POLARIZATION

Class Activities: Polarization (1)

Whiteboard

Dipole field

Sketch the E field from an ideal dipole, given the formula (and from a real dipole)

Demo

Charged rods and water

(CU Demo # 5A40.40)

http://physicslearning.colorado.edu/website_new/Common/ViewDemonstration.asp?Topic=5&SubSubtopic=5A40.40&DemoCode=5A40.40

Demonstrate the deflection of water with a charged rod, indicating that it is polarizeable. Note the HW problem on the same topic.

Tutorial

Electric Fields in Matter

Paul van Kampen – Dublin University (Tutorials 9-16, page 14)

Electric Fields in Matter tutorial. Calculate polarization of hydrogen atom, potential near a dipole, expand for small r, put into spherical coordinates.

Whiteboard

Charged fluid

Imagine two fluids, red (positive) and blue (negative), each uniform, identical, in a rectangular shape (area A, height H). This fluid is made up from N "atoms"/m^3, and each "atom" (or unit) has available a charge q (which can separate/move). Imagine the red fluid moves UP the page, uniformly, a distance "d". For them to work out

1) How much charge Q appears on the top surface? (How much on the bottom? the sides?)
2) What is sigma on the top, in terms of the given variables (N, q, d, A, and/or H)
3) What is the polarization P in terms of those variables?
4) What is sigma on the top in terms of P?=
5) What if we displace the fluid that same distance "d", but at an angle theta with respect to the vertical. What are the answers above?

Purpose was for THEM to derive sigma(bound) = P dot nhat. Took about 10 minutes, 10/12 whiteboards we looked at afterwards had gotton through part 4 correctly, and a few had dealt with the theta story. Many had a hard time getting started, visualizing the story, deciding if "q" was all the info they needed or if there was some OTHER "charge" needed. Some were confused about whether or not "H" plays a role, (e.g. a couple thought the polarization P should be calculated by looking only at the top and bottom sheets, and the distance H between them)

Class Activities: Polarization (2)

Demo

Polarize coke can

Activities: I brought rods (+ and -), an empty coke can to attract, a small smooth plastic wine cork (which CAN be budged, although friction is high so it doesn't do much, but that's really part of the point) and I brought a small low friction pivot (from Mike Thomason, it's used to put a bar magnet on, but I just laid a 1 meter wooden stick on it, and was able to get enough torque to easily move it around by attraction through polarization) Also brought an electroscope to show sign of charges.

Demo

Faraday's Ice Pail

(CU Demo # 5B20.10)

Charge is transferred to a conductor. Glass jar, filled with conducting water, wrap in al foil and charge. Capacitor. Remove glass jar from Al foil and pour out water. Another one… the glass jar has an induced polarization and that's stored and it discharges into new one. Nice intro to polarization.

Griffiths by Inquiry (Lab 7): Dielectric materials

Griffiths by Inquiry (Lab 8): Dielectrics II

Tutorial

Polarization of hydrogen atom

Paul van Kampen – Dublin University (Tutorials 9-16, page 14)

In document "Tutorials 9-16"

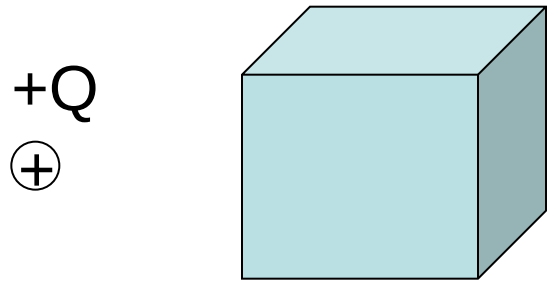
Calculate polarization of hydrogen atom, potential near a dipole, expand for small r, put into spherical coordinates.

A stationary point charge +Q is near a block of polarization material (a linear dielectric). The net electrostatic force on the block due to the point charge is

A) attractive (to the left)

B) repulsive (to the right)

C) zero

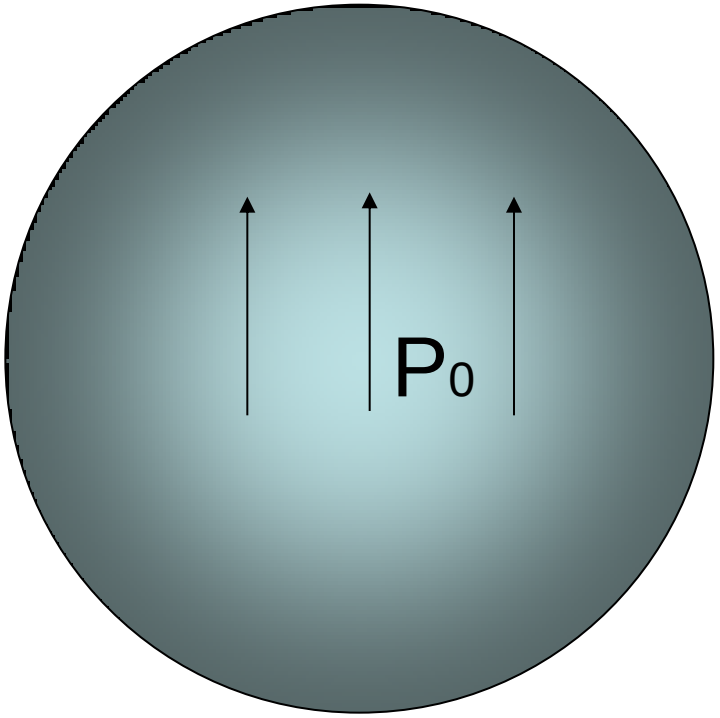


4.1

alt

The sphere below (radius a) has uniform polarization $\mathbf{P}_0$ (which points in the z direction.)

What is the total dipole moment of this sphere?



