# LAKSHYA JEE

LAKSHYA KO HAR HAAL ME PAANA HAI

## Electric Charges and Field

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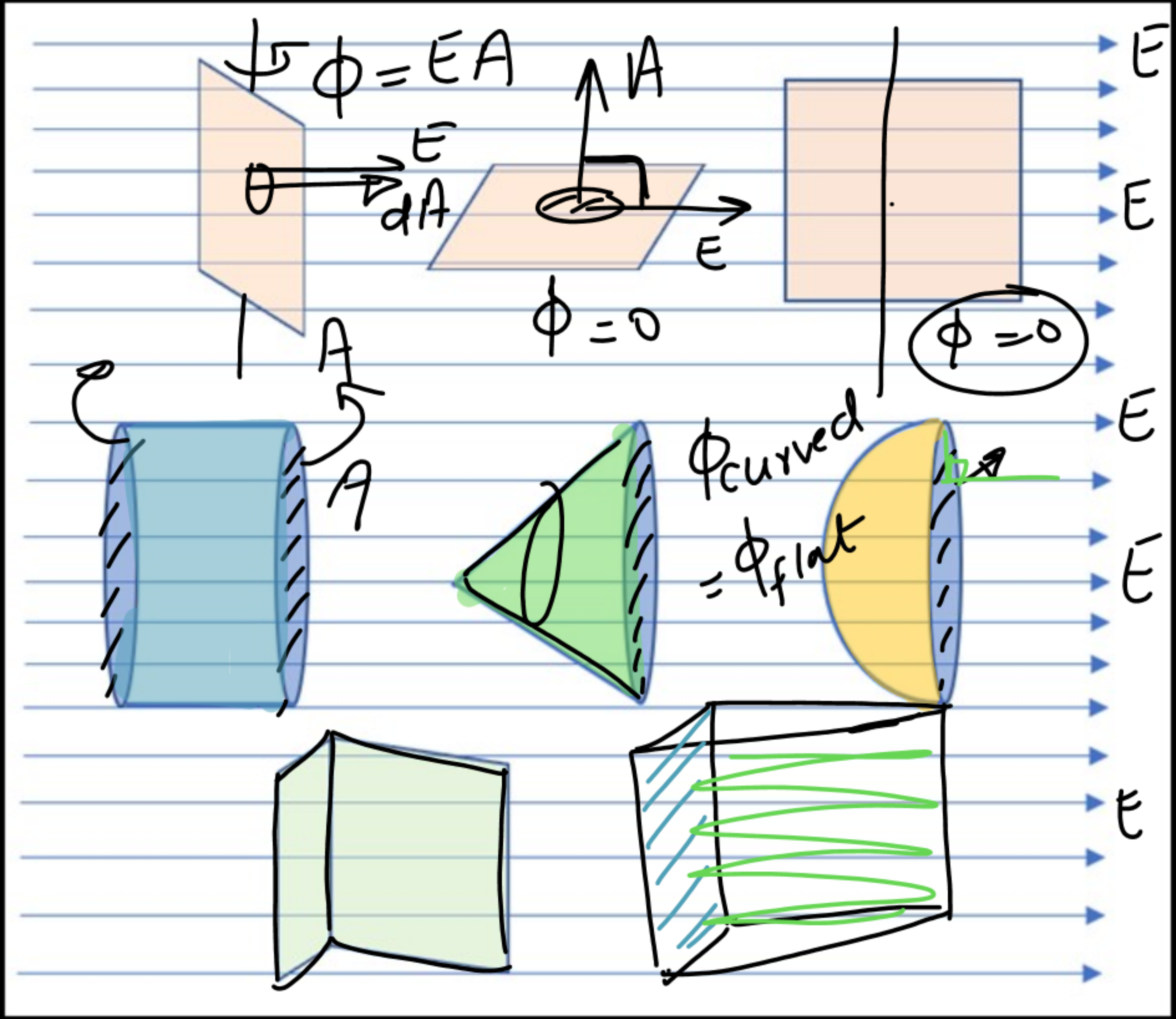
# Today's GOALS!

- ❑ Applications of Gauss Law

# Electric Flux

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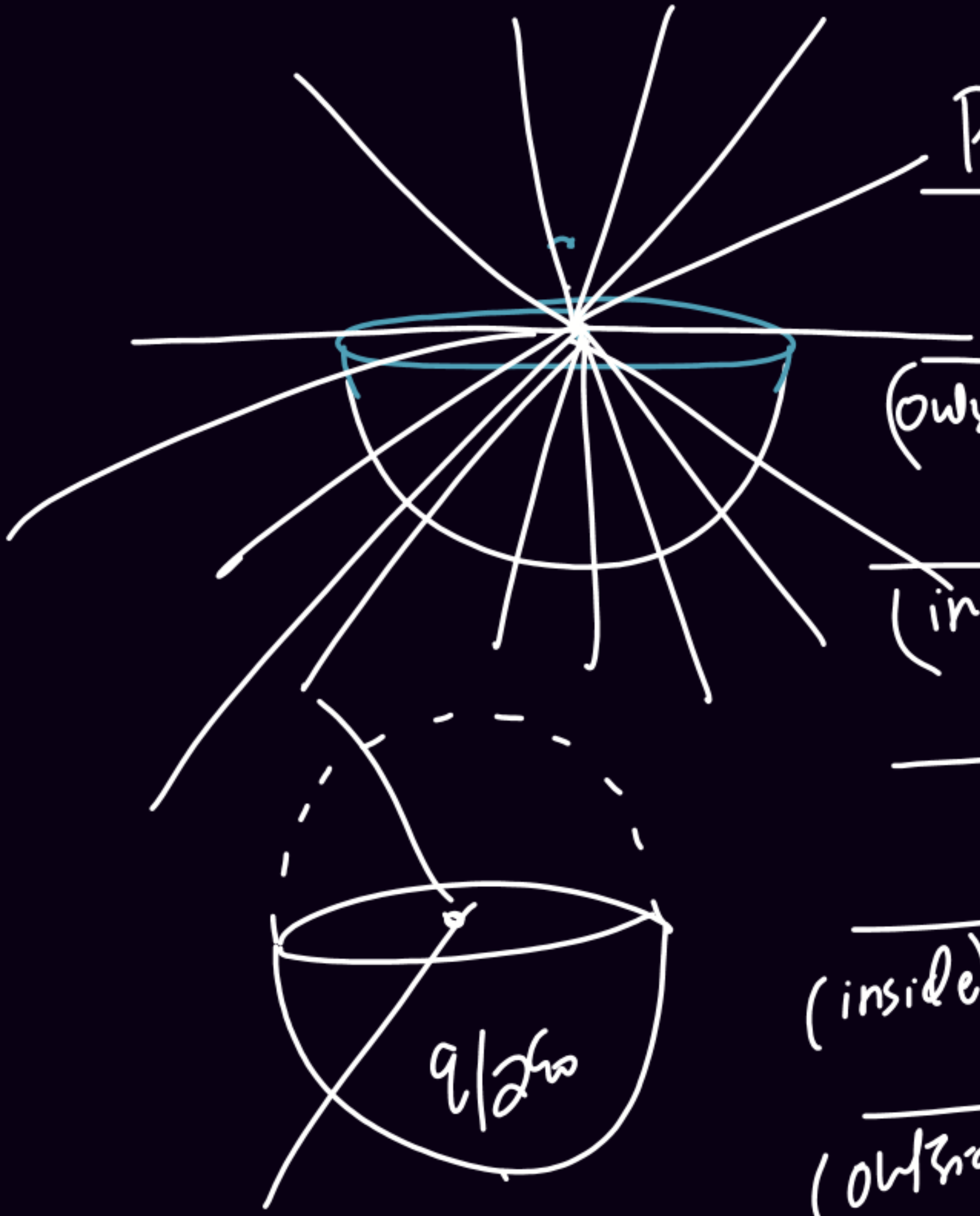
# Electric Flux

