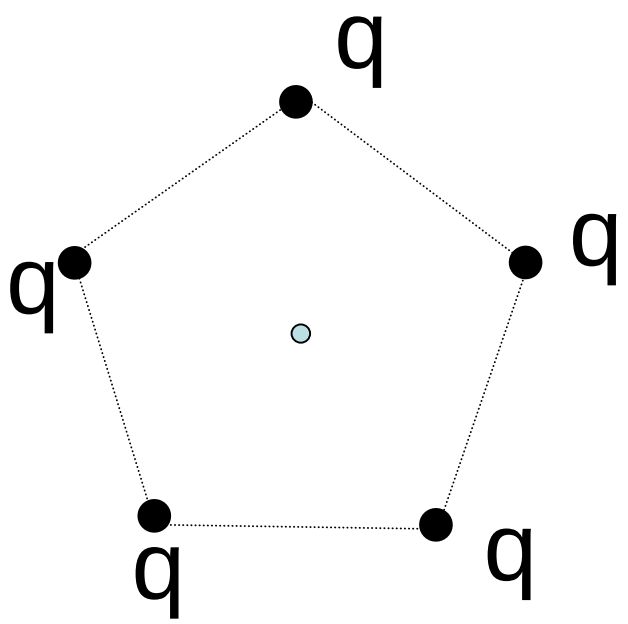
COULOMB'S LAW, E FIELDS

5 charges, q, are arranged in a regular pentagon, as shown.

What is the E field at the center?

