

Mon Feb 6, 2017

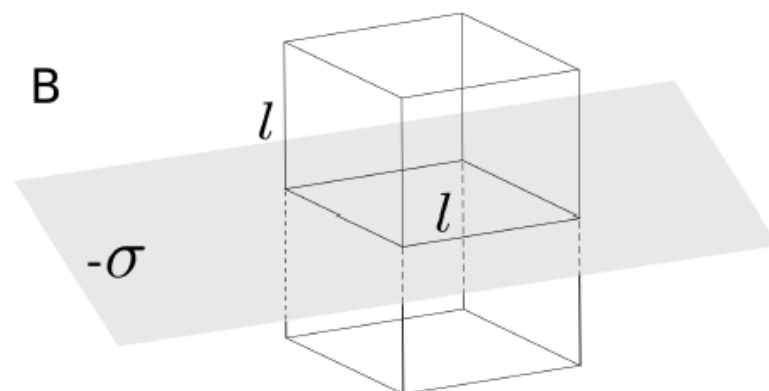
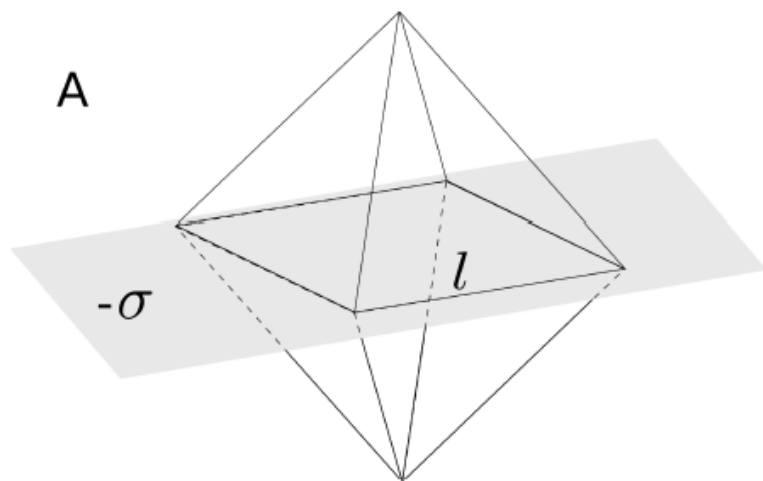
Last time

- Van de Graaff generator: demonstration
- Calculating electric field flux: Group Activity

This time

- Group Activity – review
- Properties of conductors
- Infinite charged plane: non-conducting vs. conducting
- Gauss' Law applied to conductors

(10 marks) The figure below shows an octahedral Gaussian surface made up of equilateral triangles with a square base of length l and a pill-box with a square base of length l . The horizontal plane represents a large thin sheet with uniform surface charge density $-\sigma$. Find the electric flux through the octahedral Gaussian surface.



1. **(1 mark)** In one sentence, state the meaning of Gauss' relation $\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$.

2. **(3 marks)** Find the total electric flux through the Gaussian surface in figure B and draw the surface area vectors for each face.

3. **(2 marks)** For the pill-box in figure B, using Gauss's relation; $\oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$, find an expression for the electric field in terms of the charge density σ .

4. **(1 mark)** What is the difference between the electric field flux through the pill-box and the octahedron? Explain.

5. **(2 marks)** Find the total electric flux through the octahedral Gaussian surface?

