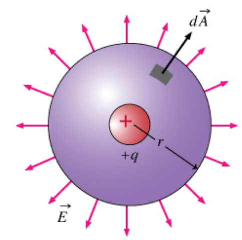
GAUSS' LAW



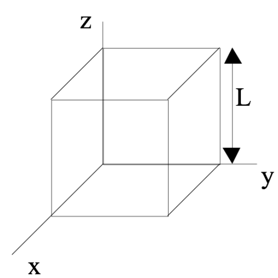
$$\oint_S \mathbf{E} \cdot d\mathbf{A} = \int_V \frac{\rho}{\varepsilon_0} d\tau$$

Which of the following are vectors?

(I) Electric field, (II) Electric flux, and/or (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 II

The space in and around a cubical box (edge length L) is filled with a constant uniform electric field, $\mathbf{E} = E_0\hat{y}$. What is the TOTAL electric flux $\oint_S \mathbf{E} \cdot d\mathbf{A}$ through this closed surface?



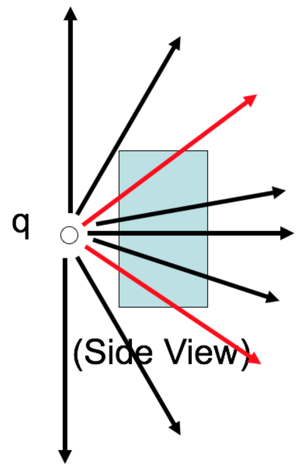
A. 0
B. E_0L^2
C. $2E_0L^2$
D. $6E_0L^2$
E. We don't know $\rho(r)$, so can't answer.

A positive point charge $+q$ is placed outside a closed cylindrical surface as shown. The closed surface consists of the flat end caps (labeled A and B) and the curved side surface (C). What is the sign of the electric flux through surface C?

A. positive
B. negative
C. zero

D. not enough information given to decide

Let's get a better look at the side view.



A positive point charge $+q$ is placed outside a closed cylindrical surface as shown. The closed surface consists of the flat end caps (labeled A and B) and the curved side surface (C). What is the sign of the electric flux through surface C?

A. positive
B. negative
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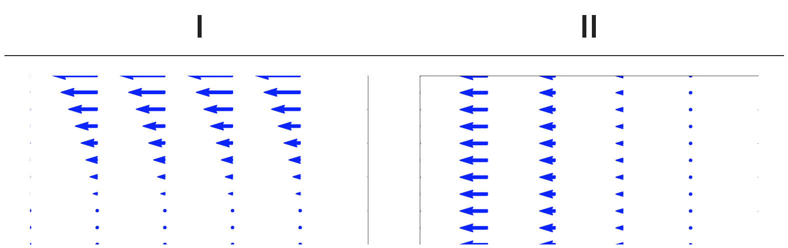
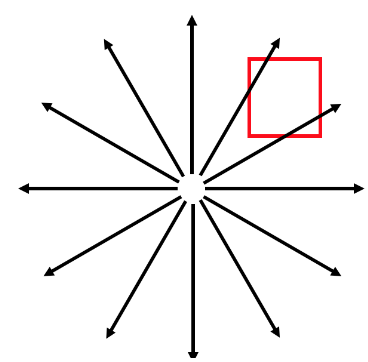
Which of the following two fields has zero divergence?



A. Both do.
B. Only I is zero
C. Only II is zero
D. Neither is zero
E. ???

What is the divergence in the boxed region?

A. Zero
B. Not zero
C. ???



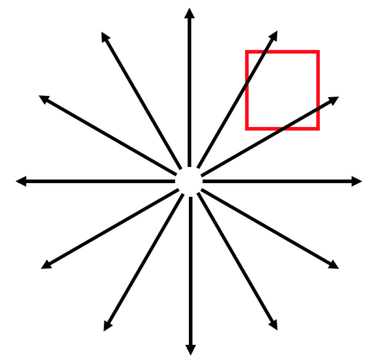
Activity: For a the electric field of a point charge,

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}\text{, compute } \nabla \cdot \mathbf{E}.$$

Hint: The front fly leaf of Griffiths suggests that the we take:

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial E_r}{\partial r}\right)$$

Remember this?



