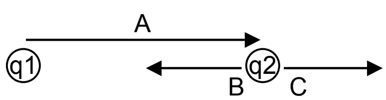
COULOMB'S LAW, E FIELDS

Coulomb's law: $\vec{\mathbf{F}}(\text{by 1 on 2}) = \frac{kq_1q_2}{\Re_{12}^2}\hat{\Re}_{12}$

In the fig, q1 and q2 are 2 m apart.

Which arrow *can* represent $\hat{\Re}_{12}$?



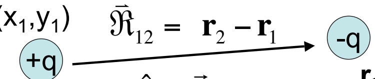
D) More than one (or NONE) of the above

E) You can't decide until you know if q1 and q2 are the same or opposite signed charges

What is $\hat{\Re}_{12}$ ("from 1 to 2") here?

$\mathbf{r}_1=(x_1,y_1)$

$\vec{\Re}_{12} = \mathbf{r}_2 - \mathbf{r}_1$



$\mathbf{r}_2=(x_2,y_2)$

$\hat{A} = \vec{A} / |A|$

A) $(x_2-x_1,\ y_2-y_1)$

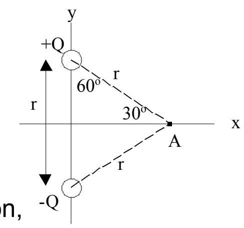
B) $(x_1-x_2,\ y_1-y_2)$

C) $(x_2-x_1,\ y_2-y_1)/\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

D) $(x_1-x_2,\ y_1-y_2)/\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

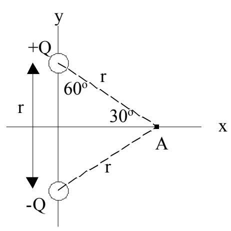
E) None of these/it depends/not sure…

Two charges +Q and -Q are fixed a distance r apart. The direction of the E field at A is…



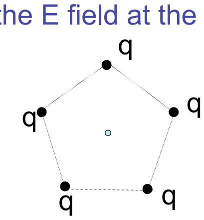
A. Up
B. Down
C. Left
D. Right
E. Some other direction, or E =0, or it's ambig. (depends on sign of q you put at A!)

Two charges +Q and -Q are fixed a distance r apart. The direction of the force on a test charge -q at A is…



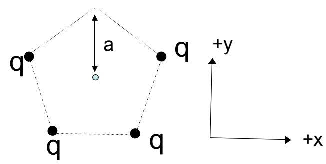
A. Up
B. Down
C. Left
D. Right
E. Some other direction, or F =0

5 charges, q, are arranged in a regular pentagon, as shown. What is the E field at the center?



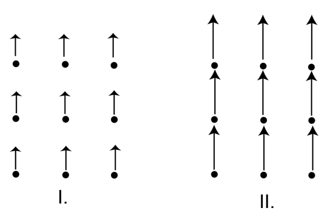
A) Zero
B) Non-zero
C) Really need trig and a calculator to decide

1 of the 5 charges has been removed, as shown. What's the E field at the center?



A) $+(kq/a^2)$ **j**
B) $-(kq/a^2)$ **j**
C) 0
D) Something entirely different!
E)This is a nasty problem which I need more time to solve

There is a uniform electric field in a region of empty space (shown at evenly spaced points) Which of the following *could* be a depiction of the electric field in this region of space?

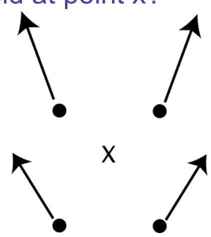


A. I only
B. II only
C. I or II
D. Neither

There is a uniform electric field in a region of empty space.
What distribution of charges could create such a field?

There is an electric field in a region of empty space (shown below at selected points).
What is the electric field at point x?

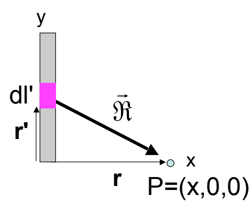
A. Up
B. Zero
C. Something else!?



To find the E- field at P from a thin line (uniform linear charge density λ):

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{1}{\mathfrak{R}^2}\hat{\mathfrak{R}}\ \lambda dl'$$

what is $\mathfrak{R}$?



