True or False: The electric field, $\mathbf{E}(\mathbf{r})$, in some region of space is zero, thus the electric potential, $V(\mathbf{r})$, in that same region of space is zero.

A. True
B. False

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A. True
B. False

ANNOUNCEMENTS

- Homework 1 due today at 5pm
  - After 3:40pm turn in to Kim Crosslan
  - Last two questions turn in on Github
- Quiz #1 - Next Friday
  - Last 20 minutes of class
  - No cheat sheets; all formulas will be provided
  - Solve a Gauss' Law Problem with spherical symmetry
  - Sketch a graph of the resulting electric field

The general solution for the electric potential in spherical coordinates with azimuthal symmetry (no ϕ dependence) is:

$$V(r,\theta) = \sum_{l=0}^{\infty} \left(A_l r^l + \frac{B_l}{r^{l+1}} \right) P_l(\cos\theta)$$

Consider a metal sphere (constant potential in and on the sphere, remember). Which terms in the sum vanish outside the sphere? (Recall: $V \rightarrow 0$ as $r \rightarrow \infty$)

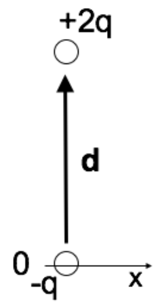
A. All the A_l's
B. All the A_l's except A_0
C. All the B_l's
D. All the B_l's except B_0
E. Something else

$$\mathbf{p} = \sum_i q_i \mathbf{r}_i$$

What is the dipole moment of this system?

(BTW, it is NOT overall neutral!)

A. $q\mathbf{d}$
B. $2q\mathbf{d}$
C. $\frac{3}{2}q\mathbf{d}$
D. $3q\mathbf{d}$
E. Someting else (or not defined)



You have a physical dipole, $+q$ and $-q$ a finite distance d apart. When can you use the expression:

$$V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\frac{\mathbf{p}\cdot\hat{\mathbf{r}}}{r^2}$$

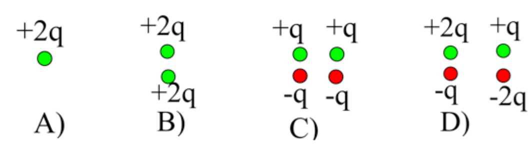
A. This is an exact expression everywhere.
B. It's valid for large r
C. It's valid for small r
D. No idea...

You have a physical dipole, $+q$ and $-q$ a finite distance d apart. When can you use the expression:

$$V(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i}{\mathfrak{R}_i}$$

A. This is an exact expression everywhere.
B. It's valid for large r
C. It's valid for small r
D. No idea...

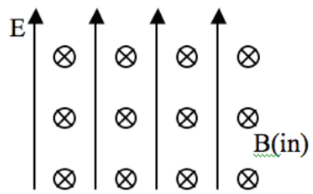
Which charge distributions below produce a potential that looks like $\frac{C}{r^2}$ when you are far away?

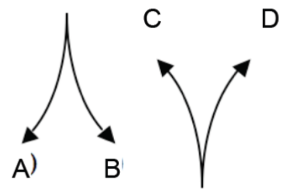


E) None of these, or more than one of these!

(For any which you did not select, how DO they behave at large r?)

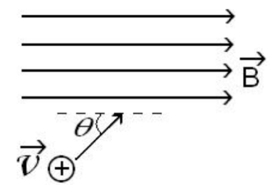
A proton ($q = +e$) is released from rest in a uniform $\mathbf{E}$ and uniform $\mathbf{B}$. $\mathbf{E}$ points up, $\mathbf{B}$ points into the page. Which of the paths will the proton initially follow?





E. It will remain stationary

A proton (speed v) enters a region of uniform $\mathbf{B}$. v makes an angle θ with $\mathbf{B}$. What is the subsequent path of the proton?



A. Helical
B. Straight line
C. Circular motion, $\perp$ to page. (plane of circle is $\perp$ to $\mathbf{B}$)
D. Circular motion, $\perp$ to page. (plane of circle at angle θ w.r.t. $\mathbf{B}$)
E. Impossible. $\mathbf{v}$ should always be $\perp$ to $\mathbf{B}$

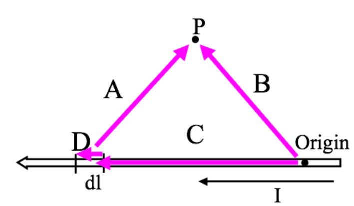
Current I flows down a wire (length L) with a square cross section (side a). If it is uniformly distributed over the entire wire area, what is the magnitude of the volume current density J?

A. $J = I/a^2$
B. $J = I/a$
C. $J = I/4a$
D. $J = a^2 I$
E. None of the above

To find the magnetic field $\mathbf{B}$ at P due to a current-carrying wire we use the Biot-Savart law,

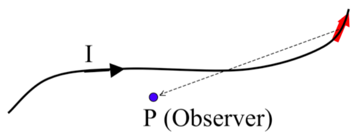
$$\mathbf{B}(\mathbf{r}) = \frac{\mu_0}{4\pi} I \int \frac{d\mathbf{l} \times \hat{\mathfrak{R}}}{\mathfrak{R}^2}$$

In the figure, with $d\mathbf{l}$ shown, which purple vector best represents $\mathfrak{R}$?