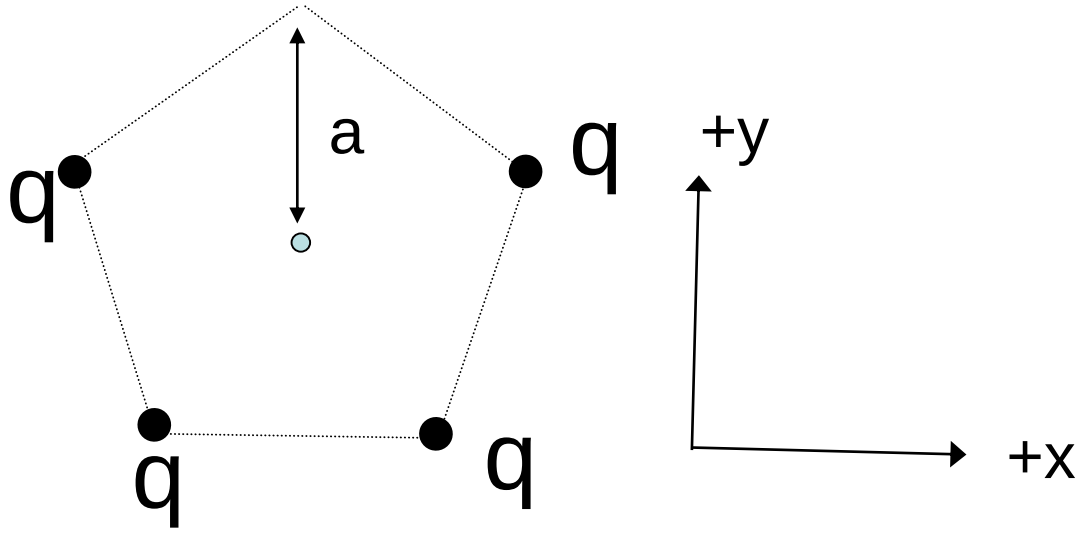


A) Zero

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) $+(kq/a^2)\,\mathbf{j}$

B) $-(kq/a^2)\,\mathbf{j}$

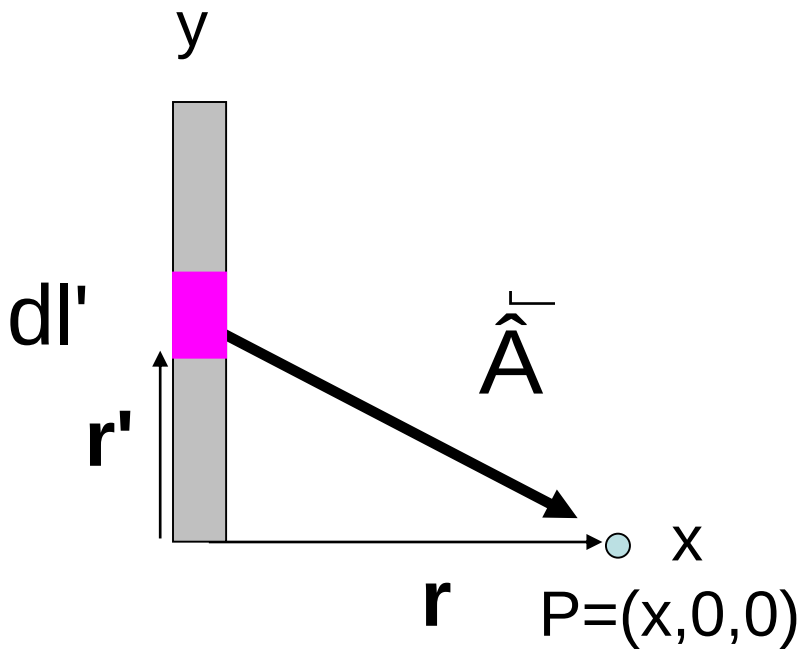
C) 0

D) Something entirely different!

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

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{1}{\hat{A}^2}\hat{\hat{A}}\, dl'$$

What is $\hat{A} = |\vec{\hat{A}}|$?

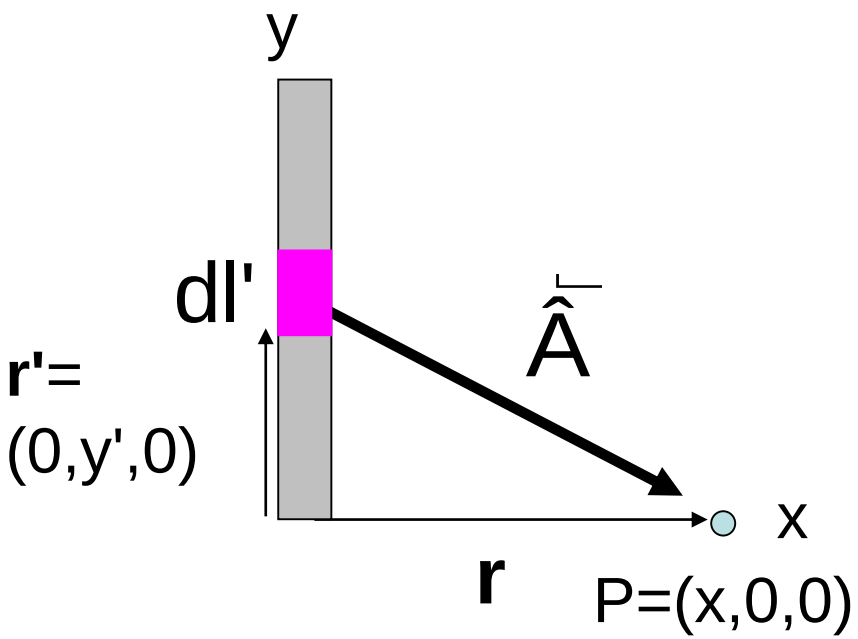


A) X B) y'

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

E) Something *completely* different!!

$$\mathbf{E}(\mathbf{r}) = \int \frac{\lambda \, dl'}{4\pi\varepsilon_0 \hat{\mathcal{R}}^3} \hat{\boldsymbol{\mathcal{R}}}$$



