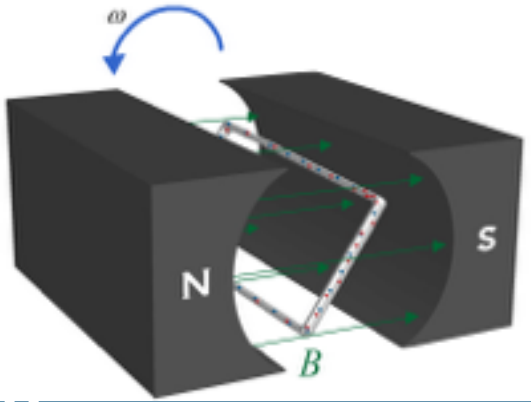
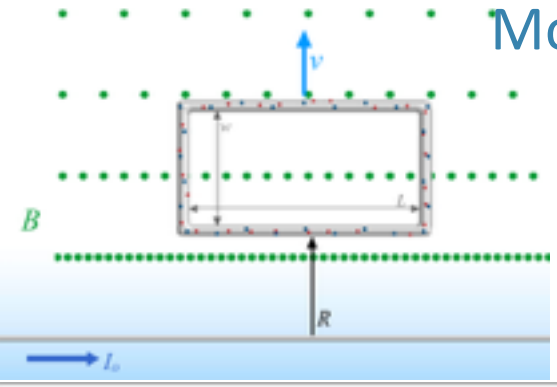
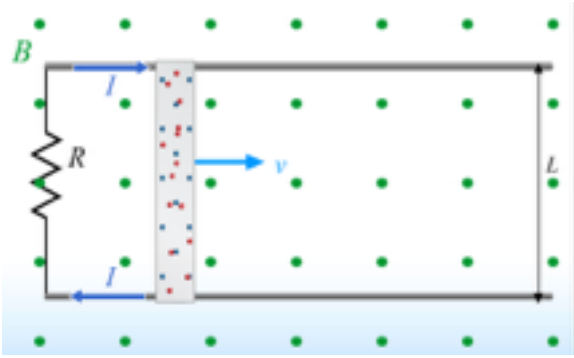


Electricity & Magnetism
Lecture 16

Today's Concept:

Motional EMF





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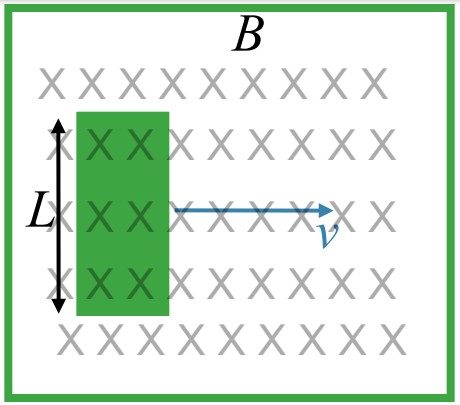
The Big Idea



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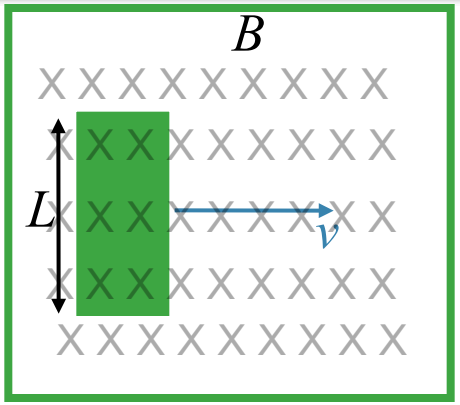
When a conductor moves through a region containing a magnetic field:



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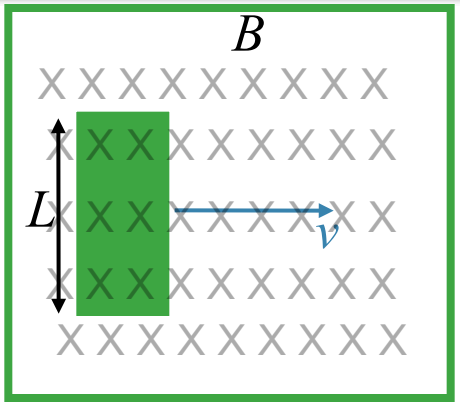
Magnetic forces may be exerted on the charge carriers in the conductor



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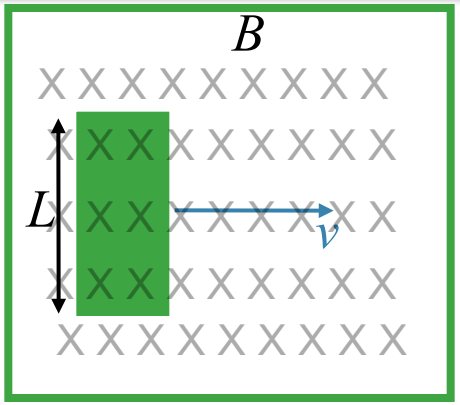

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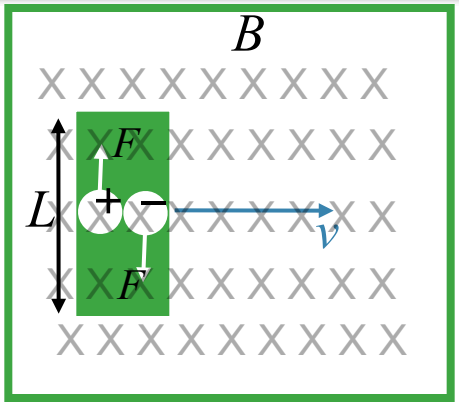

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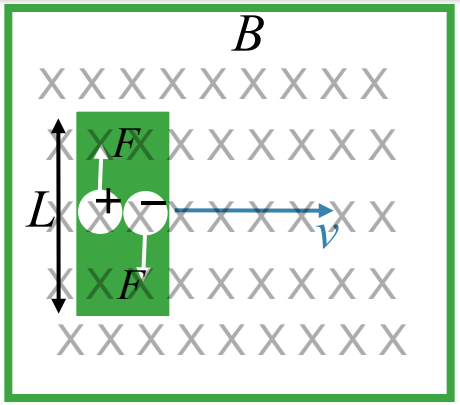

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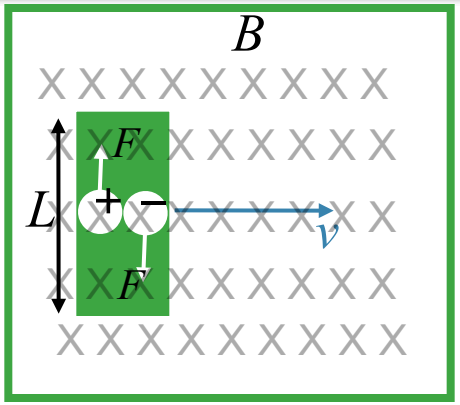

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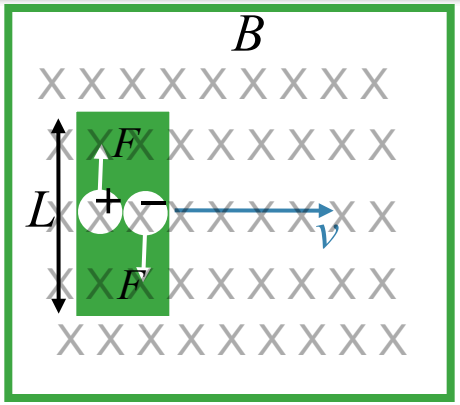

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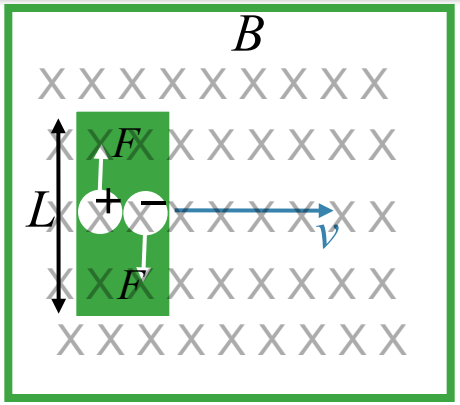

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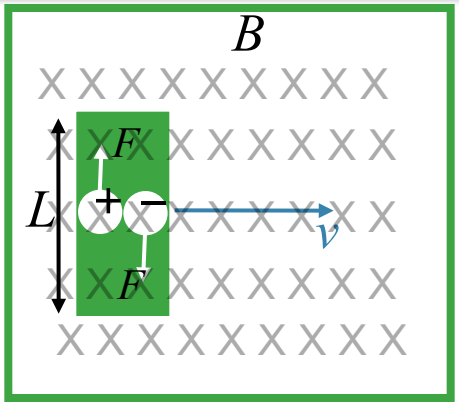

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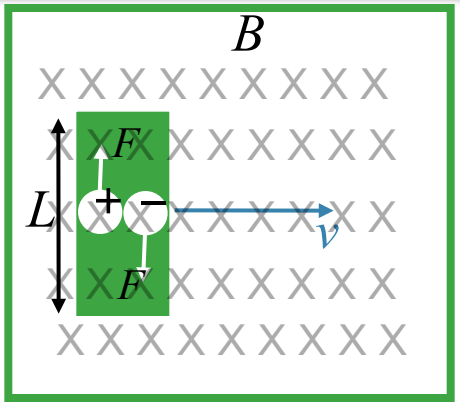

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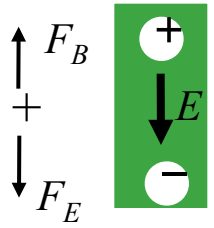

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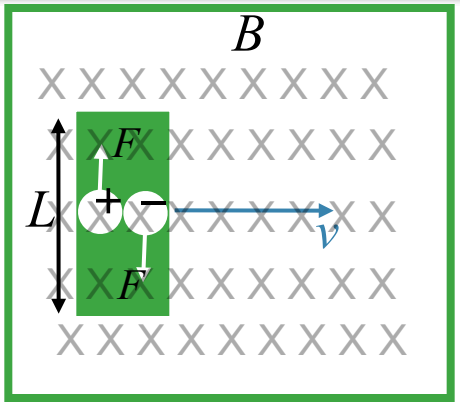

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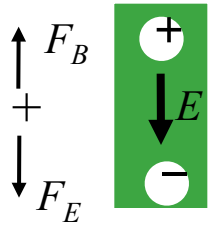

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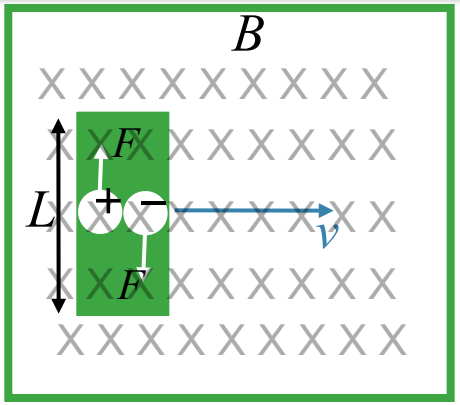

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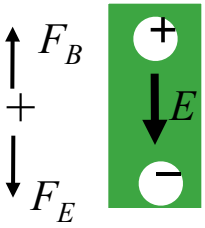

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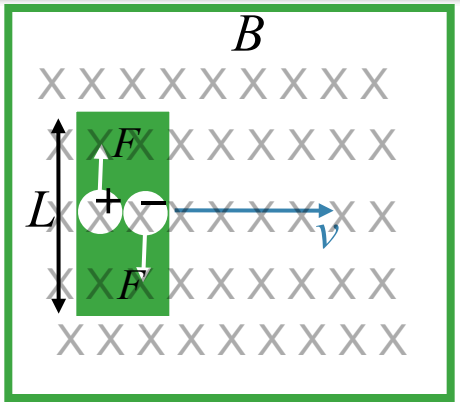

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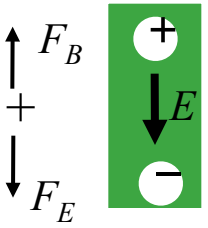

The equilibrium electric field produces a potential difference (emf) in the conductor

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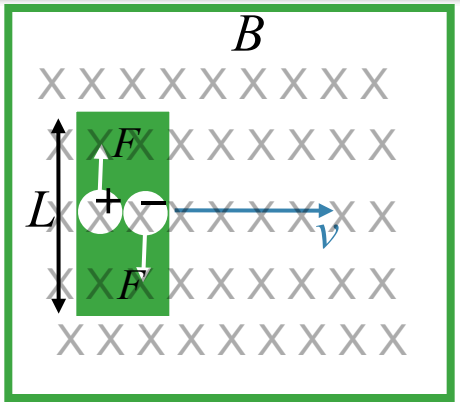

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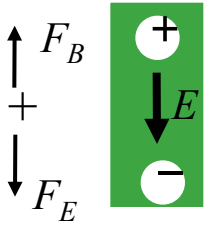

The equilibrium distribution is reached when the forces from the electric and magnetic fields cancel

The equilibrium electric field produces a potential difference (*emf*) in the conductor

$$V = EL$$

The Big Idea

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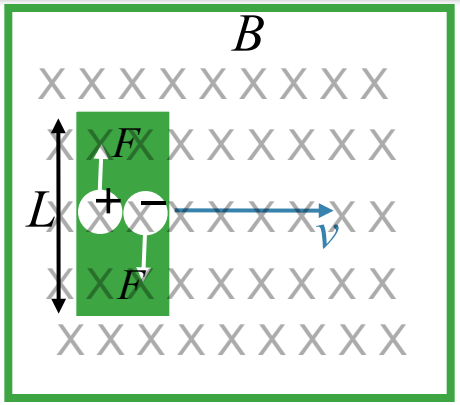

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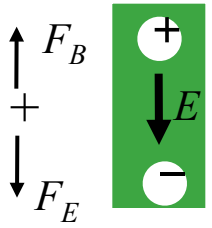

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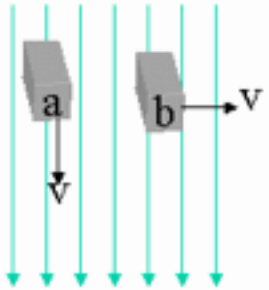
$$V = EL \rightarrow V = vBL$$

CheckPoint 2

Two identical conducting bars (shown in end view) are moving through a vertical magnetic field. Bar (a) is moving vertically and bar (b) is moving horizontally.



2) Which of the following statements is true?

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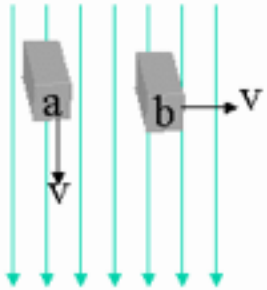

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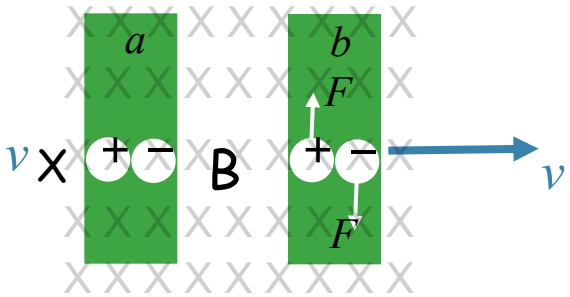

$$F_a = 0 \qquad F_b = qvB$$

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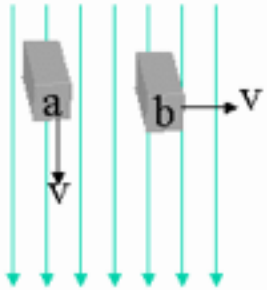

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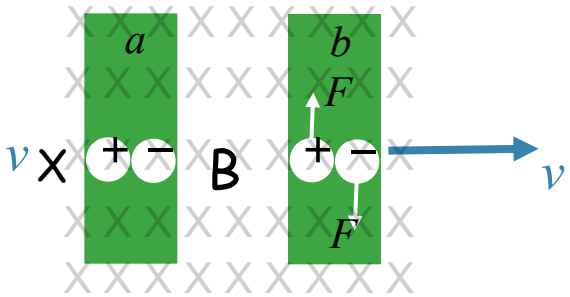
Bar *a*

No force on charges
No charge separation
No *E* field
No *emf*

Rotate picture by 90°



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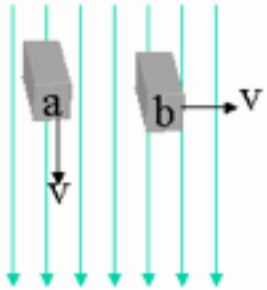

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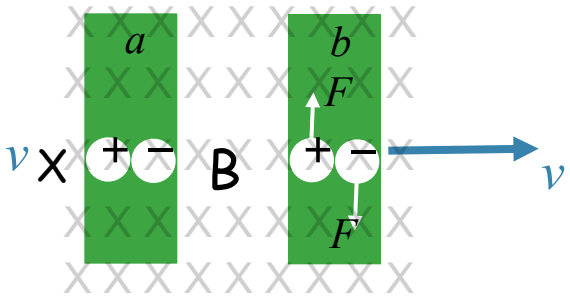

$F_a = 0$ $\quad F_b = qvB$

Bar a

No force on charges
No charge separation
No E field
No emf

Bar b

Opposite forces on charges
Charge separation
$E = vB$
$emf = EL = vBL$

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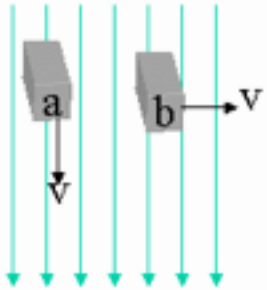

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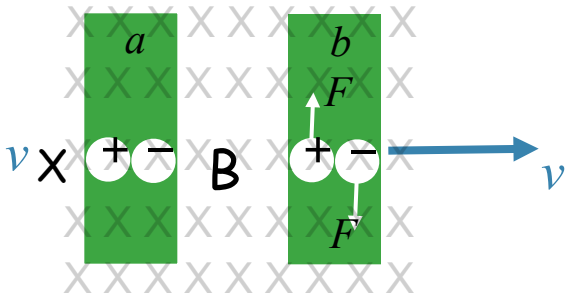

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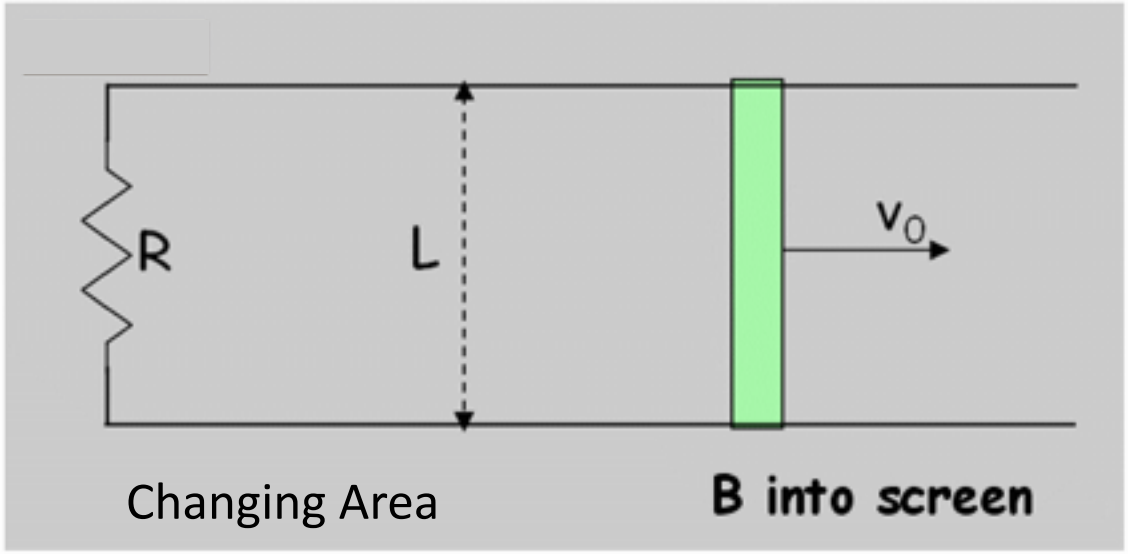
CheckPoint 4

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



The entire apparatus is placed in a uniform magnetic field pointing into the screen, and the bar is given an initial velocity to the right.

