Electricity and Magnetism

- Physics 259 – L02
- Lecture 13

Chapter 23

(please read chapter 22 of the textbook)

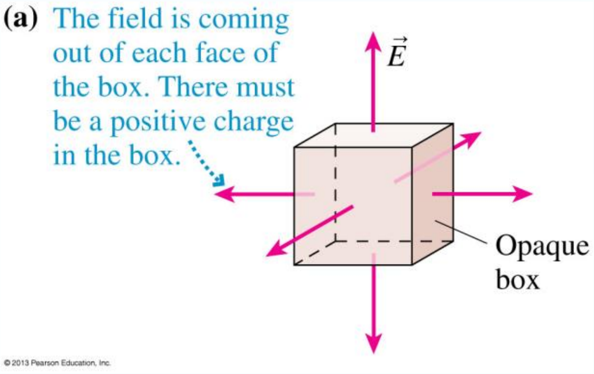
Last time

- Chapter 22 and 23.1 

This time

- Chapter 23.1 

23-1: The Electric Flux


(a) The field is coming out of each face of the box. There must be a positive charge in the box.
$\vec{E}$
Opaque box
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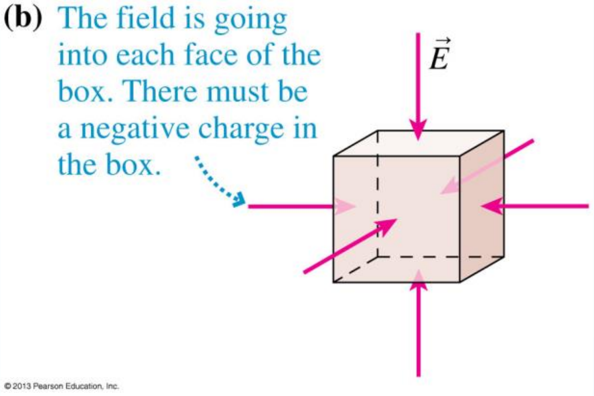
(b) The field is going into each face of the box. There must be a negative charge in the box.
$\vec{E}$
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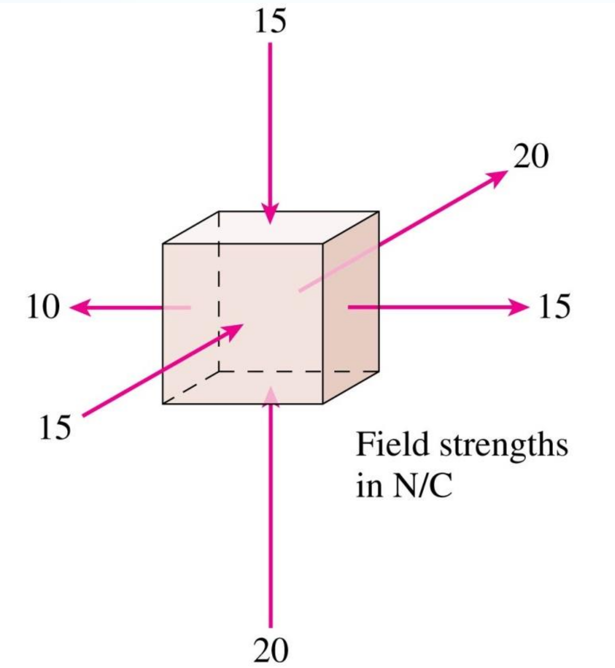
15
20
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15
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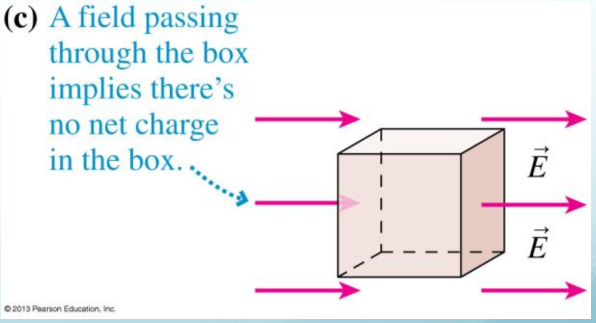
Field strengths in N/C


(c) A field passing through the box implies there's no net charge in the box.
$\vec{E}$
$\vec{E}$
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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 (especially situations with a high degree of symmetry)

(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.

