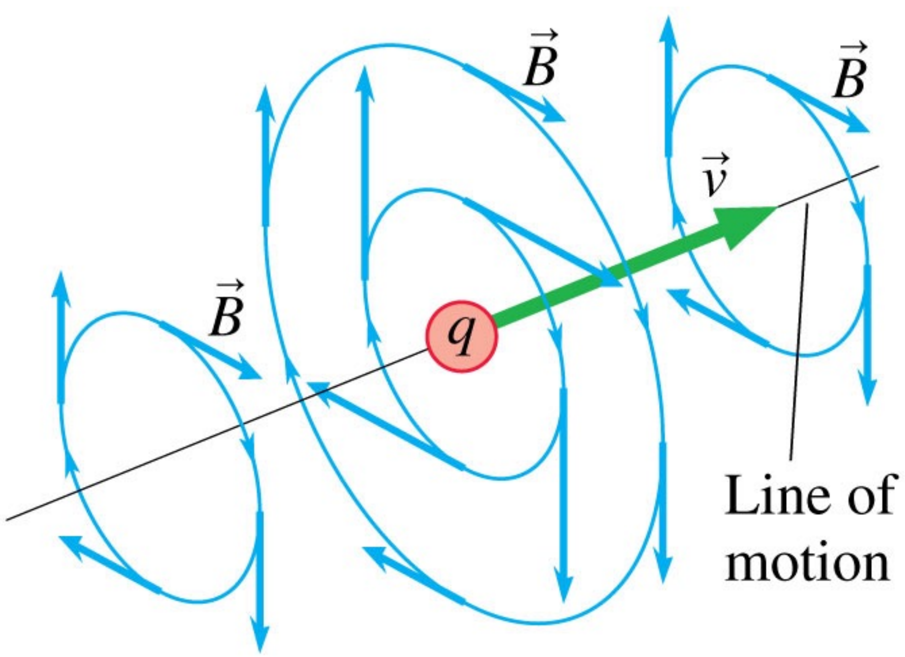
PH 220

Lance Nelson

Unanswered questions

1. What is a magnet and why does it create a magnetic field?
2. Why do magnets have a north and south pole?
3. Why do magnets pick up some objects but not others?
4. Why doesn't breaking a magnet into two pieces separate the poles.

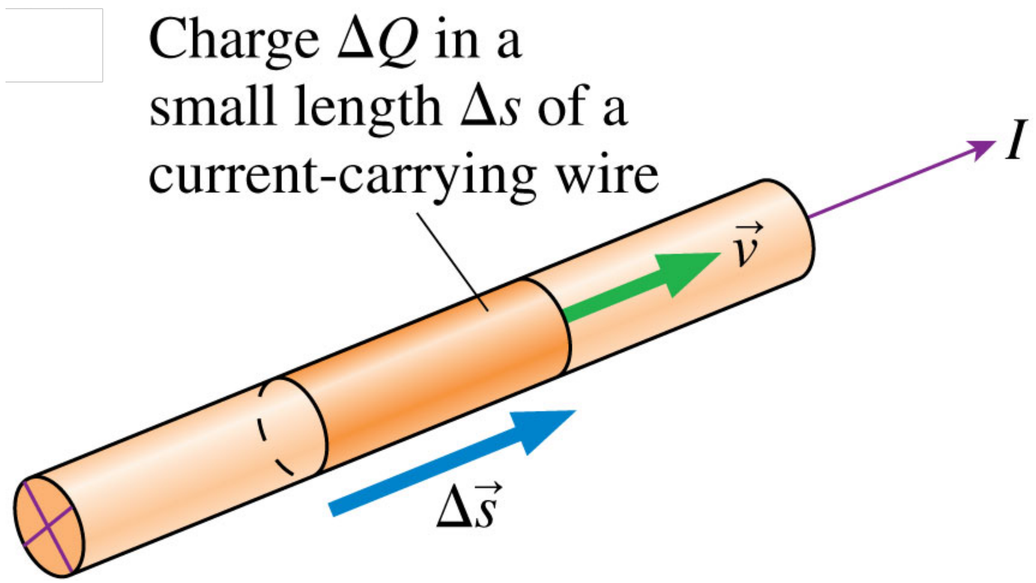


What we know so far

1. A current (charges in motion) creates a magnetic field.

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

Magnetic Field of a Current



For moving point charge…

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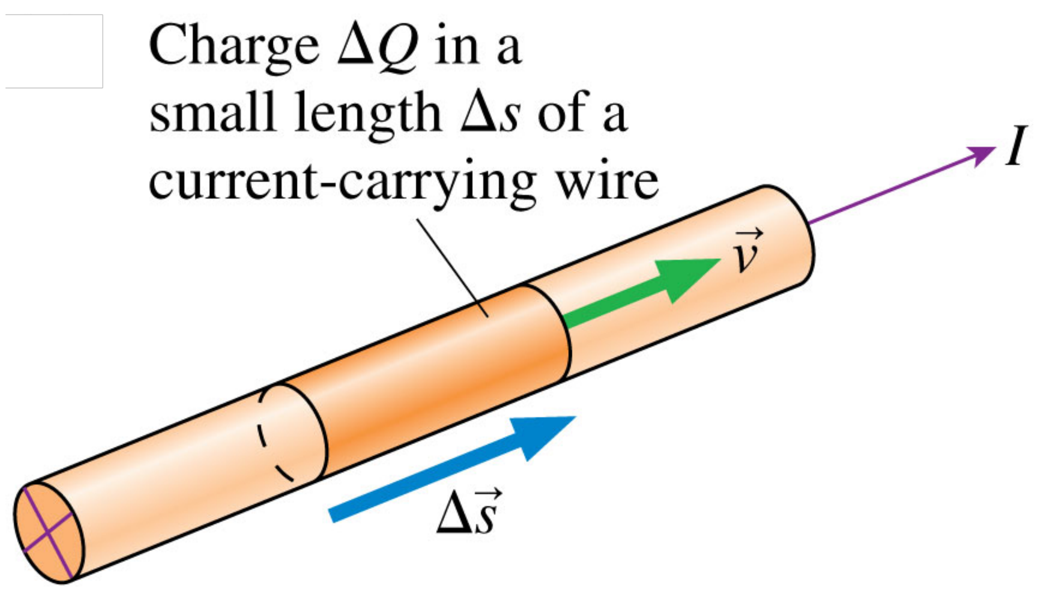

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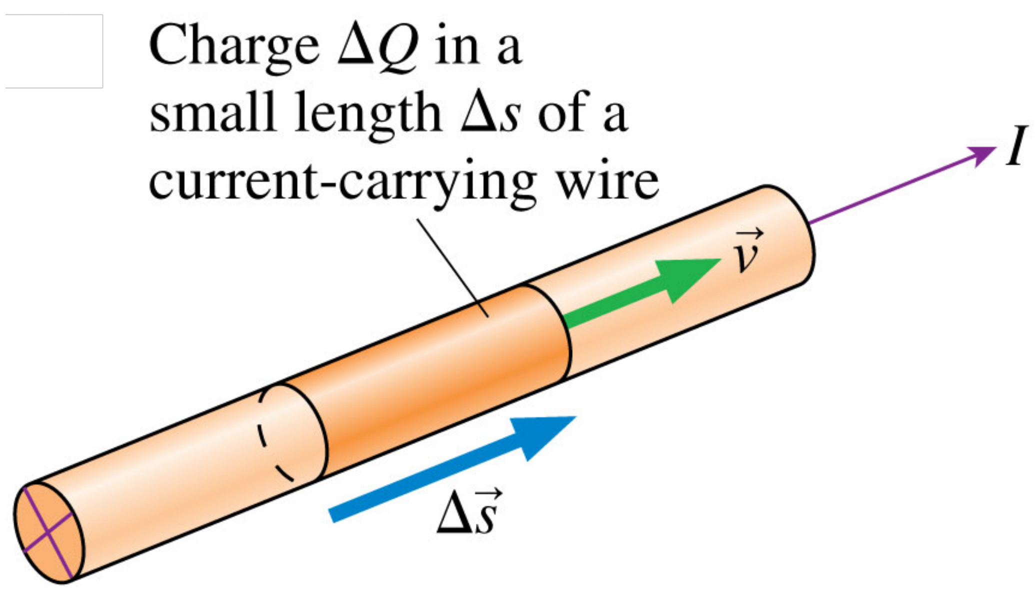

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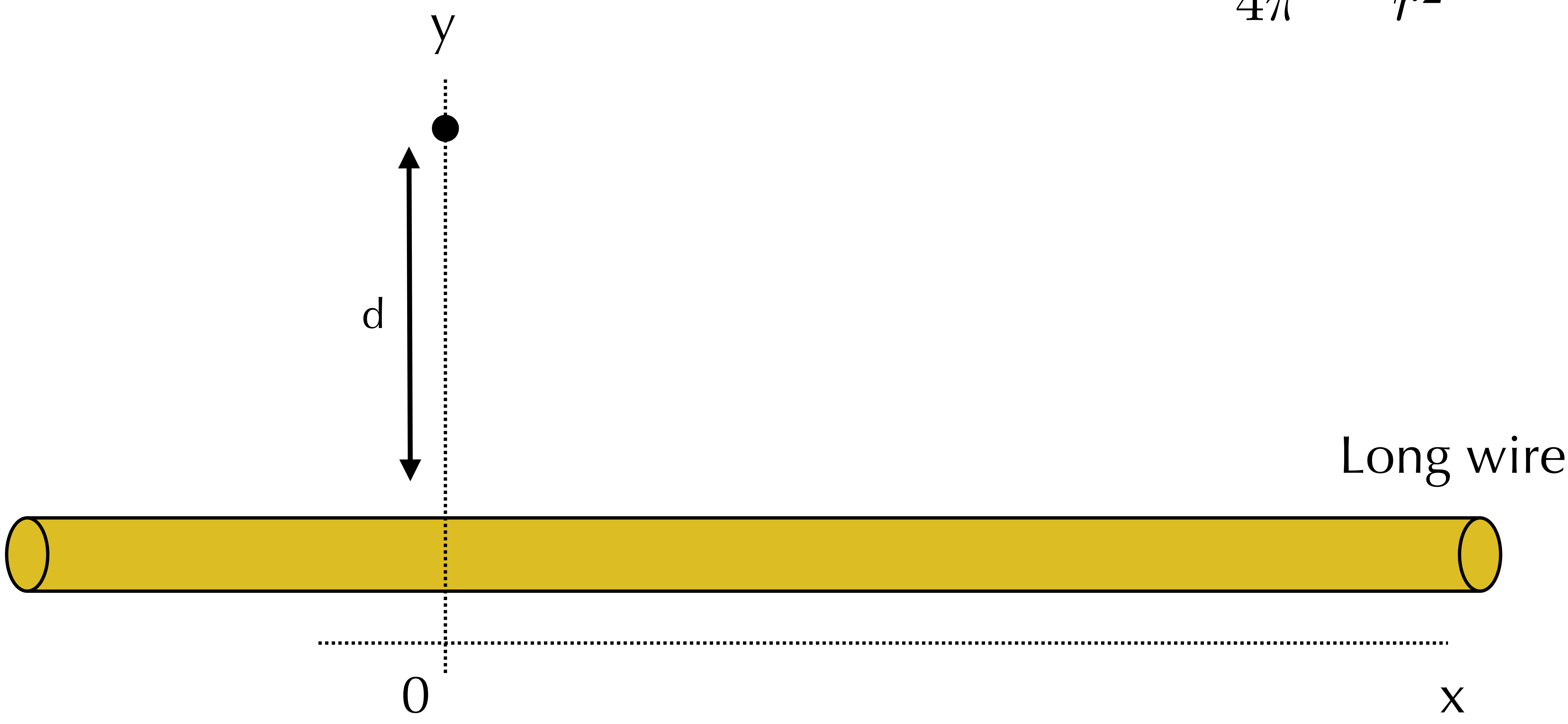
$$\vec{B} = \frac{\mu_0}{4\pi}\frac{I\vec{\Delta s}\times\hat{r}}{r^2}$$

For small segment of current carrying wire.

Let's see how to do these integrals!

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{I \vec{\Delta s} \times \hat{r}}{r^2}$$



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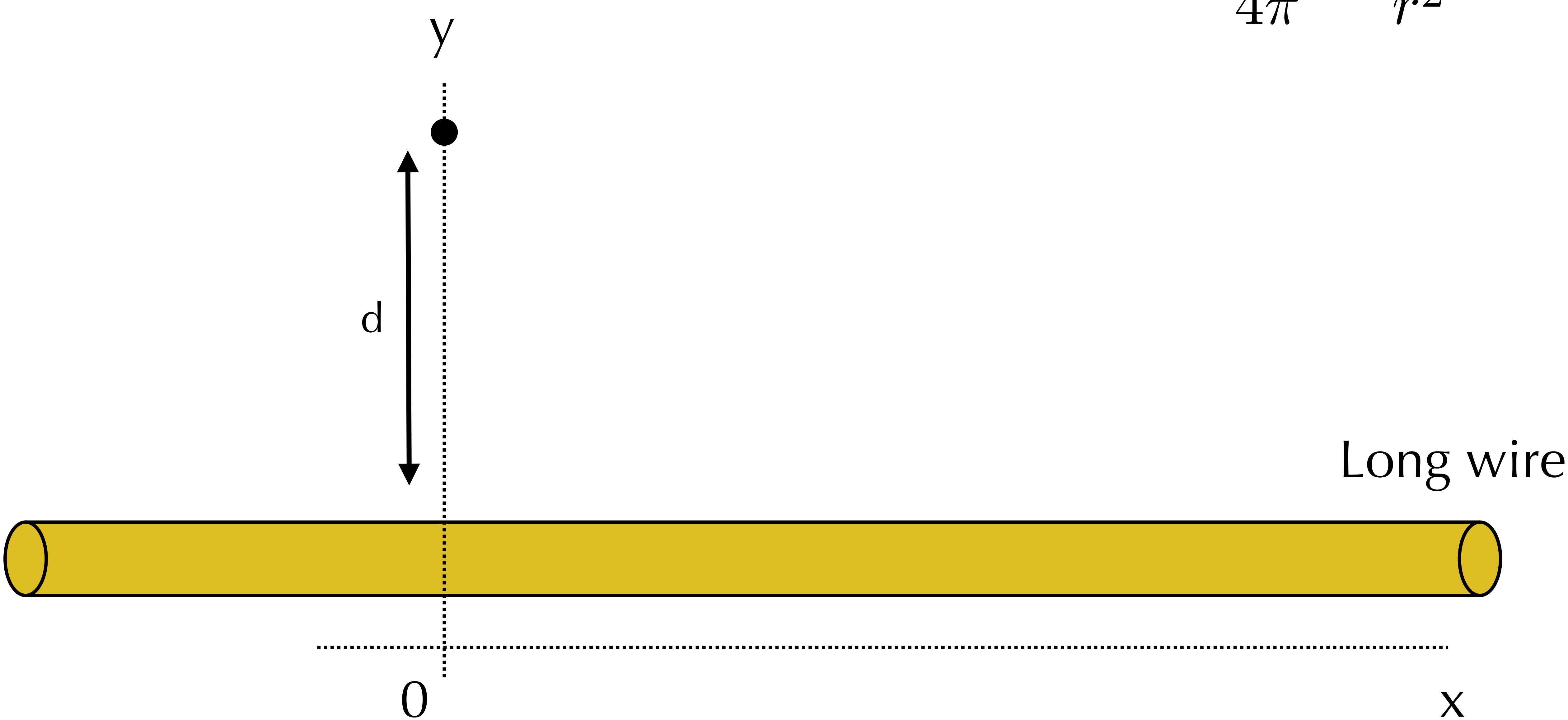

$$\vec{B} = \frac{\mu_0 I}{2\pi d}$$

Let's see how to do these integrals!

