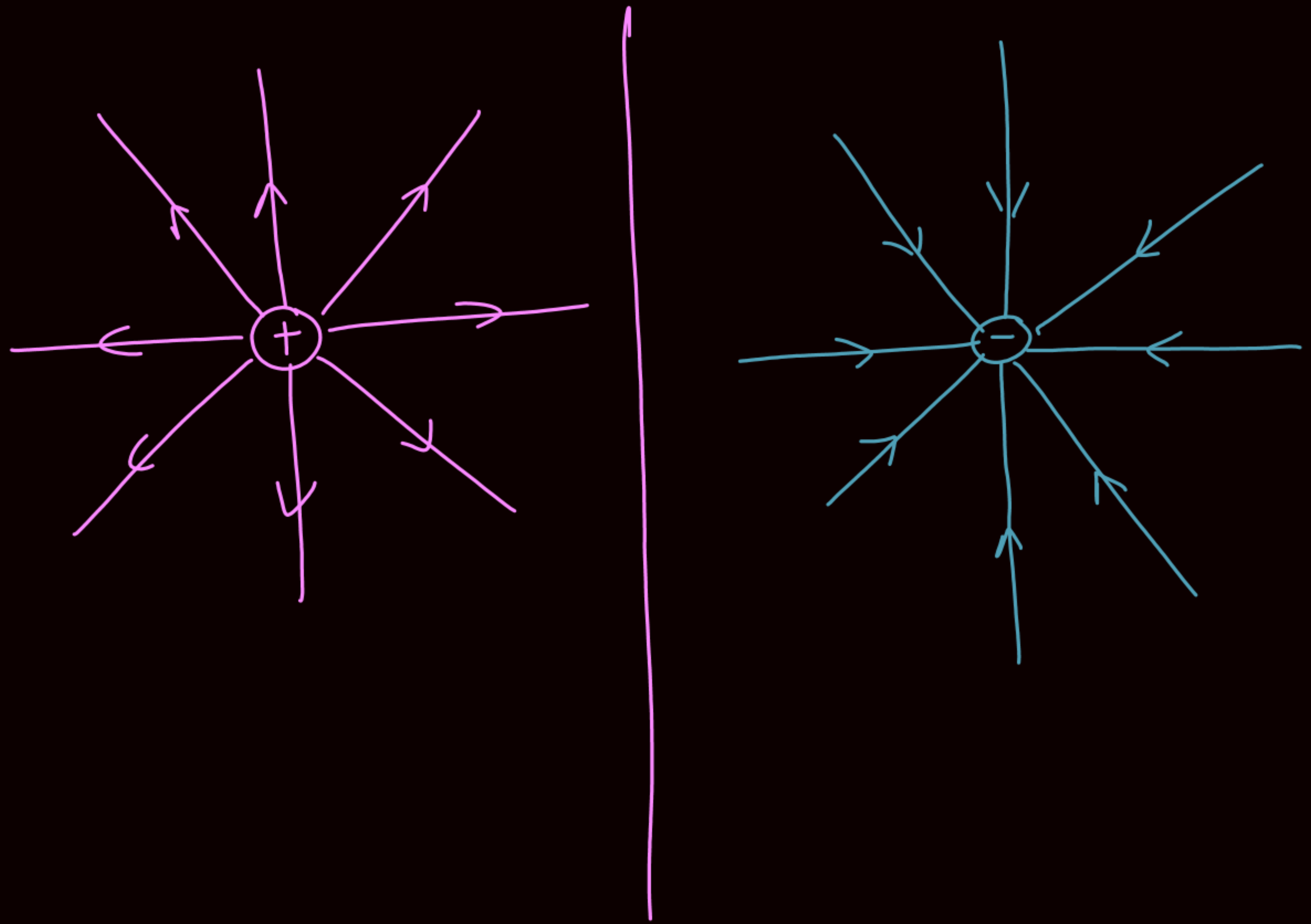
LAKSHYA KO HAR HAAL ME PAANA HAI

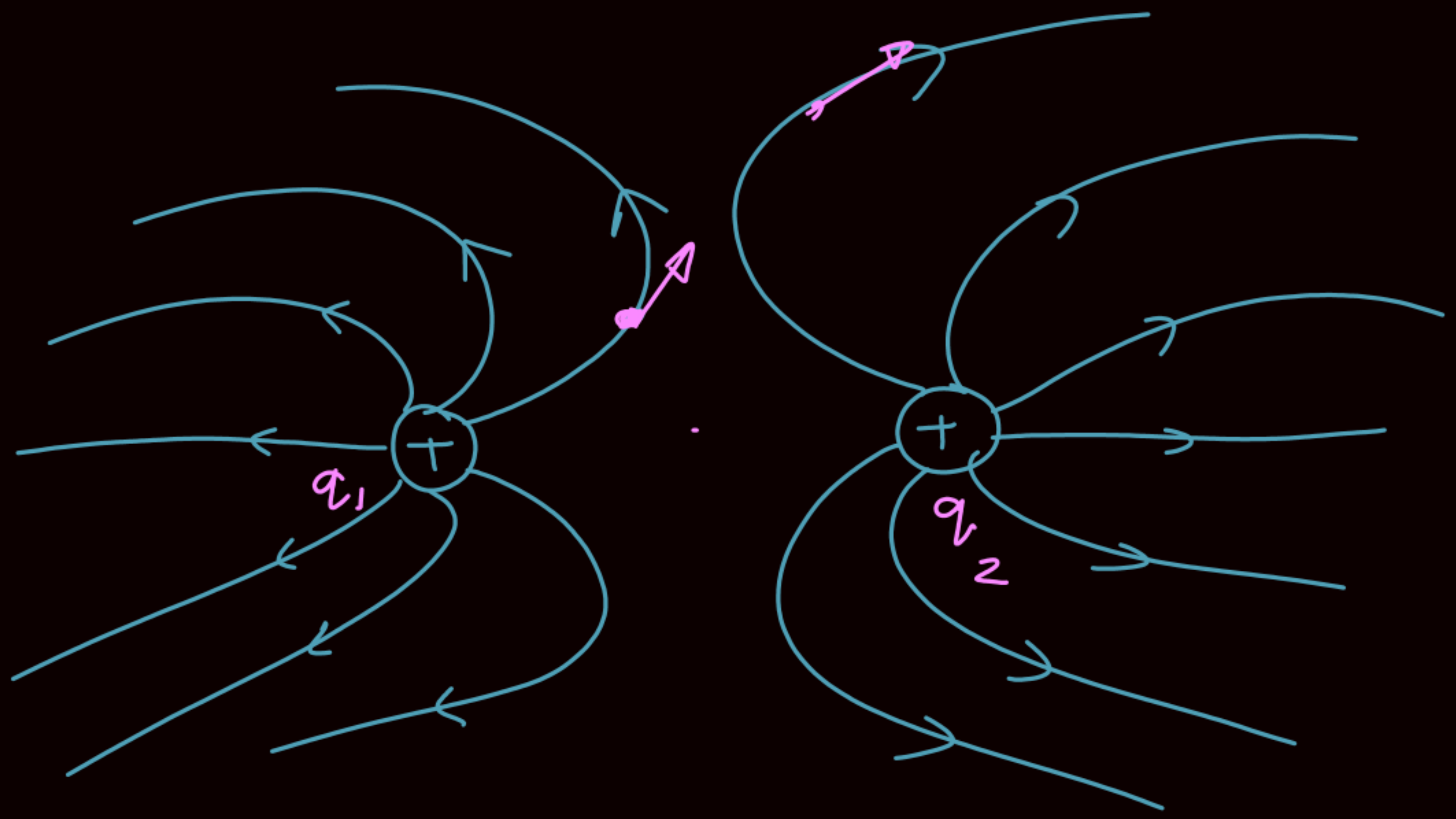
Electric Charges and Field

-Er. Rohit Gupta

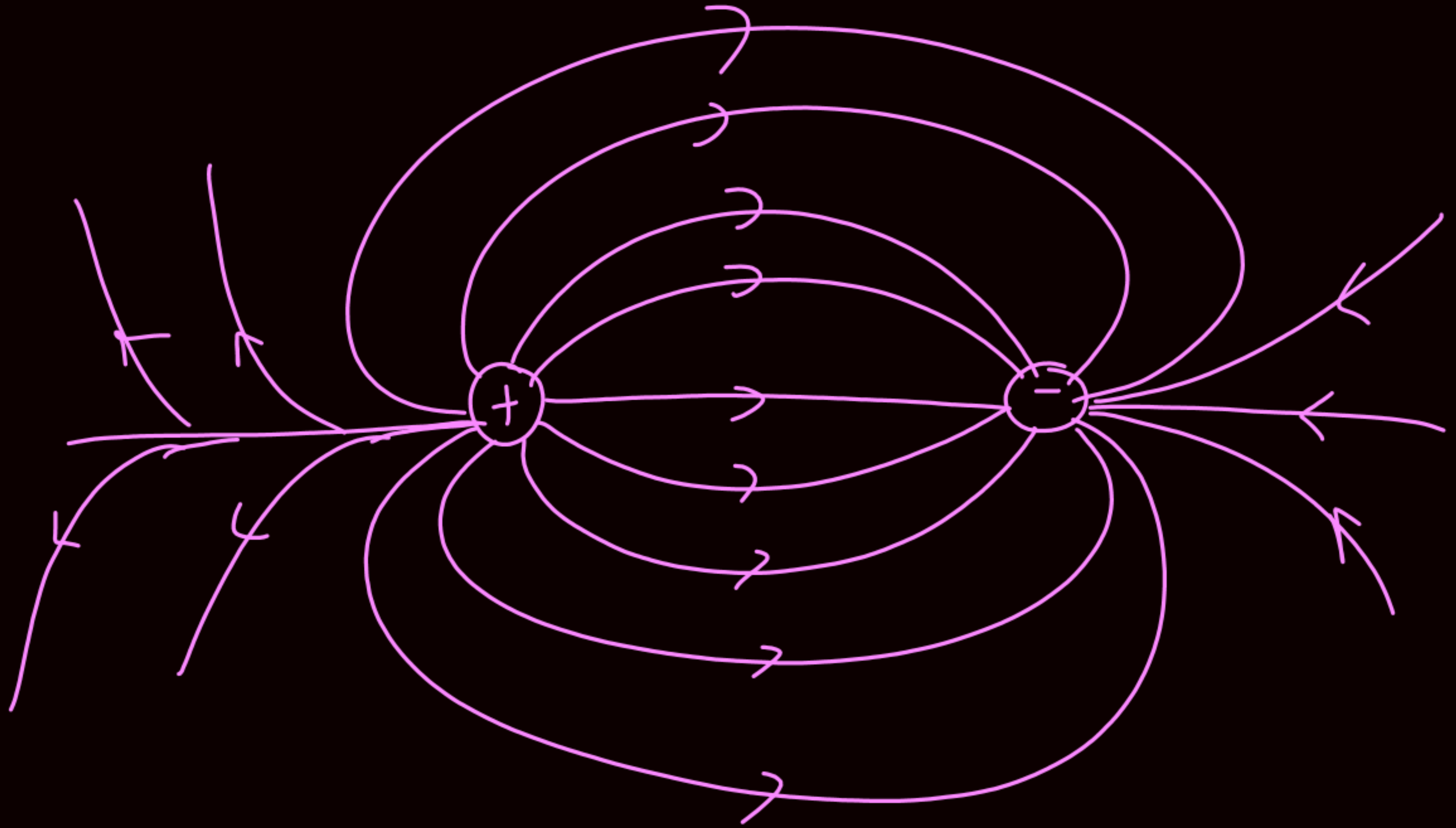
Today's GOALS!

