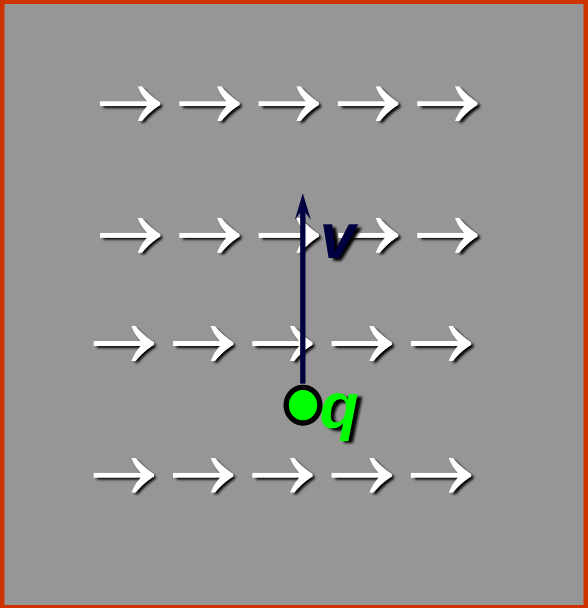
Magnetic Force III

A positive charge enters a uniform magnetic field as shown. What is the direction of the magnetic force?

1) out of the page
2) into the page
3) zero
4) to the right
5) to the left

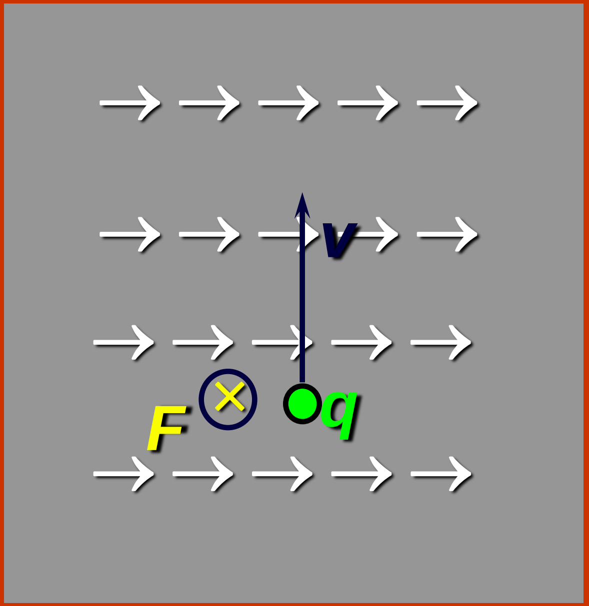


Magnetic Force III

A positive charge enters a uniform magnetic field as shown. What is the direction of the magnetic force?

1) out of the page
2) into the page
3) zero
4) to the right
5) to the left

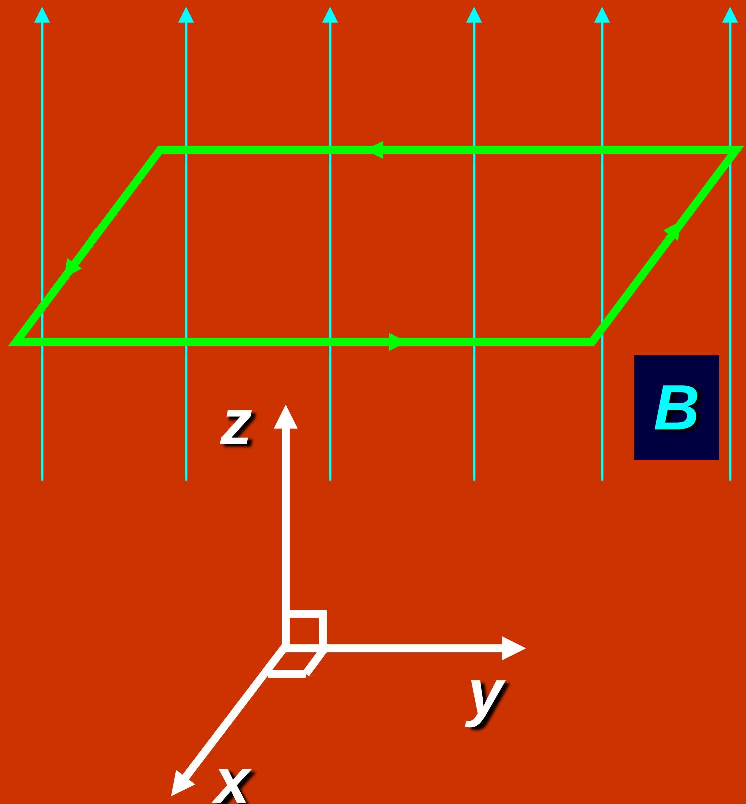
Using the right-hand rule, you can see that the magnetic force is directed into the page. Remember that the magnetic force must be perpendicular to BOTH the *B* field and the velocity.



Magnetic Force on a Loop I

A rectangular current loop is in a uniform magnetic field. What is the direction of the net force on the loop?

1) + *x*
2) + *y*
3) zero
4) - *x*
5) - *y*

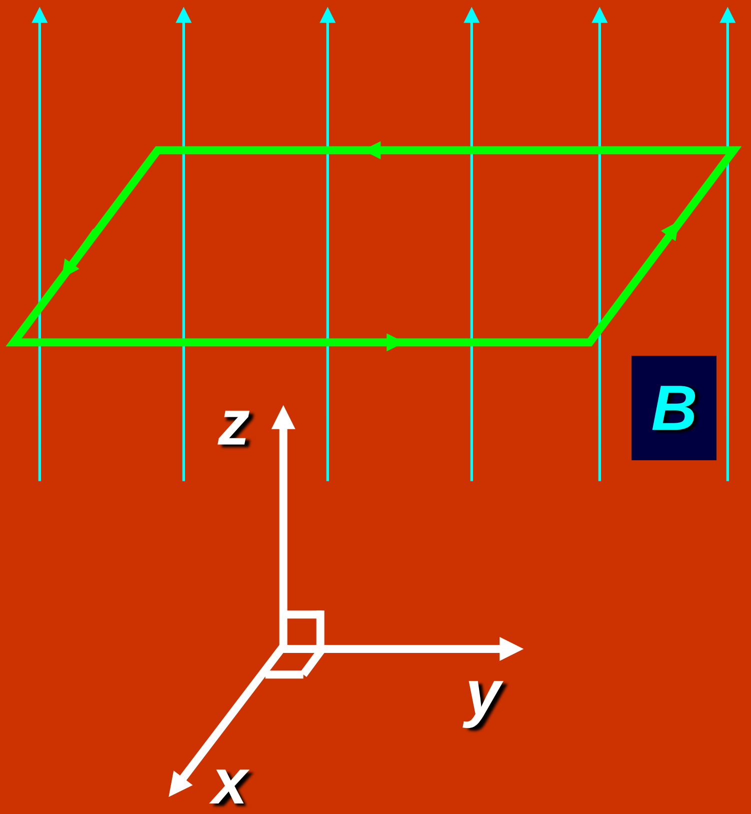


Magnetic Force on a Loop I

A rectangular current loop is in a uniform magnetic field. What is the direction of the net force on the loop?

1) + *x*
2) + *y*
3) zero
4) - *x*
5) - *y*

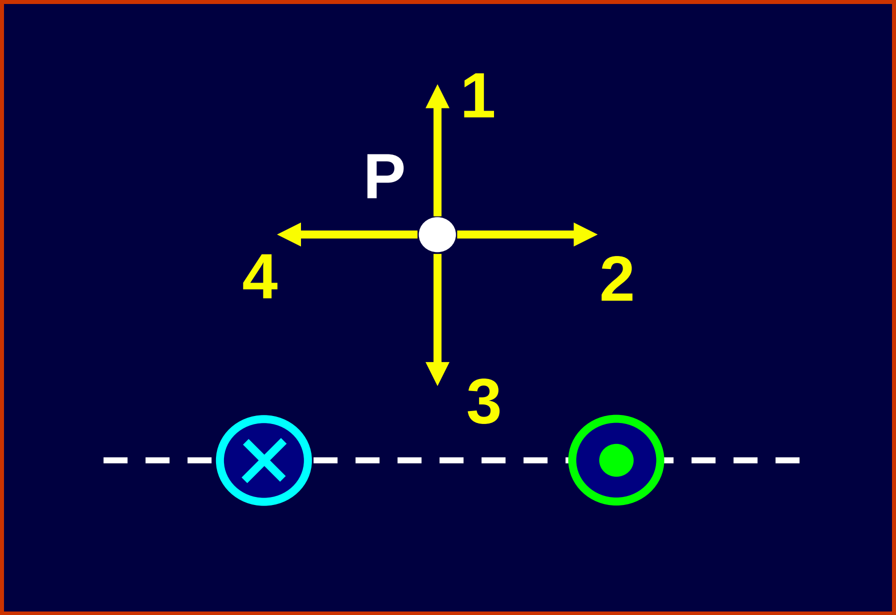
Using the right-hand rule, we find that each of the four wire segments will experience a force ***outward*** from the center of the loop. Thus, the forces of the opposing segments cancel, so the net force is **zero**.



Magnetic Field of a Wire I

If the currents in these wires have the same magnitude but opposite directions, what is the direction of the magnetic field at point P?