A) zero

B) $P_0\, a^3$

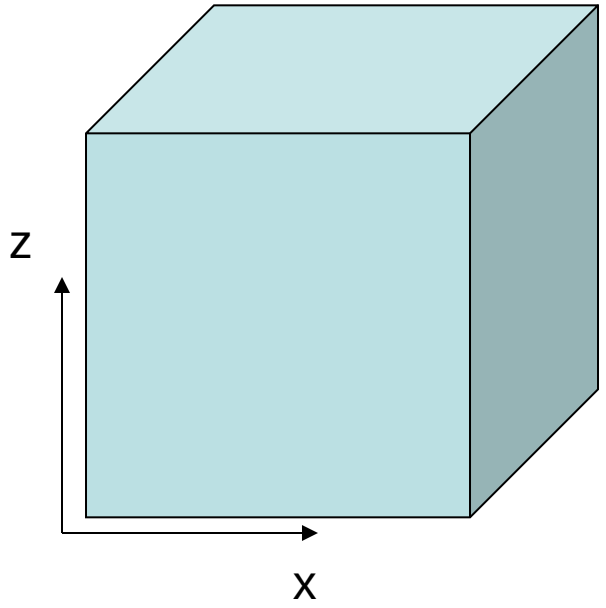
C) $4\pi a^3\, P_0/3$

D) P_0

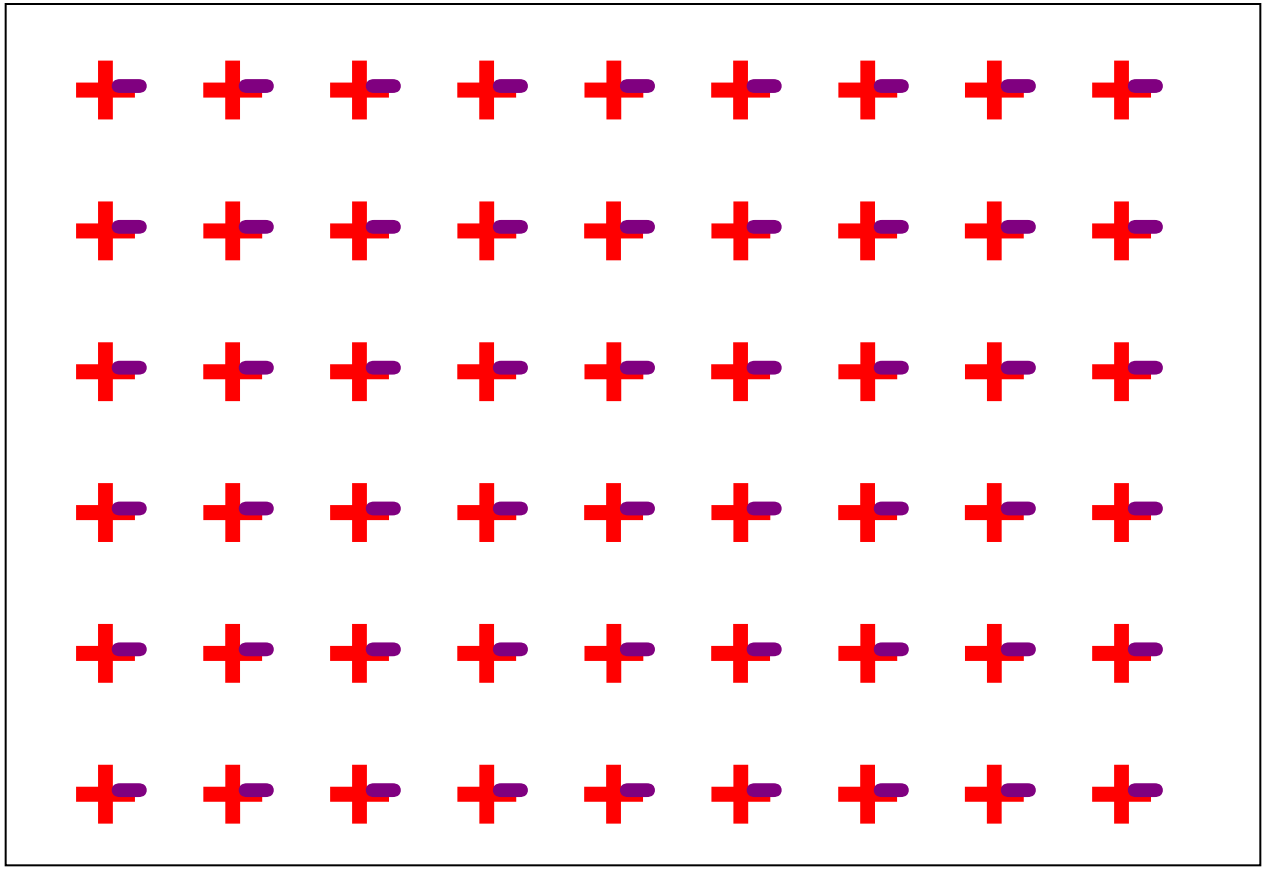
E) None of these/must be more complicated