1 $$\hat{r} = \frac{-x\hat{i} + d\hat{j}}{\sqrt{x^2 + d^2}}$$

2 $$d\vec{s} = dx\hat{i}$$

3 $$d\vec{s} \times \hat{r} = \frac{d\,dx}{\sqrt{x^2 + d^2}}$$

4 $$r^2 = x^2 + d^2$$

5 $$\frac{\mu_0 I d}{4\pi} \int_{-\infty}^{\infty} \frac{dx}{(x^2 + d^2)^{3/2}}$$

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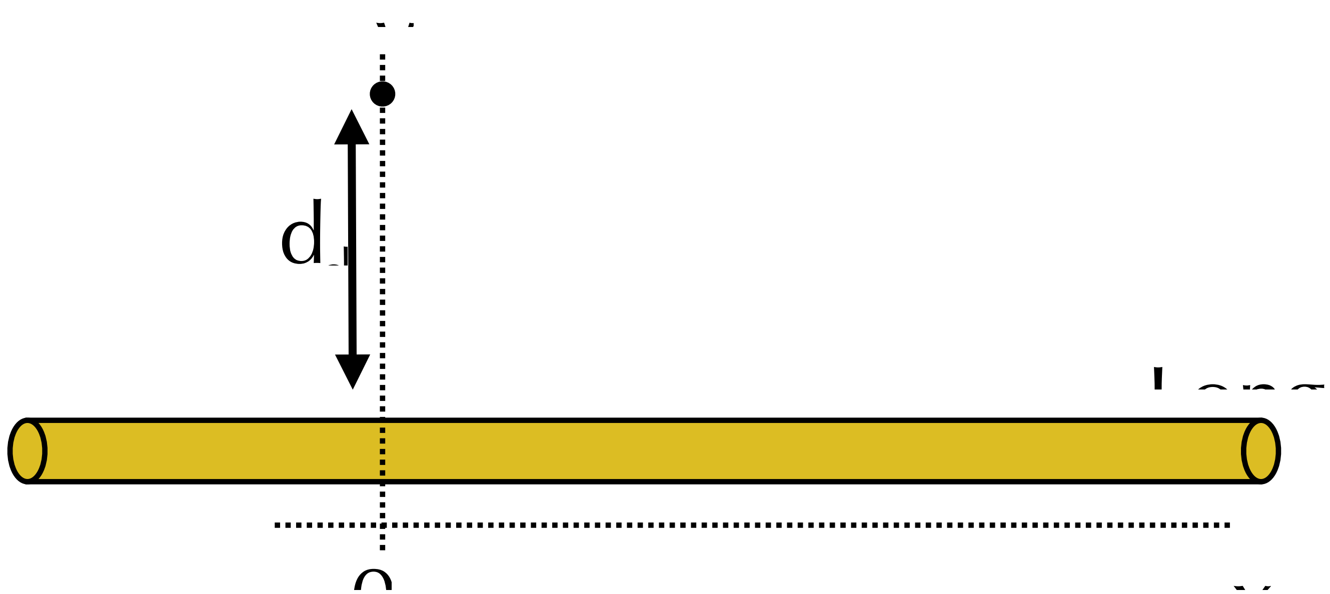

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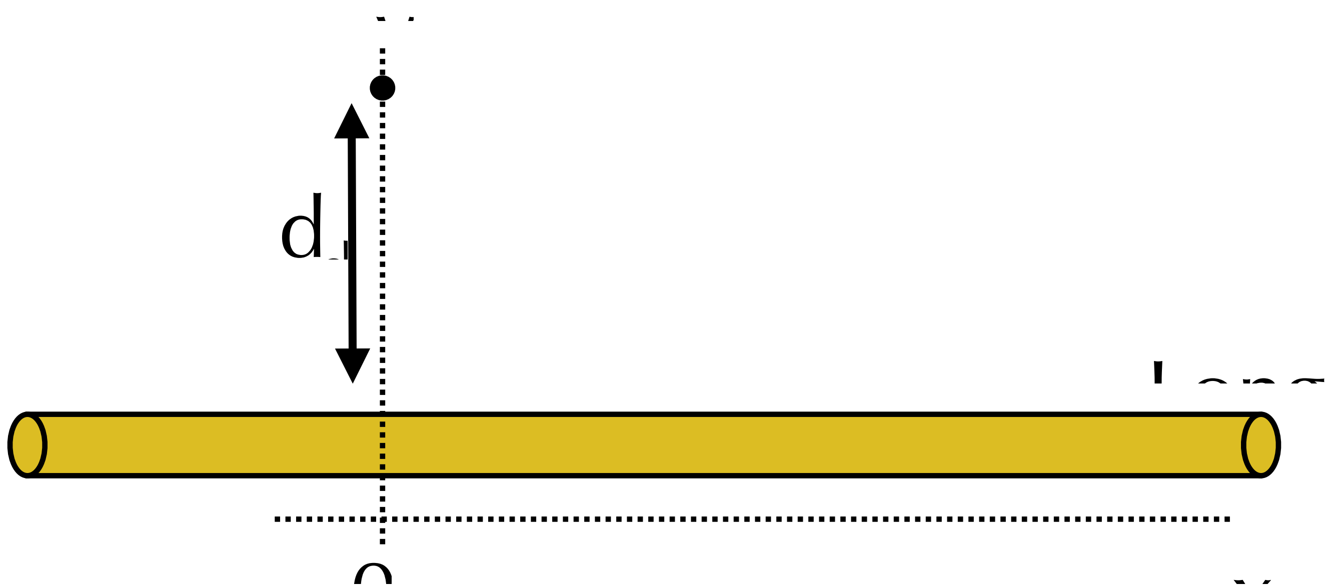

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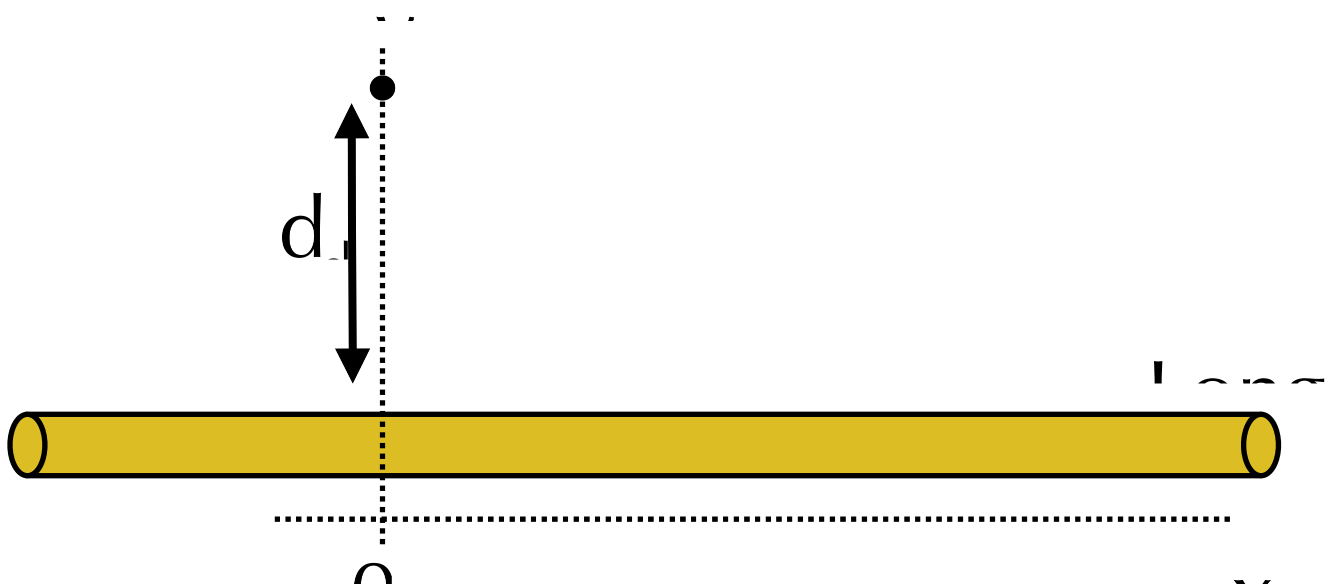
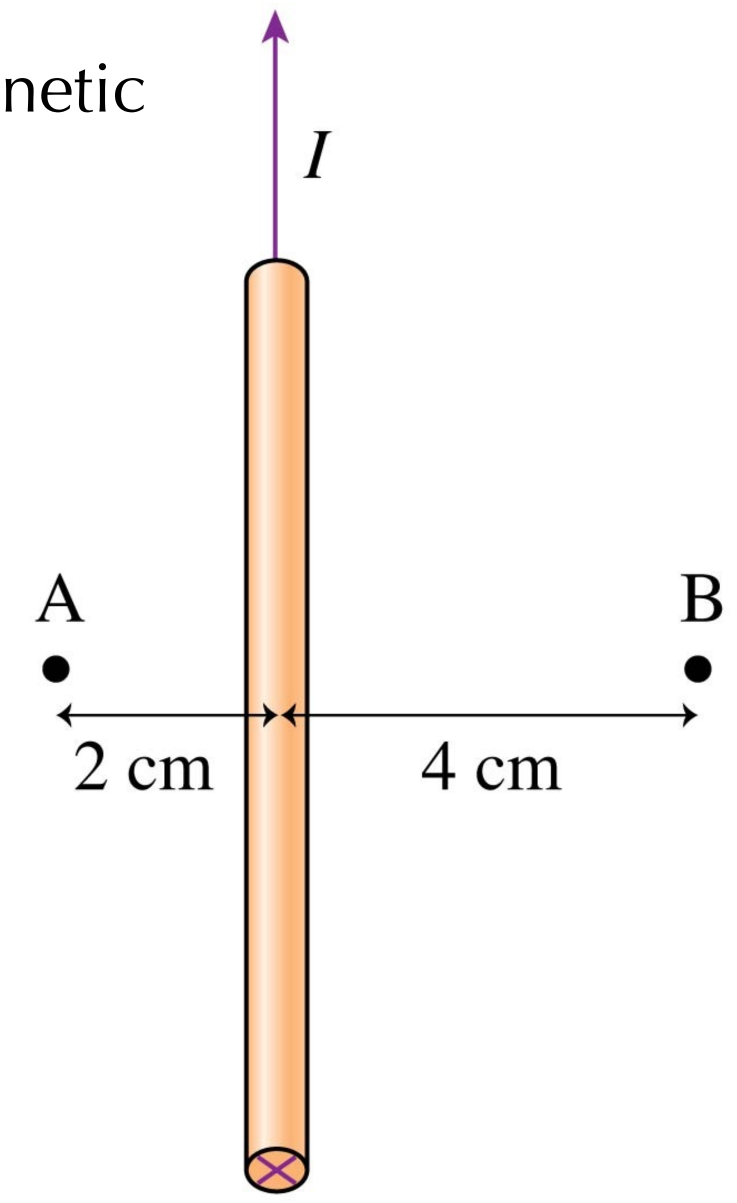


$$\boxed{\vec{B} = \frac{\mu_0 I}{2\pi d}}$$

Question #29

Compared to the magnetic field at point A, the magnetic field at point B is

A. Half as strong, same direction.
B. Can't compare without knowing *I*.
C. One-quarter as strong, same direction.
D. One-quarter as strong, opposite direction.
E. Half as strong, opposite direction.



Question #30

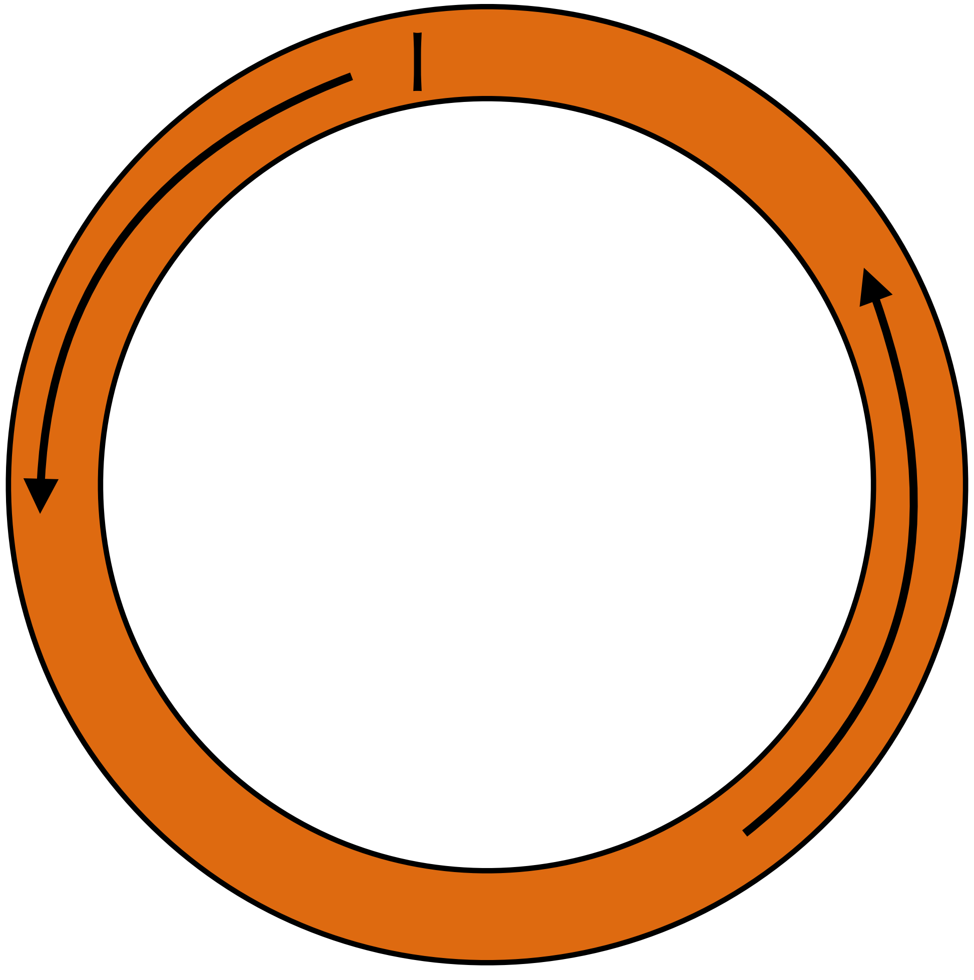
What will be the direction of the magnetic field inside the ring and outside the ring?

A Inside: into the screen. Outside: into the screen

B Inside: out of the screen. Outside: into the screen

C Inside: into the screen. Outside: out of the screen

D Inside: into the screen. Outside: out of the screen



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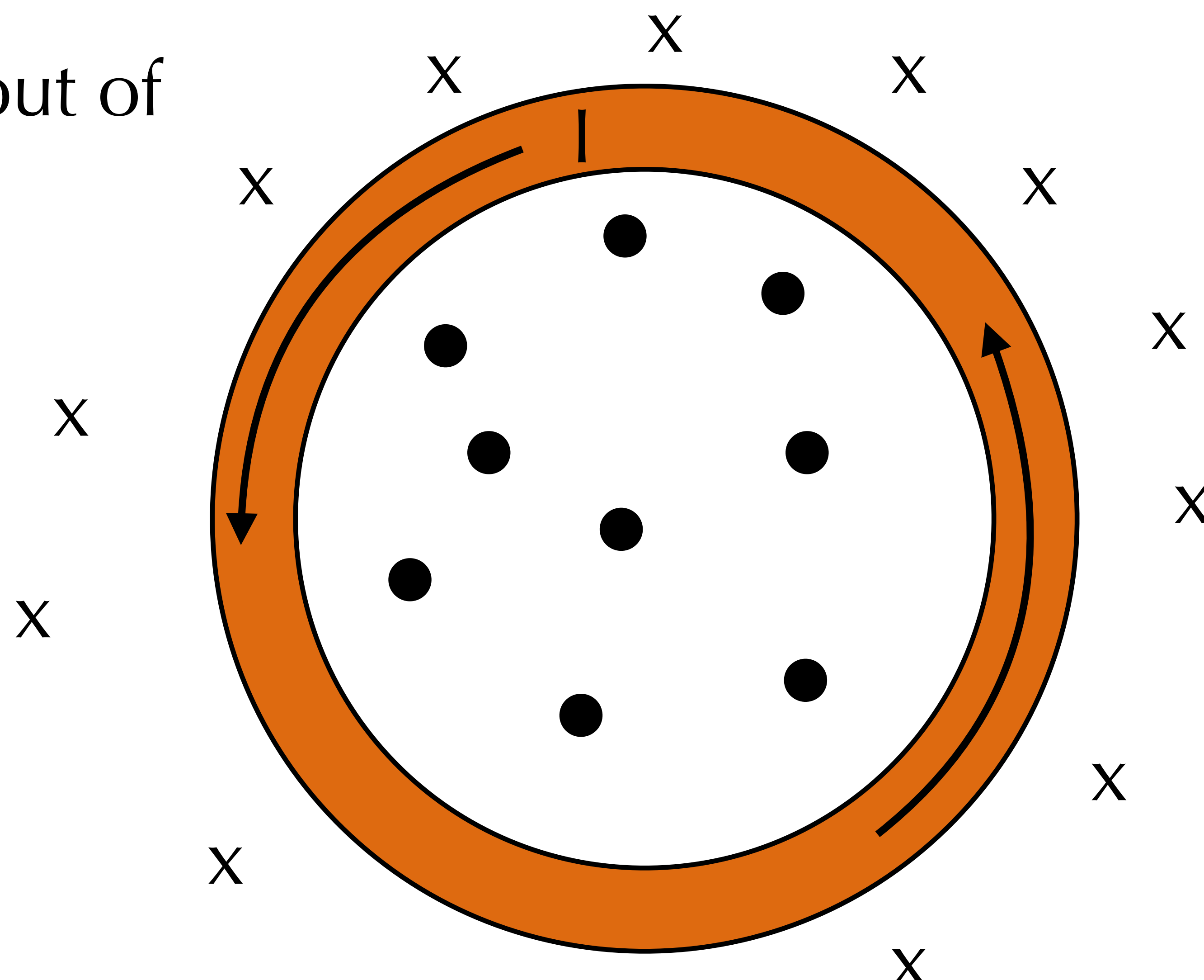
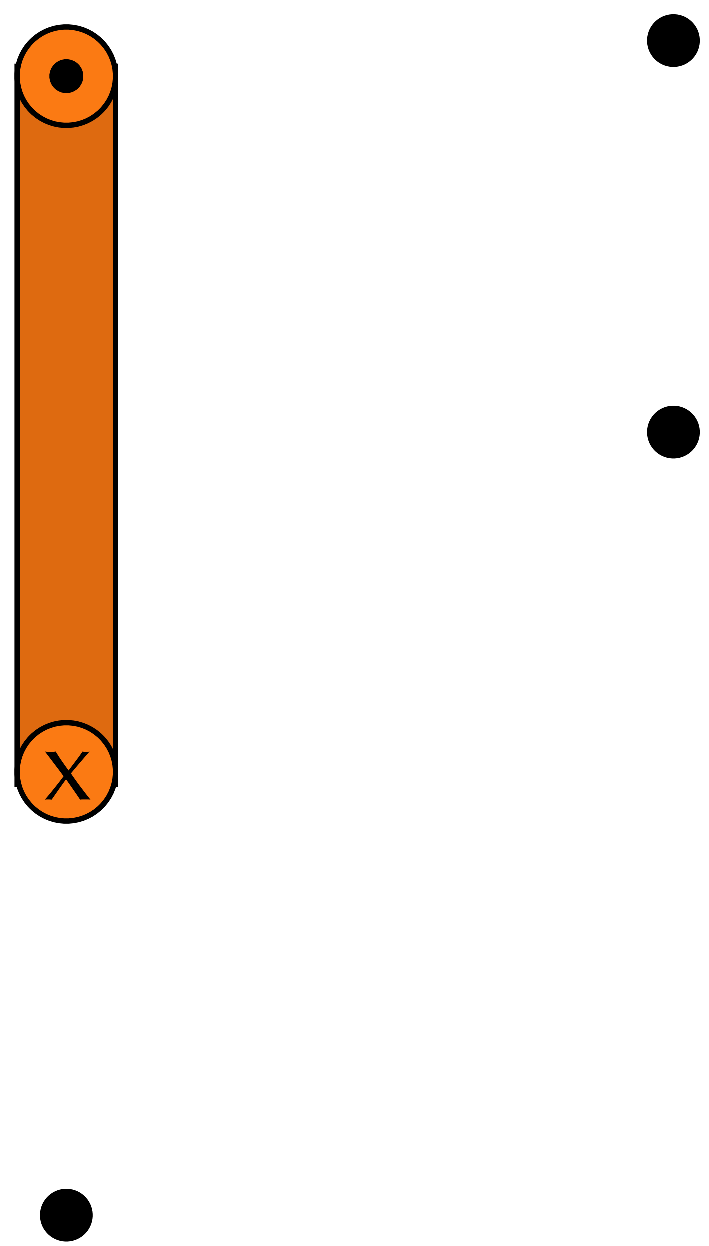
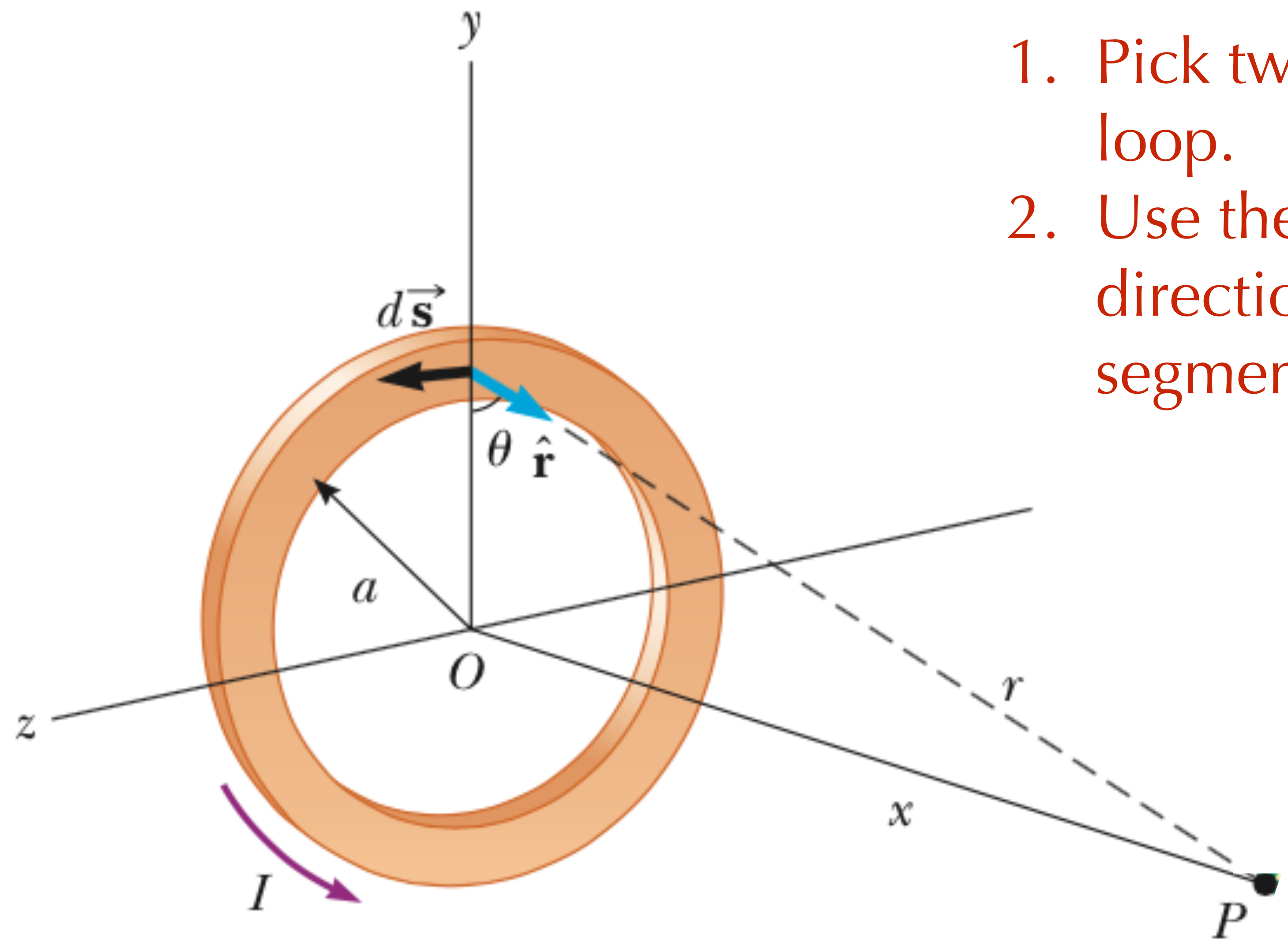