A closed surface through which an electric field passes is called **Gaussian surface**

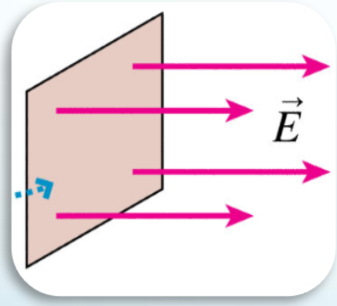
An imaginary mathematical surface

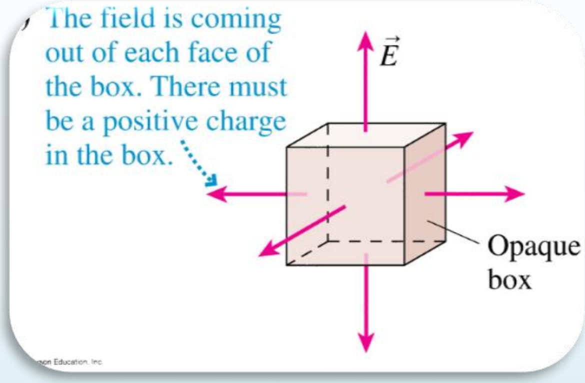
The Gaussian surface is most useful when it matches the shape of the field

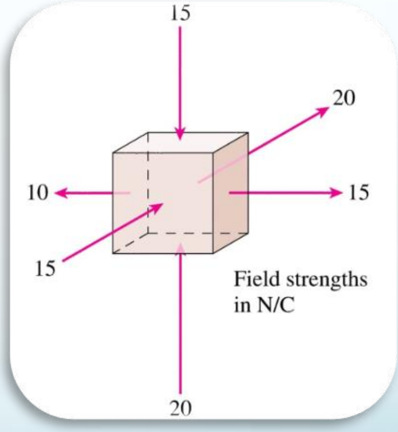
Gauss's law relates the electric field at points on a closed Gaussian surface to the net charge enclosed by that surface

Electric Flux (Φ_e)

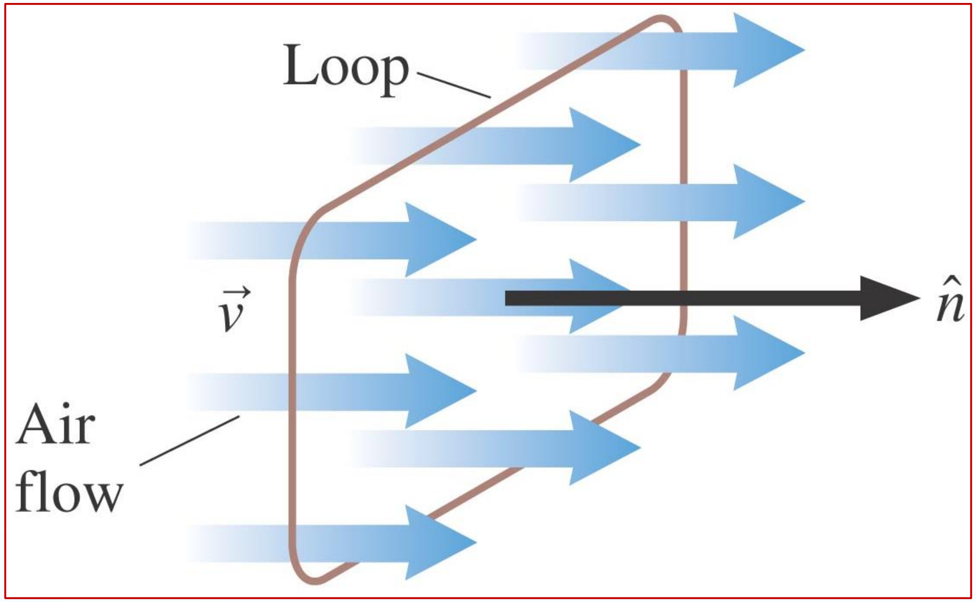
- **Amount of electric field going through a surface**
- **The number of field lines coming through a surface**