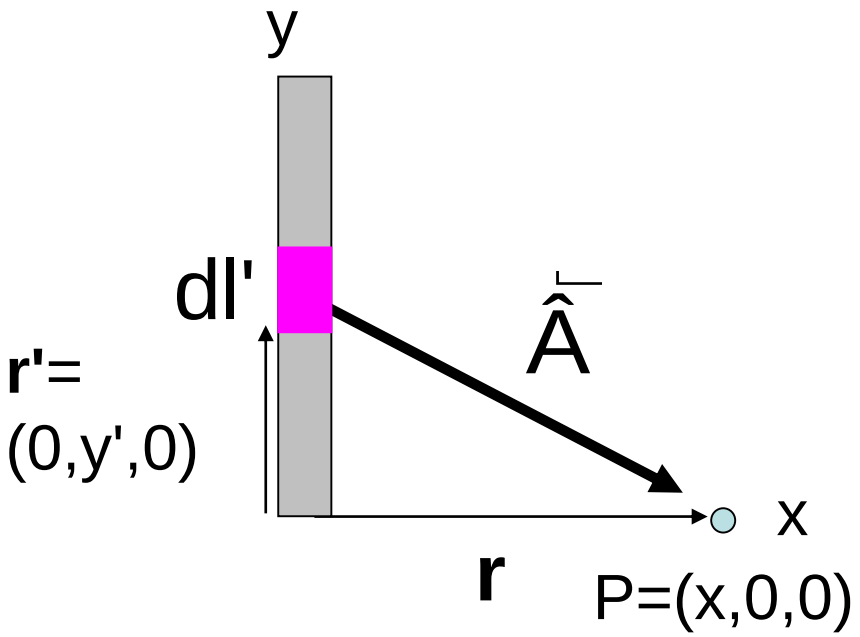
$$\mathbf{E}(\mathbf{r}) = \int \frac{\lambda\, dl'}{4\pi\varepsilon_0 \mathcal{R}^3}\vec{\mathcal{R}} \quad \text{,so} \quad \mathbf{E}_x(x,0,0) = \frac{\lambda}{4\pi\varepsilon_0}\int \ldots$$

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

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

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

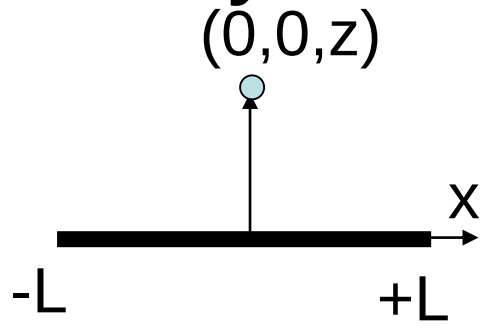
D) $\int \frac{dy'\, y'}{(x^2 + y'^2)^{3/2}}$



E) Something else

Griffiths p. 64 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?

$$E = \frac{2\lambda L}{4\pi\varepsilon_0}\times(\ldots)$$

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

E) None of these is remotely correct.

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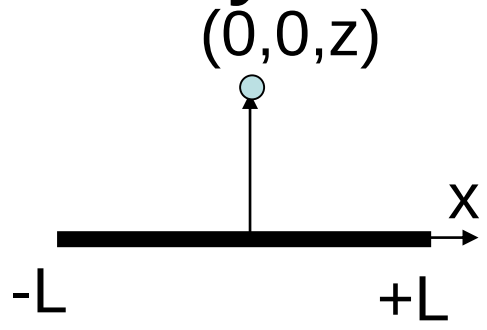

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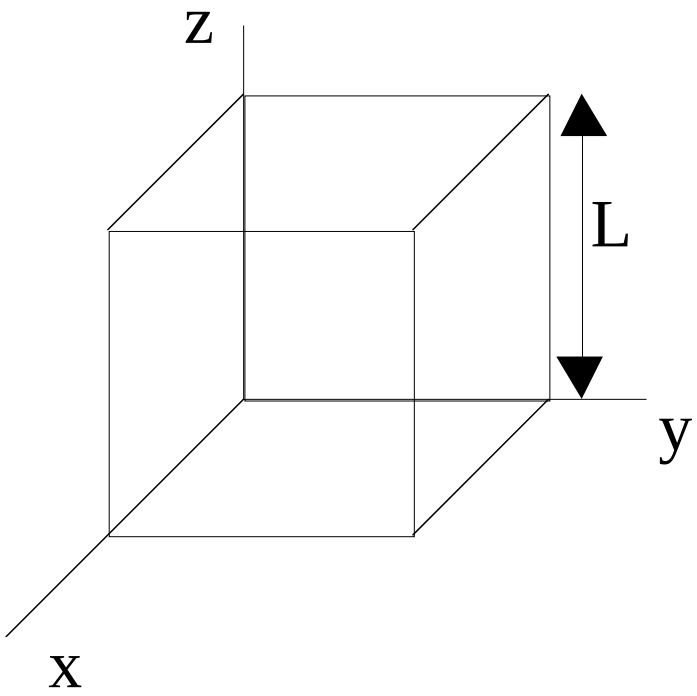
GAUSS' LAW