A) x

B) y'

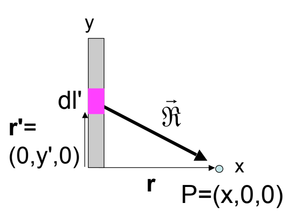
C) $\sqrt{dl'^2 + x^2}$ D) $\sqrt{x^2 + y'^2}$

E) Something *completely* different!!

$$\vec{\mathbf{E}}(\vec{\mathbf{r}}) = \int \frac{\lambda\, dl'}{4\pi\varepsilon_0 \mathfrak{R}^3}\vec{\mathfrak{R}}$$,so $$\mathbf{E}_x(x,0,0) = \frac{\lambda}{4\pi\varepsilon_0}\int \ldots$$

A) $\int \frac{dy'\ x}{x^3}$

B) $\int \frac{dy'\ x}{(x^2 + y'^2)^{3/2}}$



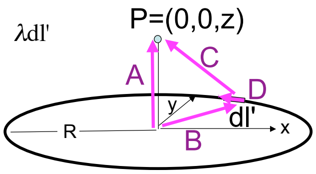
C) $\int \frac{dy'\ y'}{x^3}$

D) $\int \frac{dy'\ y'}{(x^2 + y'^2)^{3/2}}$ E) Something *else*…

To find the E- field at P from a thin ring (radius R, uniform linear charge density λ):

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{1}{\mathfrak{R}^2}\hat{\mathfrak{R}}\ \lambda dl'$$

what is $\vec{\mathfrak{R}}$?

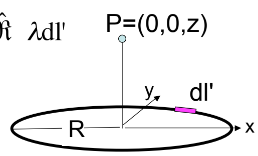


E) NONE of the arrows shown correctly represents $\vec{\mathfrak{R}}$

To find the E- field at P from a thin ring (radius R, uniform linear charge density λ):

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{1}{\mathfrak{R}^2}\hat{\mathfrak{R}}\ \lambda dl'$$

what is $\mathfrak{R}$?



A) $\sqrt{R^2 + z^2}$

B) R

C) $\sqrt{dl'^2 + z^2}$

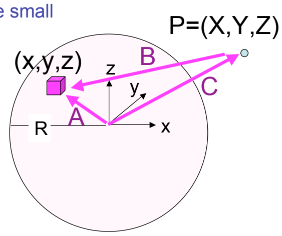
D) z

E) Something *completely* different!!

To find **E** at P from a sphere (radius R, uniform volume charge density ρ) using

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{1}{\mathfrak{R}^2}\hat{\mathfrak{R}}\ \rho\ d\tau'$$

what is $\vec{\mathfrak{R}}$ (given the small volume element shown)?

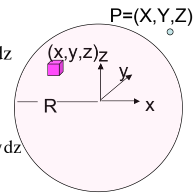


D) None of these!!

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{1}{\mathfrak{R}^2}\hat{\mathfrak{R}}\ \rho\ d\tau\ = \frac{1}{4\pi\varepsilon_0}\bullet(....?)$$

A) $\int \frac{(X,Y,Z)}{\left((X-x)^2+(Y-y)^2+(Z-z)^2\right)^2}\rho\,dx\,dy\,dz$

B) $\int \frac{(X,Y,Z)}{\left((X-x)^2+(Y-y)^2+(Z-z)^2\right)^{3/2}}\rho\,dx\,dy\,dz$

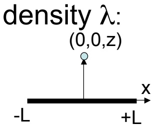


C) $\int \frac{(X-x,Y-y,Z-z)}{\left((X-x)^2+(Y-y)^2+(Z-z)^2\right)^2}\rho\,dx\,dy\,dz$

D) $\int \frac{(X-x,Y-y,Z-z)}{\left((X-x)^2+(Y-y)^2+(Z-z)^2\right)^{3/2}}\rho\,dx\,dy\,dz$ E) None of these!!!