4) The motion of the green bar creates a current through the bar

A ○ going up

B ○ going down

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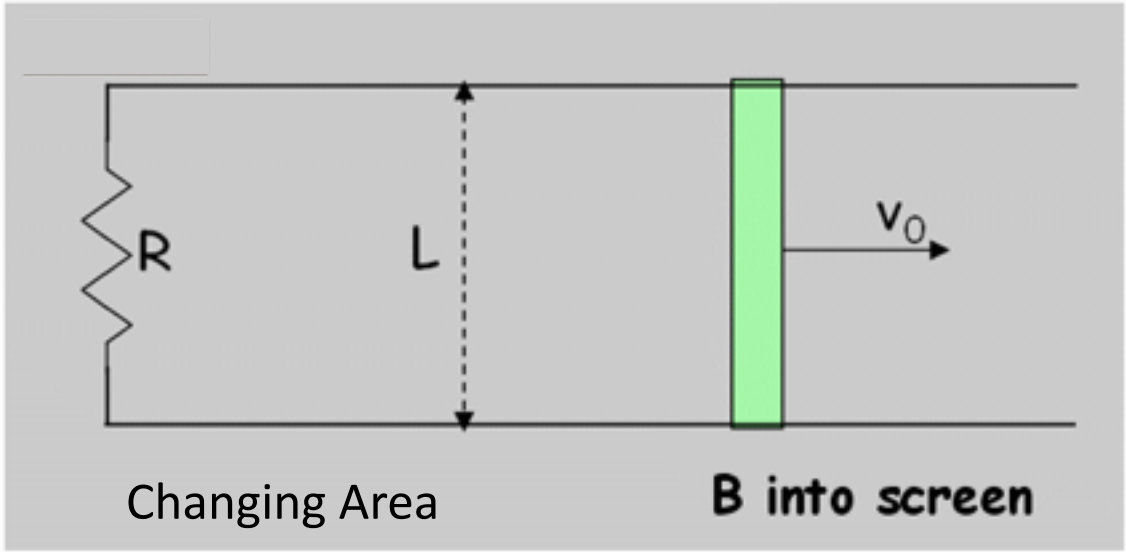
A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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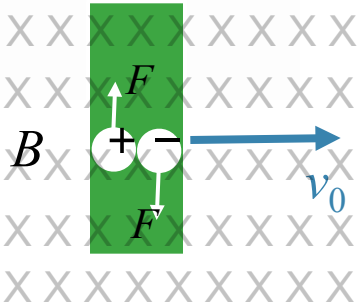

$$F_b = qv_0B$$

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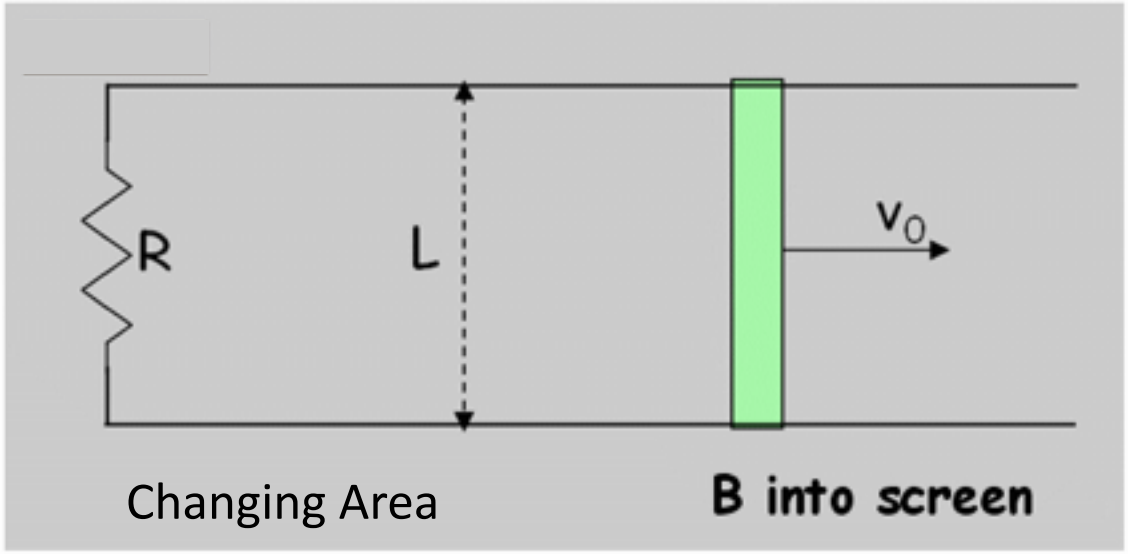

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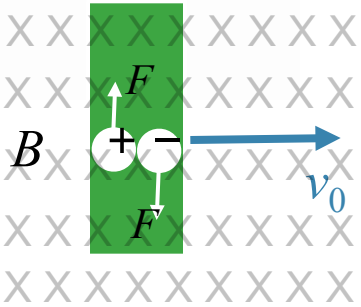
Bar

Opposite forces on charges

Charge separation

$E = v_0 B$

$emf = EL = v_0 BL$



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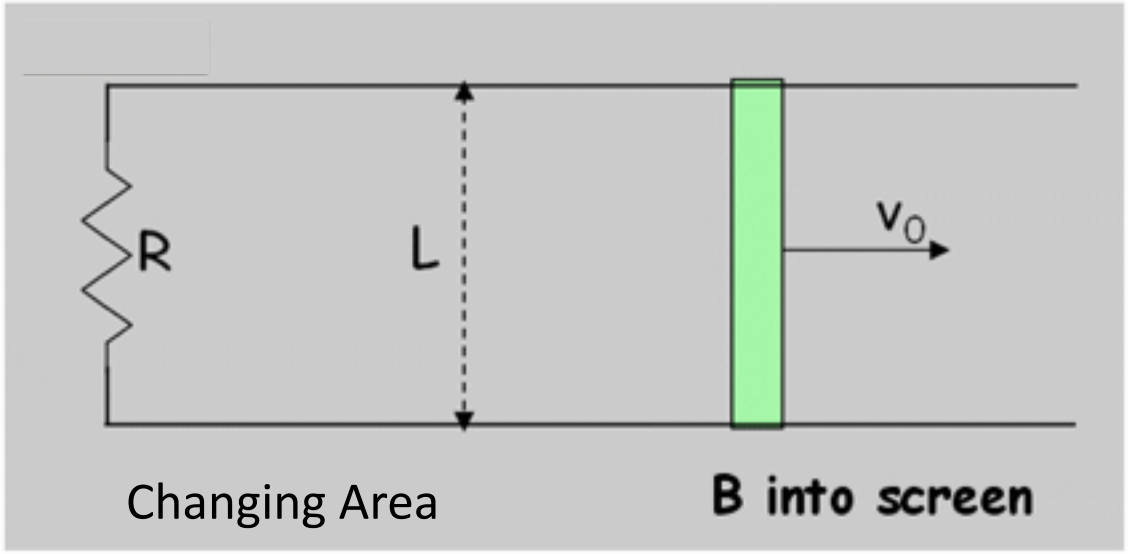


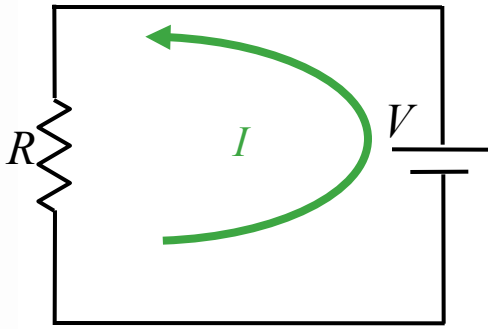
The entire apparatus is placed in a uniform magnetic field pointing into the screen, and the bar is given an initial velocity to the right.

4) The motion of the green bar creates a current through the bar

A ○ going up

B ○ going down

Equivalent circuit



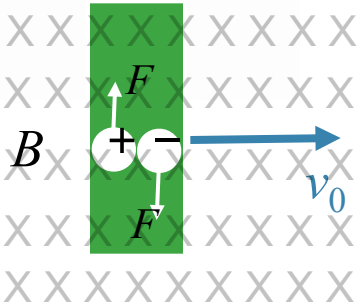
Bar

Opposite forces on charges

Charge separation

$E = v_0 B$

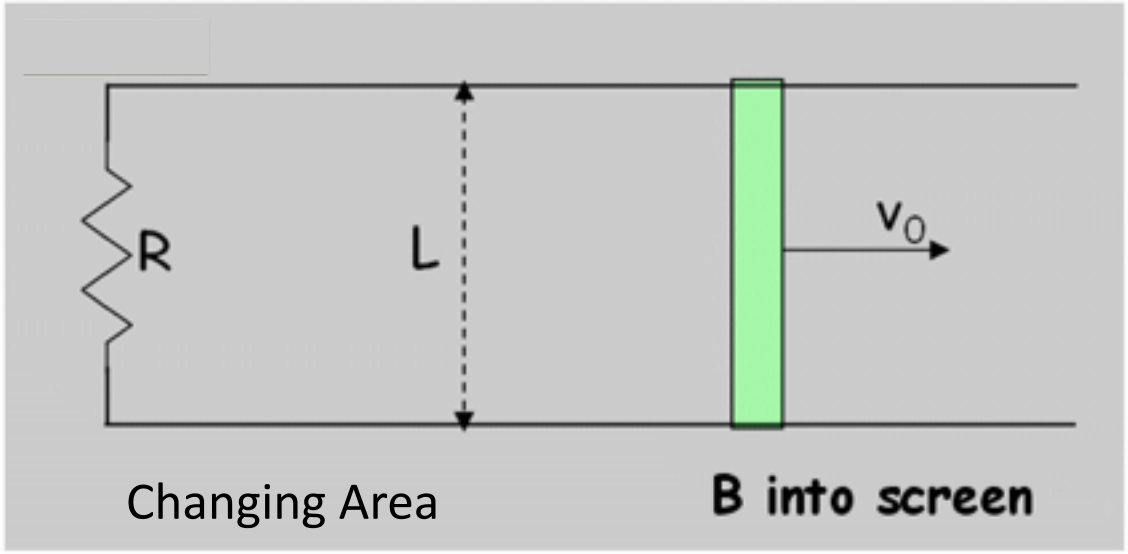
$emf = EL = v_0 BL$



$$F_b = qv_0 B$$

CheckPoint 4

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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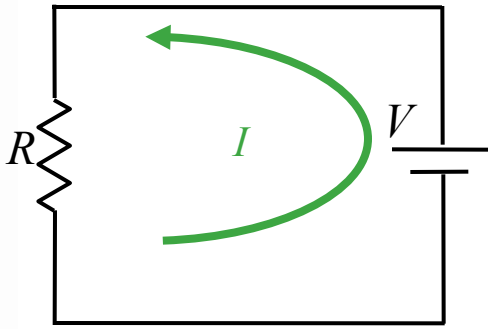

Bar

Opposite forces on charges

Charge separation

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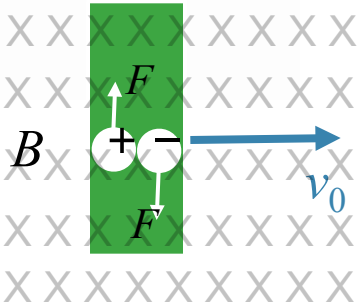
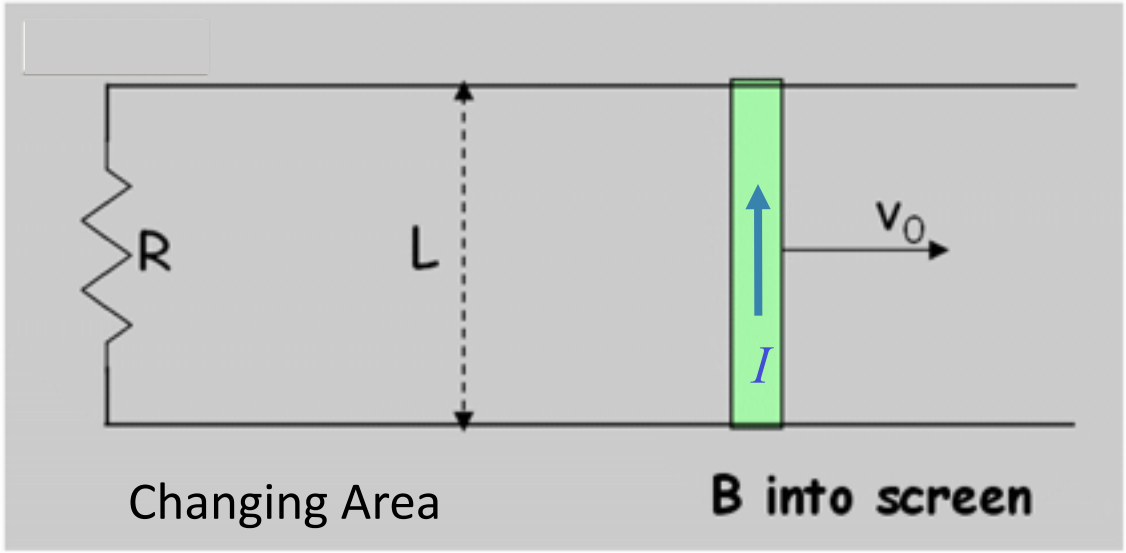


$$F_b = qv_0 B$$

CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



The entire apparatus is placed in a uniform magnetic field pointing into the screen, and the bar is given an initial velocity to the right.

5) The current through this bar results in a force on the bar

A ○ down
B ○ up
C ○ right
D ○ left
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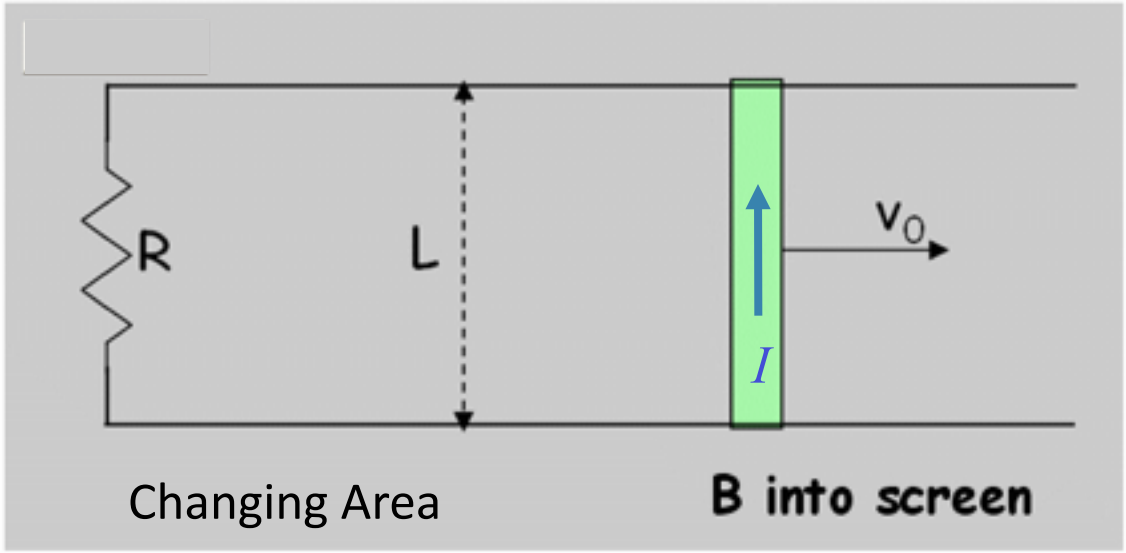
CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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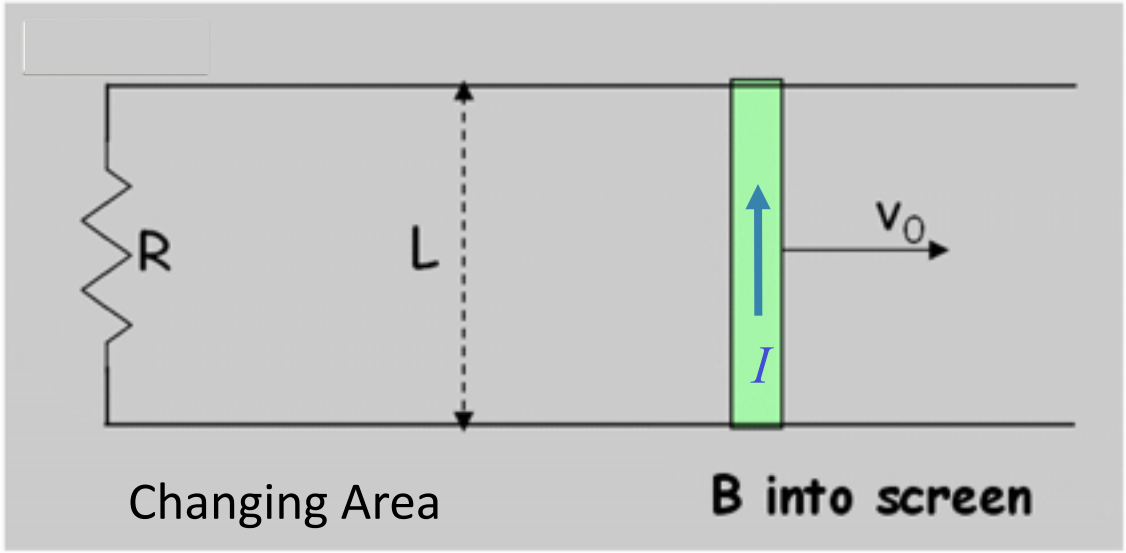
Counterclockwise Current

CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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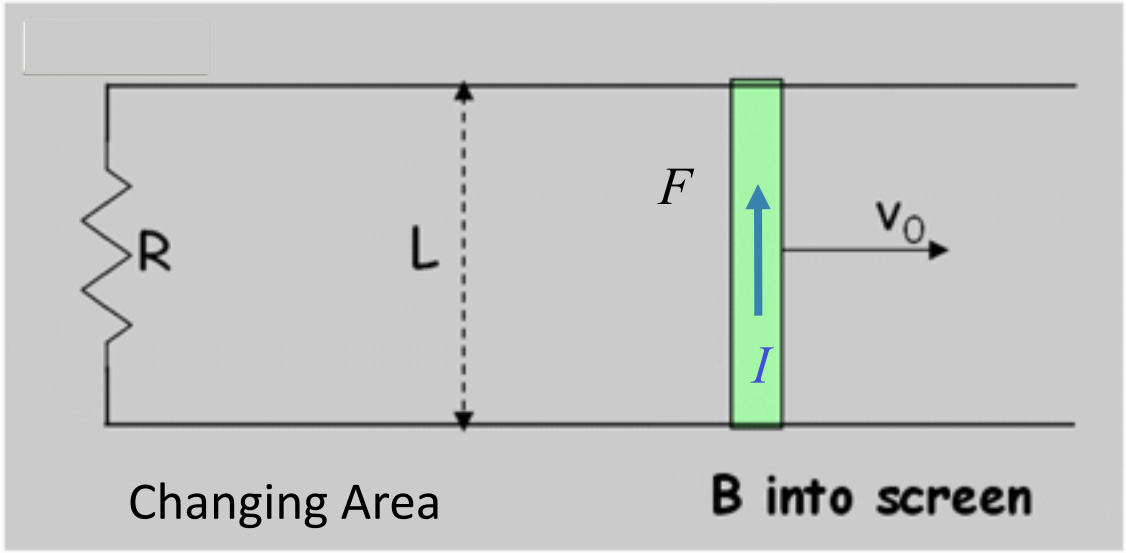
Counterclockwise Current

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

CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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

F points to left

CheckPoint 5

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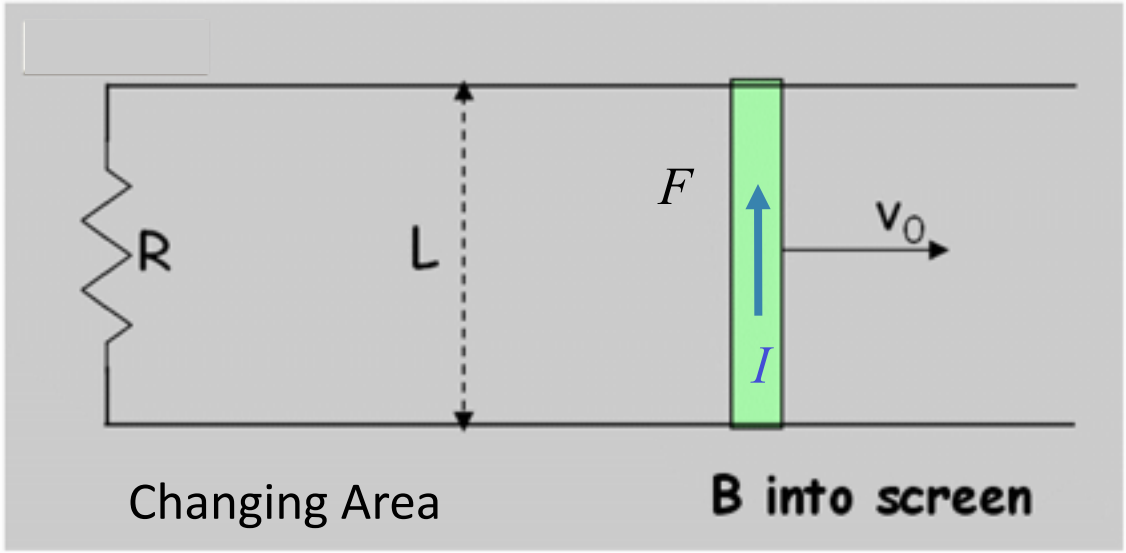

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Counterclockwise Current

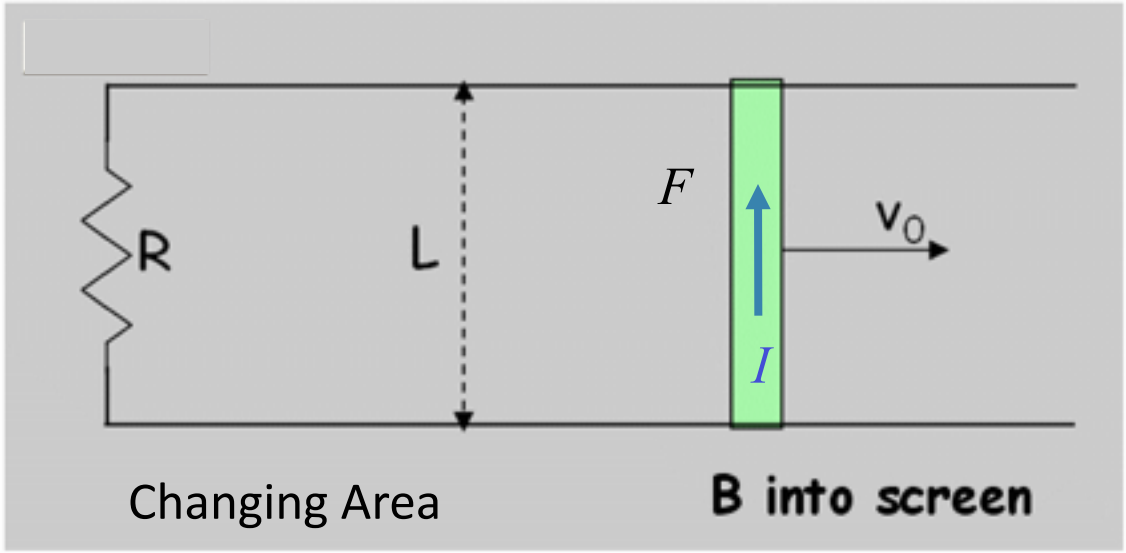
$$\vec{F} = I\vec{L} \times \vec{B}$$

F points to left

CheckPoint 5

Energy

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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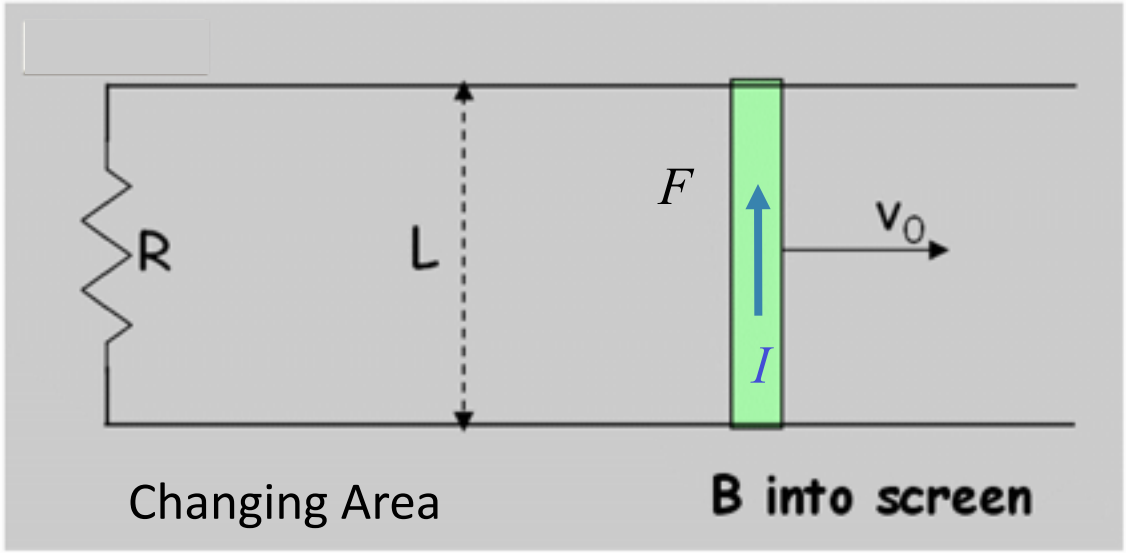

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Counterclockwise Current

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

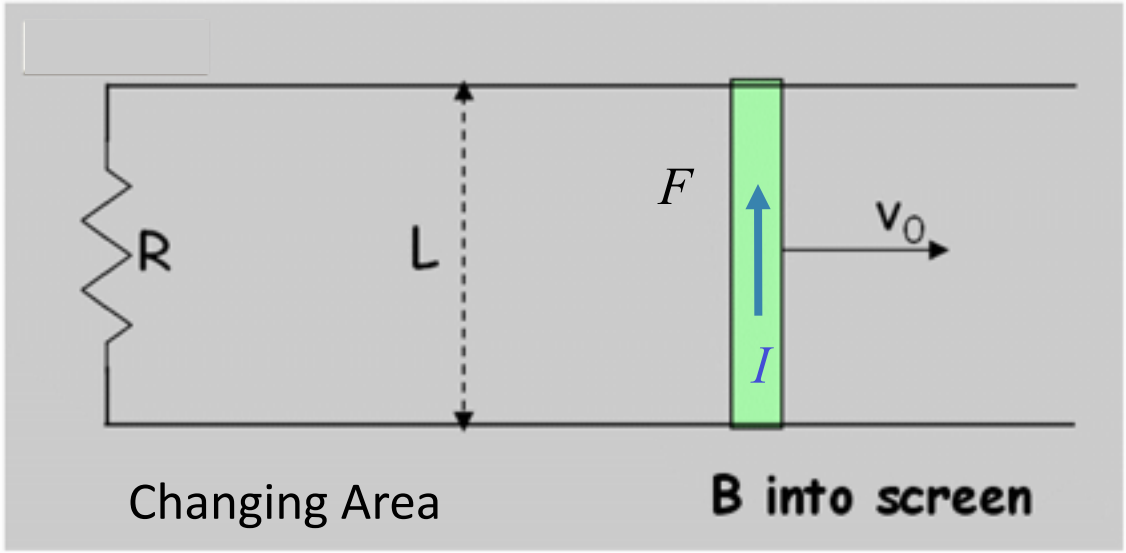
F points to left

Energy

External agent must exert force F to the right to maintain constant v

CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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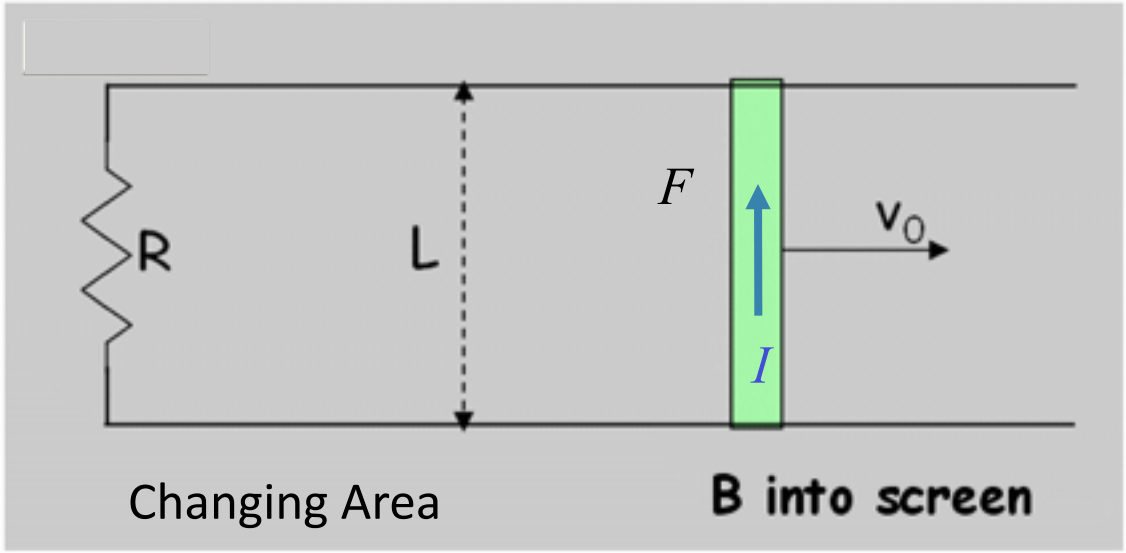

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Counterclockwise Current

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

F points to left

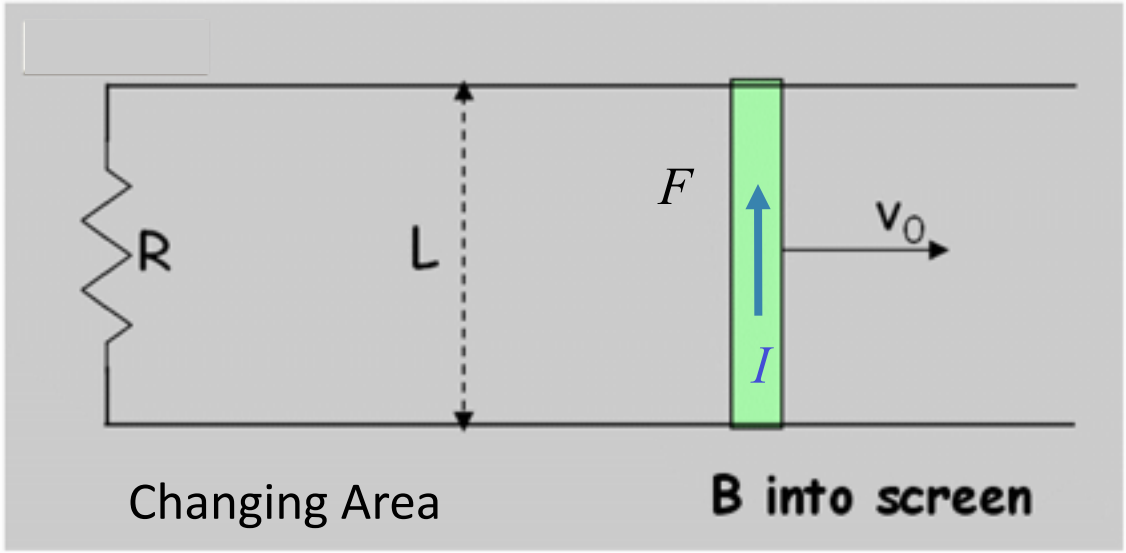
Energy

External agent must exert force F to the right to maintain constant v

This energy is dissipated in the resistor!

CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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E ○ into the screen
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Counterclockwise Current

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

F points to left

$$F = \left(\frac{vBL}{R}\right) LB$$

Energy

External agent must exert force F to the right to maintain constant v

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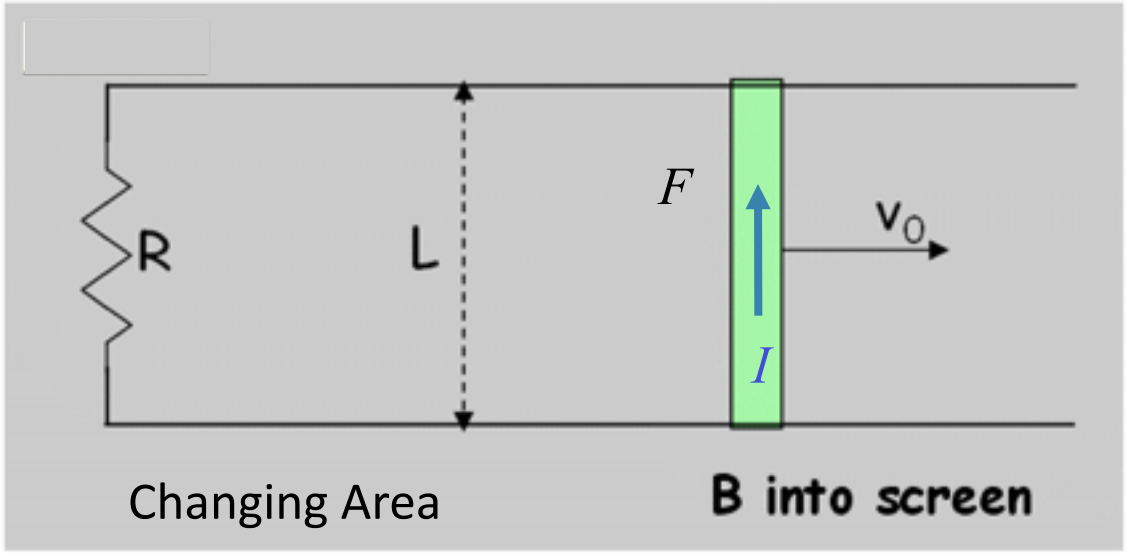
CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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Counterclockwise Current

$$\vec{F} = I\vec{L} \times \vec{B} \longrightarrow F \text{ points to left}$$

$$F = \left(\frac{vBL}{R}\right) LB$$

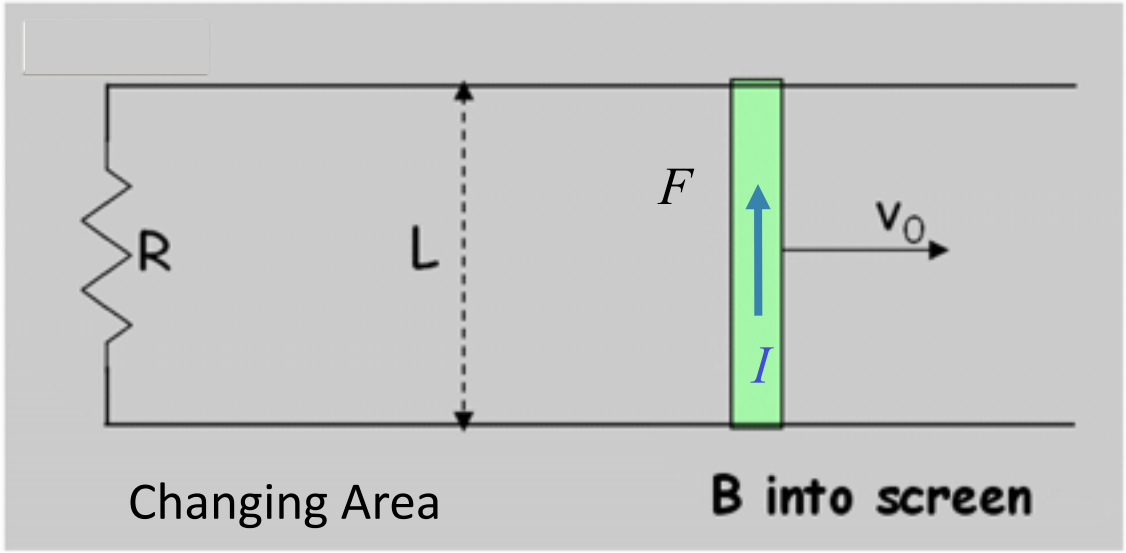
Energy

External agent must exert force F to the right to maintain constant v

This energy is dissipated in the resistor!

CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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○ out of the screen

Counterclockwise Current

$$\vec{F} = I\vec{L} \times \vec{B} \longrightarrow F \text{ points to left}$$

$$F = \left(\frac{vBL}{R}\right)LB \longrightarrow P = Fv = \left(\frac{vBL}{R}\right)LBv = I^2R$$

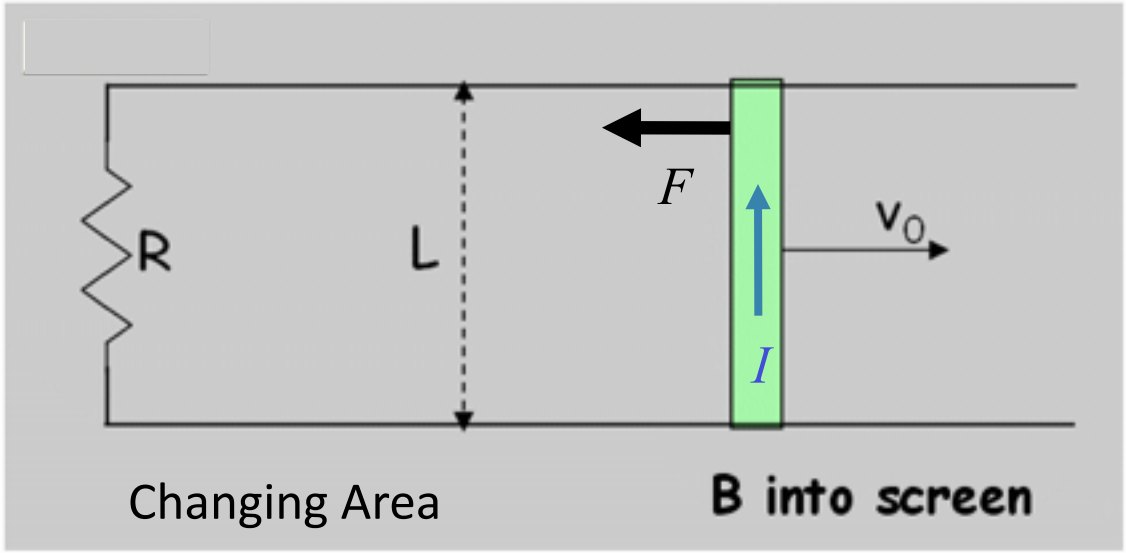
Energy

External agent must exert force F to the right to maintain constant v

This energy is dissipated in the resistor!

CheckPoint 5

A conducting bar (green) rests on two frictionless wires connected by a resistor as shown.



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Counterclockwise Current

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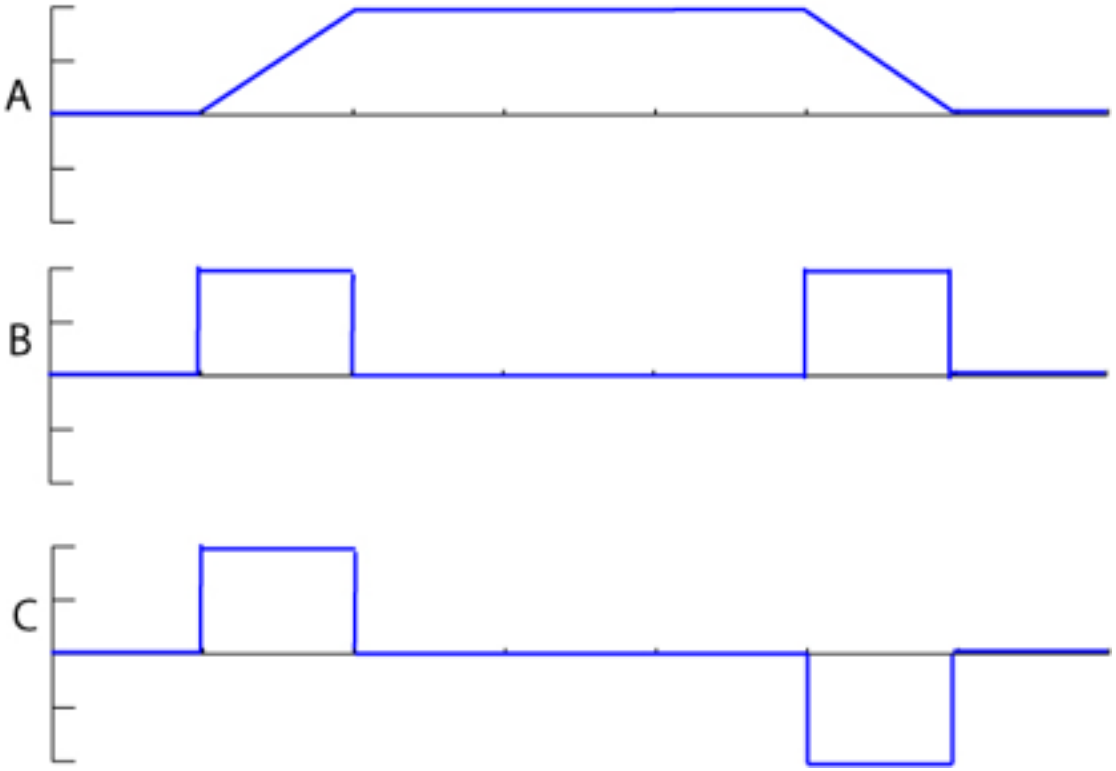
Energy

External agent must exert force F to the right to maintain constant v

This energy is dissipated in the resistor!

CheckPoint 11

A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.



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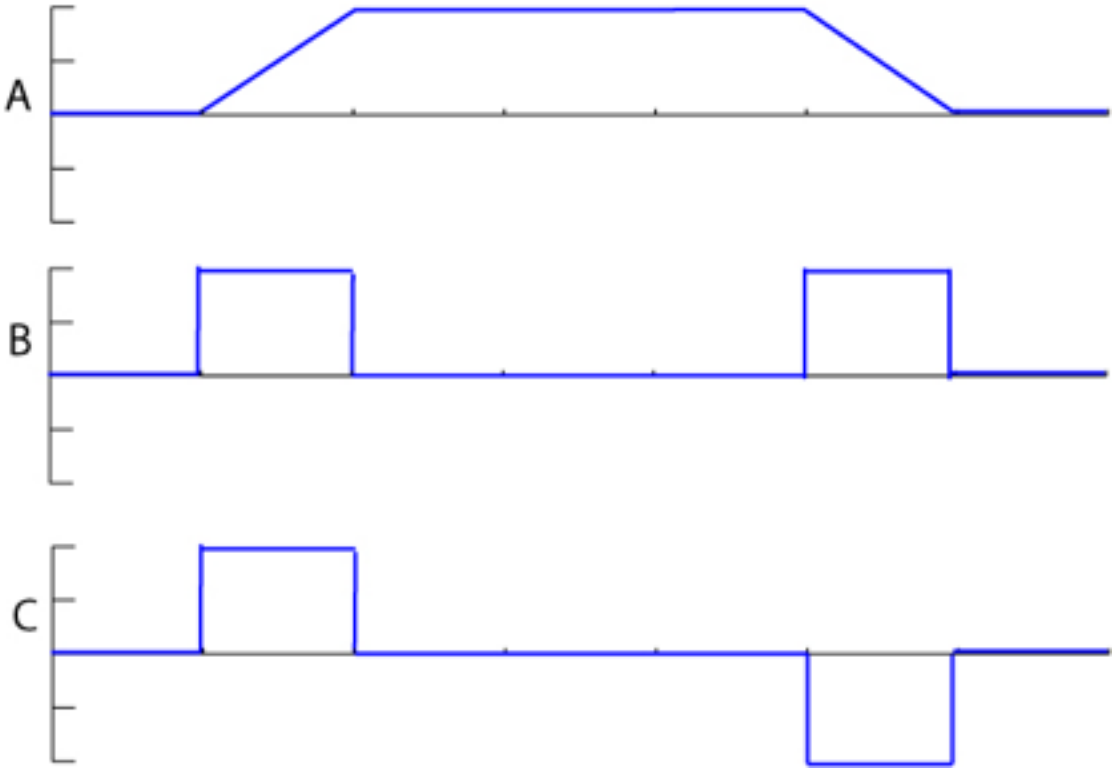
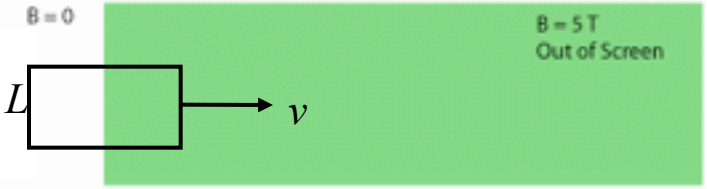


Let's step through this one

11) A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.



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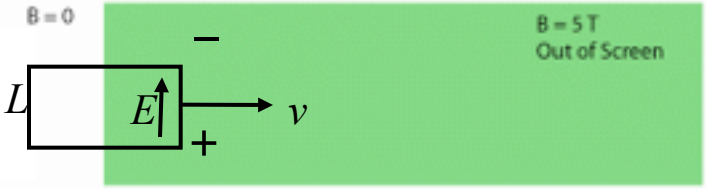

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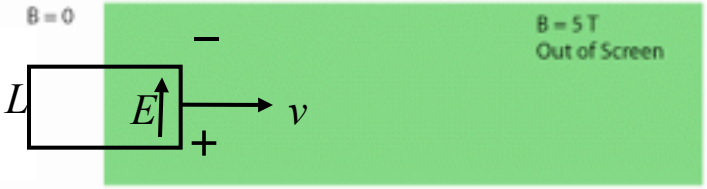
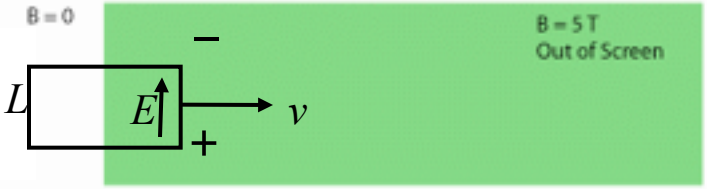
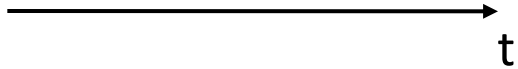


Only leading side has charge separation

$emf = BLv$ (cw current)

11) A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.





Only leading side has charge separation

$emf = BLv$ (cw current)

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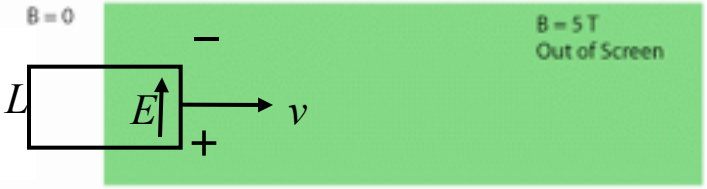

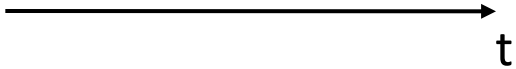

Only leading side has charge separation

$emf = BLv$ (*cw* current)

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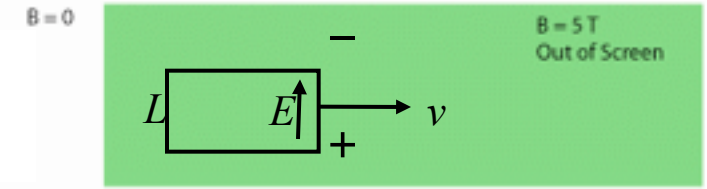

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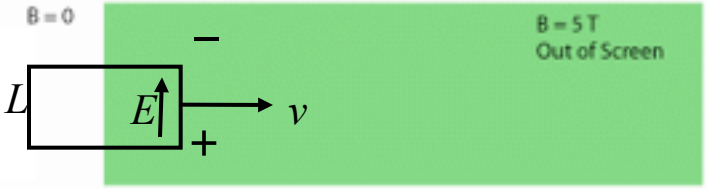

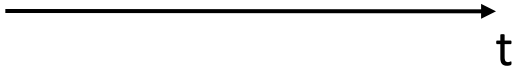

Only leading side has charge separation

$emf = BLv$ (cw current)

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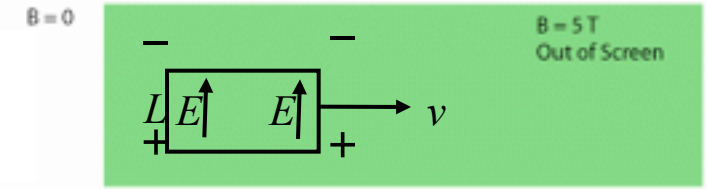

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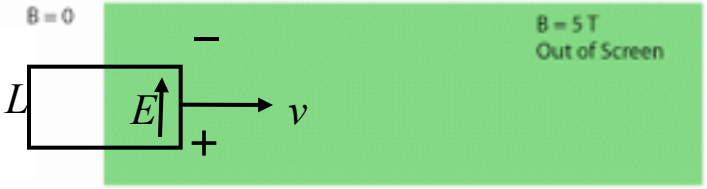

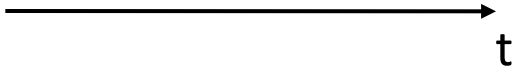

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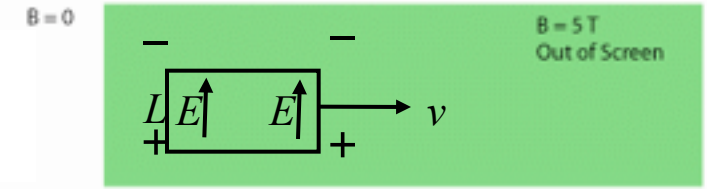

Leading and trailing sides have charge separation

$emf = BLv - BLv = 0$ (no current)

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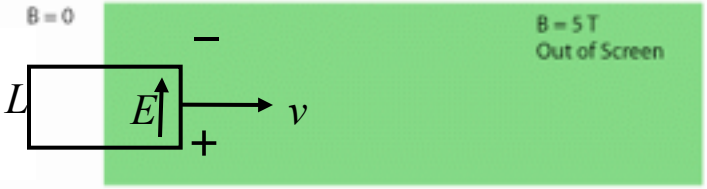
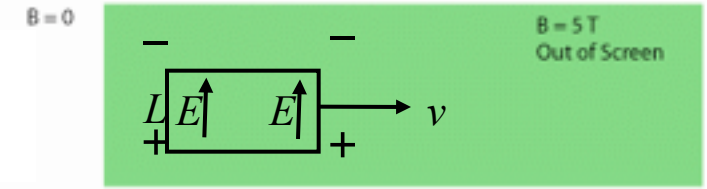
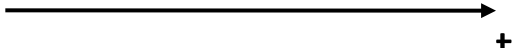


Only leading side has charge separation

$emf = BLv$ (cw current)

11) A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.

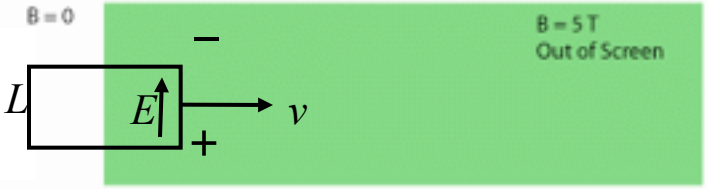




Leading and trailing sides have charge separation

$emf = BLv - BLv = 0$ (no current)

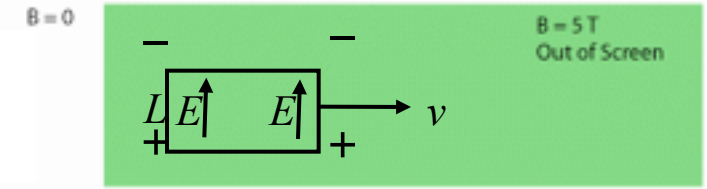
11) A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.

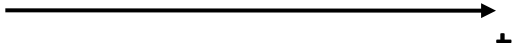


Only leading side has charge separation

$emf = BLv$ (*cw* current)

11) A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.





Leading and trailing sides have charge separation

$emf = BLv - BLv = 0$ (no current)

11) A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.

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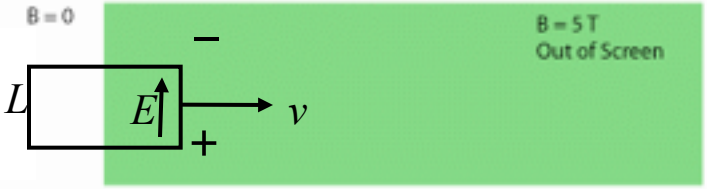
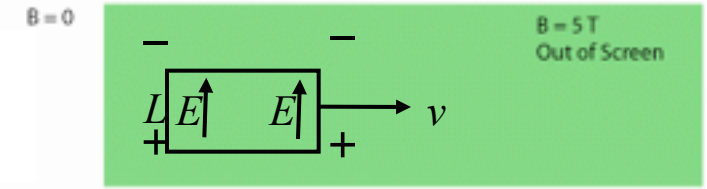
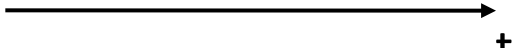


Only leading side has charge separation

$emf = BLv$ (cw current)

11) A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.