1) direction 1
2) direction 2
3) direction 3
4) direction 4
5) the *B* field is zero

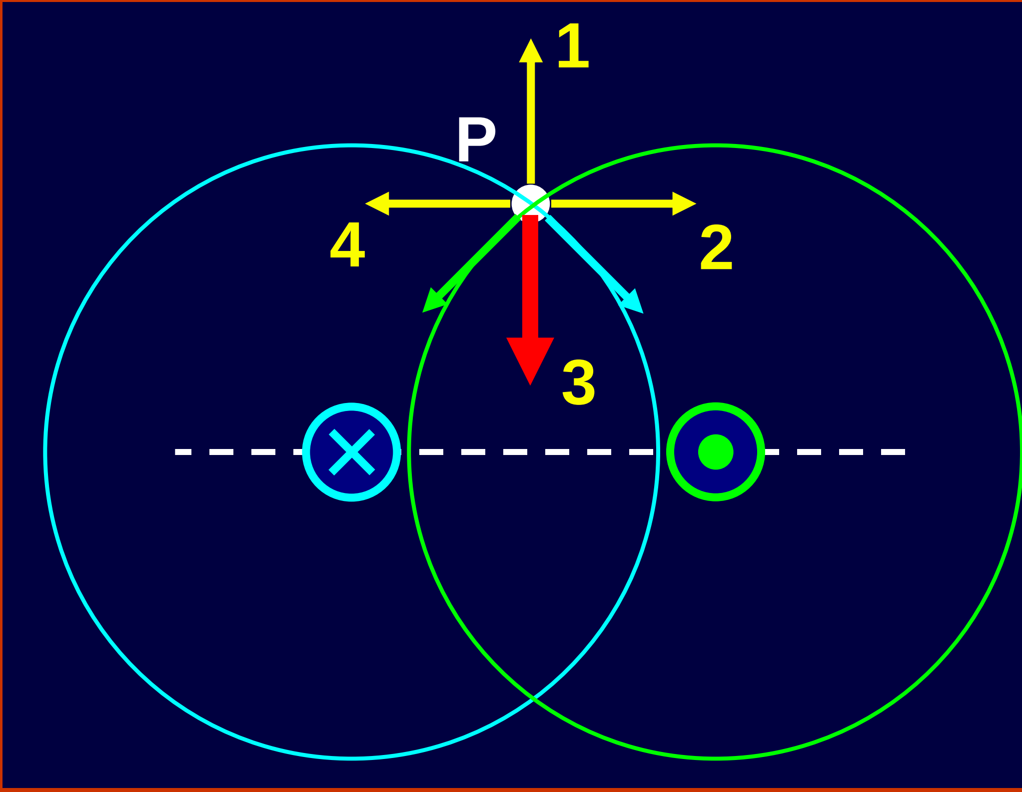


Magnetic Field of a Wire I

If the currents in these wires have the same magnitude but opposite directions, what is the direction of the magnetic field at point P?

1) direction 1
2) direction 2
3) direction 3
4) direction 4
5) the *B* field is zero

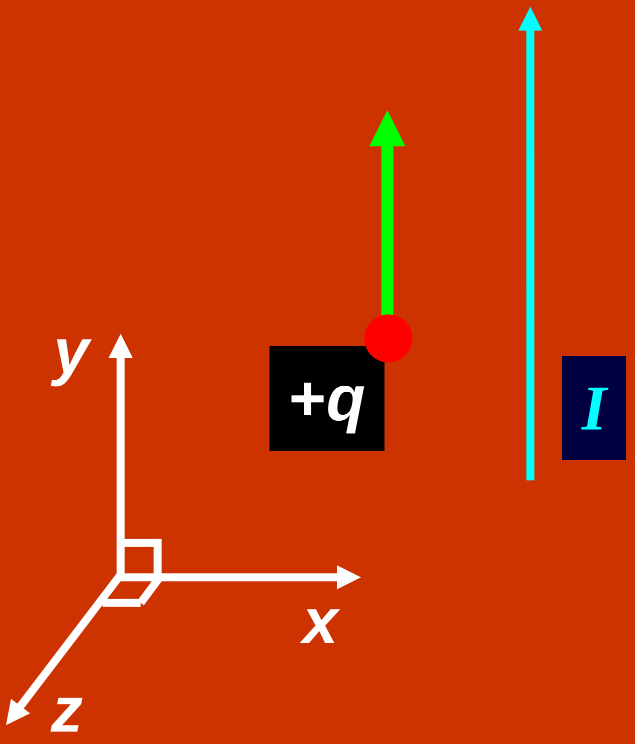
Using the right-hand rule, we can sketch the *B* fields due to the two currents. Adding them up as vectors gives a total magnetic field pointing downward.



Field and Force I

A positive charge moves parallel to a wire. If a current is suddenly turned on, in which direction will the force act?

1) + *z* (out of page)
2) - *z* (into page)
3) + *x*
4) - *x*
5) - *y*

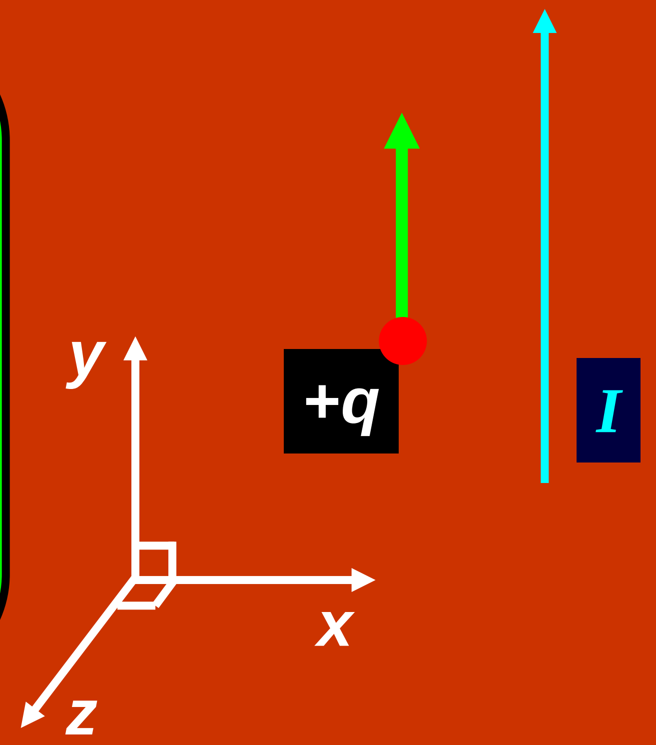


Field and Force I

A positive charge moves parallel to a wire. If a current is suddenly turned on, in which direction will the force act?

1) $+z$ (out of page)
2) $-z$ (into page)
3) $+x$
4) $-x$
5) $-y$

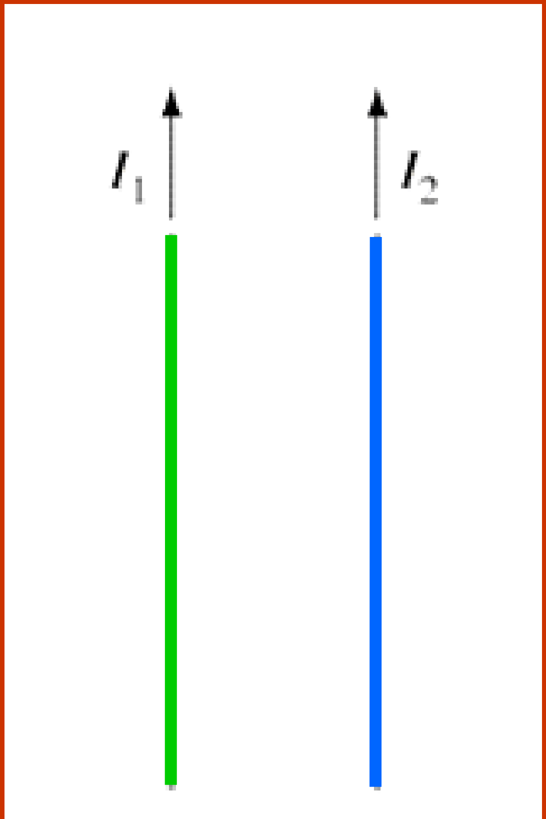
Using the right-hand rule to determine the magnetic field produced by the wire, we find that at the position of the charge $+q$ (to the left of the wire) the B field ***points out of the page***. Applying the right-hand rule again for the magnetic force on the charge, we find that $+q$ experiences a force in the ***+x direction***.



Field and Force II

Two straight wires run parallel to each other, each carrying a current in the direction shown below. The two wires experience a force in which direction?

1) toward each other
2) away from each other
3) there is no force

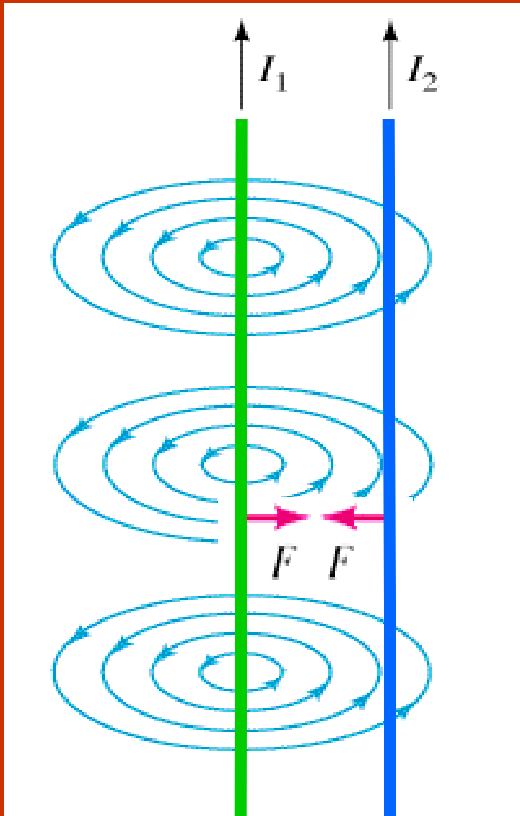


Field and Force II

Two straight wires run parallel to each other, each carrying a current in the direction shown below. The two wires experience a force in which direction?

1) toward each other
2) away from each other
3) there is no force

The current in each wire produces a magnetic field that is felt by the current of the other wire. Using the right-hand rule, we find that each wire experiences a force toward the other wire (i.e., an **attractive force**) when the **currents are parallel** (as shown).