- ❑ Electric Flux





q1
q2



Electric Flux

$$\phi = \int \vec{E} \cdot d\vec{S}$$

Physical significance: ϕ is directly proportional to the No. of electric field lines crossing a surface.

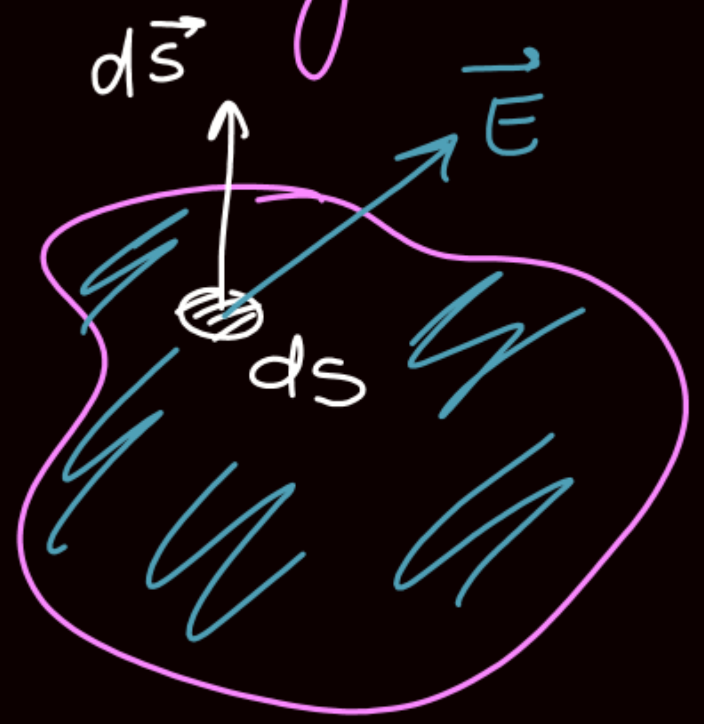
~~ϕ = No. of field lines~~

100 lines

$\phi = 100$ ✗

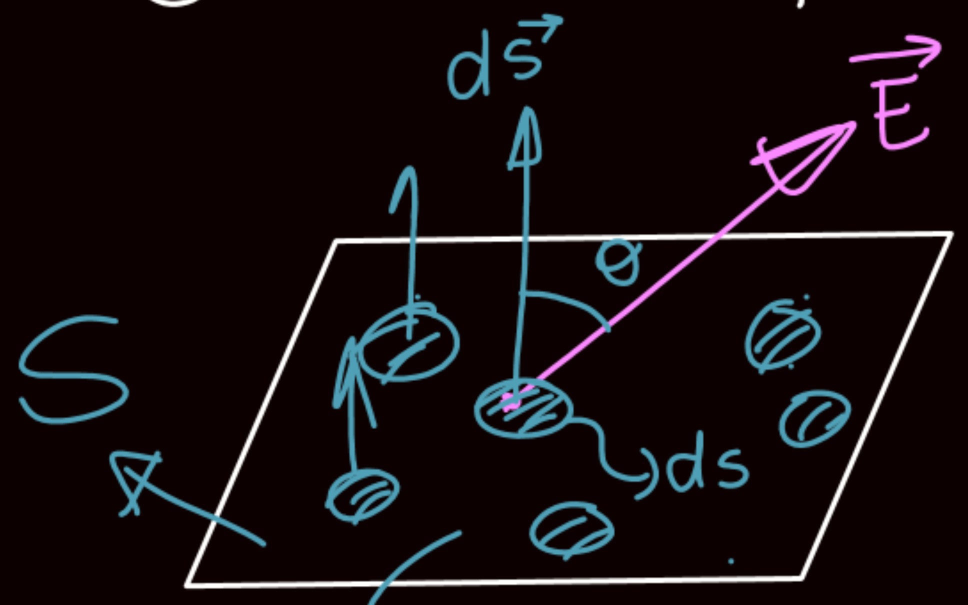
What is electric flux?

Electric flux is the surface integral of electric field.



$$\int \vec{E} \cdot d\vec{s}$$

① $\vec{E}$ is uniform & area is planner / (flat)



area vector is ⊥ to the plane of the area.

$$\phi = \int \vec{E} \cdot d\vec{s}$$

↓ uniform ($\vec{E}$)

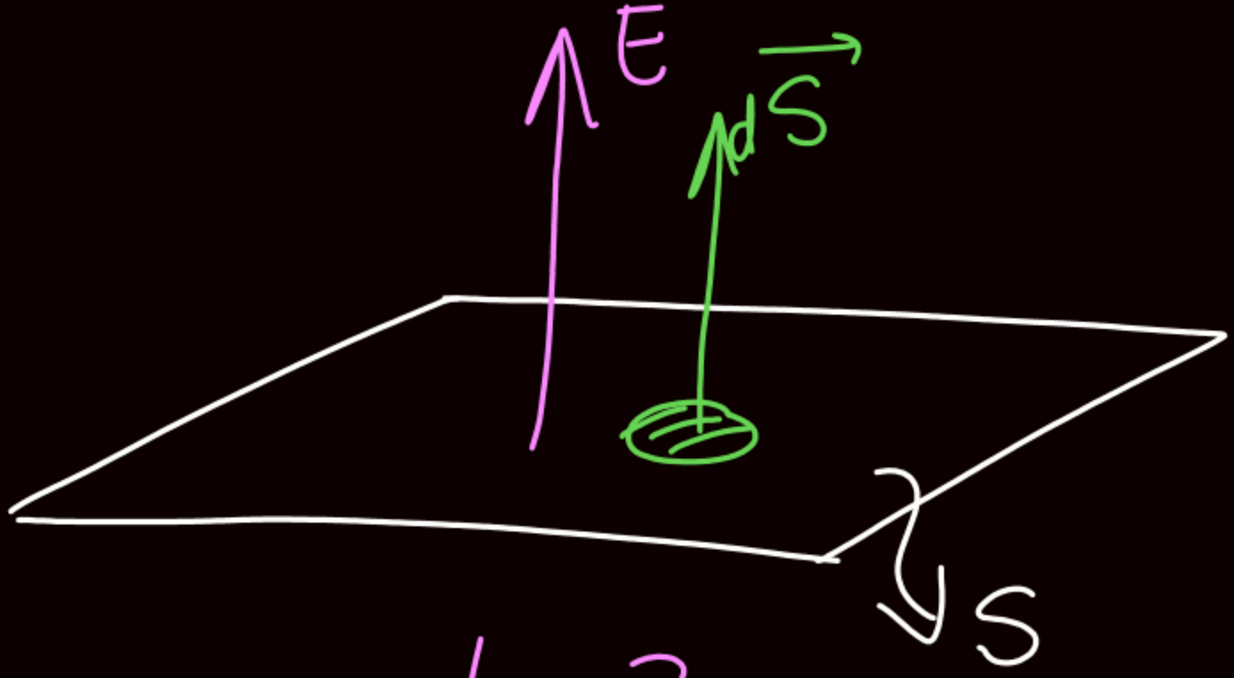
$$\phi = \vec{E} \cdot \int d\vec{s}$$

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

$\cos(180 - \theta) = -\cos\theta$

$$\phi = ES\cos\theta$$

θ → angle between E & area vector.



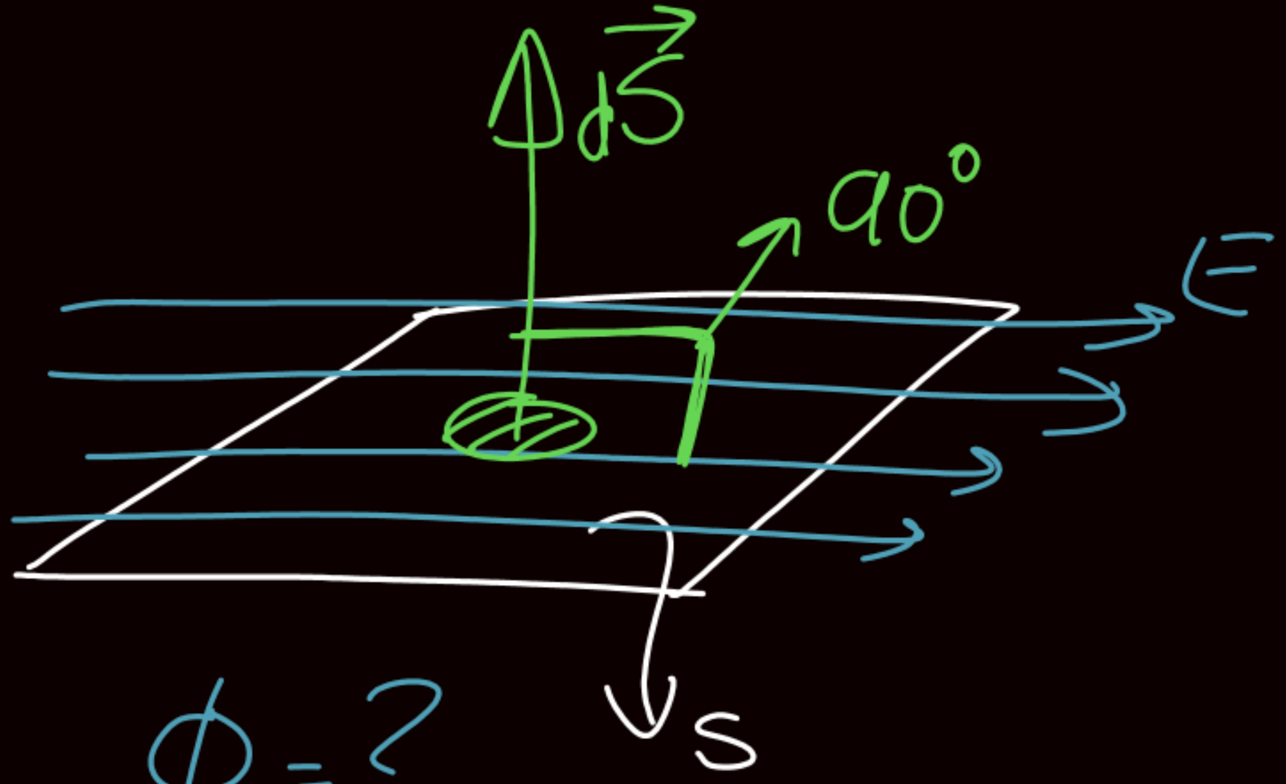
$\phi = ?$

$\phi = E S \cos 0$

$= E_{\perp} S$

↓

⊥ to the surface.

