PH 220

Lance Nelson

Review

1

2

A

Find the magnetic field produced by a point charge in motion. (or multiple point charges in motion)

Find the magnetic field produces by a current loop. (Or multiple current loops)

B

3

Asked to calculate the magnetic dipole moment.

C

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

4

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

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

6

Find the magnetic field produced by multiple lines of current.

D

E

Calculate the path integral of the B field

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F

Leverage the symmetry of the current configuration to determine magnetic field.

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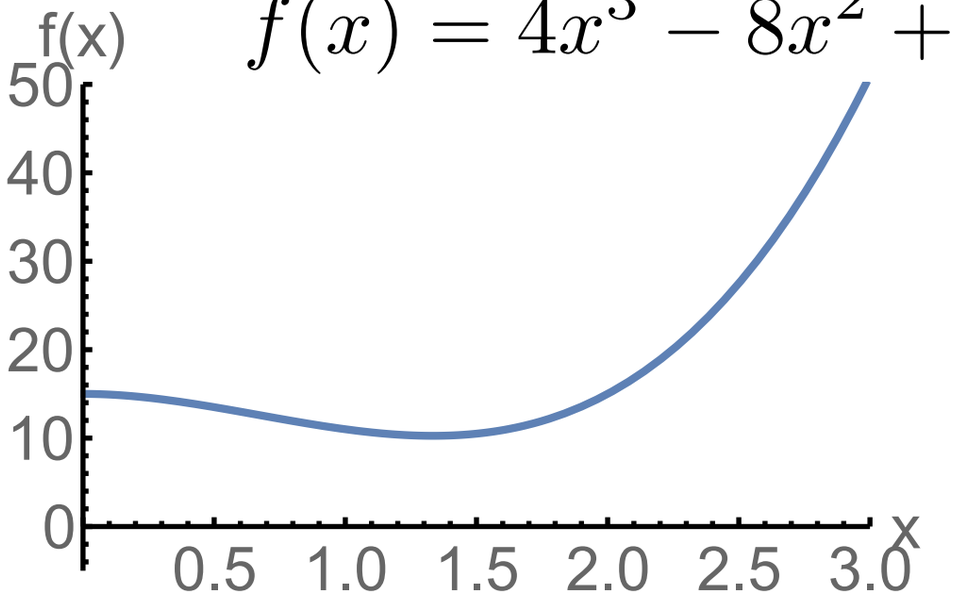
Calculus Review

Remind yourself: How would you find the length of this line

$$f(x) = 4x^3 - 8x^2 + 15$$



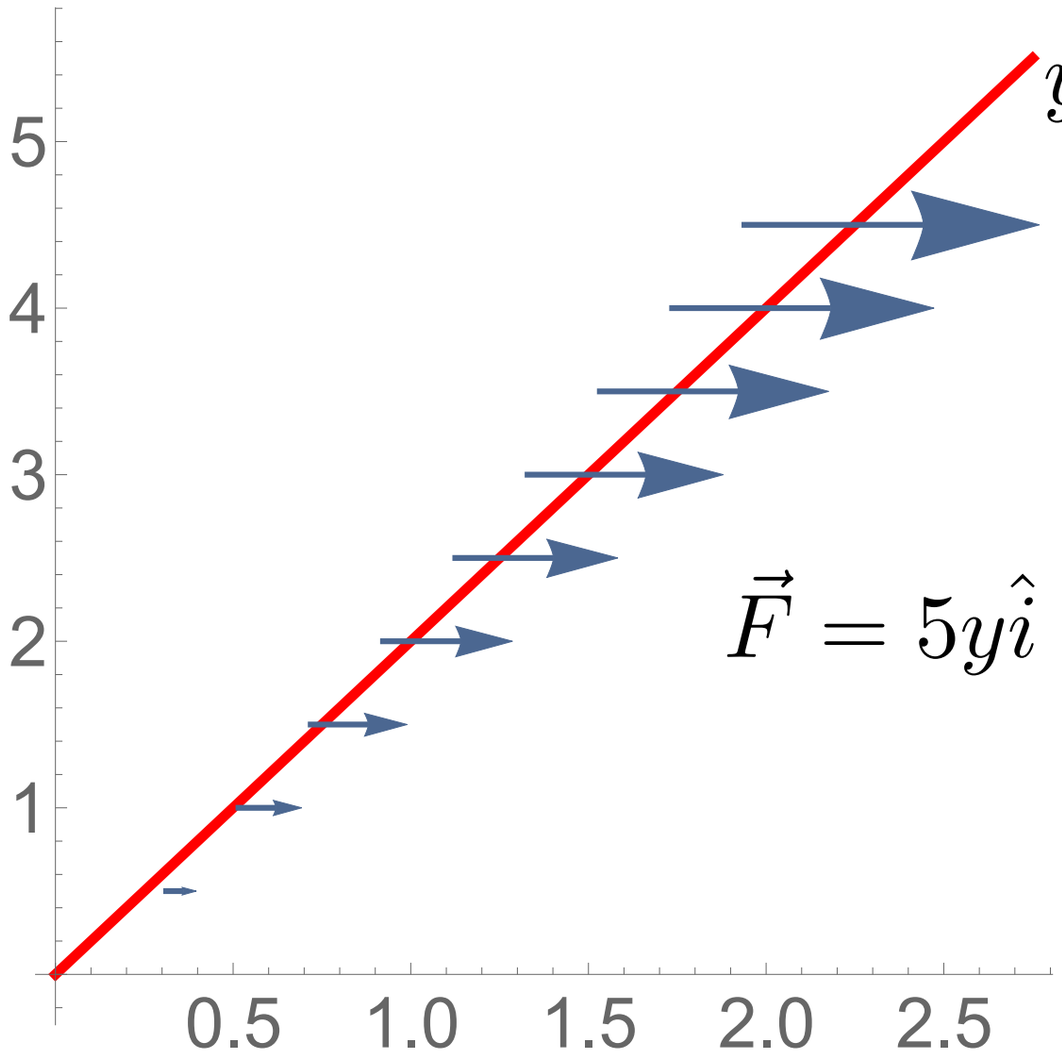
$$\int ds$$

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

$$ds = \sqrt{dx^2 + dy^2}$$

Intro to Ampere's law

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



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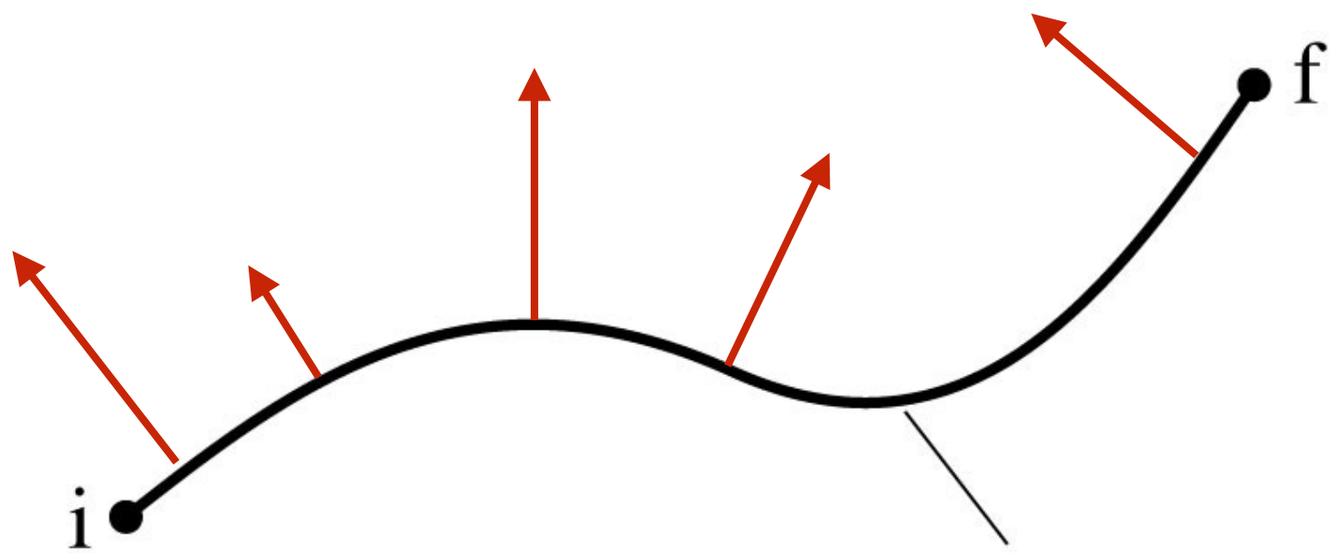
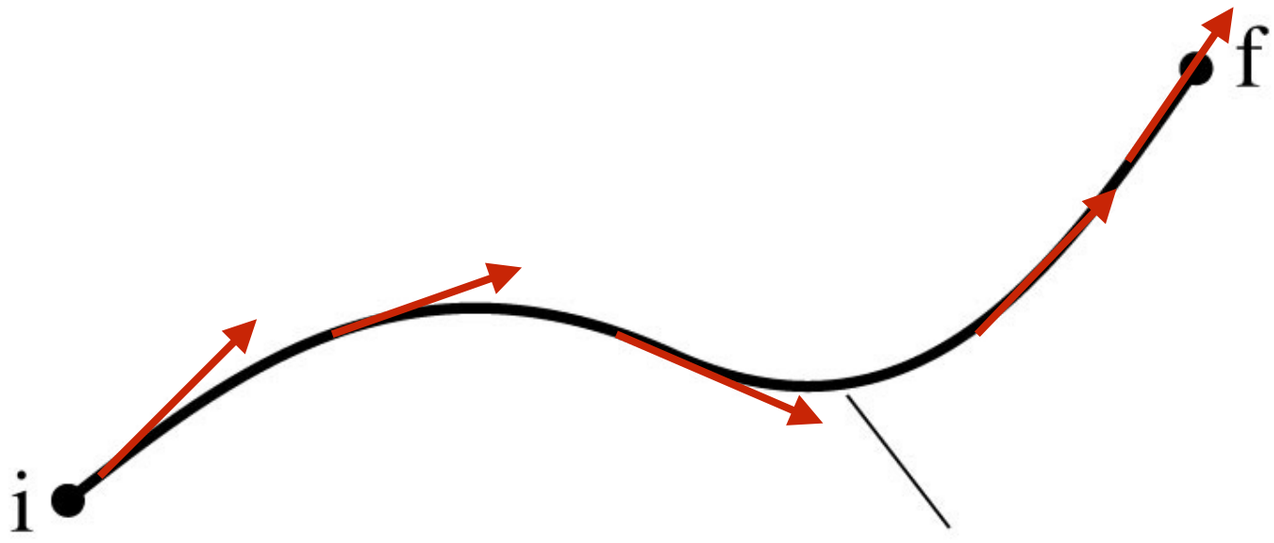
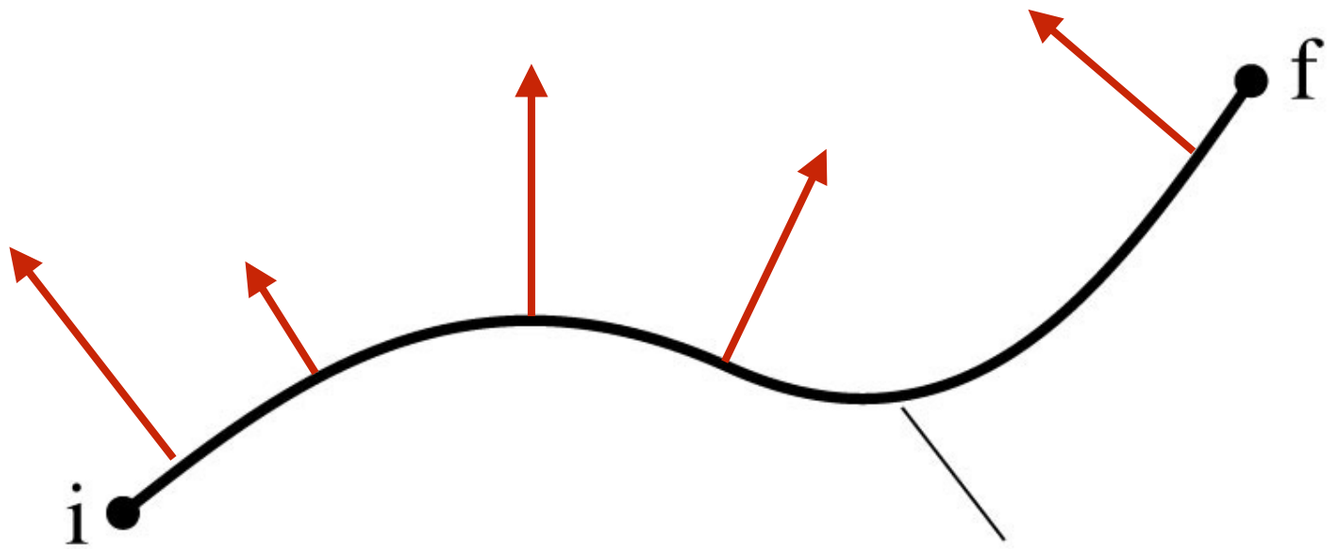


What would these line integrals be?





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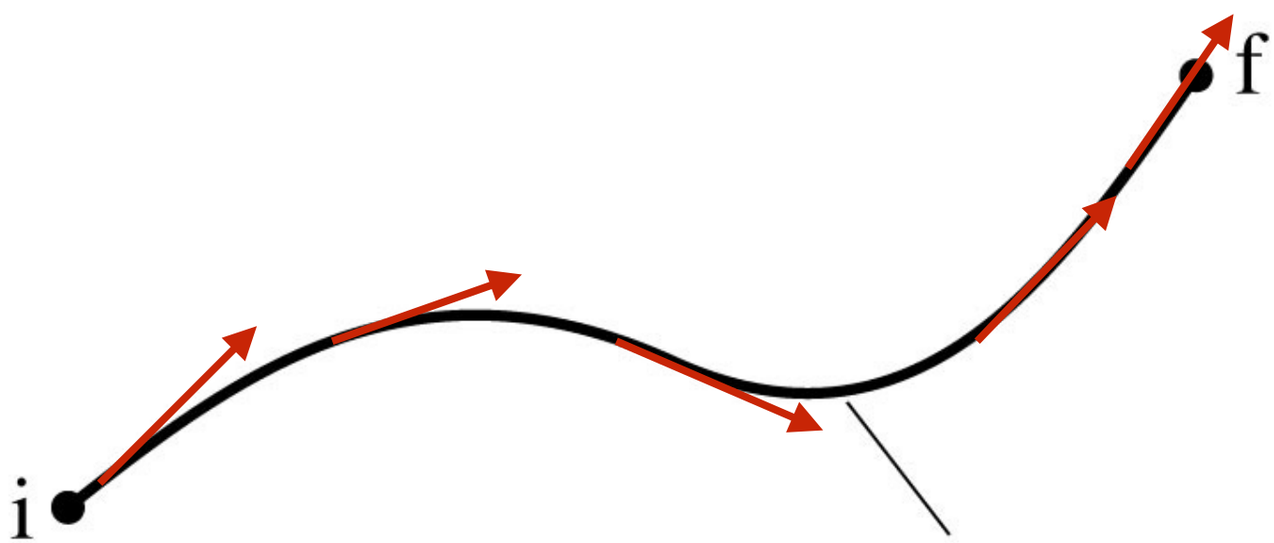
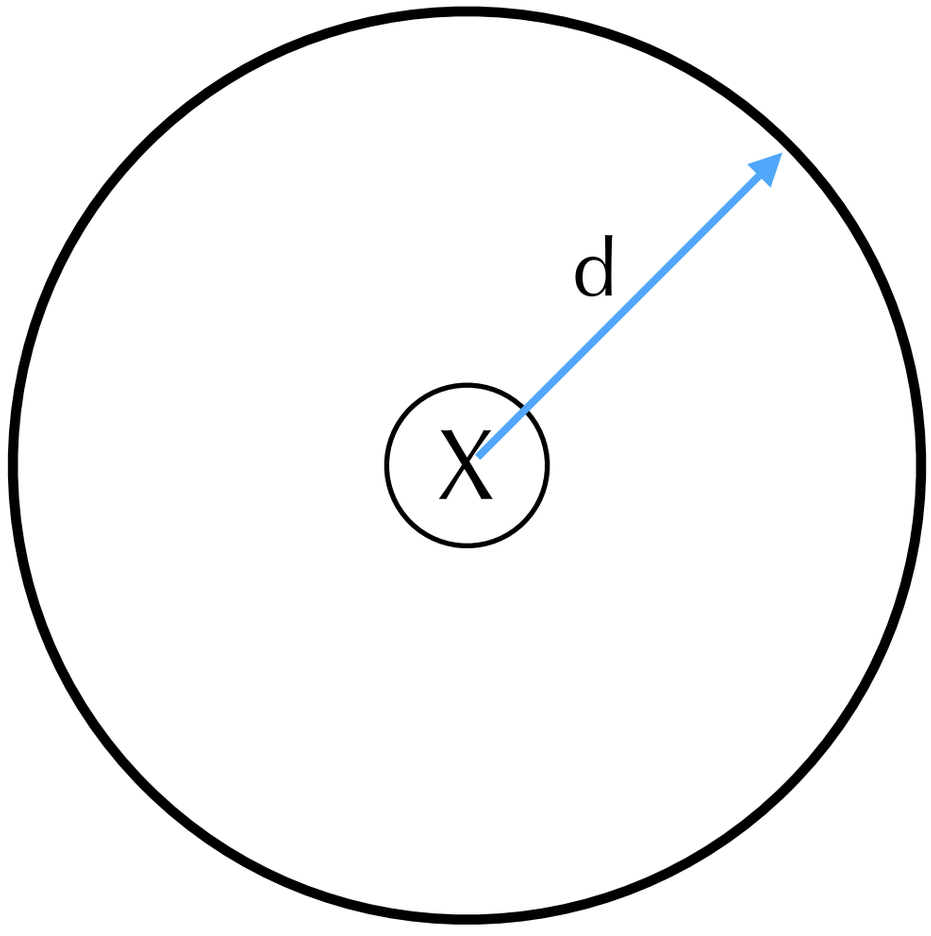
$$\int_i^f \vec{B} \cdot d\vec{s}$$



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

What is the value of this integral?



