Wed Feb 8, 2017

Last time

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

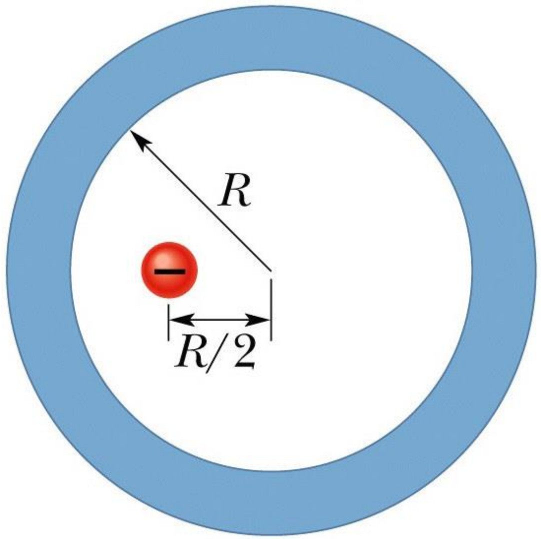
This time

- Gauss' Law applied to conductors: local surface charge density
- Electric field of a uniformly charged line
- Exercise: electric field of a coaxial cable

TopHat Question

Consider a spherical metal shell of inner radius R.
A point charge of -5.0 μC is located at a distance R/2 from the centre of the shell. If the shell is neutral –
-- what is the induced charge on its **outer surface**?

A) Zero
B) +5.0 μC
C) - 5.0 μC

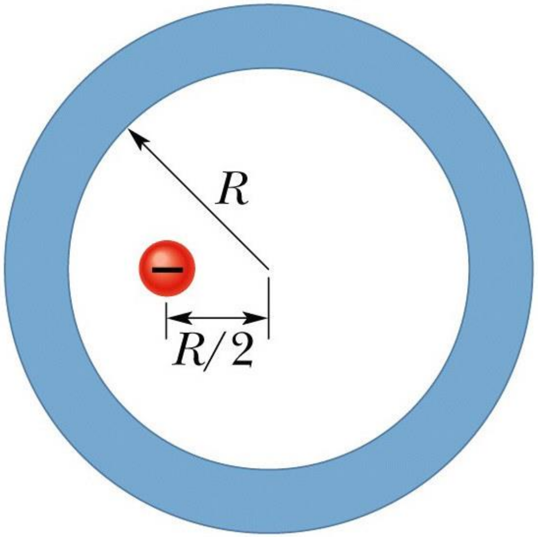


TopHat Question

Consider a spherical metal shell of inner radius R.

A point charge of - 5.0 μC is located at a distance R/2 from the centre of the shell.

If the shell is neutral, are these charges uniformly distributed on the **inner surface**?



A. Yes
B. No
C. Perhaps

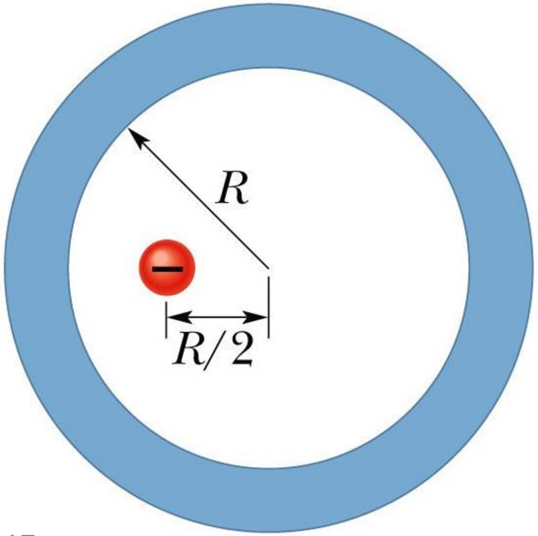
Hint: What must the electric field be inside the shell?

Charge in a hollow conductor

Consider a spherical metal shell of inner radius R.