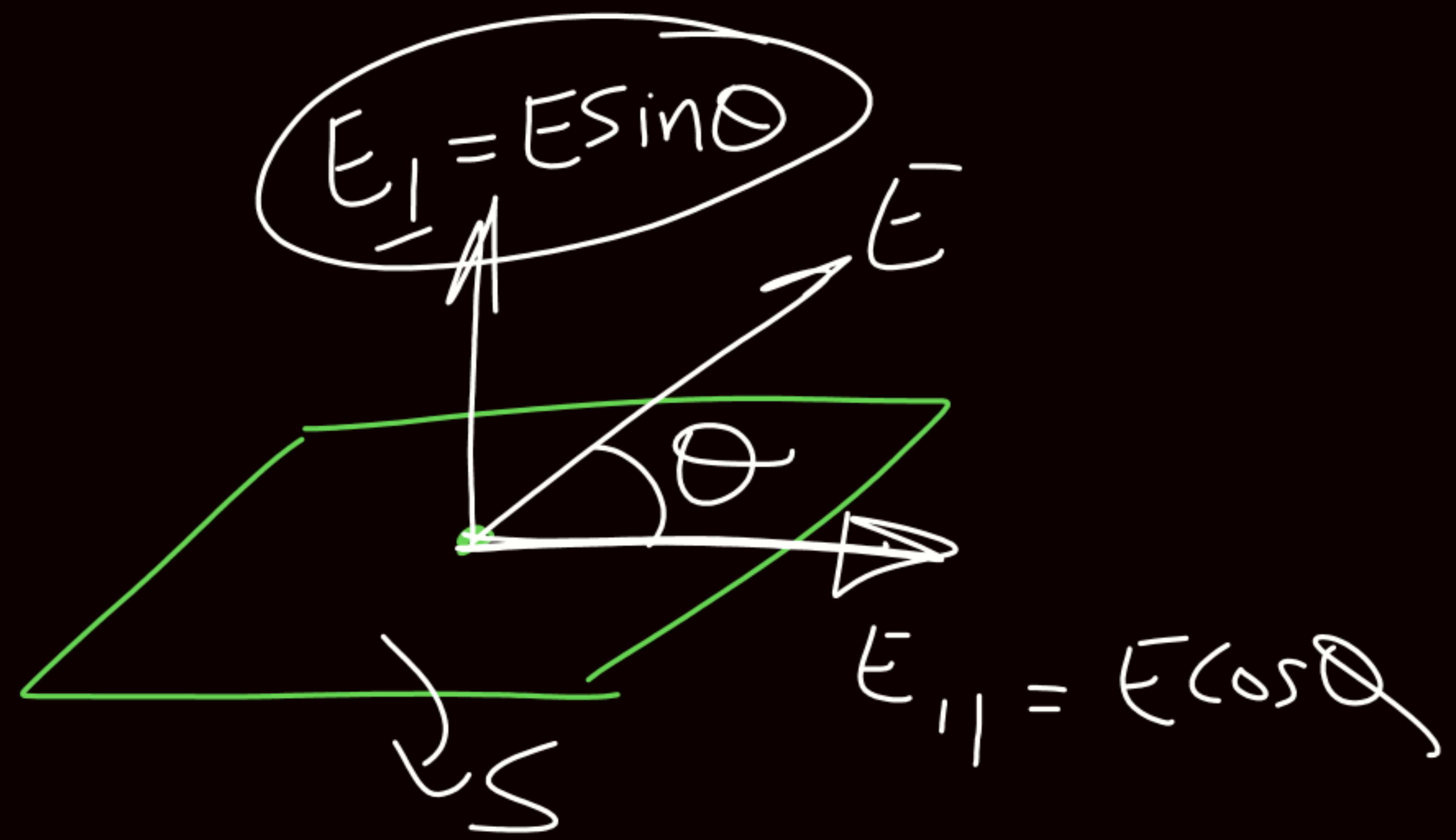


$\phi = ?$

$\phi = E S \cos 90^\circ$

$= 0.$

(If)
अगर field lines surface के parallel nikal rahi hai toh flux nahi aayega.
Flux के liye field lines ko surface ko kaat के jana hoga.

