Gauss's Law

Used to calculate electric field for continuous charge distributions

Electric Flux

→ Scalar

$$\phi_E = EA\cos\theta = \vec{E}\cdot\vec{A}$$

$\vec{A}$ → magnitude → area; direction → direction of field lines

θ → Angle b/w E & normal / perpendicular vector to the surface

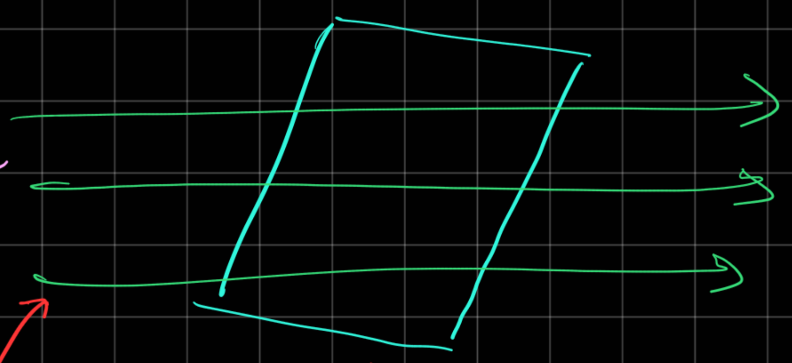
A → Area

E → Electric Field

ϕ_E → Electric Flux → No. of electric field lines that pass through the surface

$$\phi_E = \oint \vec{E}\cdot d\vec{A}$$

↳ if $\vec{E}$ is not uniform



Electric flux does not exist if a normal is perpendicular to the electric field / parallel to the surface

ϕ_E = No. of electric field lines leaving the surface − No. of electric field lines entering the surface

minus

Electric Flux

Electric Flux for closed surfaces is always zero since no. of lines entering = no. of lines leaving

Cube Example

Net Electric Flux

$-El^2 + El^2 = 0$

Cylinder Example

Curved surface does not have flux

$\Phi_E = E(\pi r^2)\cos\theta$

$= E\pi r^2$

$\Phi_E = E(\pi r^2)\cos\theta$

$= E\pi r^2$

$\therefore$ Total Electric Flux $= 2E\pi r^2$

Gauss's Law

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$K_e = \frac{1}{4\pi\epsilon_0}$$

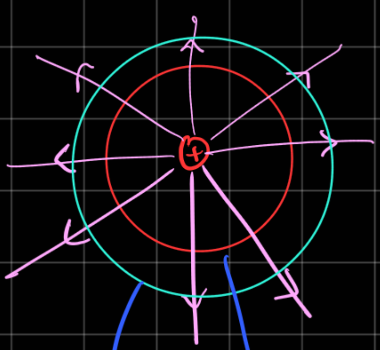
enclosed charge inside surface

$\hookrightarrow$ permitivity of free space

8.5×10^{-12}

property of a material

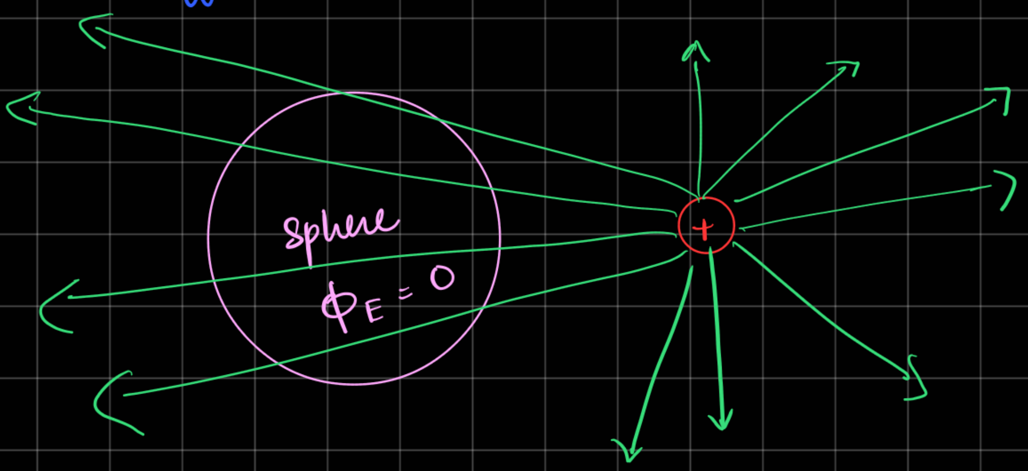
ability of material to allow electric field lines to pass through



0 electric flux = 0 electric flux

also

has electric flux



A) triples

B) doesn't change

C) ″

D) ″

Applying Gauss's Law

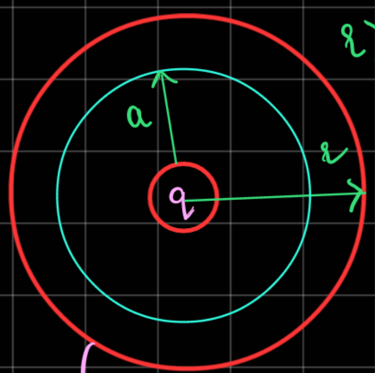
Step 1 : Define Gaussian surface to make calculation easy

Meets the requirements sphere

i) $\vec{E}$ is same at every point on surface

ii) $\vec{E}$ parallel to $\vec{A}$ $\rightarrow$ $\therefore \cos\theta = 1$ $\therefore \phi_E = \vec{E}\cdot\vec{A}$

iii) $\vec{E} \perp \vec{A}$ $\rightarrow$ $\therefore \cos\theta = 0$ $\therefore \phi_E = 0$