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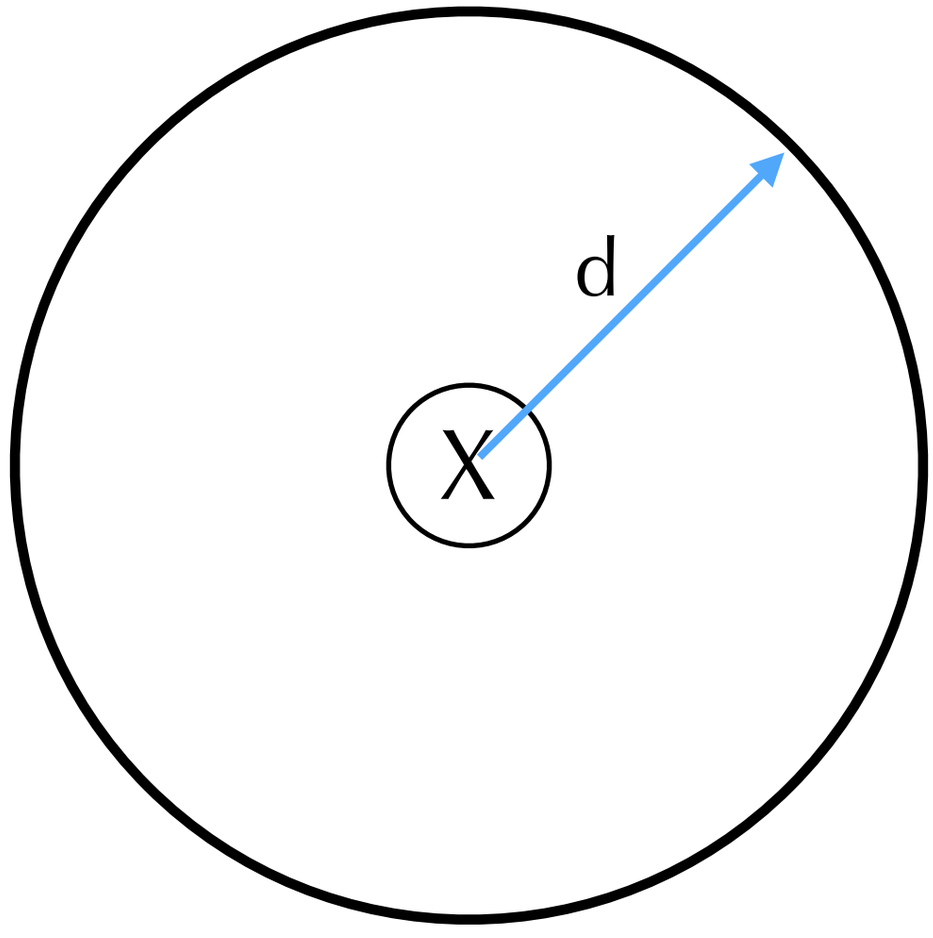

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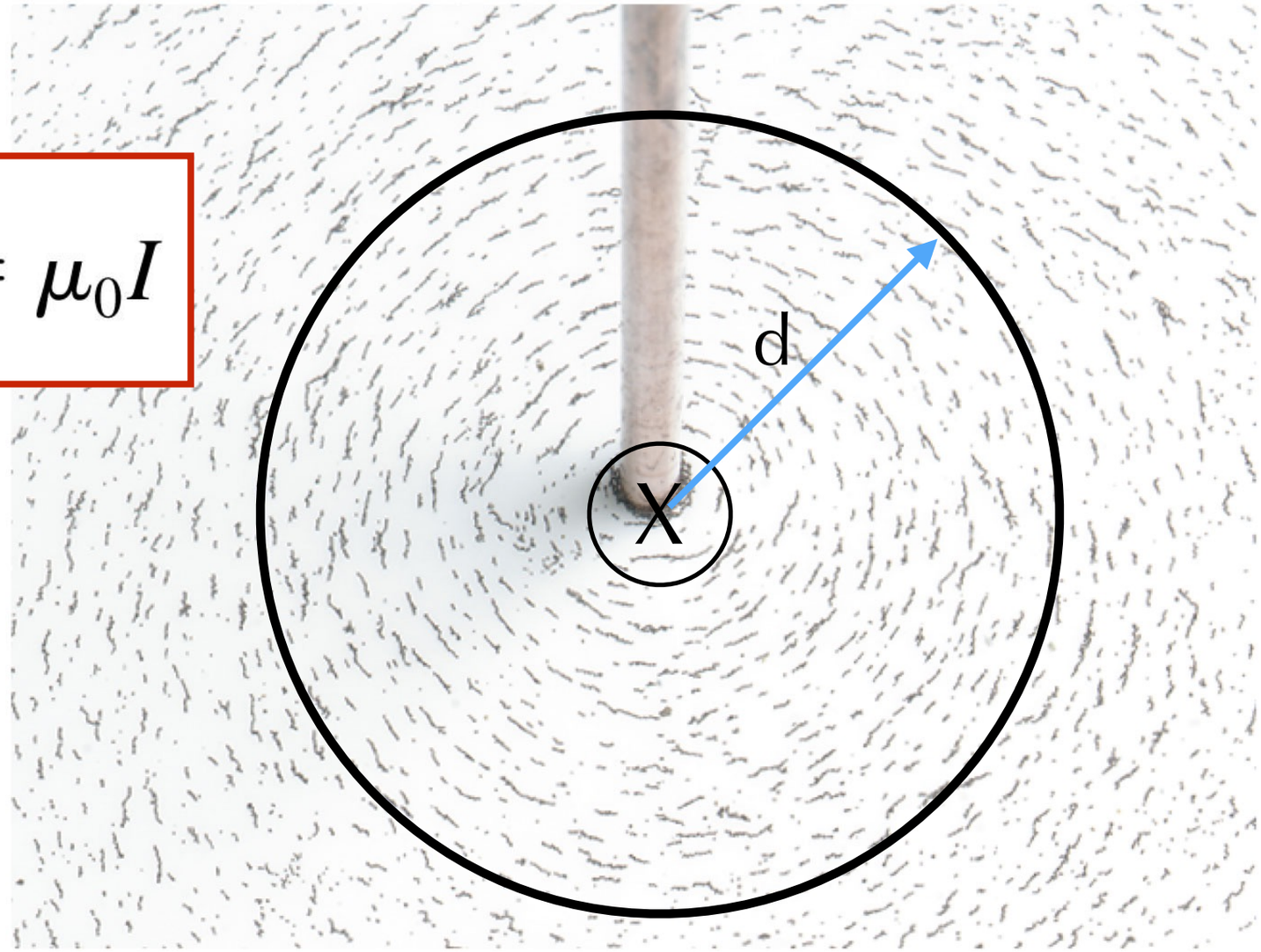


$$\oint \vec{B} \cdot d\vec{s}$$

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

Current I_3 is

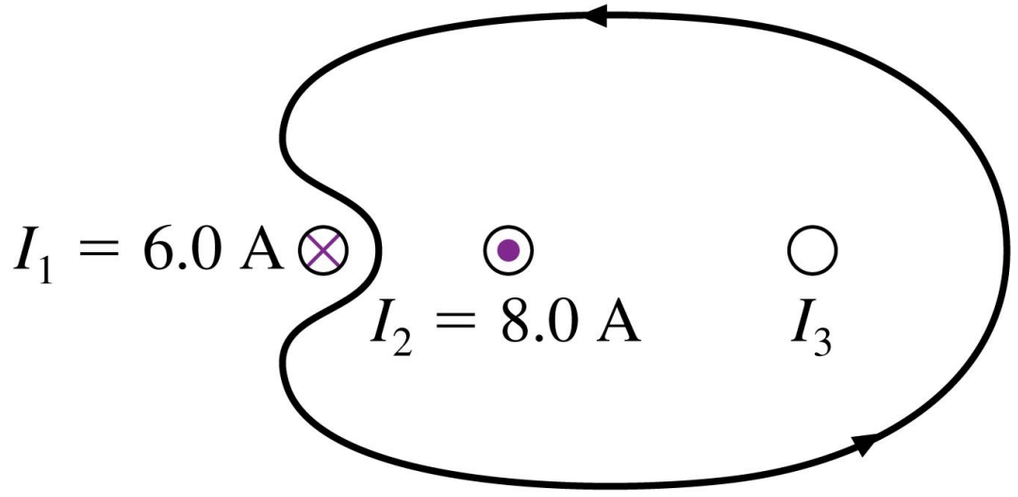
A. 0 A.

B. 1 A out of the screen.

C. 1 A into the screen.

D. 5 A out of the screen.

E. 5 A into the screen.



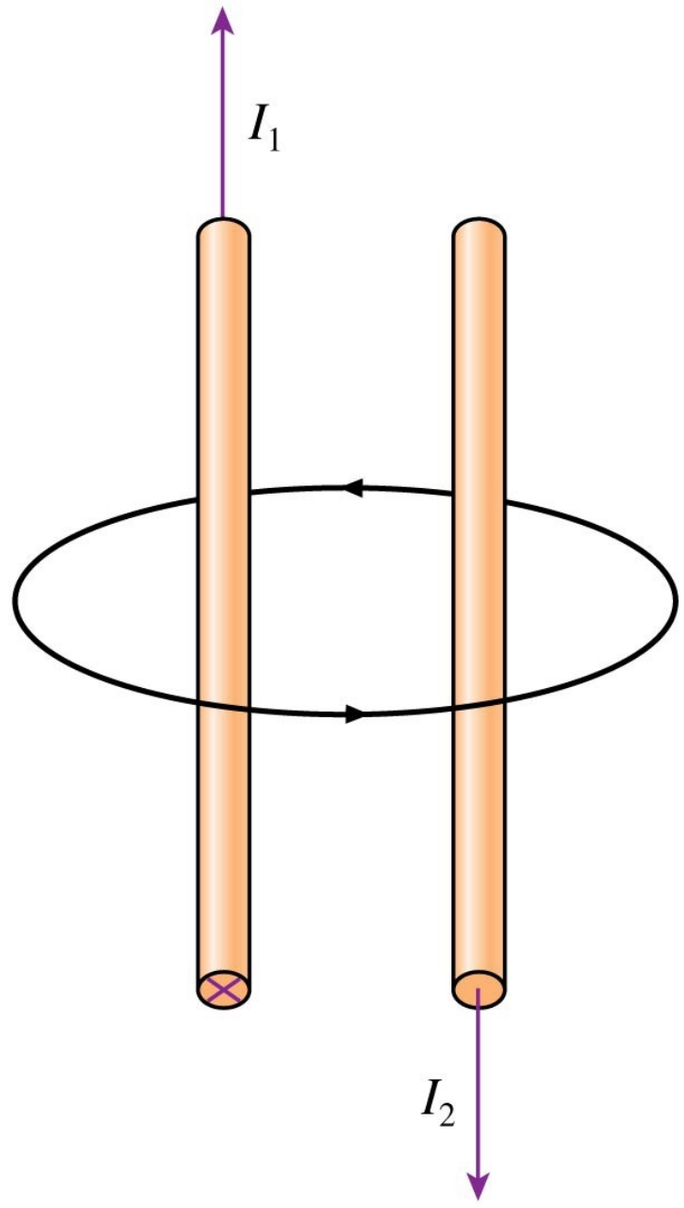
For the path shown,

A. 0.

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

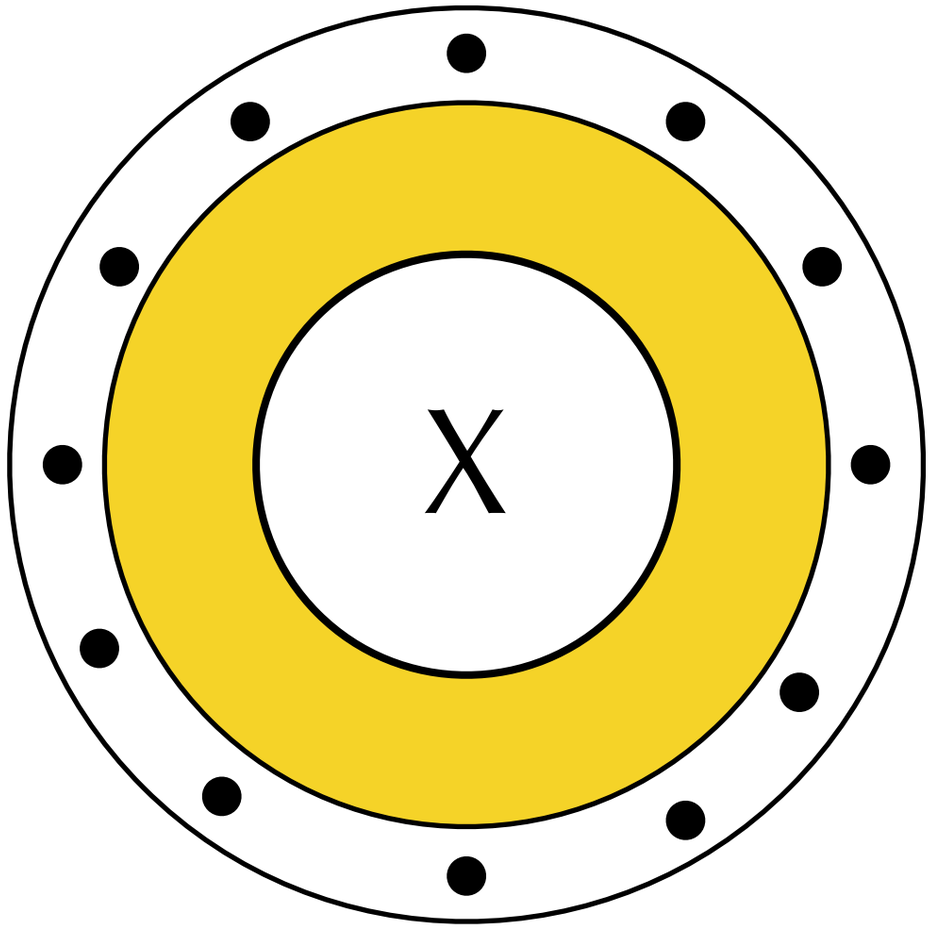
C. $\mu_0(I_2 - I_1)$.

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



Let's use Ampere's law

Find the magnetic field for $r < R_1$



Coaxial cable

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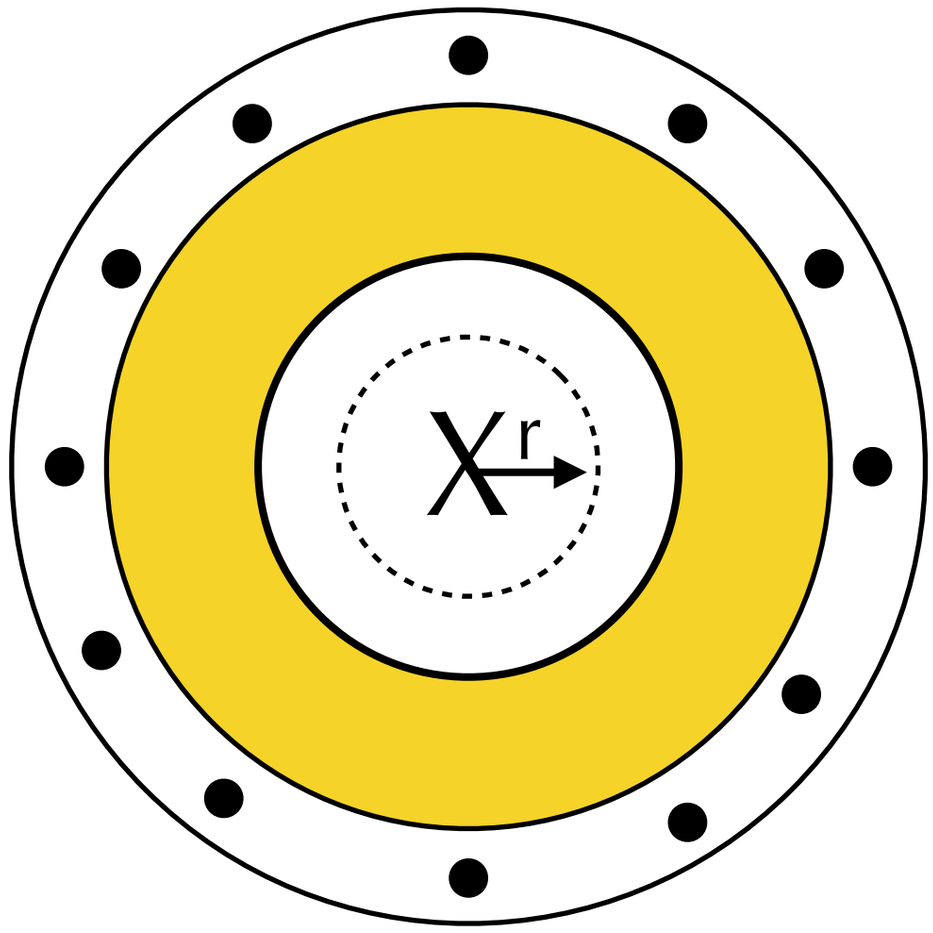

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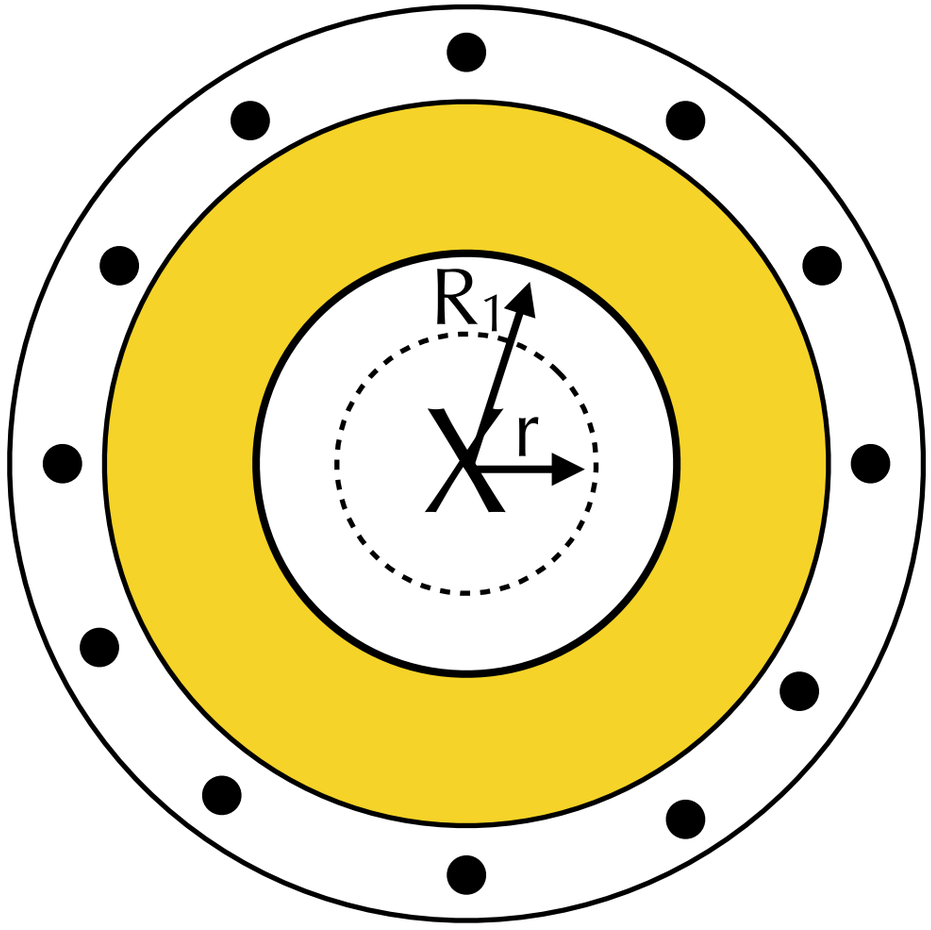

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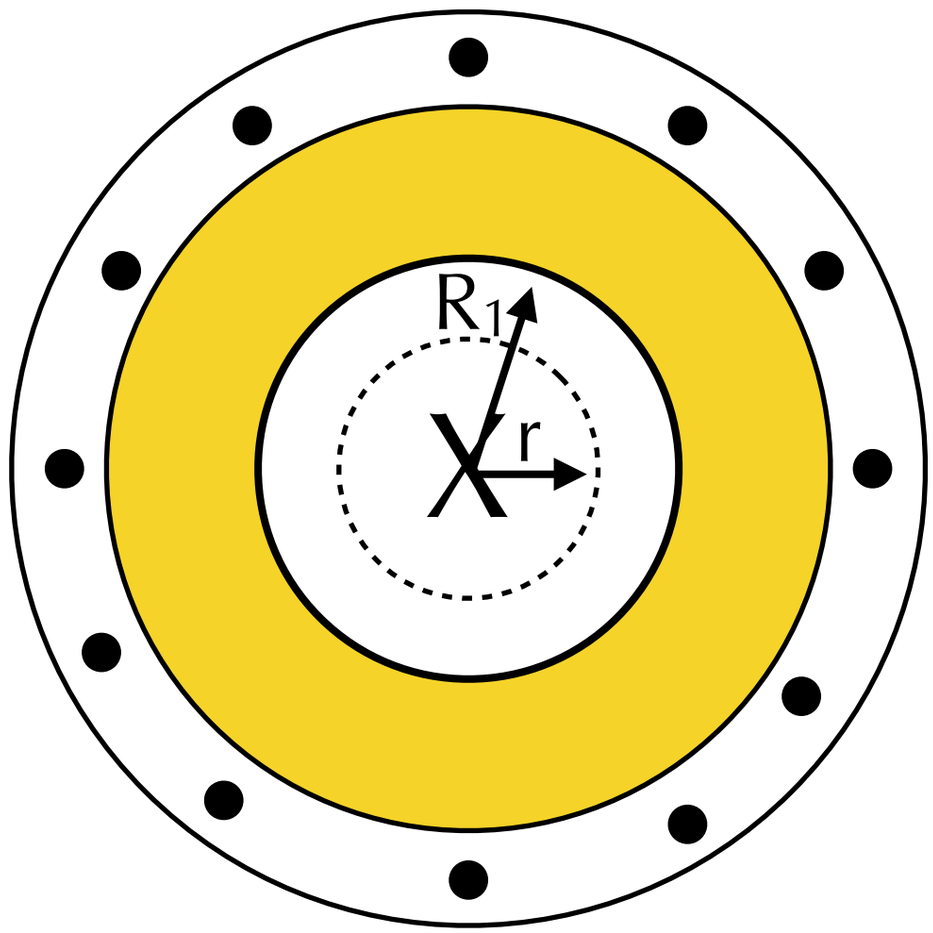