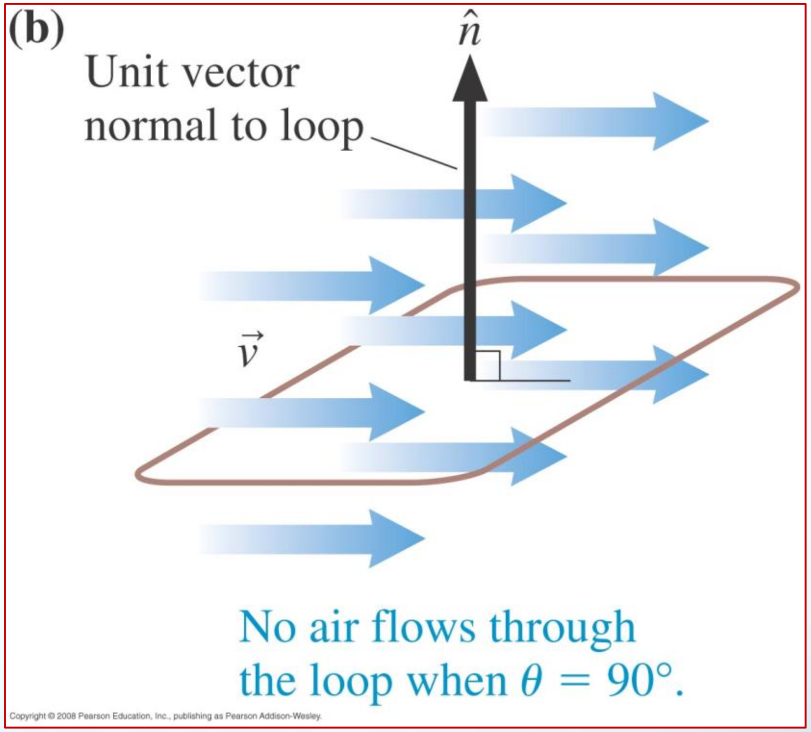


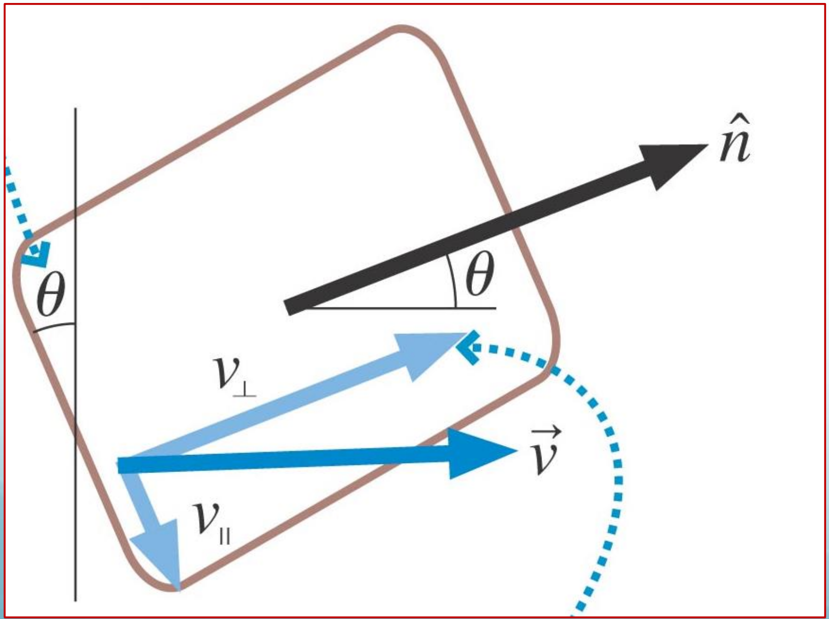




Wind going through a loop







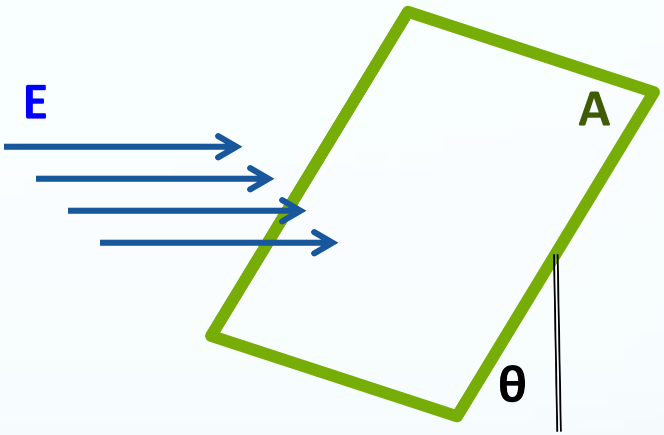
The Electric Flux

Amount of electric field going through a surface

$\Phi_e \propto E$

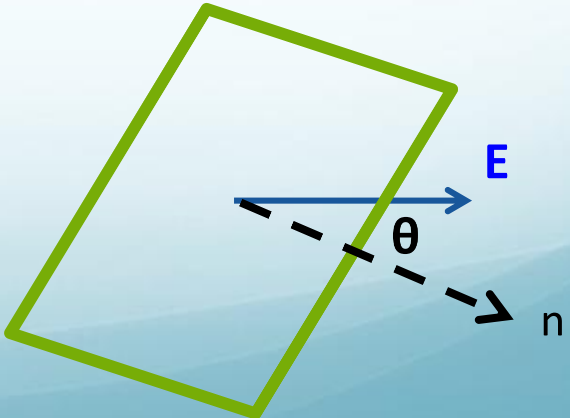
$\Phi_e \propto A$

$\Phi_e \propto \theta$