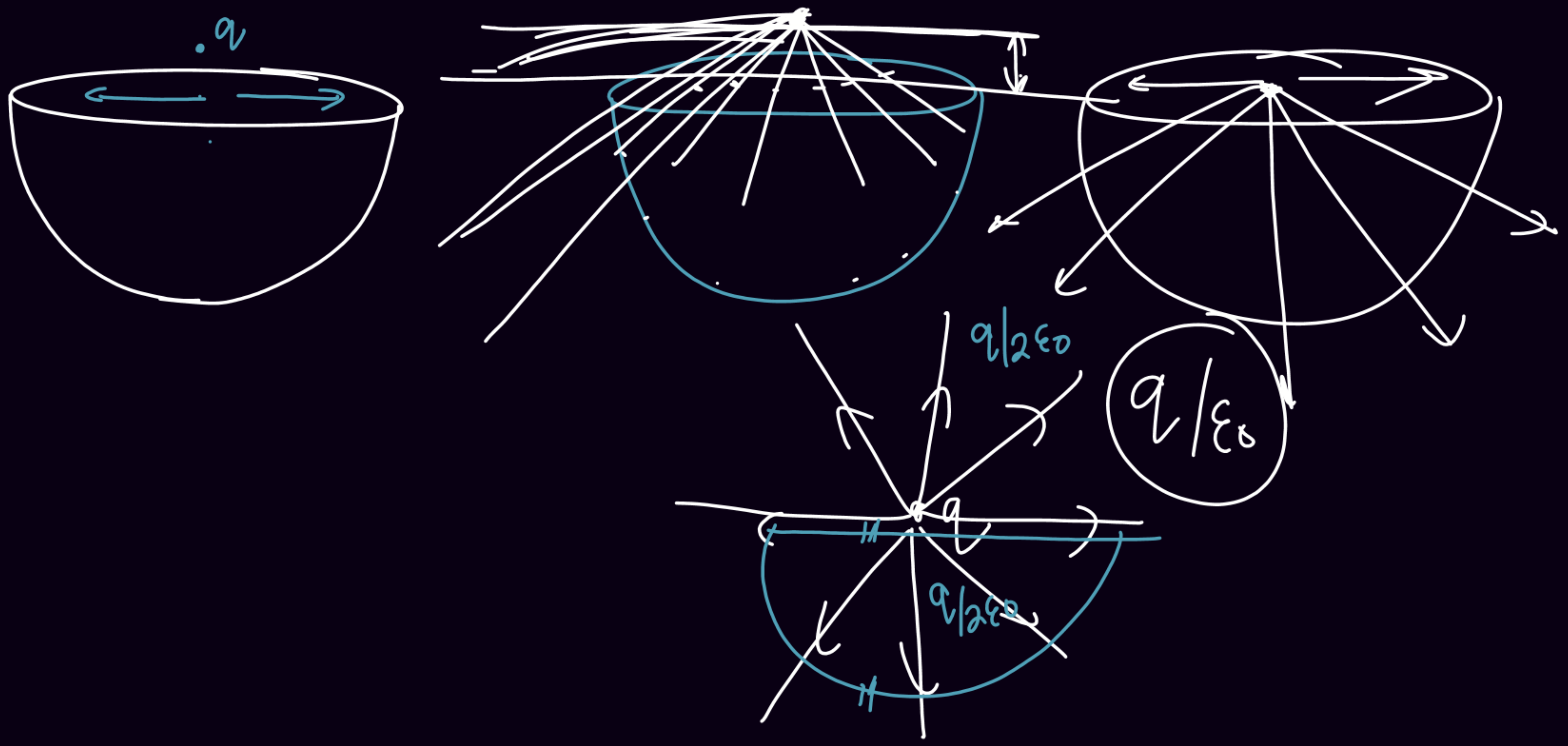
# H.W

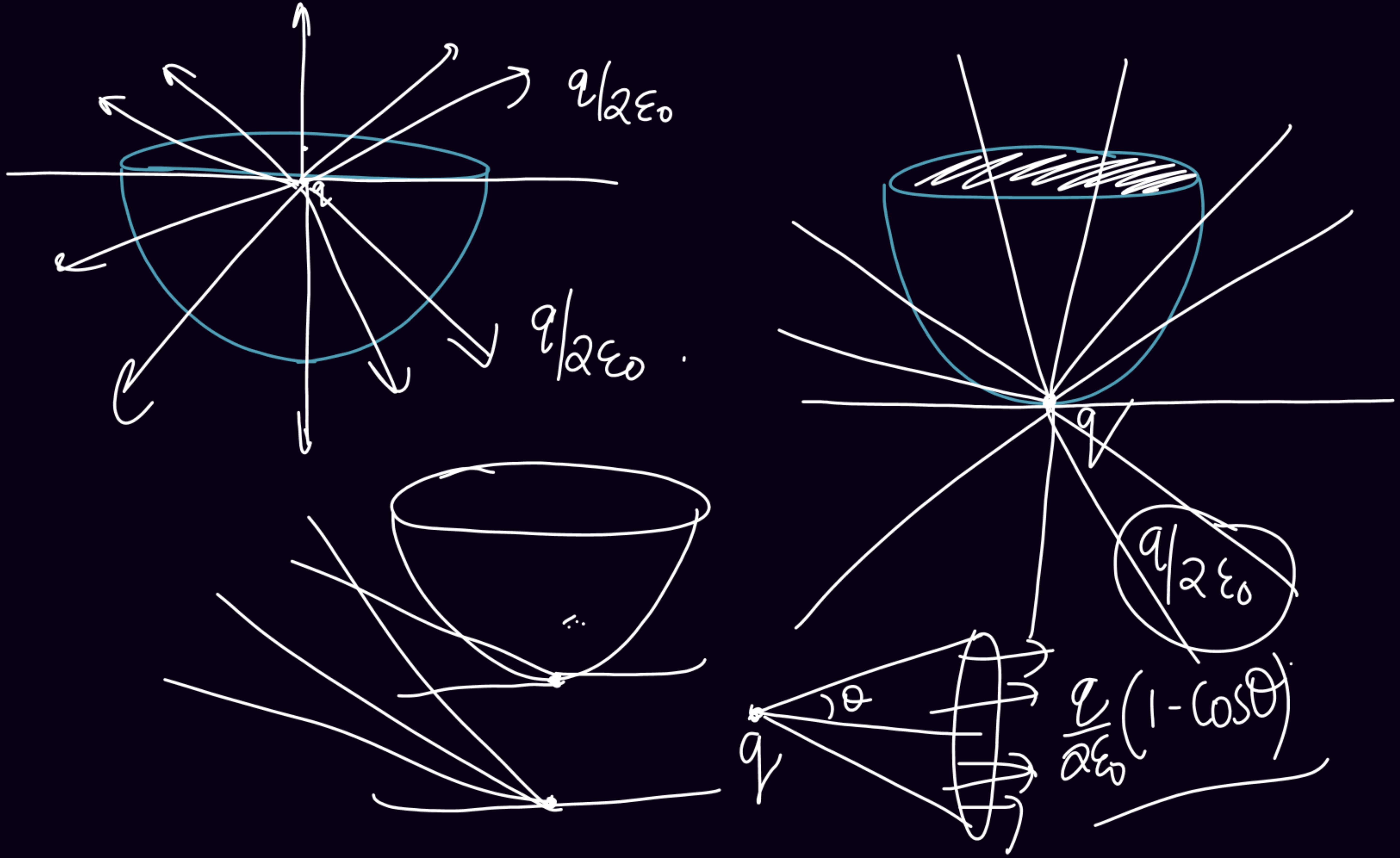


| Position | $\phi_{flat}$ | $\phi_{curved}$ | $\phi_{hemisphere}$ |
|---|---|---|---|
| 1 | $0$ | $\frac{q}{2\varepsilon_0}$ | $\frac{q}{2\varepsilon_0}$. |
| (outside) 2 | $-\frac{q}{2\varepsilon_0}$ | $\frac{q}{2\varepsilon_0}$ | $0$ |
| (inside) 3 | $\frac{q}{2\varepsilon_0}$ | $\frac{q}{2\varepsilon_0}$ | $q/\varepsilon_0$ |
| 4 | $\frac{q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$ | $\frac{q}{2\sqrt{2}\,\varepsilon_0}$. | $q/2\varepsilon_0$ |
| (inside) 5 | $\frac{q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$ | $\frac{q}{2\varepsilon_0}\left(1+1/\sqrt{2}\right)$ | $q/\varepsilon_0$. |