Coaxial cable

$$B2\pi r = \mu_0 I_{\text{in}}$$

$$B2\pi r = \mu_0 \frac{I_{\text{total}}}{\pi R_1^2} \pi r^2$$

$$B2\pi = \mu_0 \frac{I_{\text{total}}}{R_1^2} r$$

$$B = \mu_0 \frac{I_{\text{total}}}{2\pi R_1^2} r$$

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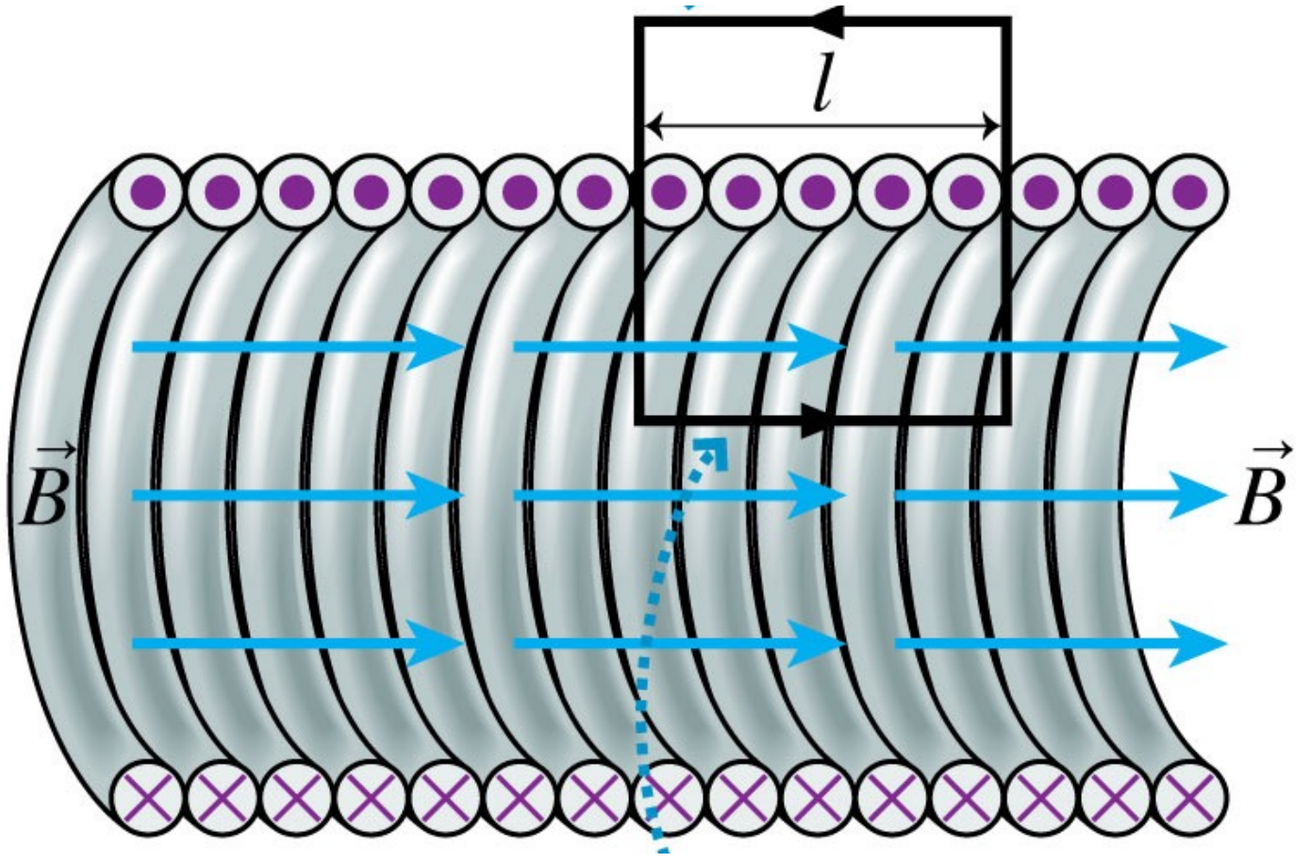
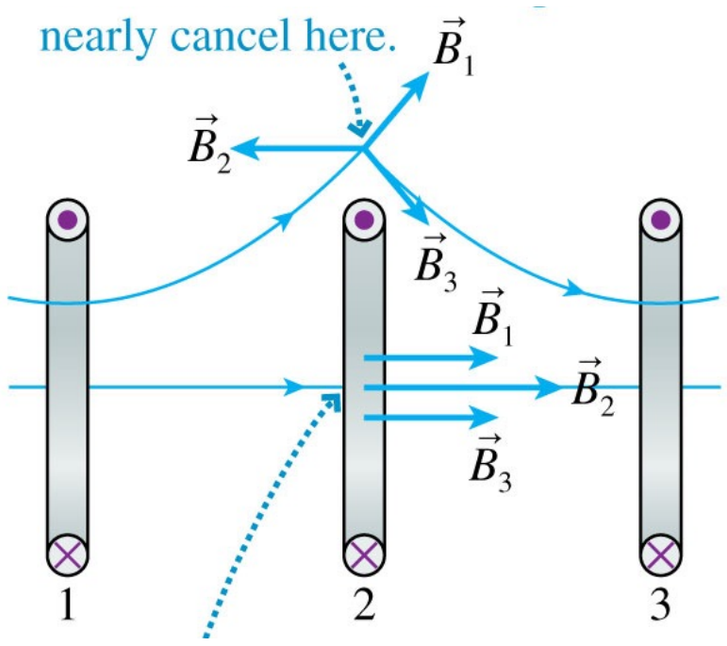


a) What can you say about the B field along the path shown?
b) Can you simplify the integral on the left hand side?
c) How much current is flowing through this loop?



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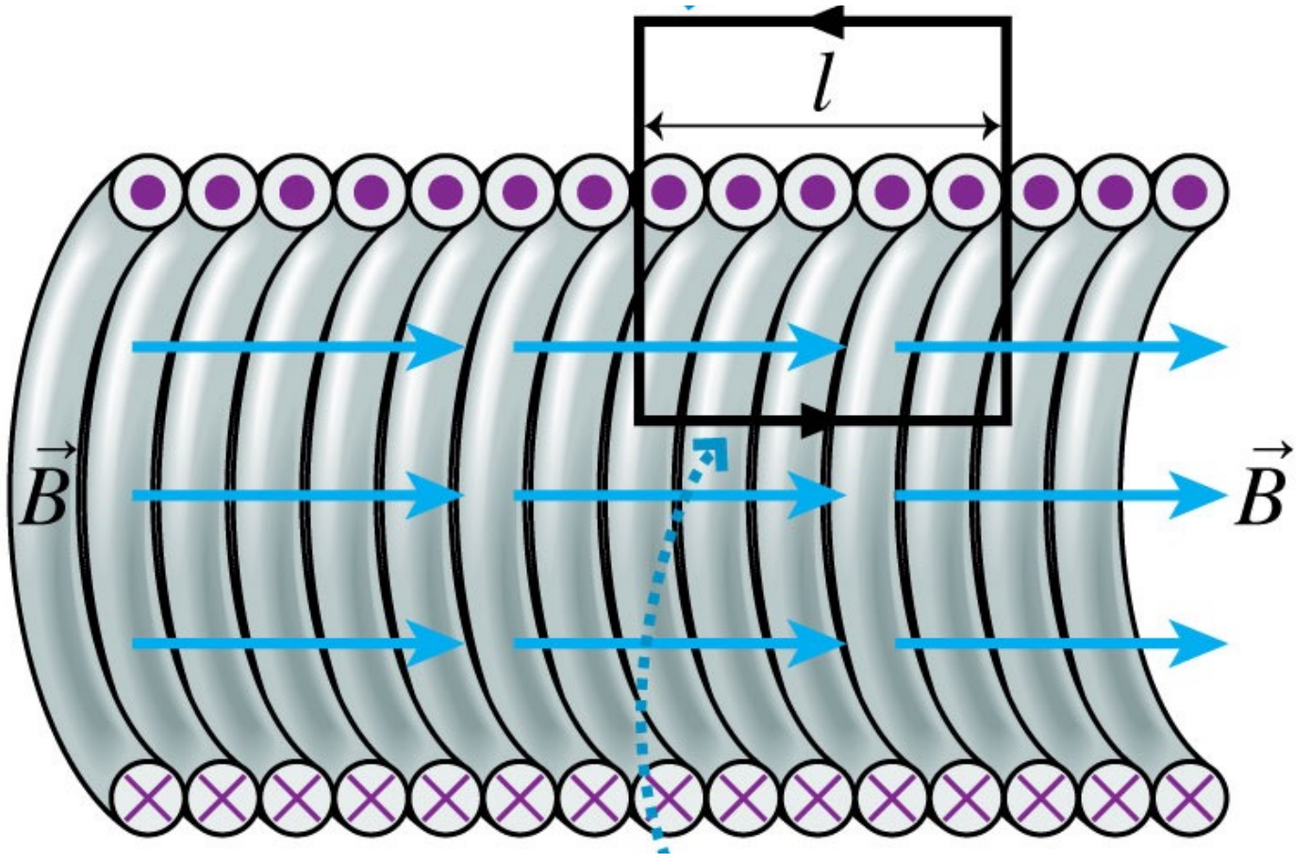

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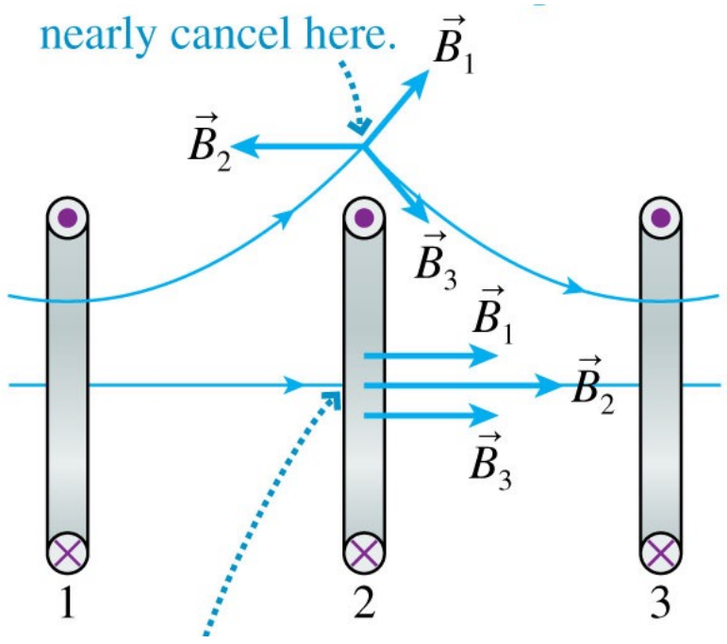

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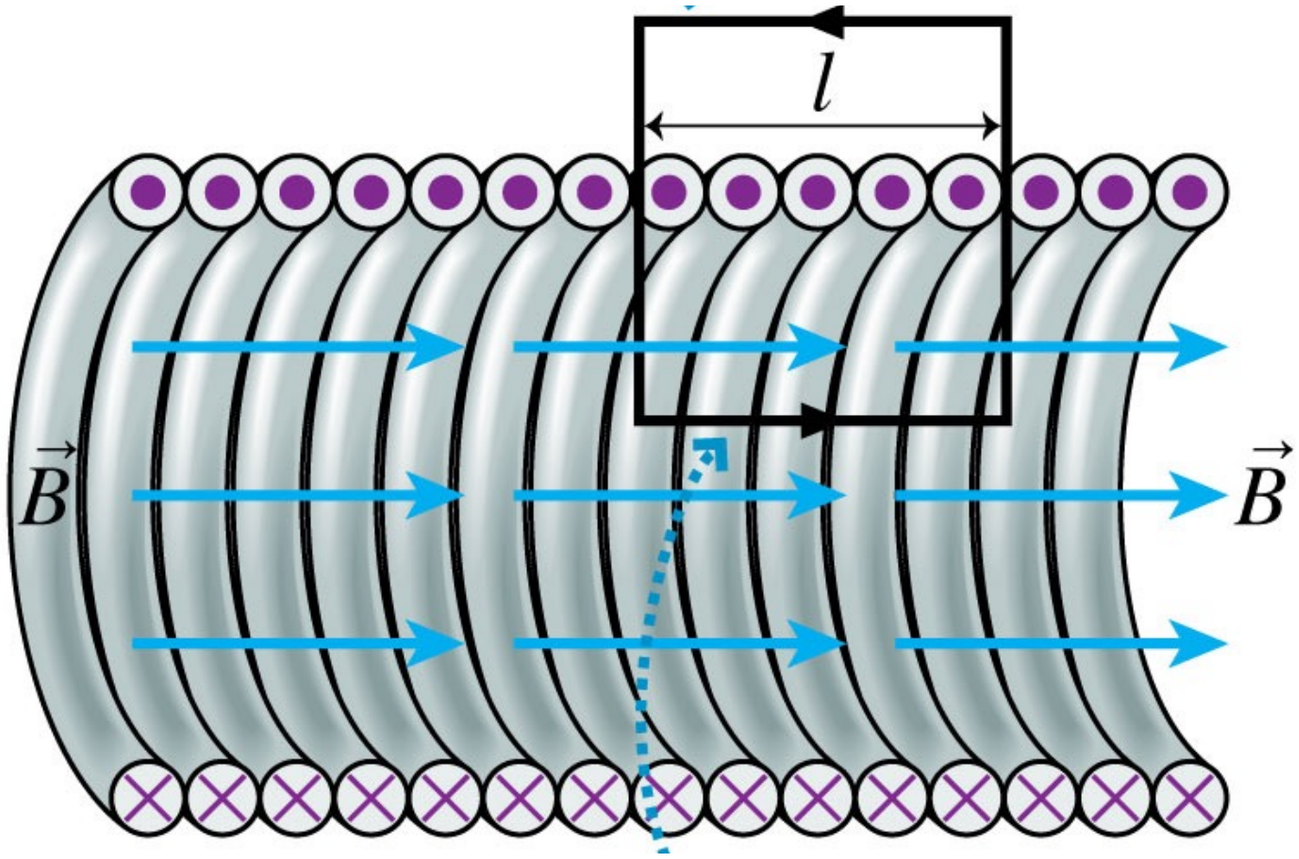

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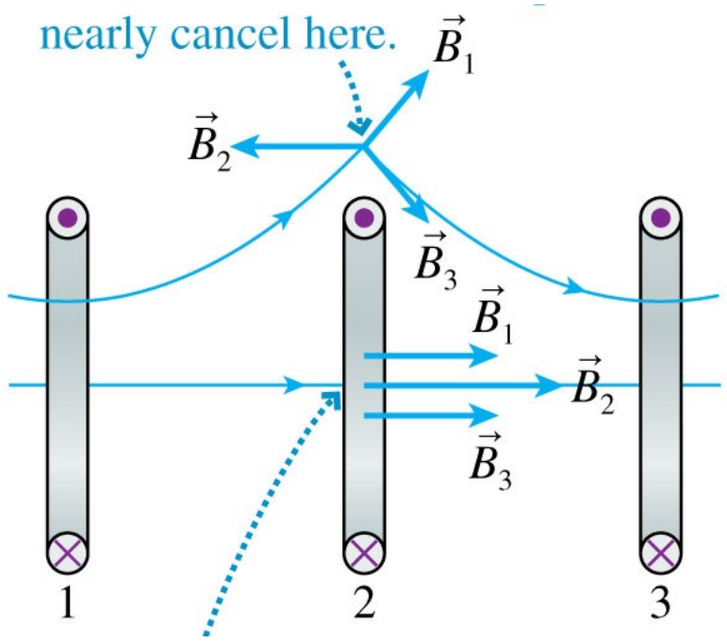


$$B = \frac{\mu_0 N I}{l} = \mu_0 n I$$

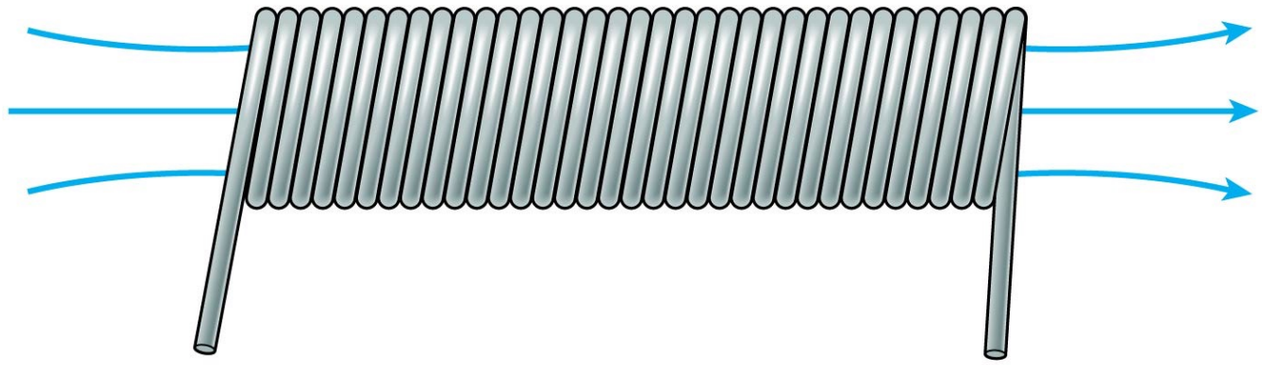
Quiz Question

The current in this solenoid

A. Enters on the left, leaves on the right.

B. Enters on the right, leaves on the left.

C. Either A or B would produce this field.



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?

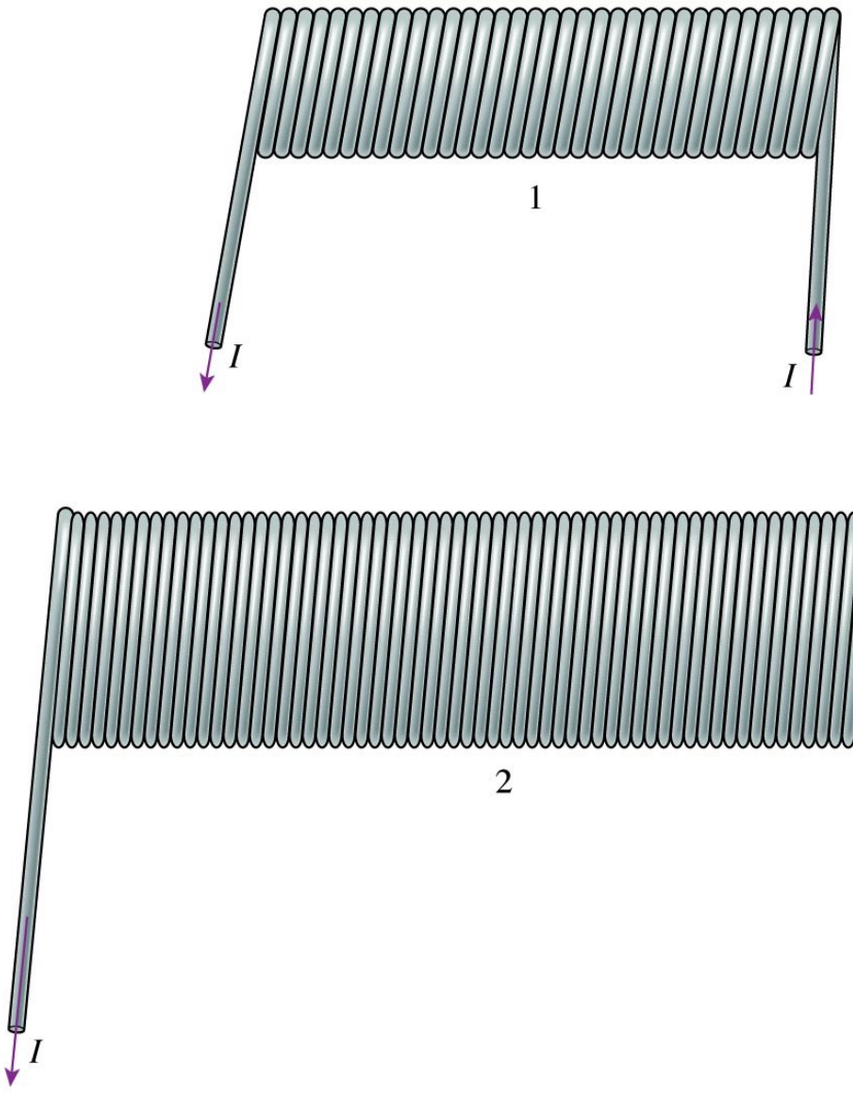
A. $B_2 = B_1/4$.

B. $B_2 = B_1/2$.

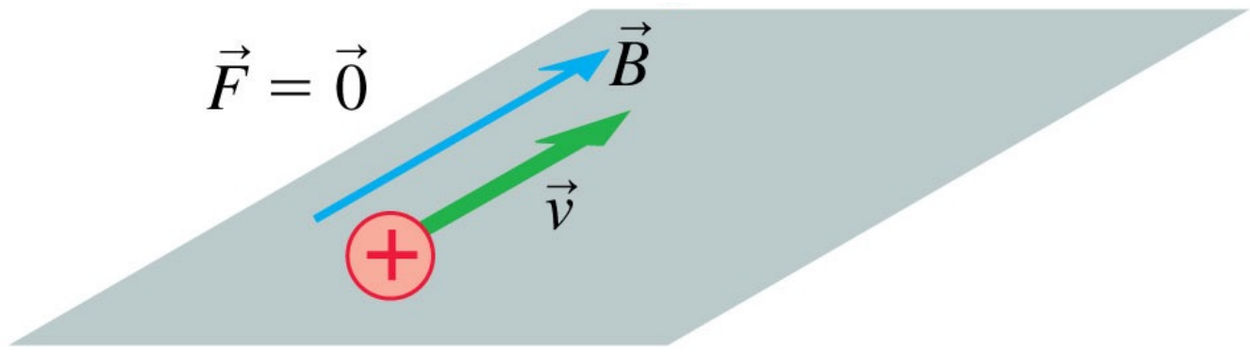
C. $B_2 = 2B_1$.