What will be the direction of the magnetic field at the points below?



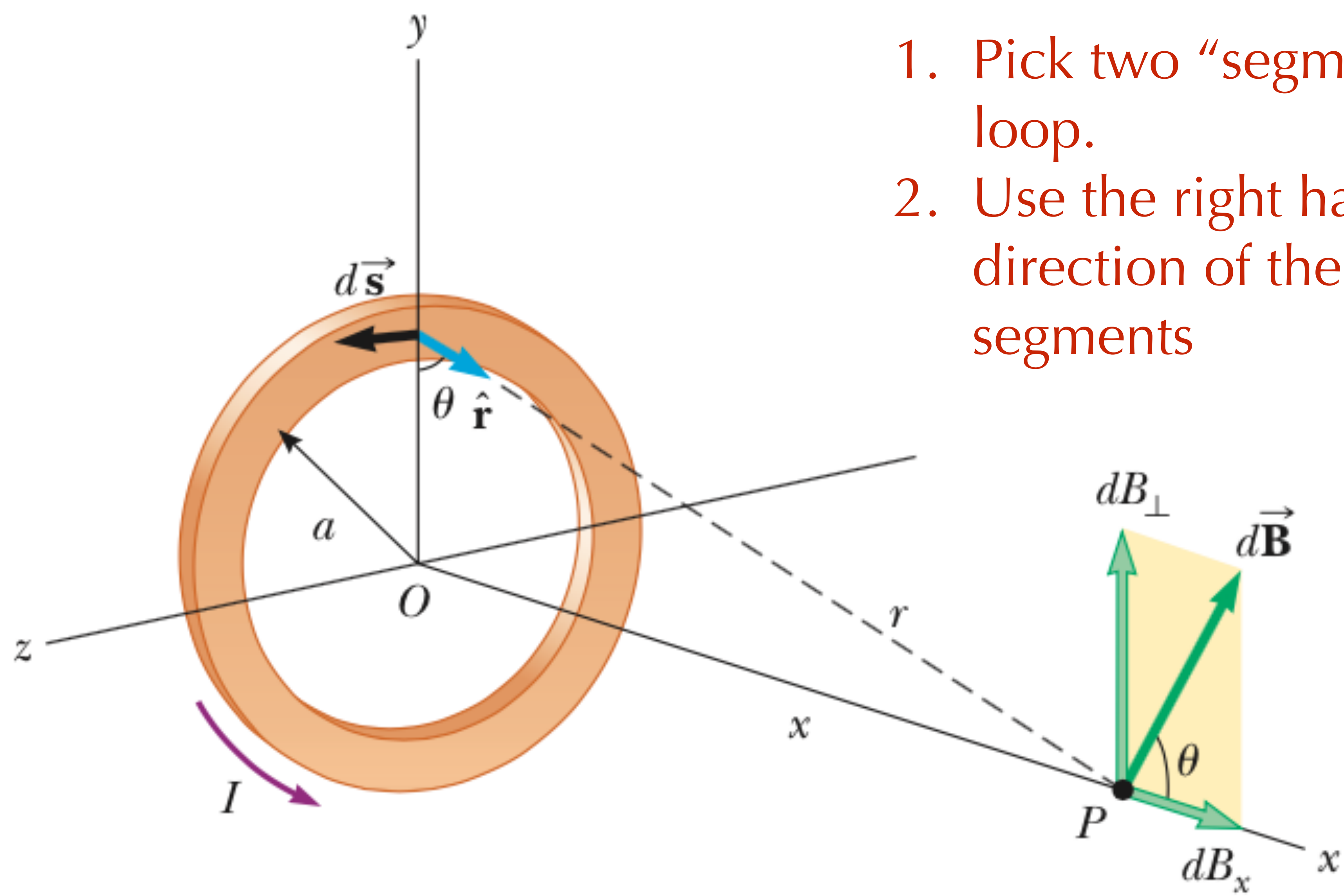
netic field at the

Current Loop



1. Pick two "segments" of current on the loop.
2. Use the right hand rule to determine the direction of the B-field due to those two segments

Current Loop



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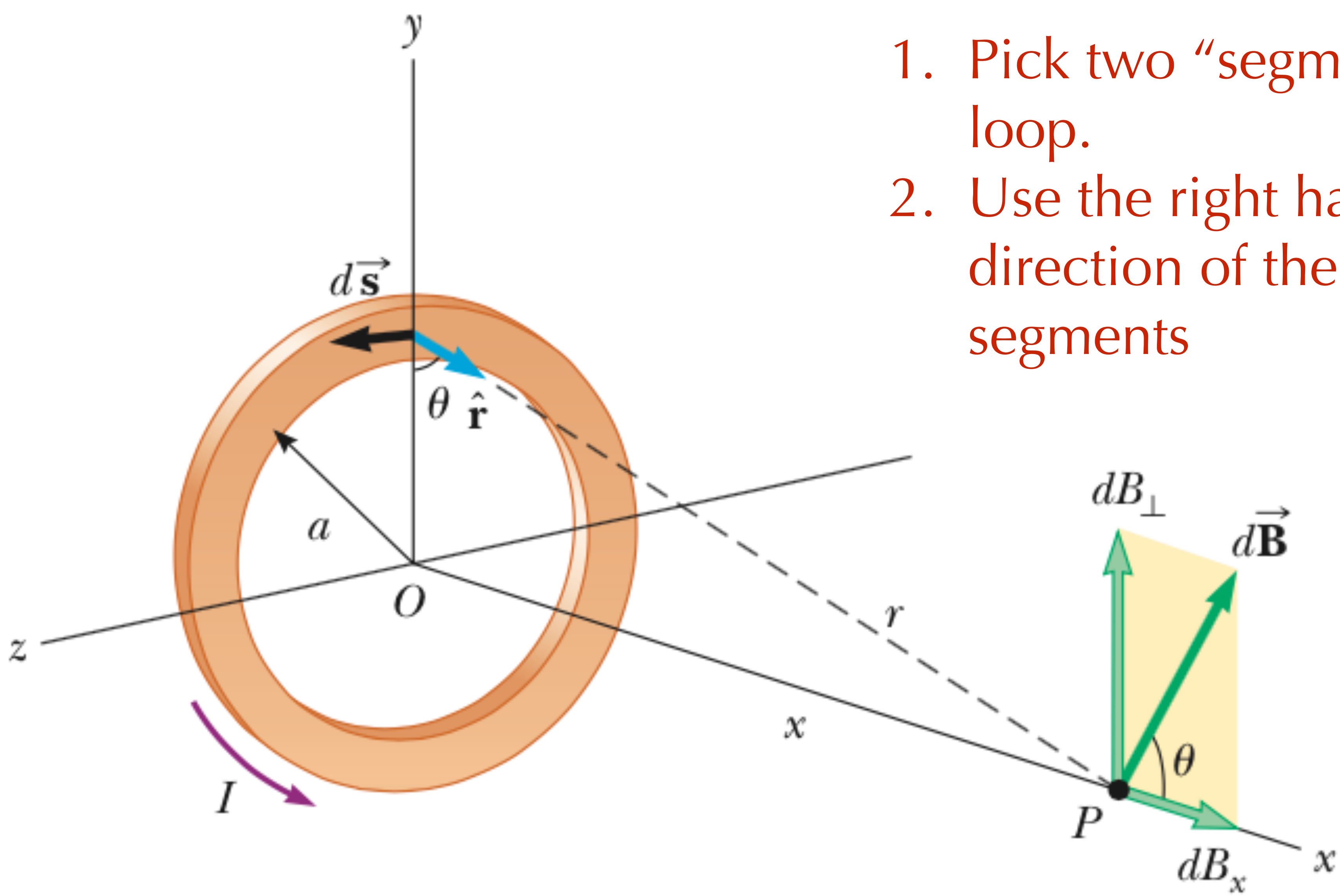

1. Pick two "segments" of current on the loop.
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$$B = \frac{\mu_0}{2} \frac{IR^2}{(z^2 + R^2)^{3/2}}$$

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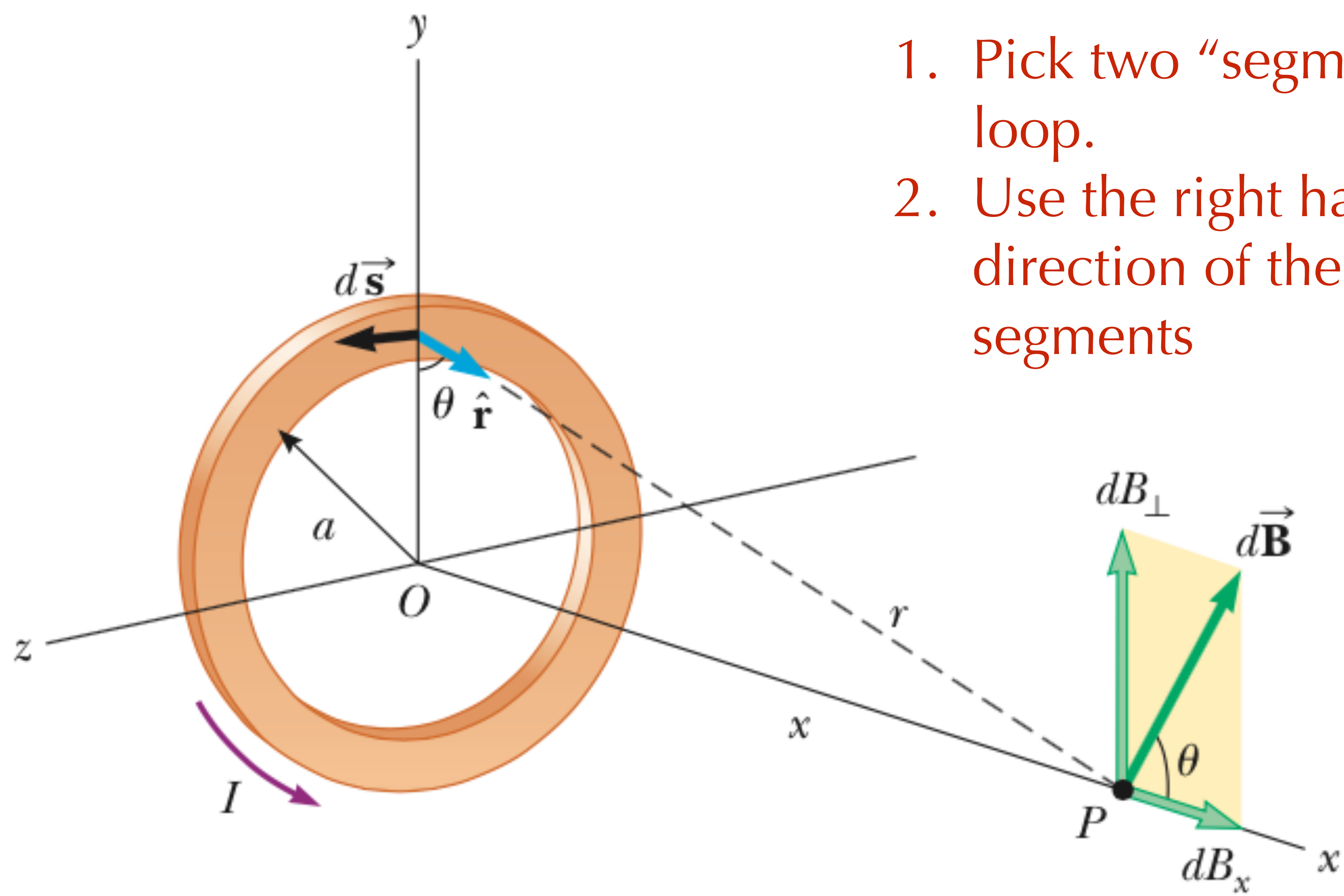

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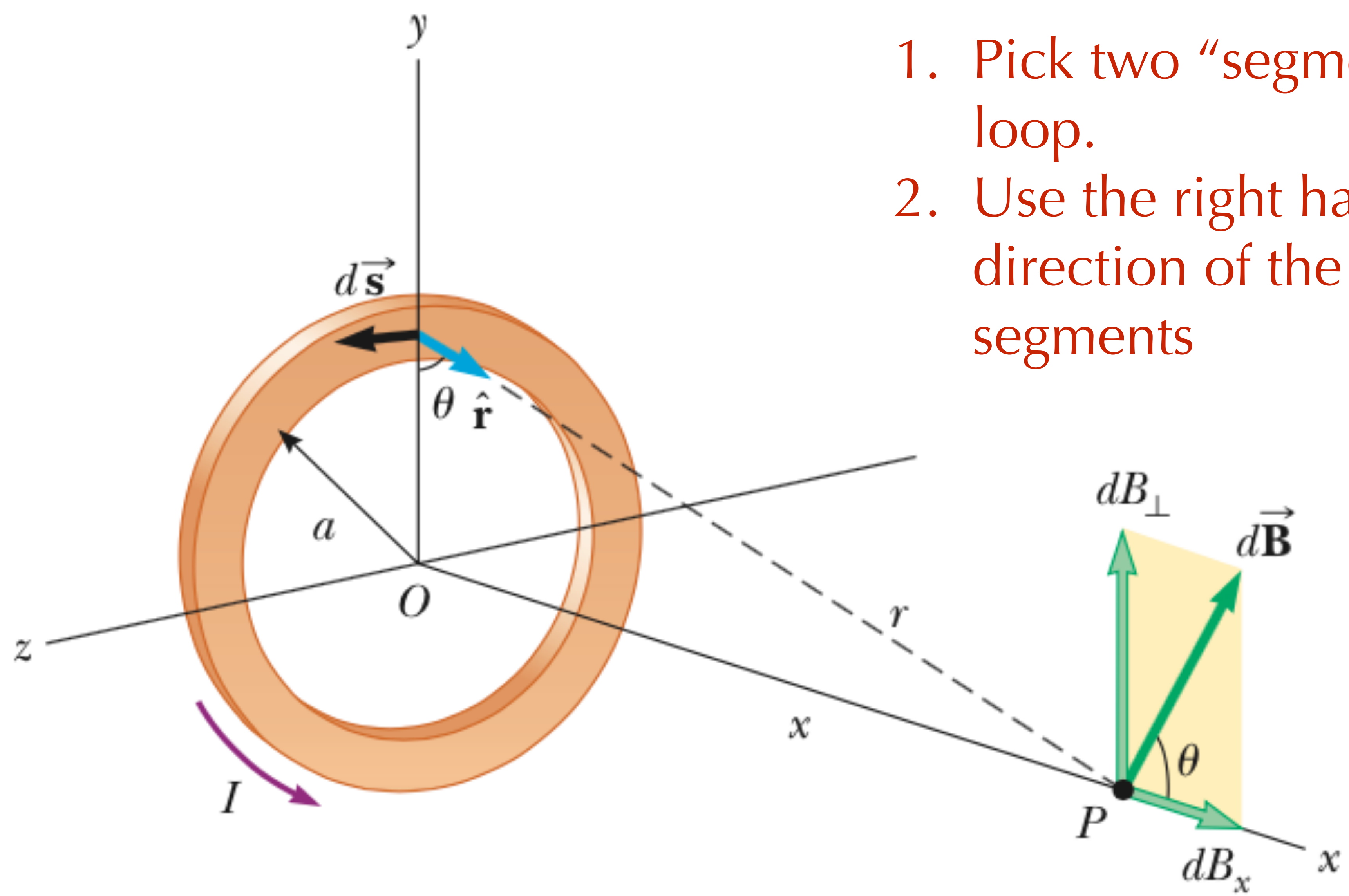
Will the field at the center of the ring be stronger or weaker than away from the center?

