Last time

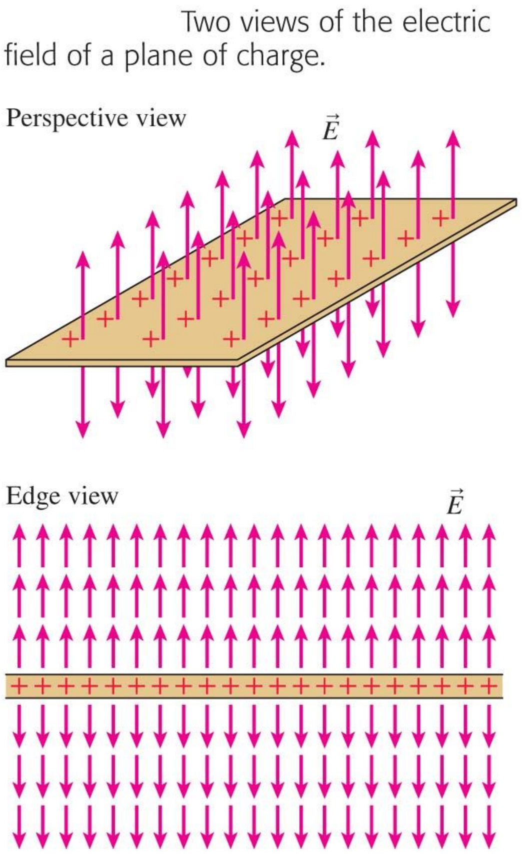
- More on the electric field for a solid spherical volume of constant charge density
- Electric field for a spherical shell of constant charge density
- Electric field for a finite rod using Coulomb's law
- Electric field for an infinitely long rod using Gauss's law

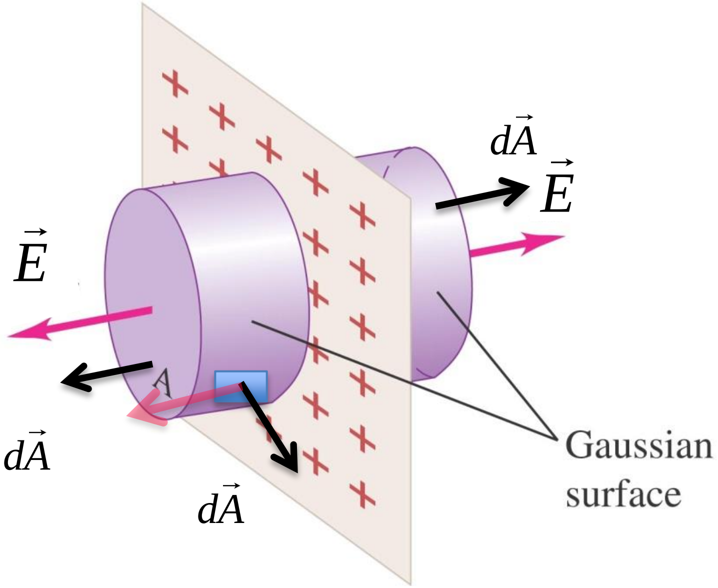
This time

- Electric field for an infinite sheet of charge
- Electric properties of conductors and Gauss's law
- Electric field for a parallel plate capacitor

The field of a large plane of charge

A Suitable Gaussian surface for an infinite sheet of charge is a cylinder or a rectangular cube.





