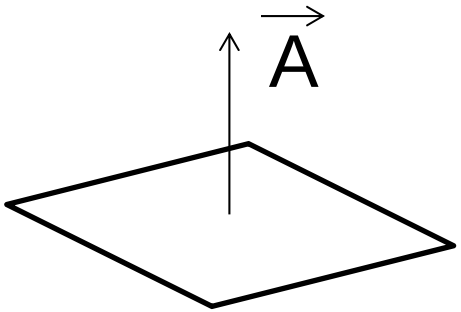
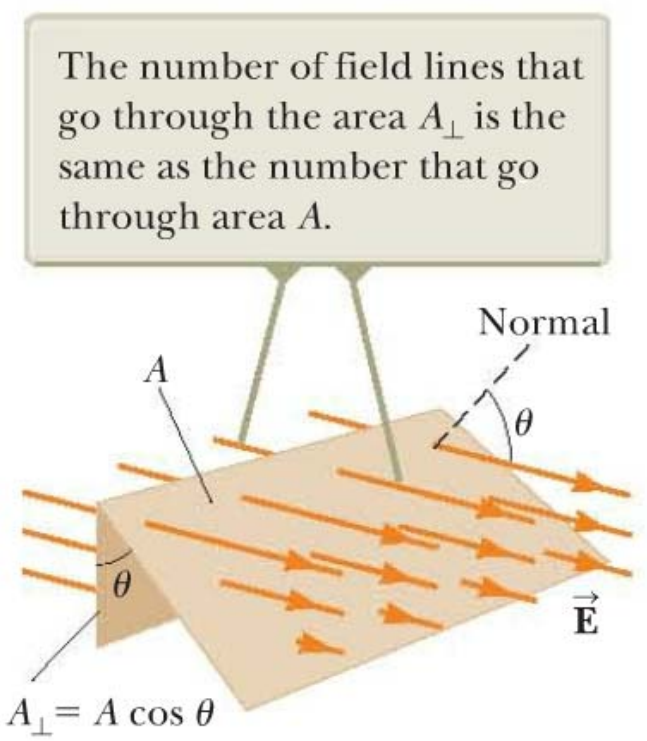
Electric Field Lines and Electric Flux

Area vector and Flux



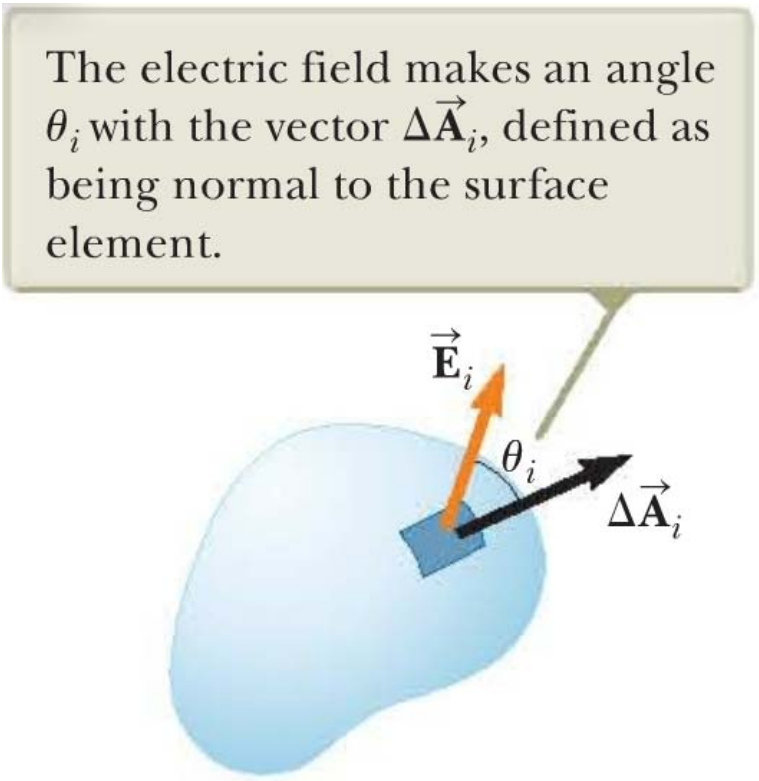
Area vector is a vector perpendicular to a plane surface with magnitude equals to the area of the plane.