| (outside) 6 | $\frac{q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$ | $-\frac{q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$ | $0$ |

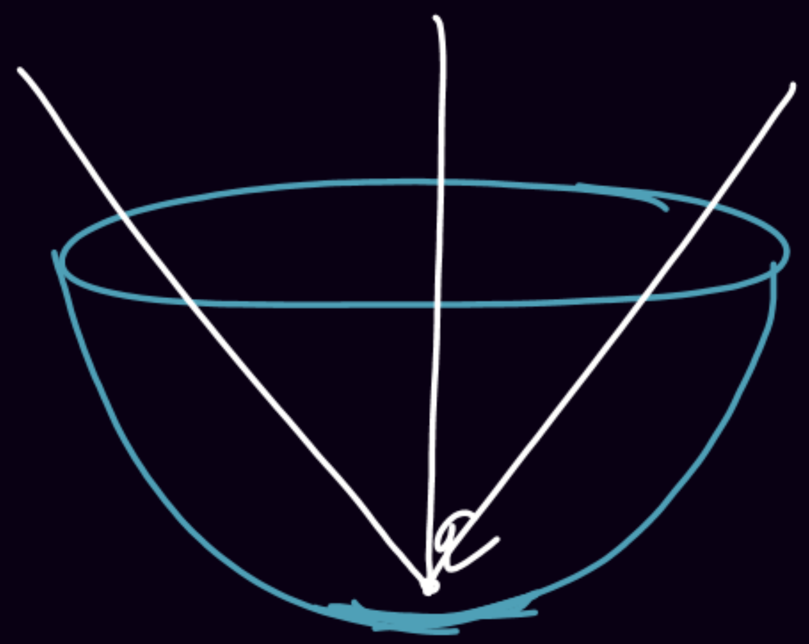

$$\frac{q}{2\varepsilon_0} - \frac{q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$$

$$\frac{q}{2\sqrt{2}\,\varepsilon_0}$$


q
q/2ε₀
q/ε₀
q
q/2ε₀


q/2ε₀
q
q/2ε₀
q
q/2ε₀
θ
q
q/2ε₀ (1 - cosθ)

5




$$\Phi_{hemisphere} = \frac{q}{\varepsilon_0}$$

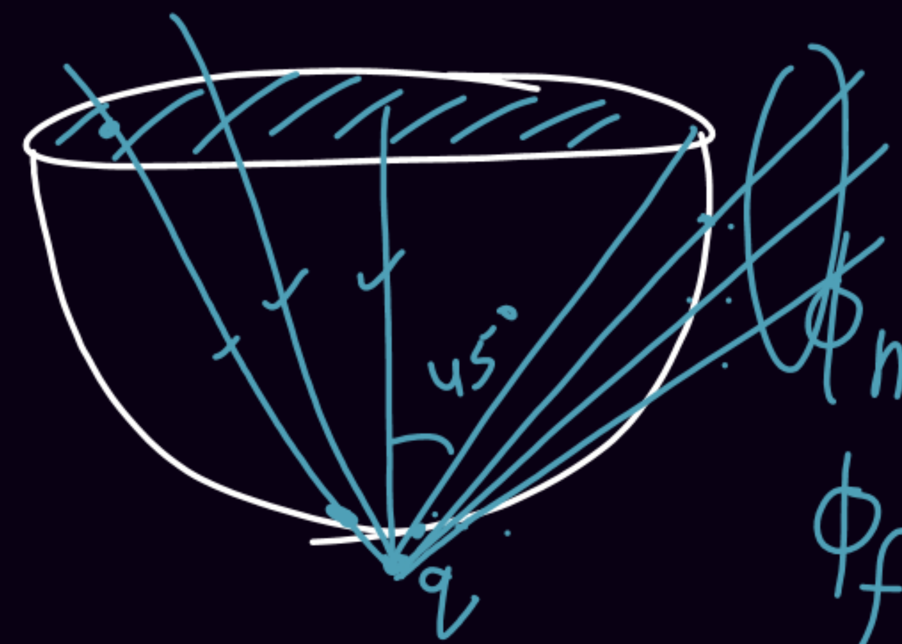
$$\Phi_{flat} = \frac{q}{2\varepsilon_0}\left(1 - \cos 45^\circ\right)$$

$$\boxed{\Phi_{curved} = \Phi_{hemisphere} - \Phi_{flat}} = \frac{q}{\varepsilon_0} - \frac{q}{2\varepsilon_0}\left(1 - \frac{1}{\sqrt{2}}\right)$$