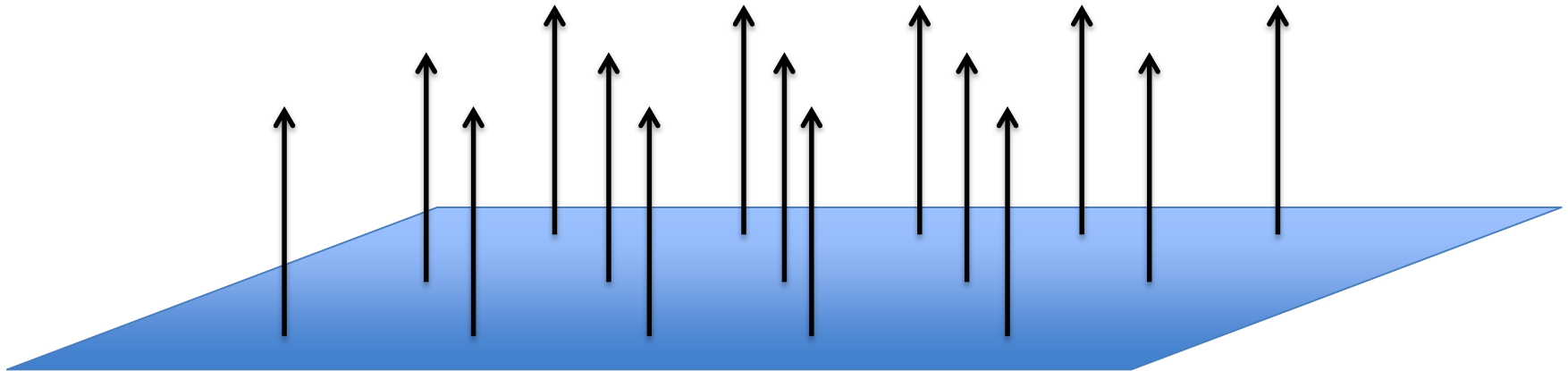
(1 mark for the correct answer) What is the electric flux through the octahedron? Express your answer in terms of σ using the relation $E = \sigma/2\epsilon_0$.

A. $-\frac{\sigma}{2\epsilon_0}l^2$ B. $-\frac{\sigma}{\epsilon_0}l^2$ C. $\frac{\sigma}{2\epsilon_0}l^2$ D. $\frac{\sigma}{\epsilon_0}l^2$

Planar Symmetry

An infinite plane is perfectly symmetric under side to side translations, and rotations in the x,y plane. Consequences:

- 1) E-field must point in same direction everywhere (translations)
- 2) E-field must point perpendicular to the surface (rotations)

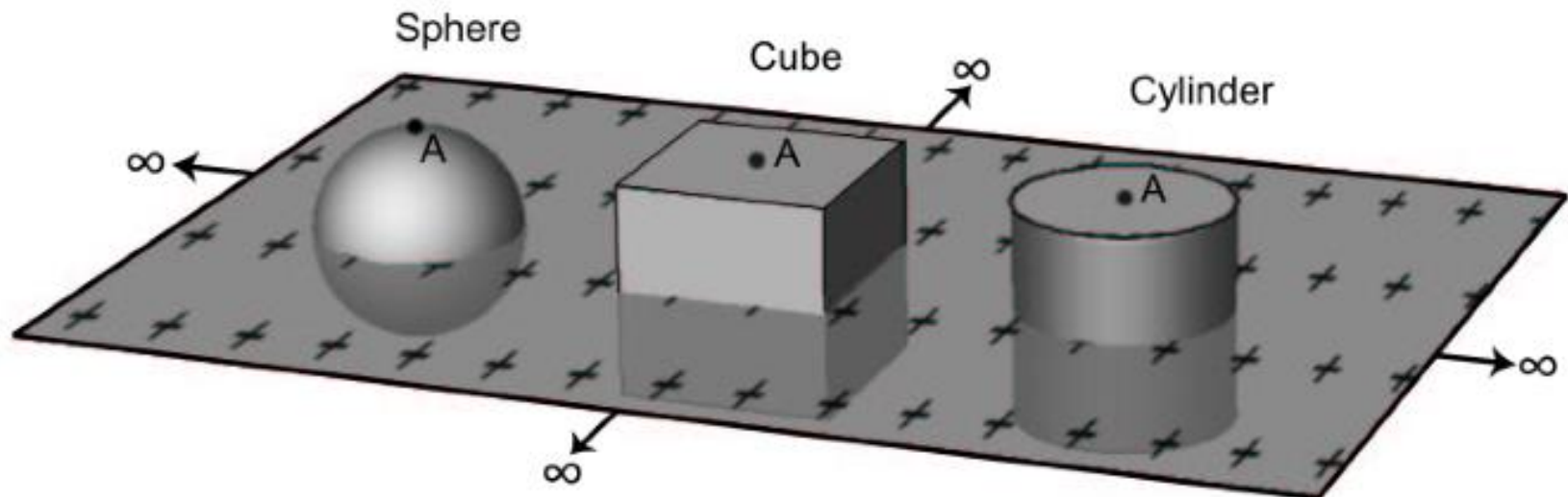


This alone is enough to predict E-field is uniform for infinite plane

Using the right symmetry

For which of these Gaussian surfaces will Gauss' law help us to calculate E at point A due to the plane of charge? *Point A is at the top center of each surface.*

