Mon Jan 30, 2017

Last time

- The electric field: demonstration
- Calculating electric field: Group Activity

This time

- Electric field visualization applet - reminder
- Introduction to Gauss' Law: the first of the four Maxwell equations of electromagnetism
- Electric Flux, calculating flux

Electric Fields

www.falstad.com/vector3de

shows electric field vectors, electric field lines, equipotential surfaces, etc. for a large number of objects we have been considering

Electric Flux; Gauss' Law

Gauss' Law is equivalent to Coulomb's law. It will provide us:

(i) an **easier way to calculate the electric field** in specific circumstances (<u>especially situations with a high degree of symmetry</u>)

(ii) a better understanding of the properties of conductors in electrostatic equilibrium (more on this as we go)

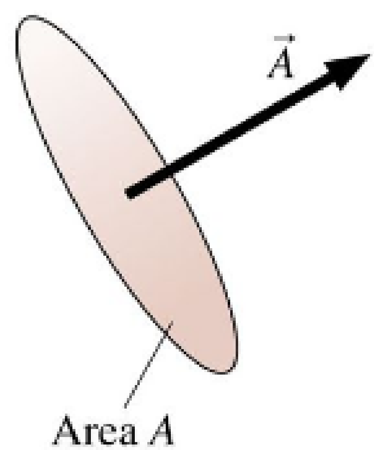
(iii) It is valid for moving charges – not limited to electrostatics.

Electric flux, passing through a **closed** Gaussian surface

$$\Phi_E = \oiint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

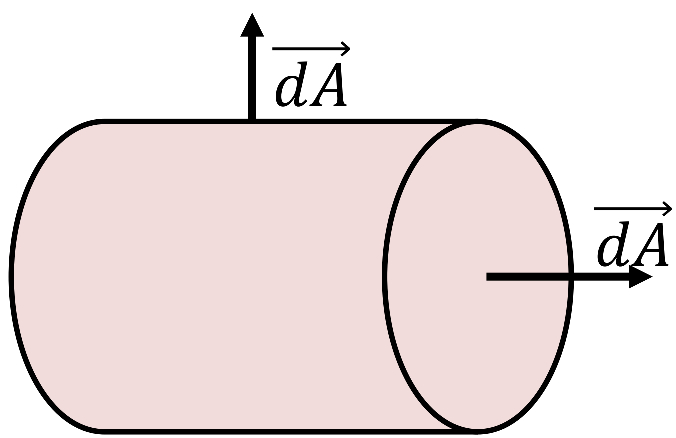
Area vector

- Area vector, $\vec{A}$:
  - magnitude is equal to the surface area
  - direction normal to the plane of the area (unit vector, $\vec{n}$)



Area vector

- Area vector, $\overrightarrow{dA}$:
  - area vector for infinitesimally small surface segment (small enough to be considered flat)
  - on closed surfaces we choose $\overrightarrow{dA}$ to point outwards



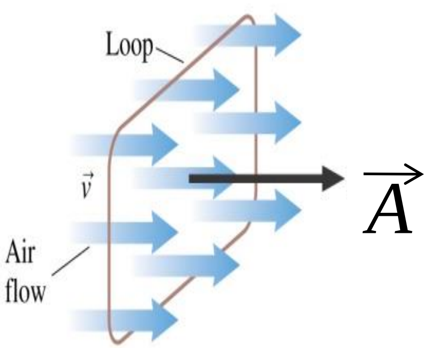
Electric flux passing through a **closed** Gaussian surface

$$\oint\!\!\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

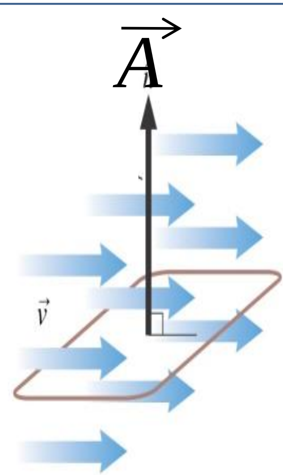
$$\boxed{\Phi_E = Q_{encl} / \varepsilon_0}$$

Gauss's law: the **net flux** passing through a closed surface (Gaussian surface) is **proportional to the net charge inside** the surface. **It does NOT depend on the shape of the surface.**