$$= \frac{q}{2\varepsilon_0} + \frac{q}{2\varepsilon_0\sqrt{2}}$$

$$= \frac{q}{2\varepsilon_0}\left(1 + \frac{1}{\sqrt{2}}\right)$$

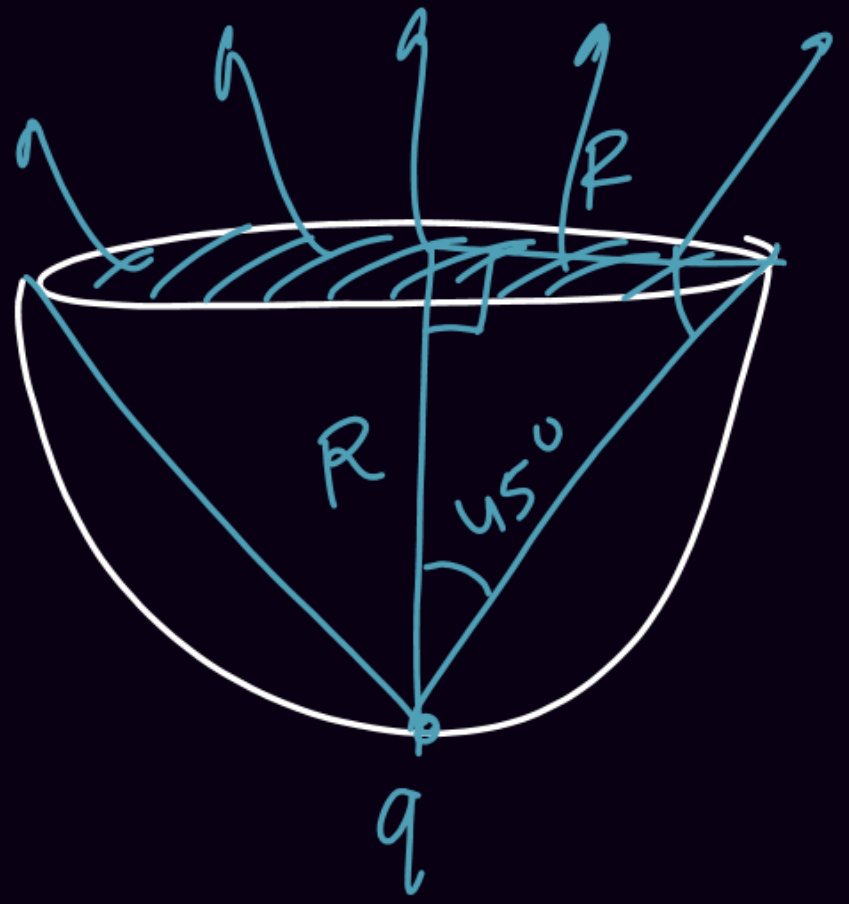
6




$$\Phi_{hemisphere} = 0$$

$$\Phi_{flat} = \frac{q}{2\varepsilon_0}\left(1 - \cos 45\right)$$

$$\Phi_{curved} = -\frac{q}{2\varepsilon_0}\left(1 - \frac{1}{\sqrt{2}}\right)$$



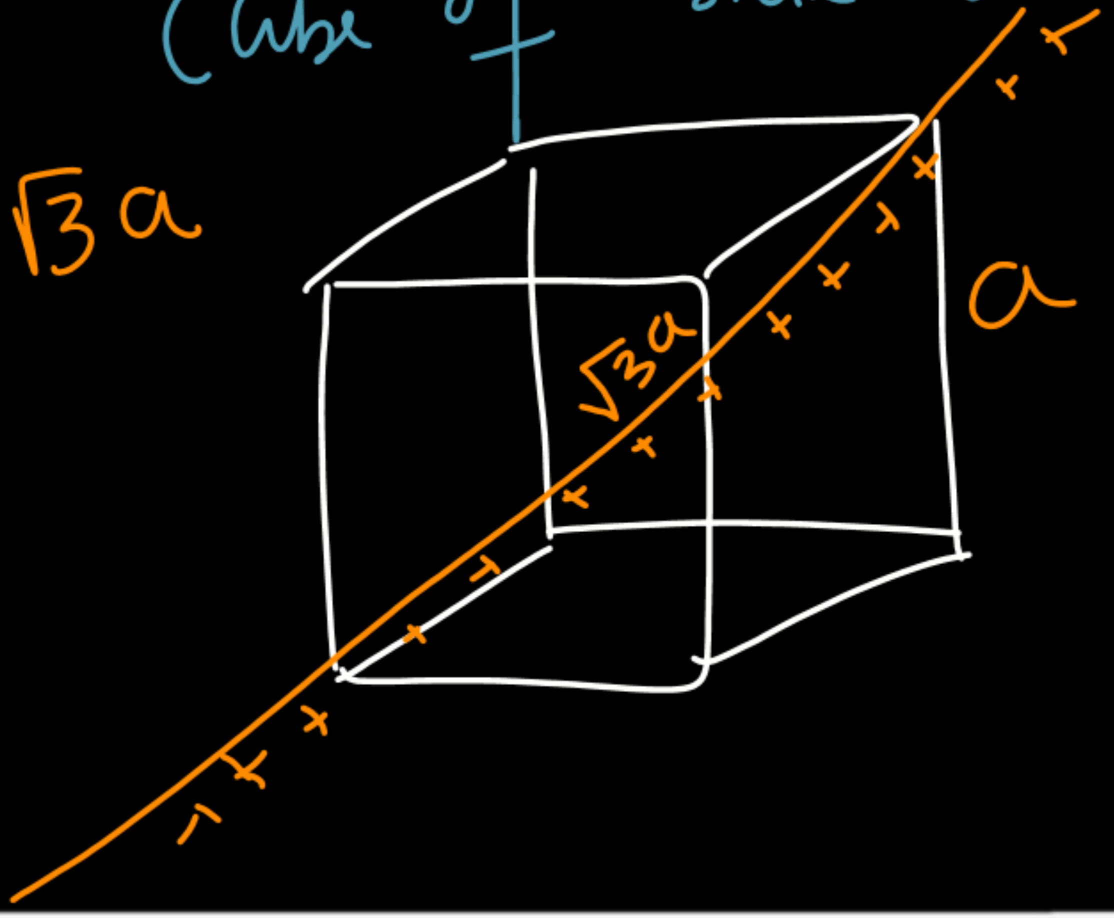

$$\Phi_{flat} = \frac{q}{2\varepsilon_0}\left(1 - \cos 45^\circ\right)$$

$$= \frac{q}{2\varepsilon_0}\left(1 - \frac{1}{\sqrt{2}}\right)$$

# Applications of Gauss Law

Q. An infinite charged wire has charged density $\lambda$. Find the max. flux this wire can produce in a cube of side 'a'.