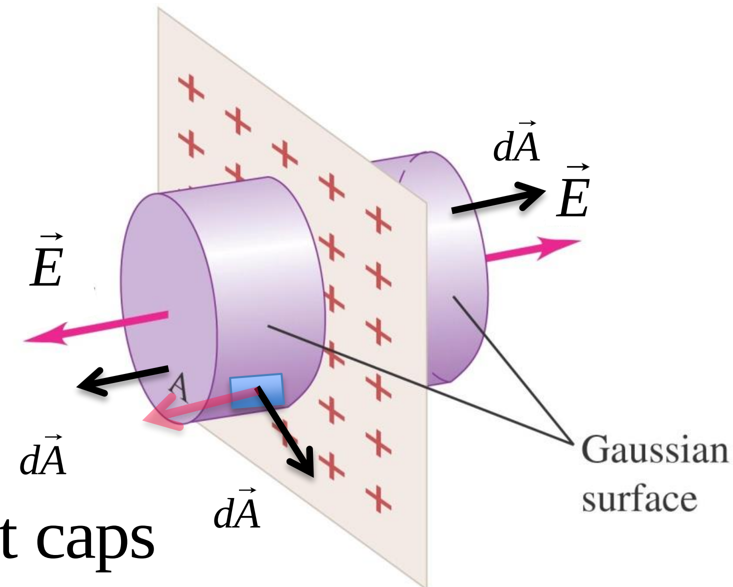
Electric field at a point on the side of the Gaussian is perpendicular to infinitesimal area vector, or parallel to the side resulting in no flux.

Electric field at a point on the caps is parallel to the infinitesimal area vector.

The field of a large plane of charge

A Suitable Gaussian surface for an infinite sheet of charge is a cylinder or a rectangular cube.

$$\oint \vec{E} \bullet d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0} \qquad Q_{enclosed} = \sigma A$$



$$\vec{E} \bullet d\vec{A} = \underset{\text{constant}}{E} \; dA$$ For the right and left caps

$$\int_{\text{right cap}} \vec{E} \bullet d\vec{A} + \int_{\text{left cap}} \vec{E} \bullet d\vec{A} + \int_{\text{side}} \underset{\underset{0}{||}}{\vec{E} \bullet d\vec{A}} = \frac{\sigma A}{\varepsilon_0} \qquad EA + EA = \frac{\sigma A}{\varepsilon_0}$$

$$\underset{\text{constant}}{E} \int_{\text{right cap}} dA + \underset{\text{constant}}{E} \int_{\text{left cap}} dA = \frac{\sigma A}{\varepsilon_0} \qquad E = \frac{\sigma}{2\varepsilon_0}$$

Conductors and electric field

Conductor is a material which has free electrons inside. These electrons are not bound to any atoms and are free to move about.

When there is no net motion of charge within the conductor, the conductor is said to be in **electrostatic equilibrium**.

Conductors and electric field

A conductor in **electrostatic equilibrium** has the following properties:

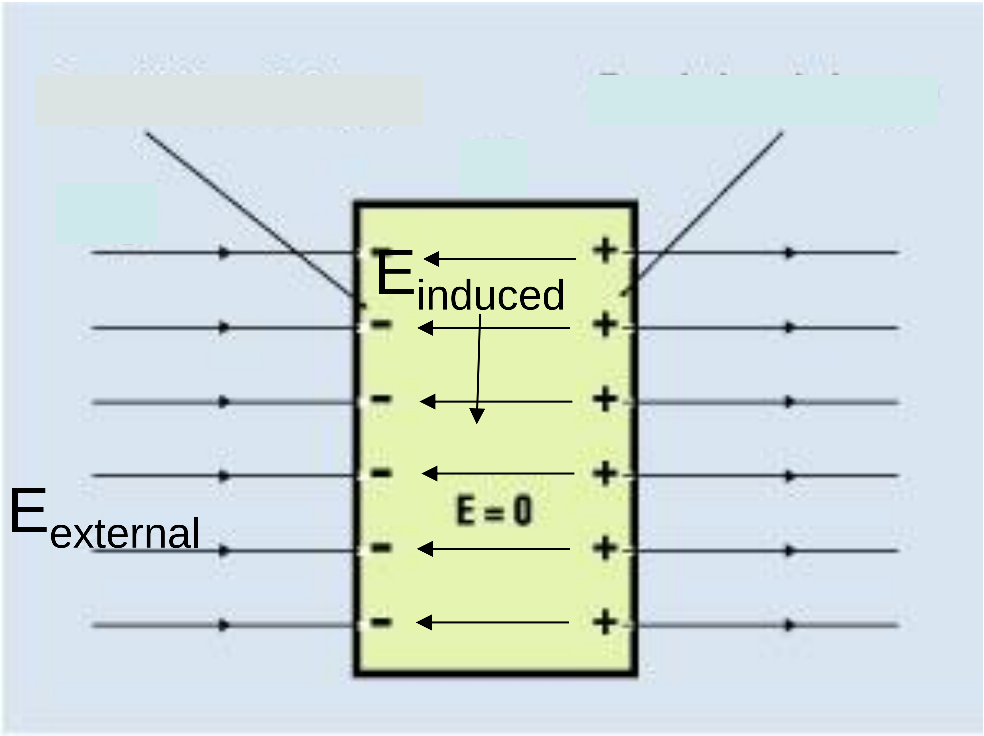
1. The electric field is zero inside the conductor.