D. $B_2 = B_1$.

E. $B_2 = 4B_1$.



Magnetic force on moving charge



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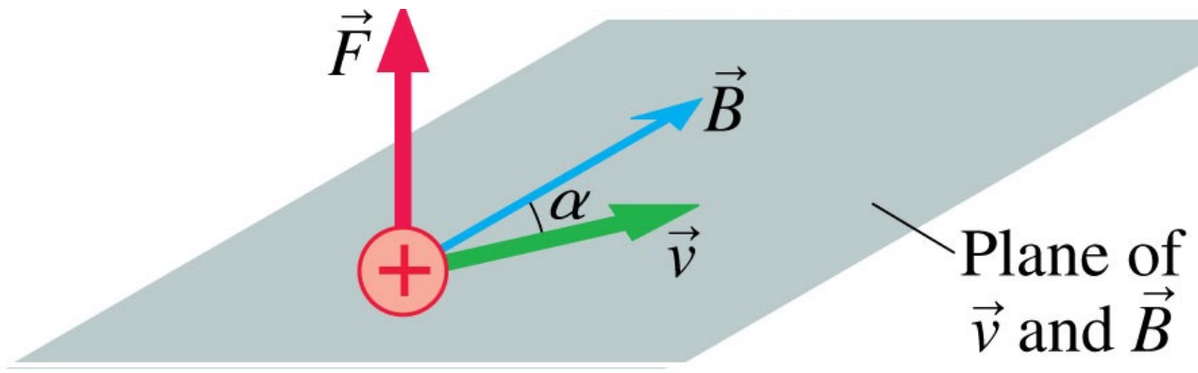

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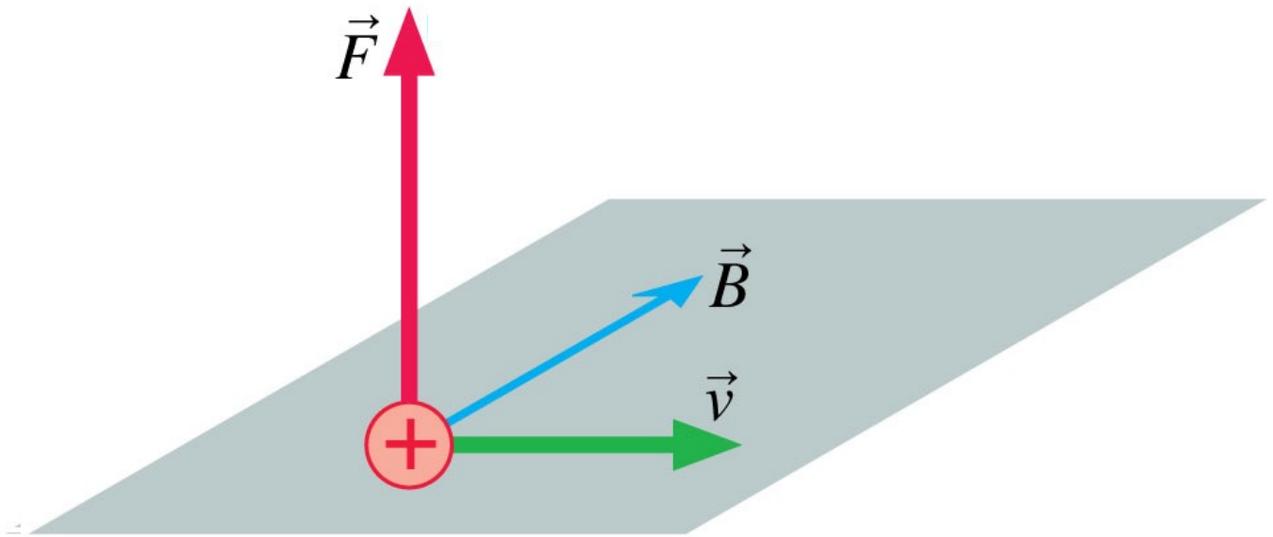

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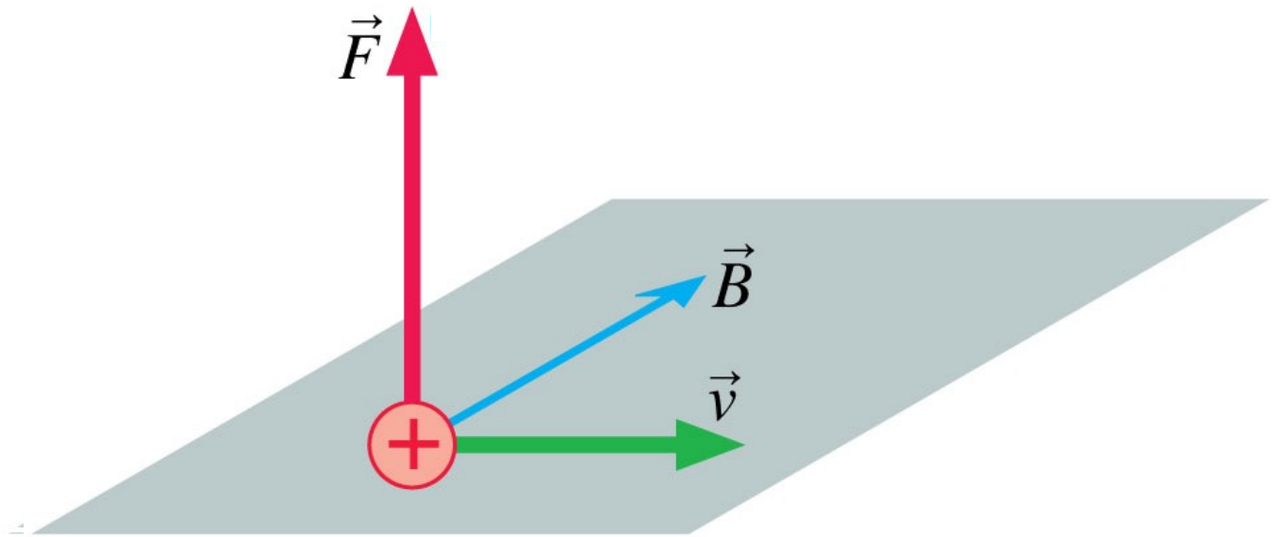
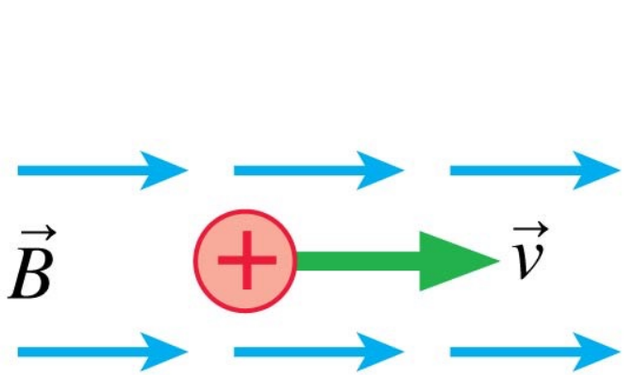
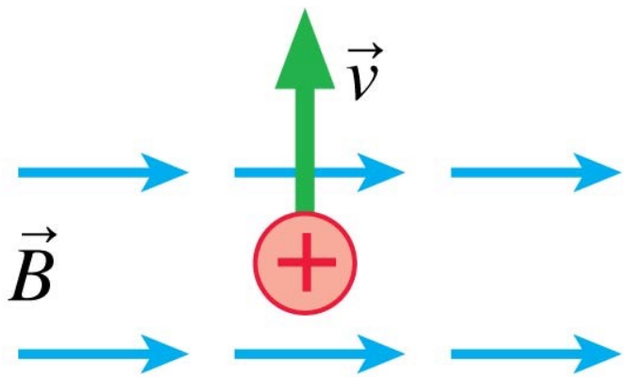
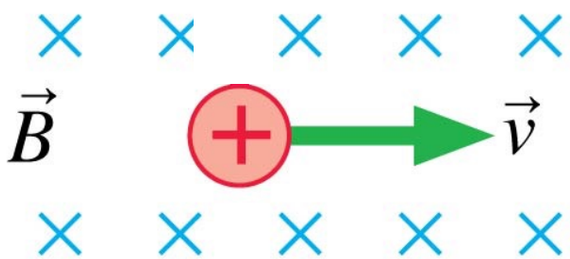


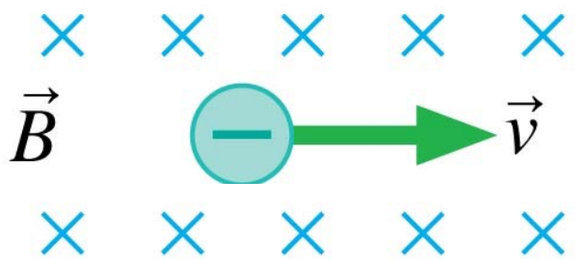
$$\vec{F} = q\vec{v} \times \vec{B}$$

Tell your neighbor what the direction of the magnetic force is









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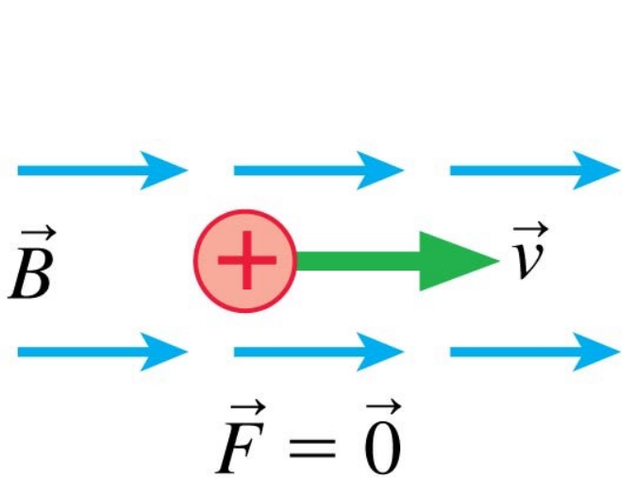

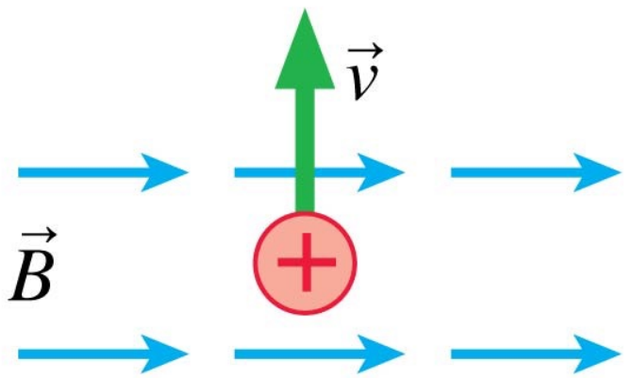

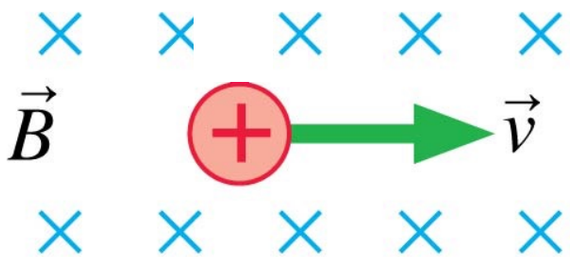

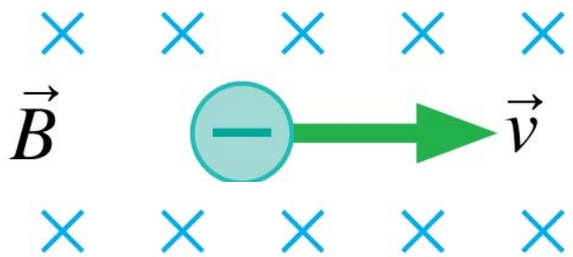

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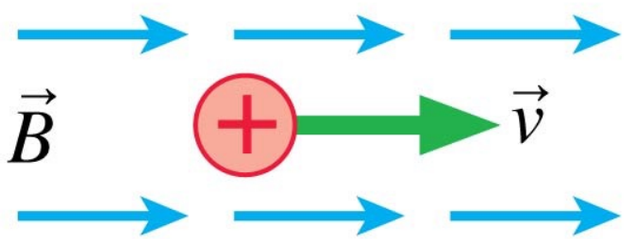

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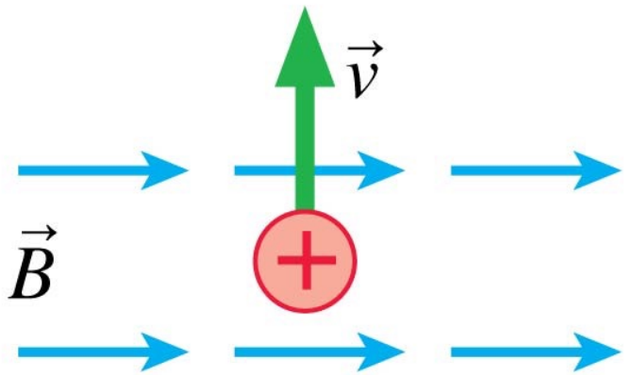
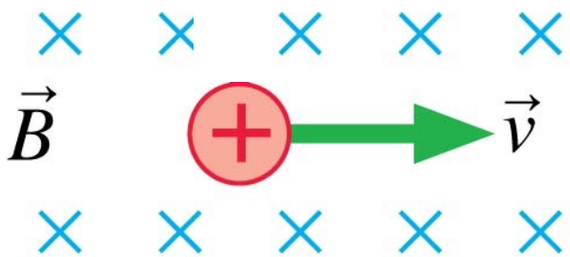
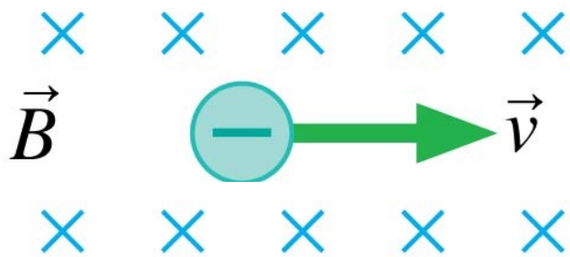


$\vec{F}$ pointing into page





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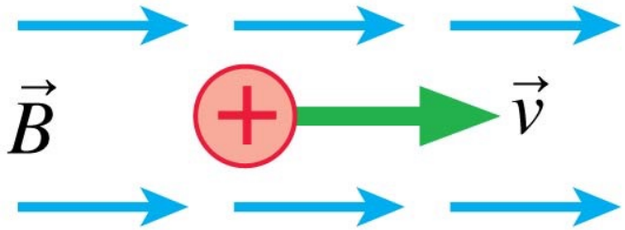

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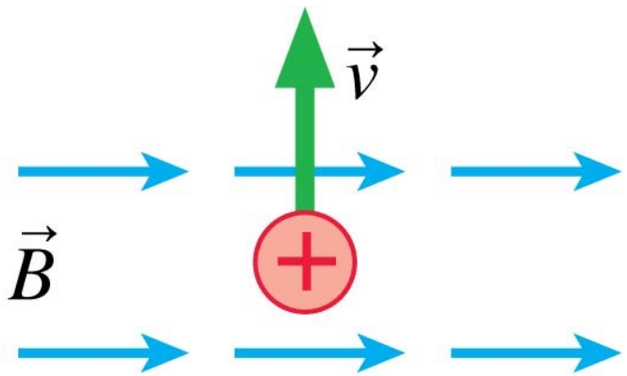
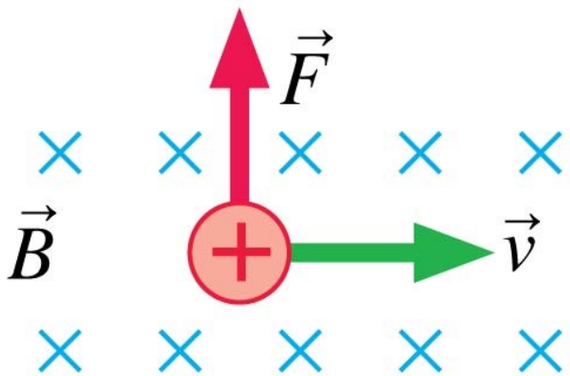
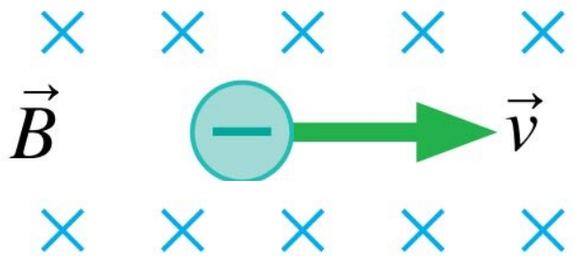
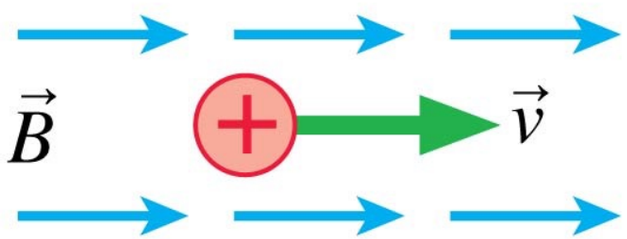


$\vec{F}$ pointing into page

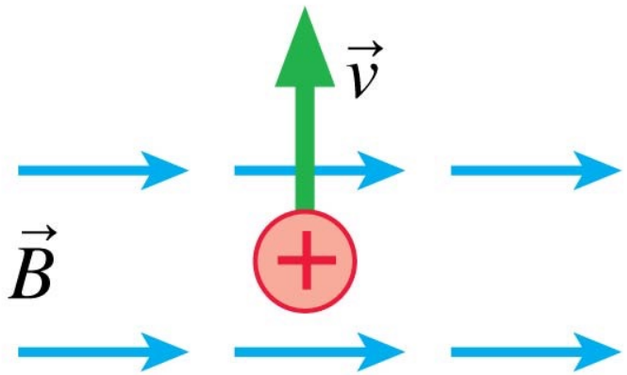




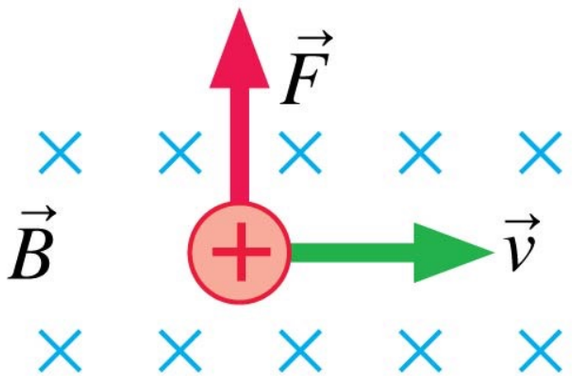
Tell your neighbor what the direction of the magnetic force is

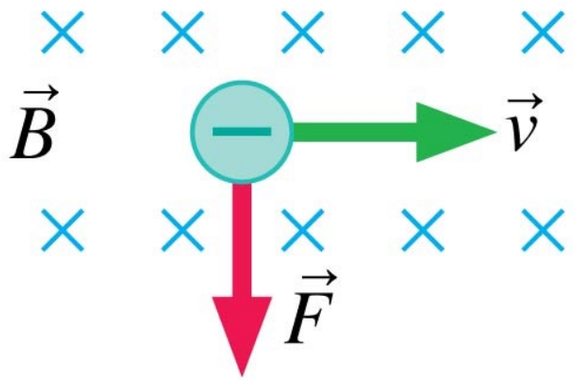


$\vec{F} = \vec{0}$



$\vec{F}$ pointing into page

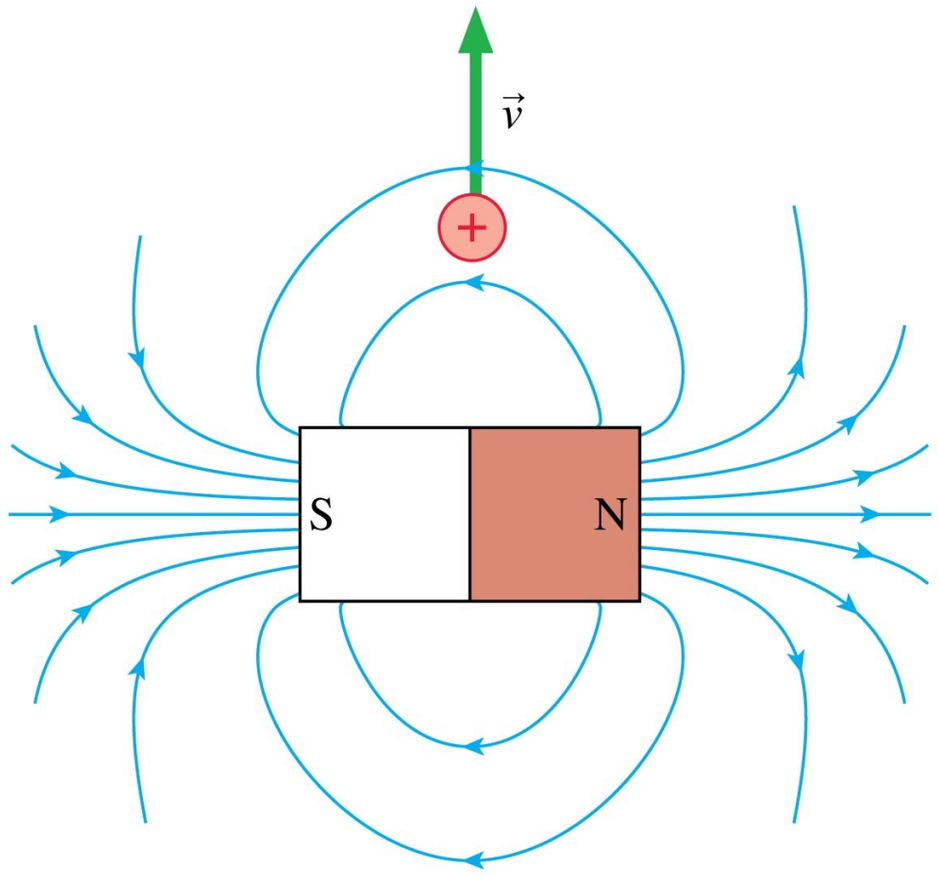




Quiz Question

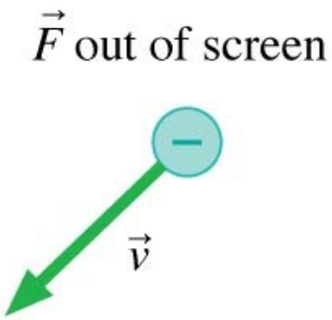
The direction of the magnetic force on the proton is

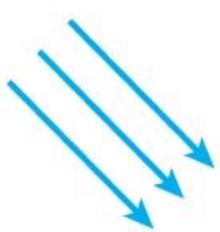
A. Out of the screen.
B. To the left.
C. Into the screen.
D. To the right.
E. The magnetic force is zero.