$Q_{in} = \lambda\sqrt{3}a$




For maximum flux, max. length of wire should be inside the cube.

$$\phi = \frac{Q_{in}}{\varepsilon_0} = \frac{\lambda\sqrt{3}a}{\varepsilon_0} \quad \underline{\text{Ans.}}$$

# Finding the electric field using gauss law

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

Gaussian Surface = Imaginary Surface

* It should be closed!

# Point charge

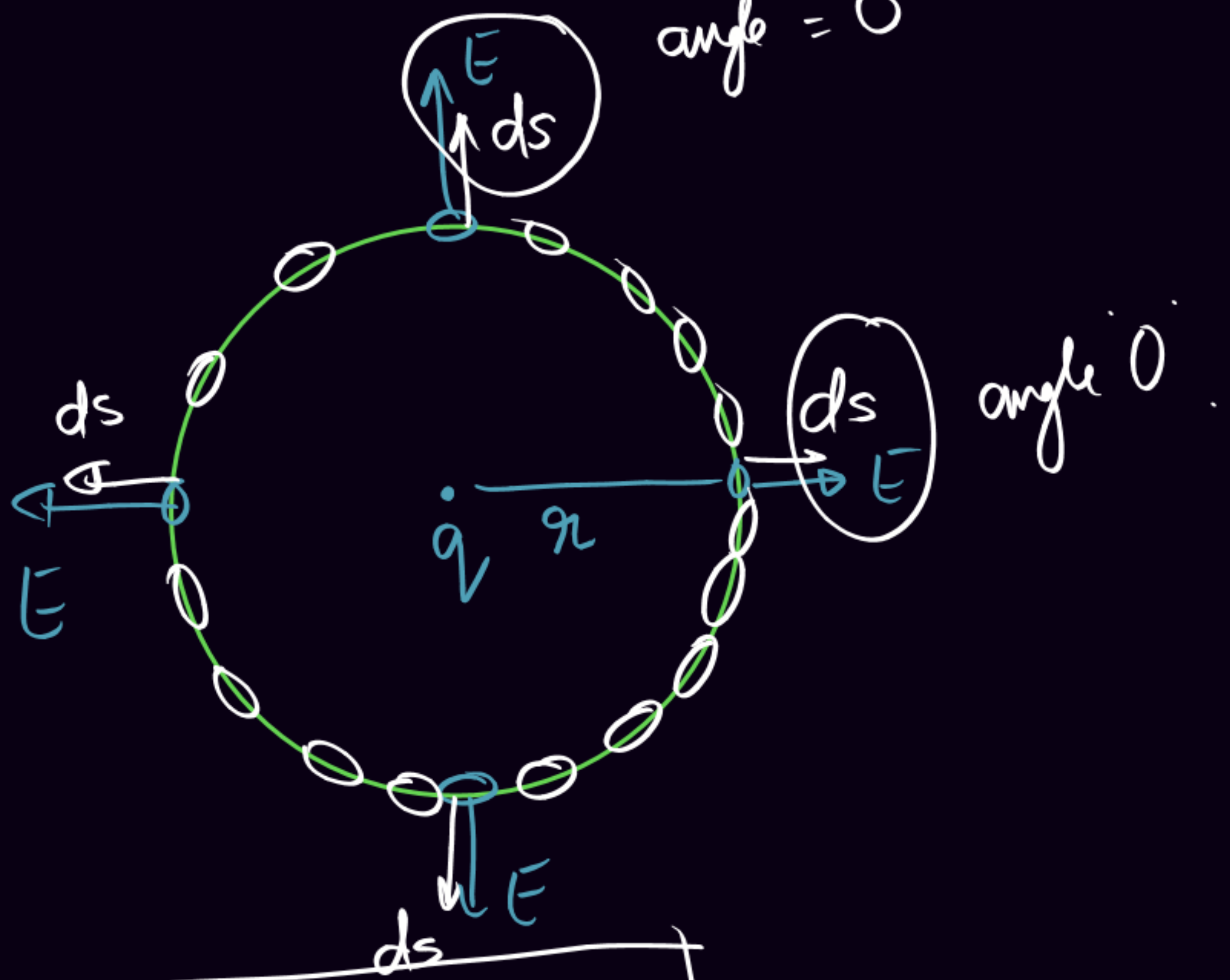
$$\oint \vec{E} \cdot \vec{ds} = \frac{q_{in}}{\varepsilon_0}$$