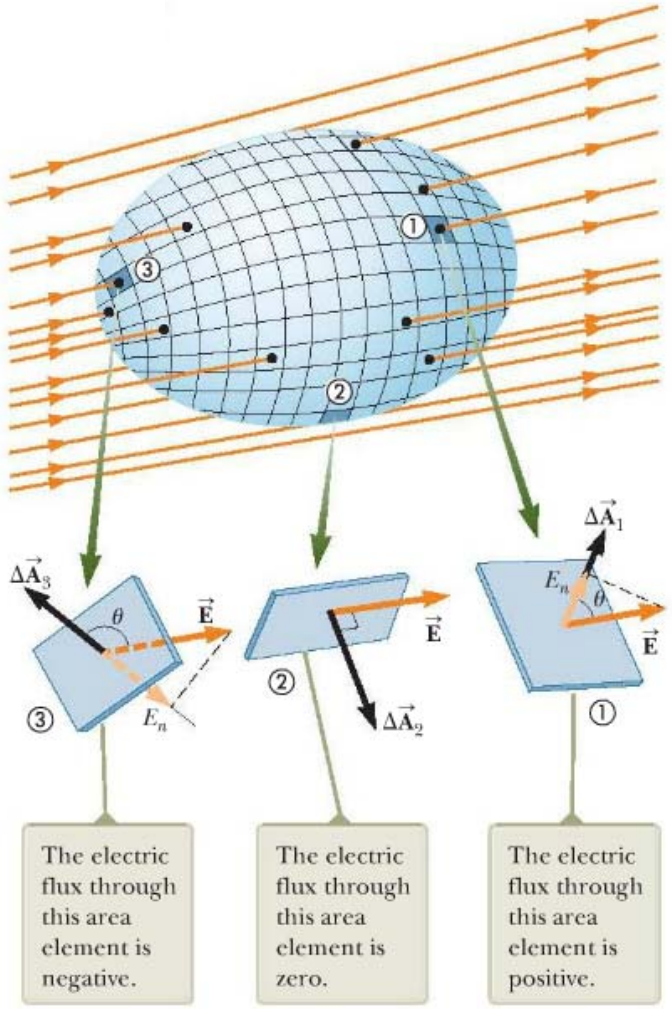


$$\text{Flux } \Phi_E = \mathrm{E\ A}\cos\theta = \vec{\mathrm{E}}\cdot\vec{\mathrm{A}}$$

Class 8. Gauss's Law

Flux for curve surface





$$d\Phi_E = \vec{E}\cdot d\vec{A} \quad \Rightarrow \quad \boxed{\Phi_E = \int \vec{E}\cdot d\vec{A}}$$

For closed surface, surface vector is positive when it is pointing outward.

Gauss's Law (Maxwell's first equation)

For *any* closed surface,

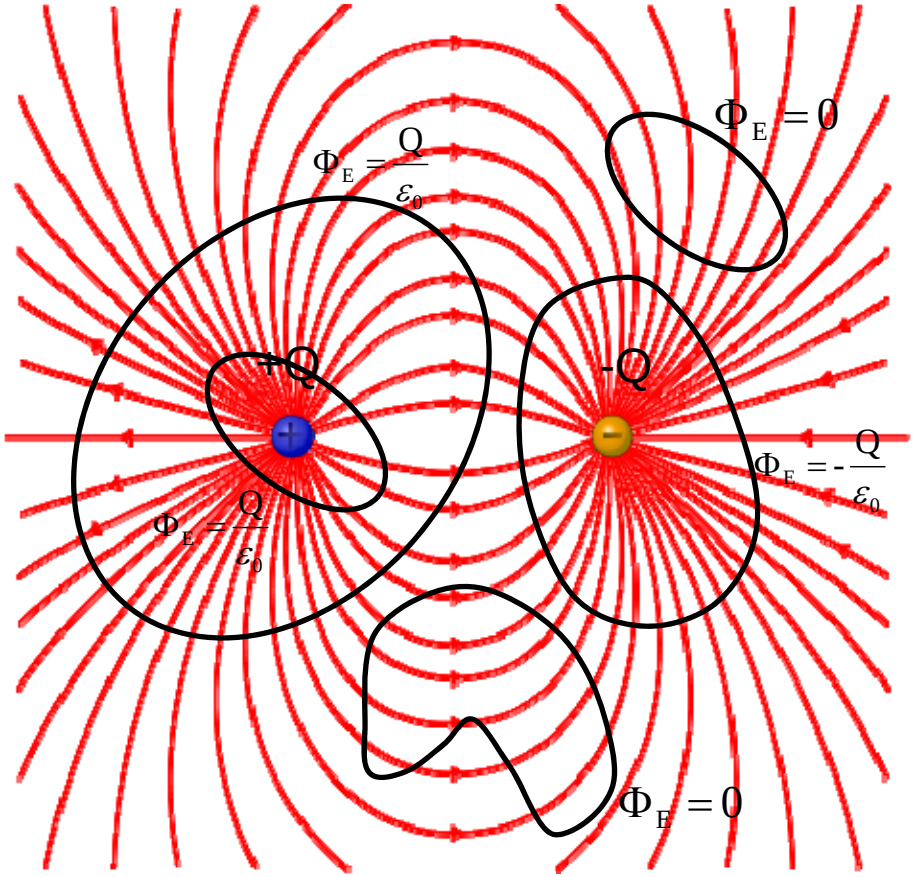
$$\varepsilon_0 \Phi_E = q_{in} \quad \text{or} \quad \varepsilon_0 \oiint \vec{E} \cdot d\vec{A} = q_{in}$$

Two types of problems that involve Gauss's Law:

1. Give you left hand side (i.e. flux through a given surface), calculate the right hand side (i.e. charge enclosed by that surface).

2. Give you right hand side (i.e. a charge distribution) , calculate the left hand side (i.e. flux and the electric field).

Example


$\Phi_E = 0$
$\Phi_E = \frac{Q}{\varepsilon_0}$
+Q
-Q
$\Phi_E = -\frac{Q}{\varepsilon_0}$
$\Phi_E = \frac{Q}{\varepsilon_0}$
$\Phi_E = 0$