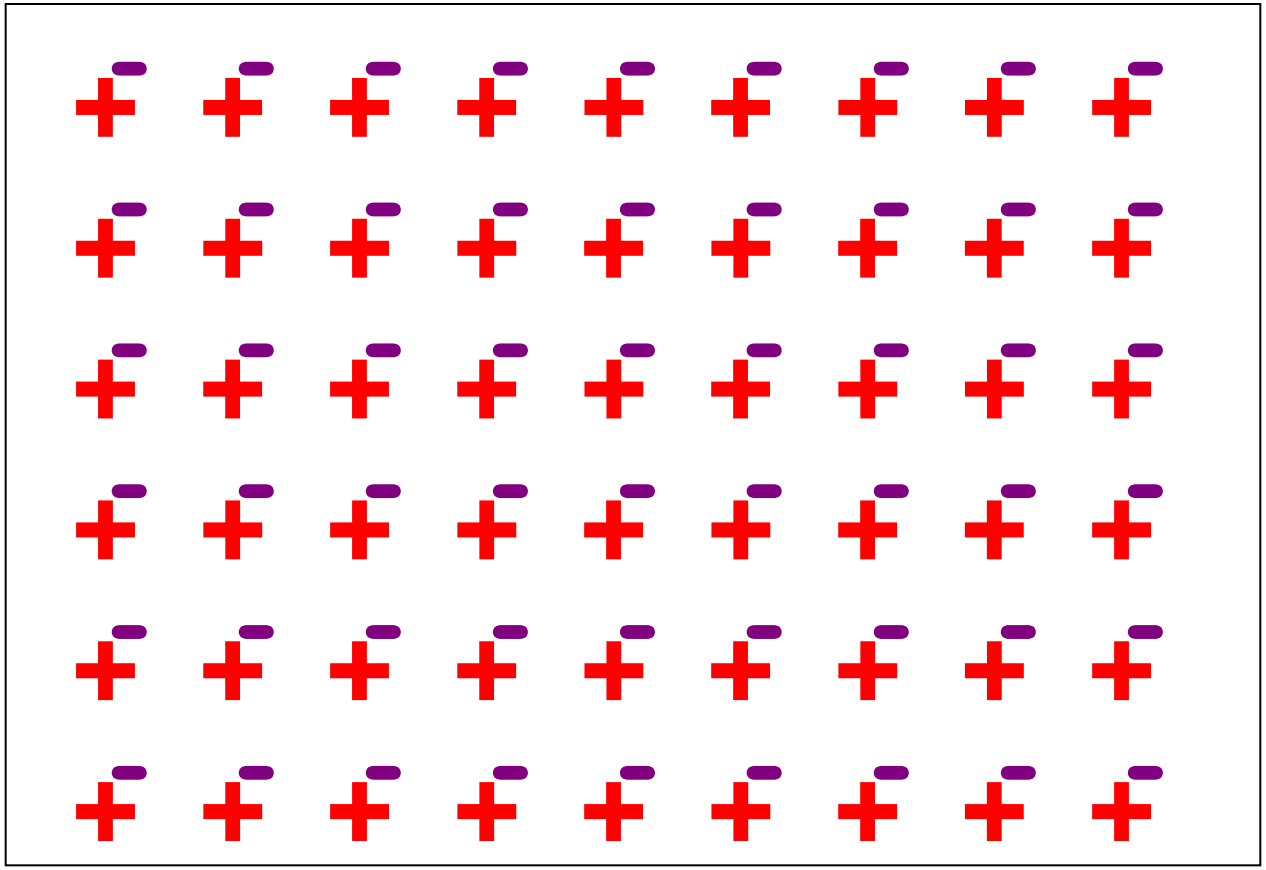
The cube below (side a) has uniform polarization $\mathbf{P}_0$
(which points in the z direction.)
What is the total dipole moment of this cube?

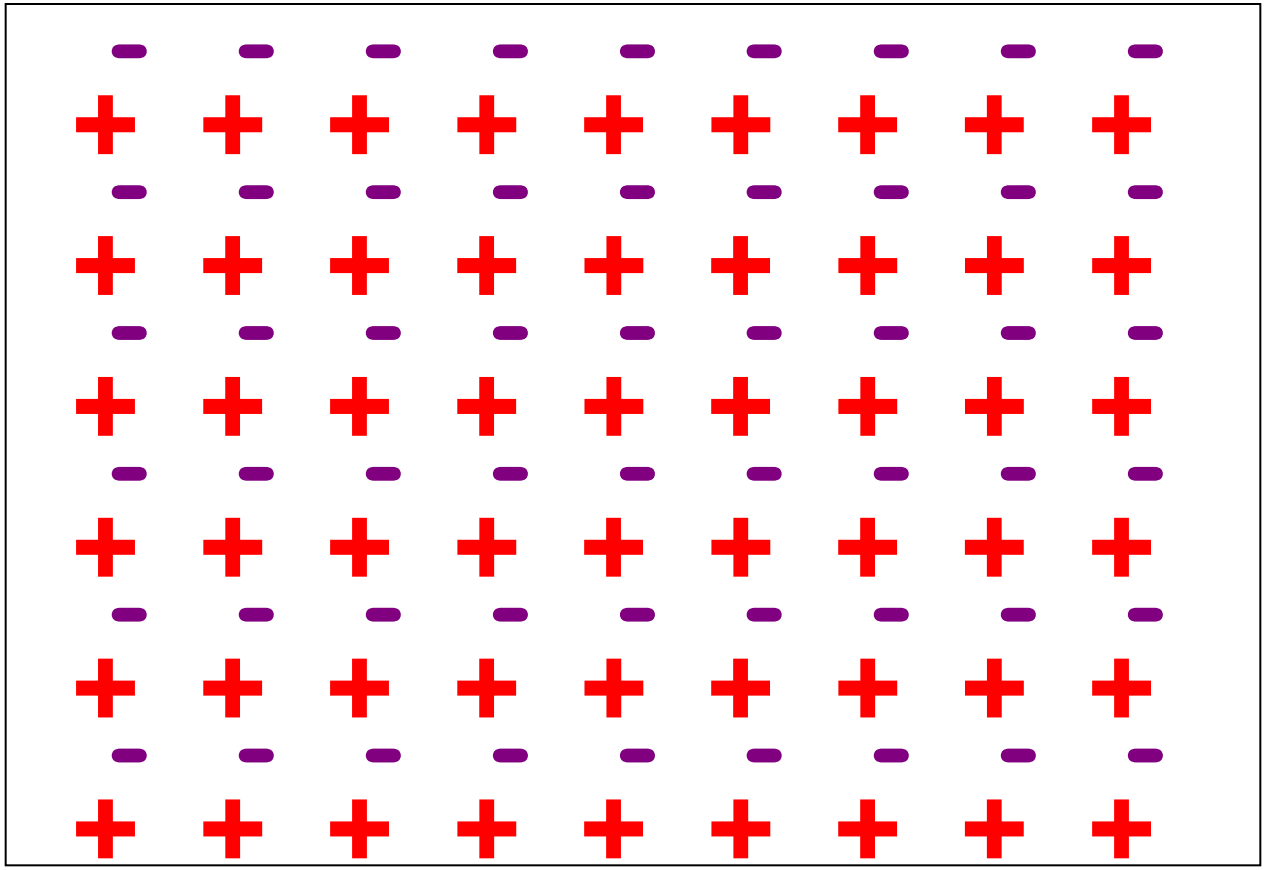
A) zero
B) $a^3\,\mathbf{P}_0$
C) $\mathbf{P}_0$
D) $\mathbf{P}_0 / a^3$
E) $2\,\mathbf{P}_0\,a^2$