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$$



TopHat question

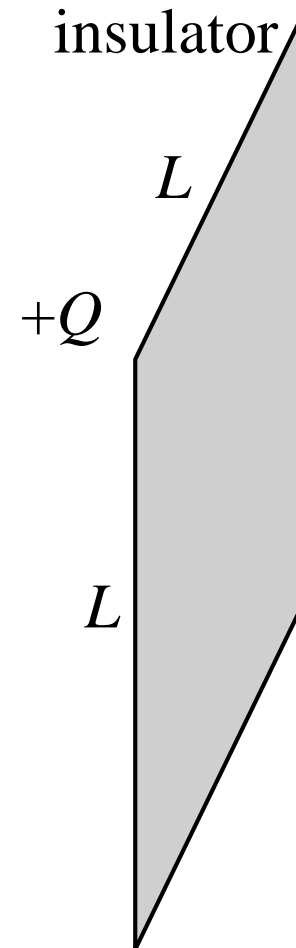
- What is the magnitude of electric field due to an **insulating plate** with surface density, σ ?

A. $E = \sigma / \epsilon_0$

B. $E = \sigma / 2\epsilon_0$

C. $E = \sigma d / 2\epsilon_0$

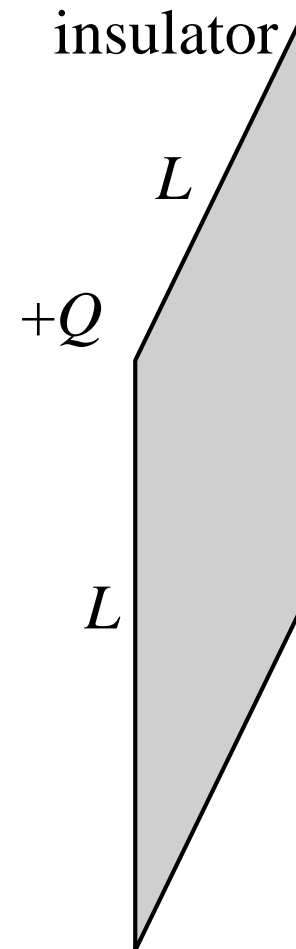
D. $E = \sigma d / \epsilon_0$



TopHat question

- What is the surface charge density on the **insulating plate**?

- A. $Q/2L^2$
- B. $Q/\epsilon_0 L^2$
- C. Q/L^2
- D. $Q/2\epsilon_0 L^2$



Conductors

A **conductor** is a material in which the charges are free to move.

This means that two things are true:

1. There is zero net charge **inside** a conductor. ($Q_{\text{net}} = 0$)
2. There is zero electric field **inside** a conductor. ($E_{\text{in}} = 0$)

Conductors -- Explanations

1. There is zero net charge **inside** a conductor. ($Q_{\text{net}} = 0$)

If there are 2 (or more) like charges inside a conductor then they will repel each other and push each other far away. (ie --to the surface)