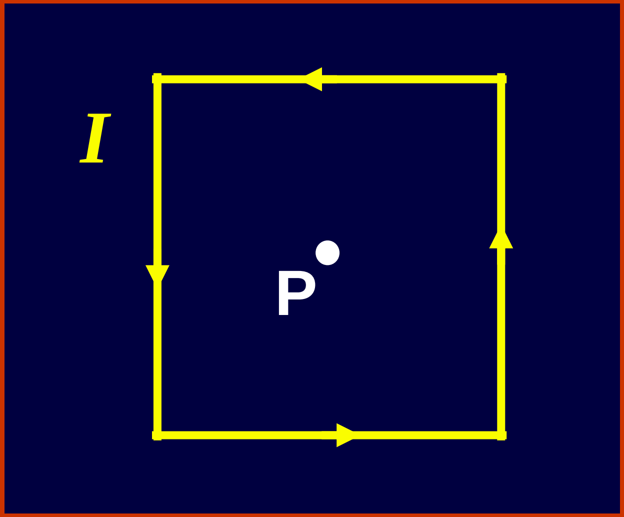


Follow-up: What happens when one of the currents is turned off?

Current Loop

What is the direction of the magnetic field at the center (point P) of the square loop of current?

1) left
2) right
3) zero
4) into the page
5) out of the page

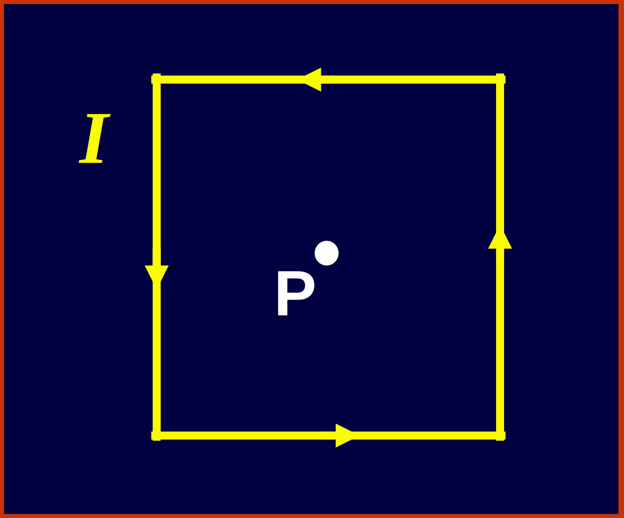


Current Loop

What is the direction of the magnetic field at the center (point P) of the square loop of current?

1) left
2) right
3) zero
4) into the page
5) out of the page

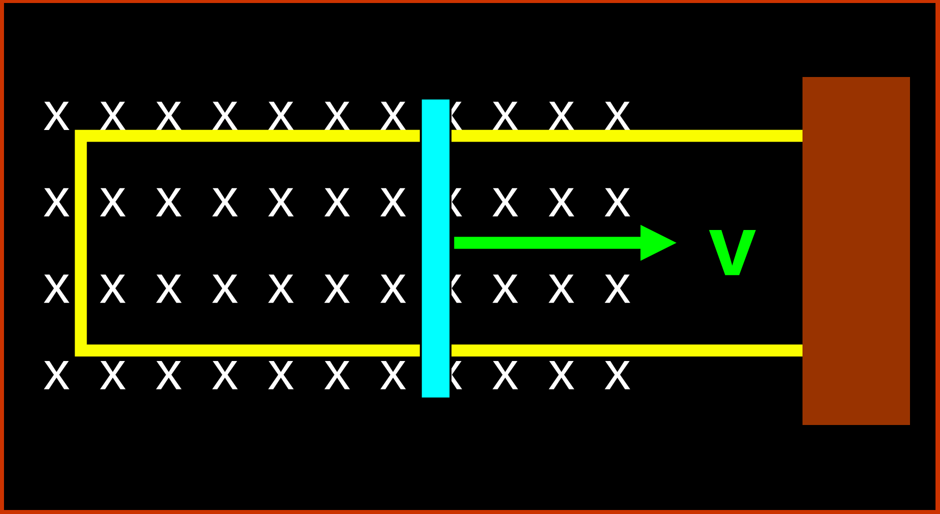
Use the right-hand rule for each wire segment to find that each segment has its *B* field pointing out of the page at point P.



Motional EMF

A conducting rod slides on a conducting track in a constant *B* field directed into the page. What is the direction of the induced current?

1) clockwise
2) counterclockwise
3) no induced current

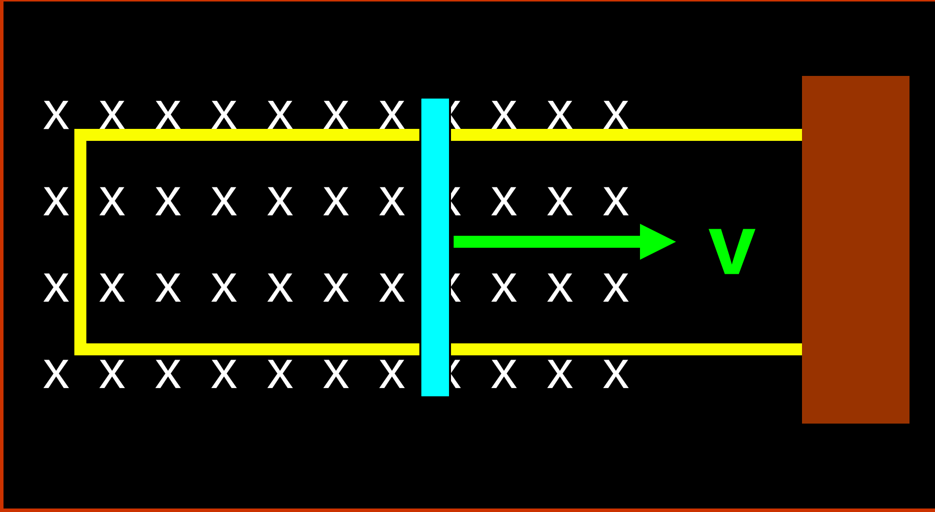


Motional EMF

A conducting rod slides on a conducting track in a constant *B* field directed into the page. What is the direction of the induced current?

1) clockwise
2) counterclockwise
3) no induced current

The *B* field points ***into the page***. The flux is ***increasing*** since the area is increasing. The induced *B* field opposes this change and therefore points ***out of the page***. Thus, the induced current runs ***counterclockwise,*** according to the right-hand rule.

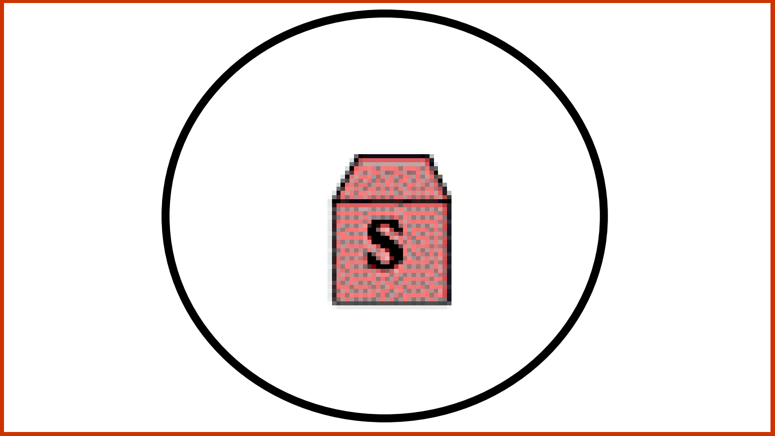


Follow-up: What direction is the magnetic force on the rod as it moves?

Moving Bar Magnet I

If a North pole moves toward the loop from above the page, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

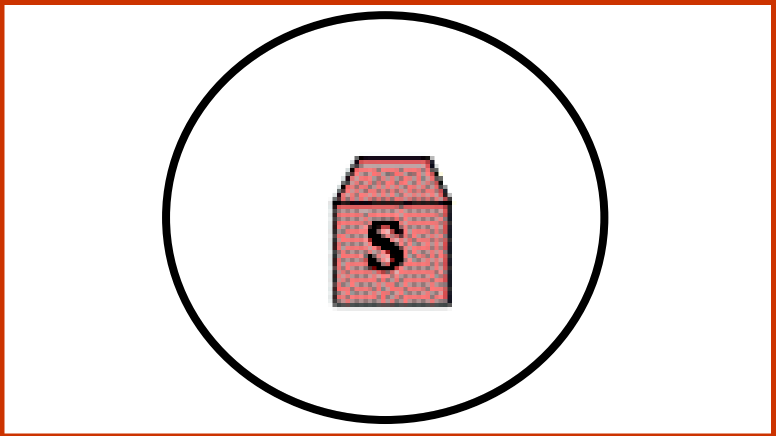


Moving Bar Magnet I

If a North pole moves toward the loop from above the page, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

The magnetic field of the moving bar magnet is pointing ***into the page*** and getting ***larger*** as the magnet moves closer to the loop. Thus the induced magnetic field has to point ***out of the page***. A ***counterclockwise*** induced current will give just such an induced magnetic field.

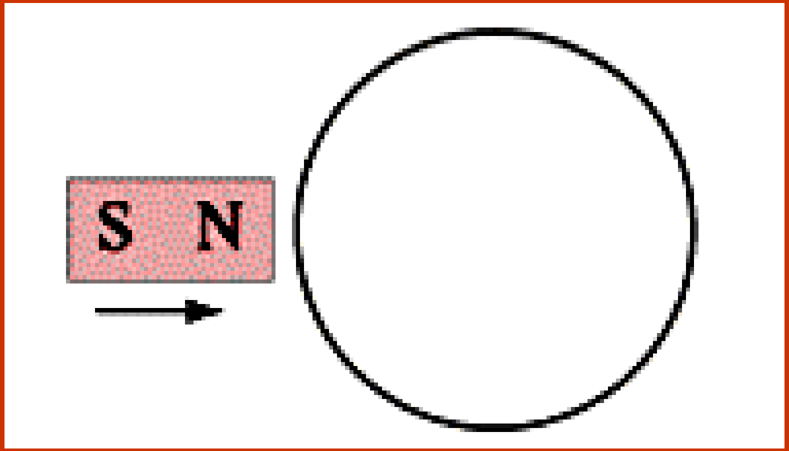


Follow-up: What happens if the magnet is stationary but the loop moves?