Leading and trailing sides have charge separation

$emf = BLv - BLv = 0$ (no current)

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Only trailing side has charge separation

$emf = BLv$ (ccw current)

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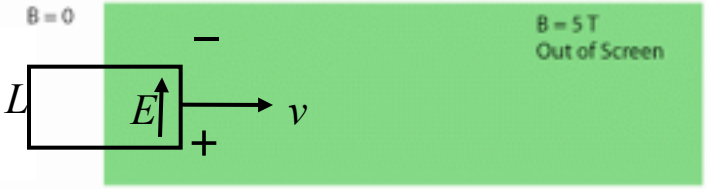

Only leading side has charge separation

$emf = BLv$ (cw current)

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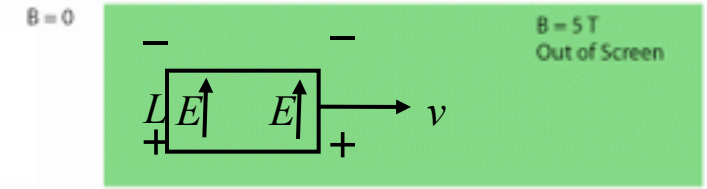

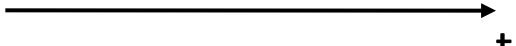

Leading and trailing sides have charge separation

$emf = BLv - BLv = 0$ (no current)

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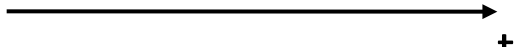
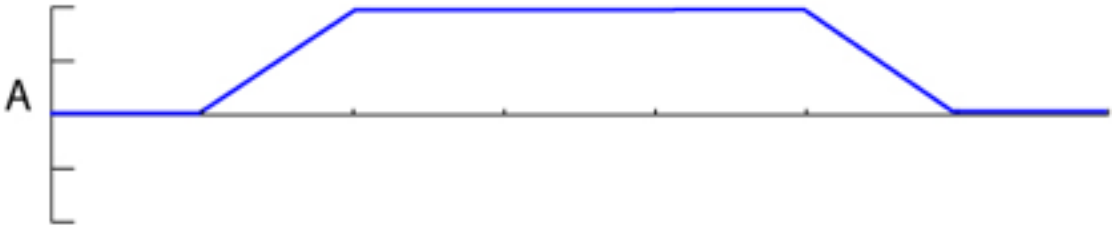


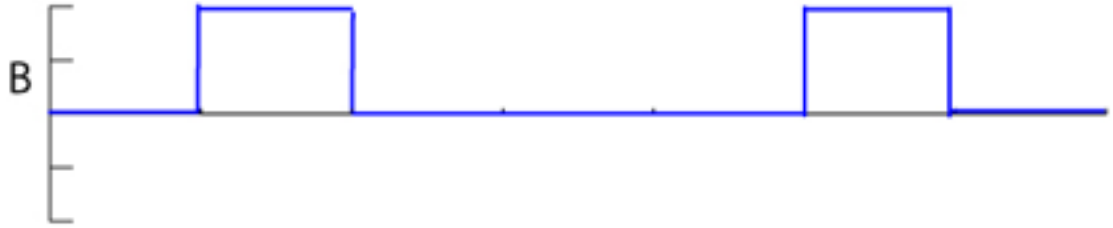
Only trailing side has charge separation

$emf = BLv$ (ccw current)

CheckPoint 11

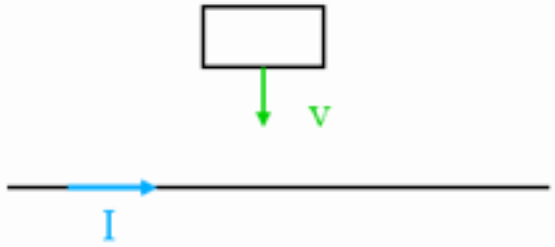
A wire loop travels to the right at a constant velocity. Which plot best represents the induced current in the loop as it travels from left of the region of magnetic field, through the magnetic field, and then entirely out of the field on the right side.





Changing B Field

6) A conducting rectangular loop moves with velocity v towards an infinite straight wire carrying current as shown.



In what direction is the induced current in the loop?

A clockwise
B counter-clockwise
C there is no induced current in the loop

Changing B Field

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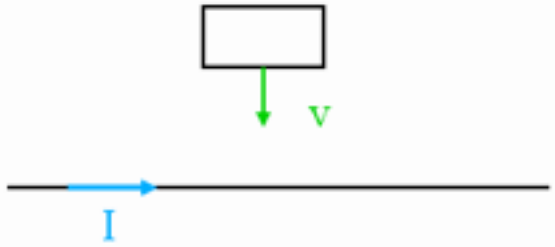

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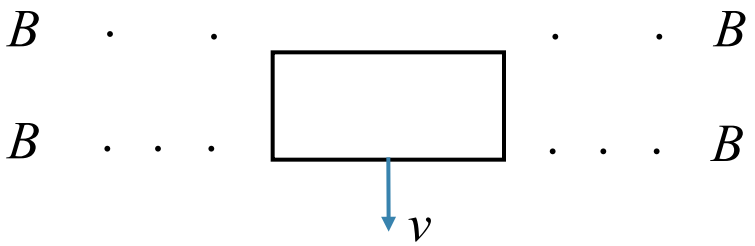

I

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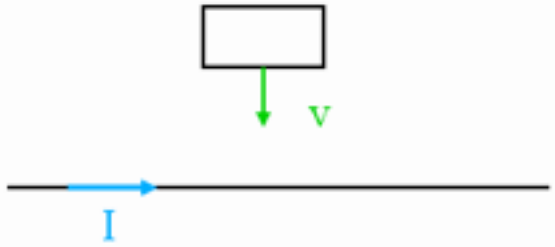

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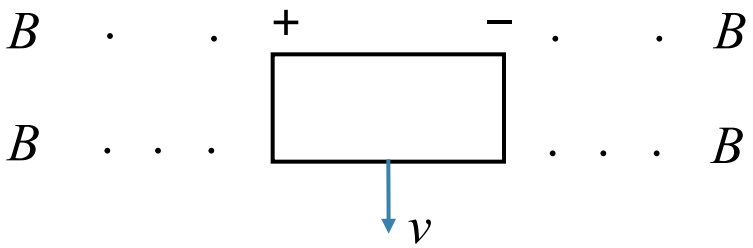

I

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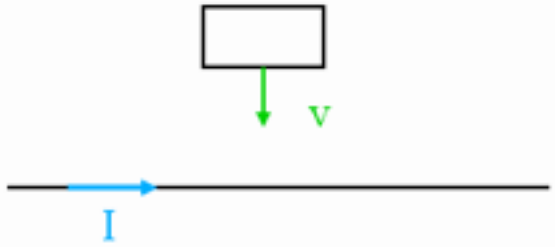

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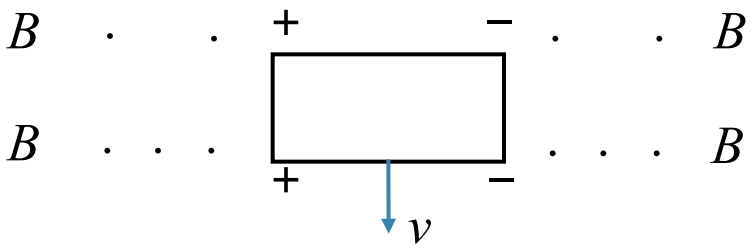

I

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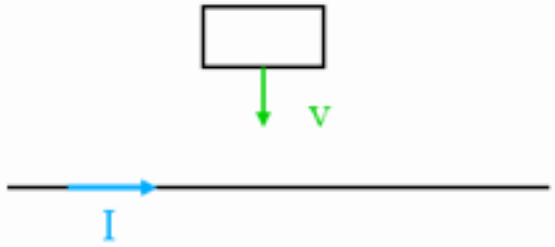

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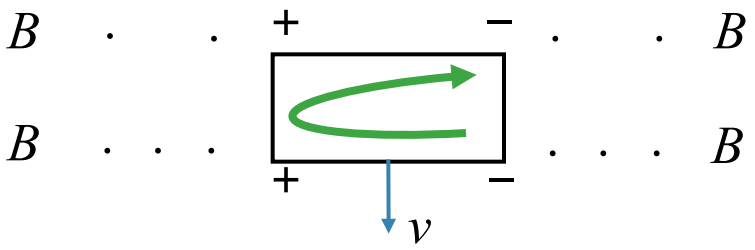

I

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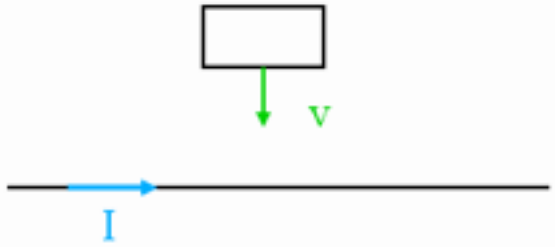

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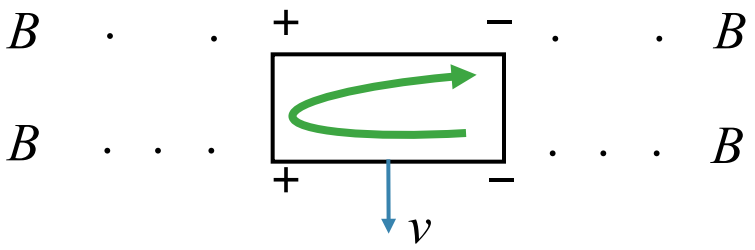
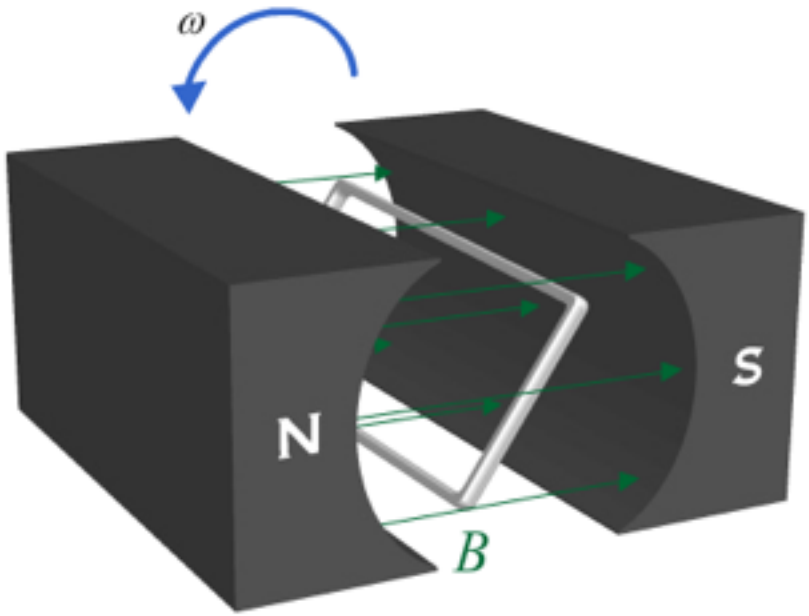
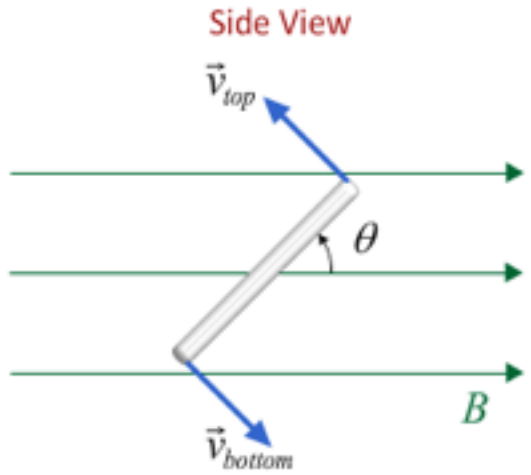


I

Generator: Changing Orientation



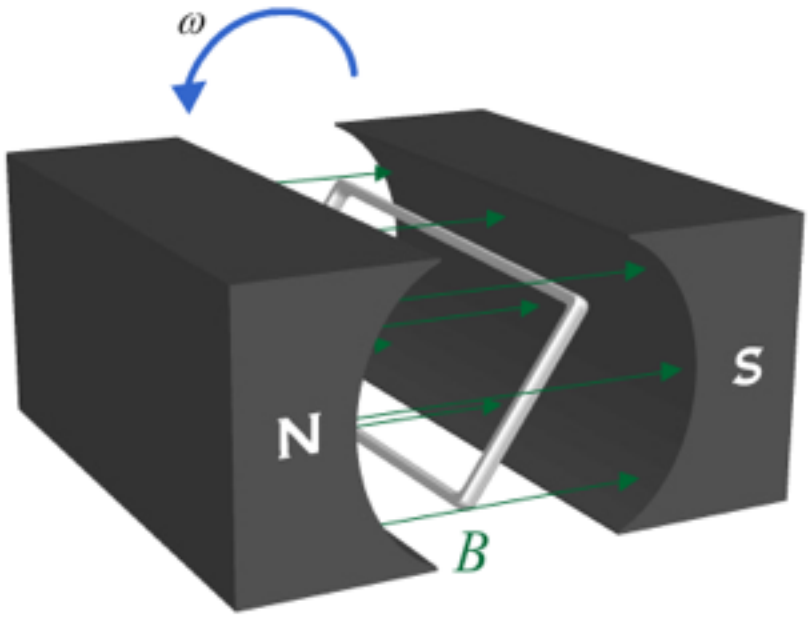


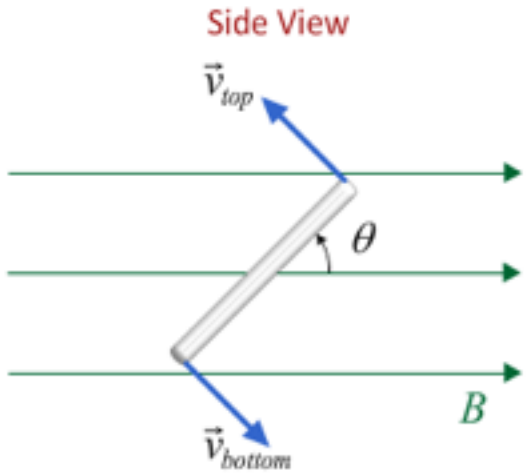
On which legs of the loop is charge separated?

A) Top and Bottom legs only
B) Front and Back legs only
C) All legs
D) None of the legs

Perpendicular to front and back legs

Generator: Changing Orientation





On which legs of the loop is charge separated?

A) Top and Bottom legs only
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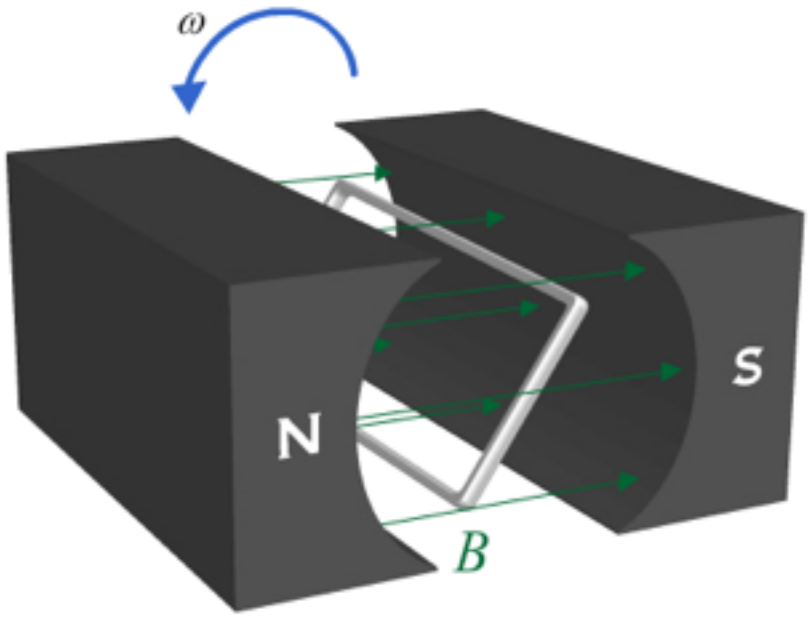
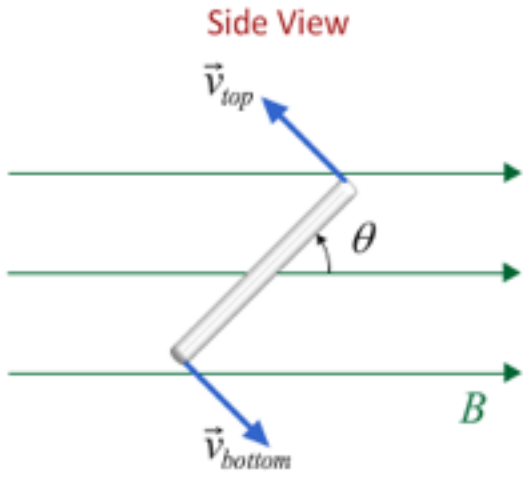
C) All legs
D) None of the legs

$\vec{v} \times \vec{B}$

Perpendicular to front and back legs

Generator: Changing Orientation





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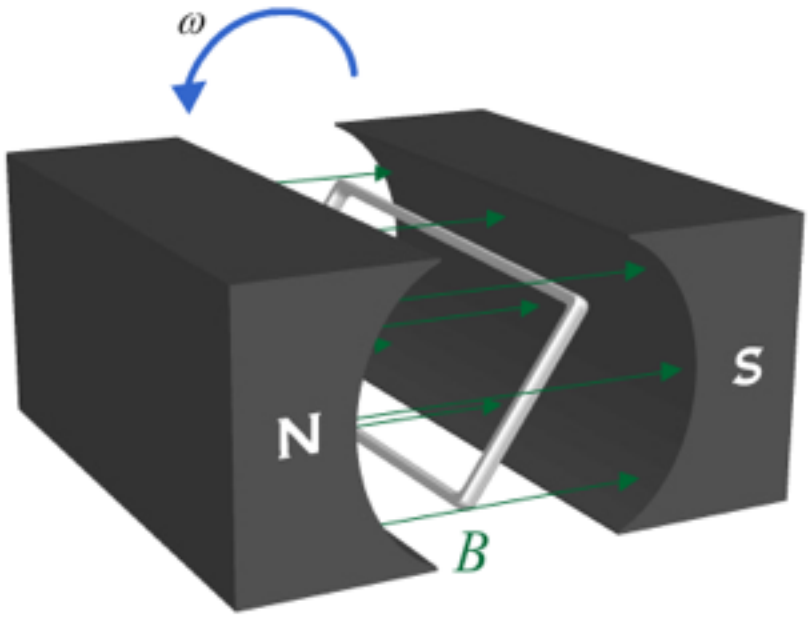
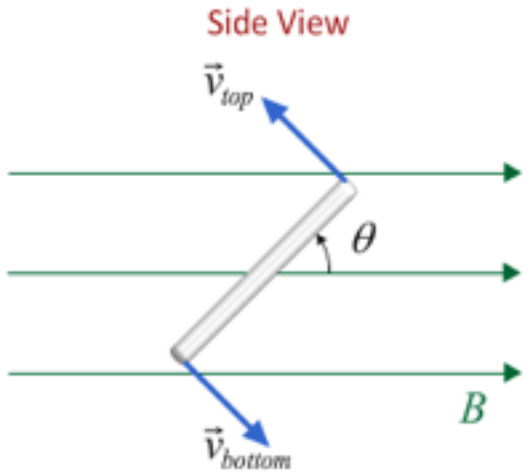
$\vec{v} \times \vec{B}$