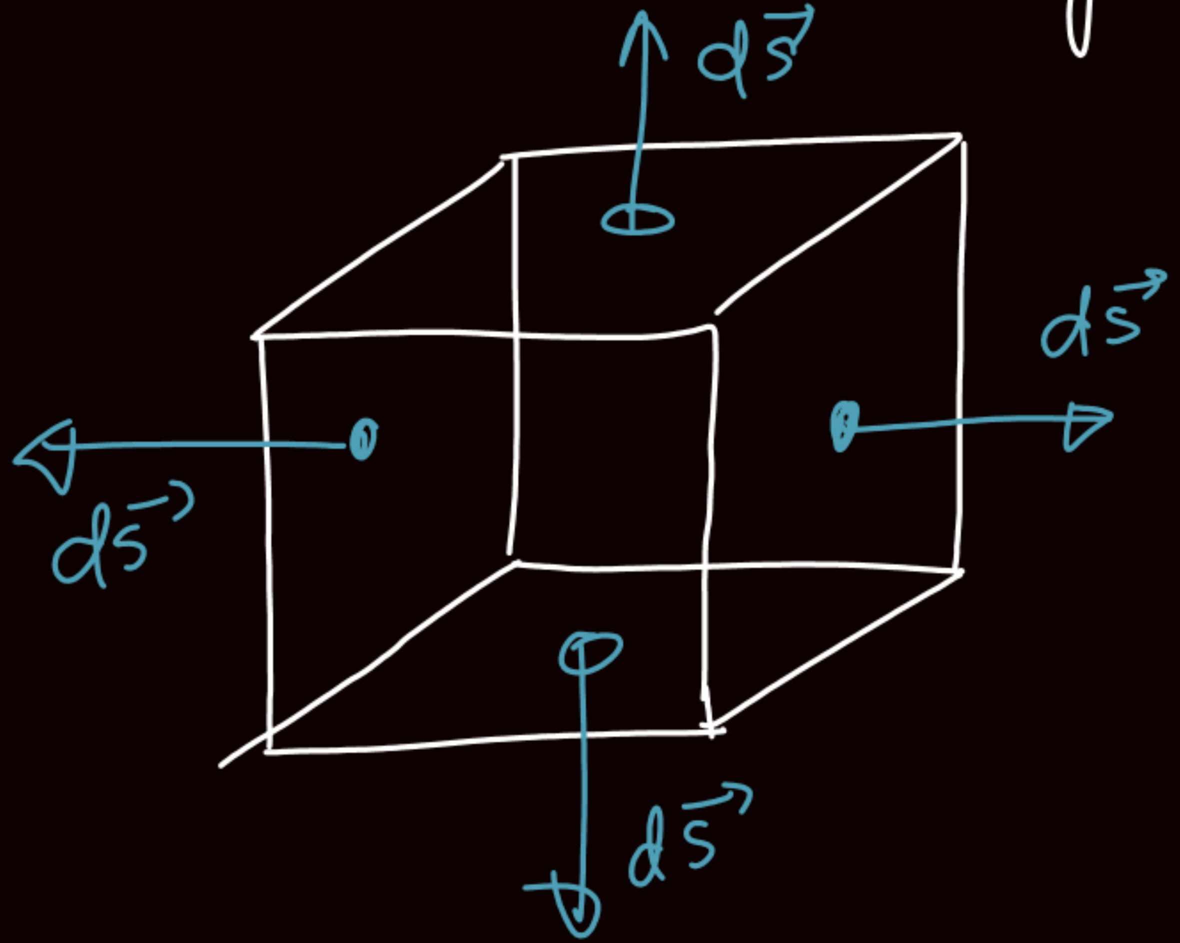


$\phi = ?$

$\phi = \bar{E}_\perp \times A = \bar{E}\sin\theta\, A$

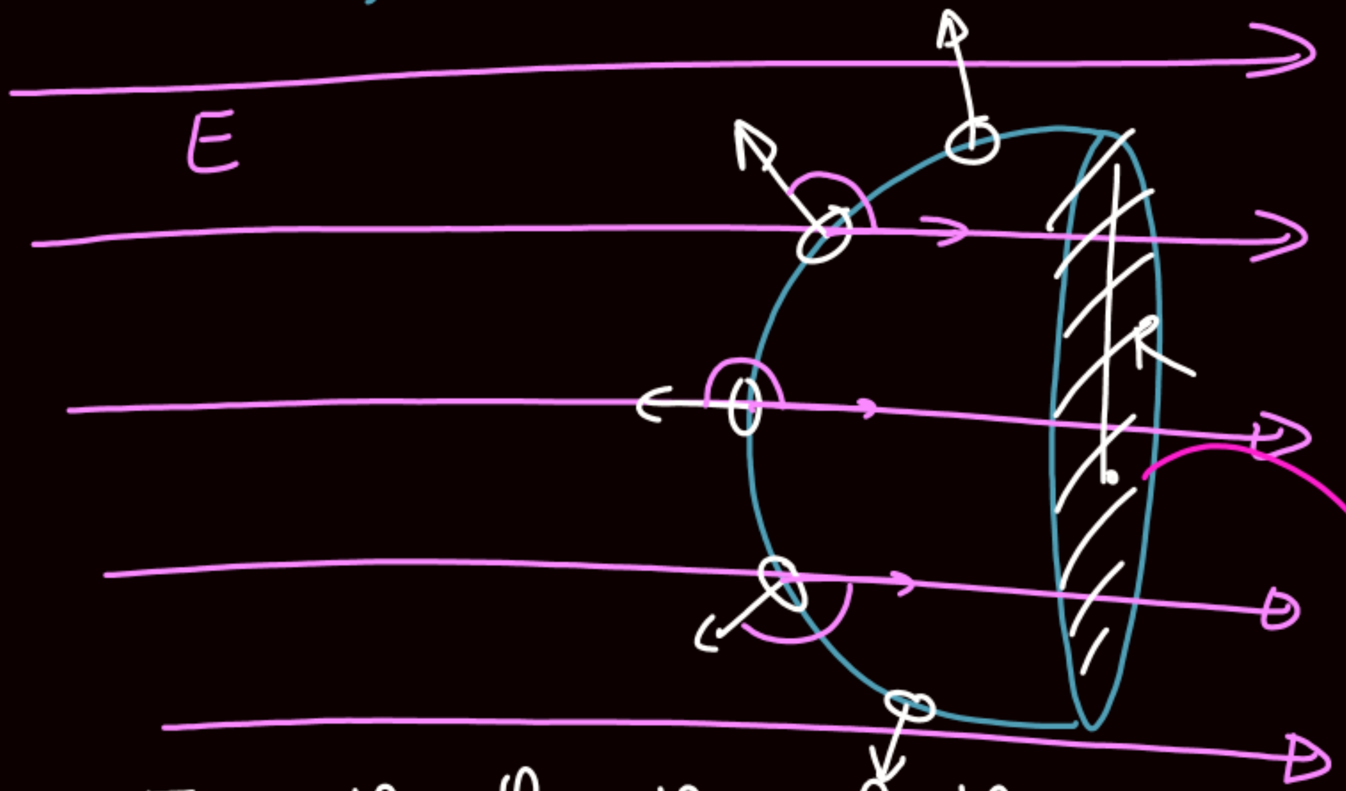
Sign convention for closed surface

Outward normal is taken as the dir. of area vector.



Outward flux is taken +ve & Inward flux is taken −ve.

② $\vec{E}$ is uniform but area is curved.



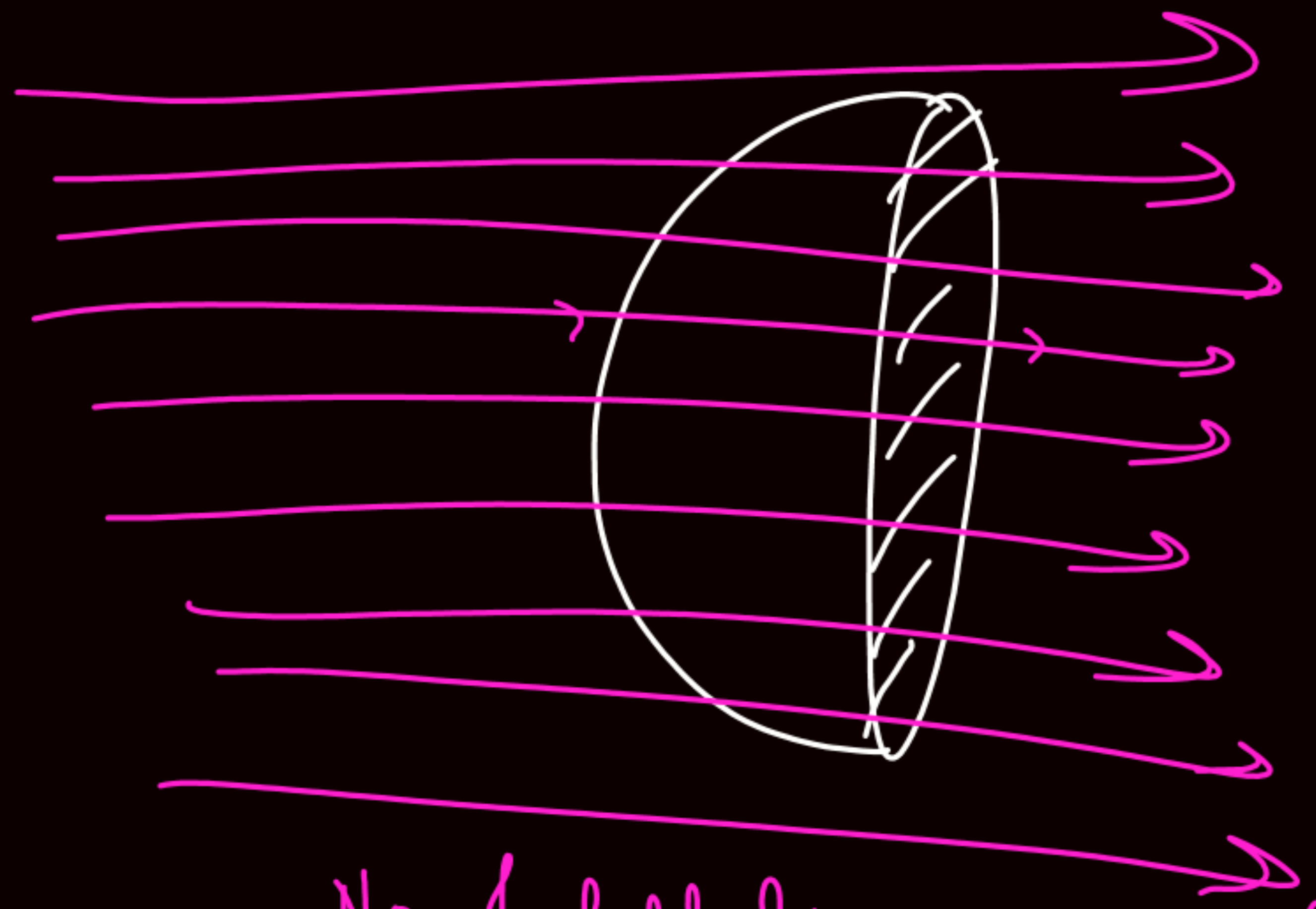
Find the flux through the curved surface of hemisphere.