Flux : amount of 'something' (air, water……) flowing through an area

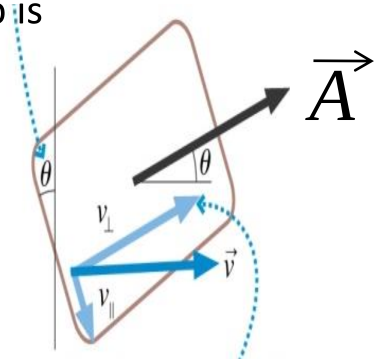


The air flowing through the loop is maximum when $\theta = 0^o$



No air flows through the loop when $\theta = 90^o$

The loop is tilted by angle θ

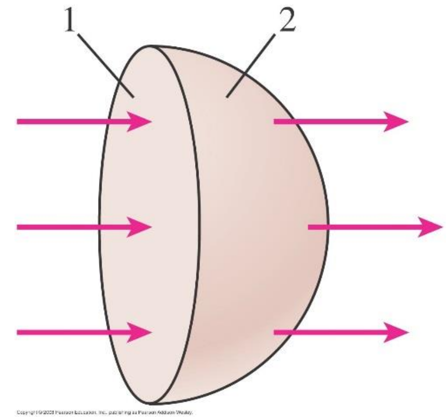


$v_\perp = v\cos\theta$ is the component of the air velocity perpendicular to the loop.

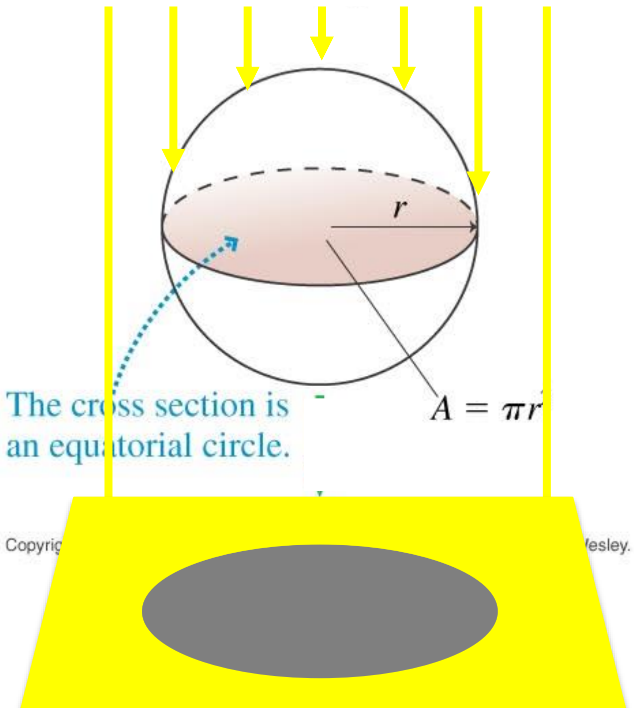
Cross-sectional area

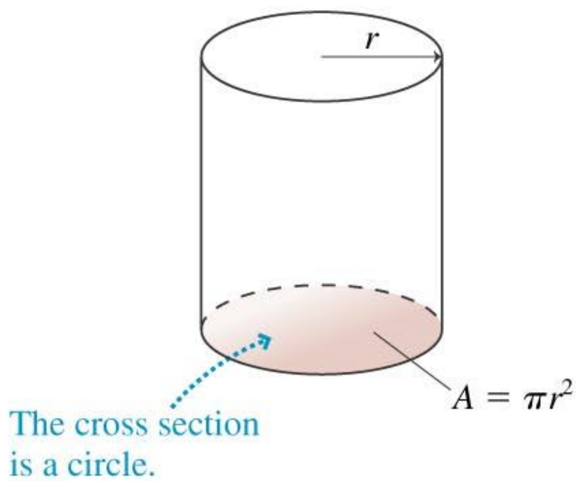
Area measured in a plane ⊥ to the direction of flow.