Parallel to top and bottom legs

Perpendicular to front and back legs

Generator: Changing Orientation





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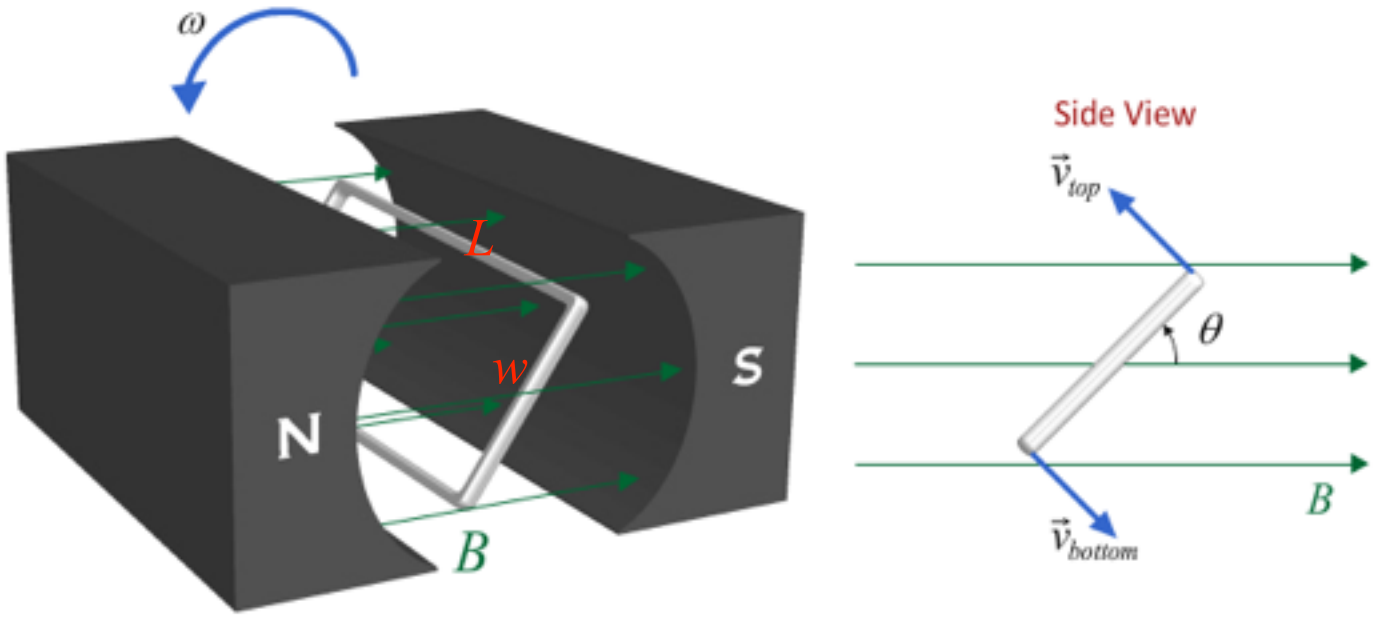


At what angle θ is *emf* the largest?

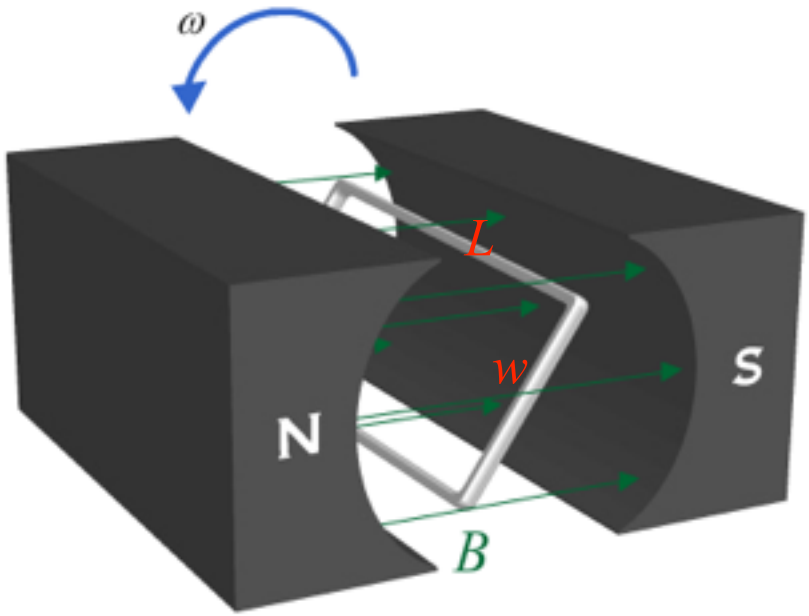
A) θ = 0

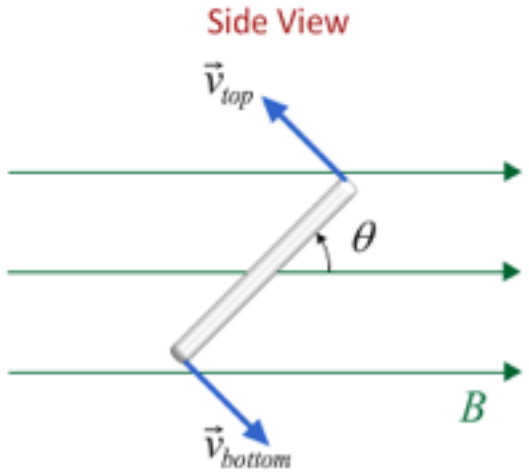
B) θ = 45°

C) θ = 90°

D) *emf* is same at all angles

Generator: Changing Orientation





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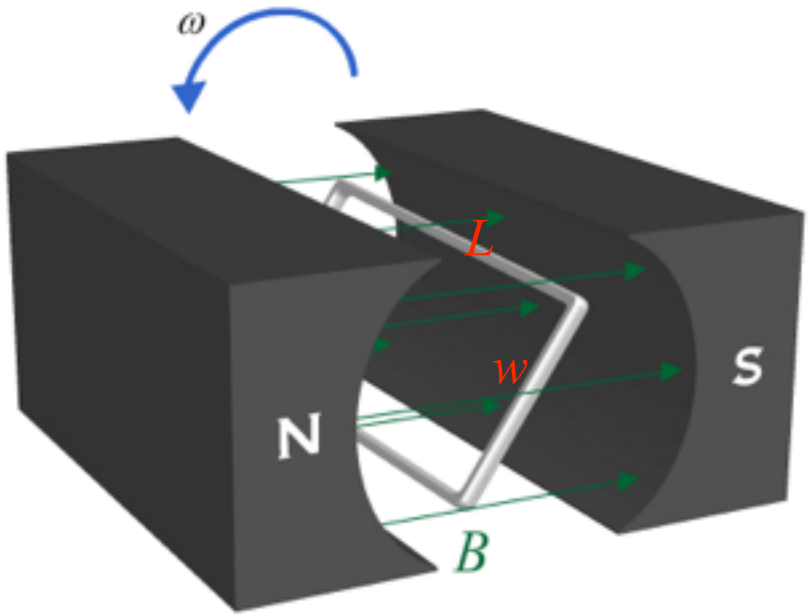

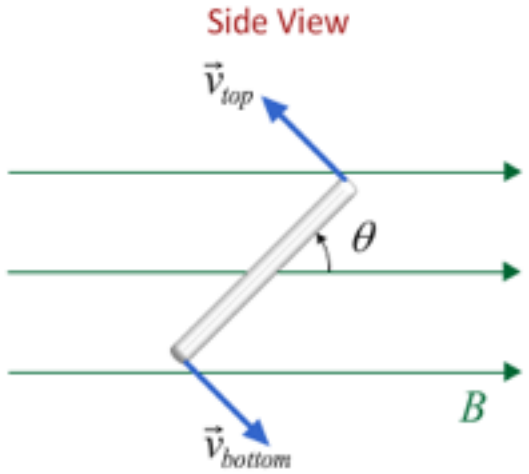

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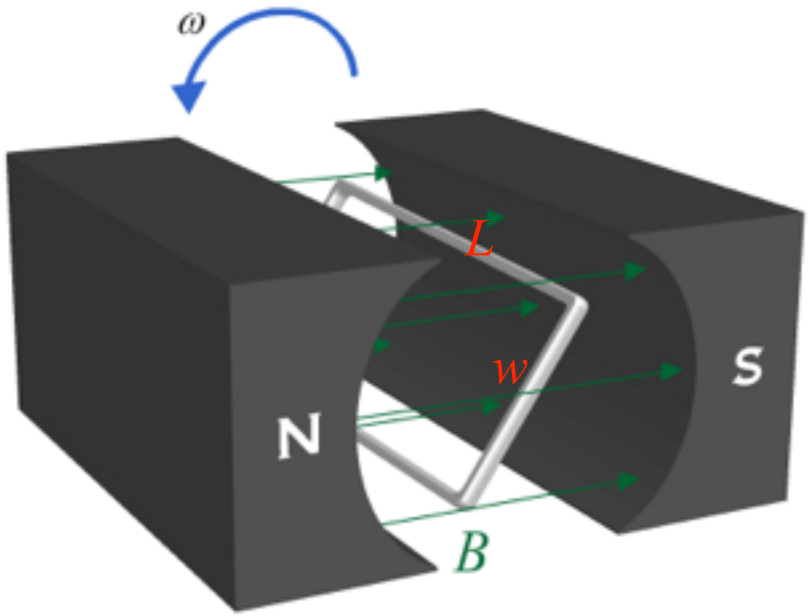
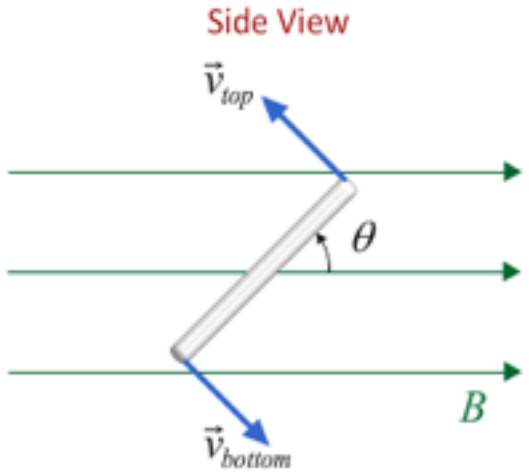
$\vec{v} \times \vec{B}$

Largest for θ = 0 (v perp to B)

Generator: Changing Orientation





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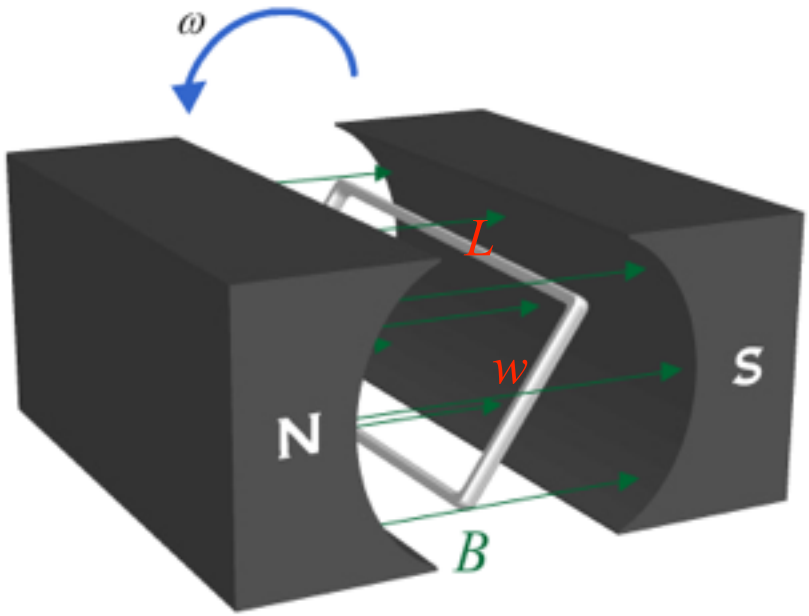
D) *emf* is same at all angles

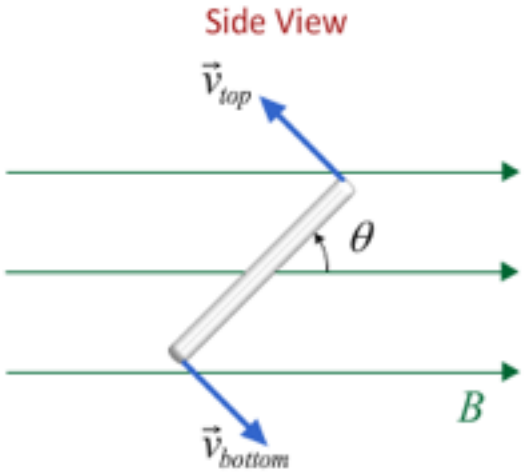
$\vec{v} \times \vec{B}$

Largest for θ = 0 (v perp to B)

$$\mathcal{E} = 2EL = 2\frac{F}{q}L = 2L|\vec{v} \times \vec{B}| = 2L\left(\frac{w}{2}\right)\omega B\cos\theta = \omega AB\cos(\omega t)$$

Generator: Changing Orientation





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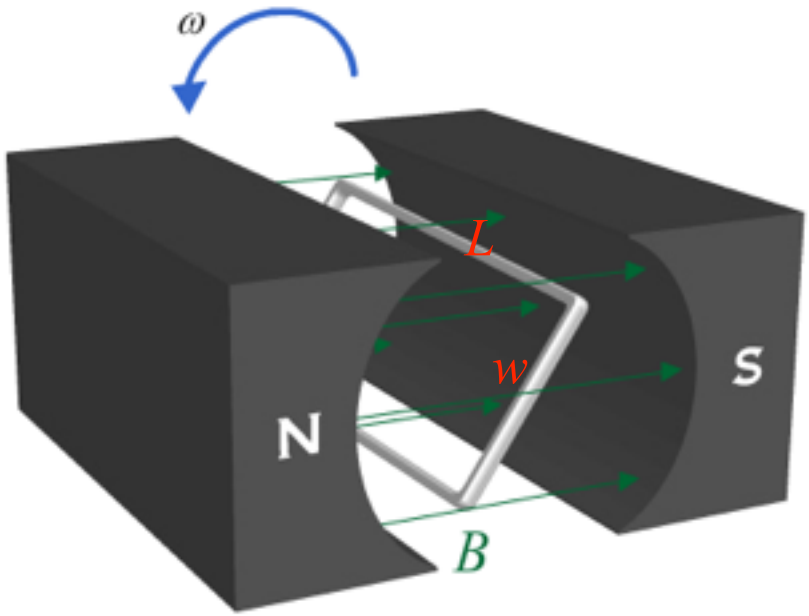
$\vec{v} \times \vec{B}$

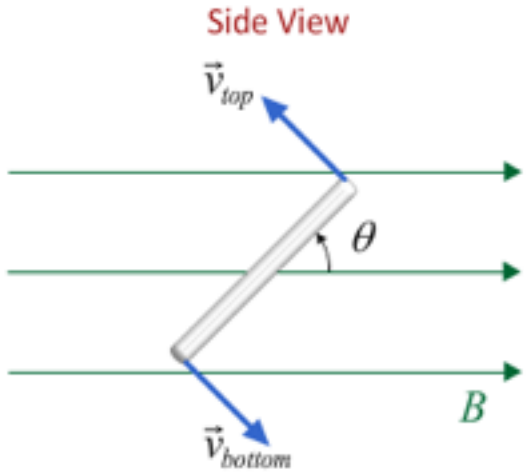
Largest for θ = 0 (v perp to B)

$$\mathcal{E} = 2EL = 2\frac{F}{q}L = 2L|\vec{v} \times \vec{B}| = 2L\left(\frac{w}{2}\right)\omega B\cos\theta = \omega AB\cos(\omega t)$$

$= v$

Generator: Changing Orientation





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$\vec{v} \times \vec{B}$

Largest for θ = 0 (v perp to B)

Be careful

w is not ω!

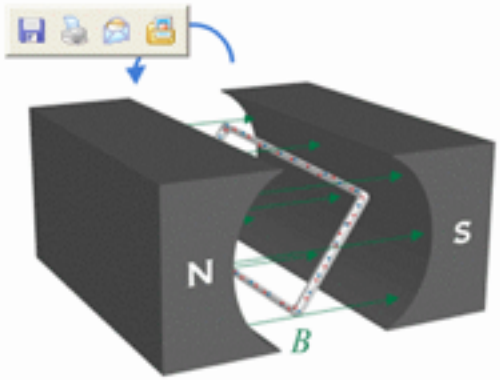
$$\mathcal{E} = 2EL = 2\frac{F}{q}L = 2L|\vec{v} \times \vec{B}| = 2L\left(\frac{w}{2}\right)\omega B\cos\theta = \omega AB\cos(\omega t)$$

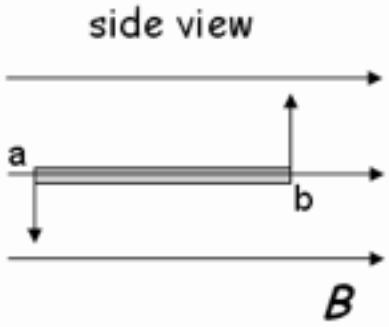
$= v$

Changing Orientation

8) A rectangular loop rotates in a region containing a constant magnetic field as shown.