$$\int \vec{E} \cdot d\vec{s}$$

$$\int E \, ds \cos\theta$$

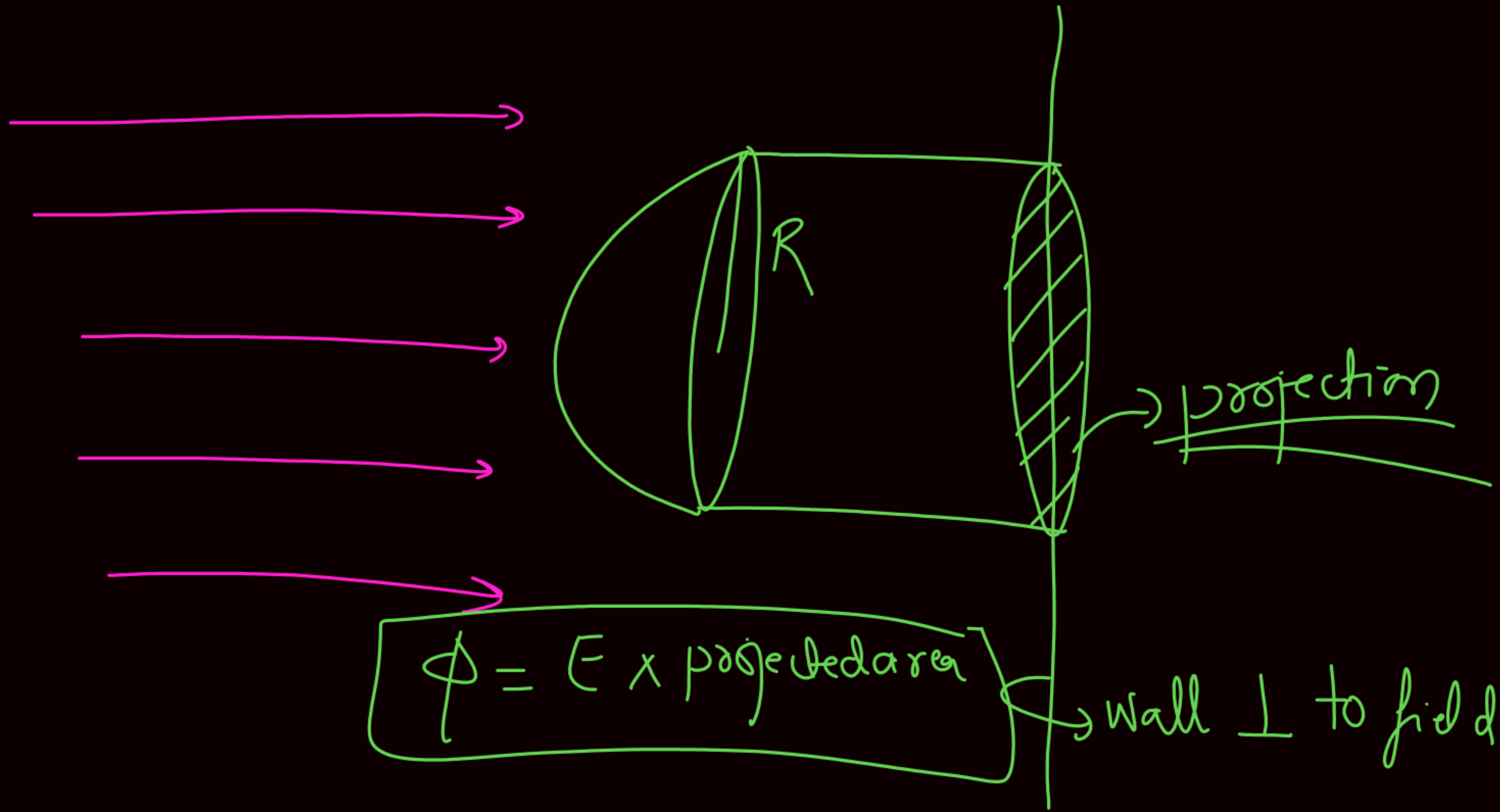
$$E \int ds \cos\theta$$

$$\Rightarrow E \times \pi R^2$$

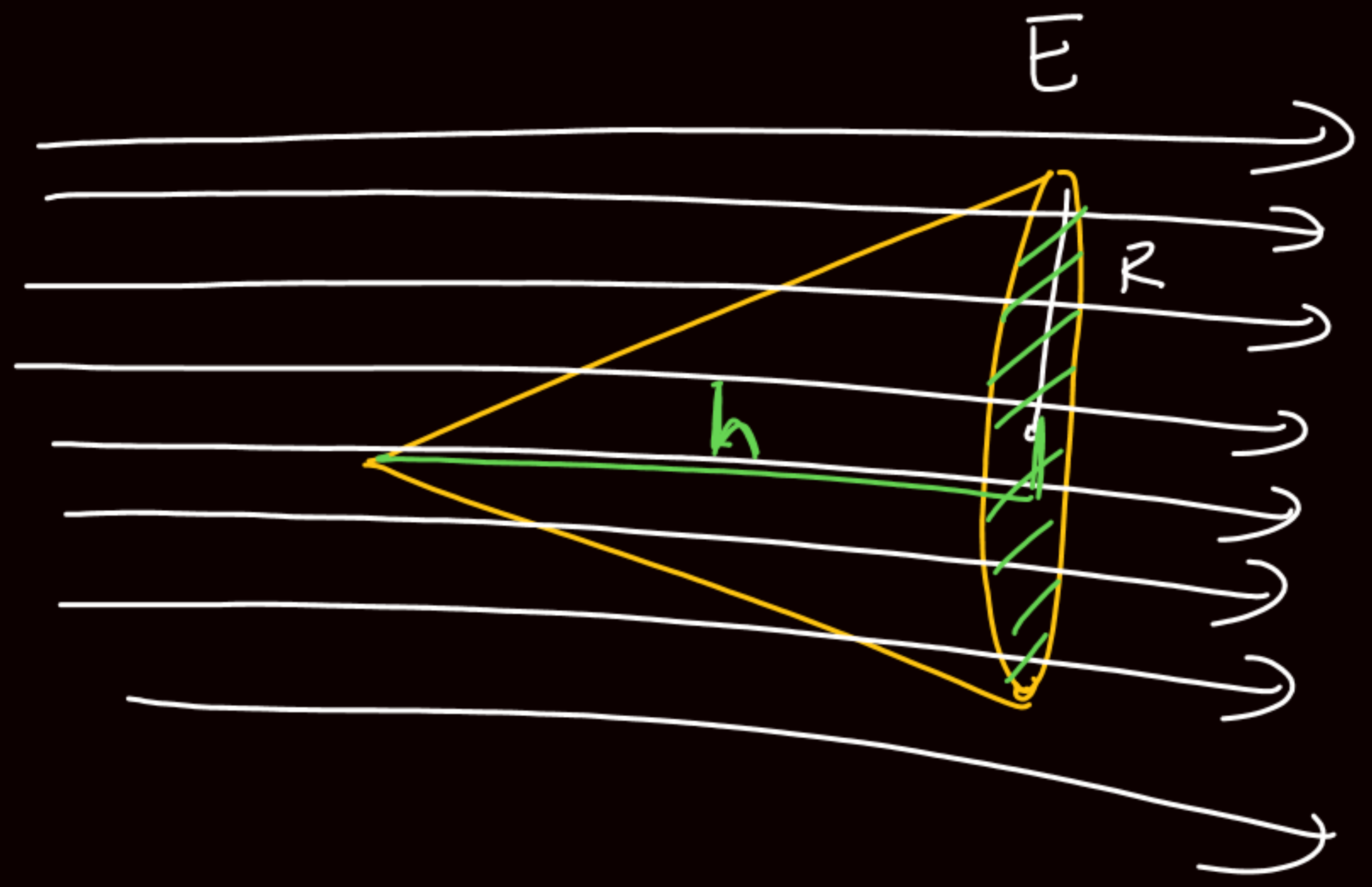


No. of field lines passing through flat surface = curved surface.