$$\oint E\, ds \cos\theta = \frac{q_{in}}{\varepsilon_0}$$

$$E \oint ds = \frac{q}{\varepsilon_0}$$

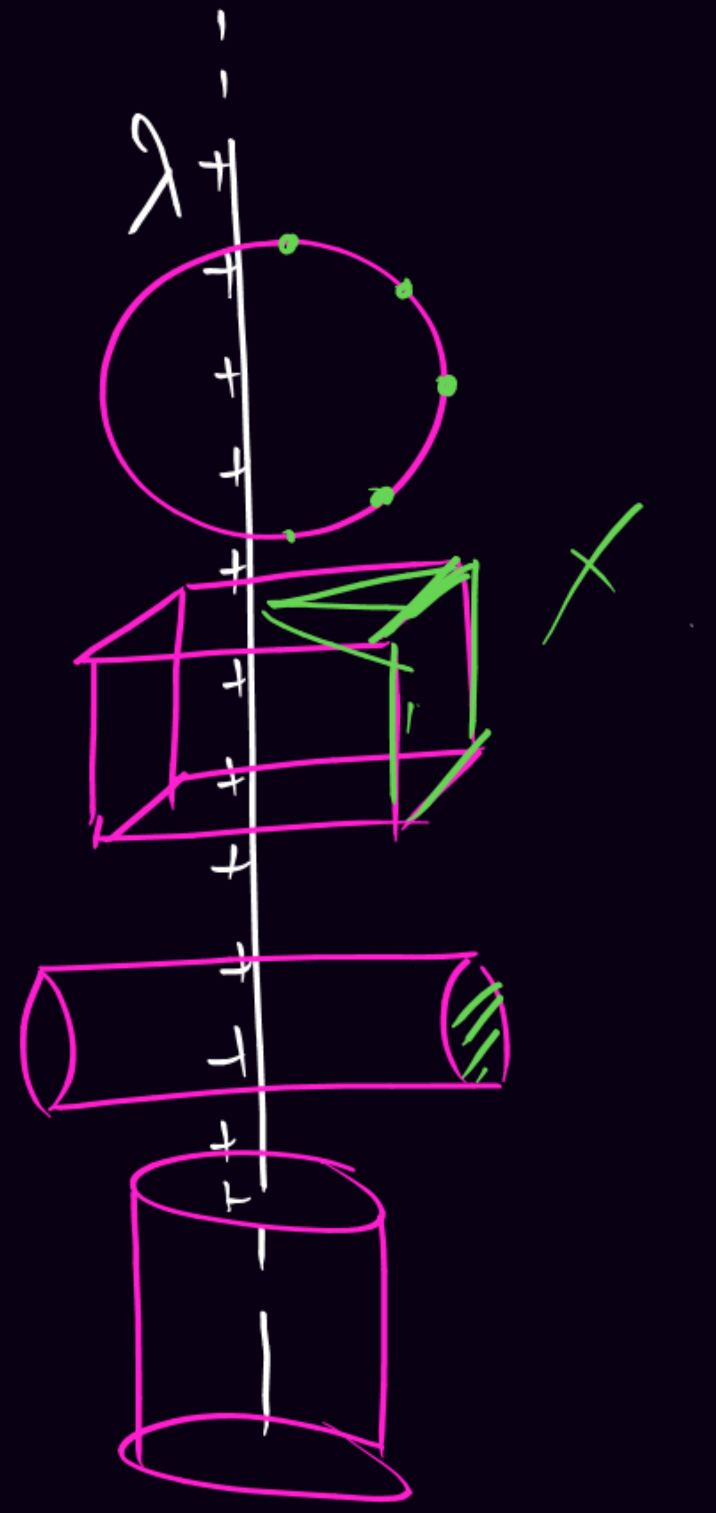
$$E\, 4\pi r^2 = q/\varepsilon_0$$

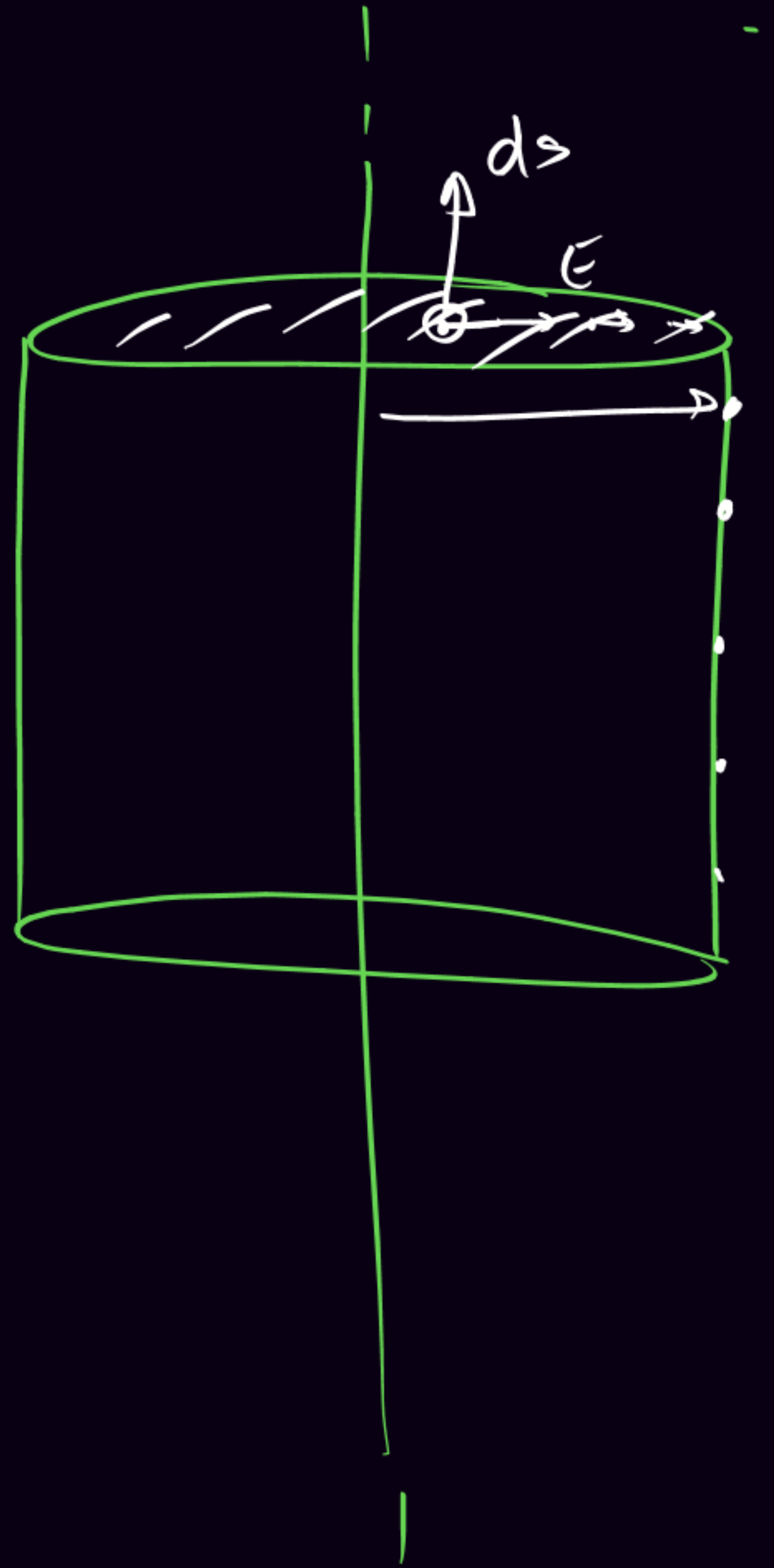
$$\boxed{E = \frac{q}{\underline{\underline{4\pi\varepsilon_0}}\, r^2} = \frac{Kq}{r^2}}$$