CheckPoint 9





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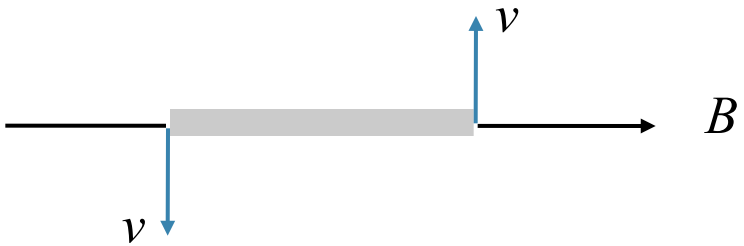

Changing Orientation

CheckPoint 9

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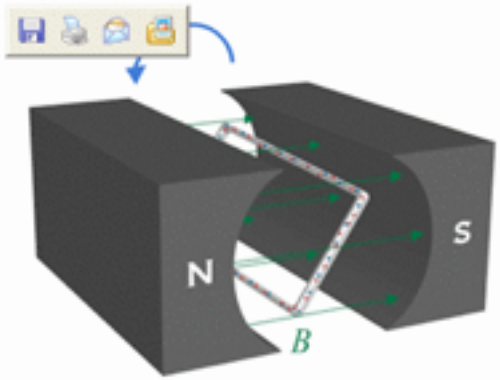

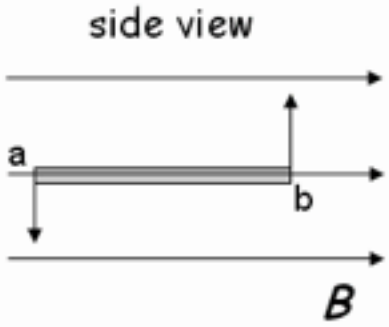

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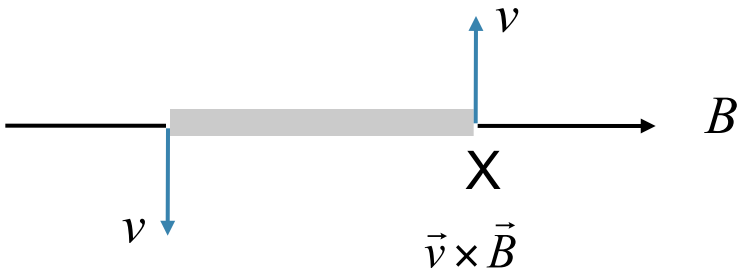

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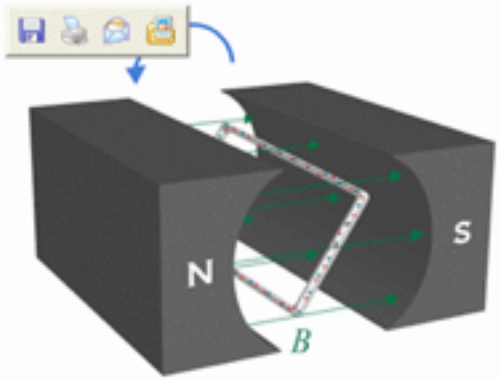

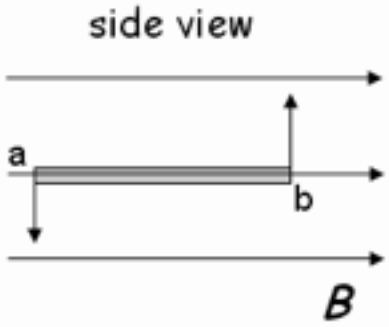

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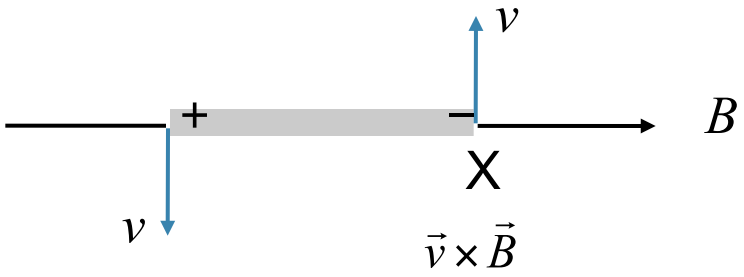

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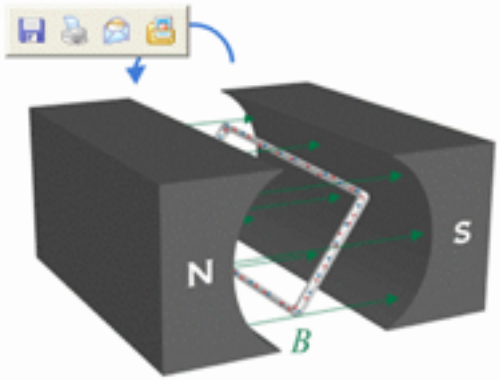

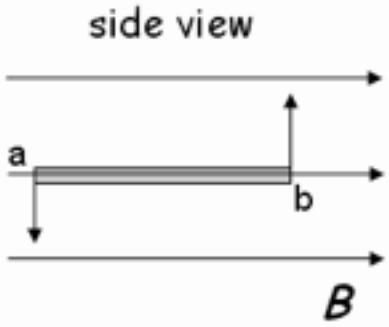

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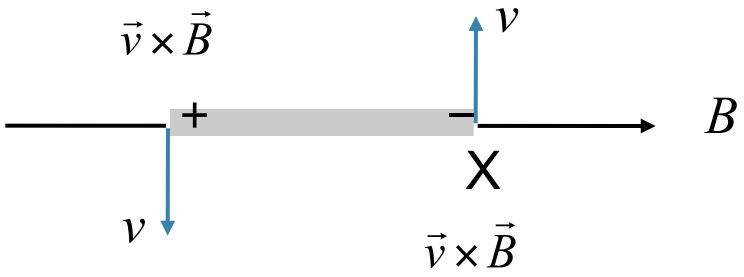

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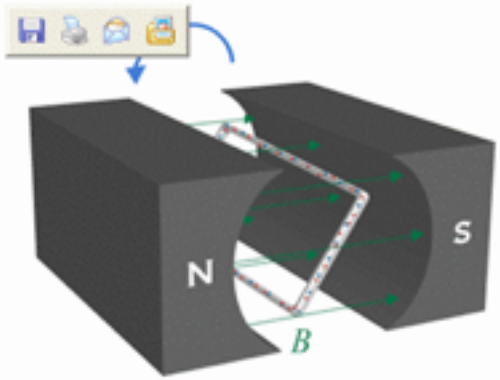

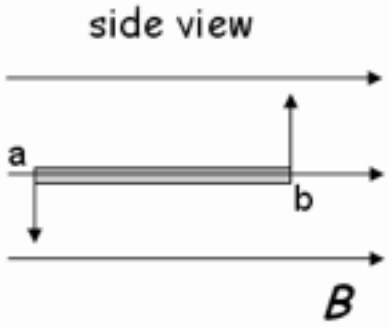

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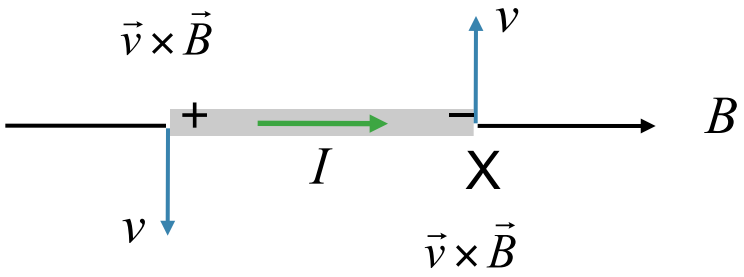

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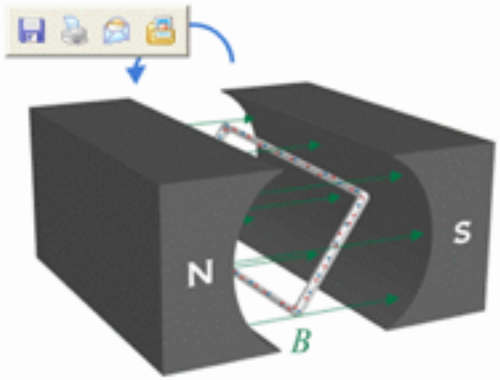

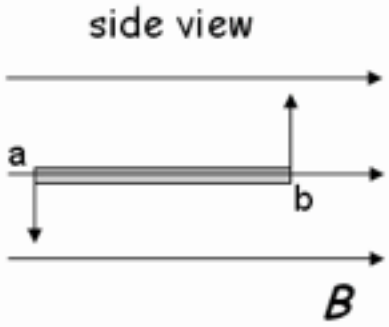

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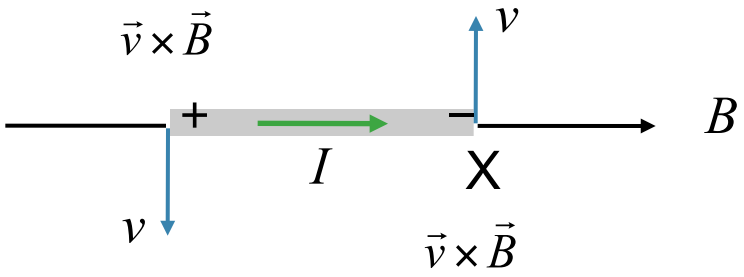
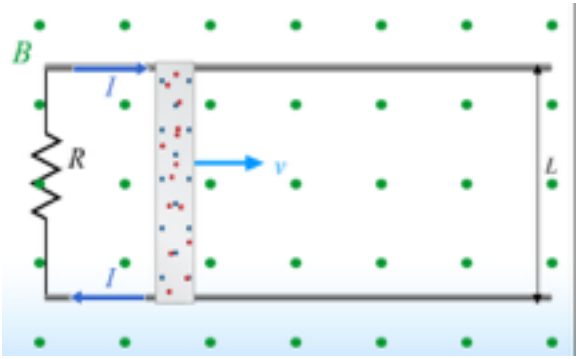
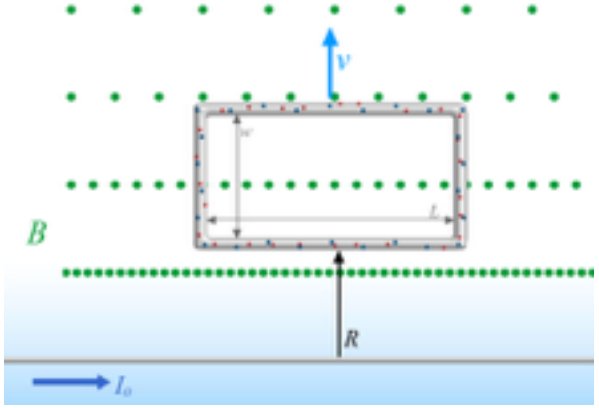
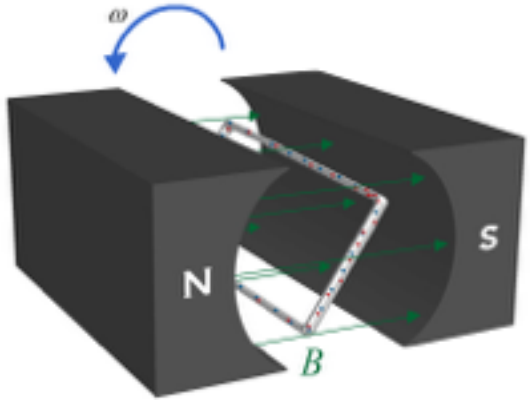


Putting it Together



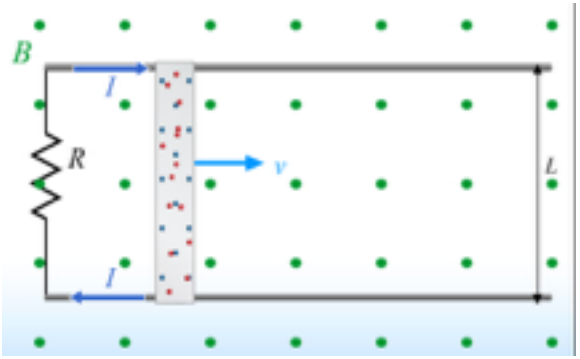


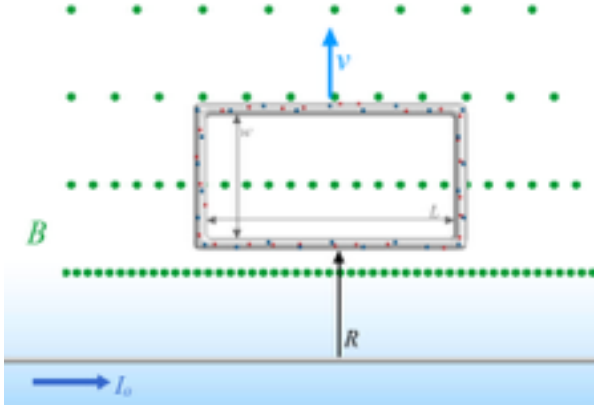


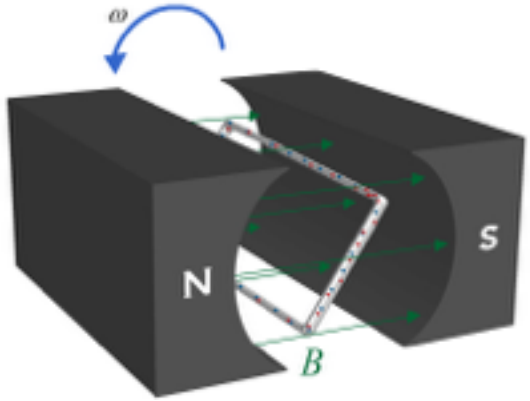
$$\Phi_B \equiv \vec{B} \cdot \vec{A}$$

B

Putting it Together







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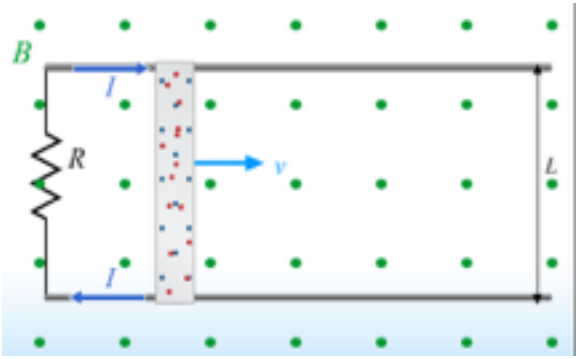
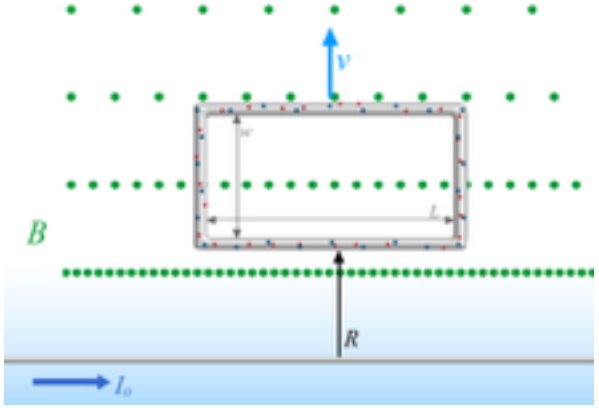
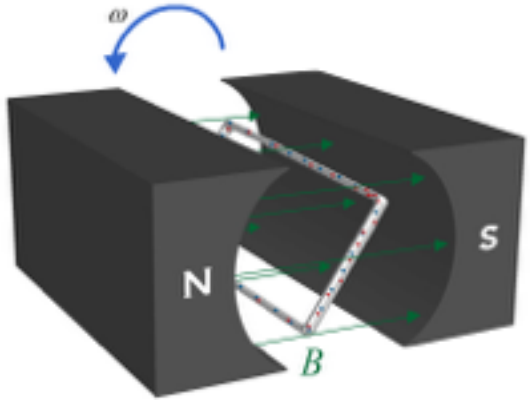
Faraday's Law

Putting it Together



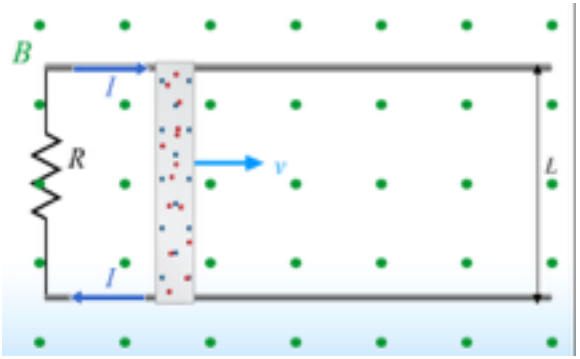


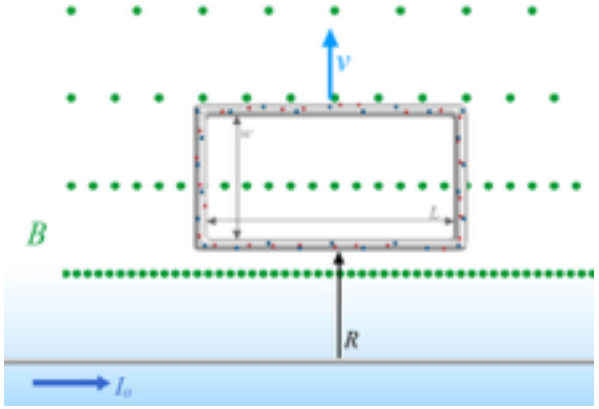


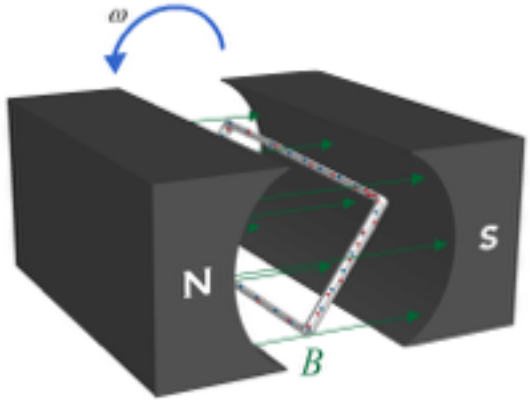
$$\Phi_B \equiv \vec{B} \cdot \vec{A}$$

Faraday's Law $$\varepsilon = -\frac{d\Phi_B}{dt}$$

Putting it Together







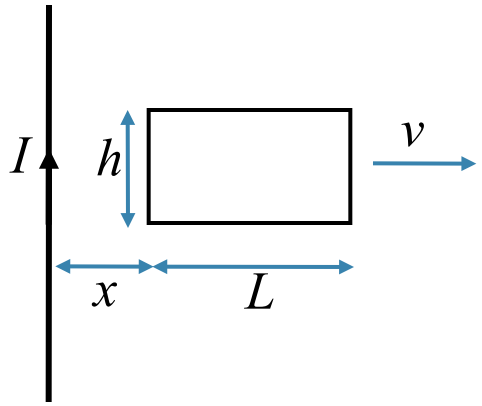
$$\Phi_B \equiv \vec{B} \cdot \vec{A}$$

Faraday's Law $$\varepsilon = -\frac{d\Phi_B}{dt}$$

We will study this law in detail next time !

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ \text{m})$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current $8\ \text{amps}$. What is the induced current in the loop when it is a distance $x = 0.7\ \text{m}$ from the wire?