$$\boxed{\Phi_e = E_{\perp} A = EA\cos\theta}$$

$$\rightarrow \Phi_e = E.A$$



QuickCheck 27.2

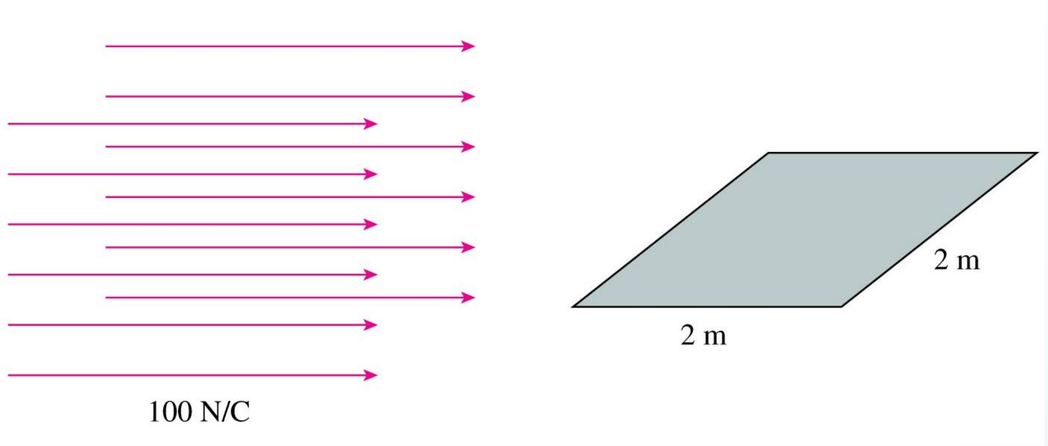
The electric flux through the shaded surface is

A. 0.

B. 200 N m/C.

C. 400 N m^2/C.

D. Some other value.



QuickCheck 27.1

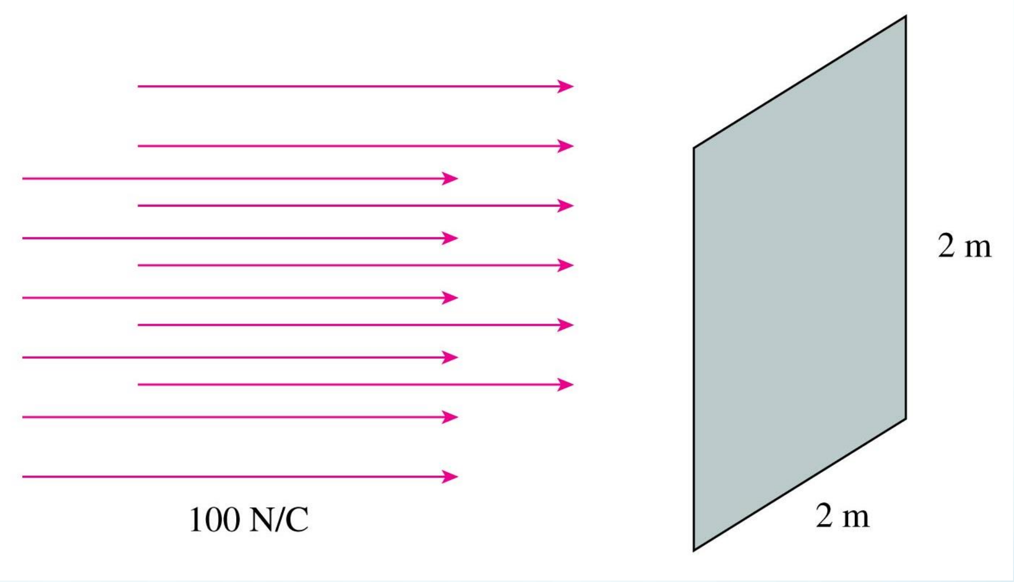
The electric flux through the shaded surface is