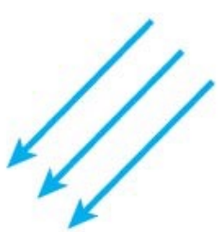
Quiz Question

Which magnetic field causes the observed force?

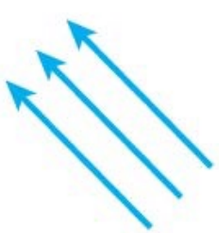




A



B



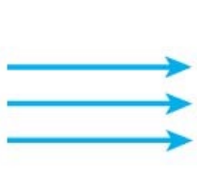
C

D

E

Quiz Question

Which magnetic field (if it's the correct strength) allows the electron to pass through the charged electrodes without being deflected?



A

B

C

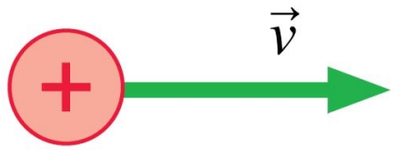
D

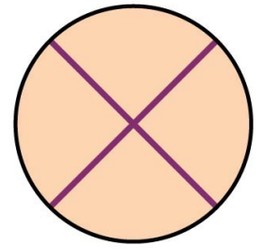
E

Quiz Question

A proton is shot straight at the center of a long, straight wire carrying current into the screen. The proton will

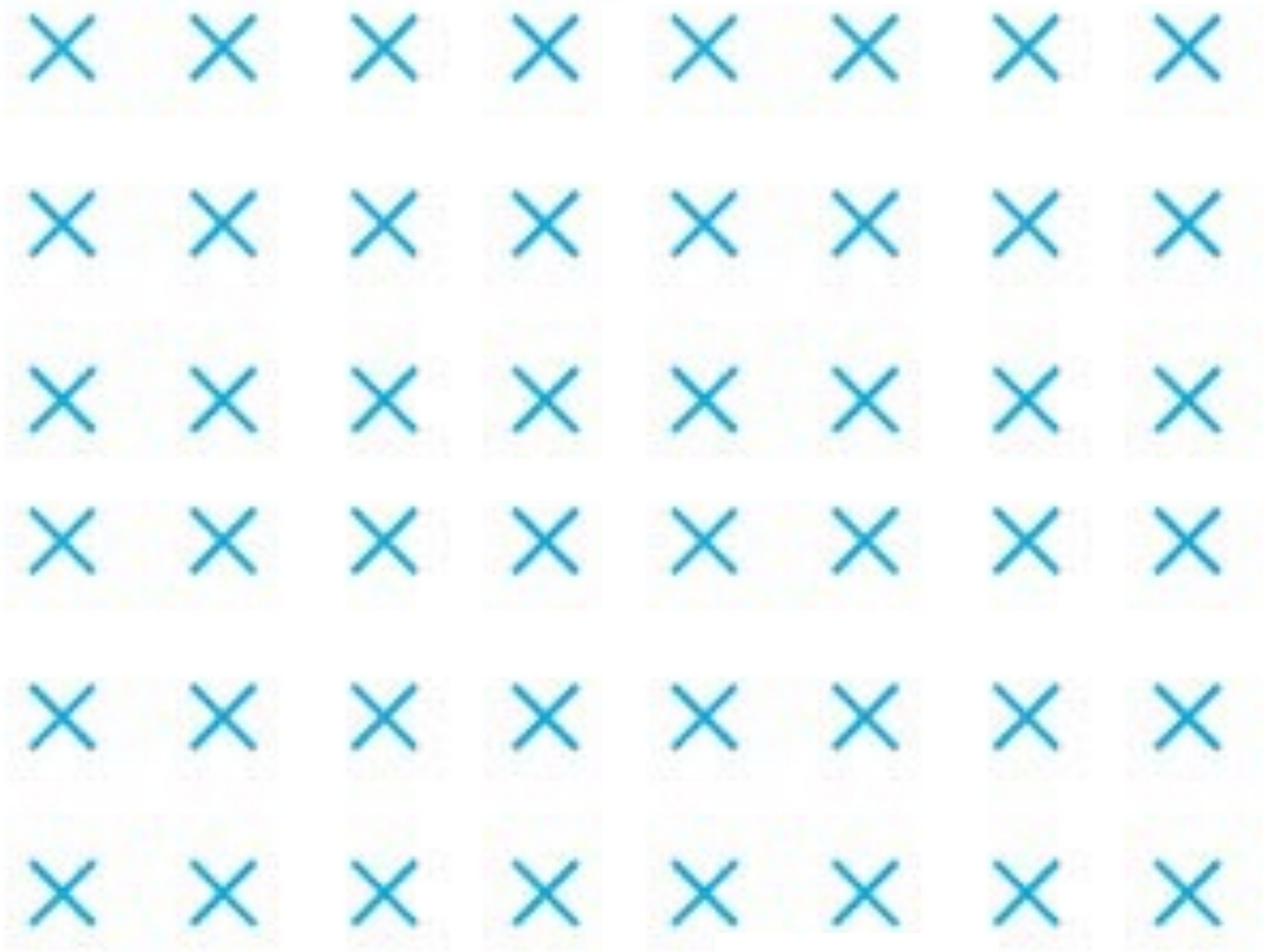
A. Go straight into the wire.
B. Hit the wire in front of the screen.
C. Hit the wire behind the screen.
D. Be deflected over the wire.
E. Be deflected under the wire.



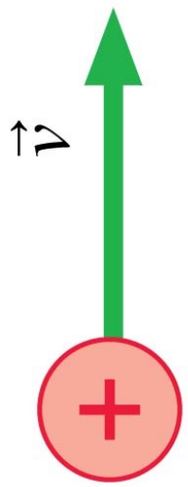


Long wire into screen

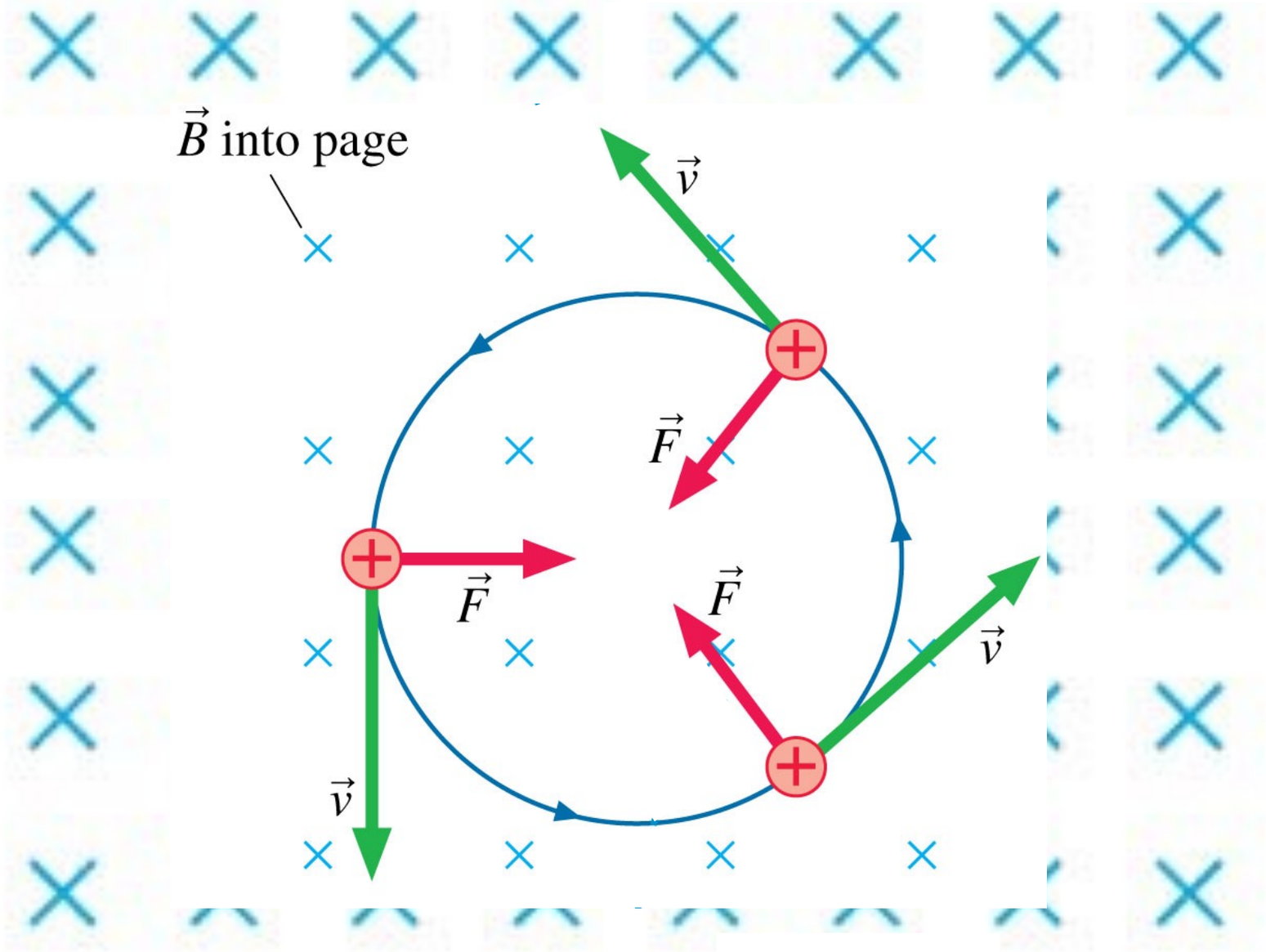
Cyclotron



What will the motion of the particle be after entering the field?



Cyclotron



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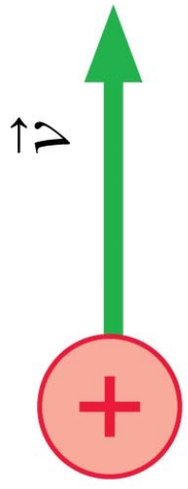
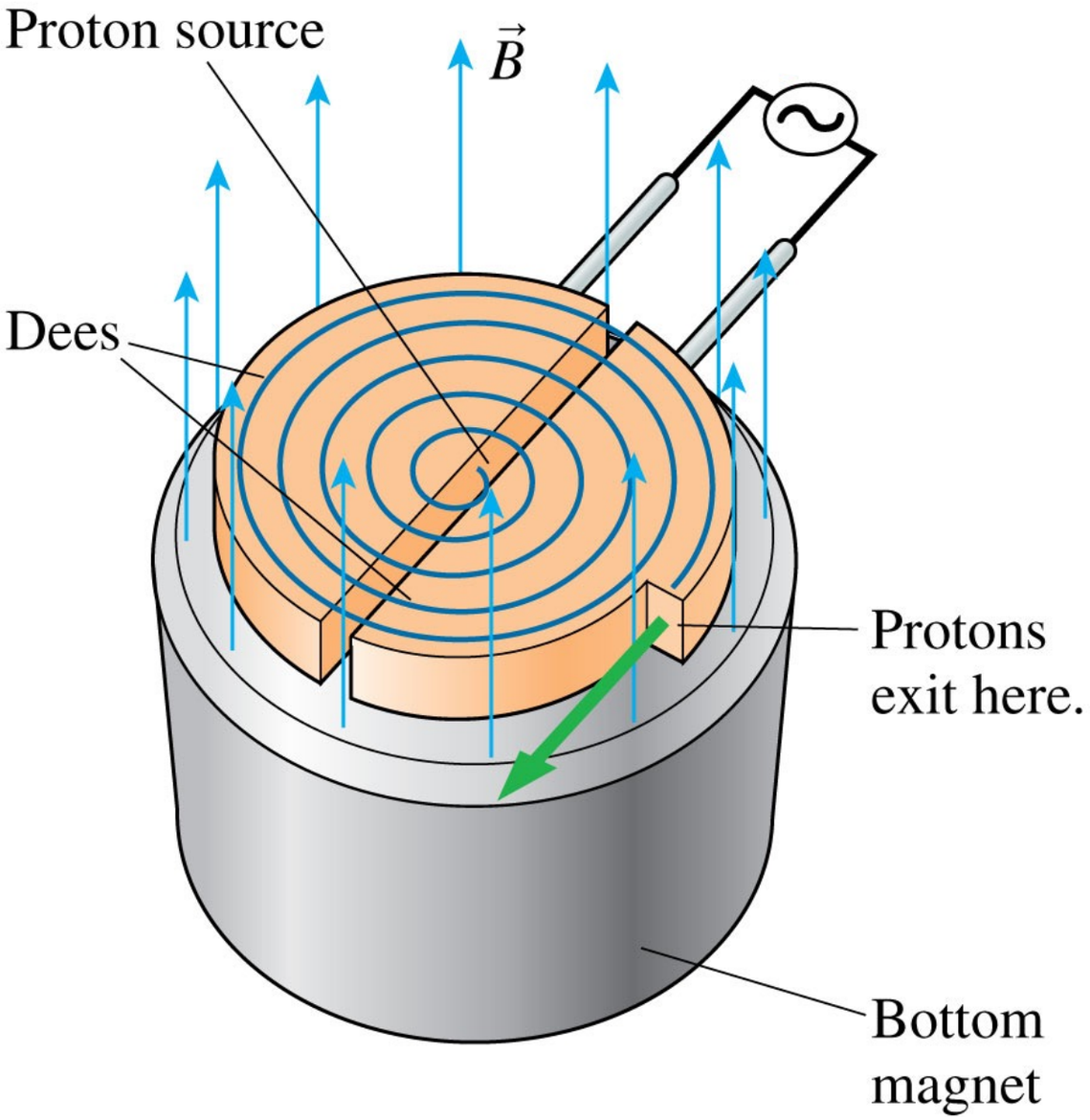
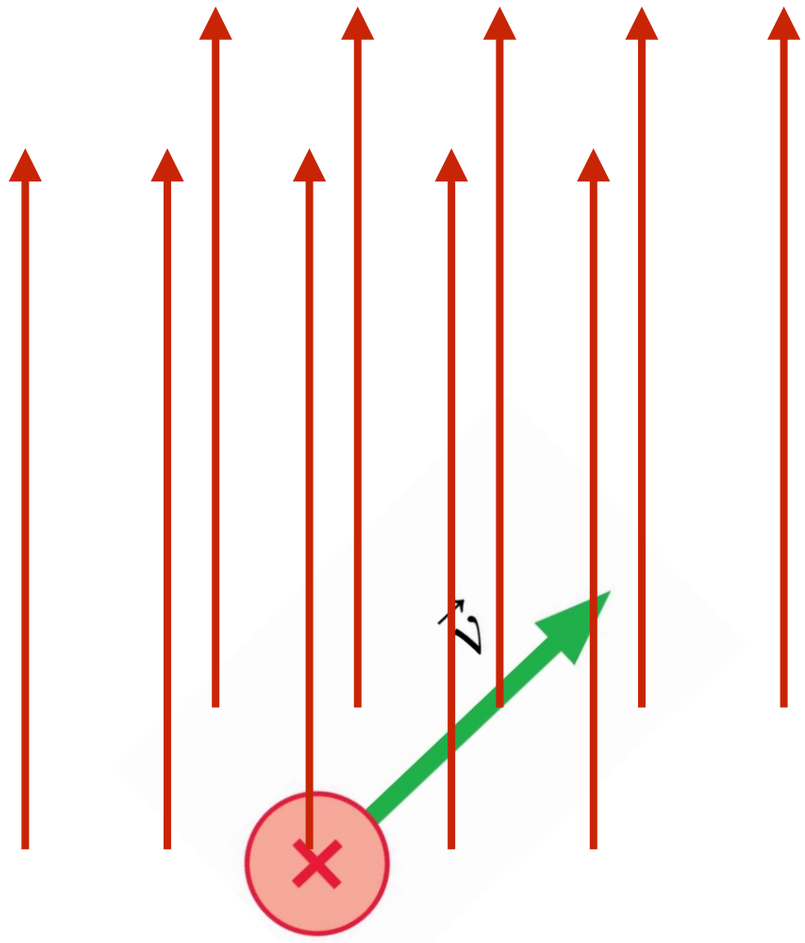
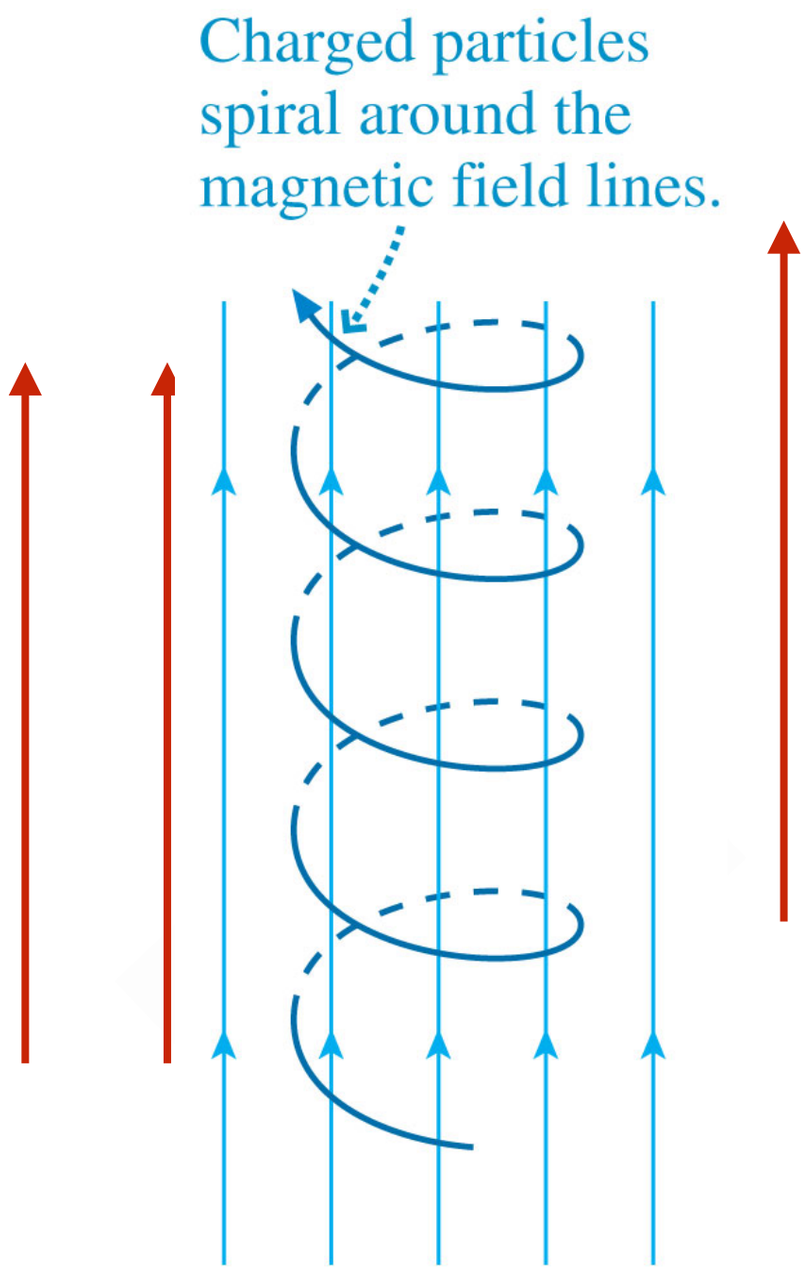


Cyclotron





If I now give the proton a component of velocity in the z direction, what will the motion look like?