Griffiths p. 63 finds E a distance z from a line segment with charge density λ:

$$\vec{\mathbf{E}} = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda L}{z\sqrt{z^2+L^2}}\hat{\mathbf{k}}$$



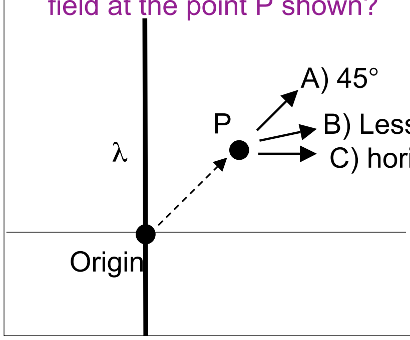
What is the approx. form for E, if z<<L?

$$E = \frac{2\lambda}{4\pi\varepsilon_0}\cdot(...)$$

A) 0 B) 1 C) 1/z D) 1/z^2

E) None of these is remotely correct.

An infinite rod has uniform charge density λ. What is the direction of the E field at the point P shown?



A) 45°

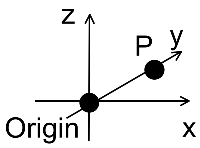
B) Less than 45°

C) horizontal

In spherical coordinates, what would be the correct description of the position vector **"r"** of the point P shown at (x,y,z) = (0, 2 m, 0)

A) $\vec{\mathbf{r}} = 2m\ \hat{r} + \pi\ \hat{\theta} + \pi/2\ \hat{\varphi}$

B) $\vec{\mathbf{r}} = 2m\ \hat{r} + \pi\ \hat{\theta} + \pi\ \hat{\varphi}$

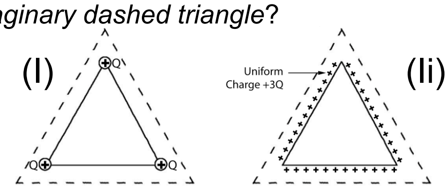


C) $\vec{\mathbf{r}} = 2m\ \hat{r} + \pi\ \hat{\theta}$

D) $\vec{\mathbf{r}} = 2m\ \hat{r}$

E) None of these

Which is true about **|E|** at points on the *imaginary dashed triangle*?



A. |**E**| is the same everywhere (uniform) in (I) ONLY
B. |**E**| is uniform in (II) ONLY
C. Uniform in both, but *different* for cases I and II
D. Uniform in both, and same for cases I and II.
E. |**E**| varies from point to point in both cases

GAUSS' LAW

Which of the following are vectors?
(I) Electric field
(II) Electric flux
(III) Electric charge

A) (I) only B) (I) and (II) only
C) (I) and (III) only
D) (II) and (III) only
E) (I), (II), and (III)

You have an E field given by
E = c **r**, (Here c = constant,
r = spherical radius vector)

What is the charge density $\rho(r)$?

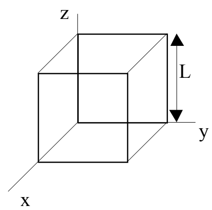
A) c B) c r C) 3 c D) 3 c r^2
E) None of these is correct

Given **E** = c **r**,
(c = constant, **r =** spherical radius vector)
We just found $\rho(r)$ = 3c.
What is the total charge Q enclosed by an imaginary sphere centered on the origin, of radius R?

Hint: Can you find it two DIFFERENT ways?

A) (4/3) π c B) 4 π c
C) (4/3) π c R^3 D) 4 π c R^3
E) None of these is correct

The space in and around a cubical box (edge length L) is filled with a constant uniform electric field, $\vec{E} = E\hat{y}$. What is the TOTAL electric flux $\oint \vec{E} \cdot d\vec{a}$ through this closed surface?

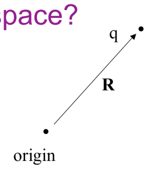


A. Zero
B. EL^2
C. $2EL^2$
D. $6EL^2$
E. We don't know ρ(r), so can't answer.

A Gaussian surface which is *not* a sphere has a single charge (q) inside it, *not* at the center. There are more charges outside. What can we say about total electric flux through this surface $\oint \vec{E} \cdot d\vec{a}$?

A) It is $q/\varepsilon 0$
B) We know what it is, but it is NOT $q/\varepsilon 0$
C) Need more info/details to figure it out.

A point charge (q) is located at position **R, as shown.** What is ρ(r), the charge density in all space?