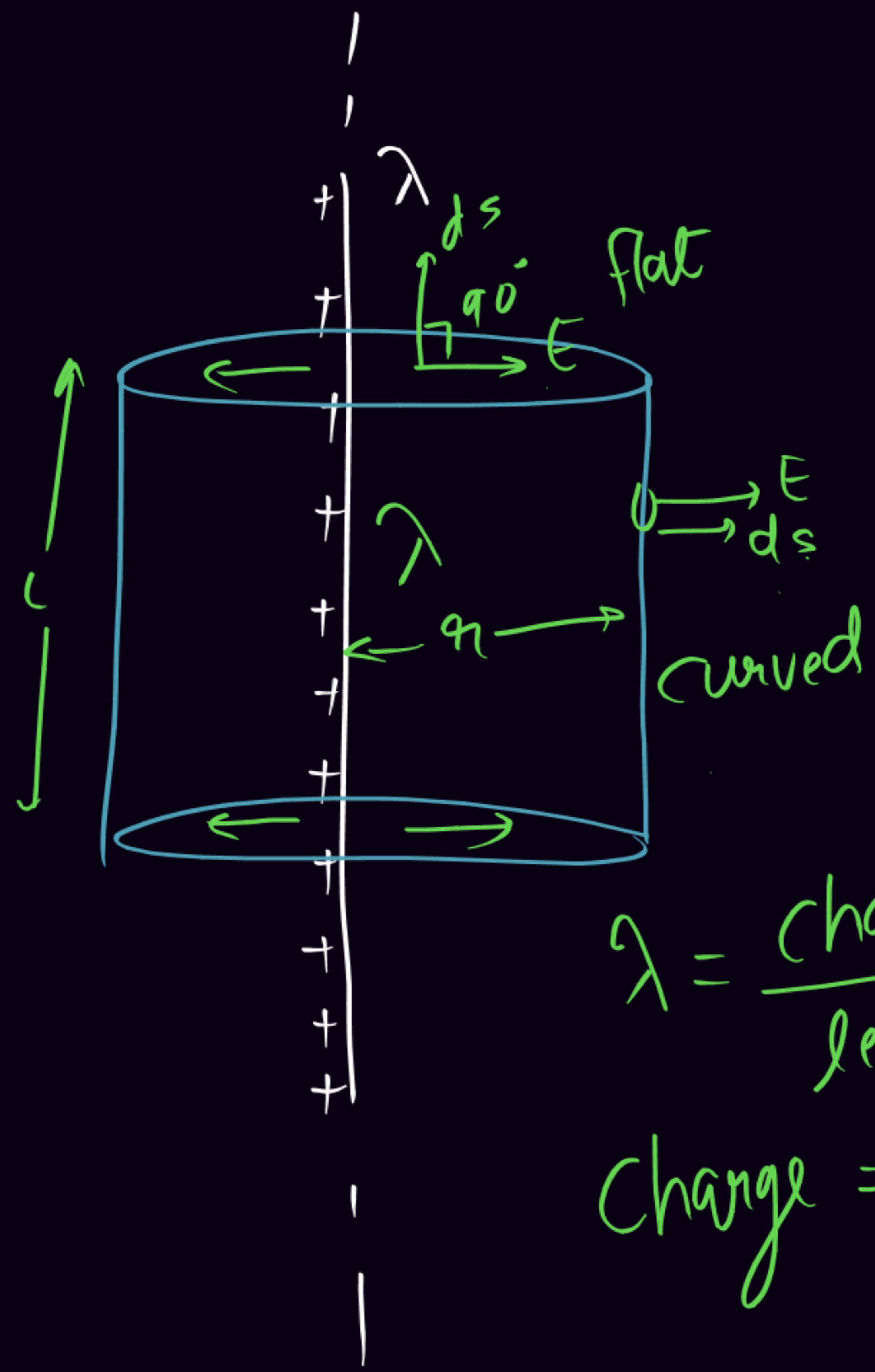



$$\boxed{\vec{A} \cdot \vec{B} = AB\cos\theta}$$

② Infinite charged wire






$$\oint \vec{E} \cdot \vec{ds} = \frac{q_{in}}{\varepsilon_0}$$

$$\int_{flat} E\, ds \cancel{\cos 90} + \int_{curved} E\, ds \cos 0 = \frac{\lambda L}{\varepsilon_0}$$

$$E \int_{curved} ds = \frac{\lambda L}{\varepsilon_0}$$

$$E\, 2\pi r \cancel{L} = \frac{\lambda \cancel{L}}{\varepsilon_0}$$

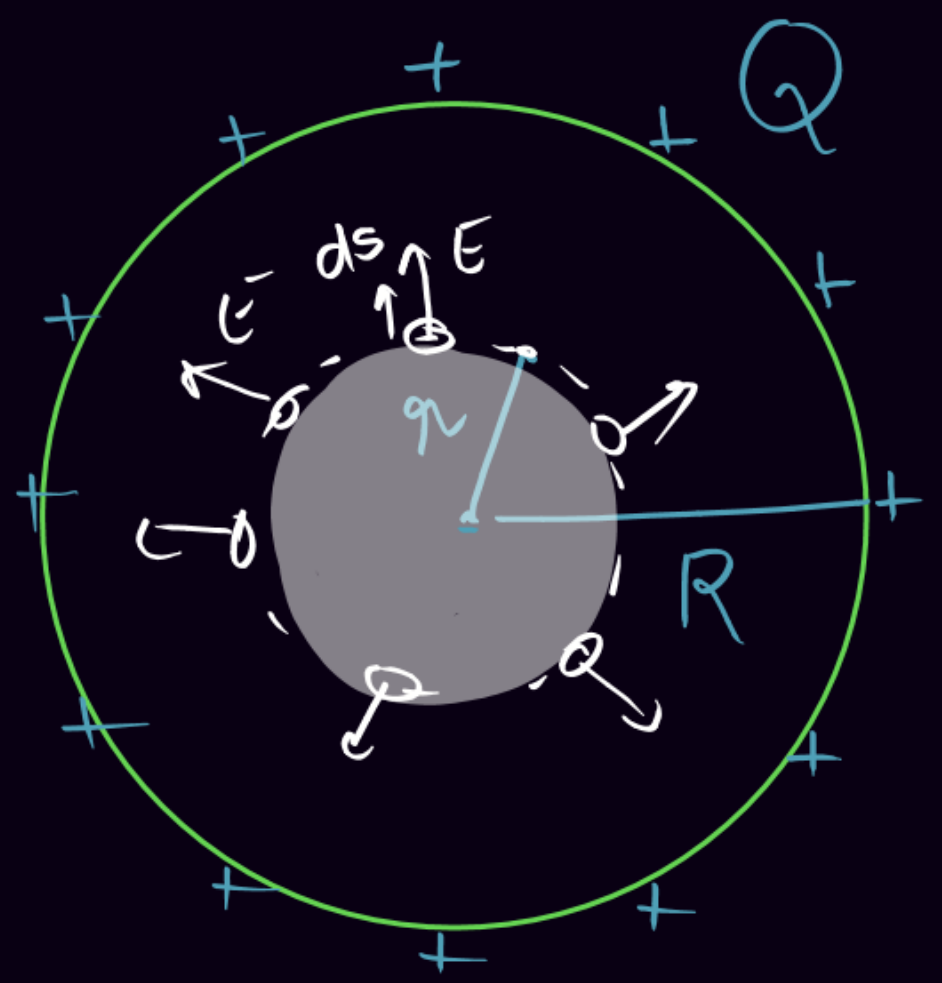
$$E = \frac{\lambda}{2\pi\varepsilon_0 r} = \frac{2K\lambda}{r}$$