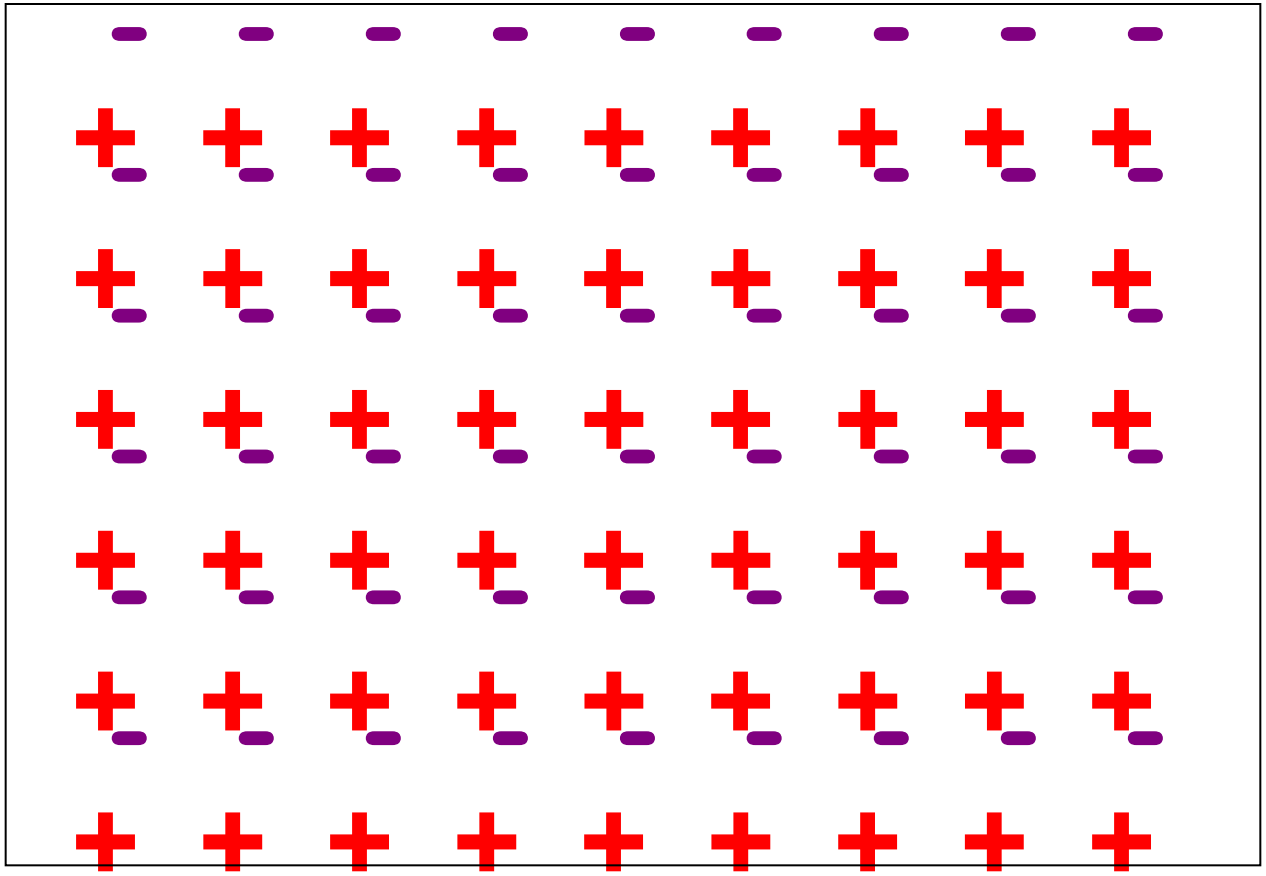


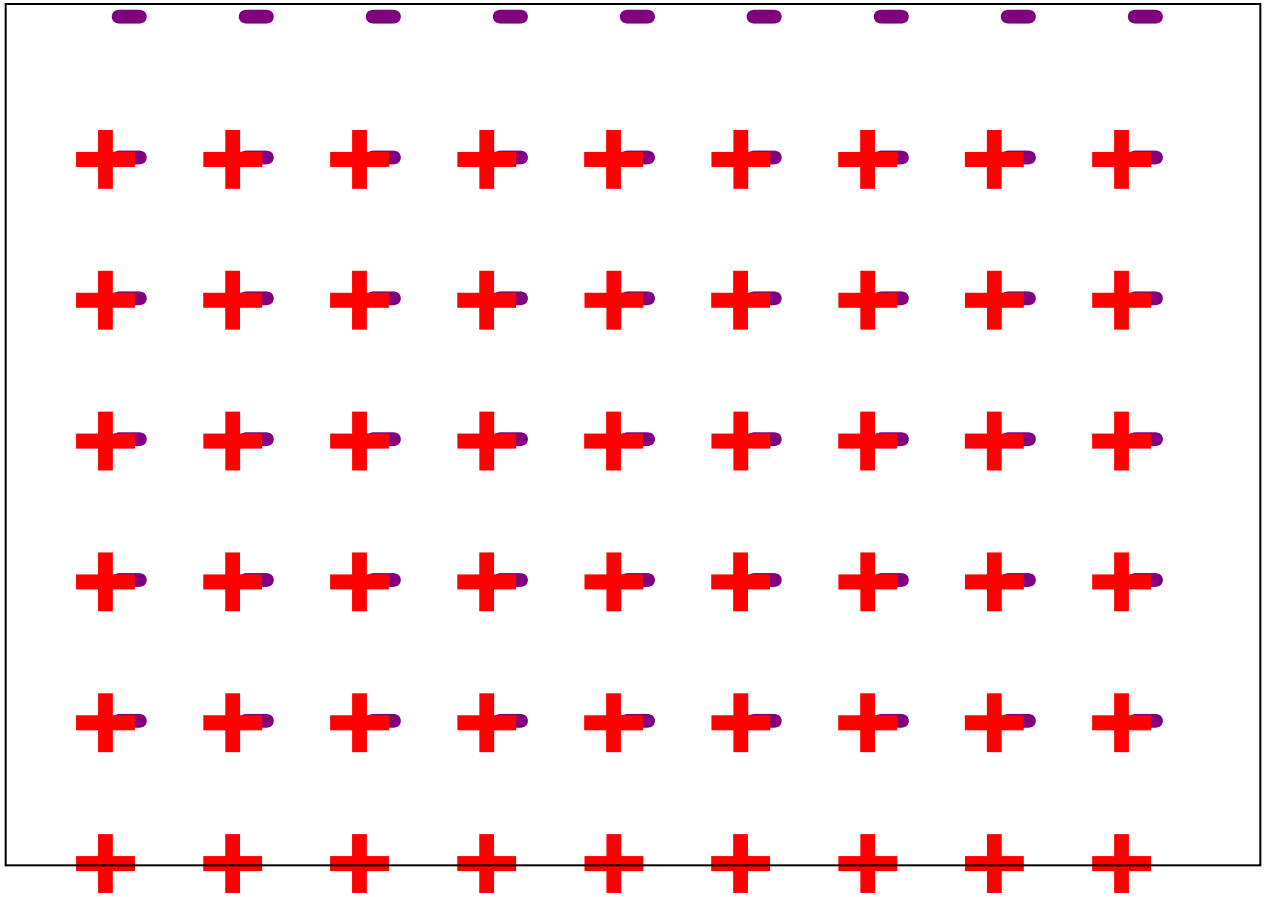
FIELD OF POLARIZED OBJECT



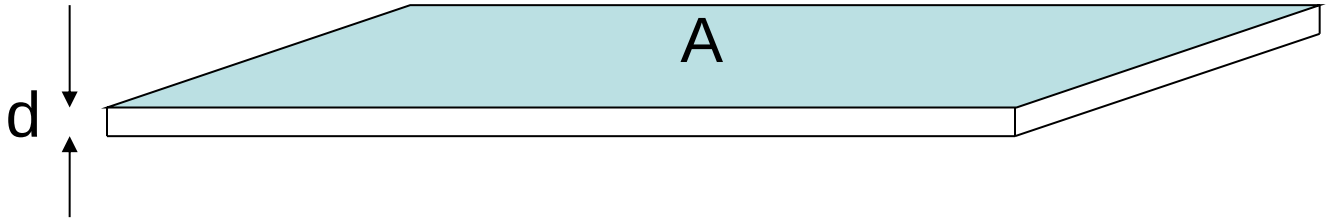








A VERY thin slab of thickness d and area A has *volume charge density* $\rho = Q / V$.
Because it's so thin, we may think of it as a *surface charge density* $\sigma = Q / A$.



The relation between ρ and σ is

A) $\sigma = \rho$

B) $\sigma = d\,\rho$

C) $d\,\sigma = \rho$

D) $\sigma = V\,\rho$

E) $V\,\sigma = \rho$

Imagine two fluids, red (+) and blue (-), each uniform, identical, in a rectangular shape (area A, height H).
This fluid has N "atoms"/m^3, and each "atom" (or unit) has available a charge q (which can separate/move). Imagine the red fluid moves UP the page, uniformly, a distance "d".