A point charge of -5.0 μC is located at a distance R/2 from the centre of the shell. If the shell is neutral:

1. Calculate the induced charge on its outer surface ?
2. Sketch the E field lines inside and outside the metal shell

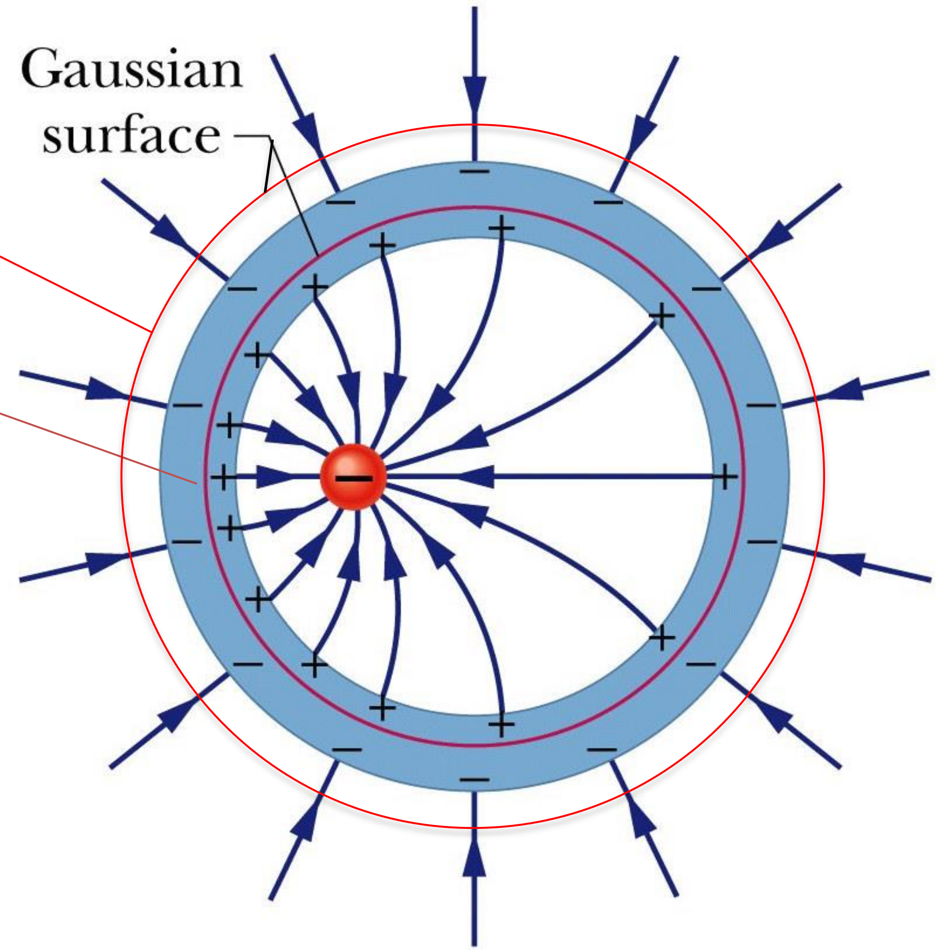


Hint: Use Gauss's law.

Solution

- Point Charge inside is $-5\mu C$
- Inner surface has $+5\ \mu C$ non-uniformly distributed
- Outer surface has $-5\ \mu C$ uniformly distributed

In this Gaussian surface, the **total charge enclosed** is –5 μC.
E = 0 inside the metal:
The **net charge** enclosed in this Gaussian surface must be **zero**.
There must be +5 μC on the inside of the shell and –5 μC on the outside.
The charges on the outside "don't know" about the inside since E = 0 inside the conductor.