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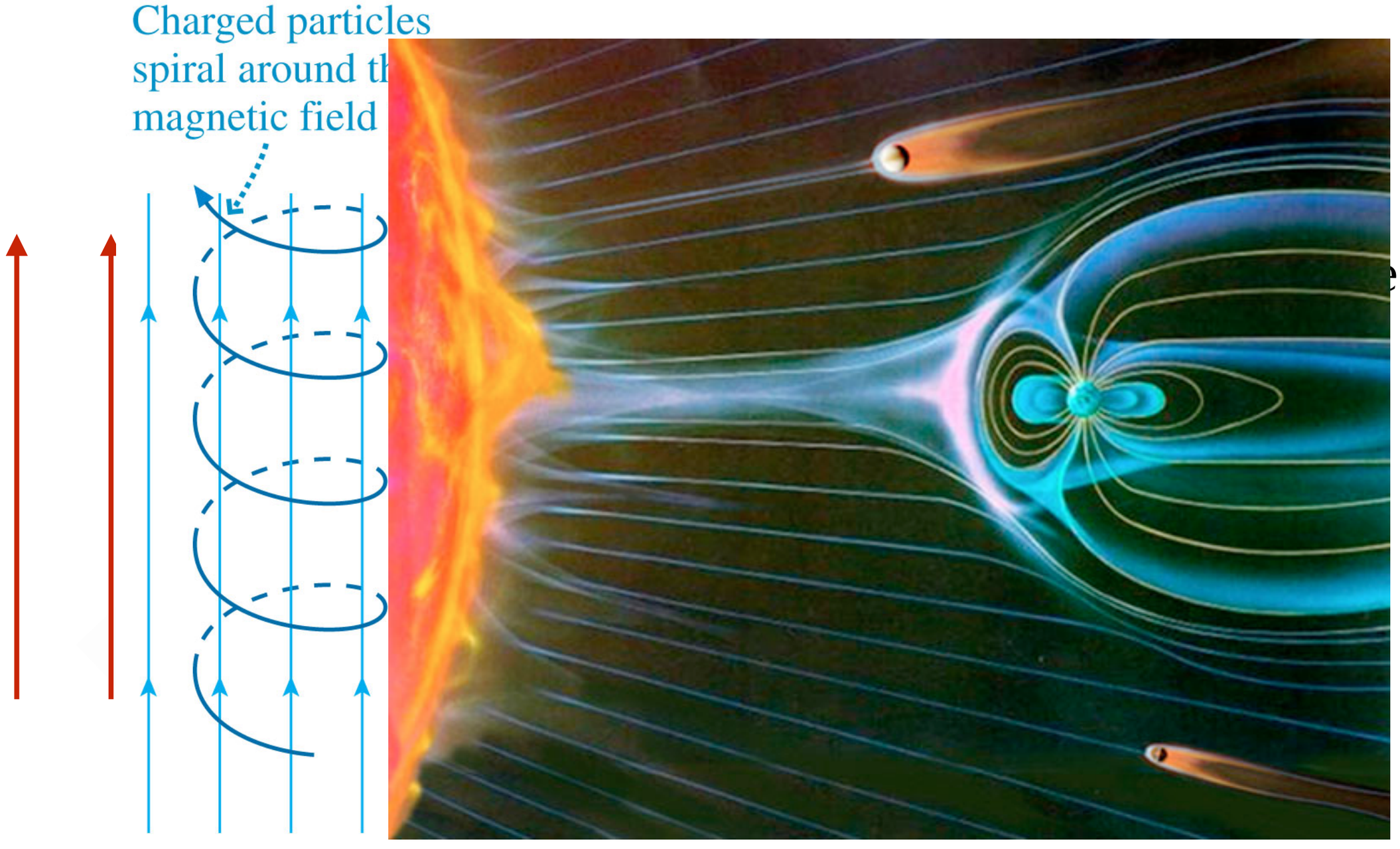
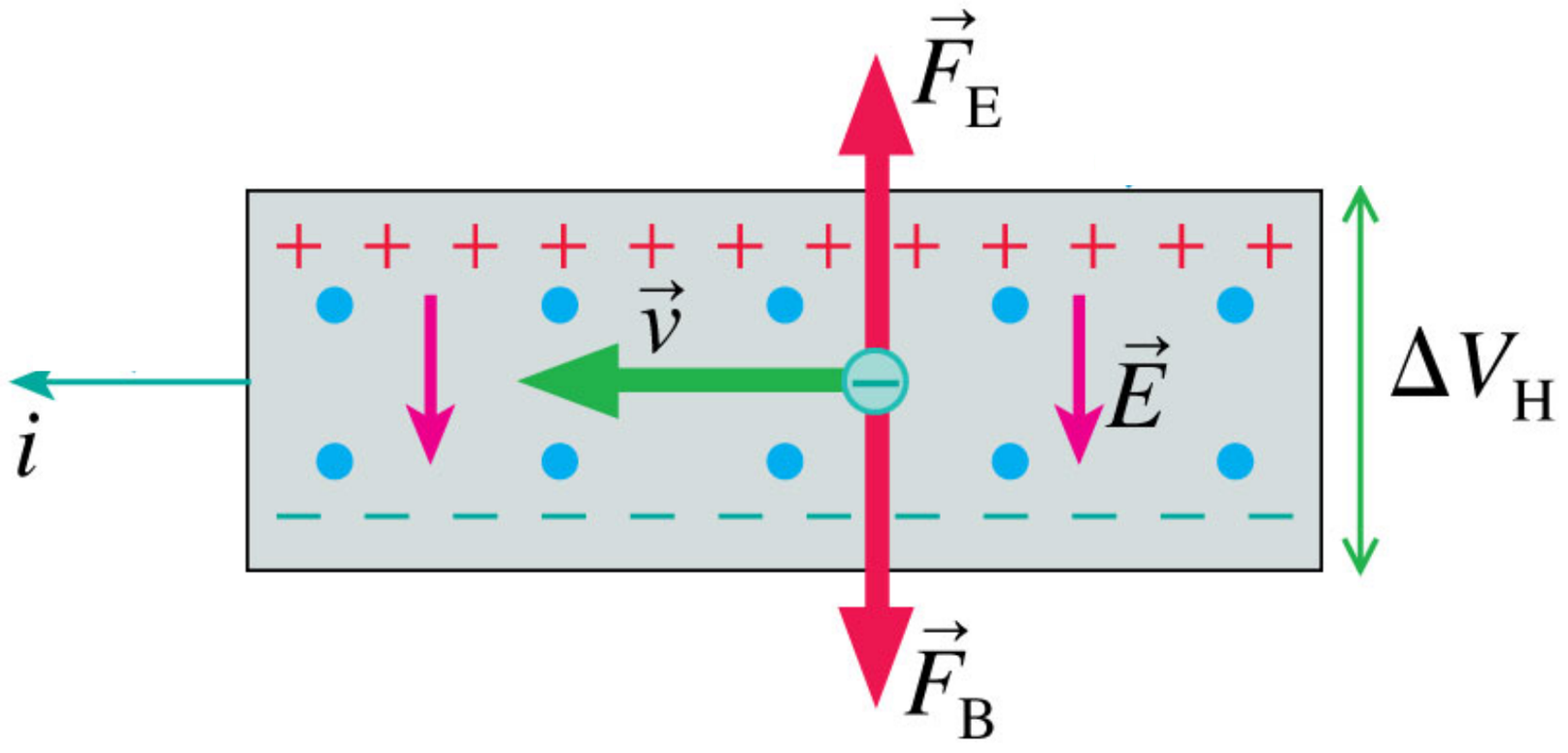