Gaussian Surface

Area of Gaussian Surface

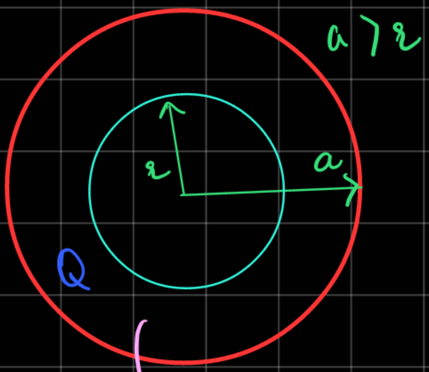
$$\phi_E = \oint E \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$\vec{E}\oint d\vec{A} = \frac{Q}{\epsilon_0}$$

$$\vec{E}\,4\pi r^2 = \frac{Q}{\epsilon_0}$$

$$E = \frac{Q}{4\pi r^2 \epsilon_0}$$

$$= \frac{k_e Q}{r^2} \qquad K = \frac{1}{4\pi \epsilon_0}$$



Gaussian Surface

$$\Phi_E = \oint \vec{E} \cdot d\hat{A} = \frac{q_{in}}{\epsilon_0}$$

$$\vec{E}\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$E(4\pi r^2) = \frac{\rho V}{\epsilon_0}$$

Volume Charge Density

$$\rho = \frac{Q}{V}$$

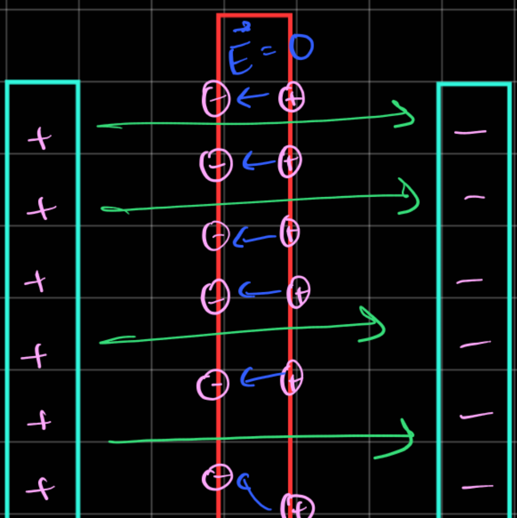
$$Q = \rho V$$

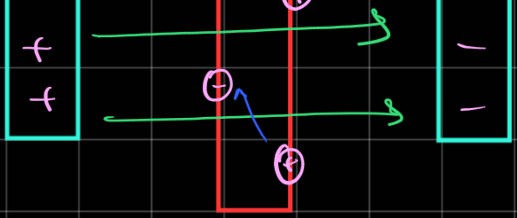
$$E(4\pi r^2) = \frac{\rho\left(\frac{4}{3}\pi r^3\right)}{\epsilon_0}$$

Electrostatic Equilibrium

Free electrons inside conductor are not moving

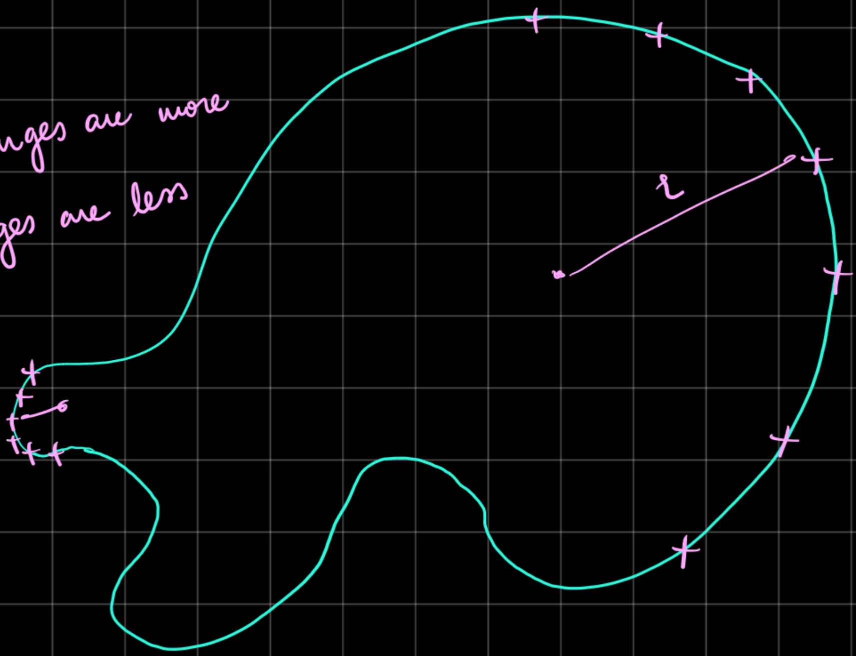
- → Electric field $(\vec{E}) = 0$
- → Electric charges are on the surface
- → $\vec{E}$ is normal to the surface $= \frac{\sigma}{\epsilon_0}$
- → For irregular shapes
  σ is bigger where the radius is smaller





This will accelerate till electric field inside conductor is as strong as the one b/w the plates

if r is small, charges are more
if r is big, charges are less



Gauss's Law is useful for uniform distribution

$$E_2 = \frac{kQ}{r^2}$$

$$E_1 = \frac{kQ}{a^3} r$$