MASTERJEE CLASSES

ELECTRIC FLUX AND GAUSS'S LAW

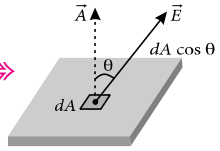
BRAIN MAP

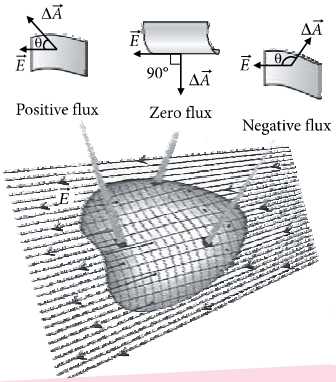
CLASS XII

ELECTRIC FLUX

Electric flux is a measure of flow of electric field through a surface. It is equal to the dot product of an area vector and electric field

- Flux of electric field E through any area A: $\phi = EA\cos\theta$ or $\phi = \vec{E}\cdot\vec{A}$
- For variable electric field or curved area $\phi = \int \vec{E}\cdot d\vec{A}$





- For a closed surface outward flux is taken to be positive while inward flux is taken to be negative.

To get a direct connection between the electric flux through closed surface and the total charge inside it.

Problem Solving Strategies

- *Select a symmetric gaussian surface as per the charge distribution.*
- *Calculate total electric charge inside the gaussian surface.*
- *For uniform charge density, simply multiply it by length, area and volume of surface.*
- *For non uniform charge density integrate it over the region enclosed the surface.*
- *Calculate electric field on the gaussians surface as per the given uniform charge distribution.*

GAUSS'S LAW

The total flux linked with a closed Gaussian surface is $(1/\varepsilon_0)$ times the charge enclosed by the closed surface *i.e.*,

$$\phi = \int_s \vec{E}\cdot\vec{dA} = \frac{1}{\varepsilon_0}(Q_{enc})$$

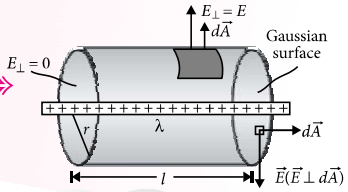
APPLICATIONS OF GAUSS'S LAW

Flux across some definite symmetric closed surfaces

- **Hemispherical body**
  In uniform electric field $\phi_{circular} = -\phi_{curved}; |\phi_{circular}| = \pi R^2 E$
  In non uniform electric field $\phi_{circular} = -\phi_{curved}; |\phi_{curved}| = 2\pi R^2 E$
- **Gaussian Cube**
  Charge kept at corner $\phi_{cube} = \frac{Q}{8\varepsilon_0}$ $\phi_{face} = \frac{Q}{24\varepsilon_0}$ $\phi_{total} = \frac{Q}{\varepsilon_0}$
  Charge kept at centre of face $\phi_{cube} = \frac{Q}{2\varepsilon_0}(5\,faces)$ $\phi_{total} = \frac{Q}{\varepsilon_0}$

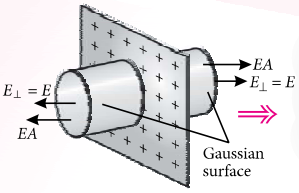
Field of a line charge

$$E_{net} = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$$



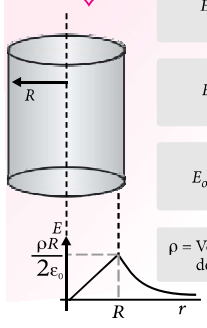
Field of an infinite plane sheet of charge

$$E = \frac{\sigma}{2\varepsilon_0}$$



Result in field due to a sheet depends only on total charge of the sheet and independent of distribution of charge.

Field due to a long uniformly charged solid cylinder



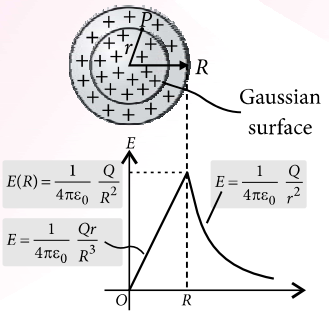
$E_{in} = \frac{\rho r}{2\varepsilon_0}$

$E_s = \frac{\rho R}{2\varepsilon_0}$

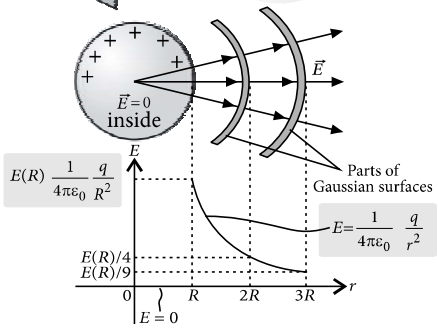
$E_{out} = \frac{\rho R^2}{2\varepsilon_0 r}$

ρ = Volume charge density

Field of a uniformly charged solid sphere and charged conducting sphere



Uniformly charged sphere



Charged conducting sphere