Current Loop



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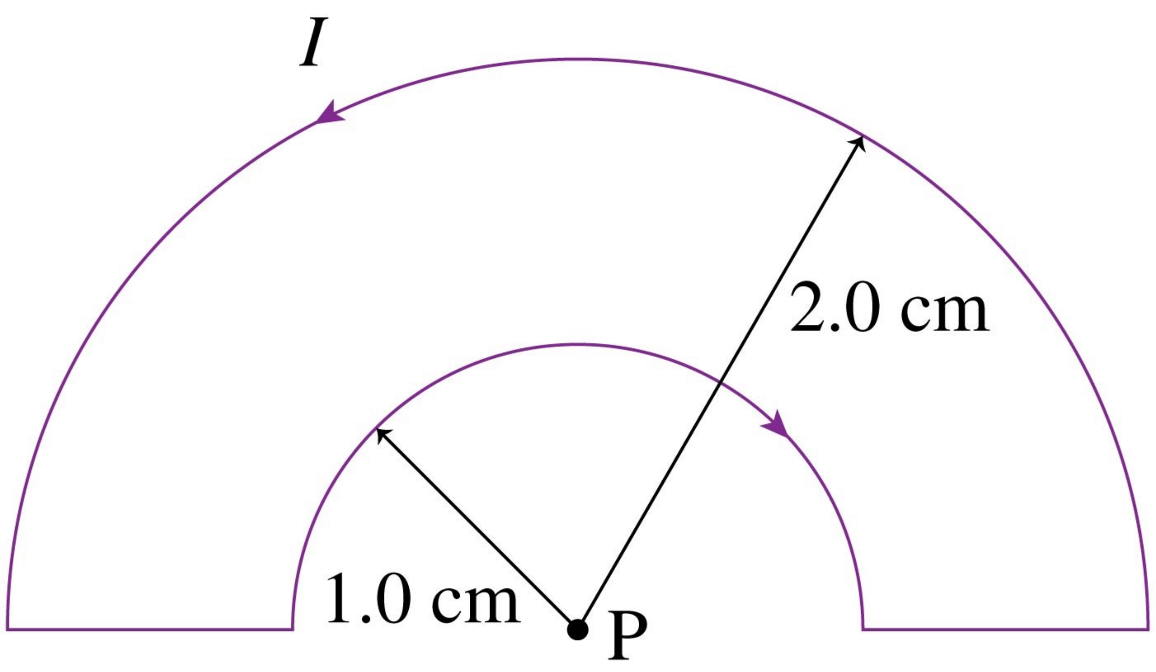
$$B = \frac{\mu_0 I}{2R}$$

Will the field at the center of the ring be stronger or weaker than away from the center?

Question #31

The magnet field at point P is

A. Out of the screen.
B. Into the screen.
C. Zero.



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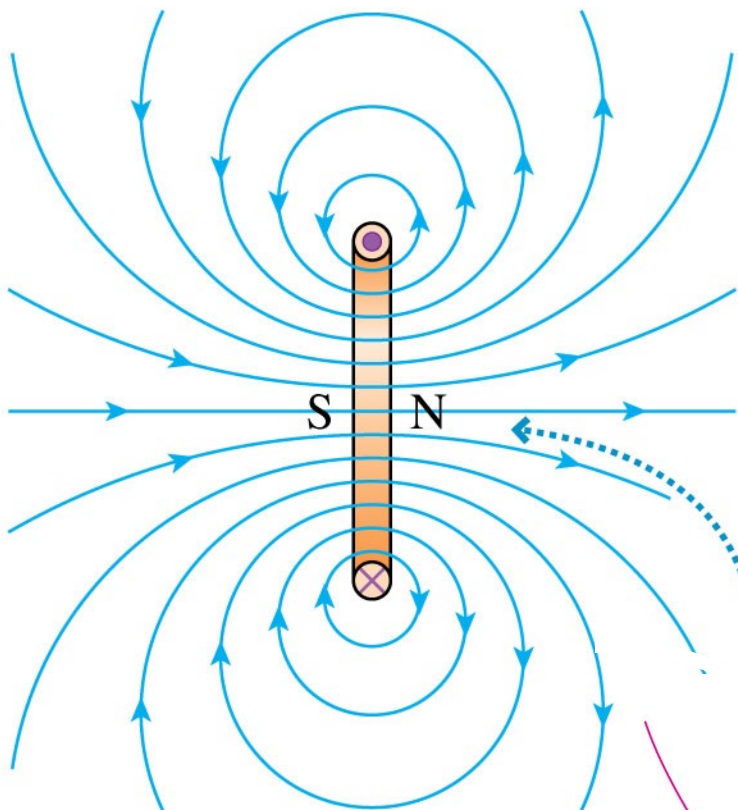
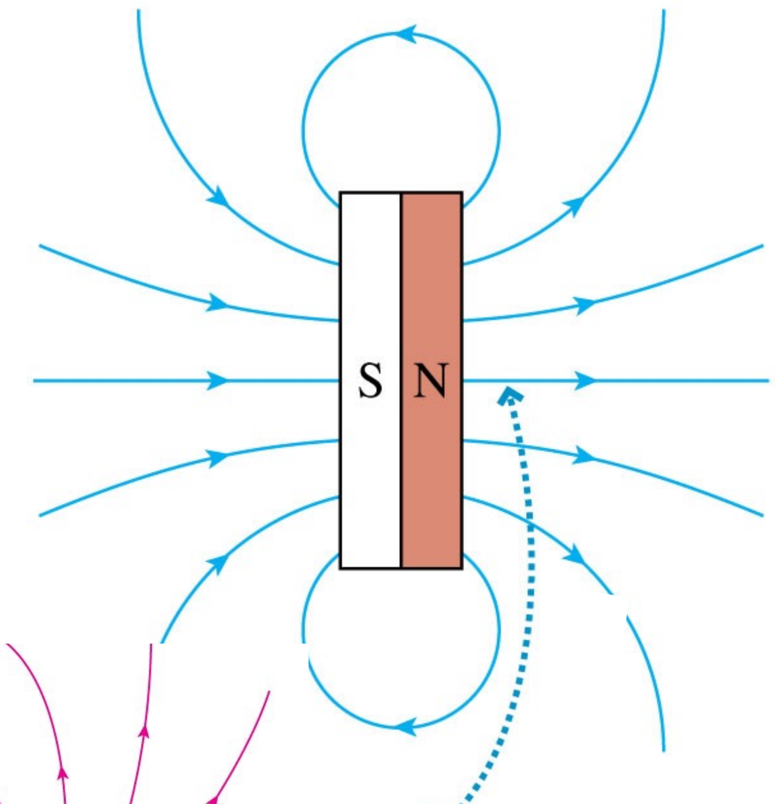
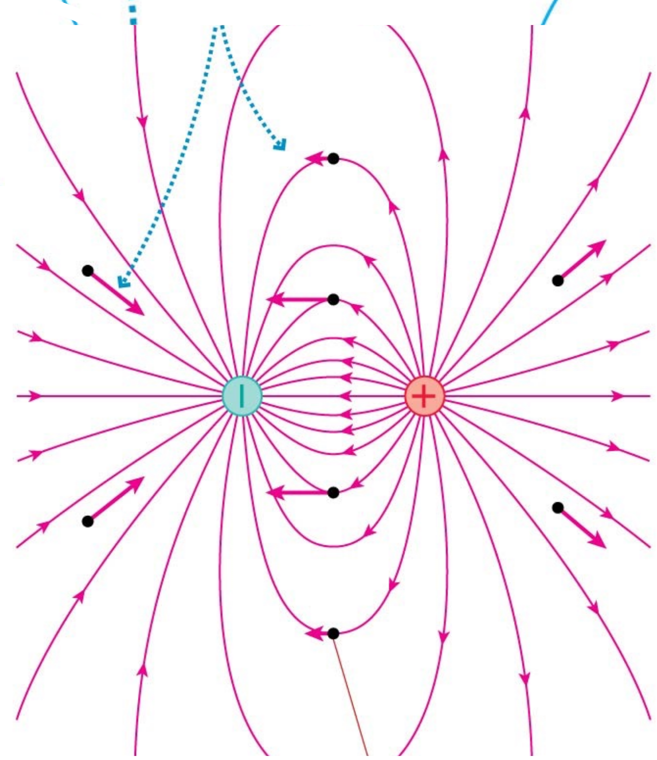


Permanent Magnet



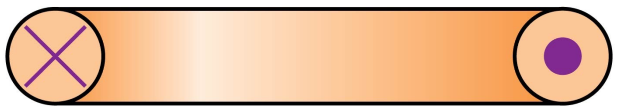


Electric Dipole

Question #32

Where is the north magnetic pole of this current loop?

A. Top side.
B. Right side.
C. Bottom side.
D. Left side.
E. Current loops don't have north poles.



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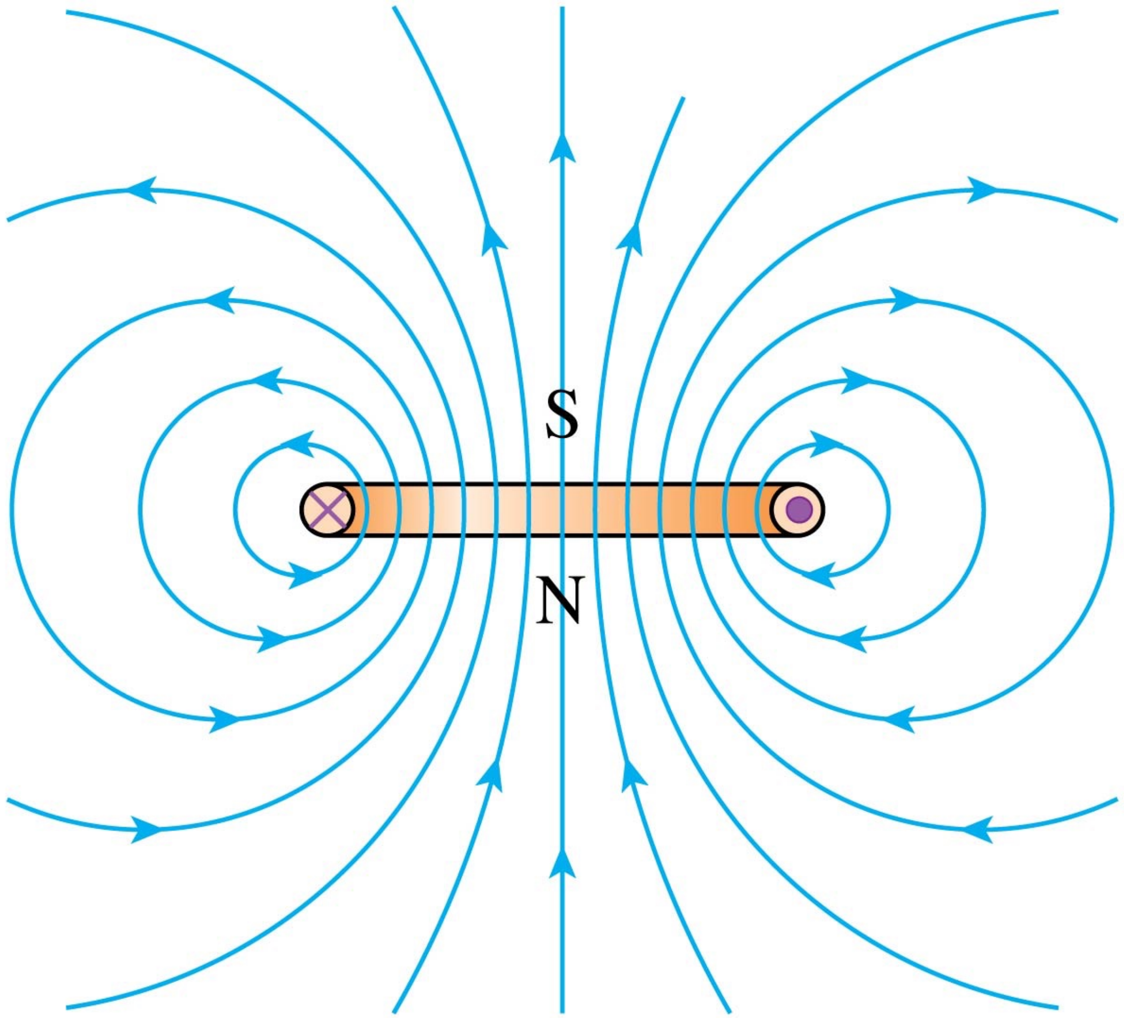
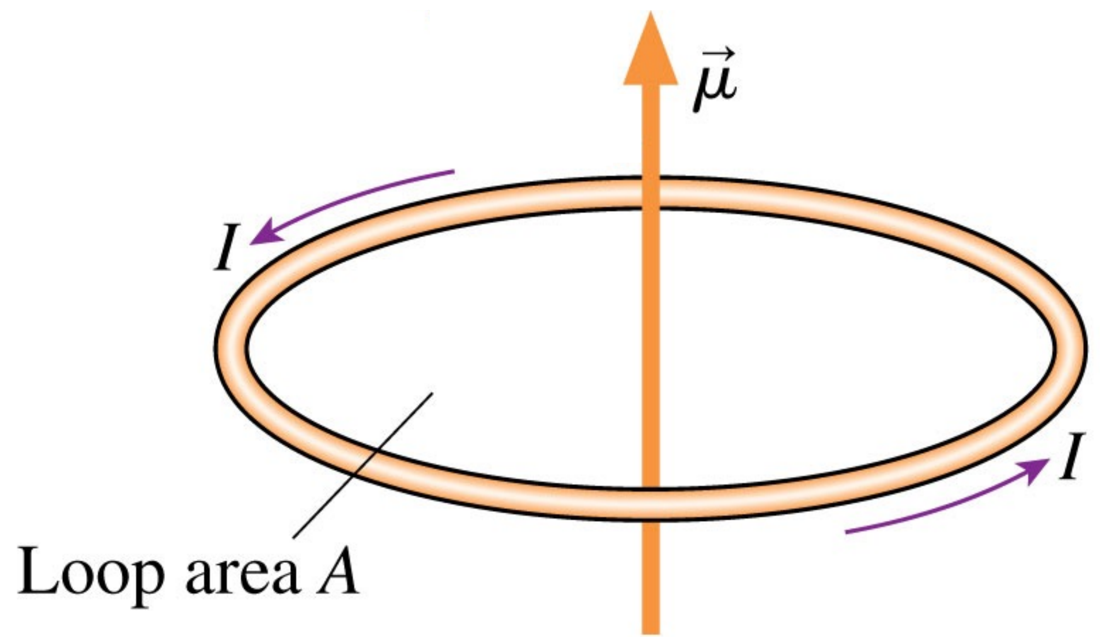


The dipole moment

$$B = \frac{\mu_0}{2} \frac{IR^2}{(z^2 + R^2)^{3/2}}$$

If z is much bigger than R what does this expression reduce to?