$$\phi_{curved} = \phi_{flat}$$

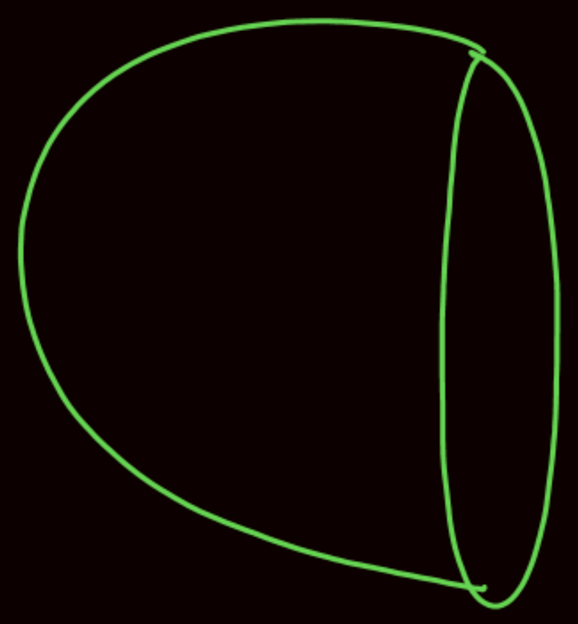


$$\phi = E \times \text{projected area}$$

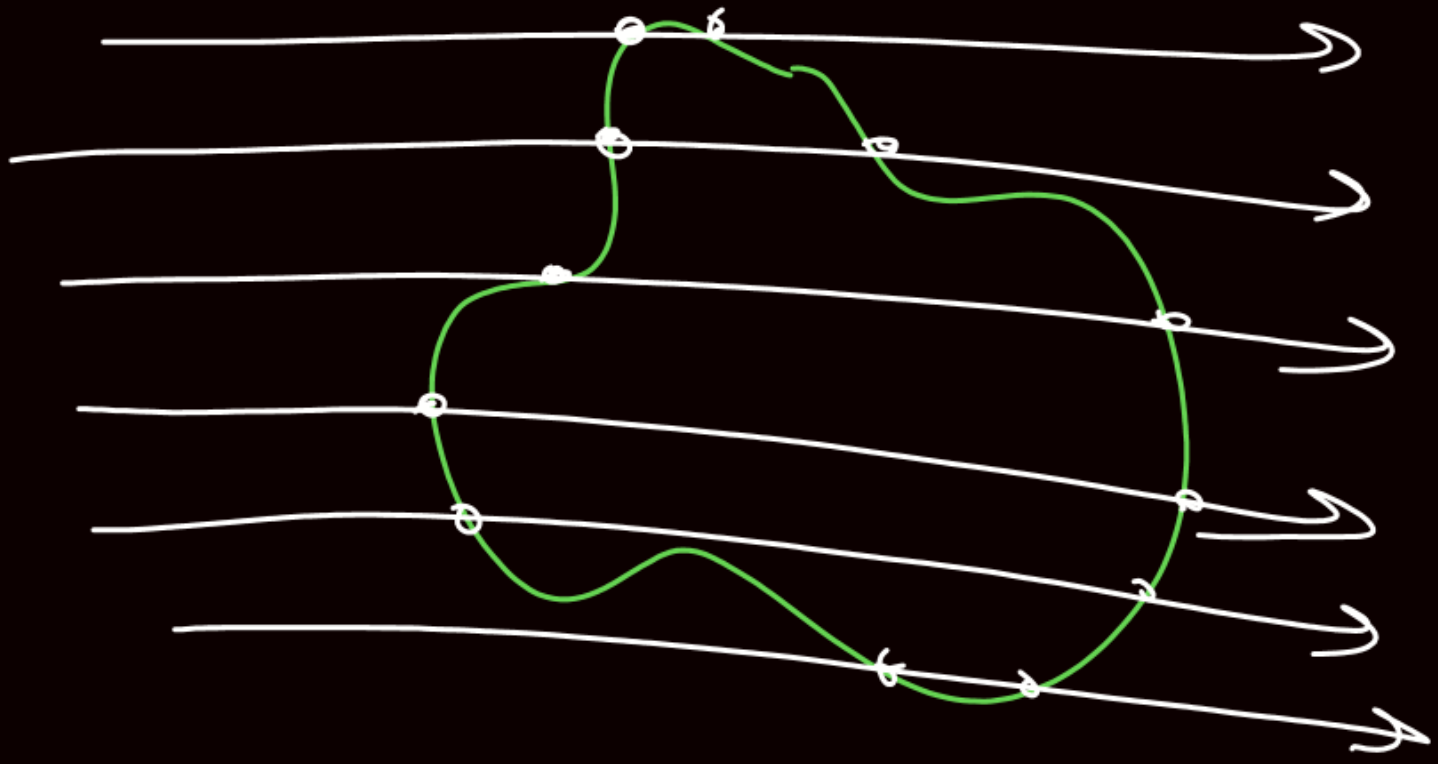


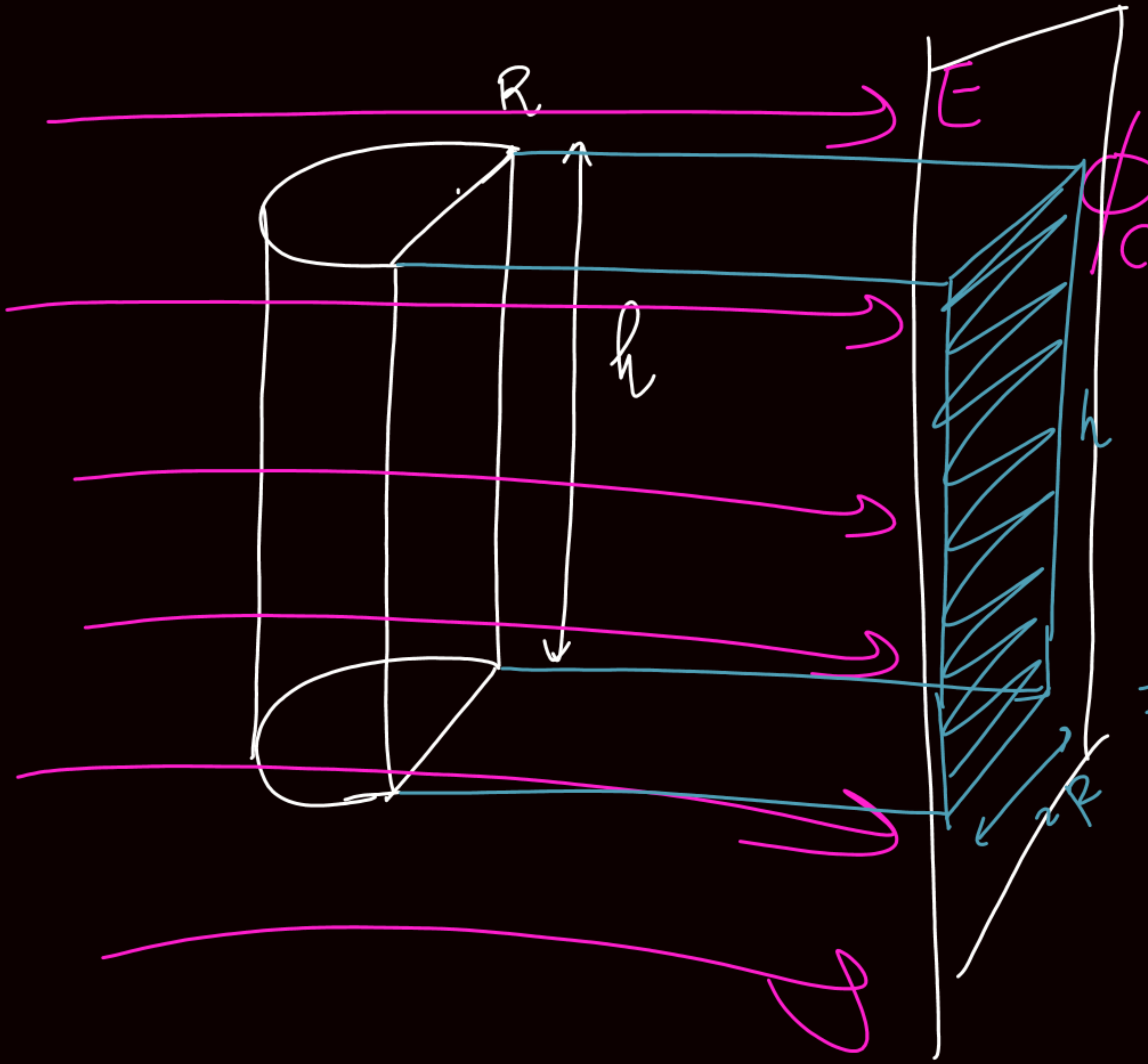
Find the flux through the curved surface of the cone.

$$\phi_{curved} = \phi_{flat} = E \times \pi R^2$$



NOTE:- Net flux passing through a closed surface placed in a uniform electric field is zero.





$\phi_{curved} = ?$

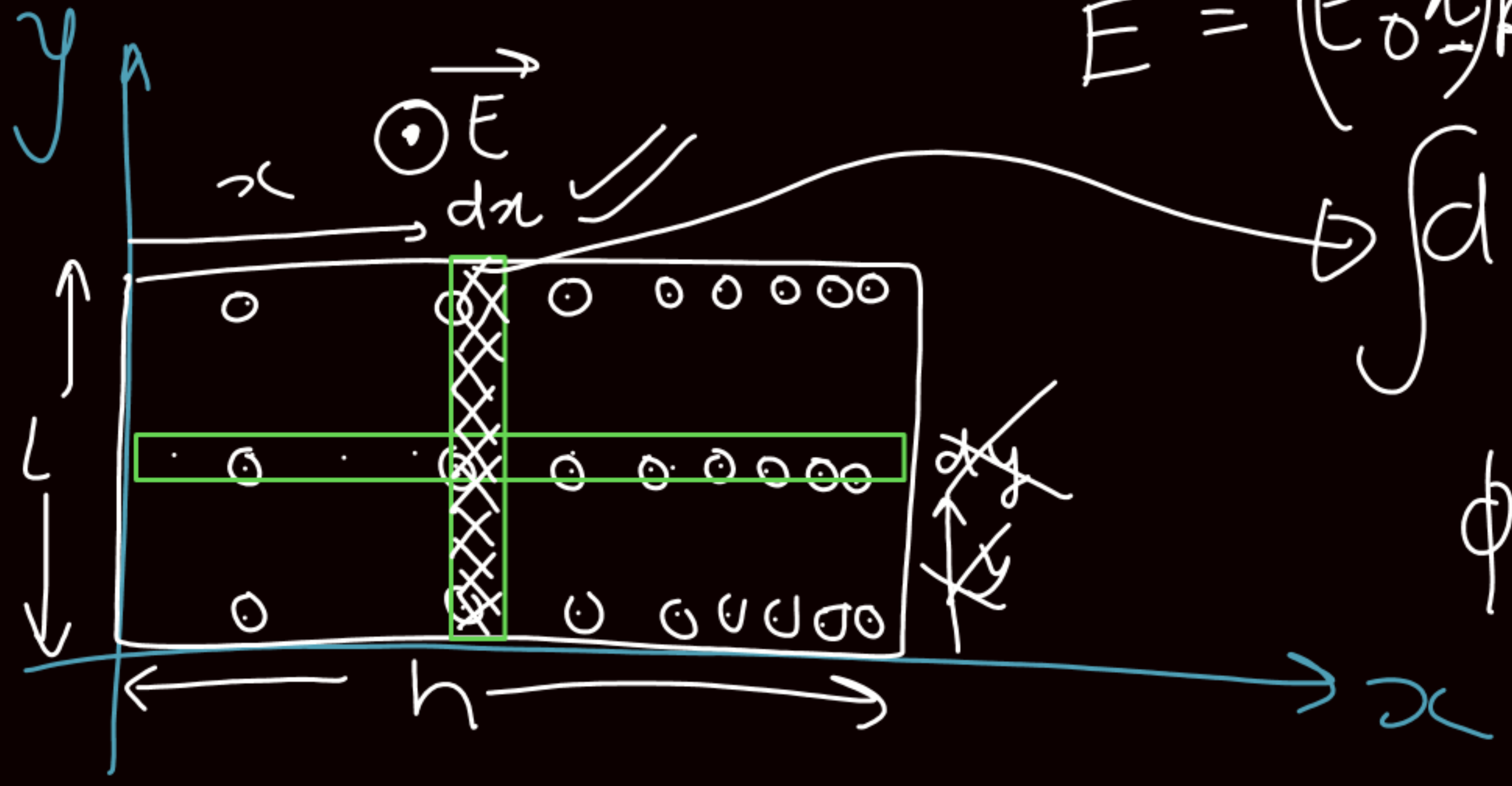
$\phi = E \times$ Projected area.

$\phi = E \times 2Rh$

Case 3

E => nonuniform

Area => flat.