Moving Bar Magnet II

If a North pole moves toward the loop in the plane of the page, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

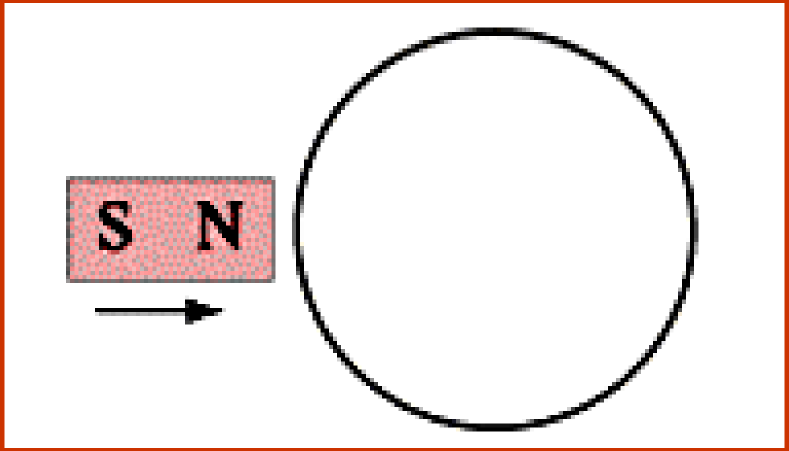


Moving Bar Magnet II

If a North pole moves toward the loop in the plane of the page, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

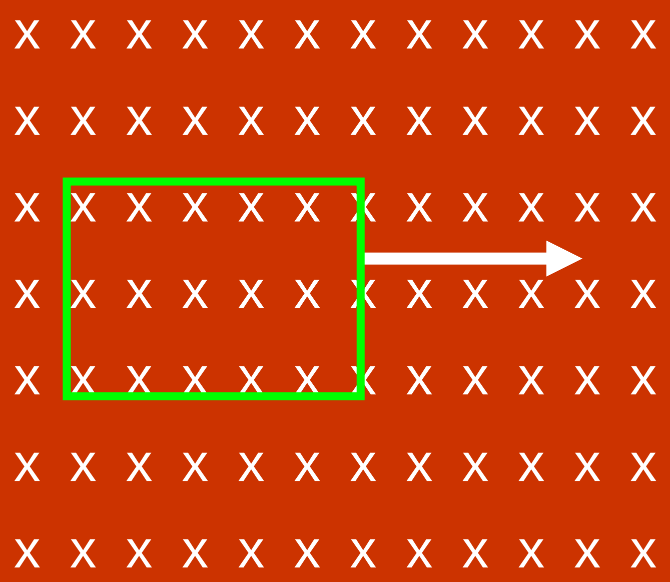
Since the magnet is moving parallel to the loop, there is **no magnetic flux through the loop**. Thus the **induced current is zero**.



Moving Wire Loop I

A wire loop is being pulled through a uniform magnetic field. What is the direction of the induced current?

1) clockwise
2) counterclockwise
3) no induced current

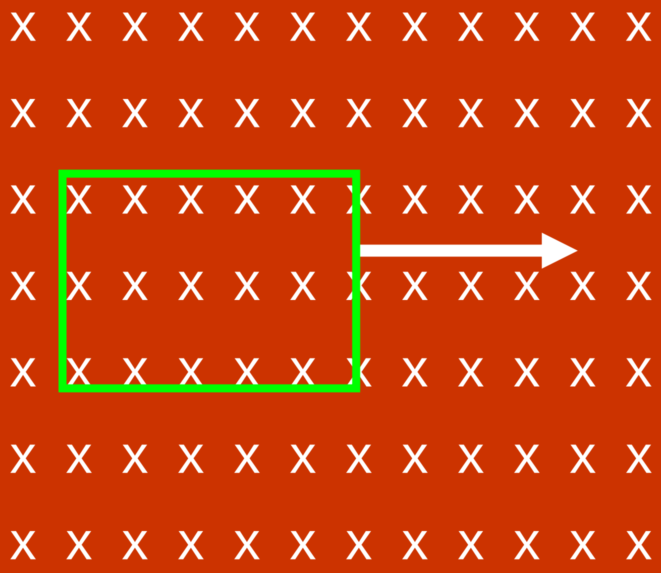


Moving Wire Loop I

A wire loop is being pulled through a uniform magnetic field. What is the direction of the induced current?

1) clockwise
2) counterclockwise
3) no induced current

Since the magnetic field is uniform, the **magnetic flux through the loop is not changing**. Thus **no current is induced**.

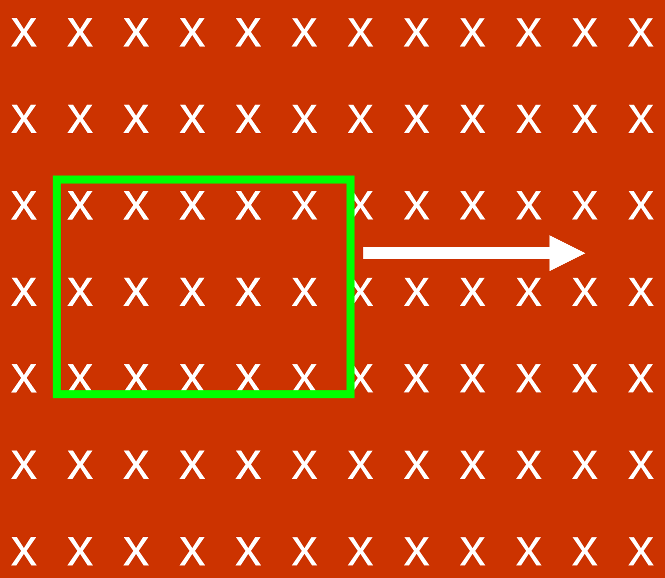


Follow-up: What happens if the loop moves out of the page?

Moving Wire Loop III

What is the direction of the induced current if the *B* **field suddenly increases** while the loop is in the region?

1) clockwise
2) counterclockwise
3) no induced current

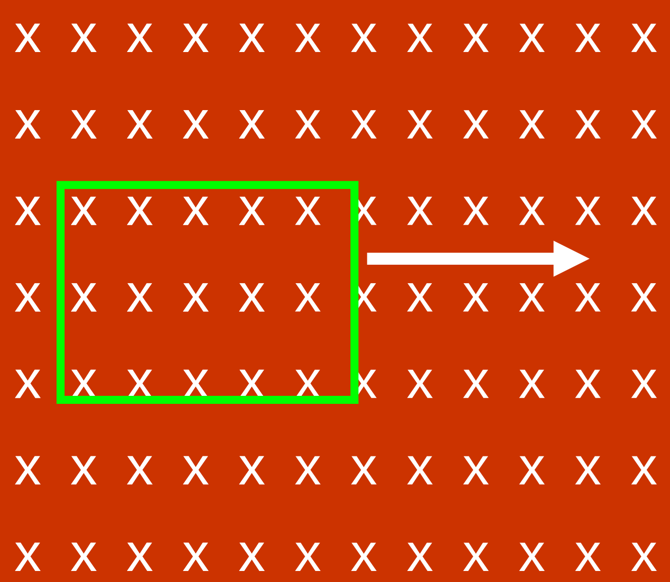


Moving Wire Loop III

What is the direction of the induced current if the *B* field suddenly increases while the loop is in the region?

1) clockwise
2) counterclockwise
3) no induced current

The increasing *B* field into the page must be countered by an induced flux out of the page. This can be accomplished by induced current in the counterclockwise direction in the wire loop.

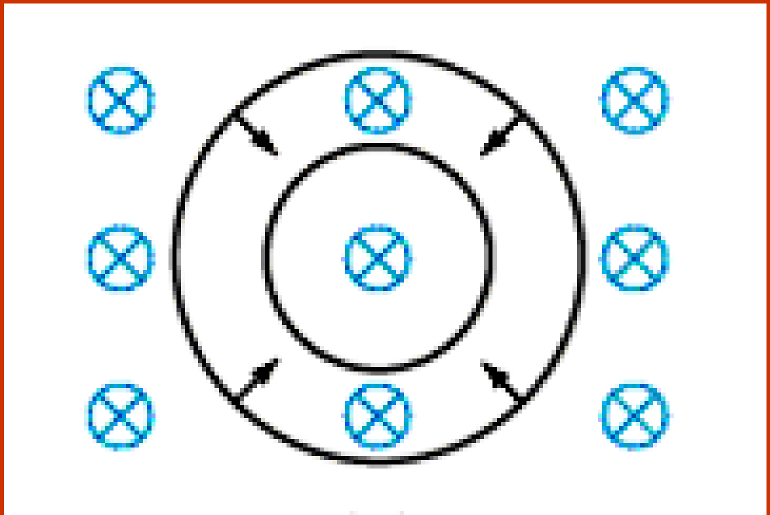


Follow-up: What if the loop stops moving while the field increases?

Shrinking Wire Loop

If a coil is shrinking in a magnetic field pointing into the page, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

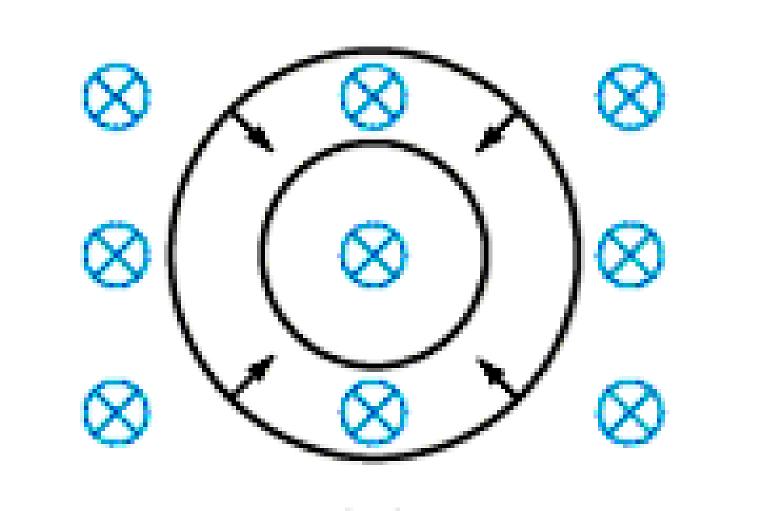


Shrinking Wire Loop

If a coil is shrinking in a magnetic field pointing into the page, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

The magnetic flux through the loop is ***decreasing***, so the induced *B* field must try to reinforce it and therefore points in the same direction—***into the page***. According to the right-hand rule, an induced ***clockwise*** current will generate a magnetic field **into the page**.