A. 0.

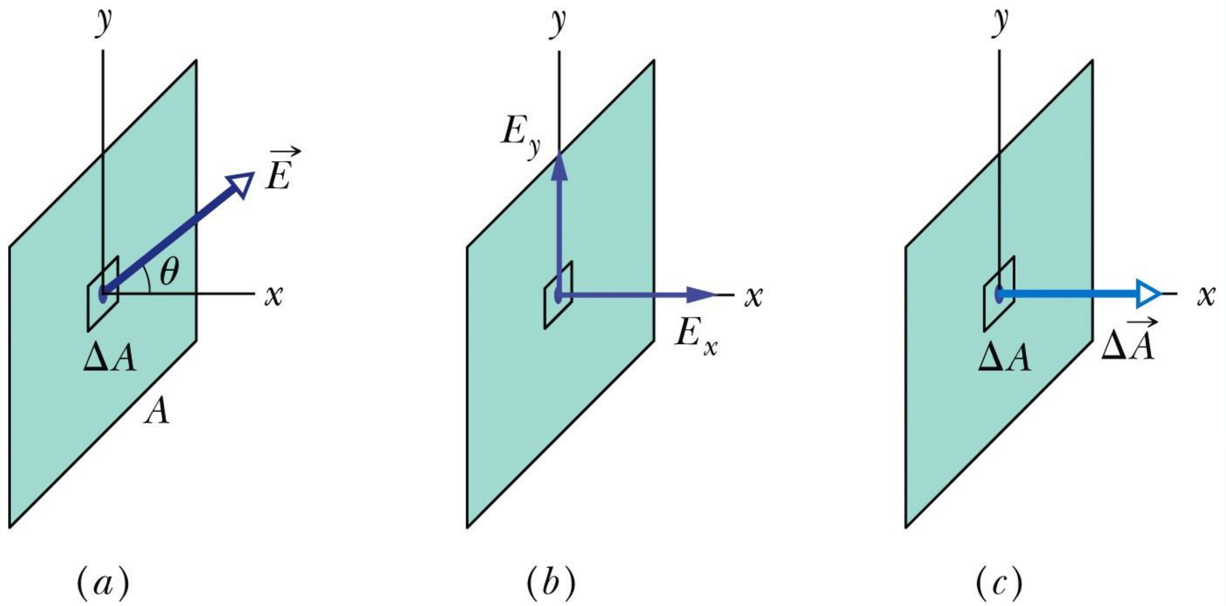
B. 200 N m/C.

C. 400 N m^2/C.

D. Flux isn't defined for an open surface.



Electric flux: Flat surface, uniform field



$$\Delta A \rightarrow \quad \Delta\Phi = E\cos(\theta)\Delta A \rightarrow \Delta\Phi = E.\Delta A$$