$$\lambda = \frac{\text{charge}}{\text{length}}$$

$$\text{Charge} = \lambda \times \text{length} = \lambda L$$

# Hollow sphere / spherical shell

(i) $r < R$ (ii) $r > R$



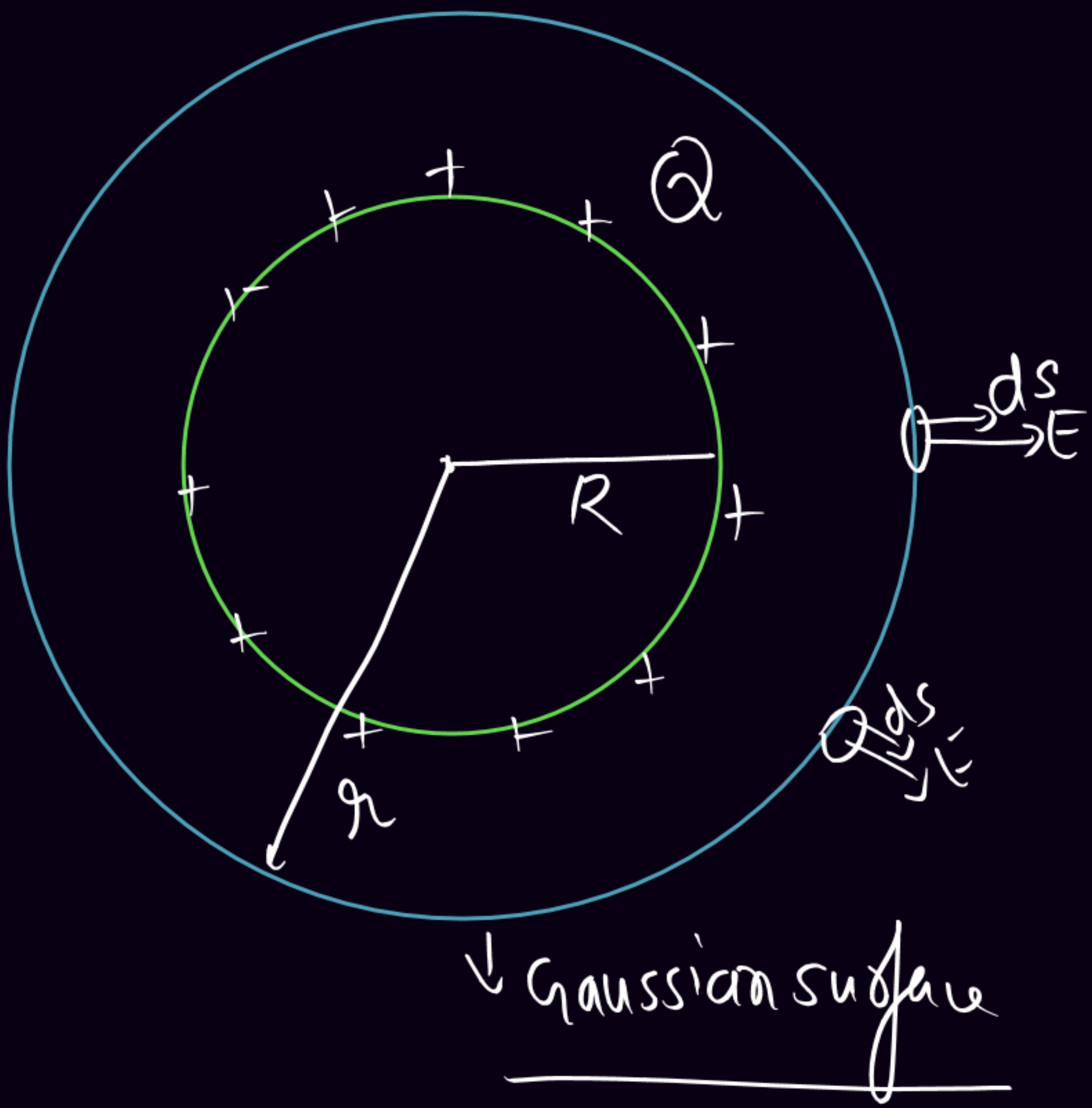

(i) Inside point $r < R$

$$\oint E\, ds \cos 0 = \frac{0}{\varepsilon_0}$$

$$E \oint ds = 0$$

$$E\, 4\pi r^2 = 0$$

$$\boxed{E_{in} = 0}$$




$$\oint E\,ds\cos\theta = \frac{Q}{\varepsilon_0}$$

$$E\,4\pi r^2 = \frac{Q}{\varepsilon_0}$$

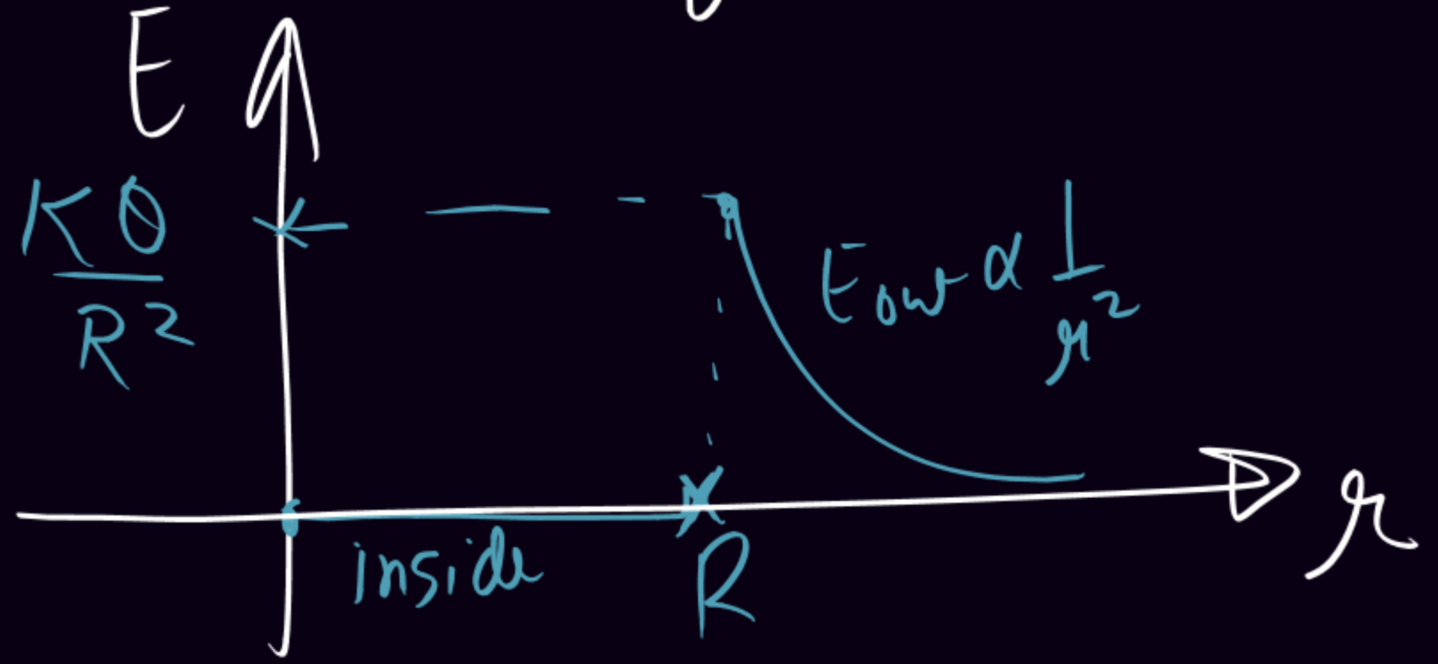
$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$\boxed{E_{out} = \frac{KQ}{r^2}}$$

# Shell th

A uniformly charged sphere behaves as a point charge placed at the center for the outside world.

$E_{out} = \frac{KQ}{r^2}$



# Thank You Lakshyians