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)

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. $2EL^2$

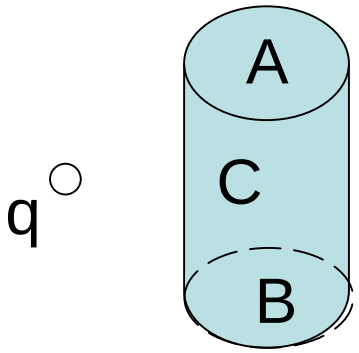
D. $6EL^2$

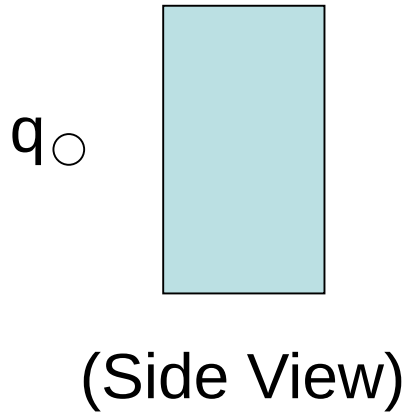
E. We don't know $\rho(r)$, so can't answer.

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



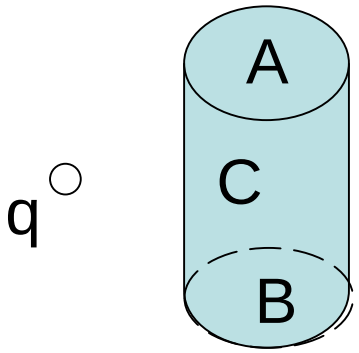


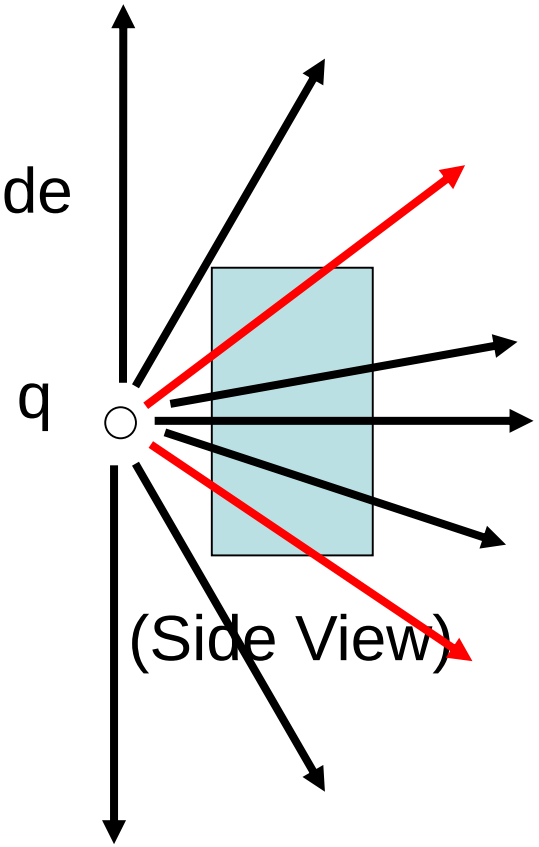
(Side View)

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 (C) zero

(D) not enough information given to decide





A Gaussian surface which is *not* a sphere has a single charge (q) inside it, *not* at the center. There are more charges outside.