1) How much charge Q appears on the top surface? (on the bottom? the sides?)

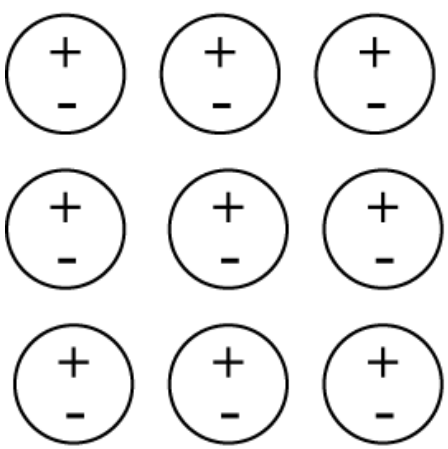
2) What is σ on the top, in terms N, q, d, A, and/or H

3) What is the polarization P in terms of those variables?

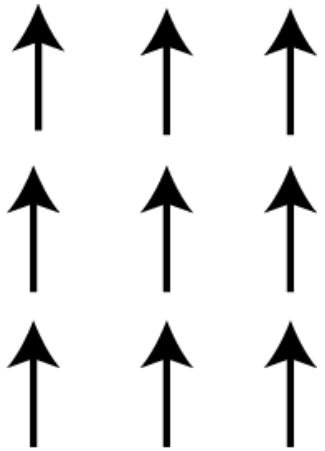
4) What is σ on the top in terms of P?=

5) What if we displace the fluid that same distance "d", but at an angle θ with respect to the vertical. What are the answers above?

In the following case, is the bound surface and volume charge zero or nonzero?



Physical dipoles



idealized dipoles

A. $\sigma_b = 0$, $\rho_b \neq 0$

B. $\sigma_b \neq 0$, $\rho_b \neq 0$

C. $\sigma_b = 0$, $\rho_b = 0$

D. $\sigma_b \neq 0$, $\rho_b = 0$

4.3
b

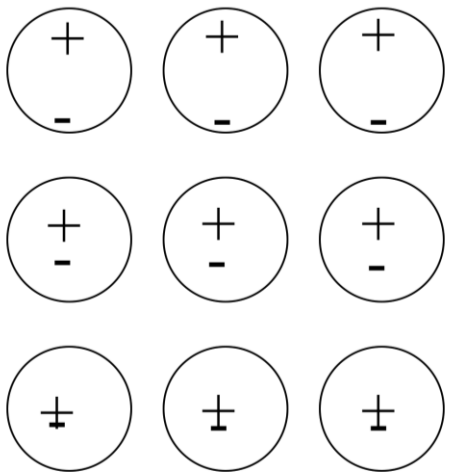
In the following case, is the bound surface and volume charge zero or nonzero?