$\vec{\mu} = (AI$, from the south pole to the north pole)

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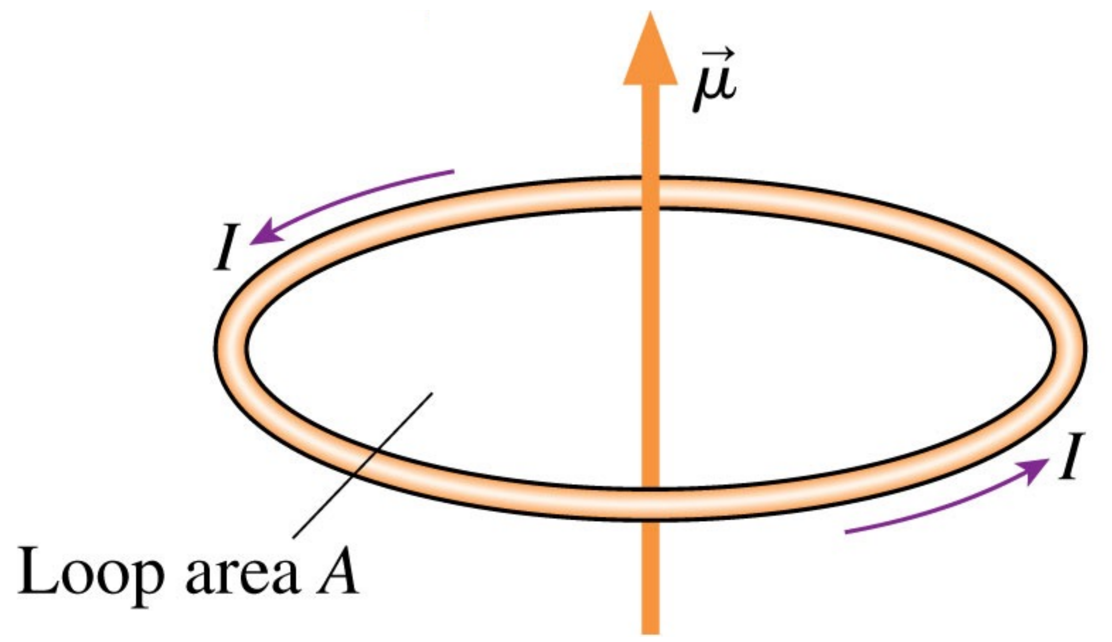
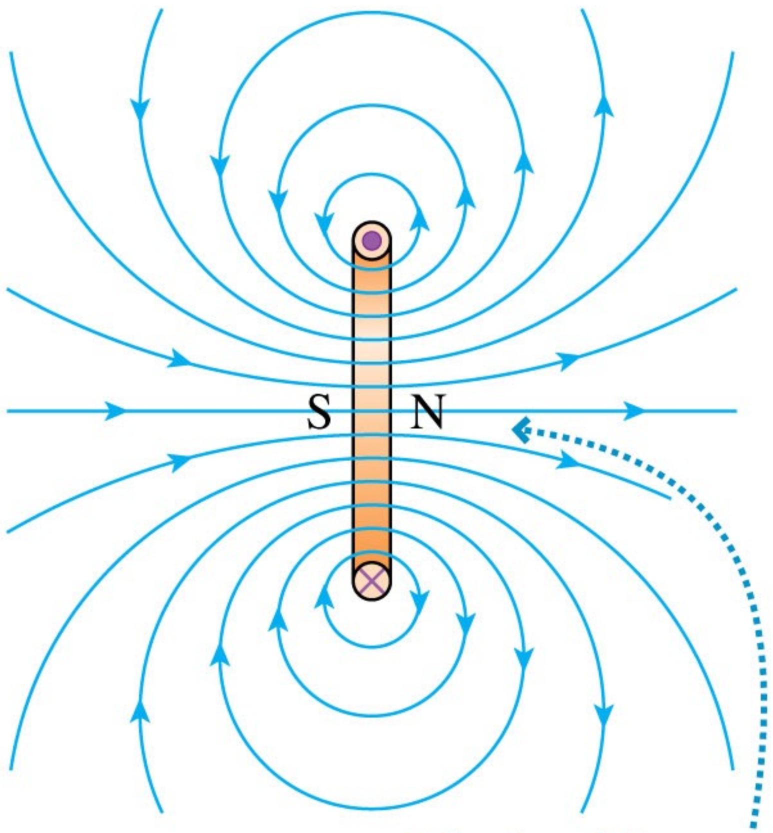


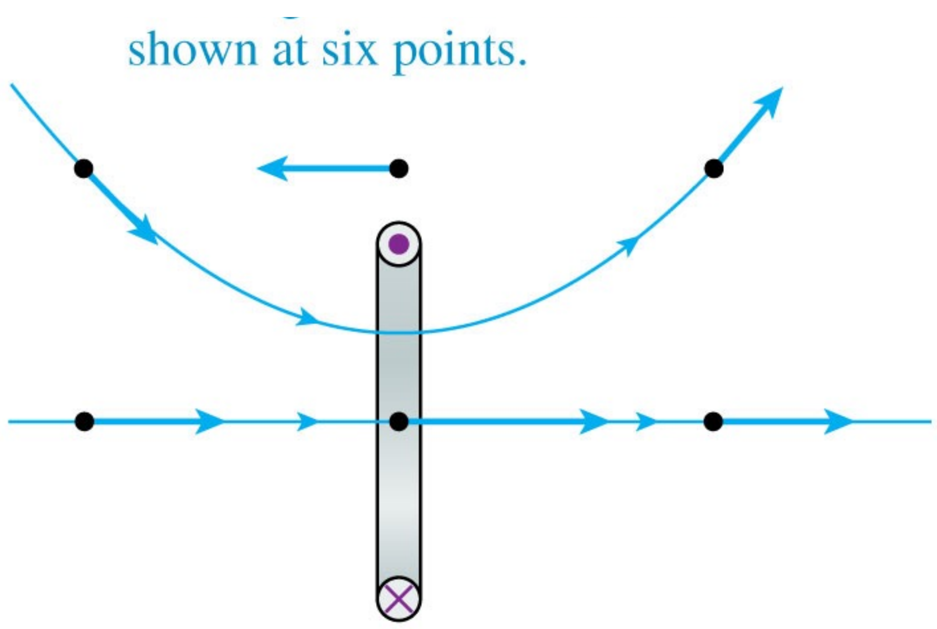
$\vec{\mu} = (AI$, from the south pole to the north pole)

$$\vec{B}_{\text{dipole}} = \frac{\mu_0}{4\pi} \frac{2\vec{\mu}}{z^3} \quad \text{(on the axis of a magnetic dipole)}$$

What if I put multiple coils next to each other?

Draw two more coils on either side of this one and determine the strength and direction of the magnetic field inside and outside of the coils.





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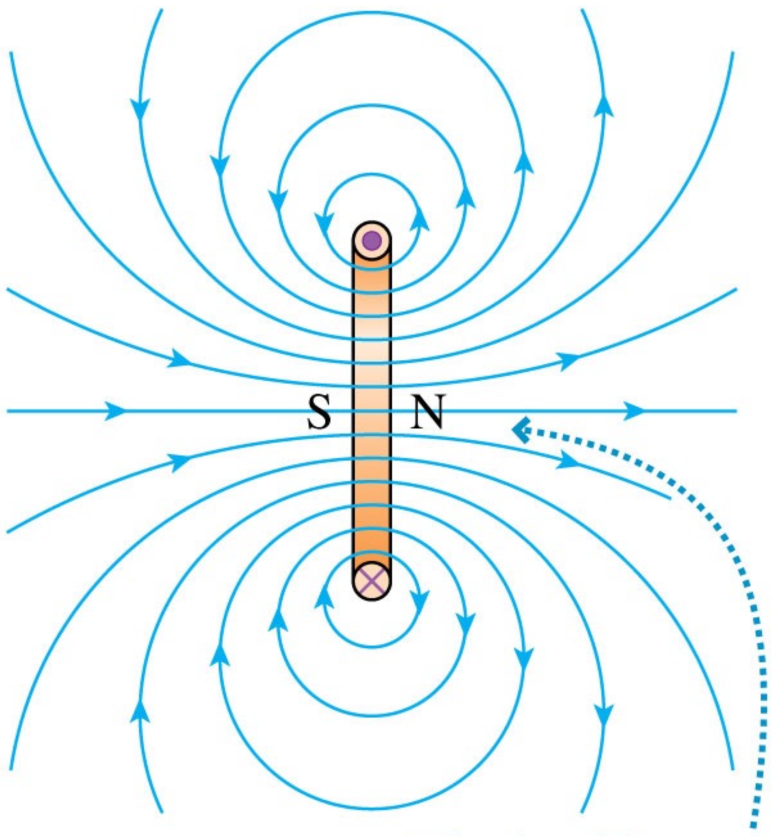
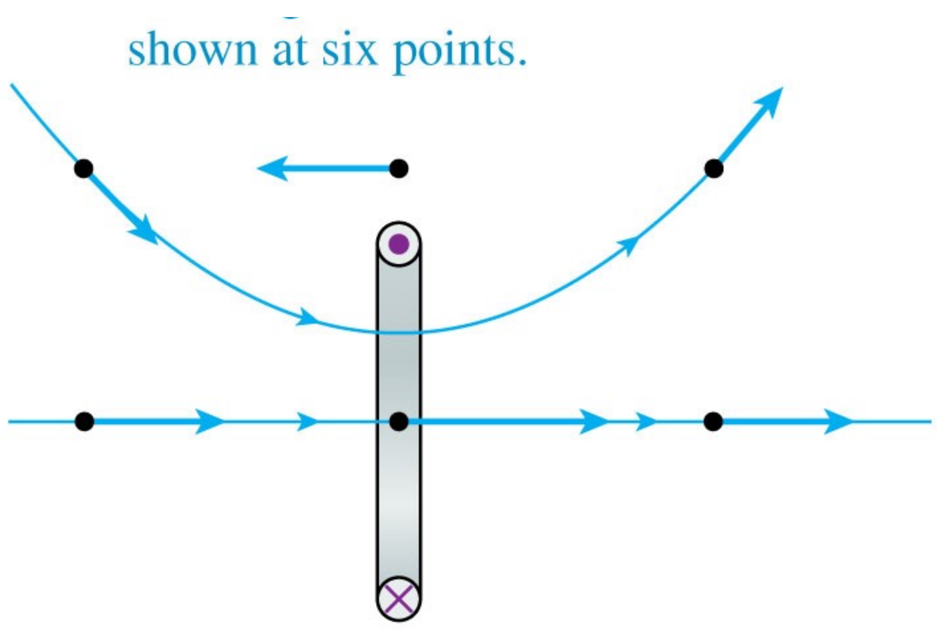
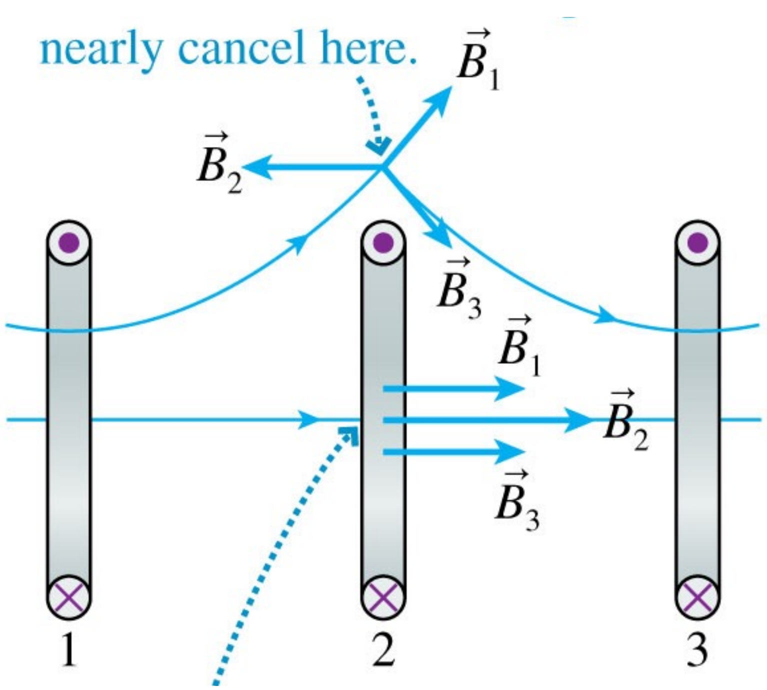
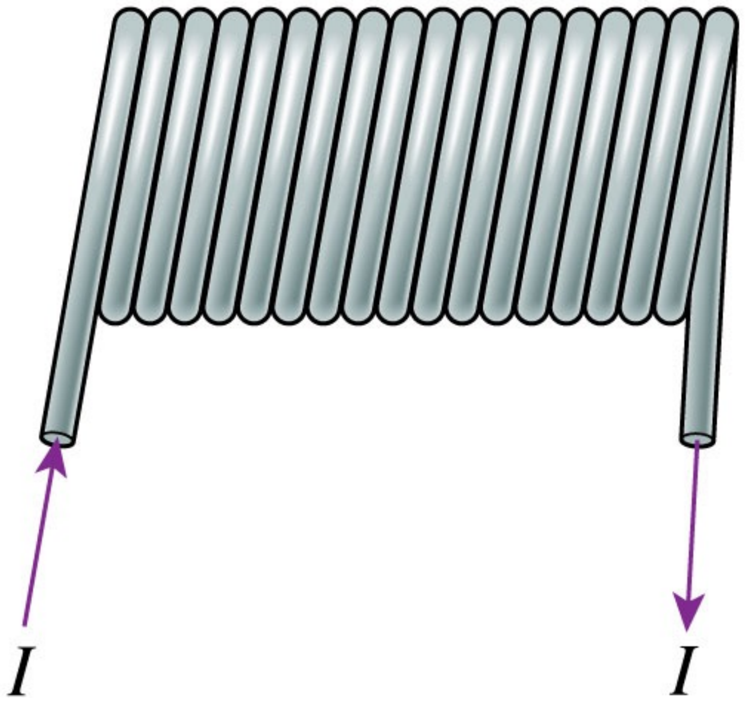






Solenoid



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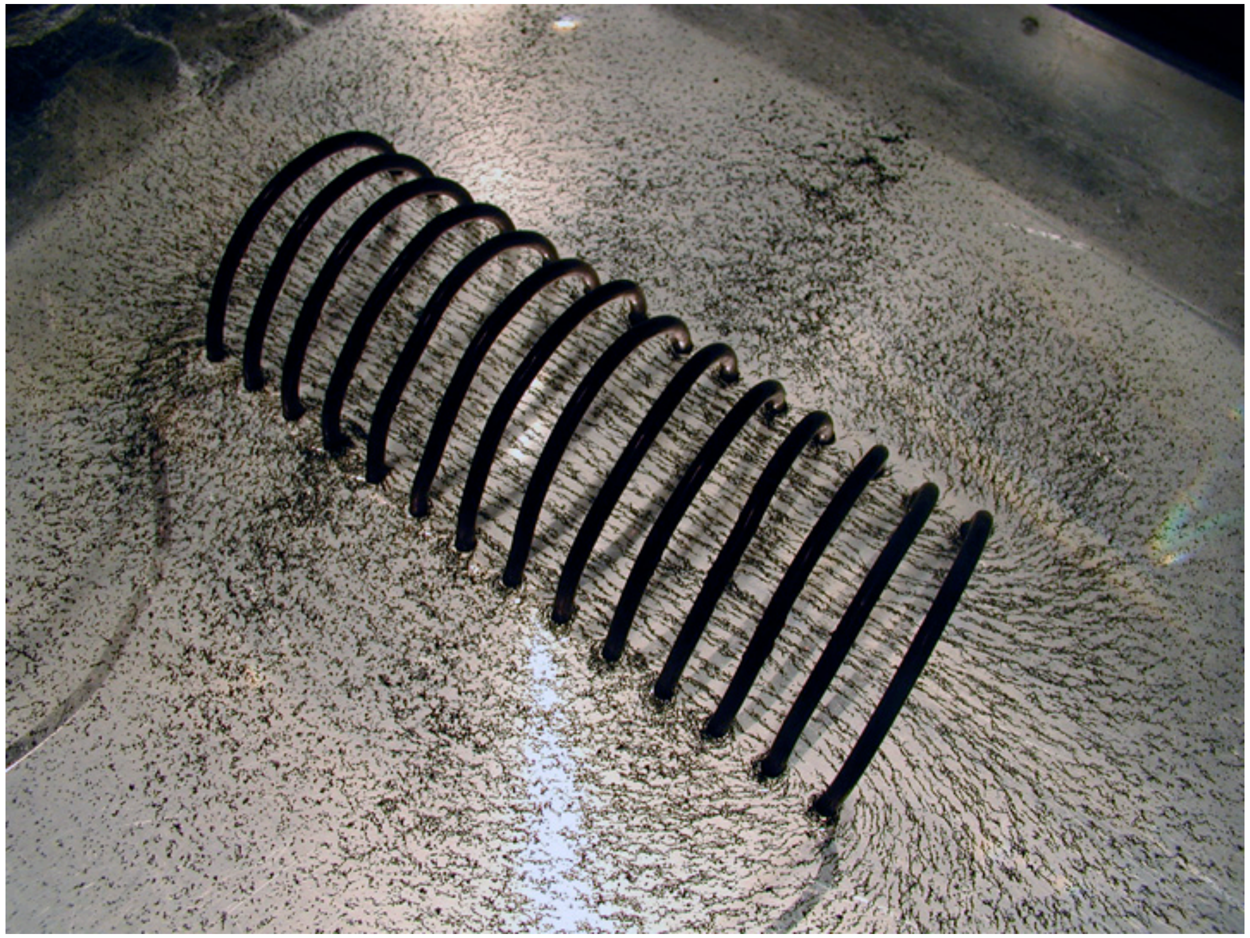

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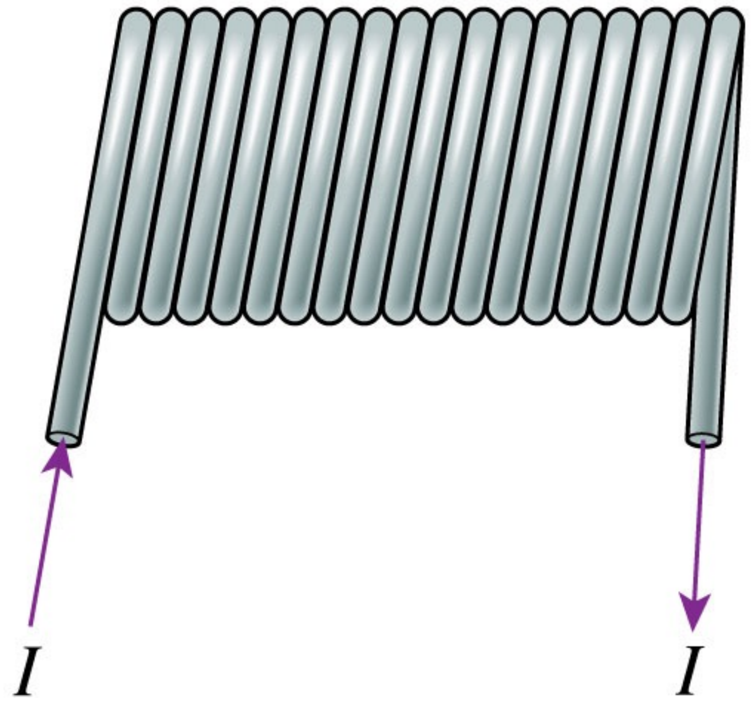

