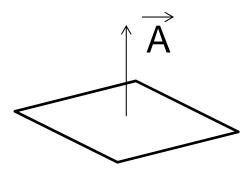
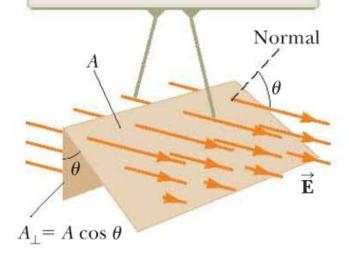
Class 5: Gauss's Law

## Area vector and Flux



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

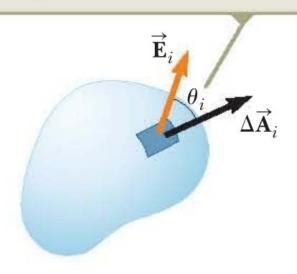
The number of field lines that go through the area  $A_{\perp}$  is the same as the number that go through area A.



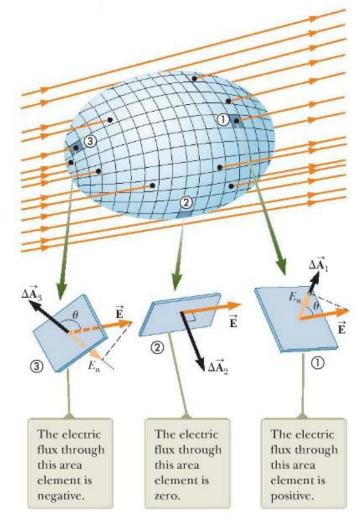
Flux 
$$\Phi_{E} = E A \cos \theta = \vec{E} \cdot \vec{A}$$

## Flux for curve surface

The electric field makes an angle  $\theta_i$  with the vector  $\Delta \vec{A}_i$ , defined as being normal to the surface element.



$$d\Phi_{E} = \vec{E} \cdot d\vec{A} \implies \Phi_{E} = \int \vec{E} \cdot d\vec{A}$$



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

## Gauss's Law (Maxwell's first equation)

For any closed surface,

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

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).

$$\varepsilon_0 \Phi_{\rm E} \Rightarrow q_{\rm in}$$

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

$$\varepsilon_0 \Phi_{\rm E} \leftarrow q_{\rm in}$$

In some simple (but important ) cases, we can then calculate electric field from the flux.

$$E \leftarrow \mathcal{E}_0 \Phi_E \leftarrow q_{in}$$