A. $\sigma_b = 0$, $\rho_b \neq 0$

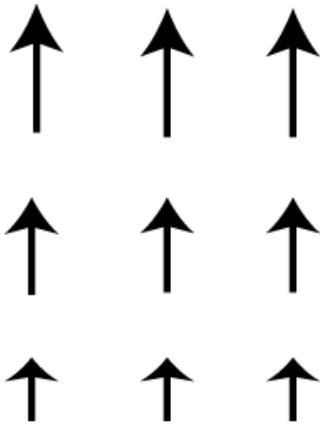
B. $\sigma_b \neq 0$, $\rho_b \neq 0$

C. $\sigma_b = 0$, $\rho_b = 0$

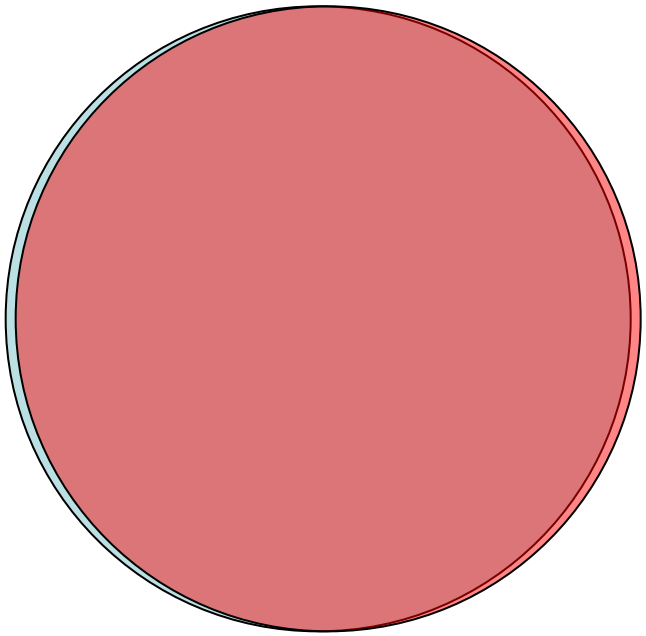
D. $\sigma_b \neq 0$, $\rho_b = 0$

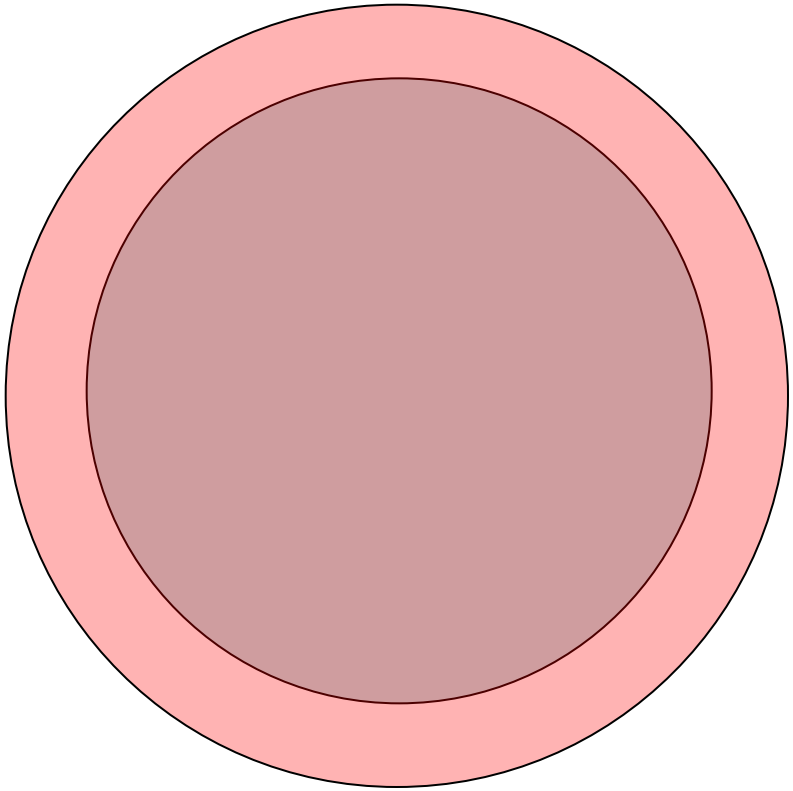


Physical dipoles



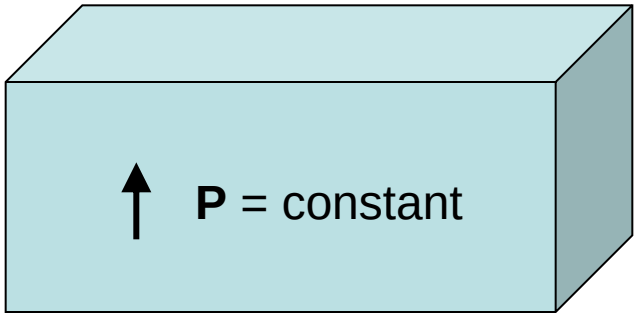
idealized dipoles





A linear dielectric in the shape of a rectangular block has a uniform polarization **P** (due to an external E-field) parallel to an edge, as shown. How many of the sides of the block have a non-zero surface charge density?

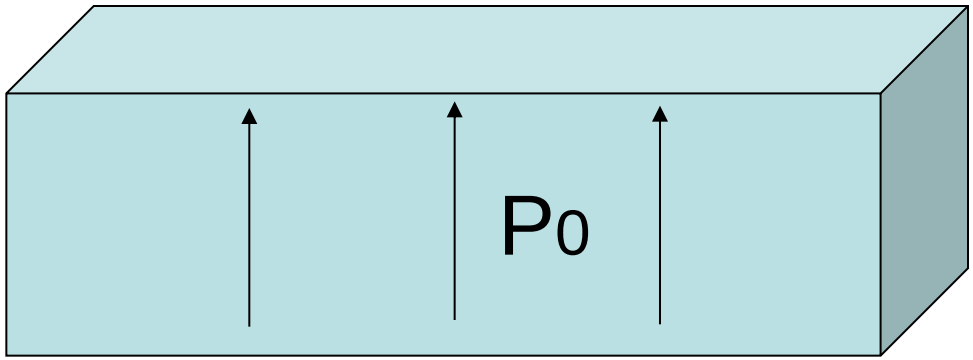
A) 1 B) 2 C) 4 D) 6 E) 0



4.4

A dielectric slab (top area A, height h) has been polarized, with **P=**P_0 (in the +z direction)

What is the surface charge density, σ_b, on the bottom surface?



A) 0

B) $-P_0$

C) P_0

D) $P_0 A h$

E) $P_0 A$

Are σ_b and ρ_b due to real charges?

A) Of course not! They are as fictitious as it gets! (Like in the ‘method of images.’)