$$\Phi_e = \int \vec{E}.d\vec{A} = \vec{E}.\vec{A}$$

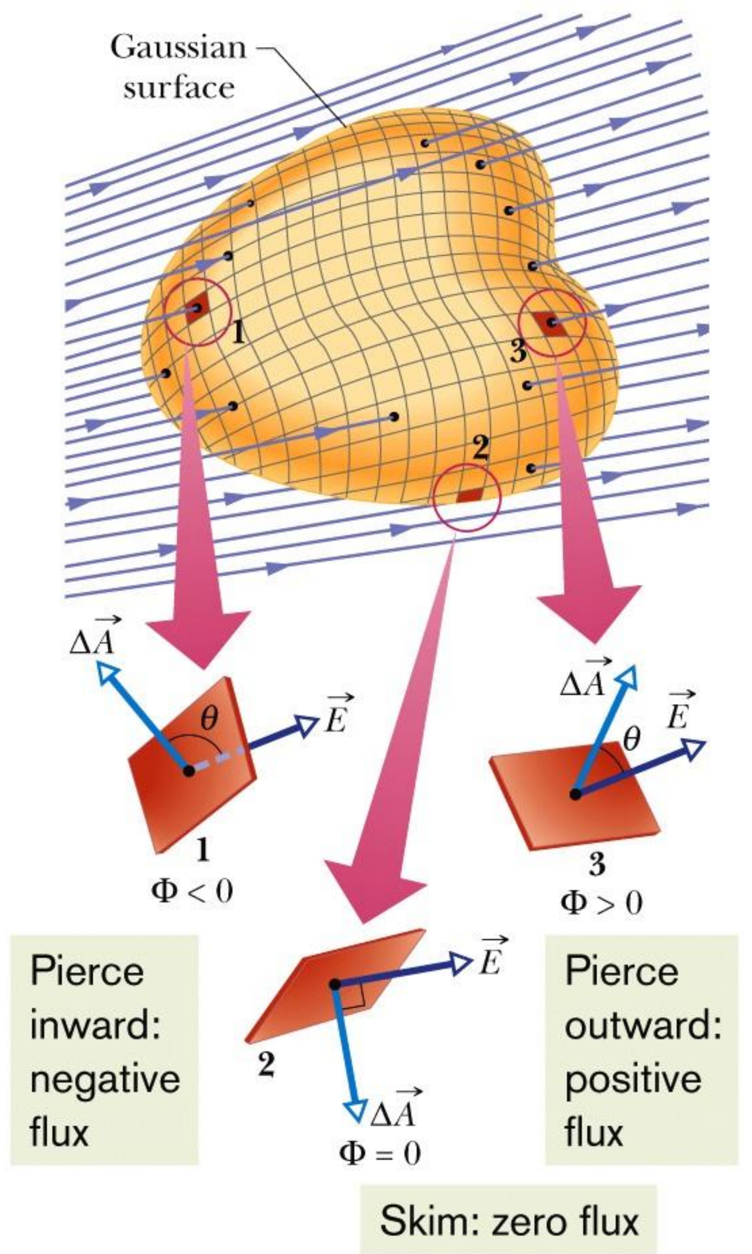
Electric flux: Closed surface, uniform field

Total flux through a surface →
Integrating the dot product over the full surface.

$$\Phi = \int \vec{E} \cdot d\vec{A} \quad \text{(total flux).}$$

The **net flux** through a closed surface (which is used in Gauss' law) →

$$\Phi = \oint \vec{E} \cdot d\vec{A} \quad \text{(net flux).}$$



Tactics: Evaluating surface integrals

For uniform E:

$$\Phi_e = \oint \vec{E}.d\vec{A} =$$

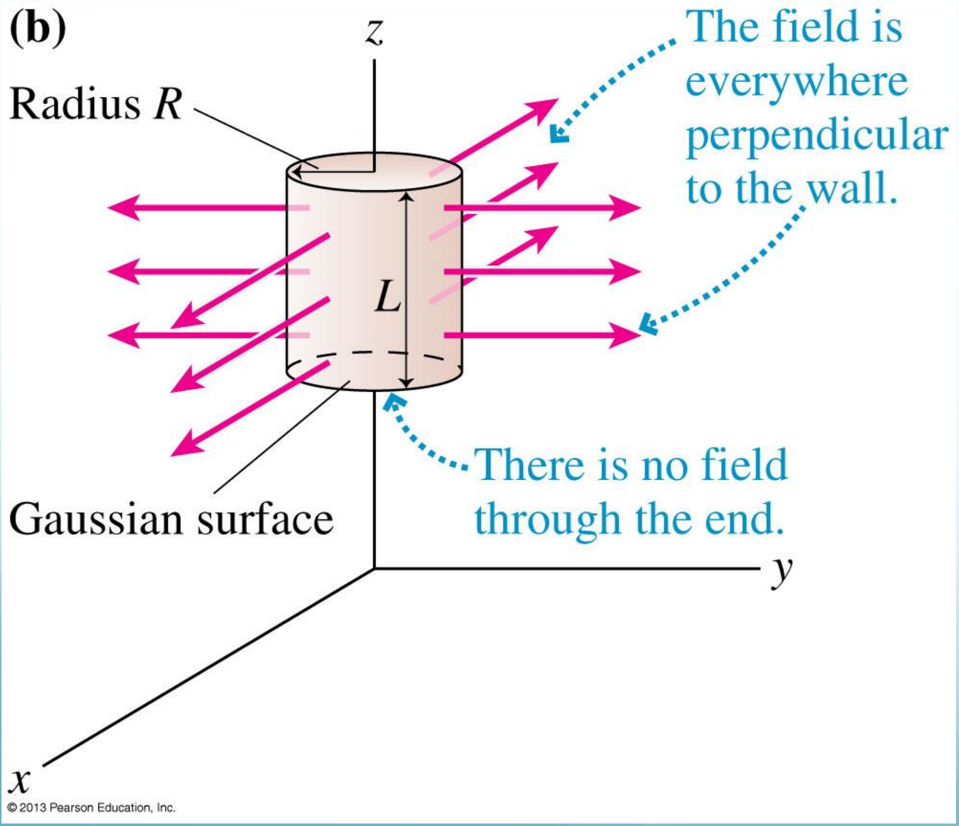
Finding the flux through a closed surface