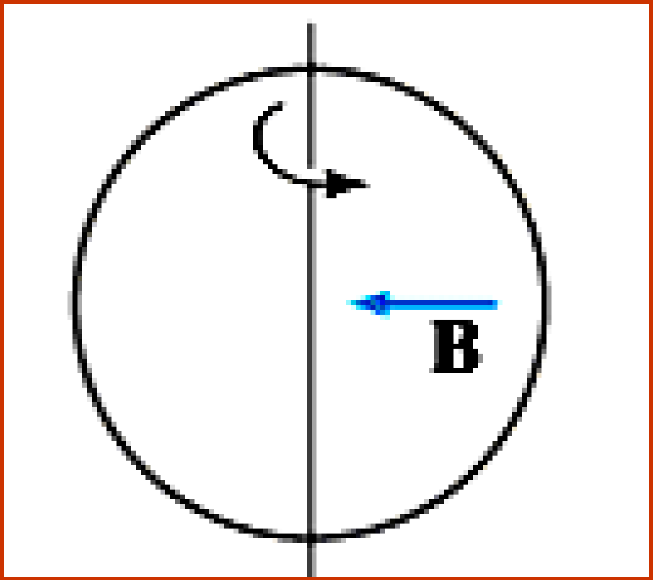


Follow-up: What if the *B* field is oriented at 90° to its present direction?

Rotating Wire Loop

If a coil is rotated as shown, in a magnetic field pointing to the left, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

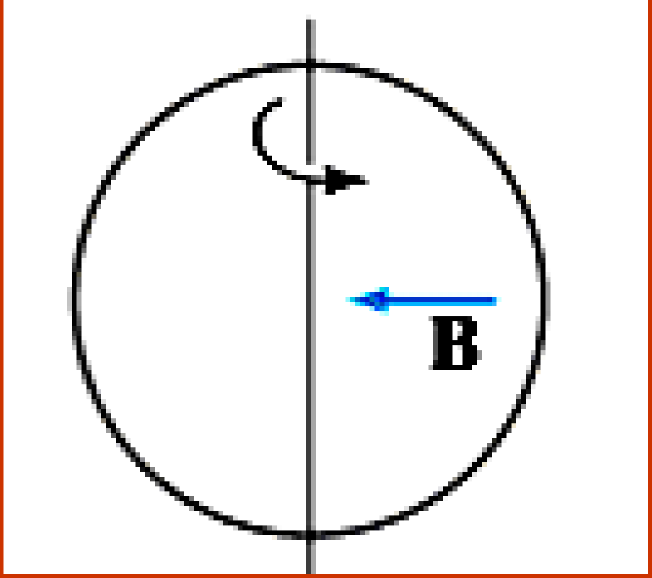


Rotating Wire Loop

If a coil is rotated as shown, in a magnetic field pointing to the left, in what direction is the induced current?

1) clockwise
2) counterclockwise
3) no induced current

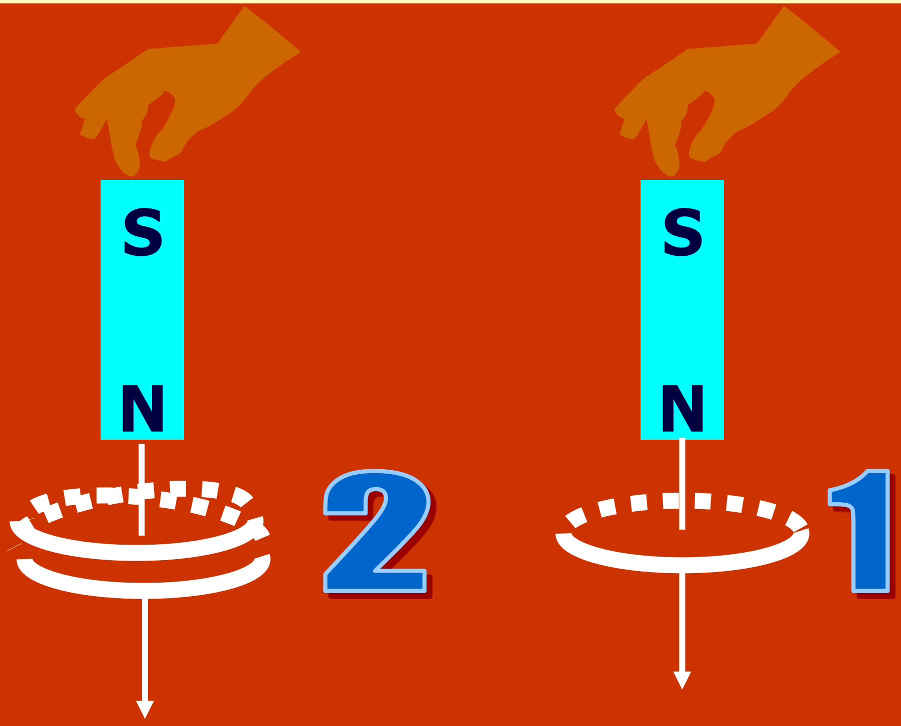
As the coil is rotated into the *B* field, the magnetic flux through it ***increases***. According to Lenz's Law, the induced *B* field has to ***oppose this increase***, thus the new *B* field points ***to the right***. An induced ***counterclockwise*** current produces just such a *B* field.



Voltage and Current I

Wire 1 (length L) forms a **one-turn loop**, and a bar magnet is dropped through.
Wire 2 (length $2L$) forms a **two-turn loop**, and the same magnet is dropped through.
Compare the magnitude of the **induced voltages** in these two cases.

1) $V_1 > V_2$
2) $V_1 < V_2$
3) $V_1 = V_2 \neq 0$
4) $V_1 = V_2 = 0$



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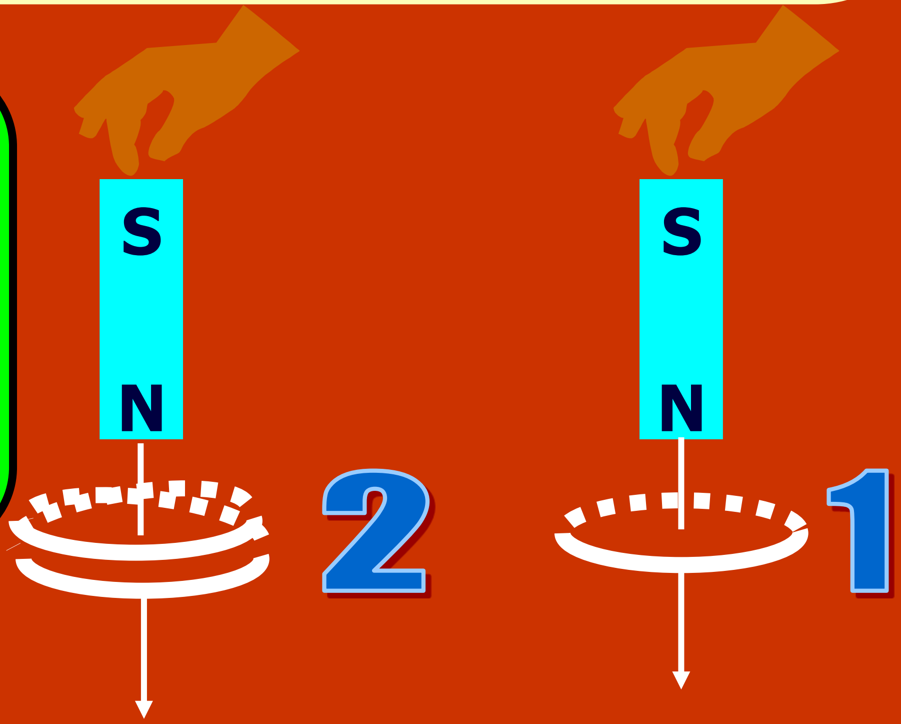
1) $V_1 > V_2$
2) $V_1 < V_2$
3) $V_1 = V_2 \neq 0$
4) $V_1 = V_2 = 0$

Faraday's Law: $$\mathcal{E} = -N \frac{\Delta \Phi_B}{\Delta t}$$

depends on N (number of loops) so the induced emf is twice as large in the wire with 2 loops.



Voltage and Current II

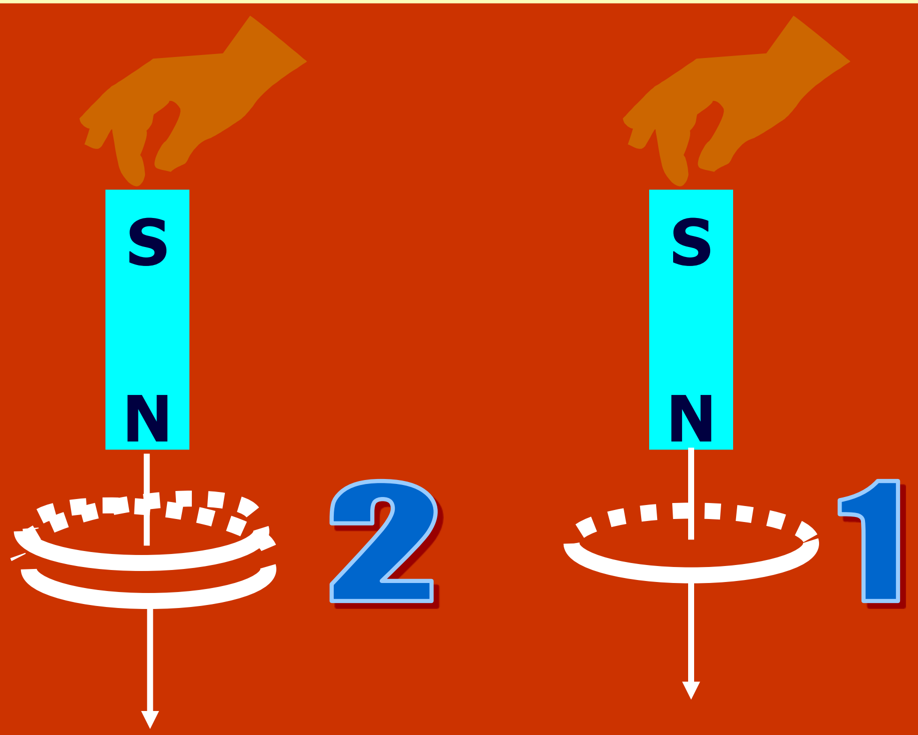
Wire 1 (length L) forms a one-turn loop, and a bar magnet is dropped through.
Wire 2 (length $2L$) forms a two-turn loop, and the same magnet is dropped through.
Compare the magnitude of the induced currents in these two cases.