2. There is zero electric field **inside** a conductor. ($E_{\text{in}} = 0$)

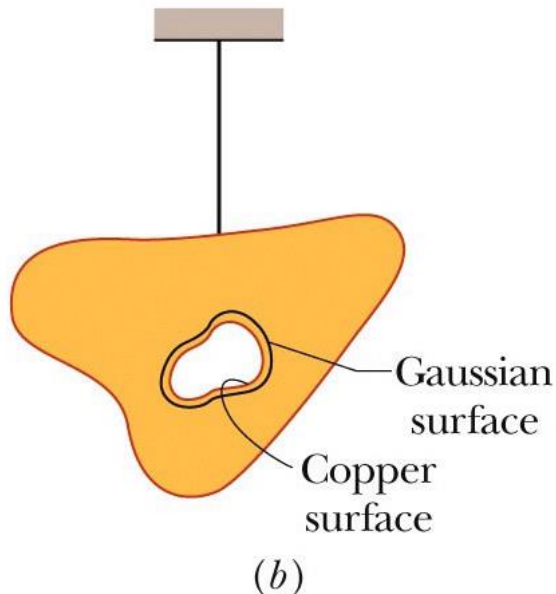
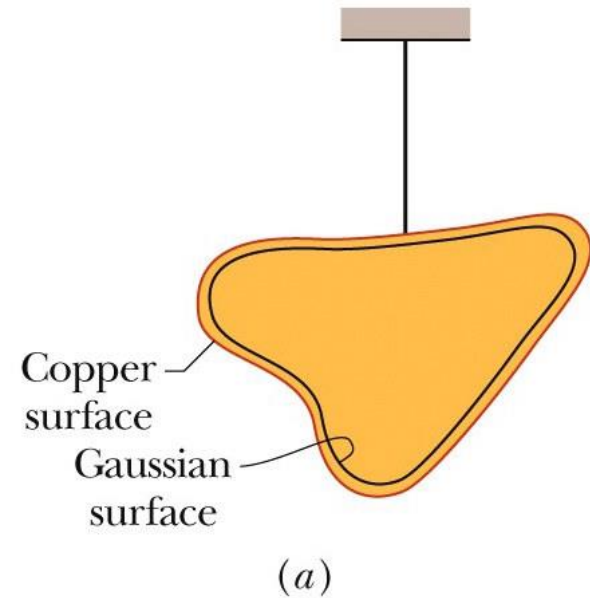
If there is a non-zero E field then $F = qE$ implies there is a net force which means charges would move until