What is the value of:

$$\int_{-\infty}^{\infty} x^2\delta(x-2)dx$$

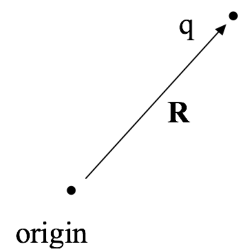
A. 0
B. 2
C. 4
D. ∞
E. Something else

Activity: Compute the following integrals. Note anything special you had to do.

- Row 1-2: $\int_{-\infty}^{\infty} xe^x\delta(x-1)dx$
- Row 3-4: $\int_{\infty}^{-\infty} \log(x)\delta(x-2)dx$
- Row 5-6: $\int_{-\infty}^{0} xe^x\delta(x-1)dx$
- Row 6+: $\int_{-\infty}^{\infty}(x+1)^2\delta(4x)dx$

A point charge (q) is located at position $\mathbf{R}$, as shown. What is $\rho(\mathbf{r})$, the charge density in all space?

A. $\rho(\mathbf{r}) = q\delta^3(\mathbf{R})$
B. $\rho(\mathbf{r}) = q\delta^3(\mathbf{r})$
C. $\rho(\mathbf{r}) = q\delta^3(\mathbf{R} - \mathbf{r})$
D. $\rho(\mathbf{r}) = q\delta^3(\mathbf{r} - \mathbf{R})$
E. Something else??



What are the units of $\delta(x)$ if x is measured in meters?

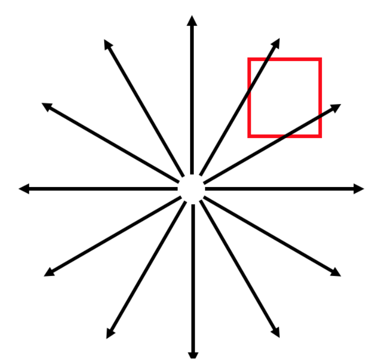
A. $\delta(x)$ is dimension less ('no units')
B. $[\mathrm{m}]$: Unit of length
C. $[\mathrm{m}^2]$: Unit of length squared
D. $[\mathrm{m}^{-1}]$: 1 / (unit of length)
E. $[\mathrm{m}^{-2}]$: 1 / (unit of length squared)

What are the units of $\delta^3(\mathbf{r})$ if the components of $\mathbf{r}$ are measured in meters?

A. $[\mathrm{m}]$: Unit of length
B. $[\mathrm{m}^2]$: Unit of length squared
C. $[\mathrm{m}^{-1}]$: 1 / (unit of length)
D. $[\mathrm{m}^{-2}]$: 1 / (unit of length squared)
E. None of these.

What is the divergence in the boxed region?

A. Zero
B. Not zero
C. ???

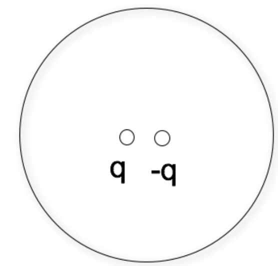


A Gaussian surface which is *not* a sphere has a single charge (q) inside it, *not* at the center. There are more charges outside. What can we say about total electric flux through this surface $\oint_S \mathbf{E} \cdot d\mathbf{A}$?

A. It is q/ε_0.
B. We know what it is, but it is NOT q/ε_0.
C. Need more info/details to figure it out.

An electric dipole ($+q$ and $-q$, small distance d apart) sits centered in a Gaussian sphere.

What can you say about the flux of $\mathbf{E}$ through the sphere, and $|\mathbf{E}|$ on the sphere?



A. Flux = 0, E = 0 everywhere on sphere surface
B. Flux = 0, E need not be zero everywhere on sphere
C. Flux is not zero, E = 0 everywhere on sphere
D. Flux is not zero, E need not be zero…

Tutorial follow-up:

Does the charge σ on the beam line affect the particles being accelerated inside it?

A. Yes
B. No
C. ???

Think: Why? Or why not?

Tutorial follow-up:

Could the charge σ affect the electronic equipment outside the tunnel?

A. Yes
B. No
C. ???

Think: Why? Or why not?