A) $\rho(\vec{\mathbf{r}}) = q\delta^3(\vec{\mathbf{R}})$

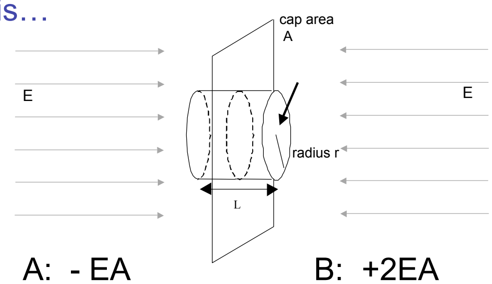
B) $\rho(\vec{\mathbf{r}}) = q\delta^3(\vec{\mathbf{r}})$

C) $\rho(\vec{\mathbf{r}}) = q\delta^3(\vec{\mathbf{r}} - \vec{\mathbf{R}})$

D) $\rho(\vec{\mathbf{r}}) = q\delta^3(\vec{\mathbf{R}} - \vec{\mathbf{r}})$

E) None of these

The flux through the pillbox surface is…



A: - EA

B: +2EA

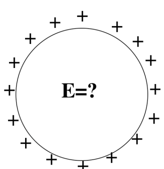
C: $(-2A+L\pi r^2)$ E

D: $L\pi r^2$ E

E: None of these

A spherical *shell* has a uniform positive charge density on its surface. (There are no other charges around)

What is the electric field *inside* the sphere?



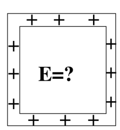
A: **E**=0 everywhere inside

B: **E** is non-zero everywhere in the sphere

C: **E**=0 only at the very center, but non-zero elsewhere inside the sphere.

D: Not enough info given

A cubical non-conducting *shell* has a uniform positive charge density on its surface. (There are no other charges around) What does Gauss' law tell us about the E field *inside* the cube?



A: **E**=0 everywhere inside

B: **E** is non-zero everywhere in the cube

C: **E**=0 only at the very center, but non-zero elsewhere inside the cube.

D: Not enough info given

The surface of a thin-walled insulating cubical box is given a uniform surface charge. What can be inferred about the E field everywhere **INSIDE** the box, using Gauss' Law?

A) |E| everywhere is zero

B) |E| everywhere must be uniform but non-zero

C) Direction of **E** everywhere must be radially out from the center of the box

D) Direction of **E** everywhere must be perpendicular to one of the sides

E) None of the above

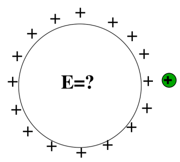
Now we add a single extra charge Q just outside the sphere (fixing all the other charges exactly as they were)

What is the electric field *inside* the sphere?

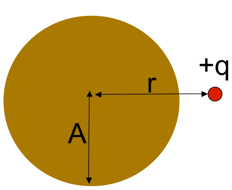
A: 0 everywhere inside

B: non-zero everywhere in the sphere

C: Not enough info given



A point charge +q sits outside a solid *neutral* copper sphere of radius A. What is the magnitude of the E-field at the center of the sphere?



A) $|E| = kq/r^2$

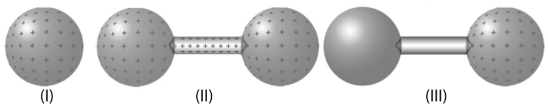
B) $|E| = kq/A^2$

C) $|E| = kq/(r-A)^2$

D) $|E| = 0$

E) None of these

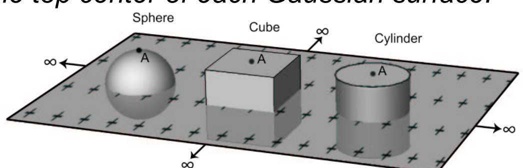
In which of the following can E (anywhere) be calculated easily from Gauss' Law?



A. (I) only
B. (II) only
C. (I) and (II) only
D. (I) and (III) only
E. (I), (II) and (III)

I. insulating sphere w/ uniform volume charge
II. insulating dumbbell w/ uniform volume charge
III. same as (II) but only one sphere charged

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



A) Only the sphere B) Only the cylinder
C) Only the cylinder and the cube
D) Only the sphere and the cylinder
E) All surfaces will work

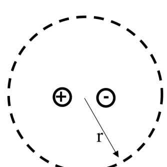
A dipole sits near the origin. We draw an imaginary Gaussian sphere (radius r) around it.