2. Any excess charge on an isolated conductor must reside on the surface.

3. The electric field just outside the conductor is perpendicular to the conductor's surface and has the magnitude of σ / ε_0.

4. On an irregular shaped conductor, charge tend to accumulate at the locations where radius of curvature of the shape is smaller**, sharper edges accumulate higher surface charge density.**

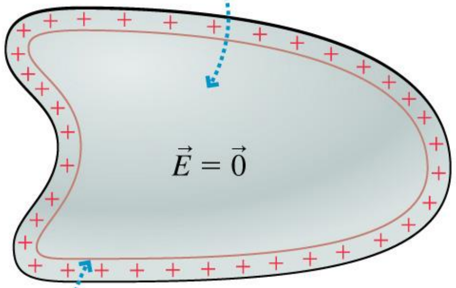
If a conductor is placed in an electric field, charges will move within the conductor until the interior field is zero.



$$\overrightarrow{E}_{\text{external}} + \overrightarrow{E}_{\text{induced}} = 0$$

If external electric field is weak charge density induced on the sides of the conductor is small.
If external electric field is strong charge density induced on the sides of the conductor is large.

Any excess charge on an isolated conductor must reside on the surface.



$$\oint \vec{E} \bullet d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$$

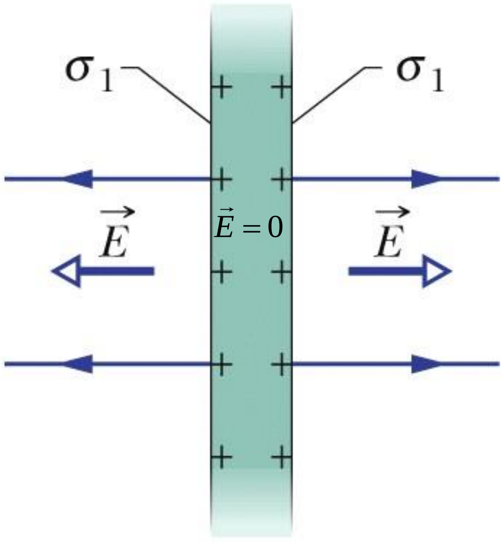
Since electric field is zero everywhere inside the conductor drawing any shape or size Gaussian inside the conductor leads to the conclusion that the net charge enclosed by the Gaussian must be zero.

$$\underset{\underset{0}{||}}{\oint \vec{E} \bullet d\vec{A}} = \frac{Q_{enclosed}}{\varepsilon_0} \Rightarrow Q_{enclosed} = 0$$

We therefore conclude that any excess charge on an isolated conductor must reside on the surface.