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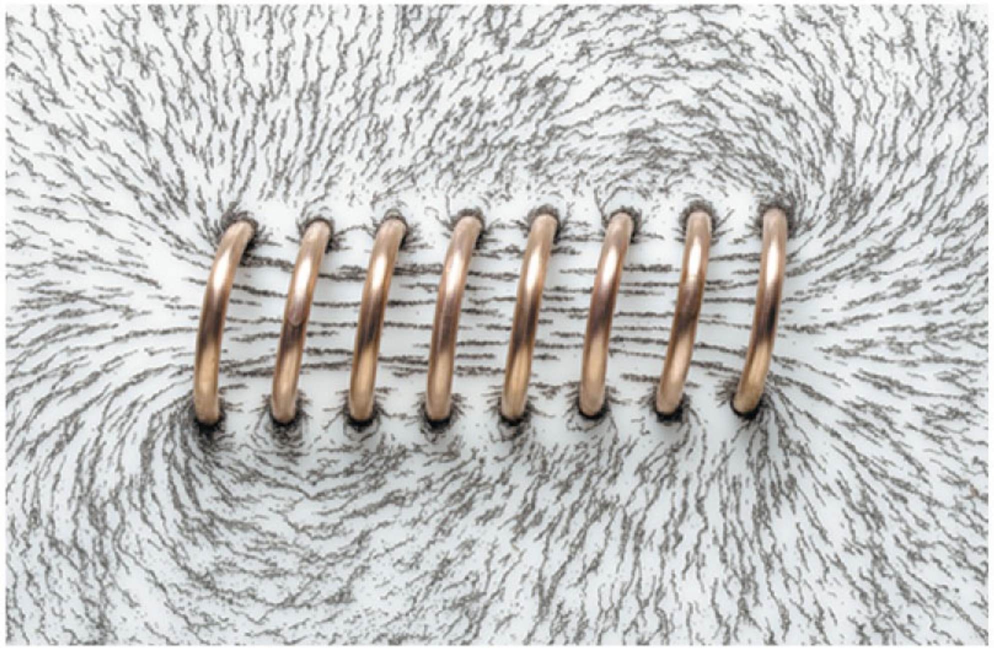
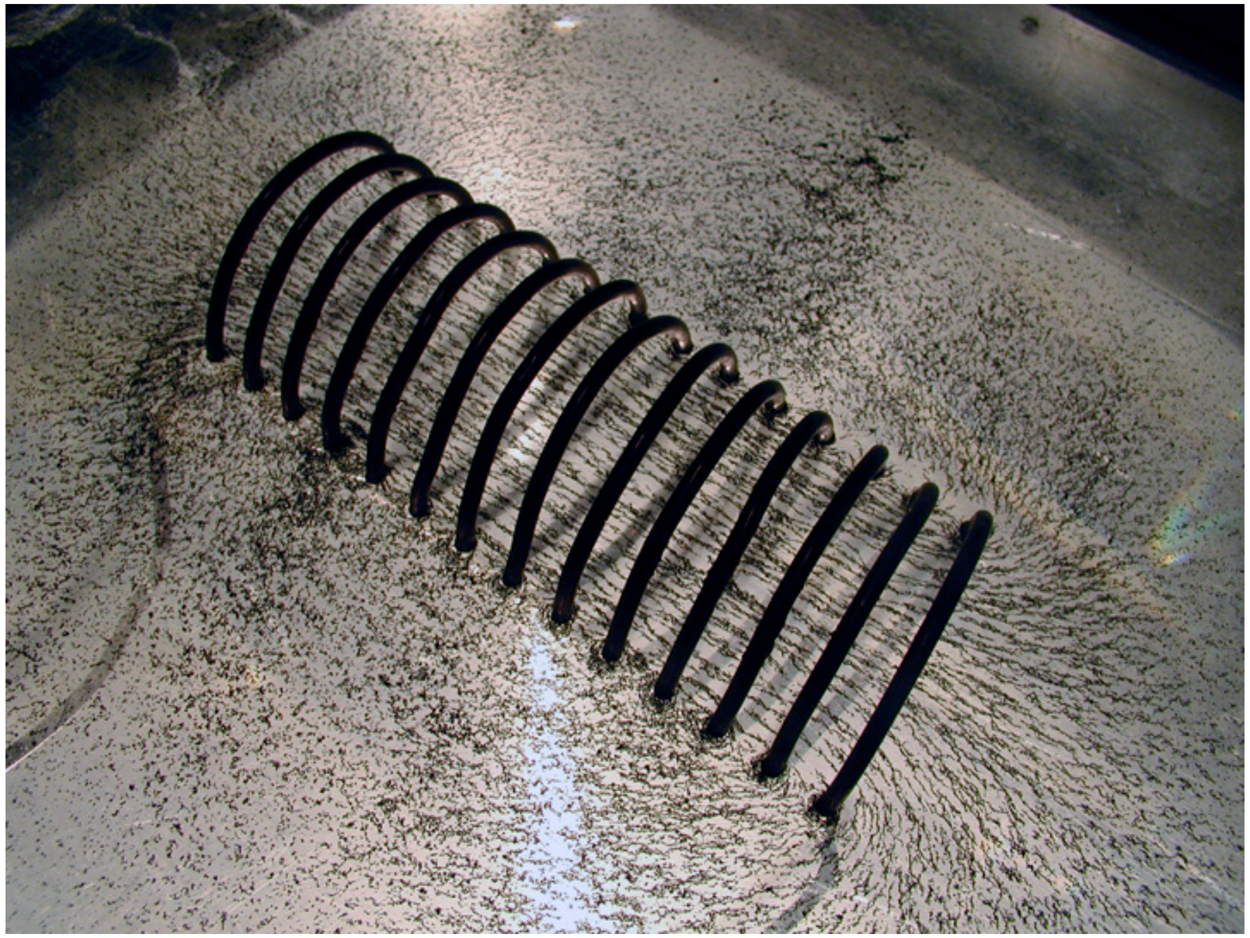
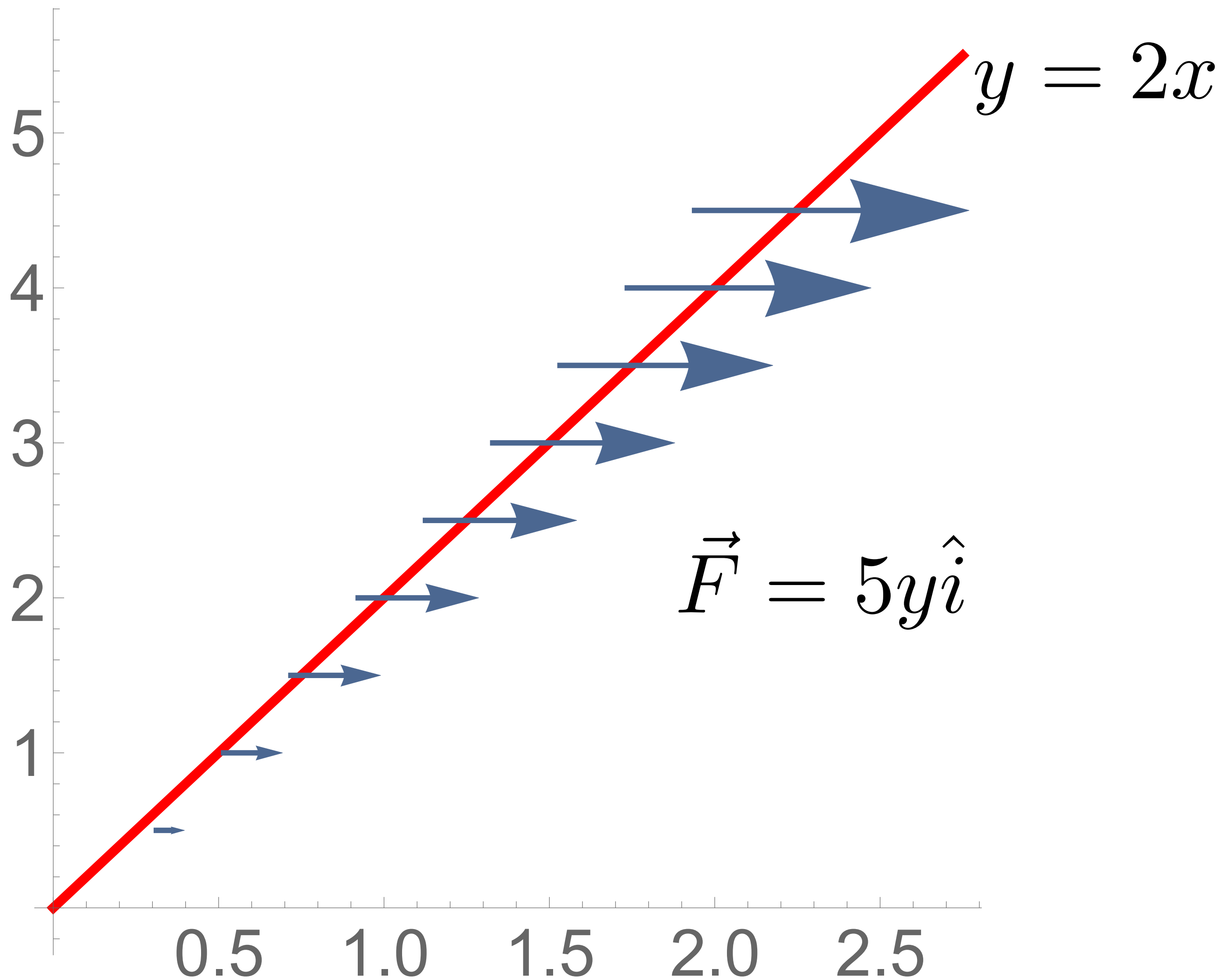




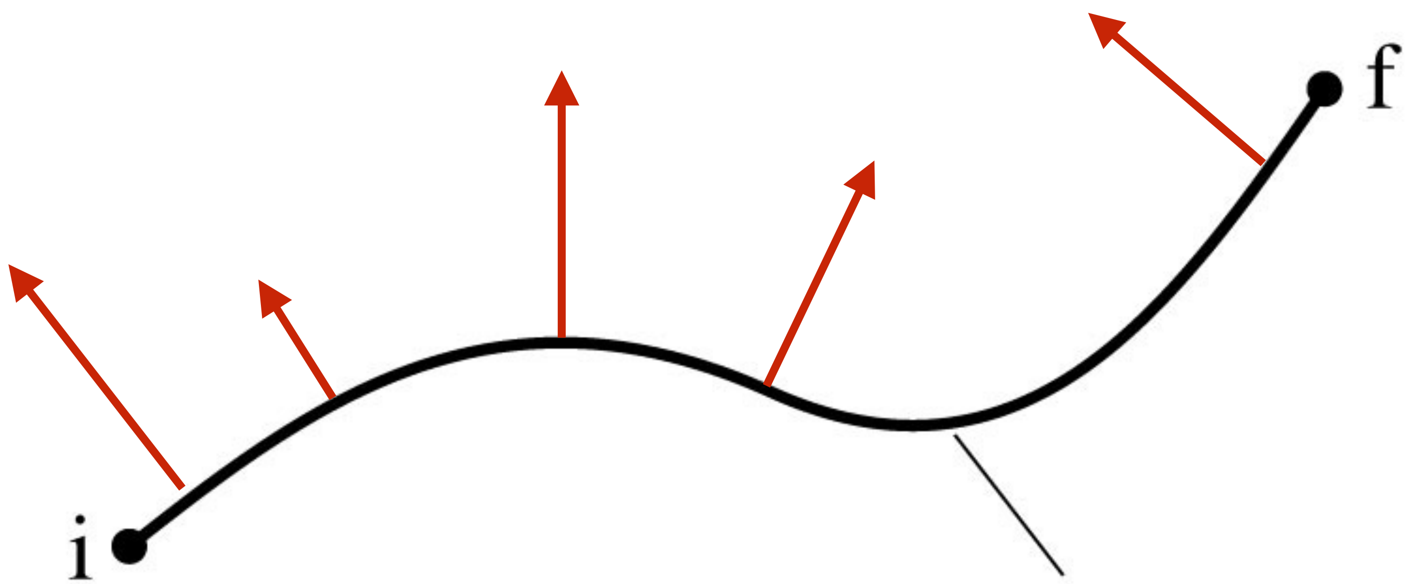
Intro to Ampere's law

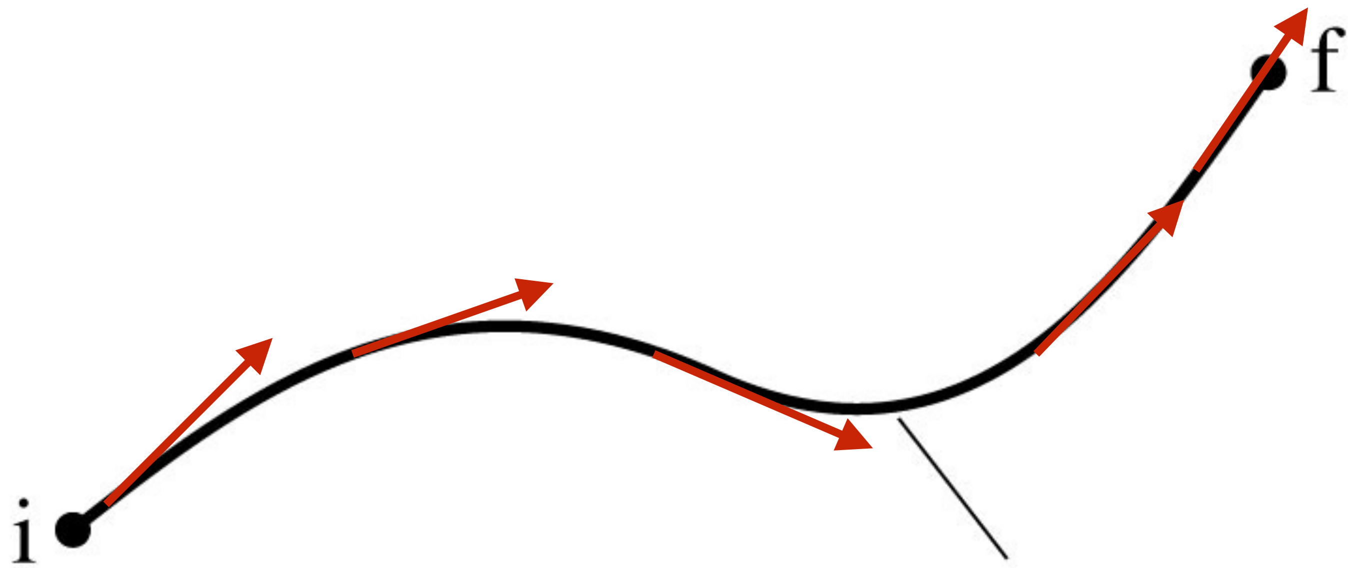


$$\int \vec{F} \cdot d\vec{s}$$

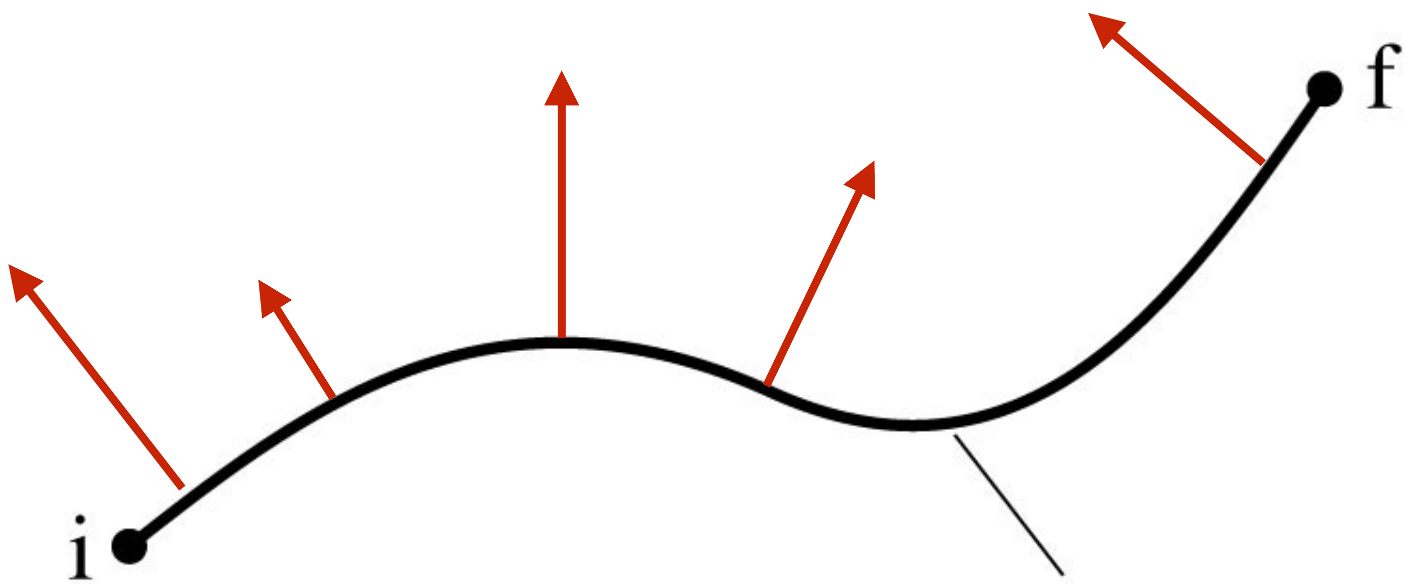
$$d\vec{s} = dx\hat{i} + dy\hat{j}$$

$$x = t \quad y = 2t$$



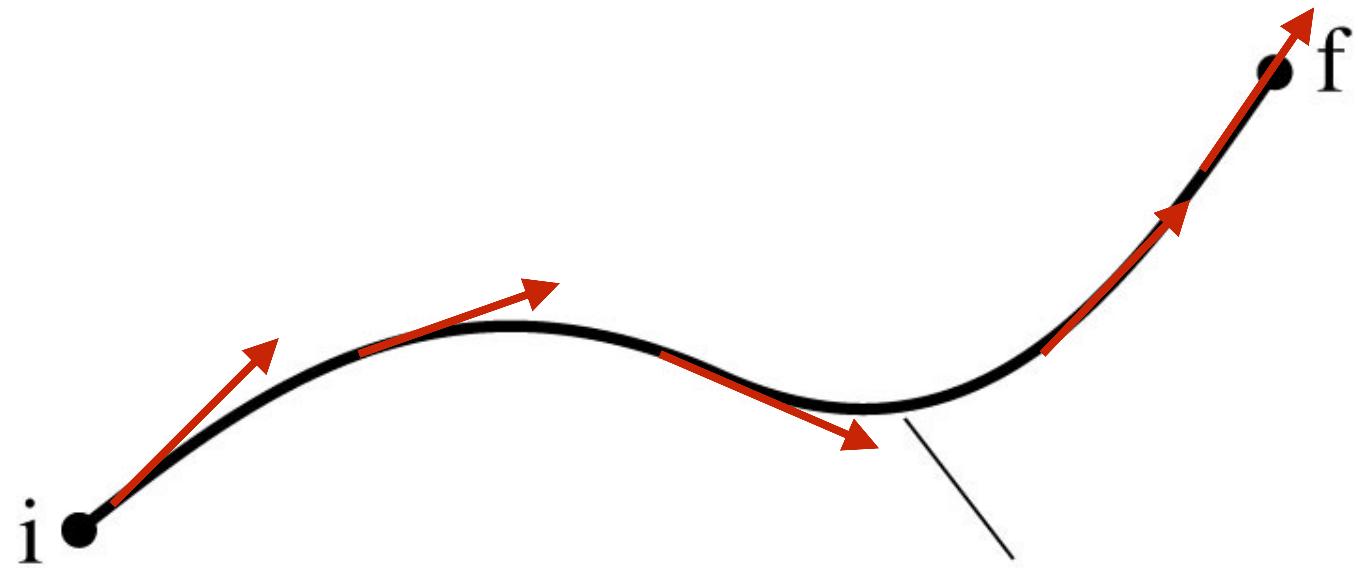


What would these line integrals be?