1. Divide the closed surface into pieces that are tangent to the electric field, perpendicular to the electric field, or with a specific angle
2. Evaluate the surface integral

The Electric Flux through a Closed Surface

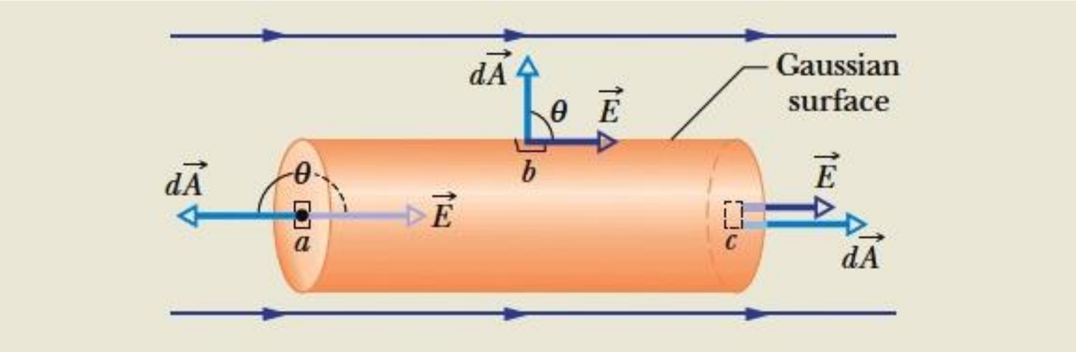
$$\Phi_e = \oint \vec{E} \cdot d\vec{A}$$

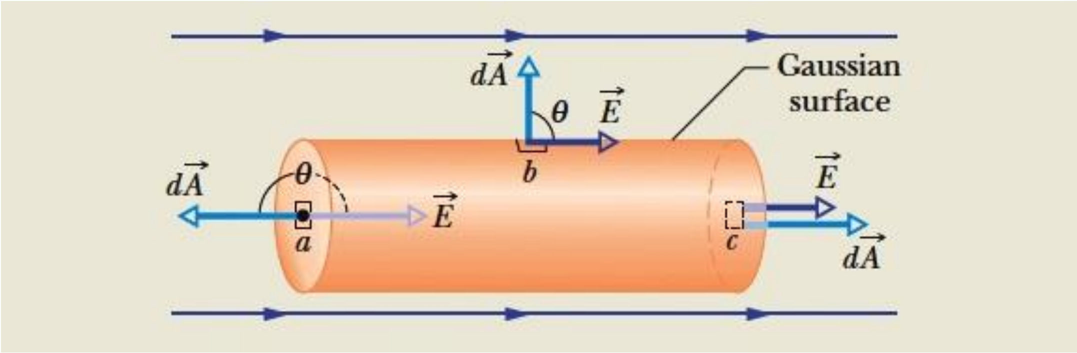
The area vector dA of a closed surface is always defined to point toward the outside



Electric Flux: Example

Figure 23-6 shows a Gaussian surface in the form of a closed cylinder (a Gaussian cylinder or G-cylinder) of radius R. It lies in a uniform electric field $\vec{E}$ with the cylinder's central axis (along the length of the cylinder) parallel to the field. What is the net flux Φ of the electric field through the cylinder?





$d\vec{A}$
θ
$\vec{E}$
Gaussian surface
b
$d\vec{A}$
θ
$\vec{E}$
a
$\vec{E}$
c
$d\vec{A}$

This section we talked about:

Chapter 23.1

See you on Wednesday