1) $I_1 > I_2$

2) $I_1 < I_2$

3) $I_1 = I_2 \neq 0$

4) $I_1 = I_2 = 0$



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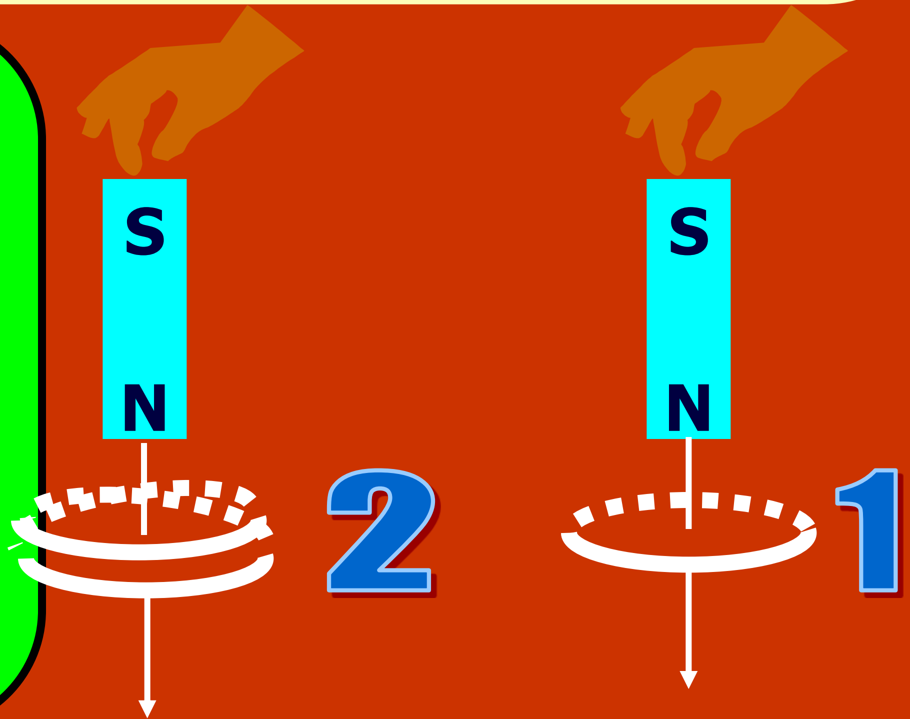
Compare the magnitude of the induced currents in these two cases.

1) $I_1 > I_2$
2) $I_1 < I_2$
3) $I_1 = I_2 \neq 0$
4) $I_1 = I_2 = 0$

Faraday's law:

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$$

says that the induced emf is twice as large in the wire with 2 loops. The current is given by Ohm's law: $I = V/R$. Since Wire 2 is twice as long as Wire 1, it has twice the resistance, so the current in both wires is the same.



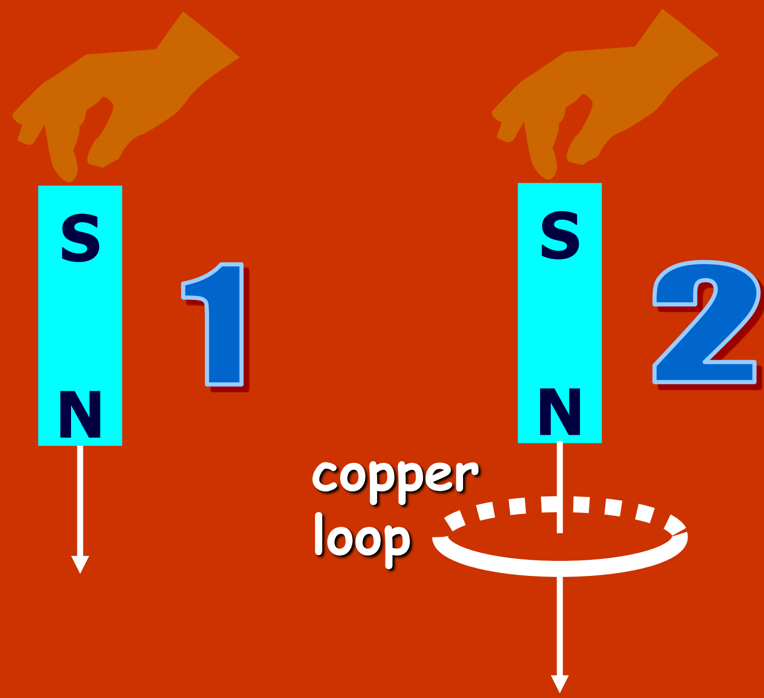
Falling Magnet I

A bar magnet is held above the floor and dropped. In 1, there is nothing between the magnet and the floor. In 2, the magnet falls through a copper loop. How will the magnet in case 2 fall in comparison to case 1?

1) it will fall slower

2) it will fall faster

3) it will fall the same



Falling Magnet I

A bar magnet is held above the floor and dropped. In 1, there is nothing between the magnet and the floor. In 2, the magnet falls through a copper loop. How will the magnet in case 2 fall in comparison to case 1?

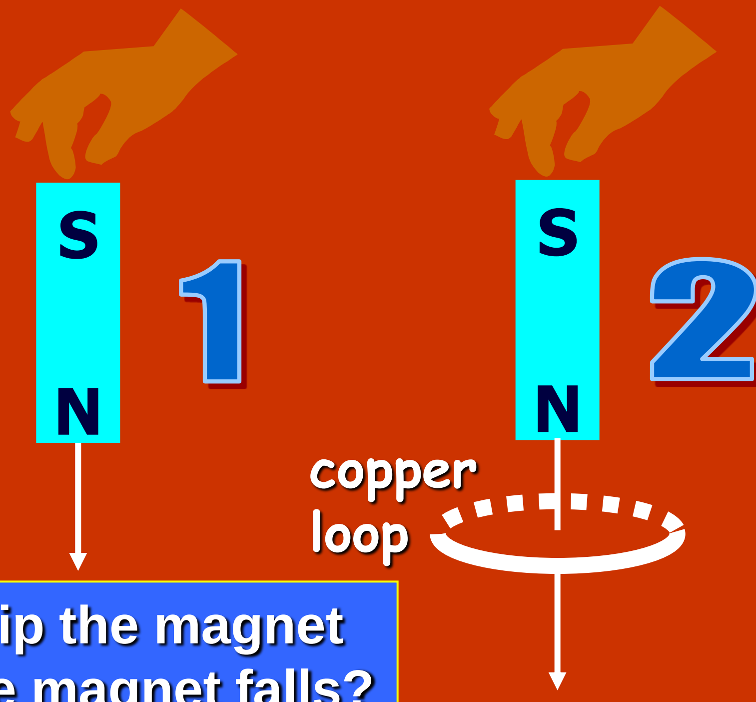
1) it will fall slower

2) it will fall faster

3) it will fall the same

When the magnet is falling from ***above*** the loop in 2, the induced current will produce a ***North pole on top of the loop***, which repels the magnet.

When the magnet is ***below*** the loop, the induced current will produce a ***North pole on the bottom of the loop***, which attracts the South pole of the magnet.

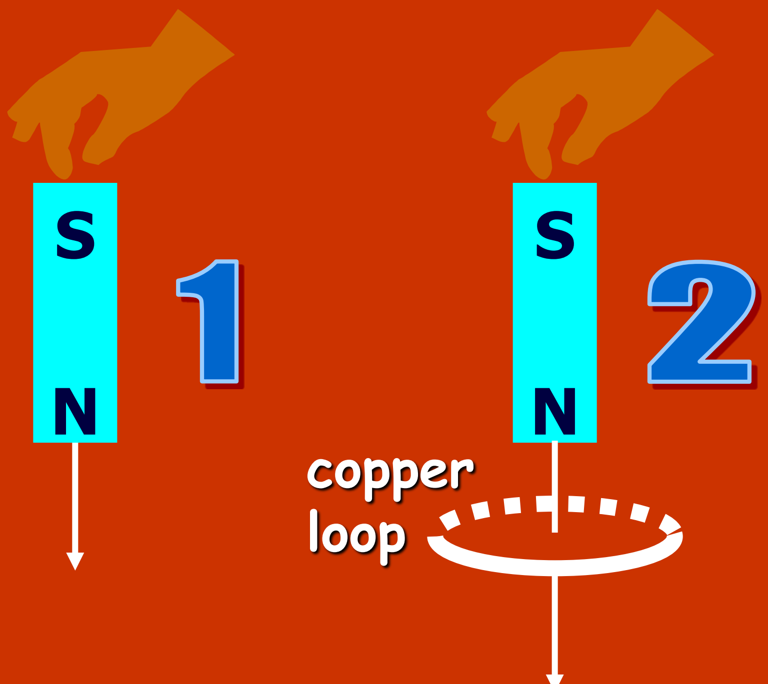


Follow-up: What happens in case 2 if you flip the magnet so that the South pole is on the bottom as the magnet falls?