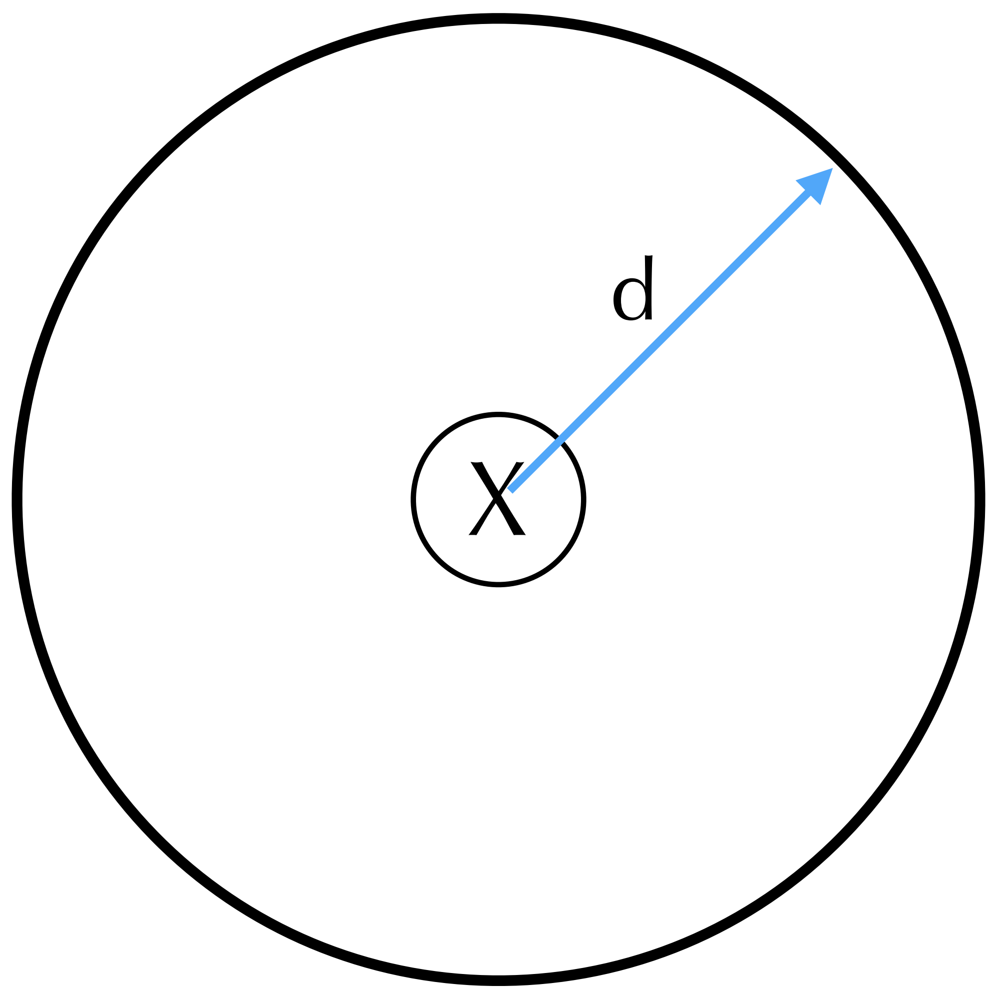
What would these line integrals be?

$$\int_i^f \vec{B} \cdot d\vec{s}$$



Ampere's Law: Like Gauss's law but for magnetism

What is the value of this integral?



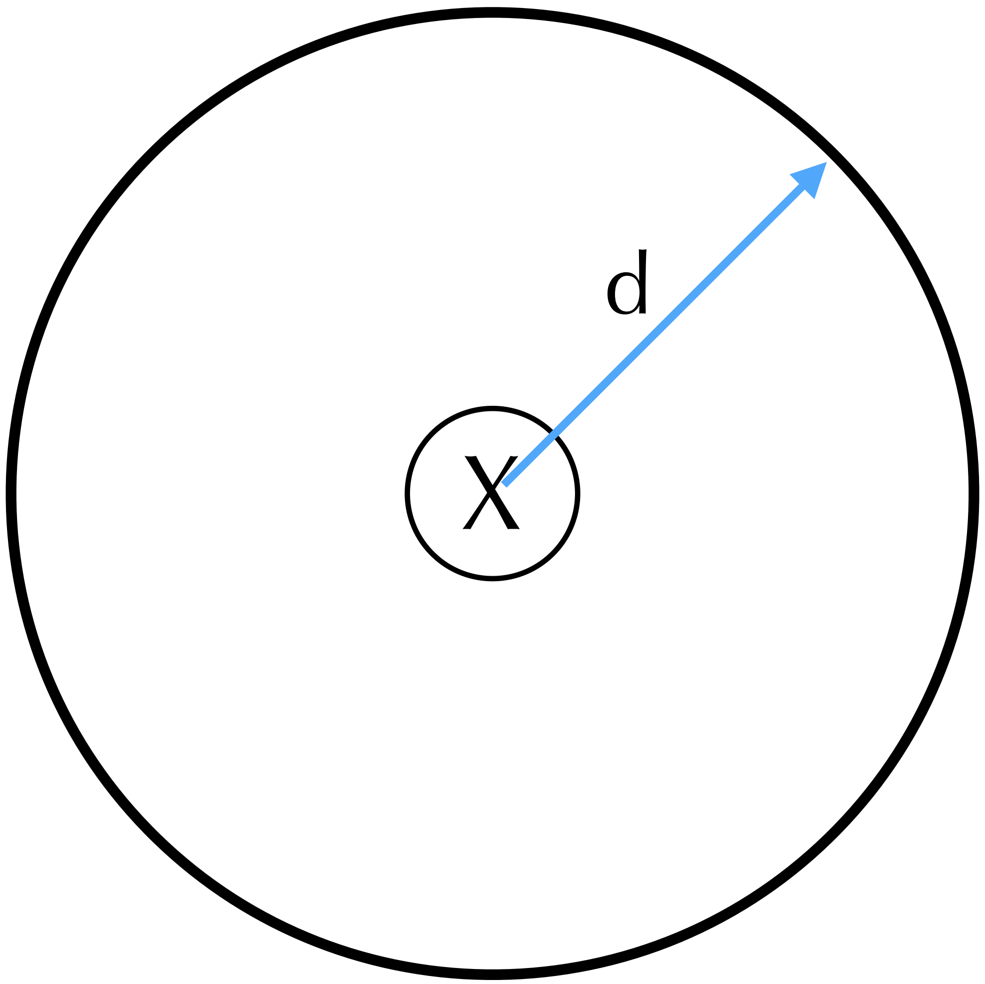
$$\oint \vec{B} \cdot d\vec{s}$$

Ampere's Law: The path integral depends on the current enclosed by the loop.

Ampere's Law: Like Gauss's law but for magnetism

What is the value of this integral?

$$\boxed{\oint \vec{B} \cdot d\vec{s} = \mu_0 I}$$



$$\oint \vec{B} \cdot d\vec{s}$$

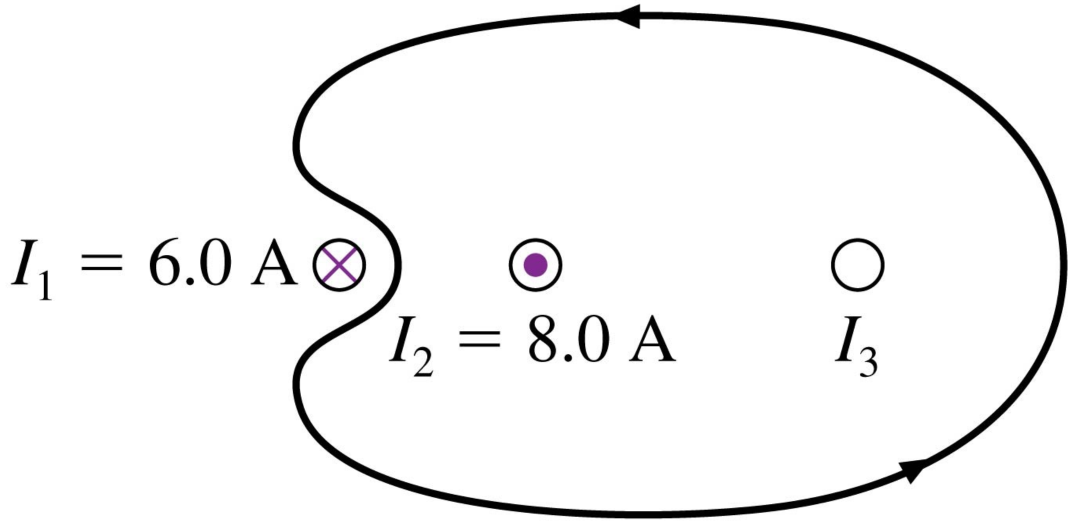
Ampere's Law: The path integral depends on the current enclosed by the loop.

Quiz Question

The line integral of B around the loop is $\mu_0 \cdot 7.0$ A.

Current I_3 is

A. 1 A into the screen.
B. 1 A out of the screen.
C. 0 A.
D. 5 A out of the screen.
E. 5 A into the screen.



Quiz Question

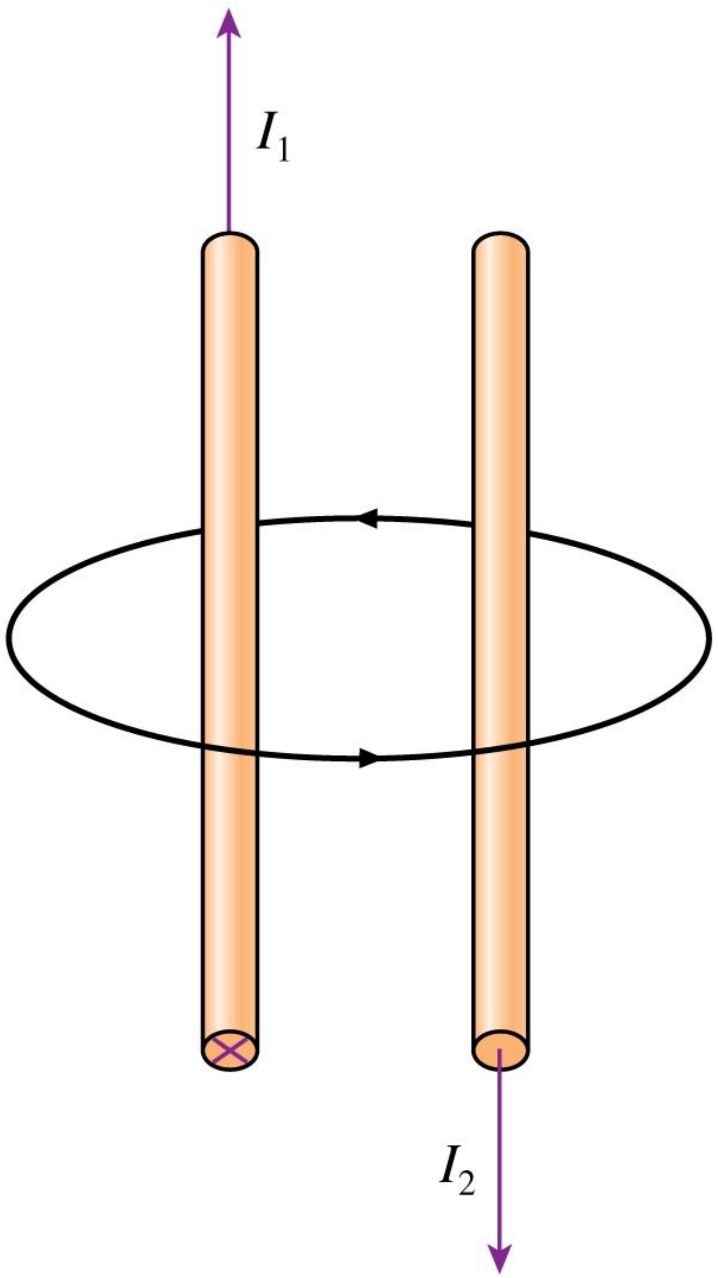
For the path shown,

A. 0.

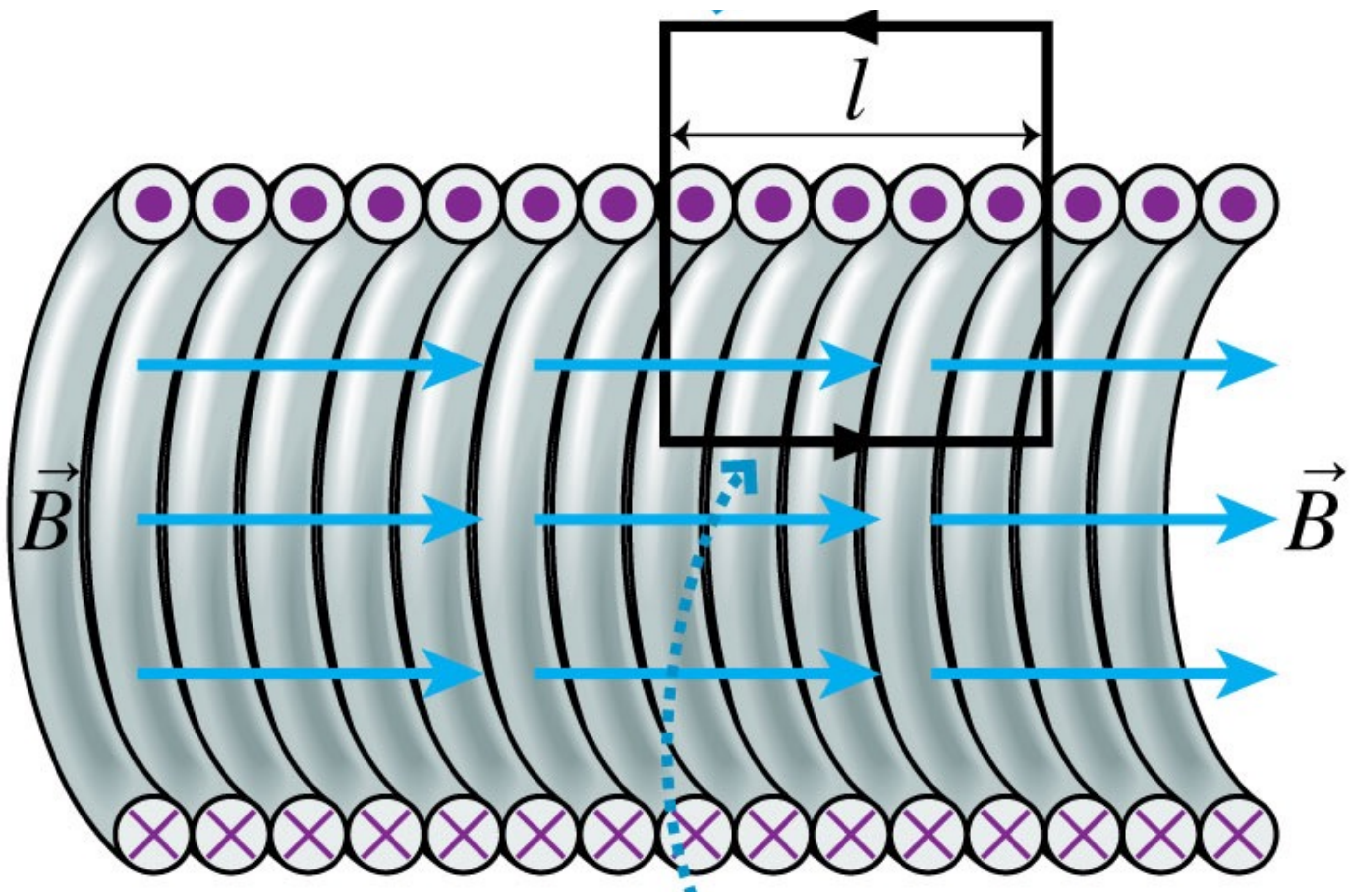
B. $\mu_0(I_1 + I_2)$.