Application: Microwaves

Properties of Conductors

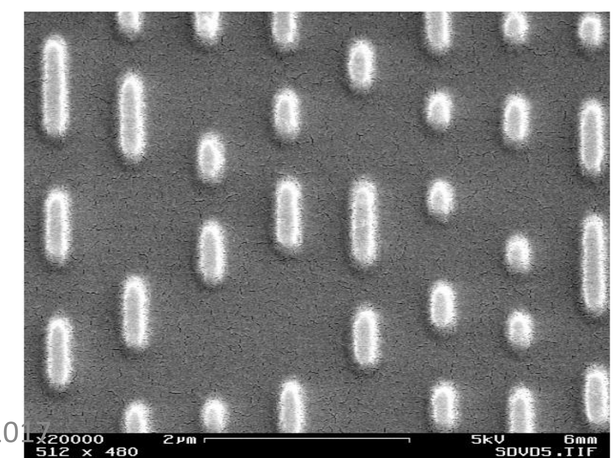
Summary:

- 1. The electric field is zero inside a conductor. – Static Case
- 2. All excess charge is distributed over the outside surface.

  Inside, a conductor is neutral.
- 3. The electric field outside a conductor is parallel to the area vector (perpendicular to the surface) at each point and has a magnitude **$E = \sigma/\varepsilon_0$**
- 4. The charge density is greatest where the radius of curvature is smallest.

Example: CD in the microwave.