Gauss' law says: $\oint_{surf} \vec{E} \cdot d\vec{a} = \frac{Q_{inside}}{\varepsilon_0}$

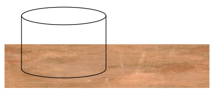
Do we conclude that E=0 everywhere around that sphere?

A)Yes, E=0 everywhere

B) No, E is not 0 at all points on that sphere.



We have a large copper plate with uniform surface charge density σ. Imagine the Gaussian surface drawn below. Calculate the E-field a distance s *above* the conductor surface.

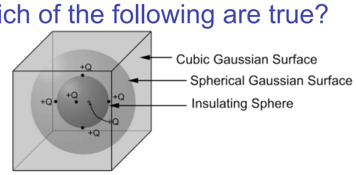


A) $|E| = \sigma/\varepsilon_0$
B) $|E| = \sigma/2\varepsilon_0$
C) $|E| = \sigma/4\varepsilon_0$
D) $|E| = (1/4\pi\varepsilon_0)(\sigma/s^2)$
E) $|E| = 0$

You have two hollow insulating spheres:
(I) +6Q distributed uniformly on its surface
(II) 6 point charges +Q arranged equidistant from one another on the sphere.
What is true about |E| INSIDE the spheres?

A. |E|=0 everywhere in both
B. non-zero everywhere in both
C. 0 in (II), but varies in (I)
D. 0 in (II), but uniform and non-zero in (I)
E. None of the above

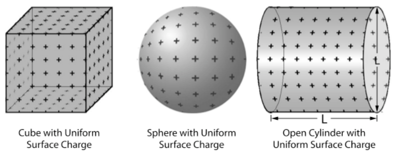
6 point charges +Q are put on a hollow insulating sphere. Shown are a spherical and cubic Gaussian surface concentric with the sphere. Which of the following are true?



(I) E constant on the cubic Gaussian surface
(II) E constant on the spherical Gaussian surface
(III) E radially outward on spherical Gaussian surface

A) I only B) II only C) III only D) II+ III only E) other

Three thin-walled insulating objects have net charge +Q uniformly distributed on their surfaces. We can use Gauss' law to find E at a point outside due to:



A) cube only B) sphere only
C) Sphere and cylinder only
D) Sphere and cube only
E) All three objects

Which of the following are true?

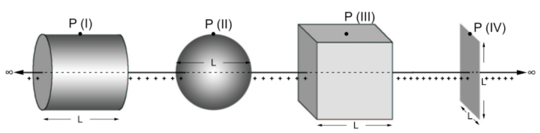
(I) If **E=0** at every point on a Gaussian surface, Φ_E through the surface must be zero

(II) If there is no charge enclosed inside a Gaussian surface, **E** everywhere on the surface must be zero

(III) If Φ_E =0 through a Gaussian surface, **E** everywhere on the surface must be zero

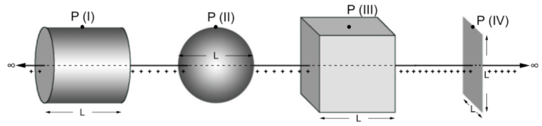
A) I only B) II only C) I and II only
D) I and III only E) II and III only

4 Gaussian surfaces are coaxial with an infinitely long line of charge with uniform λ. Choose all surfaces through which $\Phi_E = \lambda L / \varepsilon_0$



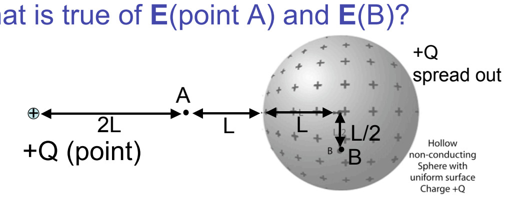
A) I only B) I and II only C) I and III only
D) I, II, and III only E) All four.

4 Gaussian surfaces are coaxial with an infinitely long line of charge with uniform λ.
Choose all surfaces which can be used to find E at point P using Gauss' law



A) I only B) I and II only C) I and III only
D) I, II, and III only E) All four.