Charged particles
spiral around th
magnetic field

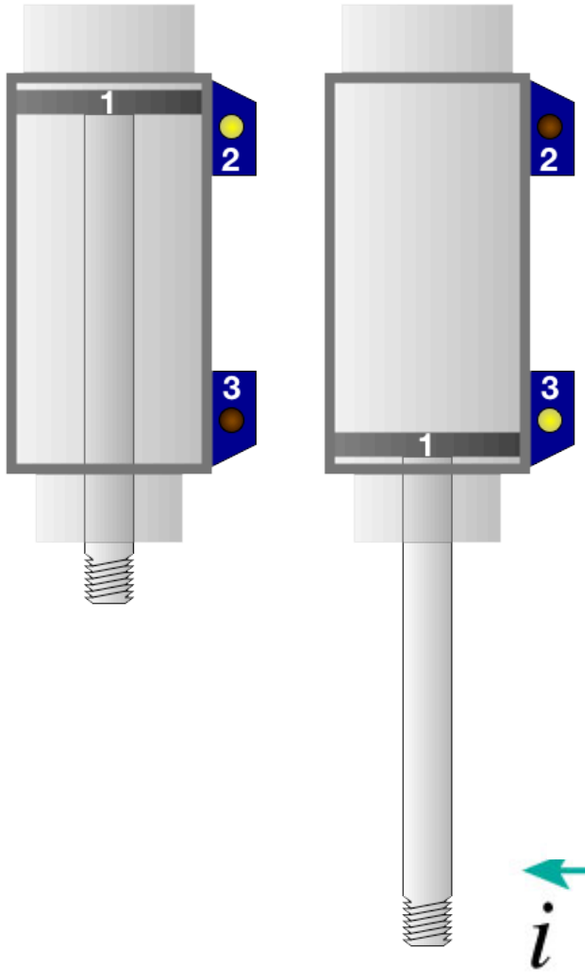
The Hall Effect

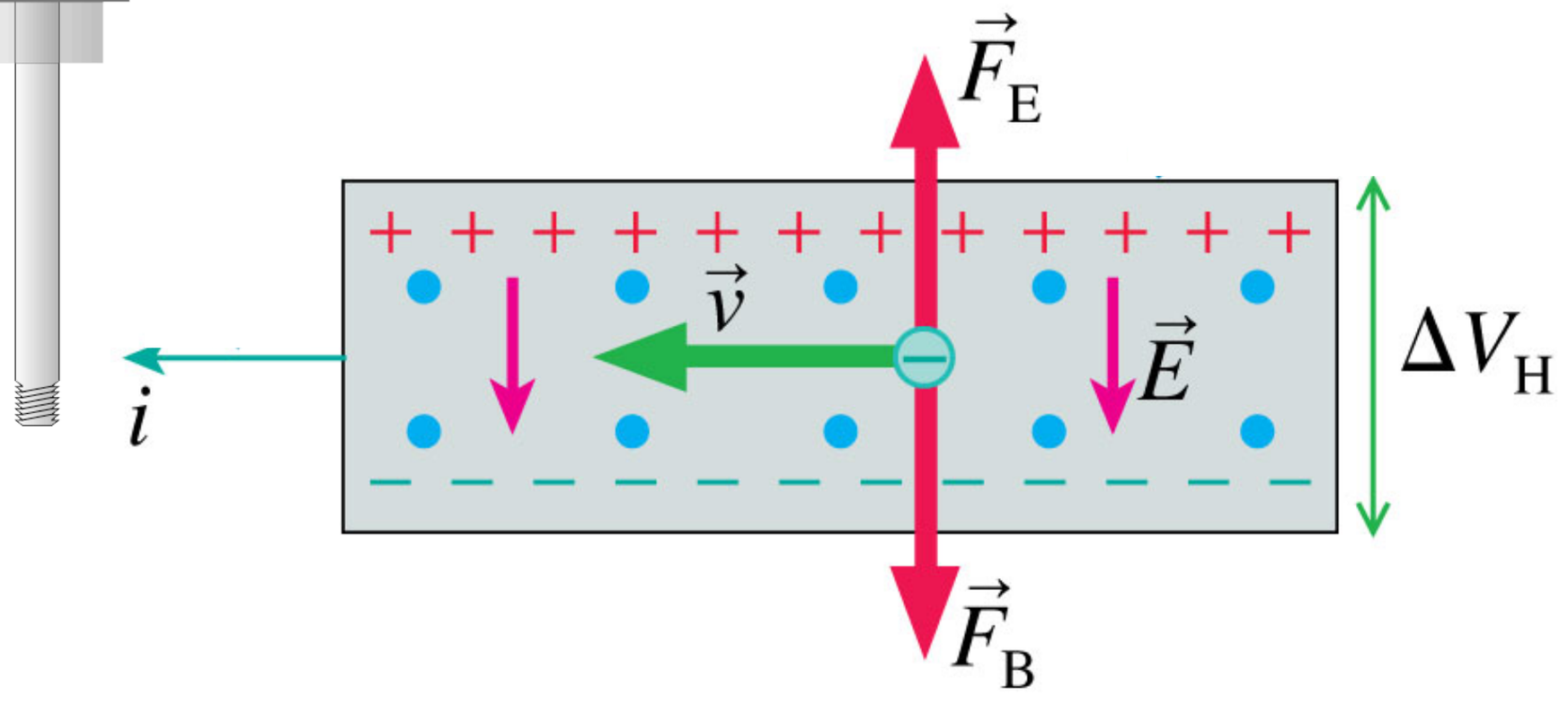


video demo

$$\Delta V_H = \frac{IB}{tne}$$

The Hall Effect

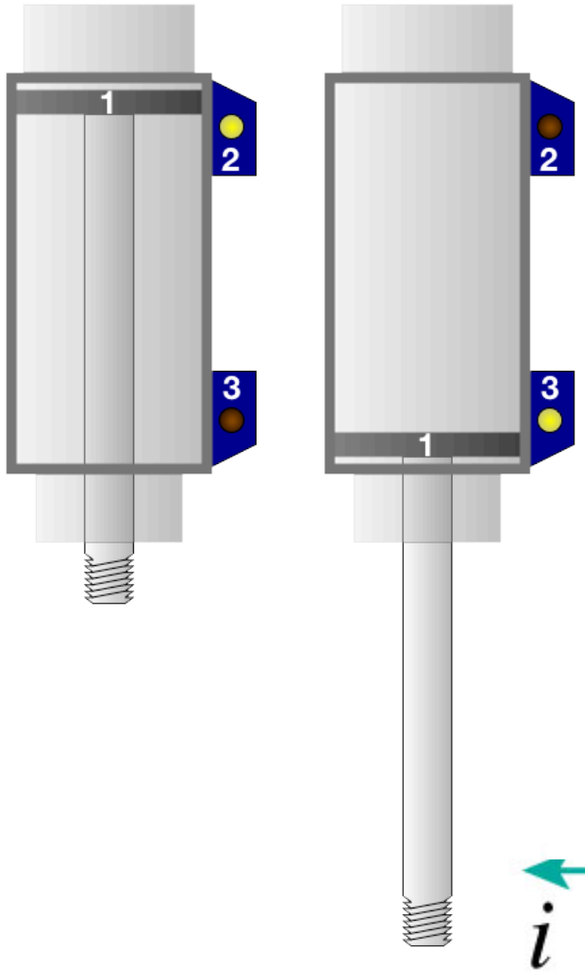


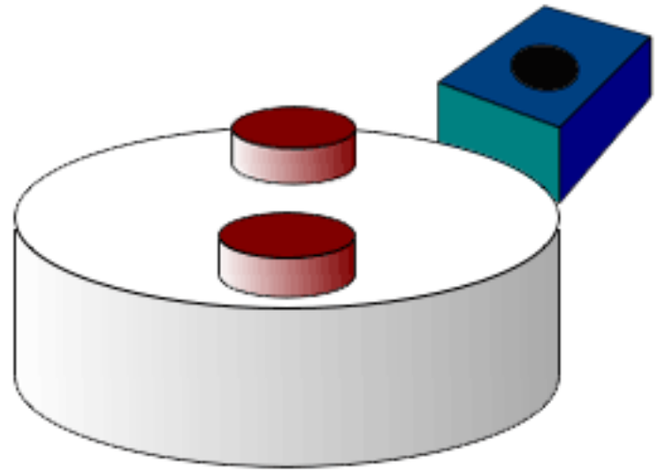


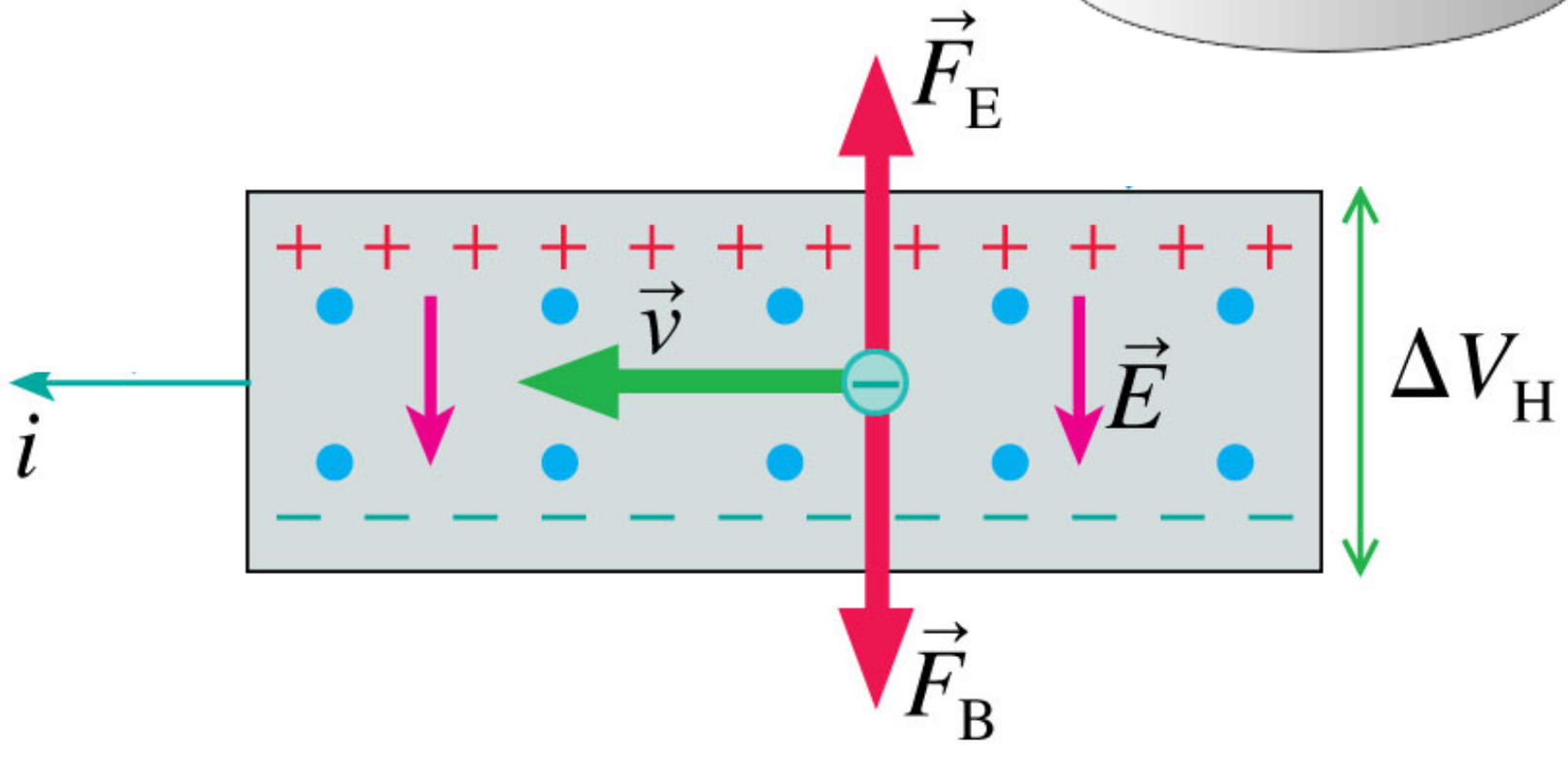
video demo

$$\Delta V_{\mathrm{H}} = \frac{IB}{tne}$$

The Hall Effect







video demo

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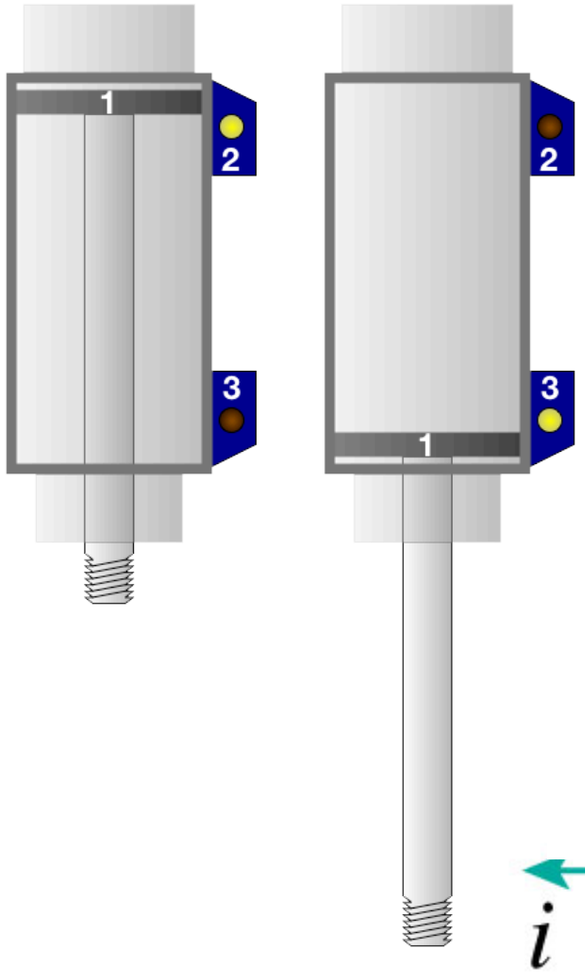
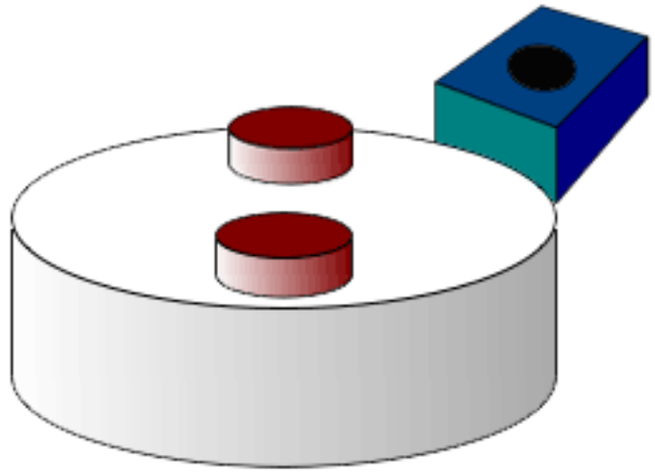
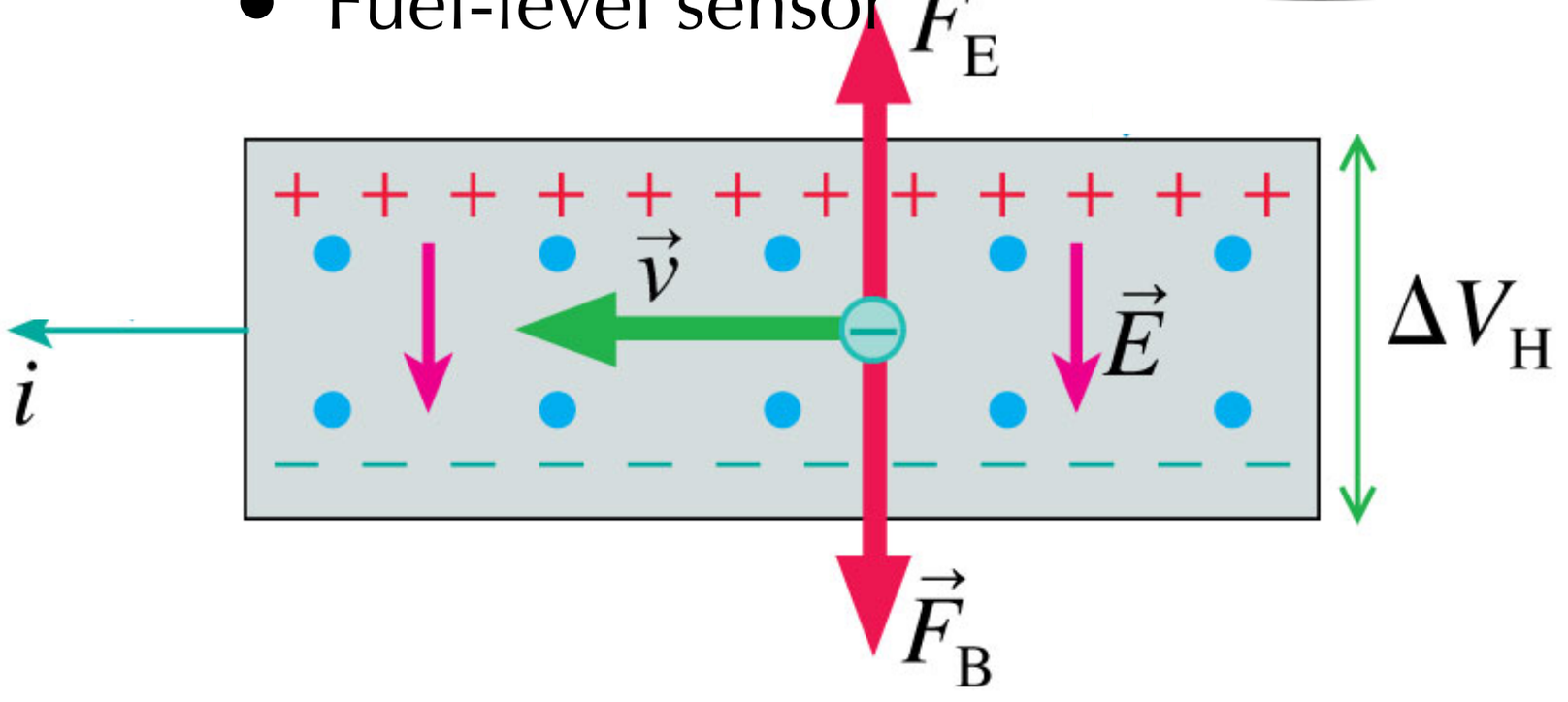
The Hall Effect



- Proximity Sensing
- Positioning
- Speed Detection
- Current Sensing
- Fuel-level sensor

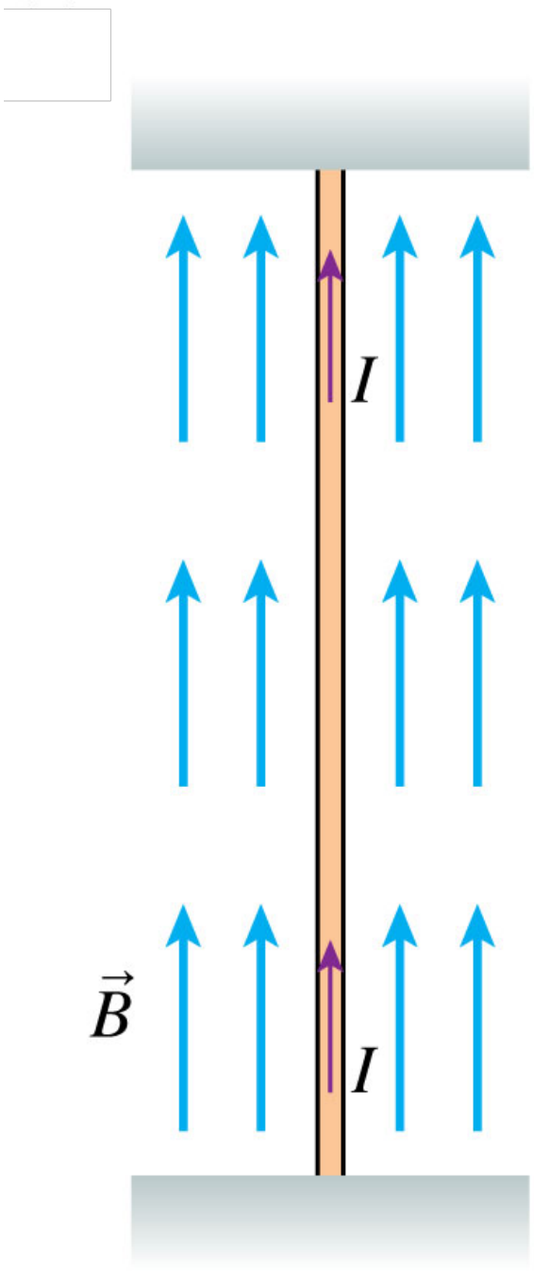




video demo

$$\Delta V_H = \frac{IB}{tne}$$

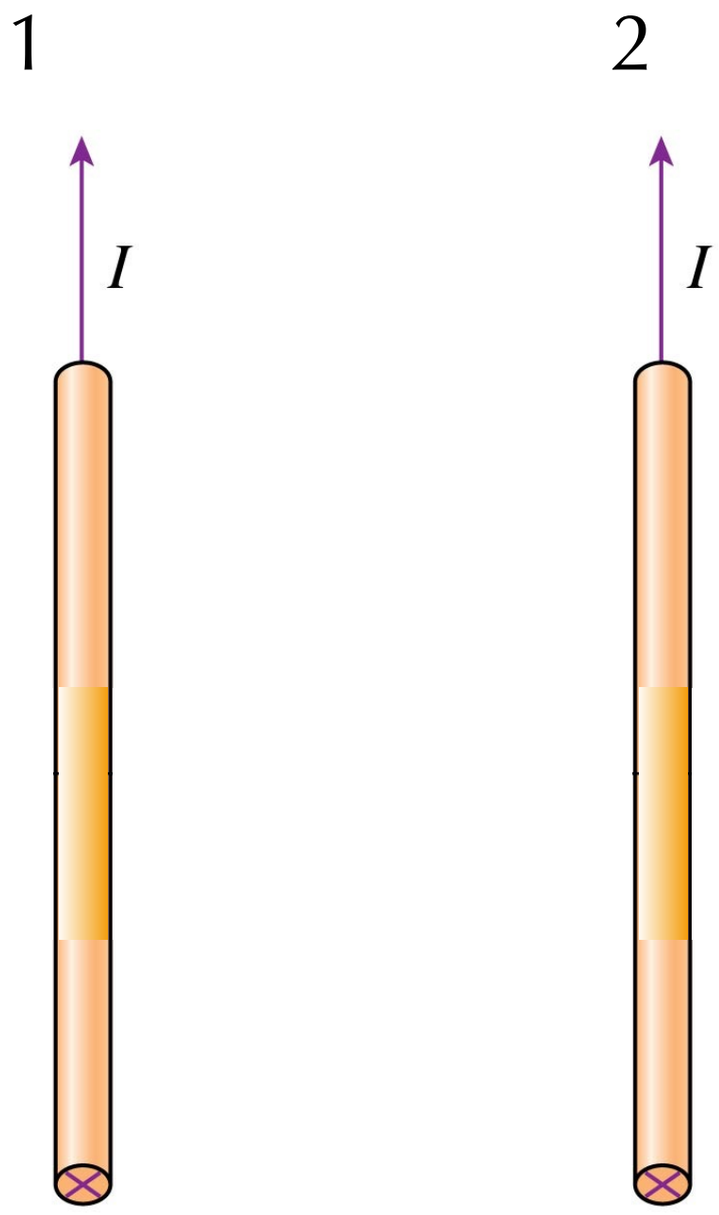
Magnetic force on current



Demo!

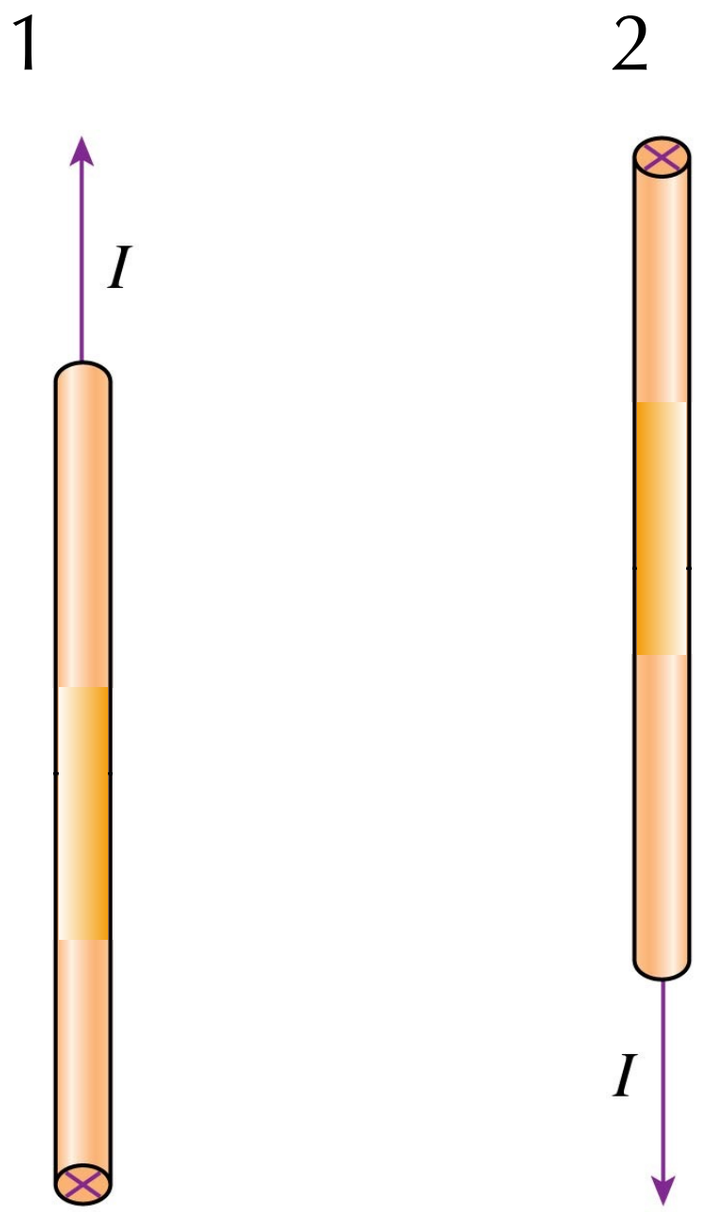
$$\vec{F} = I\vec{l} \times \vec{B}$$

Force on two current-carrying wires



What is the direction of the force exerted by wire 1 onto wire 2?

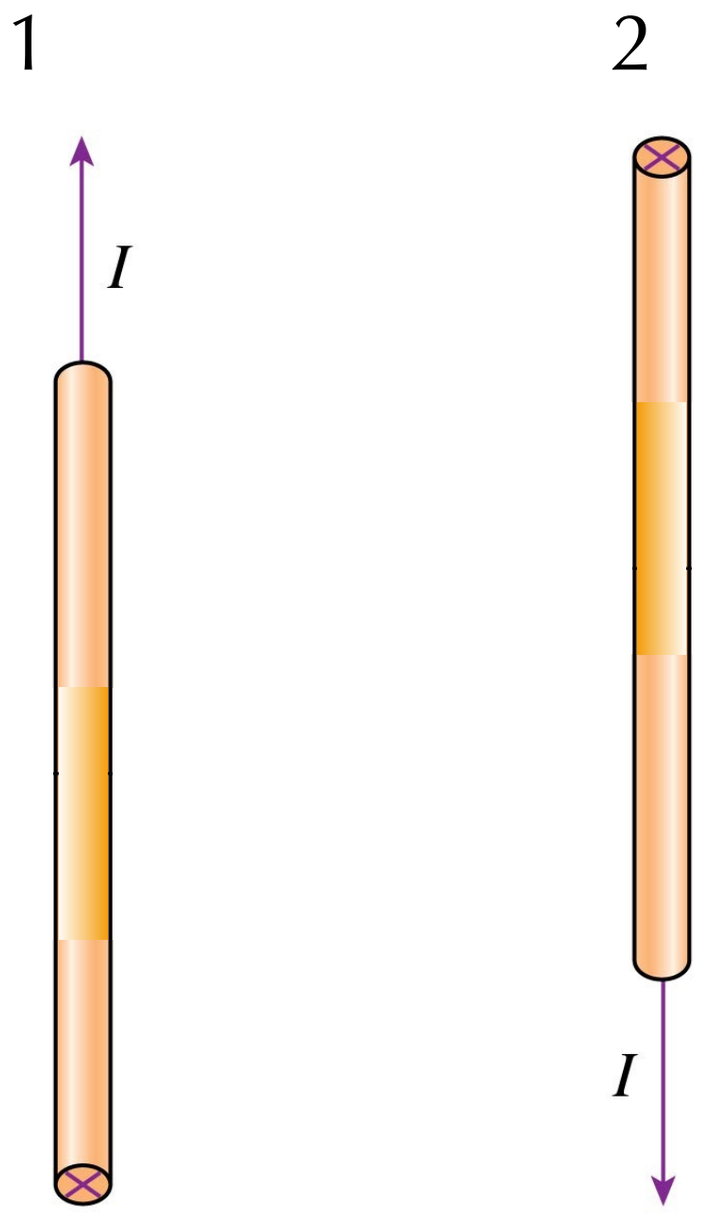
Force on two current-carrying wires



What is the direction of the force exerted by wire 1 onto wire 2?

What about now?

Force on two current-carrying wires

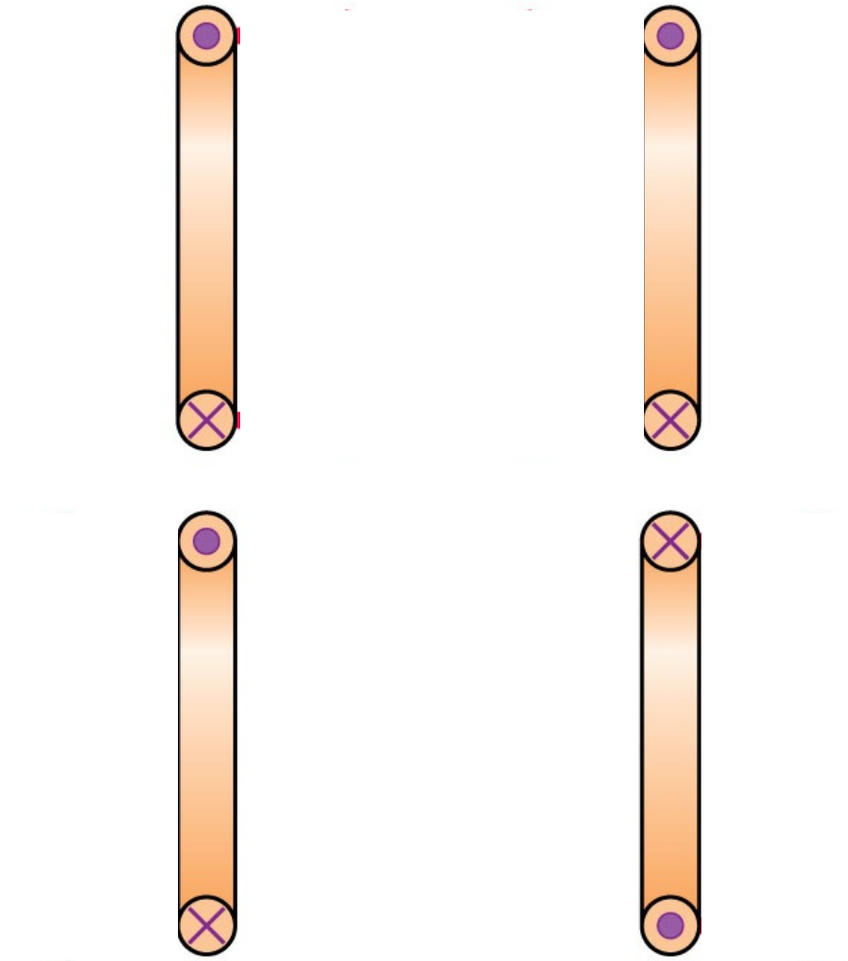


What is the direction of the force exerted by wire 1 onto wire 2?

What about now?

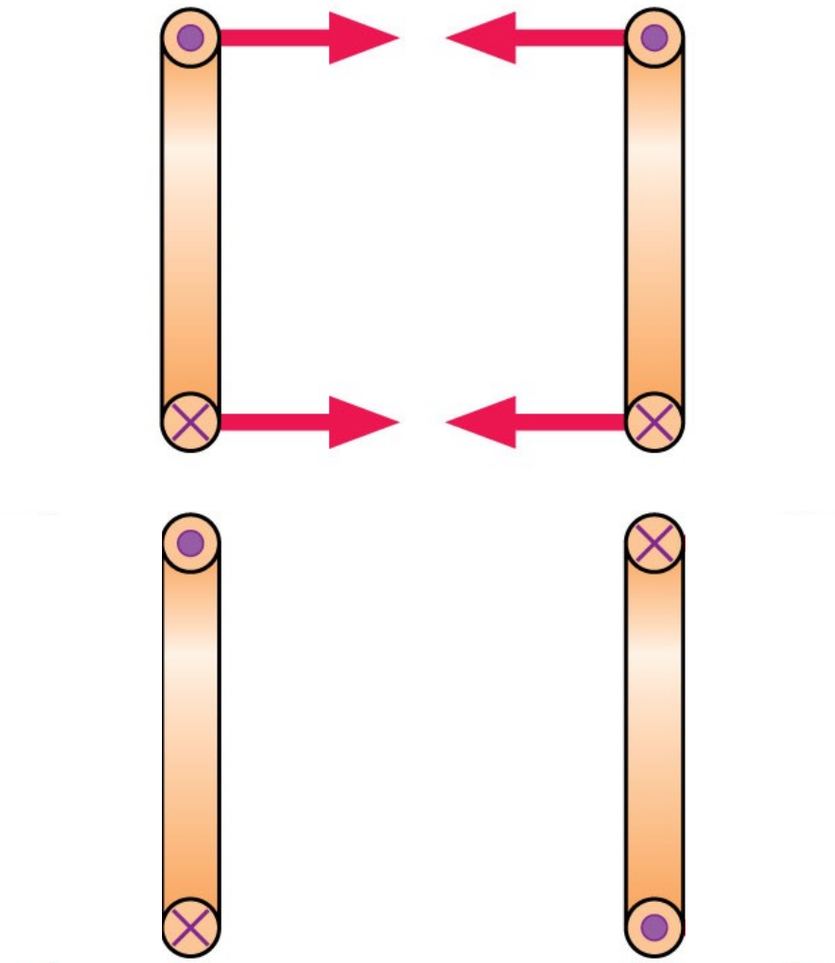
$$F = I_1 l B_2 = I_1 l \frac{\mu_0 I_2}{2\pi d}$$

Force on current loops



What are the forces on these current loops?