Image: close-up of the surface of a CD

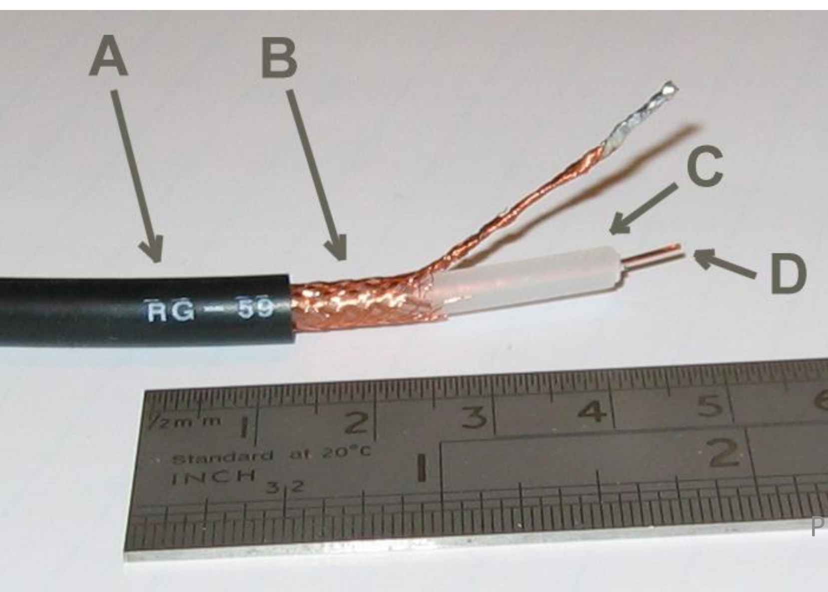


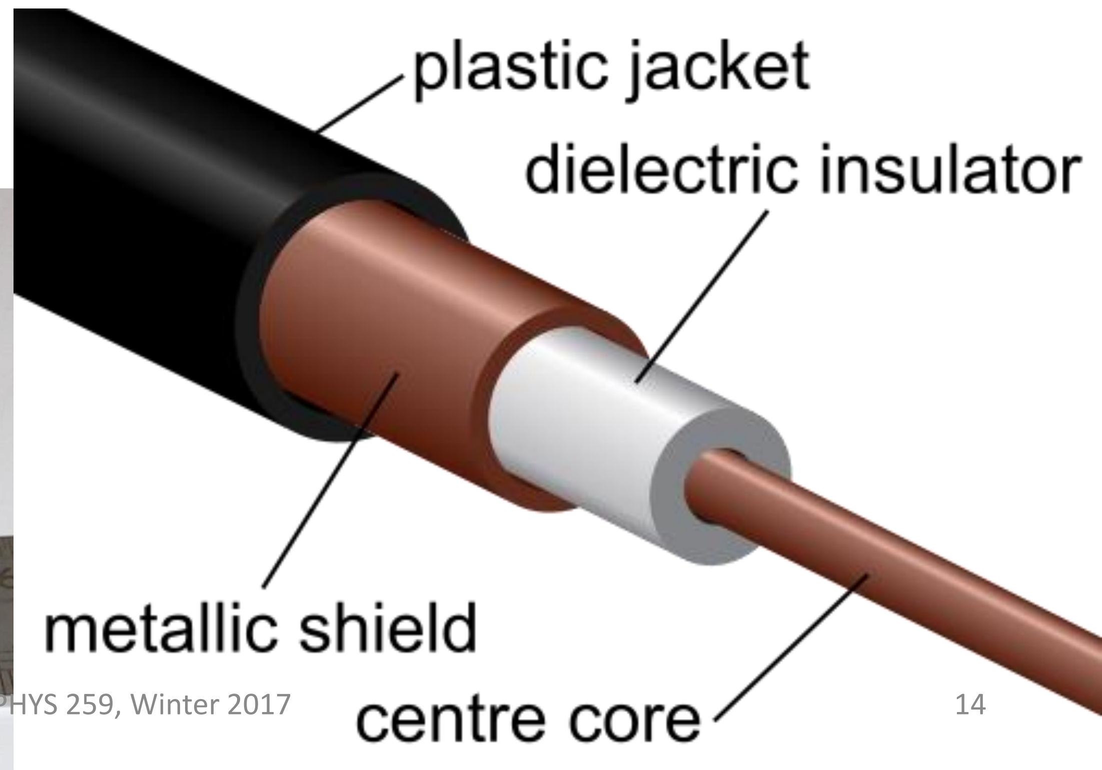
CD in the microwave

Exercise: Coaxial Cable

Assume there is a charge **+Q** on the centre core and **-Q** on the metallic shield. (Ignore the dielectric insulator and plastic jacket.)

Find the electric field outside the metallic shield (**E_2**) and just outside the central core (**E_1**).





Wed Feb 8, 2017 – lecture 2

Last time

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- Infinite charged plane: non-conducting vs. conducting
- Gauss' Law applied to conductors

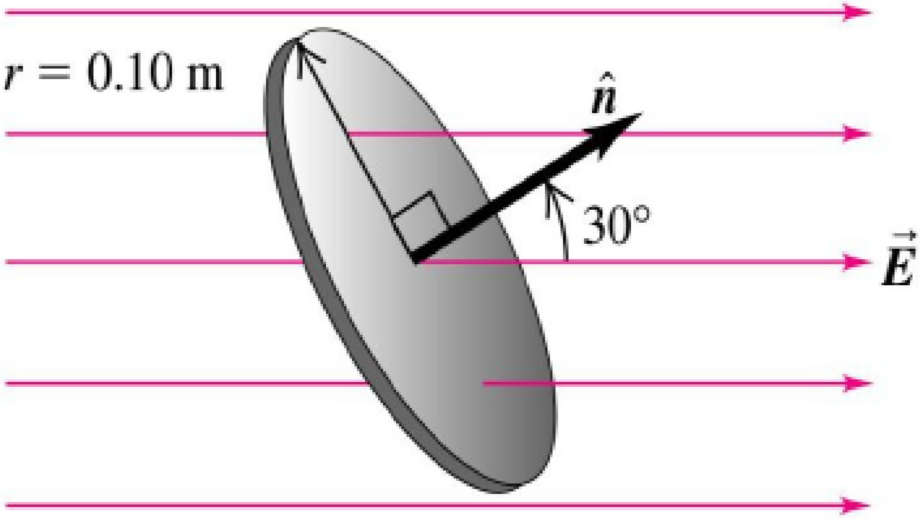
This time

- Examples (as many as we can solve ☺)

Example

A circular disk with a radius of 10 cm is inclined at 30° with respect to an electric field of 2.30E5 N/C.