A point charge +Q is near a thin hollow insulating sphere (radius L) with charge +Q uniformly distributed on its surface.
What is true of **E**(point A) and **E**(B)?



A) **E**(A)=0, **E**(B)<>0 B) **E**(A)<>0, **E**(B) =0
C) Both nonzero D) Both 0 E) ??

Griffiths

Griffiths

POTENTIAL

The formula for E field is $\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\iiint \frac{\rho(\mathbf{r}')\,\hat{\mathfrak{R}}}{\mathfrak{R}^2}d\tau'$

(with $\vec{\mathfrak{R}} = \mathbf{r} - \mathbf{r}' = (x - x', y - y', z - z')$)

However, it turns out (check!) that $\frac{\hat{\mathfrak{R}}}{\mathfrak{R}^2} = -\nabla \frac{1}{|\mathfrak{R}|}$

where $\nabla = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)$

Question: is the following mathematically ok?

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\iiint \rho(\mathbf{r}')\left(-\nabla \frac{1}{|\mathfrak{R}|}\right)d\tau' = -\nabla \frac{1}{4\pi\varepsilon_0}\iiint \frac{\rho(\mathbf{r}')}{|\mathfrak{R}|}d\tau'$$

A) Yes B) No C) ???

Which of the following electric fields could exist in a finite region of space that contains no charges?

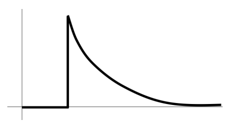
(a) $Axyz(\hat{i} + \hat{j})$

(b) $A(2xy\hat{i} - xz\hat{k})$

(c) $A(xz\hat{i} - xz\hat{j})$

(d) $A(-xy\hat{j} + xz\hat{k})$

(e) $A(+xy\hat{j} + xz\hat{k})$



Could this be a plot of |E|(r)? Or V(r)?
(for SOME physical situation?)

A) Could be E(r), or V(r)

B) Could be E(r), but can't be V(r)

C) Can't be E(r), could be V(r)

D) Can't be either

E) ???

Given a sphere with uniform surface charge density σ what can you say about the potential V *inside* this sphere? (Assume as usual, $V(\infty)=0$)

A) V=0 everywhere inside
B) V = non-zero constant everywhere inside
C) V must vary with position, but is zero at the center.
D) None of these.

Why is $\int \vec{E} \cdot d\vec{l} = 0$ in electrostatics?

a) Because $\nabla X \vec{E} = 0$

b) Because E is a conservative field

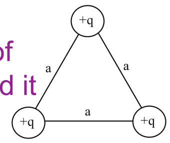
c) Because the potential between two points is independent of the path

d) All of the above

e) NONE of the above - it's not true!

WORK & ENERGY

Three identical charges +q sit on an equilateral triangle.



What would be the final KE of the *top* charge if you released it (keeping the other two fixed)

A) $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}$

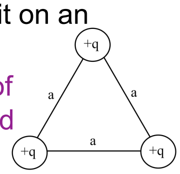
B) $\frac{1}{4\pi\varepsilon_0}\frac{2q^2}{3a}$

C) $\frac{1}{4\pi\varepsilon_0}\frac{2q^2}{a}$

D) $\frac{1}{4\pi\varepsilon_0}\frac{3q^2}{a}$

E) other/not sure

Three identical charges +q sit on an equilateral triangle.



What would be the final KE of the *top* charge if you released *all three?*

A) $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}$

B) $\frac{1}{4\pi\varepsilon_0}\frac{2q^2}{3a}$

C) $\frac{1}{4\pi\varepsilon_0}\frac{2q^2}{a}$

D) $\frac{1}{4\pi\varepsilon_0}\frac{3q^2}{a}$

E) other/not sure

CONDUCTORS

CAPACITORS

Given a pair of very large, flat, conducting capacitor plates (with surface charge densities +/- σ) what is the E field in the region between the plates?

A) $\sigma/2\varepsilon_0$
B) σ/ε_0
C) $2\sigma/\varepsilon_0$
D) $4\sigma/\varepsilon_0$
E) Something else/ not determined