Force on current loops



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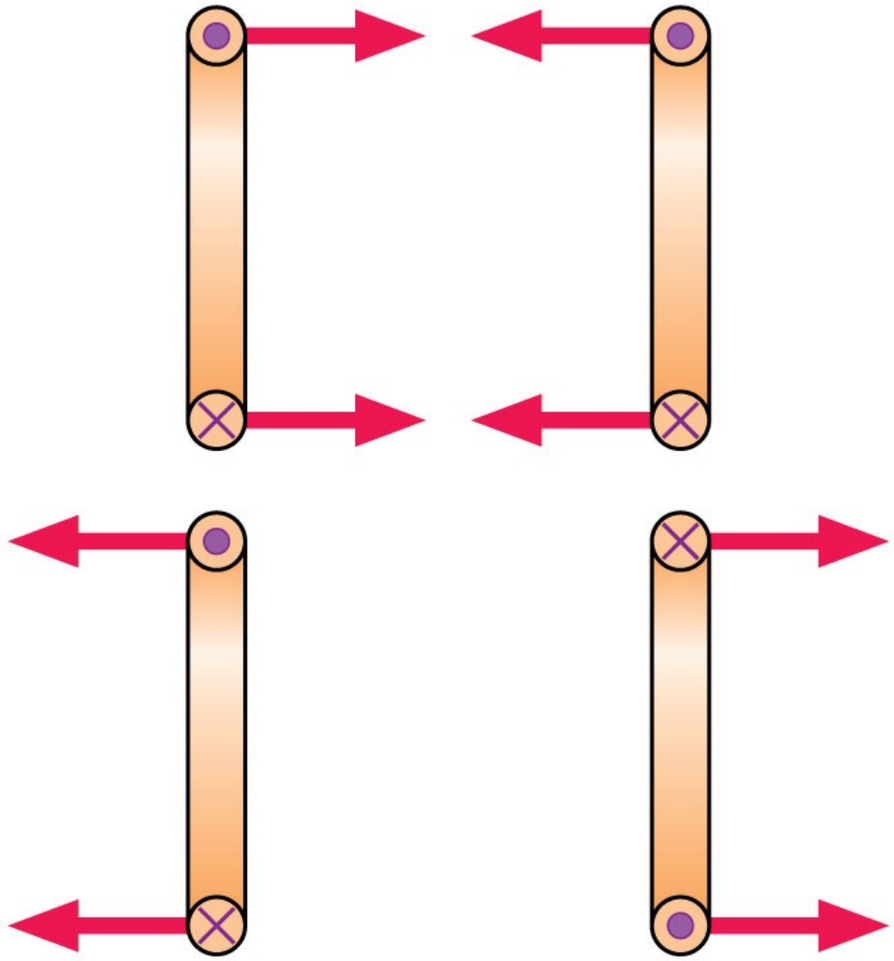
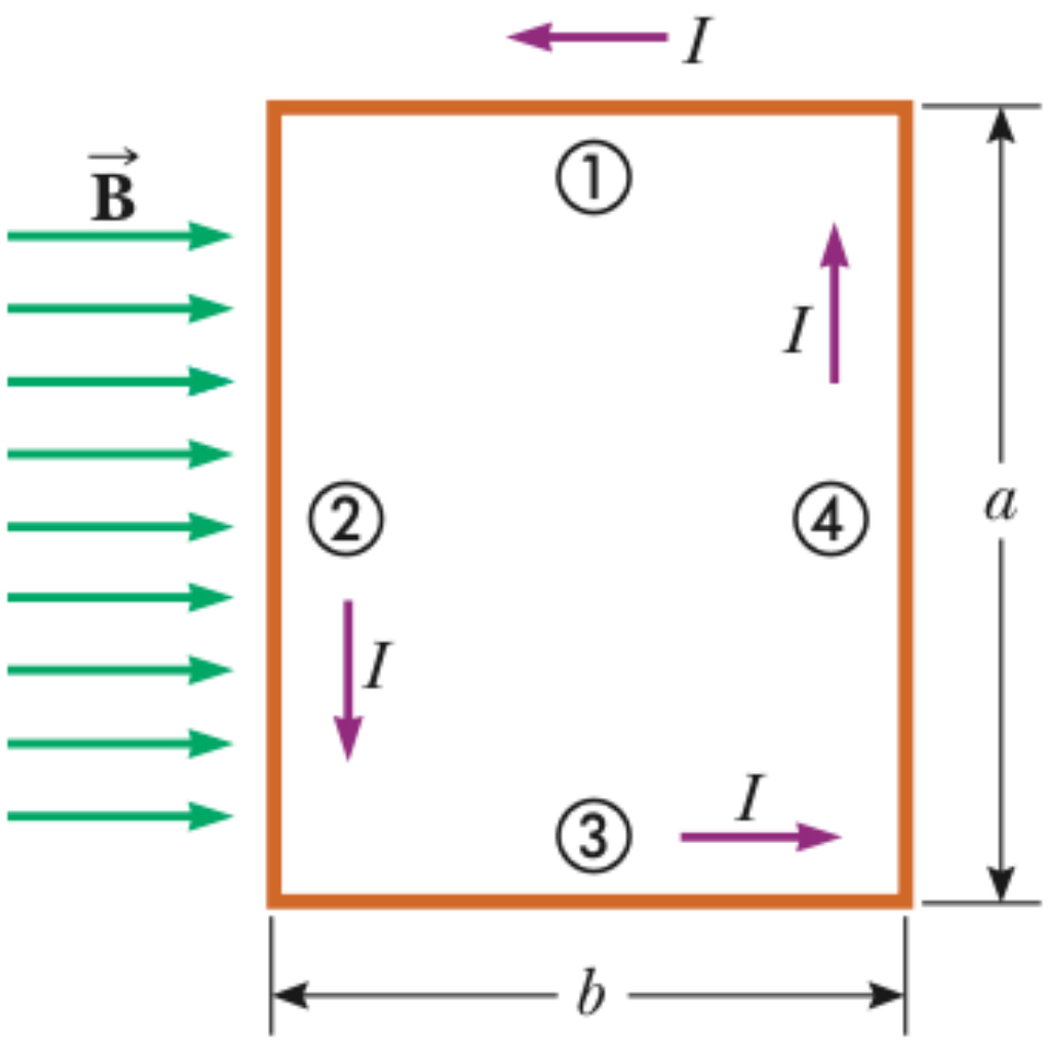


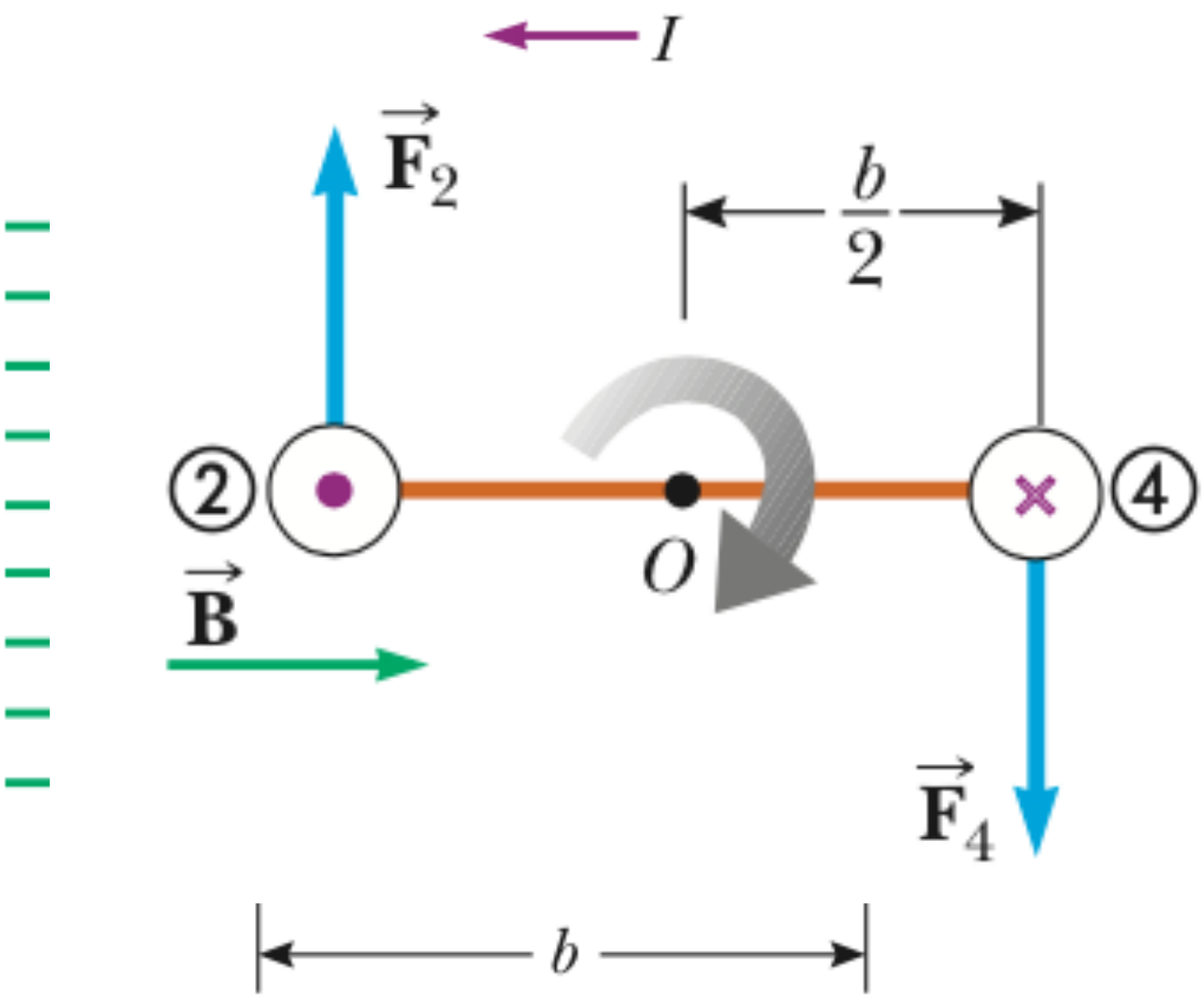
What are the forces on these current loops?

Torque on current loop



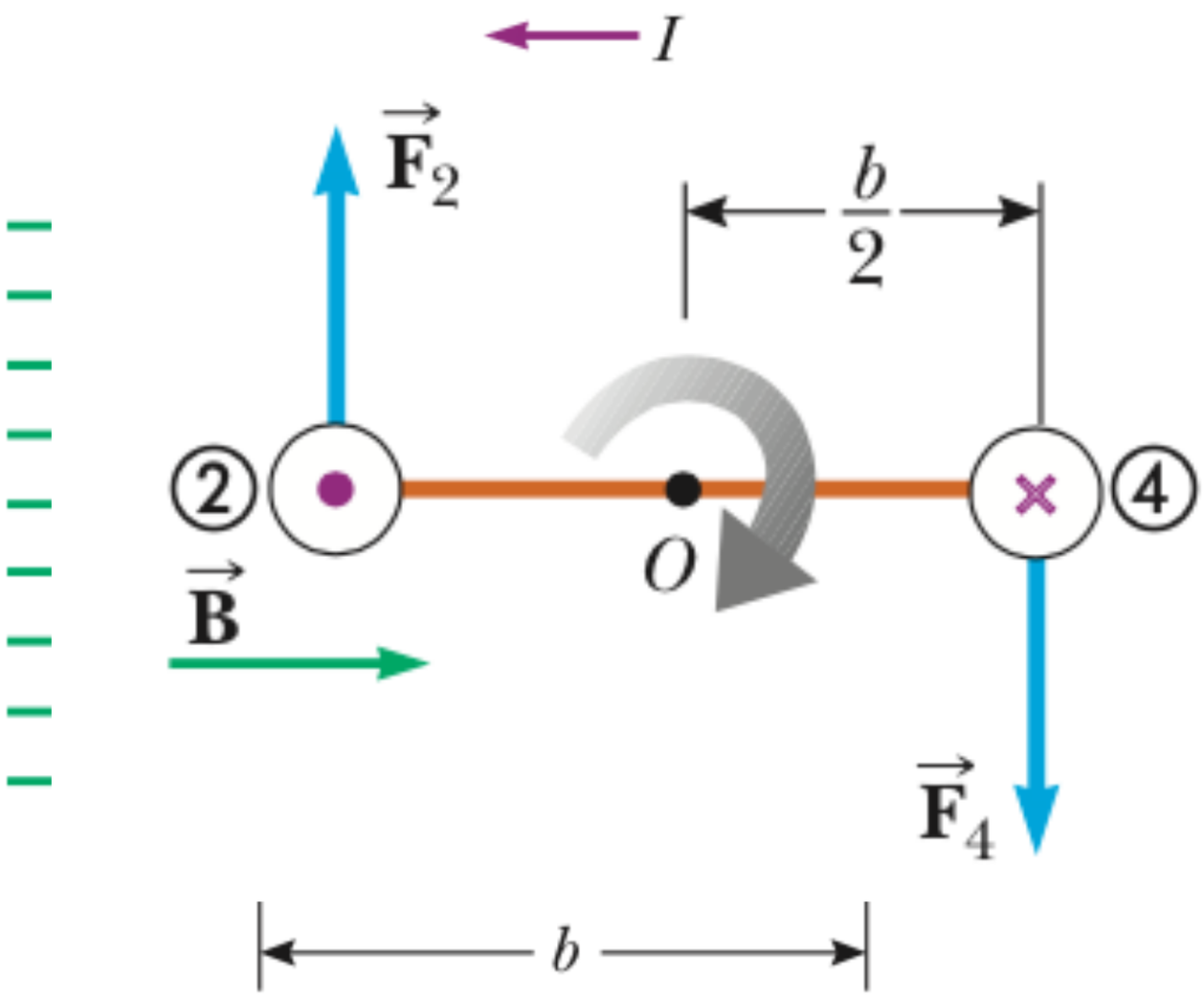
What are the forces on each wire segment?

Torque on current loop



What are the forces on each wire segment?

Torque on current loop



What are the forces on each wire segment?

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

Quiz Question

If released from rest, the current loop will

A. Move upward.
B. Move downward.
C. Rotate counterclockwise.
D. Rotate clockwise.
E. Do something not listed here.

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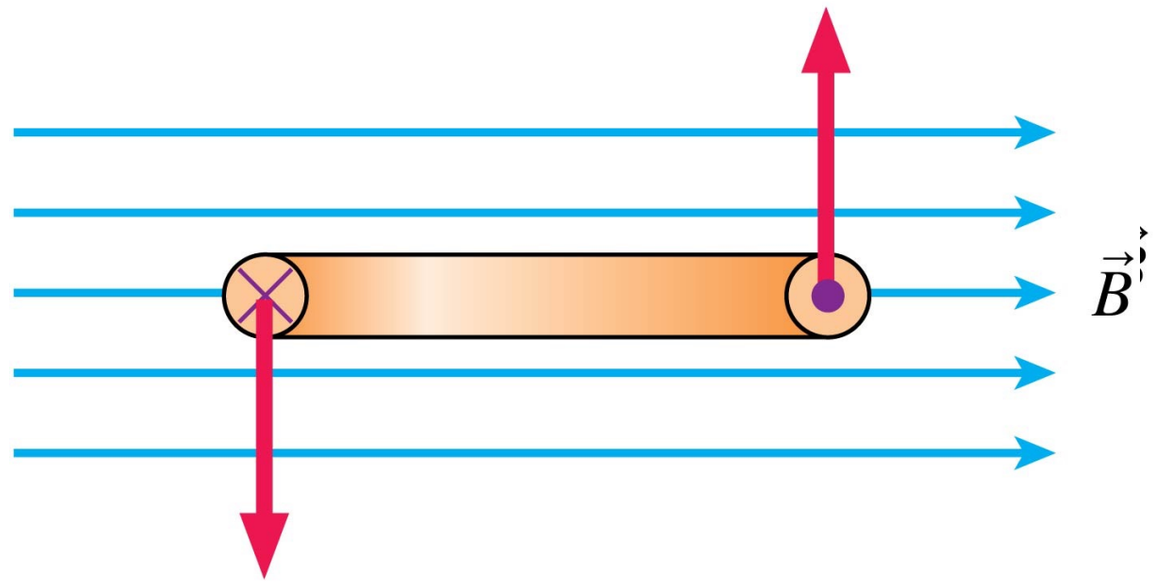
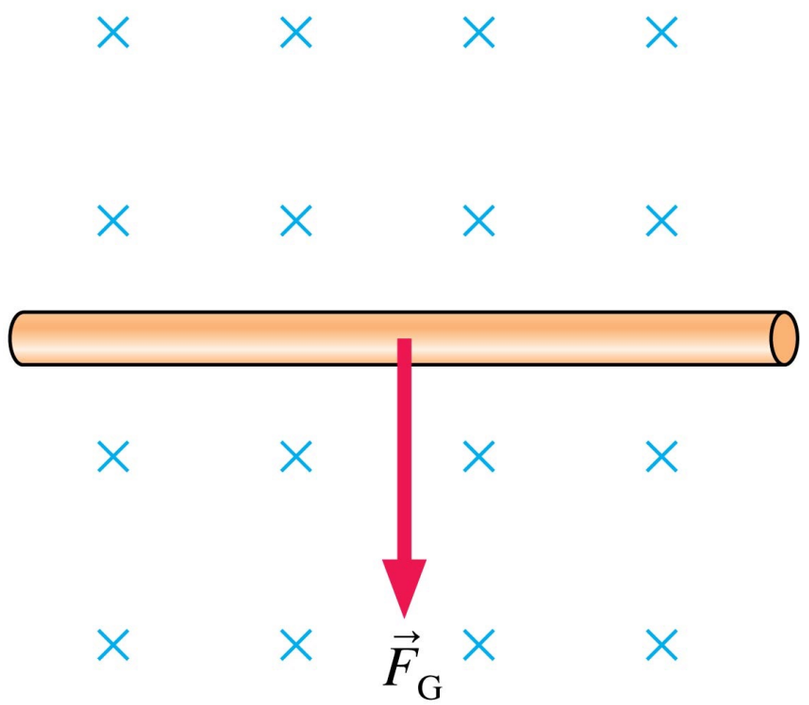
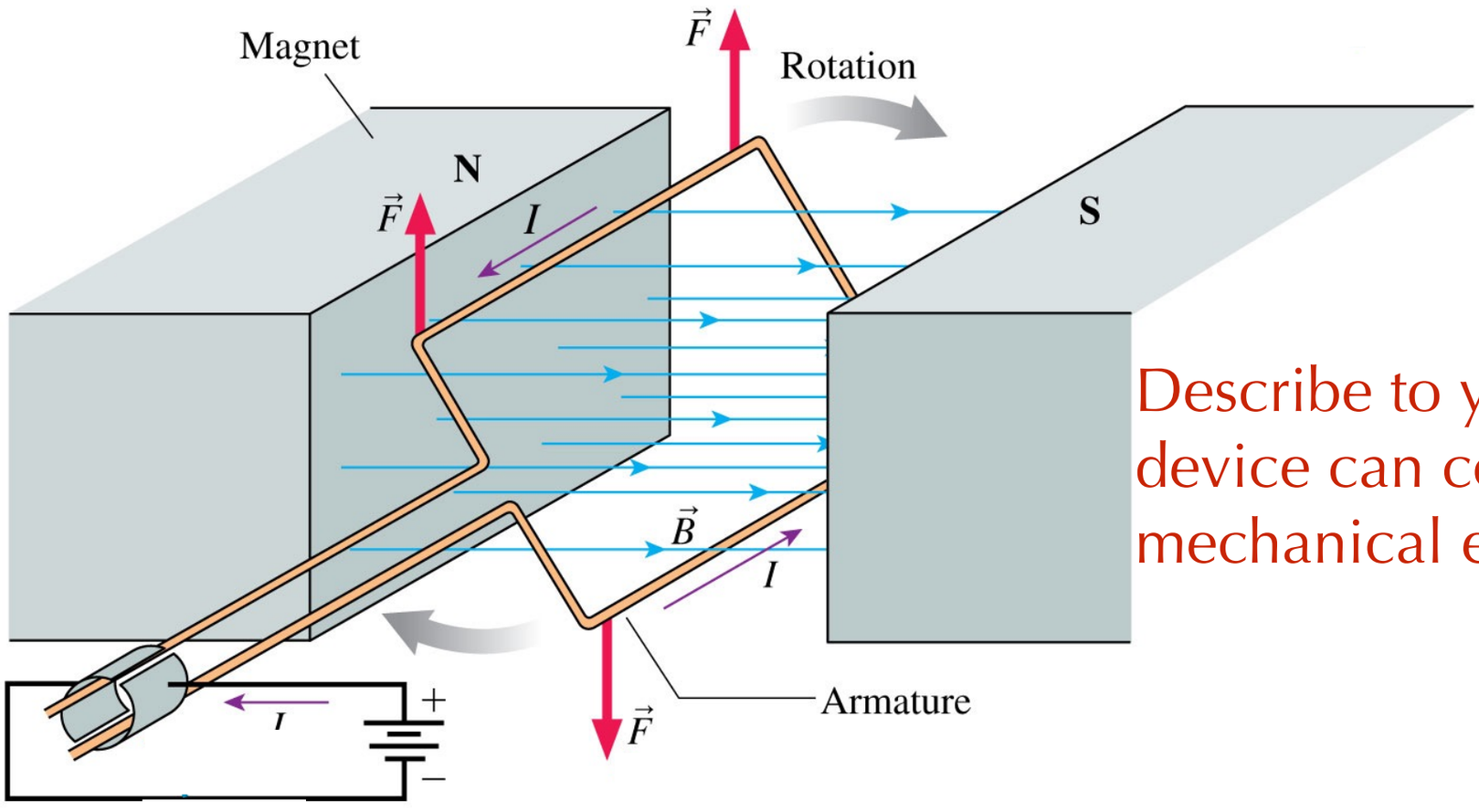


The horizontal wire can be levitated – held up against the force of gravity – if the current in the wire is

A. Right to left.
B. Left to right.
C. It can't be done with this magnetic field.



A simple electric motor



Describe to your neighbor how this device can convert electrical energy into mechanical energy.