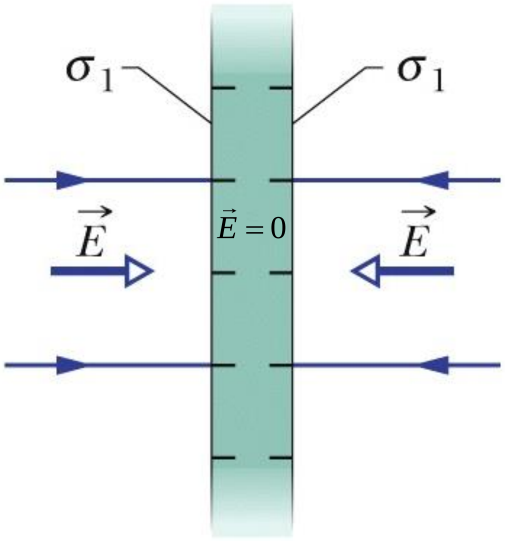
Large conducting plate

Edge views



(a)

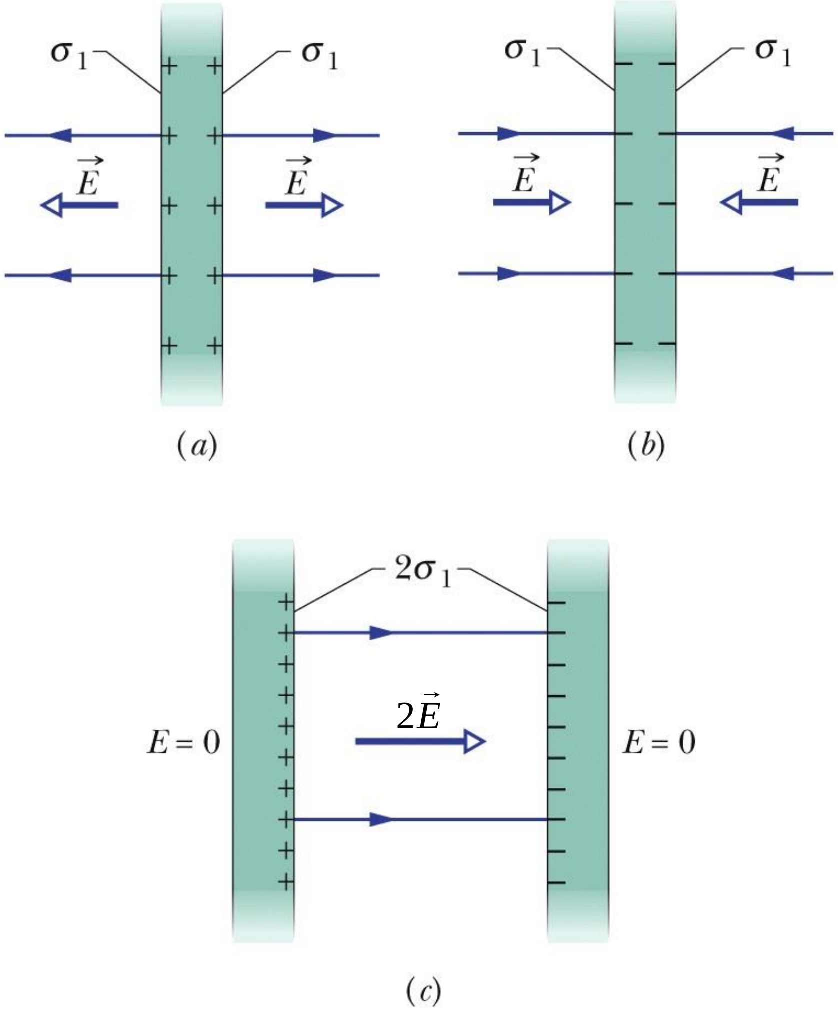
$$E = \frac{\sigma_1}{\varepsilon_0}$$



(b)

$$E = \frac{\sigma_1}{\varepsilon_0}$$

Putting the two plates together



Application: Makes a parallel plate capacitor!

Electric field inside a solid (not a shell) conductor