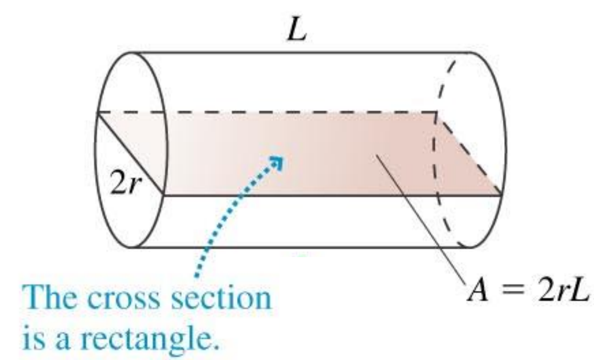
Area of shadow cast by || light rays



Flux through 1 = Flux through 2





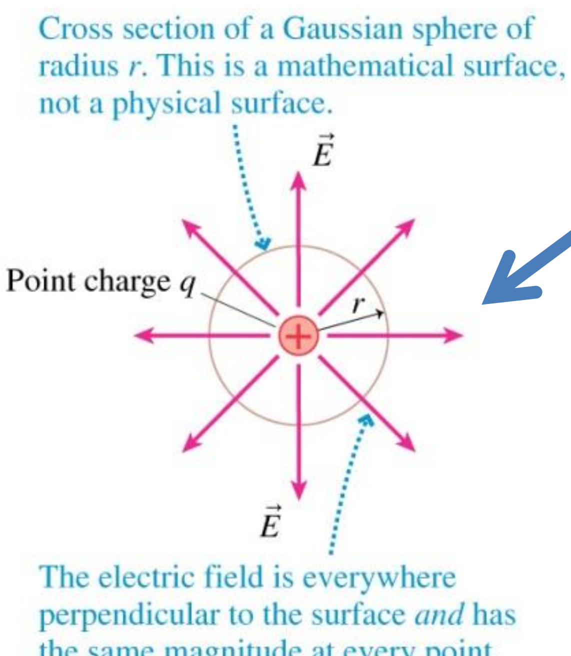


Electric flux passing through a **closed** Gaussian surface

$$\oint \vec{E} \cdot \overrightarrow{da} = \frac{Q_{enclosed}}{\epsilon_0}$$

$$\boxed{F_E = Q_{encl} / e_0}$$

Flux : amount of 'something' (air, water……) flowing through an area

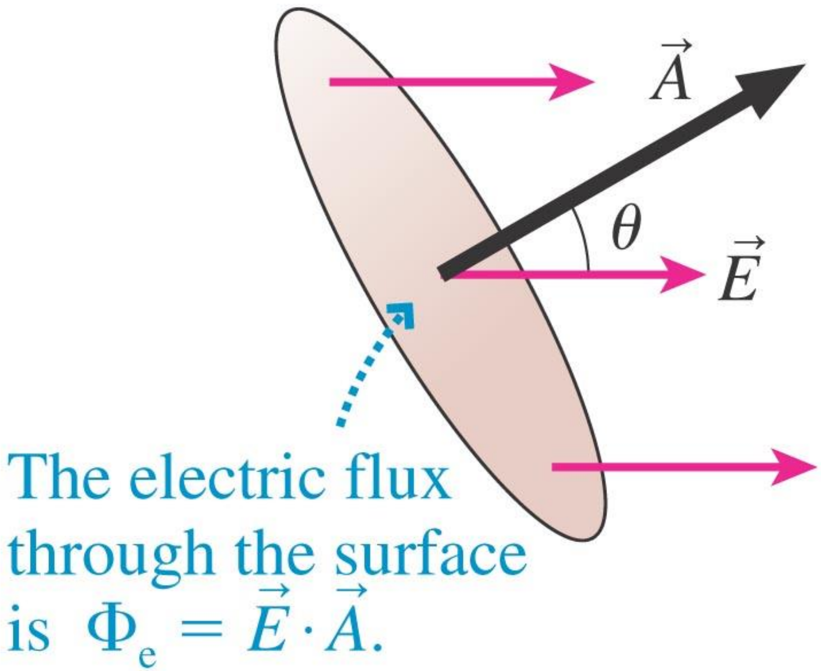


The flux passing **out** of the closed Gaussian surface is **positive**. The flux is: $\boxed{F_E = +q / e_0}$

If the positive charge is replaced by a negative charge, the flux would be:

$$\boxed{F_E = -q / e_0}$$

<u>Electric flux</u> through a surface with area A



$$\Phi_E = EAcos\theta$$

How to evaluate $\Phi_E = \oiint \vec{E} \cdot d\vec{A}$

- If the electric field is tangent to the surface:

$$\Phi = 0$$

- If the electric field is normal to the surface and is constant at every point:

$$\Phi = EA$$

TopHat Questions