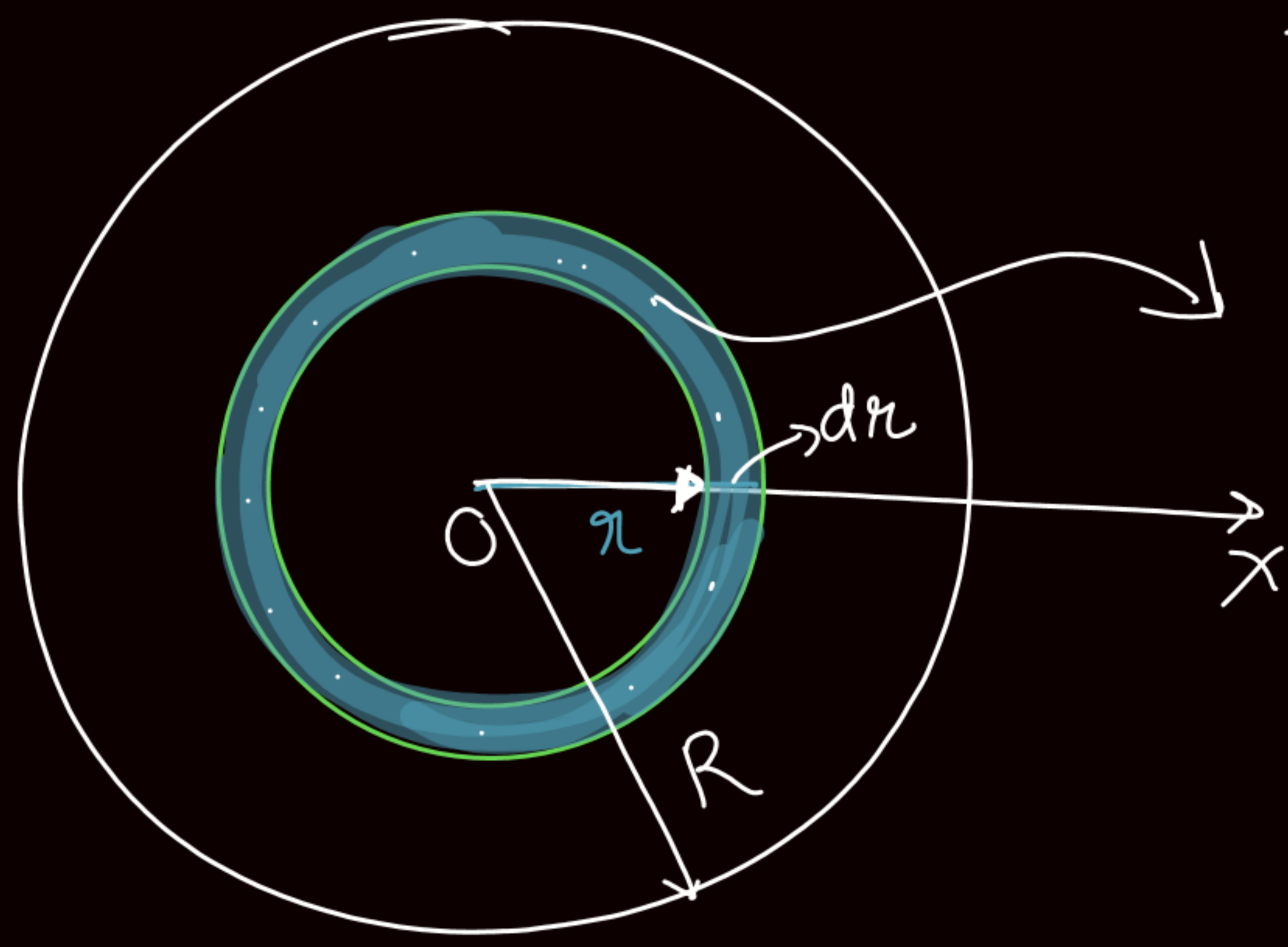
$$\vec{E} = (E_0 x)\hat{k}$$

$$\int d\phi = \int_0^h (E_0 x)\, L\, dx$$

$$\phi = E_0 L \frac{x^2}{2}\Big|_0^h$$

$$= \frac{1}{2} E_0 L h^2 .$$

Q



$\vec{E} = E_0 r \hat{k}$

$2\pi r\, dr = dA$

$$\int_0^{\phi} d\phi = \int_0^{R} (E_0 r)(2\pi r\, dr)$$

$$= E_0 2\pi \frac{R^3}{3}$$

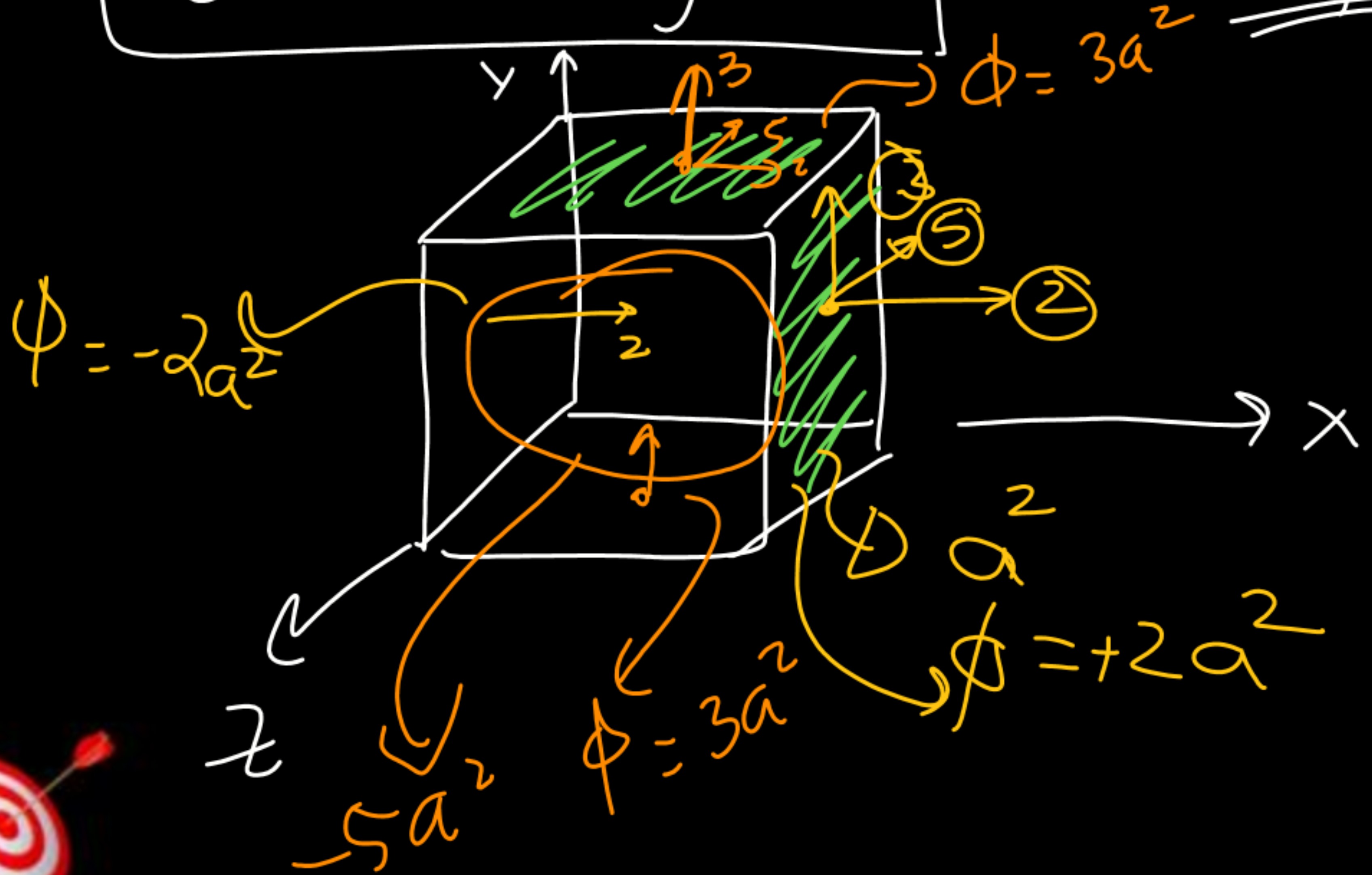
$$= \frac{2}{3} E_0 \pi R^2$$

$$\frac{r^{2+1}}{2+1}$$

Electric field in space is E = 2i +3j -5k, find the electric flux passing through the whole cube and through its individual faces. Side length of cube is 'a' and its edges are parallel to the coordinate axis.

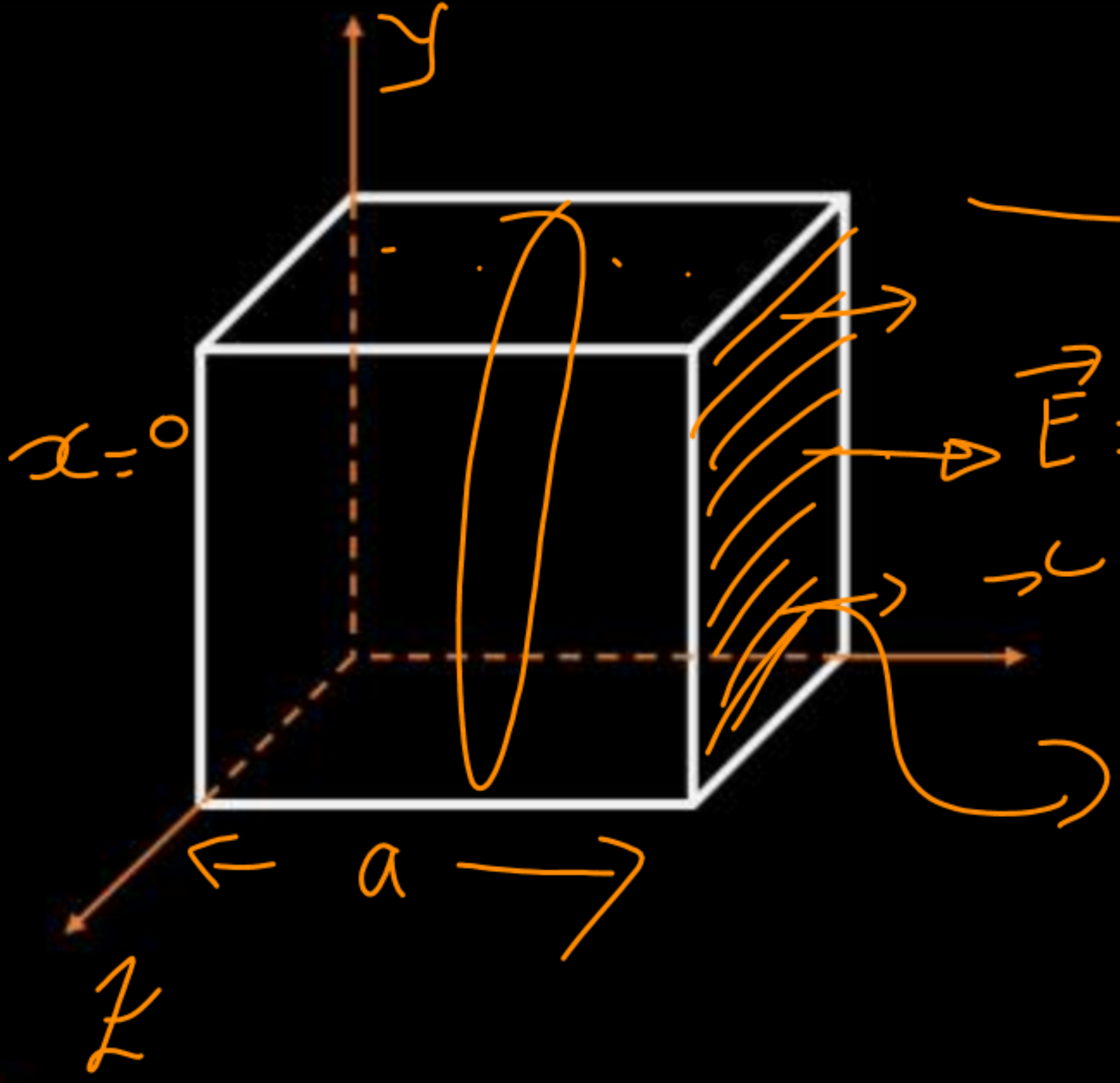
$\vec{E} = 2\hat{i} + 3\hat{j} - 5\hat{k}$ → Uniform

$\phi_{cube} = 0$



Electric field in space is E = xi, find the electric flux passing through the whole cube and through its individual faces. Side length of cube is 'a' and its edges are parallel to the coordinate axis.