What is the total electric flux through the surface?



$$\Phi_E = \vec{E} \cdot \vec{A}$$

$$= 2.30 \times 10^5 \, N/C \;\; \pi (0.10\, m)^2 \;\cos 30^o$$

$$= 6257.6078\, N\, m^2/C \approx \; 6.26 \times 10^3 \;\; N\, m^2/C$$

TopHat (exam question)

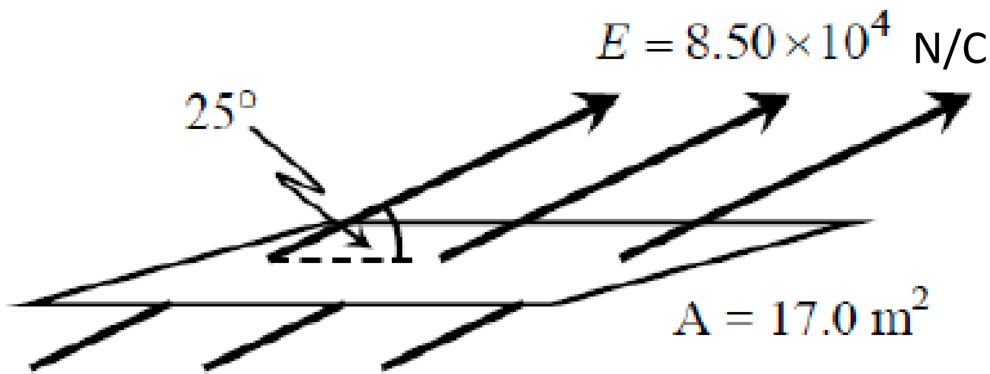
The electric flux through the area, A, shown below is closest to

a. 1.45×10^{6} N·m^2 /C

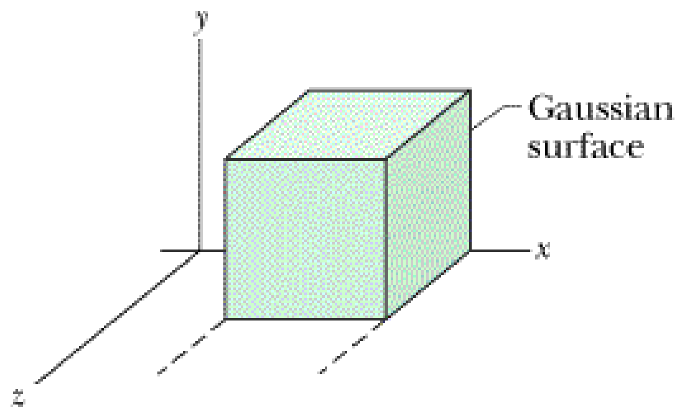
b. 1.31×10^{6} N·m^2 /C

c. 6.11×10^{5} N·m^2 /C

d. 2.11×10^{3} N·m^2 /C



An electric field given by $\vec{E} = 6.1\hat{i} - 9.1(y^2 + 8.5)\hat{j}$ pierces the Gaussian cube of edge length 0.260 m and positioned as shown in the figure. (The magnitude E is in newtons per coulomb and the position x is in meters.) What is the electric flux through the **(a)** top face, **(b)** bottom face, **(c)** left face, and **(d)** back face? **(e)** What is the net electric flux through the cube?



The figure shows two nonconducting spherical shells fixed in place. Shell 1 has uniform surface charge density $+5.2\ \mu C/m^2$ on its outer surface and radius 4.2 cm; shell 2 has uniform surface charge density $+3.3\ \mu C/m^2$ on its outer surface and radius 2.2 cm; the shell centers are separated by L = 12.1 cm. What is the x-component (with sign) of the net electric field at x = 2.0 cm?