B) Of course they are! They are as real as it gets! (Like σ and ρ in Chapter 2.)

C) I have no idea ☹

A dielectric sphere is uniformly polarized,

$$\mathbf{P} = +P_0 \hat{z}$$

What is the surface charge density?

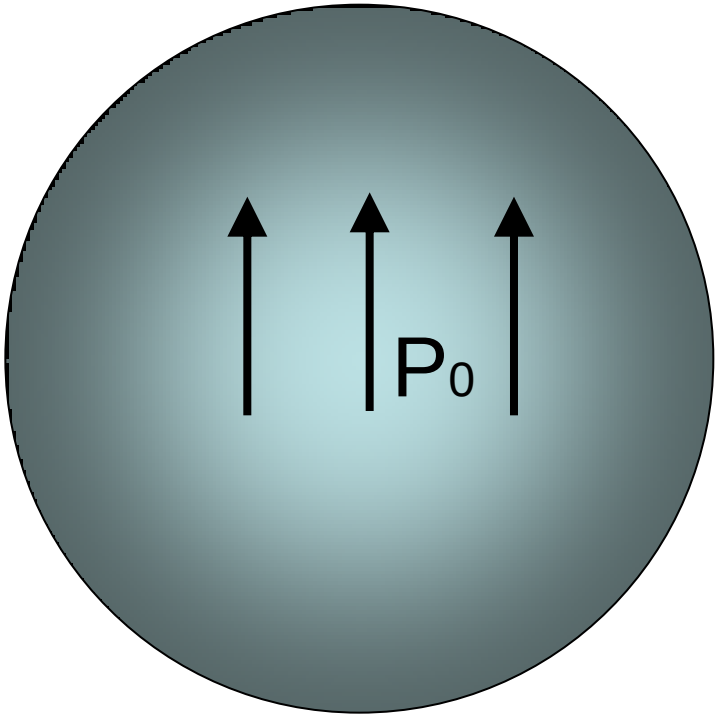
A) 0

B) Non-zero Constant

C) constant*sin(θ)

D) constant*cos(θ)

E) ??



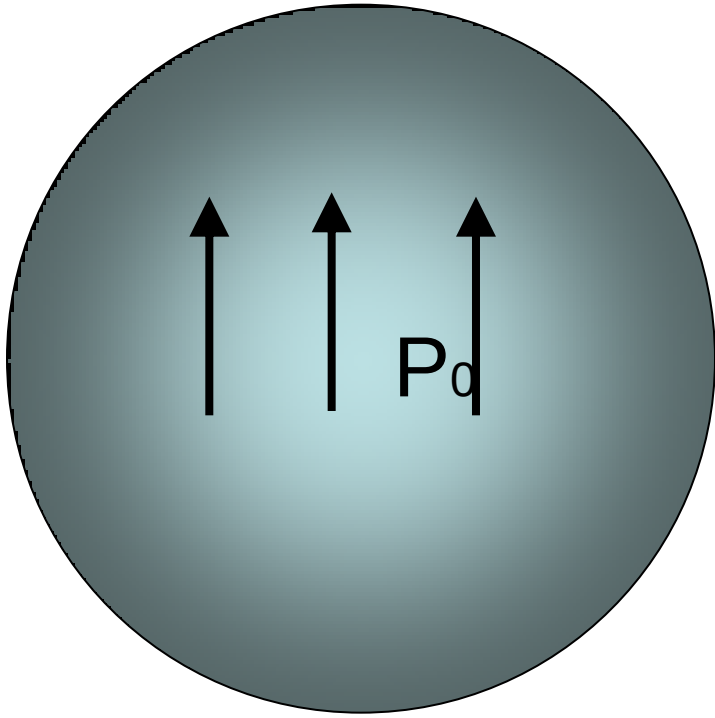
A dielectric sphere is uniformly polarized,

$$\mathbf{P} = +P_0 \hat{z}$$

What is the surface charge density?

$$s_{bound} = \mathbf{P} \cdot \hat{n}$$

$$r_{bound} = \nabla \cdot \mathbf{P}$$



A) 0

B) Non-zero Constant

C) sin(θ)

D) cos(θ)

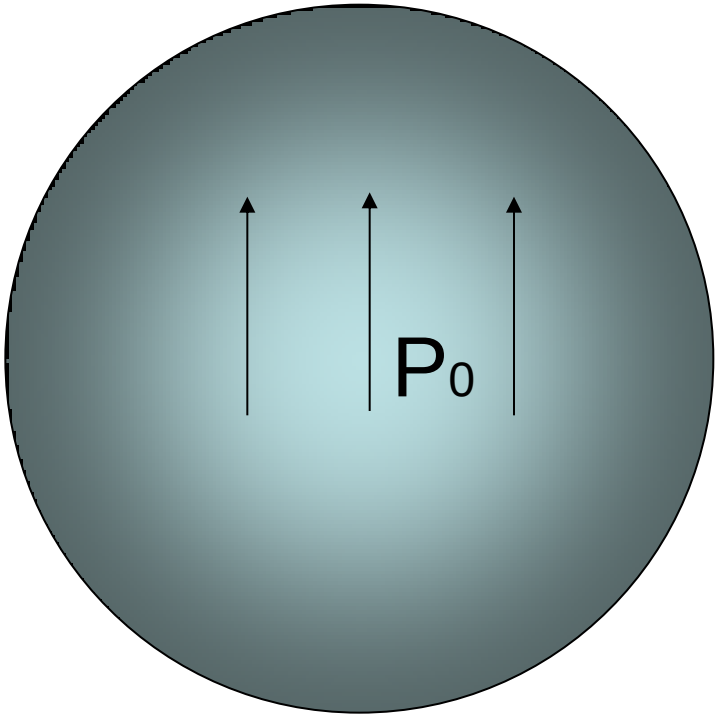
E) ??

4.1

alt

The sphere below (radius a) has uniform polarization $\mathbf{P}_0$ (which points in the z direction.)

What is the total dipole moment of this sphere?