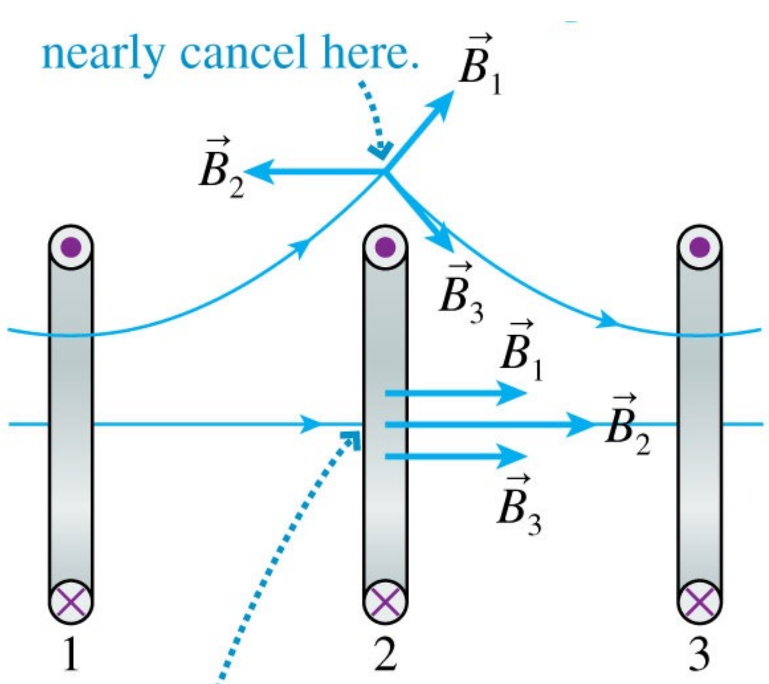
C. $\mu_0(I_2 - I_1)$.

D. $\mu_0(I_1 - I_2)$.



Let's use Ampere's law





a) What can you say about the B field along the path shown?
b) Can you simplify the integral on the left hand side?
c) How much current is flowing through this loop?

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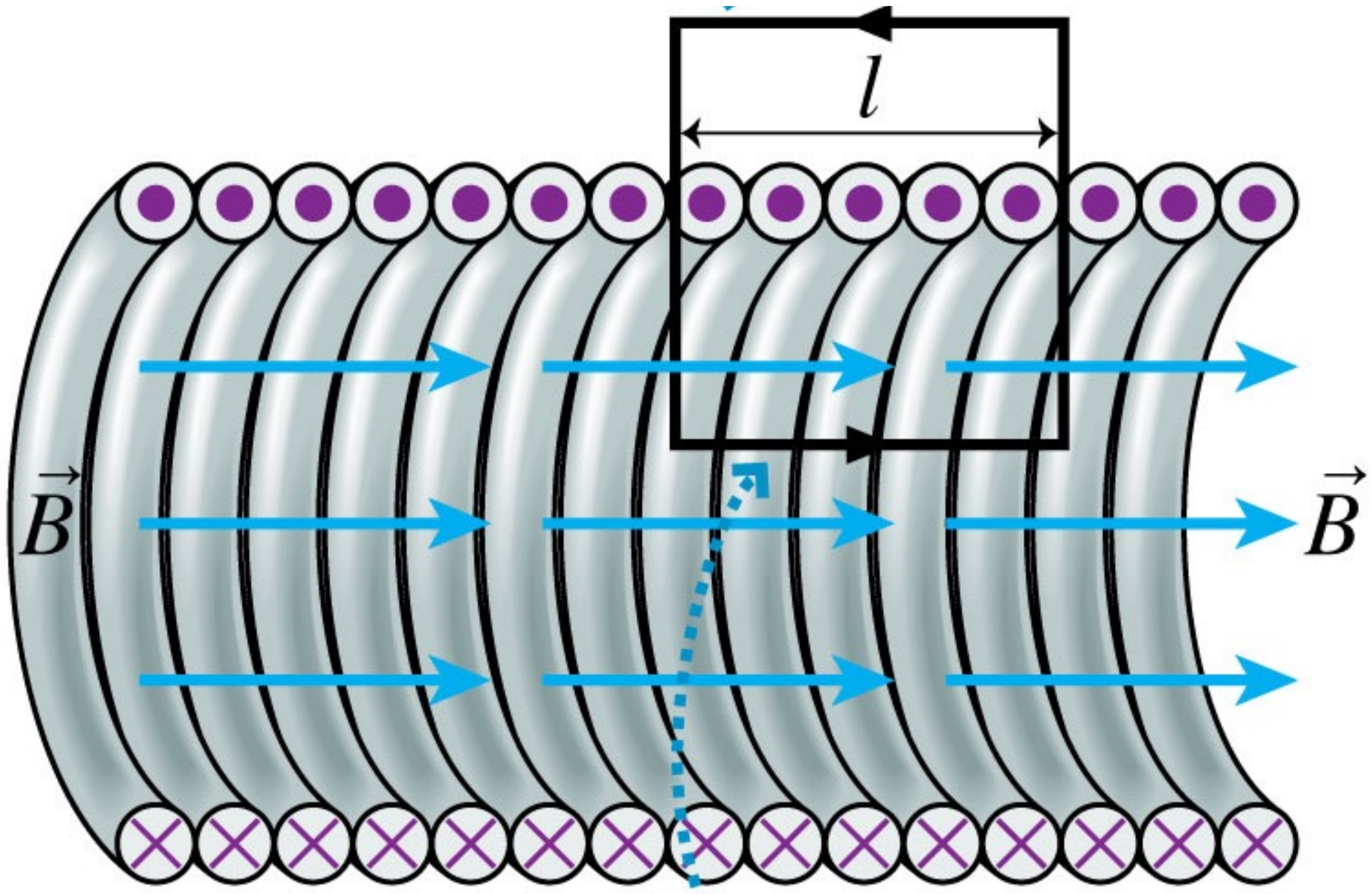

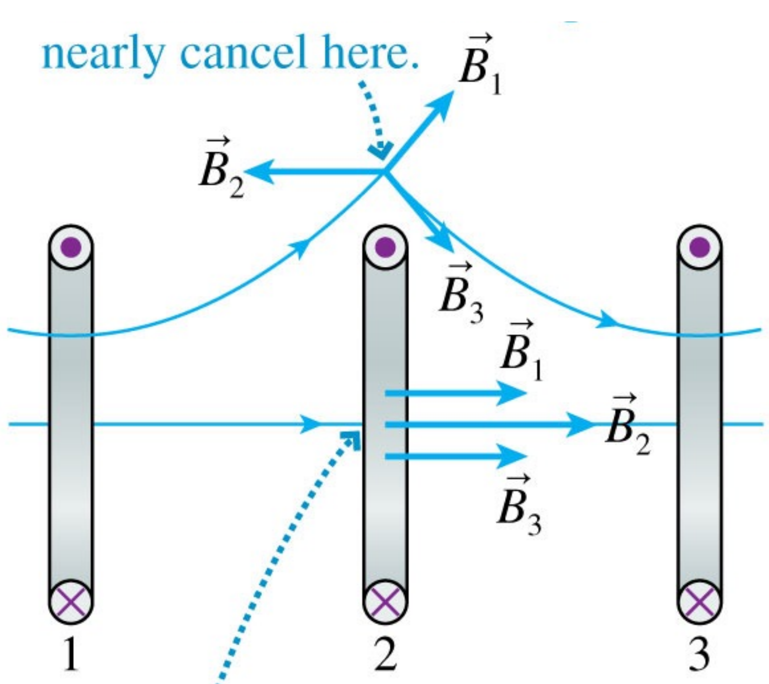

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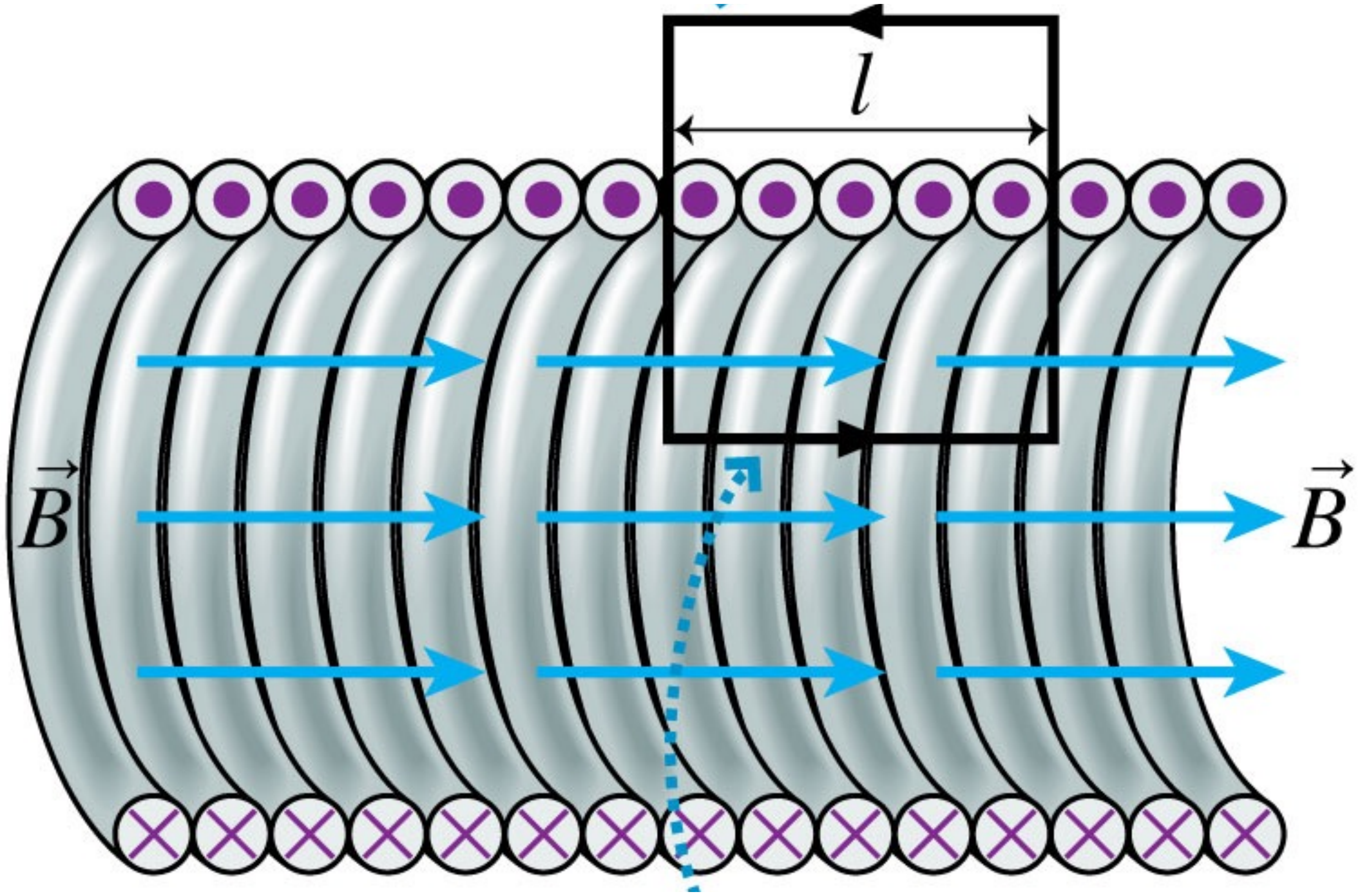

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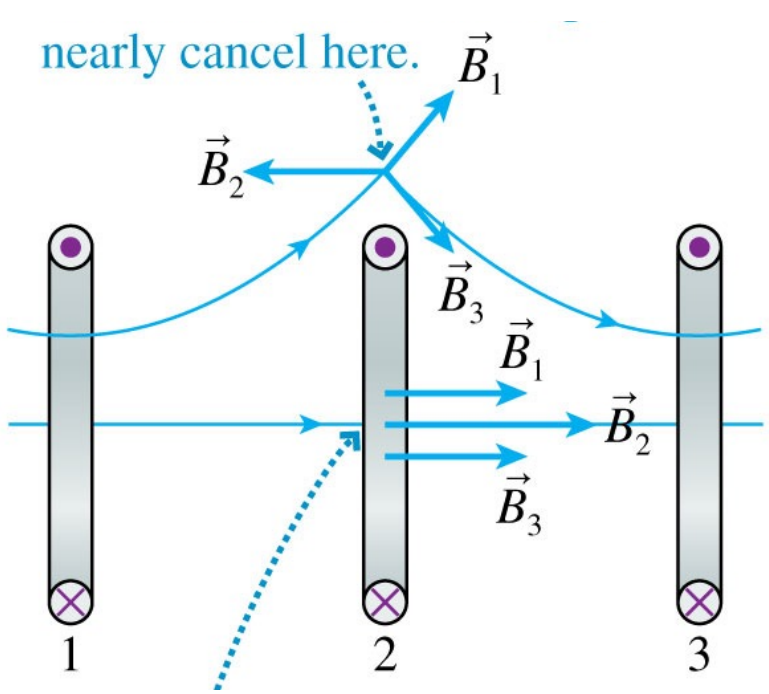
a) What can you say about the B field along the path shown?
b) Can you simplify the integral on the left hand side?
c) How much current is flowing through this loop?



$$B = \frac{\mu_0 N I}{l} = \mu_0 n I$$

Quiz Question

Solenoid 2 has twice the diameter, twice the length, and twice as many turns as solenoid 1. How does the field B_2 at the center of solenoid 2 compare to B_1 at the center of solenoid 1?

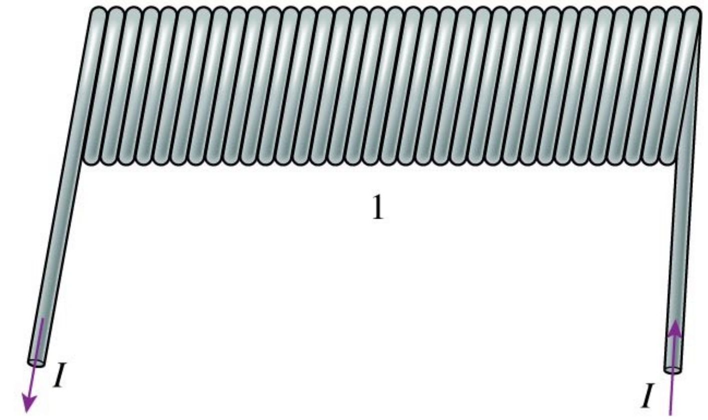
A. $B_2 = B_1/4$.

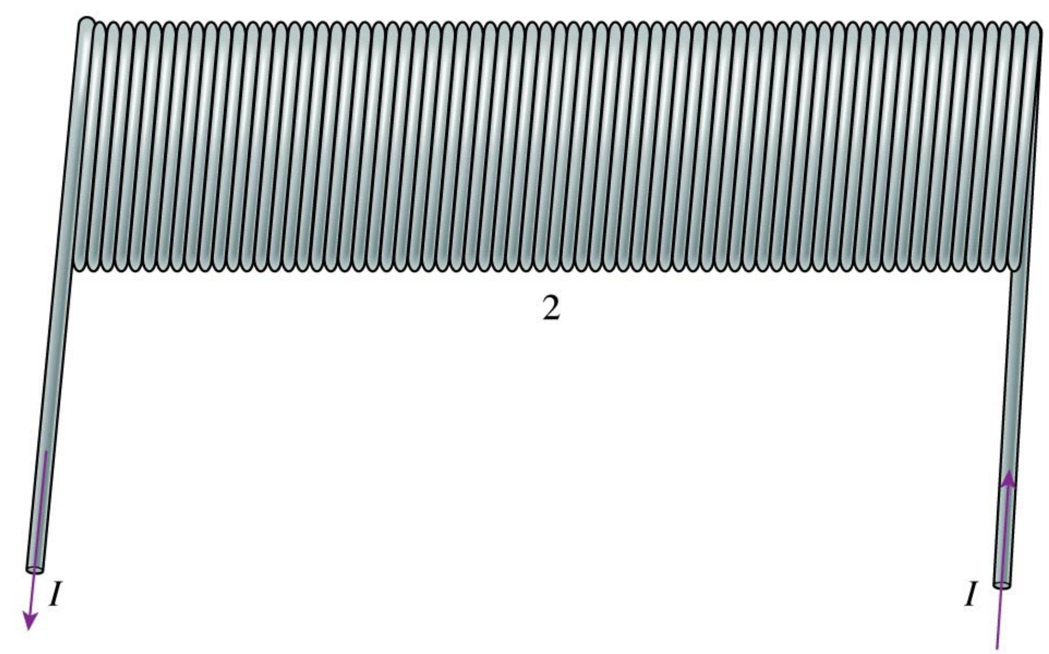
B. $B_2 = B_1/2$.

C. $B_2 = 2B_1$.

D. $B_2 = B_1$.

E. $B_2 = 4B_1$.

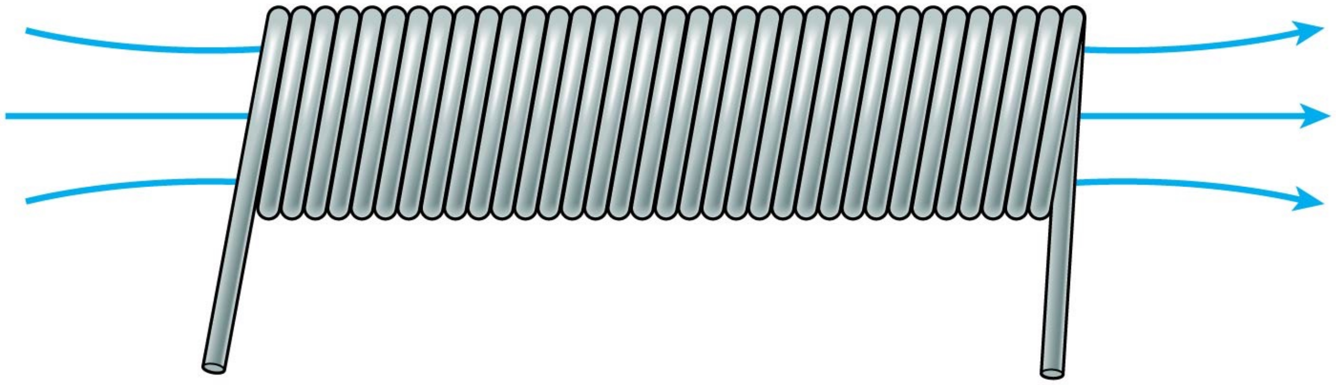




Quiz Question

The current in this solenoid

A. Enters on the left, leaves on the right.
B. Either A or B would produce this field.
C. Enters on the right, leaves on the left.



Powerful MRI machines