Falling Magnet II

If there is induced current, doesn't that cost energy? Where would that energy come from in case 2?

1) induced current doesn't need any energy
2) energy conservation is violated in this case
3) there is less KE in case 2
4) there is more gravitational PE in case 2



Falling Magnet II

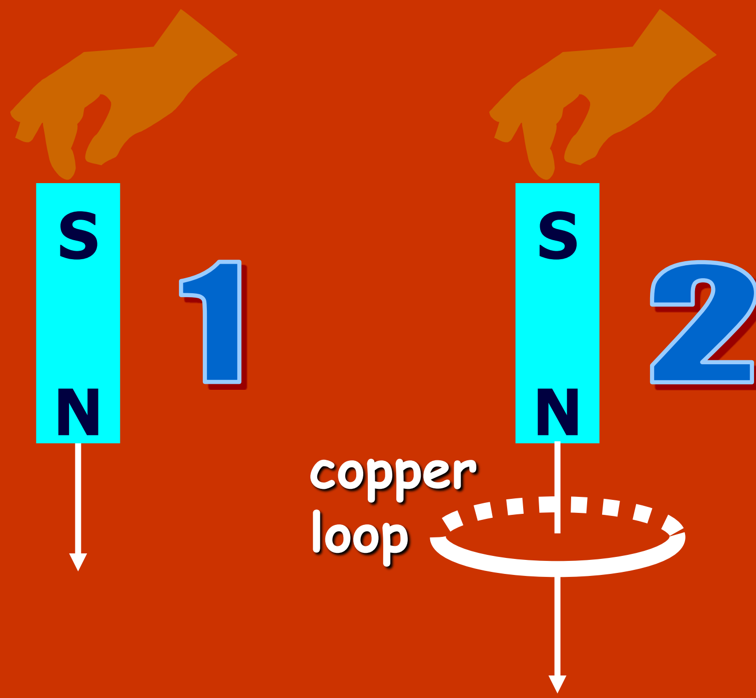
If there is induced current, doesn't that cost energy? Where would that energy come from in case 2?

1) induced current doesn't need any energy
2) energy conservation is violated in this case
3) there is less KE in case 2
4) there is more gravitational PE in case 2

In both cases, the magnet starts with the same initial gravitational PE.

In case 1, all the gravitational PE has been converted into kinetic energy.

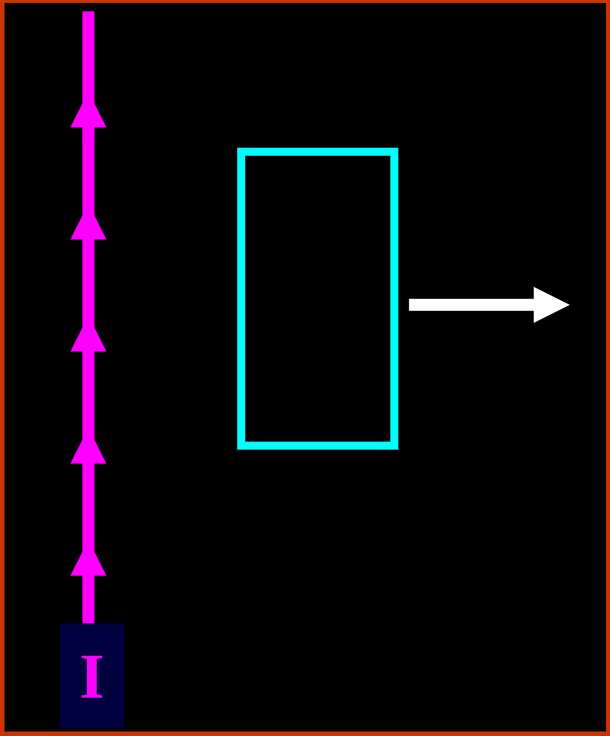
In case 2, we know the magnet falls slower, thus there is less KE. The difference in energy goes into making the induced current.



Loop and Wire I

A wire loop is being pulled away from a current-carrying wire. What is the direction of the induced current in the loop?

1) clockwise
2) counterclockwise
3) no induced current

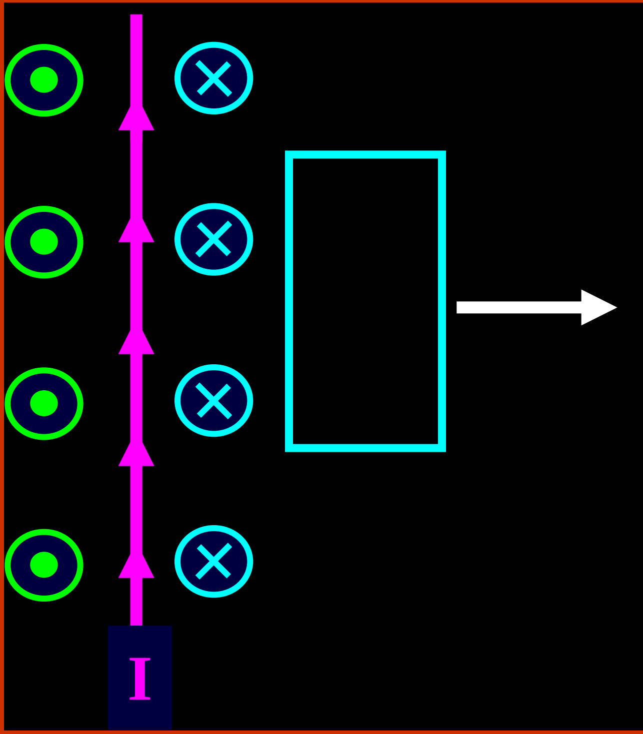


Loop and Wire I

A wire loop is being pulled away from a current-carrying wire. What is the direction of the induced current in the loop?

1) clockwise
2) counterclockwise
3) no induced current

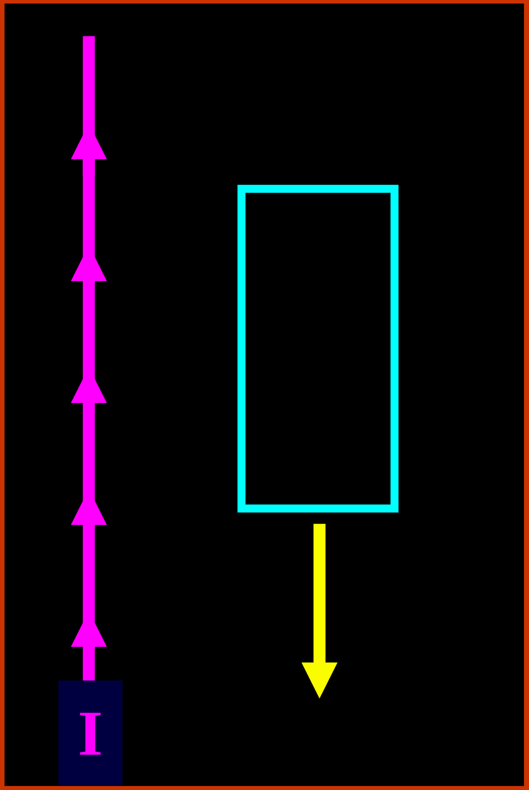
The magnetic flux is ***into the page*** on the right side of the wire and ***decreasing*** due to the fact that the loop is being pulled away. By Lenz's Law, the induced *B* field will ***oppose this decrease***. Thus, the new *B* field points ***into the page,*** which requires an induced ***clockwise*** current to produce such a *B* field.



Loop and Wire II

What is the induced current if the wire loop moves in the direction of the yellow arrow ?

1) clockwise
2) counterclockwise
3) no induced current

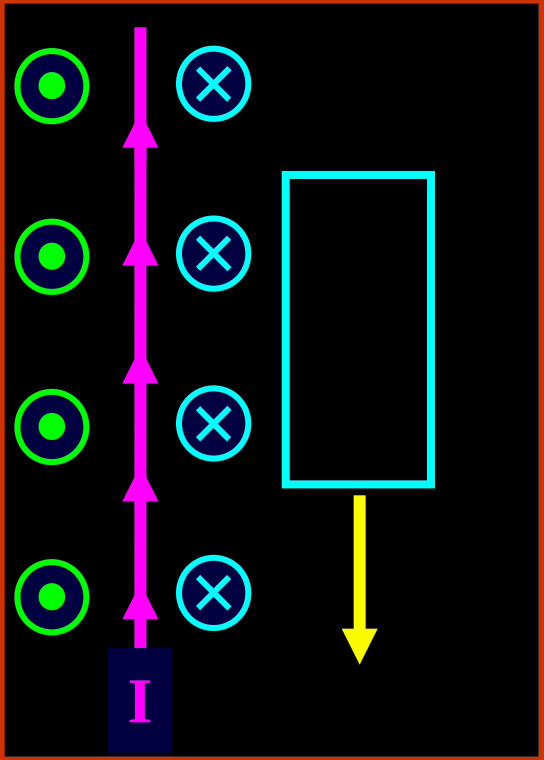


Loop and Wire II

What is the induced current if the wire loop moves in the direction of the yellow arrow ?

1) clockwise
2) counterclockwise
3) no induced current

The magnetic flux through the loop is not changing as it moves parallel to the wire. Therefore, there is no induced current.



Magic Loop

A wire loop is in a uniform magnetic field. Current flows in the wire loop, as shown. What does the loop do?