the force on them is zero – we have a **STATIC** situation. (Equilibrium)

Hollow Conductors

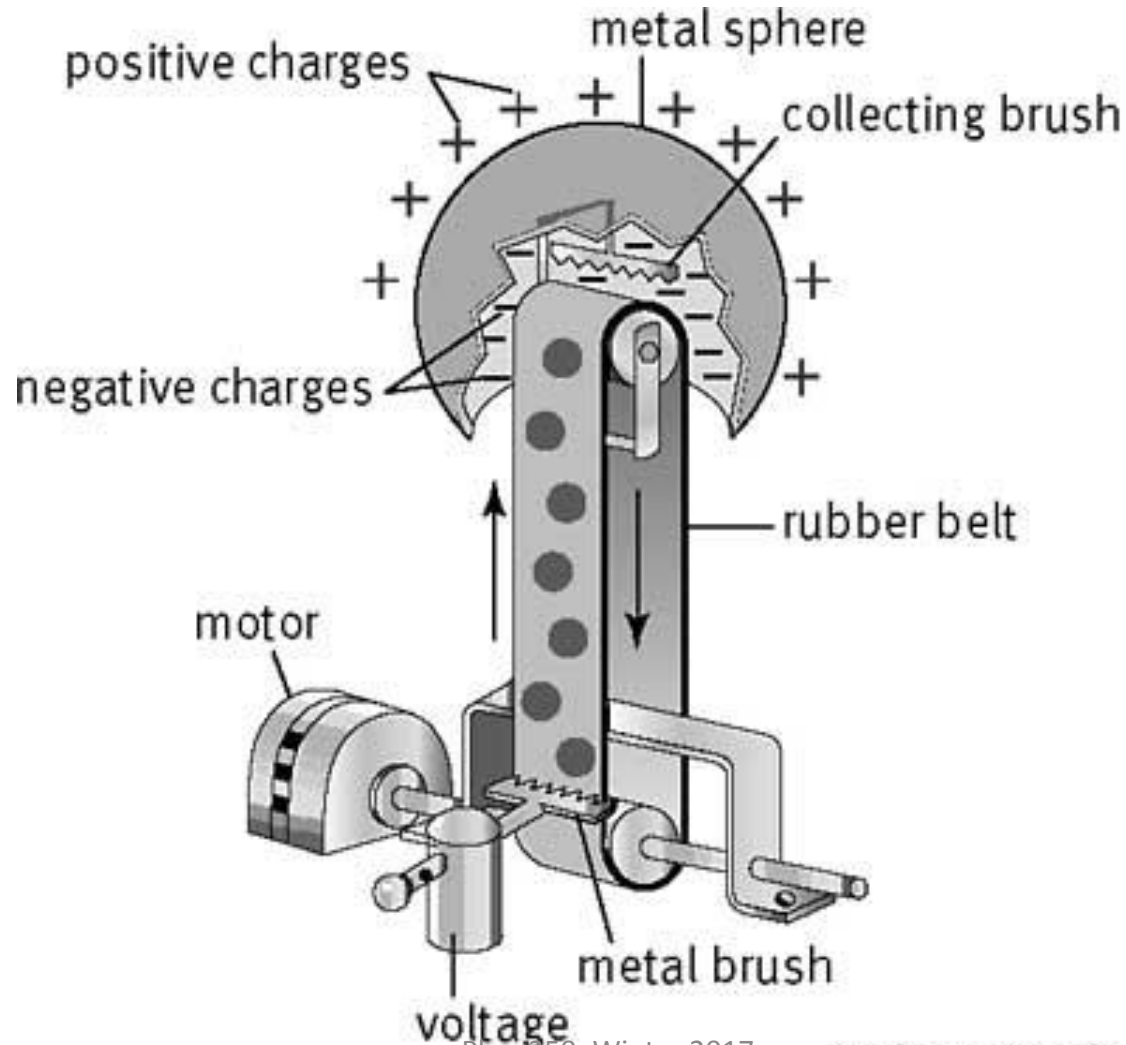
The electric field inside a conductor is zero. This immediately implies that conductors are electrically neutral in their interiors.