A) zero

B) $P_0\, a^3$

C) $4\pi a^3\, P_0/3$

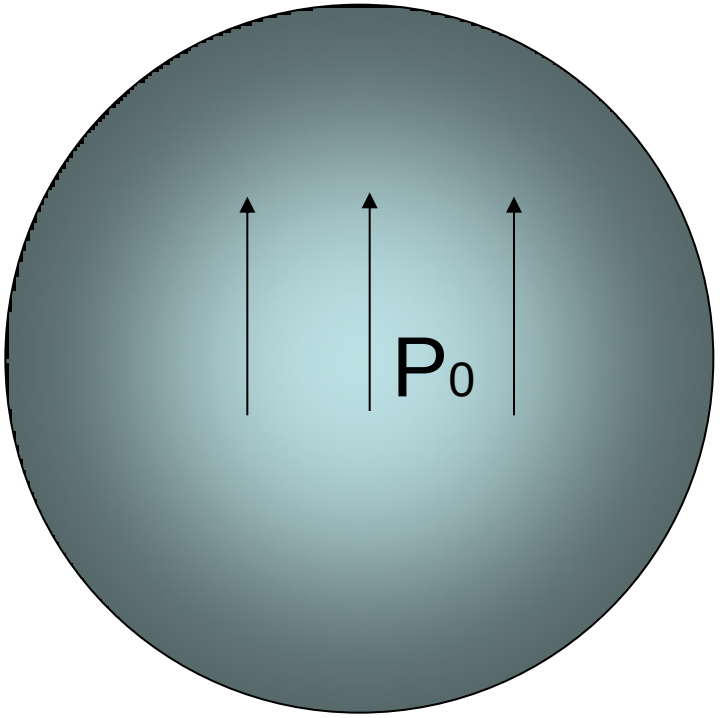
D) P_0

E) None of these/must be more complicated

A dielectric sphere is uniformly polarized,

$$\mathbf{P} = +P_0 \hat{z}$$

What is the volume charge density?



A) 0

B) Non-zero Constant

C) Depends on r, but not θ

D) Depends on θ, but not r

E) ?

FORCE AND ENERGY

4.11

We argued that C goes UP by a factor of ε_r if you fill a capacitor with dielectric.

What happens to the stored energy of a capacitor if it's filled with a dielectric?

A) It goes up

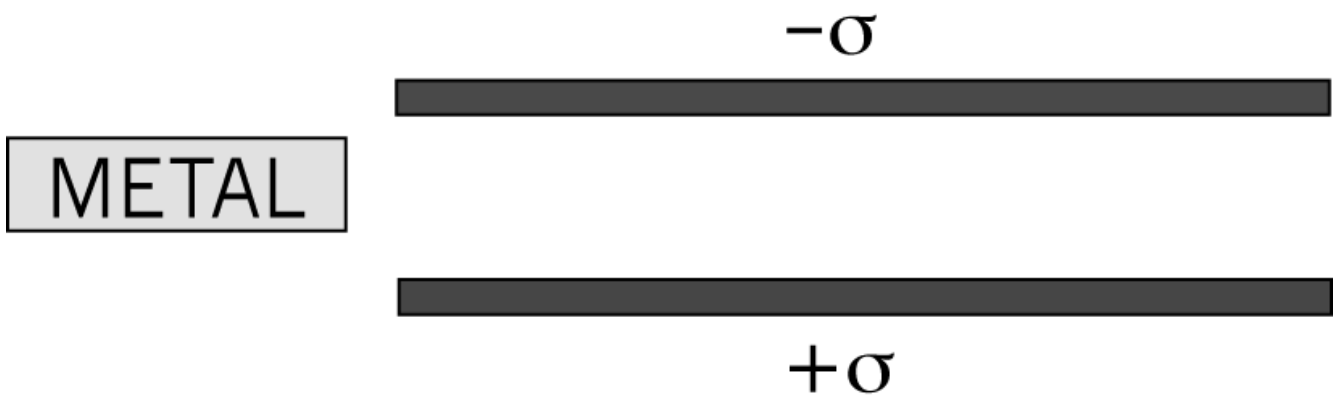
B) It goes down

C) It is unchanged

D) The answer depends on what else is "held fixed" (V? Q?)

4.12

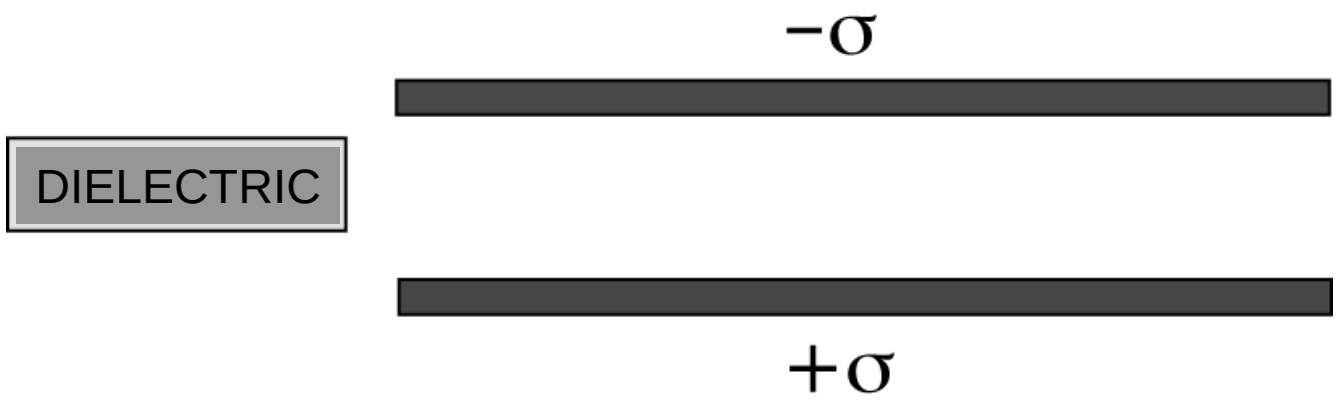
If we push this conductor inside the *isolated* capacitor, will it be drawn into the capacitor or repelled?



A. It gets sucked into the capacitor
B. It gets pushed out from the capacitor
C. I just don’t know.

4.12
b

If we push this dielectric inside the *isolated* capacitor, will it be drawn into the capacitor or repelled?



A. It gets sucked into the capacitor
B. It gets pushed out from the capacitor
C. I just don’t know.