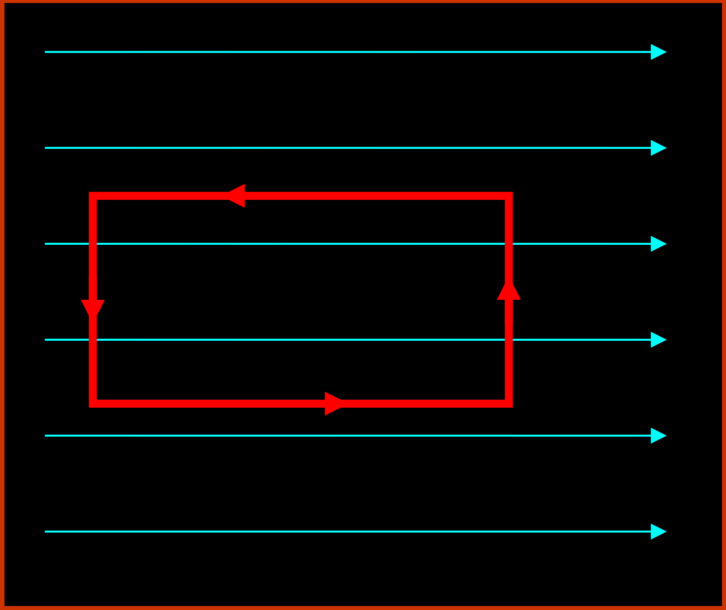
(1) moves to the right

(2) moves up

(3) remains motionless

(4) rotates

(5) moves out of the page



Magic Loop

A wire loop is in a uniform magnetic field. Current flows in the wire loop, as shown. What does the loop do?

(1) moves to the right

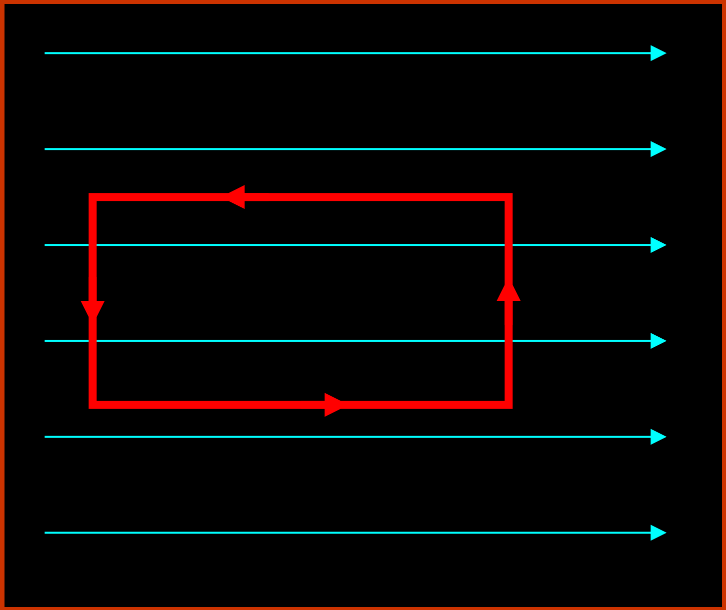
(2) moves up

(3) remains motionless

(4) rotates

(5) moves out of the page

There is no magnetic force on the top and bottom legs, since they are parallel to the *B* field. However, the magnetic force on the right side is into the page, and the magnetic force on the left side is out of the page. Therefore, the entire loop will tend to rotate.

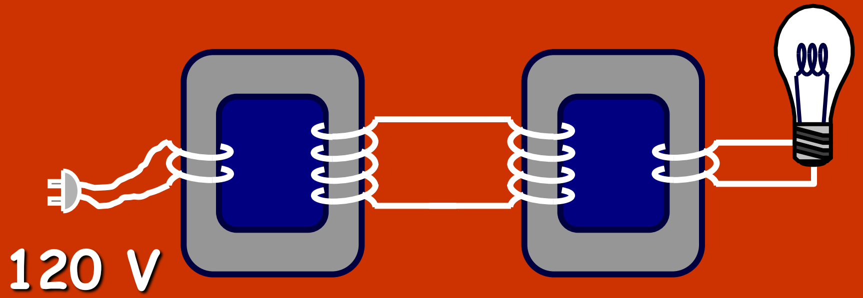


This is how a motor works !!

Transformers I

What is the voltage across the lightbulb?

1) 30 V
2) 60 V
3) 120 V
4) 240 V
5) 480 V

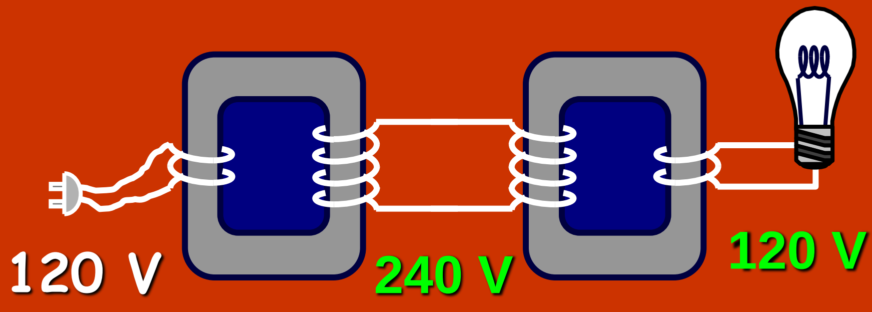


Transformers I

What is the voltage across the lightbulb?

1) 30 V
2) 60 V
3) 120 V
4) 240 V
5) 480 V

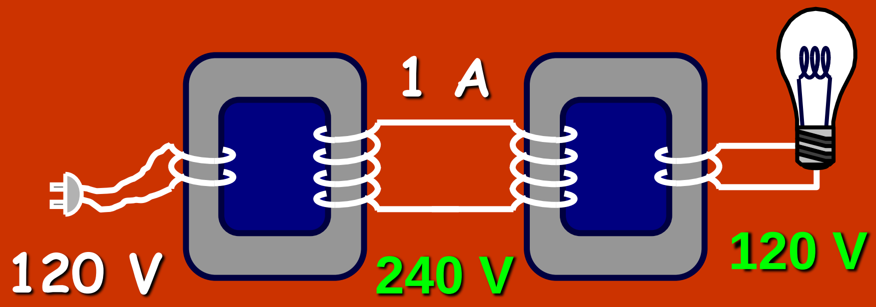
The first transformer has a 2:1 ratio of turns, so the voltage doubles. But the second transformer has a 1:2 ratio, so the voltage is halved again. Therefore, the end result is the same as the original voltage.



Transformers II

Given that the intermediate current is 1 A, what is the current through the lightbulb?

1) 1/4 A
2) 1/2 A
3) 1 A
4) 2 A
5) 5 A



Transformers II

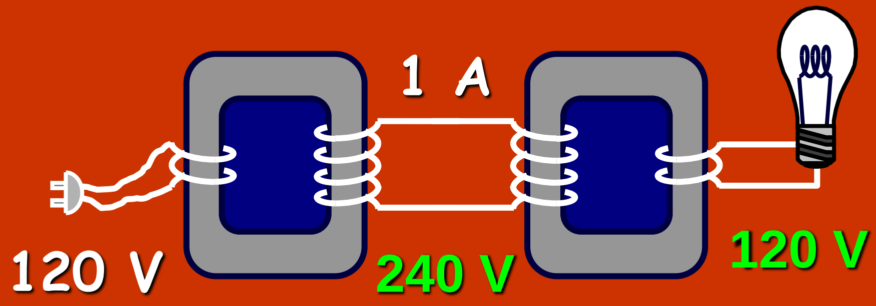
Given that the intermediate current is 1 A, what is the current through the lightbulb?

1) 1/4 A
2) 1/2 A
3) 1 A
4) 2 A
5) 5 A

Power in = Power out

$240\ V \times 1\ A = 120\ V \times ???$

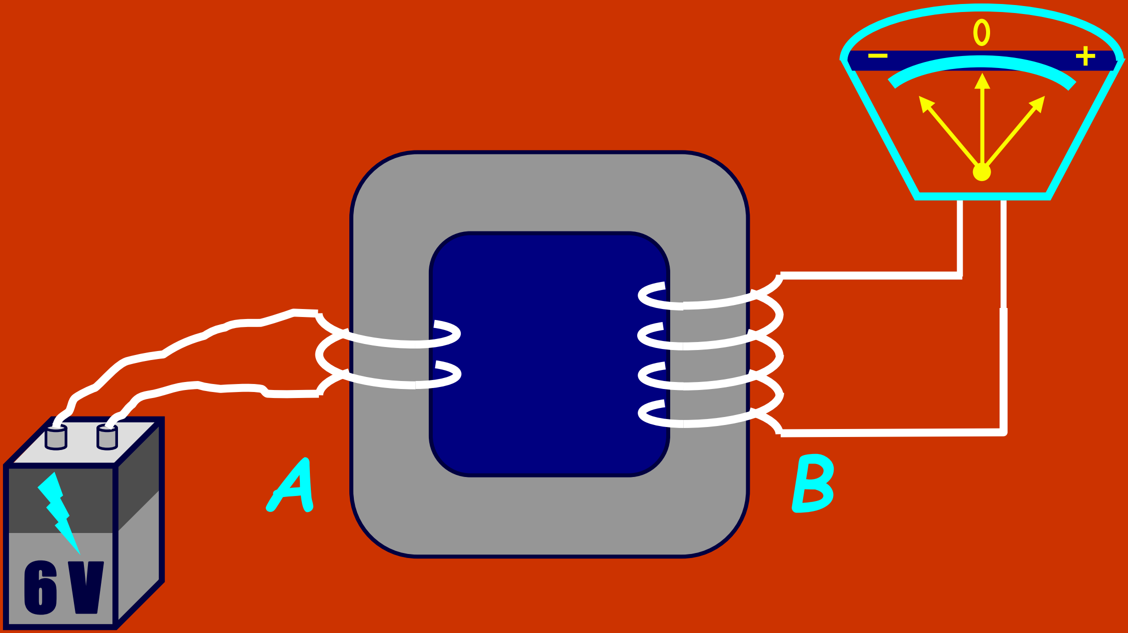
The unknown current is 2 A.



Transformers III

A 6 V battery is connected to one side of a transformer. Compared to the voltage drop across coil A, the voltage across coil B is:

1) greater than 6 V
2) 6 V
3) less than 6 V
4) zero



Transformers III

A 6 V battery is connected to one side of a transformer. Compared to the voltage drop across coil A, the voltage across coil B is:

1) greater than 6 V
2) 6 V
3) less than 6 V
4) zero

The voltage across B is zero. Only a changing magnetic flux induces an EMF. Batteries can only provide DC current.