$$\oint \vec{E} \cdot d\vec{A} = 0 = \frac{q_{enc}}{\epsilon_0}$$

This also means that the surface of a hollow cavity inside a conductor cannot carry any excess charge. All excess charge must reside on the outside surface only.

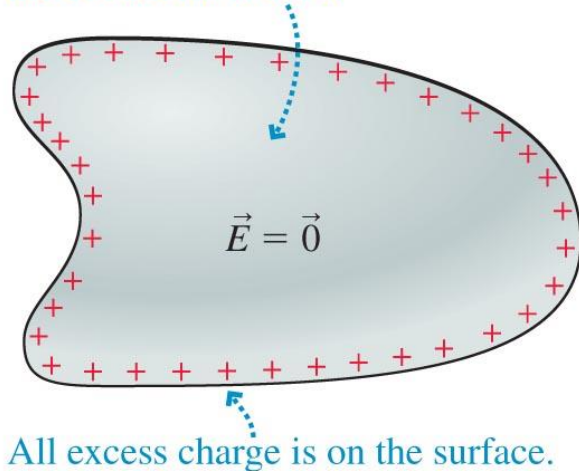


Van de Graaff generator

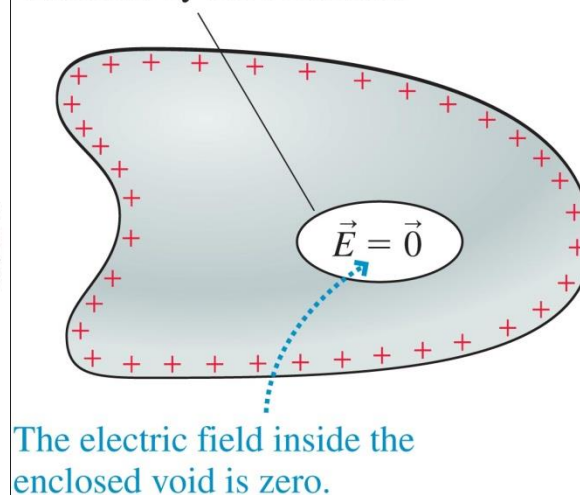


Summary of Conductors and Electric Fields

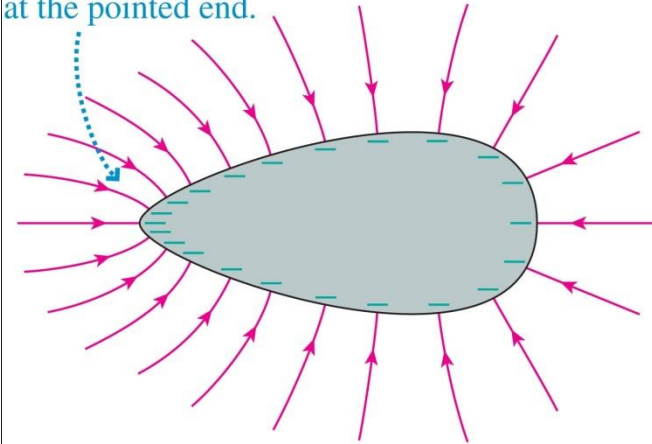
- (a) The electric field inside the conductor is zero.



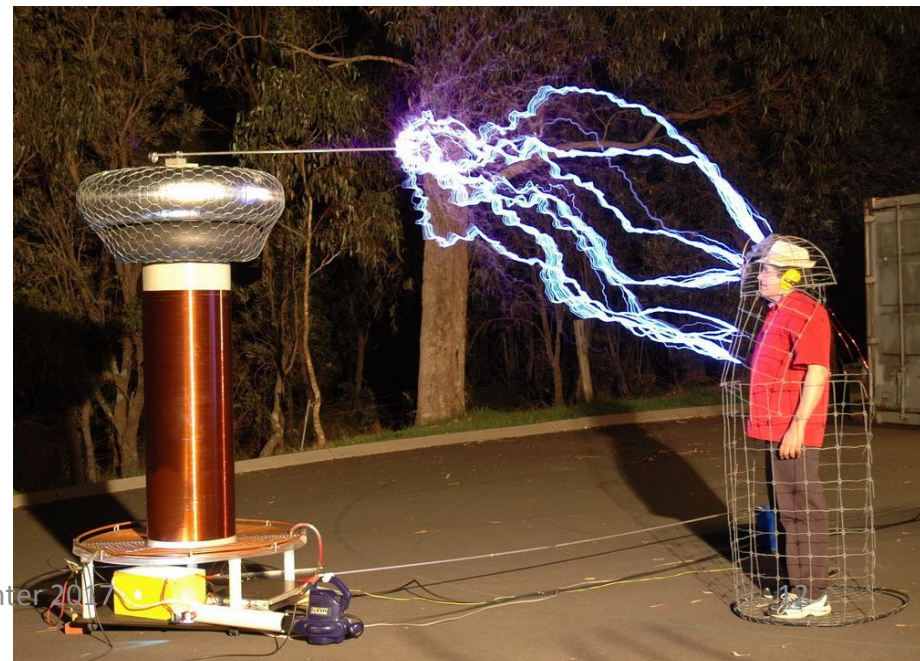
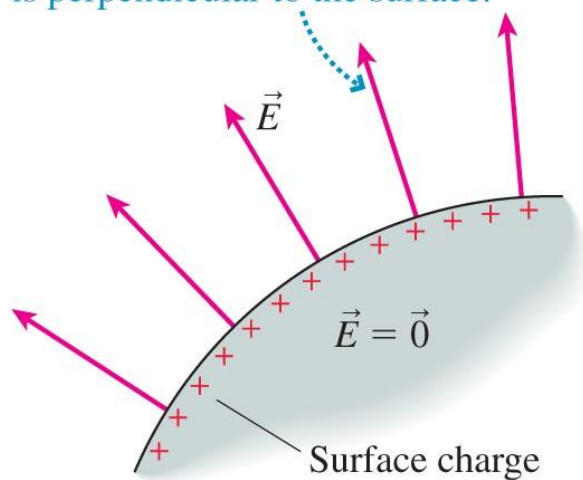
A void completely enclosed by the conductor



The charges are closer together and the electric field is strongest at the pointed end.



- (b) The electric field at the surface is perpendicular to the surface.



Faraday cage

- <https://www.youtube.com/watch?v=ve6XGKZxYxA>

Electric field due to conducting plate