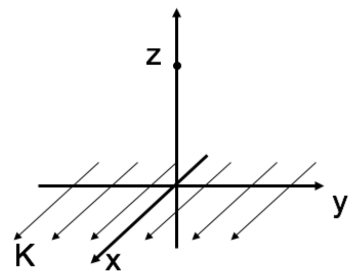
E) None of these!

What do you expect for direction of $\mathbf{B}(P)$? How about direction of $d\mathbf{B}(P)$ generated JUST by the segment of current $d\mathbf{l}$ in red?



A. $\mathbf{B}(P)$ in plane of page, ditto for $d\mathbf{B}(P$, by red)
B. $\mathbf{B}(P)$ into page, $d\mathbf{B}(P$, by red) into page
C. $\mathbf{B}(P)$ into page, $d\mathbf{B}(P$, by red) out of page
D. $\mathbf{B}(P)$ complicated, ditto for $d\mathbf{B}(P$, by red)
E. Something else!!

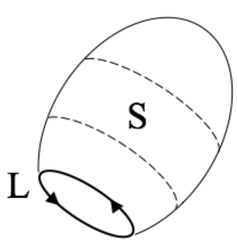
Consider the B-field a distance z from a current sheet (flowing in the +x-direction) in the z = 0 plane. The B-field has:



A. y-component only
B. z-component only
C. y and z-components
D. x, y, and z-components
E. Other

Stoke's Theorem says that for a surface S bounded by a perimeter L, any vector field $\mathbf{B}$ obeys:

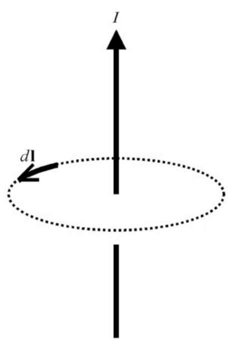
$$\int_S (\nabla \times \mathbf{B}) \cdot dA = \oint_L \mathbf{B} \cdot d\mathbf{l}$$



Does Stoke's Theorem apply for any surface S bounded by a perimeter L, even this balloon-shaped surface S?

A. Yes
B. No
C. Sometimes

Much like Gauss's Law, Ampere's Law is always true (for magnetostatics), but only useful when there's sufficient symmetry to "pull B out" of the integral.



So we need to build an argument for what $\mathbf{B}$ looks like and what it can depend on.

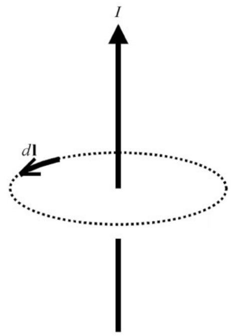
For the case of an infinitely long wire, can $\mathbf{B}$ point radially (i.e., in the $\hat{s}$ direction)?

A. Yes
B. No
C. ???

Continuing to build an argument for what $\mathbf{B}$ looks like and what it can depend on.

For the case of an infinitely long wire, can $\mathbf{B}$ depend on z or ϕ?

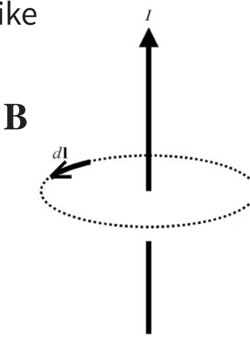
A. Yes
B. No
C. ???



Finalizing the argument for what $\mathbf{B}$ looks like and what it can depend on.

For the case of an infinitely long wire, can $\mathbf{B}$ have a $\hat{z}$ component?

A. Yes
B. No
C. ???



Gauss' Law for magnetism, $\nabla \cdot \mathbf{B} = 0$ suggests we can generate a potential for $\mathbf{B}$. What form should the definition of this potential take (Φ and $\mathbf{A}$ are placeholder scalar and vector functions, respectively)?

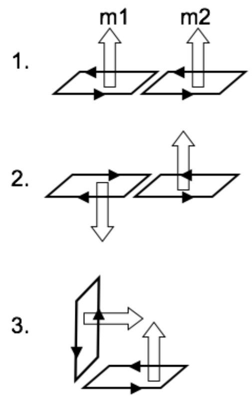
A. $\mathbf{B} = \nabla \Phi$
B. $\mathbf{B} = \nabla \times \Phi$
C. $\mathbf{B} = \nabla \cdot \mathbf{A}$
D. $\mathbf{B} = \nabla \times \mathbf{A}$
E. Something else?!

We can compute $\mathbf{A}$ using the following integral:

$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi} \int \frac{\mathbf{J}(\mathbf{r}')}{\mathfrak{R}} d\tau'$$

Can you calculate that integral using spherical coordinates?

A. Yes, no problem
B. Yes, r' can be in spherical, but $\mathbf{J}$ still needs to be in Cartesian components
C. No.



Two magnetic dipoles m_1 and m_2 (equal in magnitude) are oriented in three different ways.

Which ways produce a dipole field at large distances?

A. None of these
B. All three
C. 1 only
D. 1 and 2 only
E. 1 and 3 only