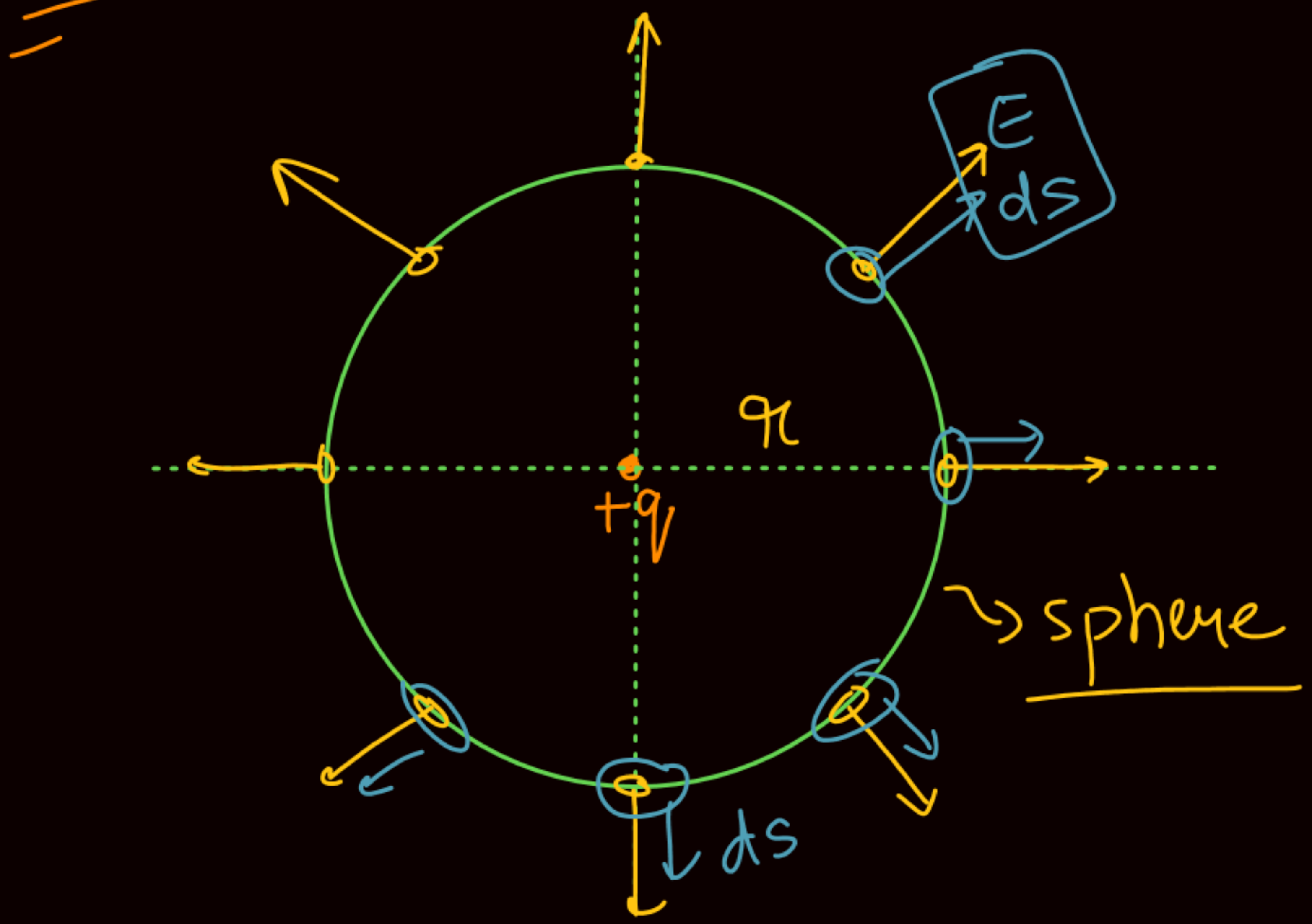
$E = x\hat{i}$ ← non uniform



$\phi_{cube} =$

$\phi = E \times \text{area}$
$= a \times a^2 = a^3$

4. E => non uniform; area = curved.



$$\phi = \int \vec{E} \cdot \vec{ds}$$

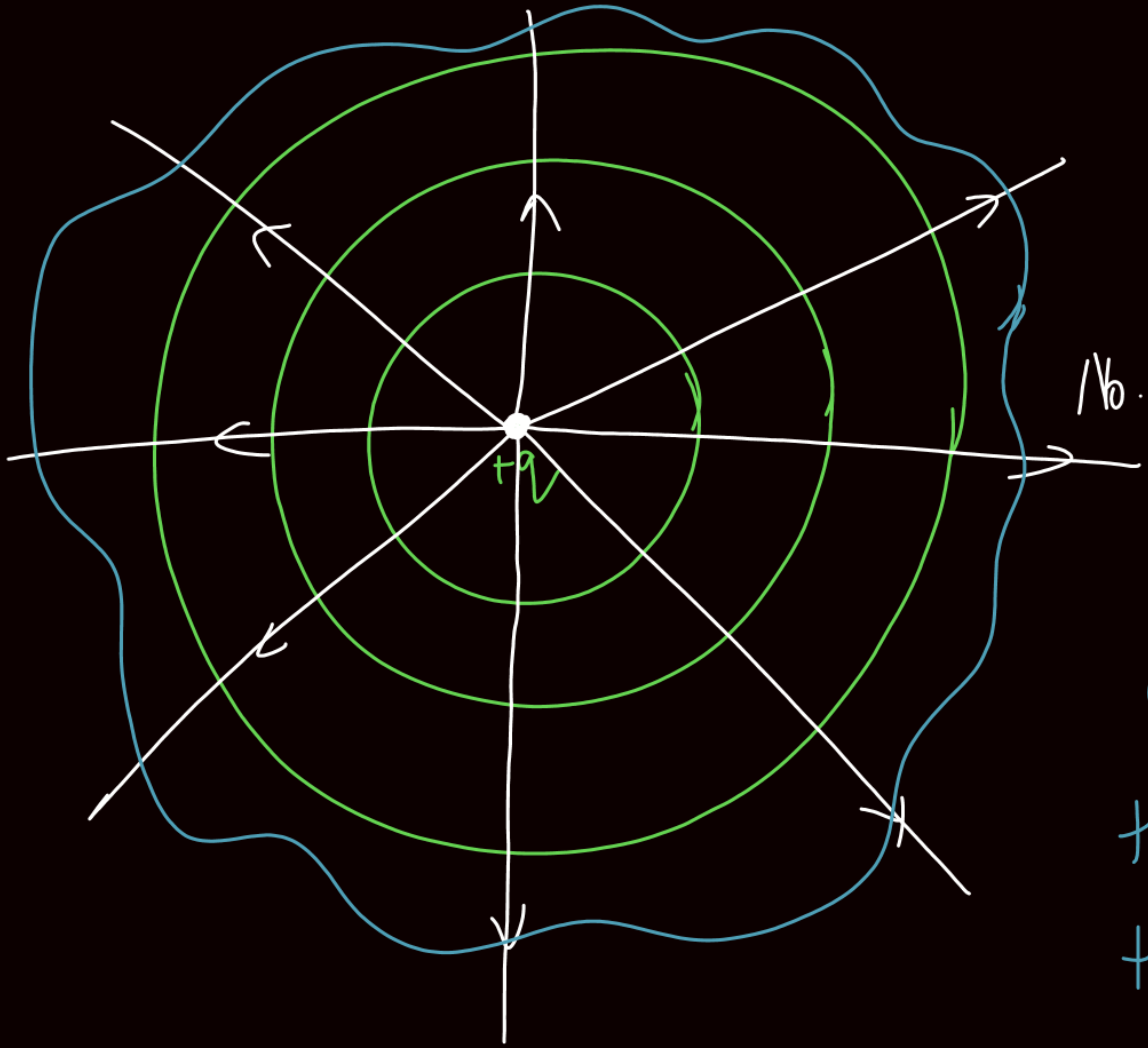
$$= \int E\, ds \cos 0$$

$$= E \int ds$$

$$= \frac{Kq}{r^2} 4\pi r^2$$

$$= \frac{1}{4\pi\varepsilon_0} q\, 4\pi$$

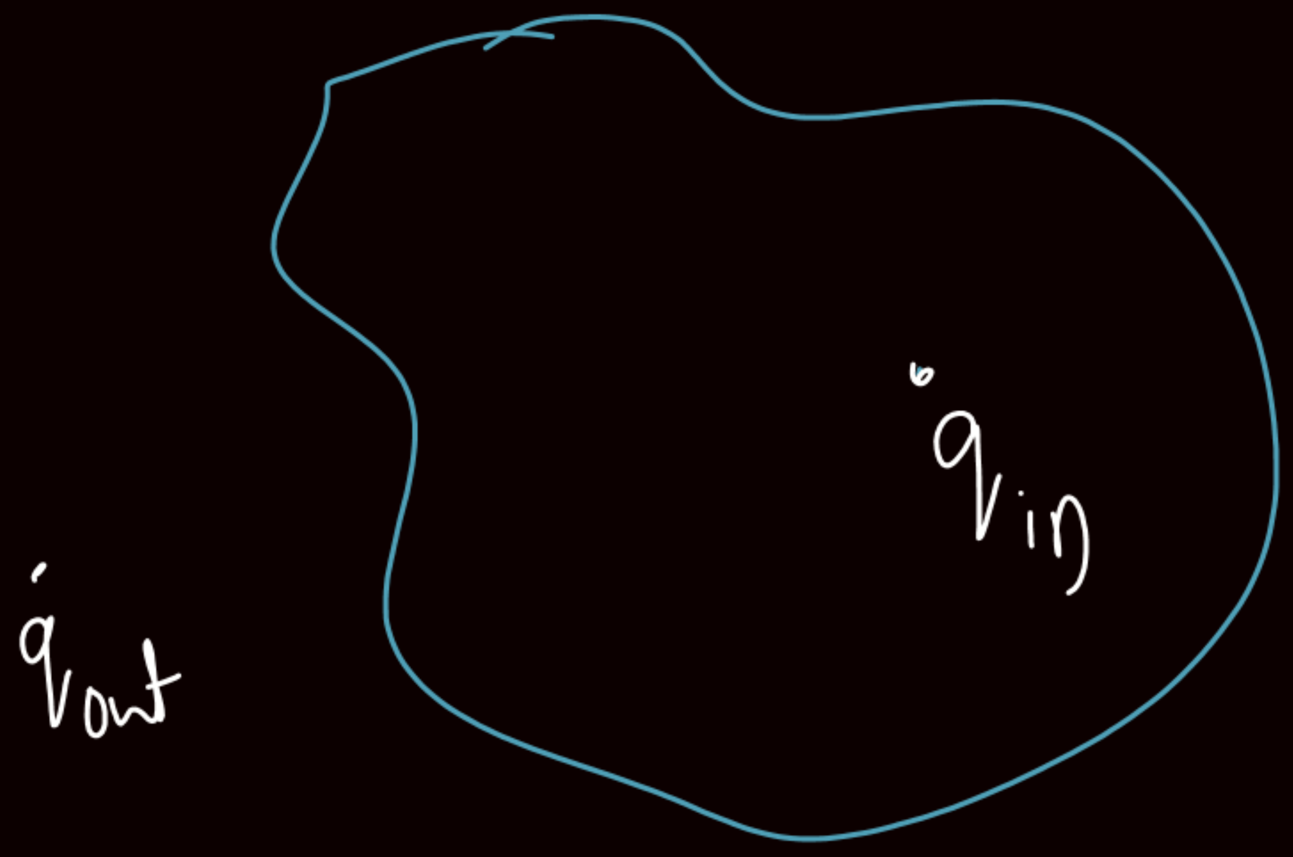
$$\boxed{\phi = \frac{q}{\varepsilon_0}}$$ (independent of r).



$\phi_{sphere_1} = \phi_{sphere_2} = \phi_{sphere_3}$

No. of F.L. are equal through all the spheres.

Gauss law :- Electric flux passing through a closed surface is $\frac{1}{\varepsilon_0}$ times the charge enclosed by the surface.



$$\phi_{\text{closed surface}} = \oint \vec{E} \cdot d\vec{s} = \frac{q_{in}}{\varepsilon_0}$$

It is due to all the charges

Thank You Lakshyians