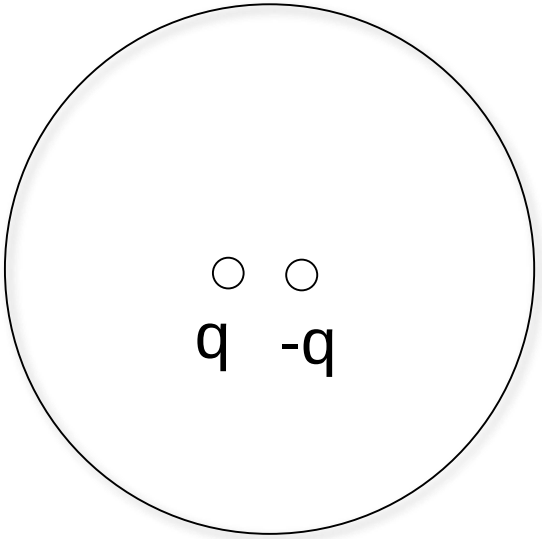
What can we say about total electric flux through this surface $\oint \vec{E} \cdot d\vec{a}$?

A) It is q/ε0

B) We know what it is, but it is NOT q/ε0

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 E through the sphere, and |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…

Deep questions to ponder

- Is Coulomb's force law valid for *all* separation distances? (How about r=0?)
- What is the physics origin of the r^2 dependence of Coulomb's force law?
- What is the physics origin of the $1/\varepsilon_0$ dependence of Coulomb's force law?
- What is the physics origin of the $1/4\pi$ factor in Coulomb's force law?
- What really *is* electric charge?
- Why is electric charge quantized (in units of *e*)?
- What really is *negative* vs. *positive* electric charge (i.e. –*e* vs. +*e*)?
- Why does the Coulomb force vary as the *product* of charges $q_1 q_2$?
- What really is the *E*-field associated with e.g. a point electric charge, *e*?
- Are electric field lines real? Do they *really* exist in space and time?

Johann Carl Friedrich Gauss
(30 April 1777 – 23 February 1855)
was a German mathematician and physicist

Child prodigy

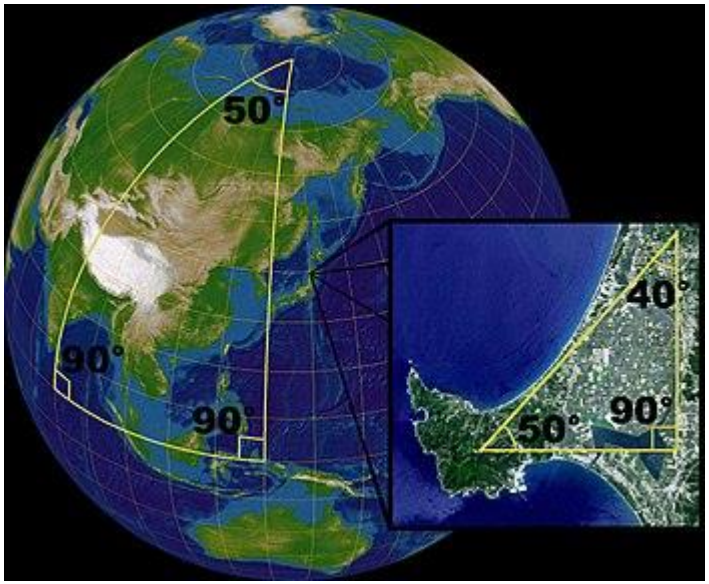
Magnetism
In 1831, Gauss developed a collaboration with physicist Wilhelm Weber, leading to new knowledge in magnetism, including finding a representation for the unit of magnetism in terms of mass, charge, and time - now named the Gauss - the discovery of Kirchhoff's circuit laws in electricity, and formulating his namesake law.

They constructed the first electro-mechanical telegraph in 1833 which connected the observatory (where Gauss was director) with the institute for physics in Göttingen.

Geodetic survey

In 1818 Gauss carried out a geodetic survey of the Kingdom of Hanover and
came up with the notion of Gaussian curvature.

Non-Euclidean geometries
Gauss claimed to have discovered the possibility of non-Euclidean geometries but never published it.



Gauss selected the topic for Bernhard Riemann's inaugural lecture.

Riemannian geometry became the basis of Einstein's theory of general relativity