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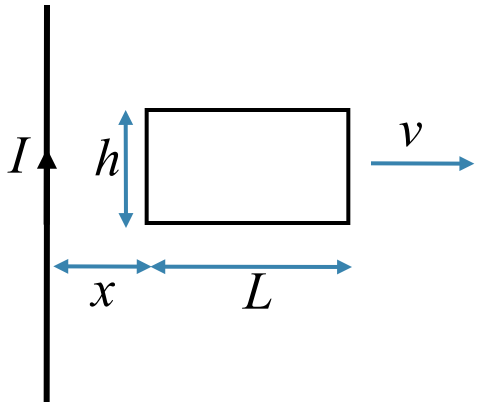

Conceptual Analysis:

Long straight current creates magnetic field in region of the loop.

Vertical sides develop *emf* due to motion through B field

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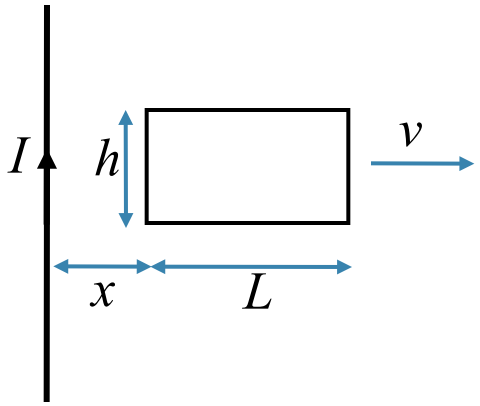

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Strategic Analysis:

Calculate B field due to wire.

Calculate motional *emf* for each segment

Use net *emf* and Ohm's law to get current

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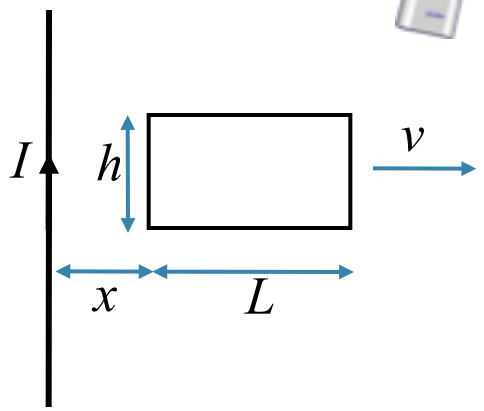

What is the direction of the B field produced by the wire in the region of the loop?

A) Into the page

B) Out of the page

C) Left

D) Right

E) Up

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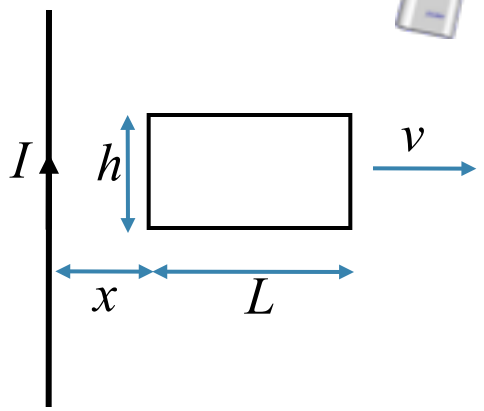

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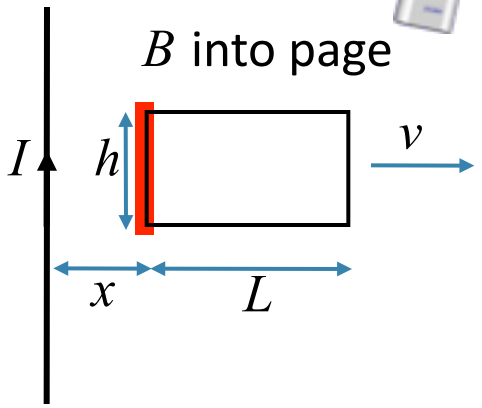

What is the *emf* induced on the left segment?

A) Top is positive

B) Top is negative

C) Zero

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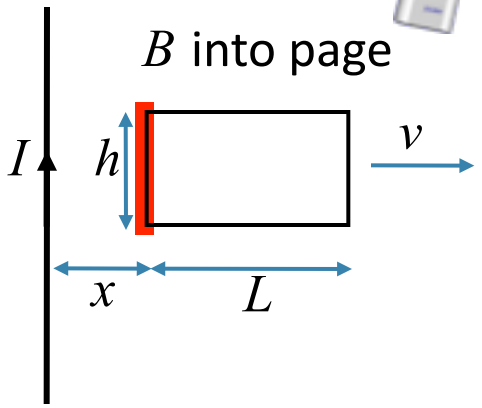

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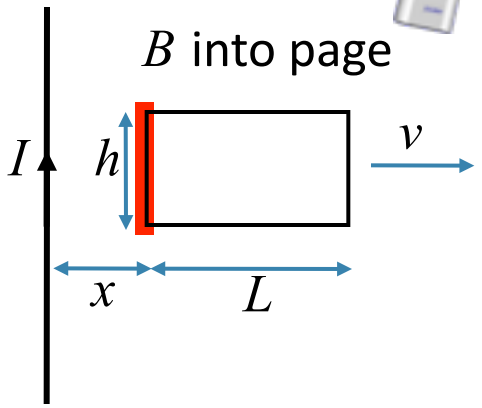

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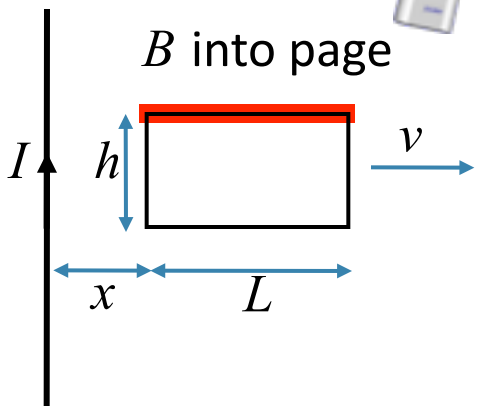

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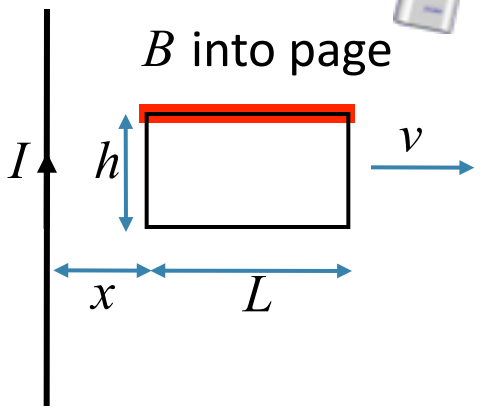

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perpendicular to wire

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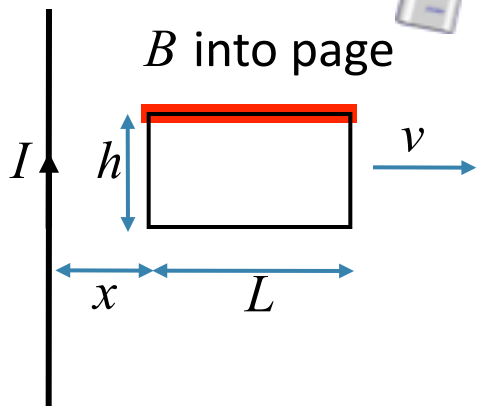

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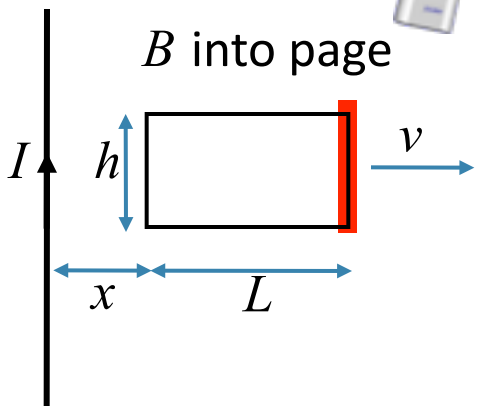

What is the *emf* induced on the right segment?

A) Top is positive

B) Top is negative

C) Zero

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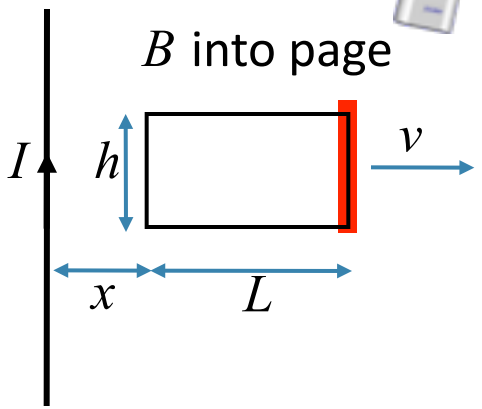

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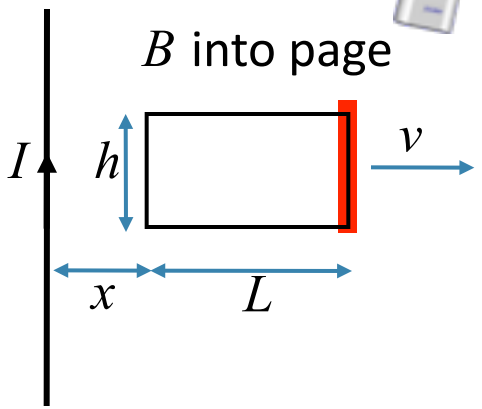
$\vec{v} \times \vec{B}$ 

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



What is the *emf* induced on the right segment?

A) Top is positive

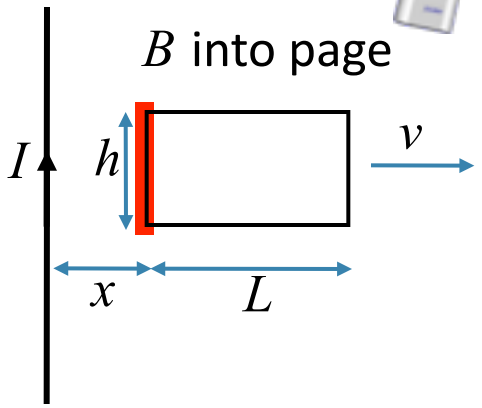
B) Top is negative

C) Zero

$\vec{v} \times \vec{B}$ 

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



Which expression represents the *emf* induced in the left wire?

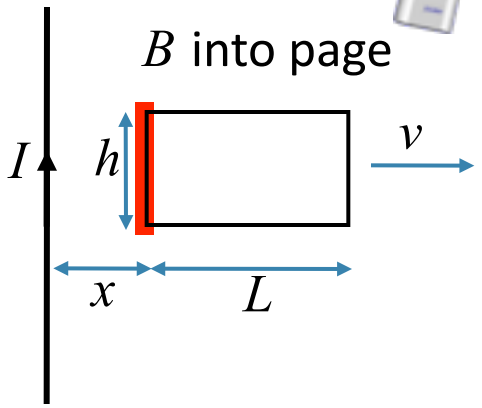
A) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi x} Lv$

B) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi x} hv$

C) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi (L + x)} Lv$

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



Which expression represents the *emf* induced in the left wire?

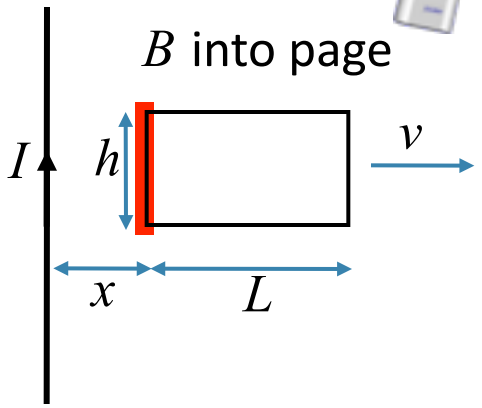
A) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi x} Lv$ $\qquad qvB = qE$

B) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi x} hv$

C) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi (L + x)} Lv$

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



Which expression represents the *emf* induced in the left wire?

A) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi x} Lv$

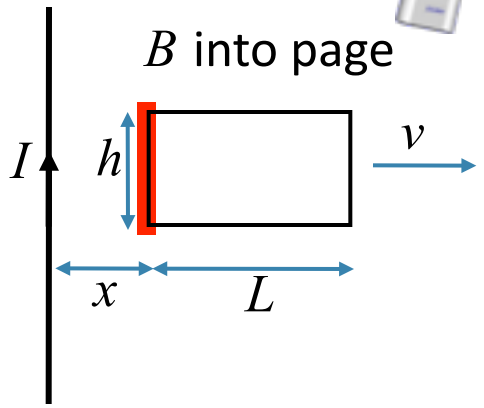
$qvB = qE \rightarrow E = vB$

B) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi x} hv$

C) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi (L + x)} Lv$

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



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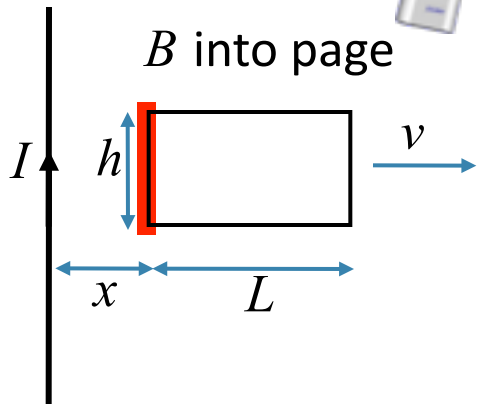
C) $\varepsilon_{left} = \dfrac{\mu_o I}{2\pi (L+x)} Lv$

$qvB = qE \rightarrow E = vB \rightarrow \varepsilon = Eh = vBh$

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



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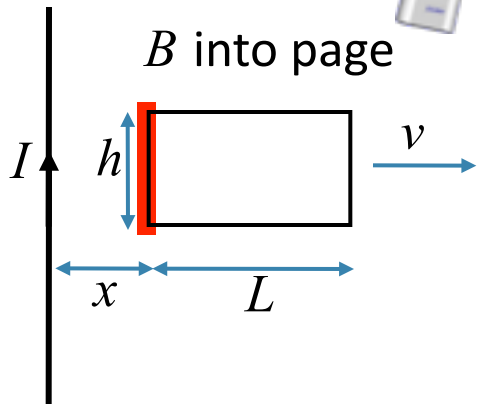
$B = \dfrac{\mu_o I}{2\pi x}$

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



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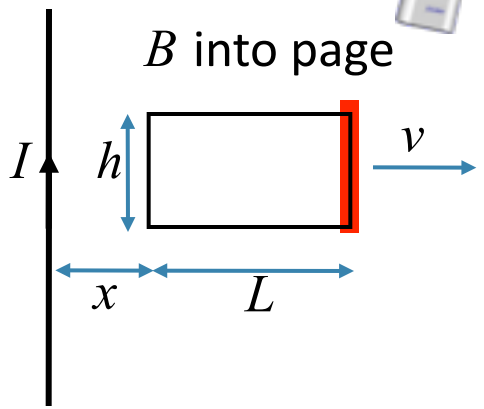
Example Problem

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ m$) with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



Which expression represents the *emf* induced in the right wire?

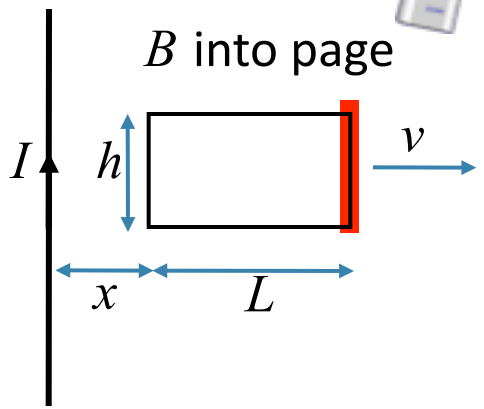
A) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi(L+x)} hv$

B) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi x} hv$

C) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi(h+x)} Lv$

Example Problem

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ m$) with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



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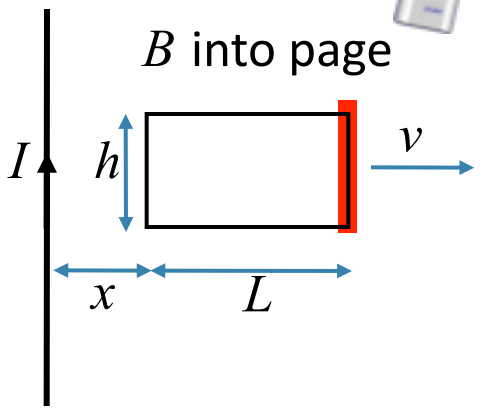
C) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi(h+x)} Lv$

$qvB = qE \rightarrow E = vB \rightarrow \varepsilon = Eh = vBh$

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



Which expression represents the *emf* induced in the right wire?

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B) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi x} hv$

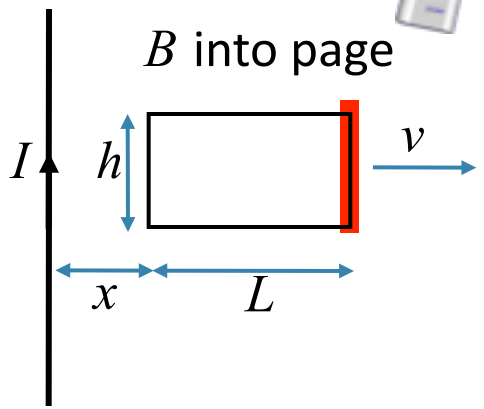
C) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi(h+x)} Lv$

$qvB = qE \rightarrow E = vB \rightarrow \varepsilon = Eh = vBh$

$B = \dfrac{\mu_o I}{2\pi(L+x)}$

Example Problem

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ m)$ with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



Which expression represents the *emf* induced in the right wire?

A) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi(L+x)} hv$

B) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi x} hv$

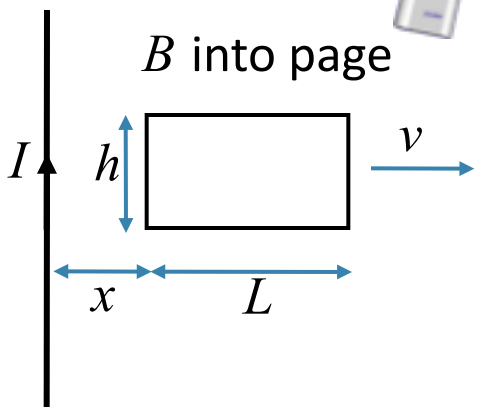
C) $\varepsilon_{right} = \dfrac{\mu_o I}{2\pi(h+x)} Lv$

$qvB = qE \rightarrow E = vB \rightarrow \varepsilon = Eh = vBh$

$B = \dfrac{\mu_o I}{2\pi(L+x)} \rightarrow \varepsilon = \dfrac{\mu_o I}{2\pi(L+x)} hv$

Example Problem

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ m$) with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



Which expression represents the total *emf* in the loop?

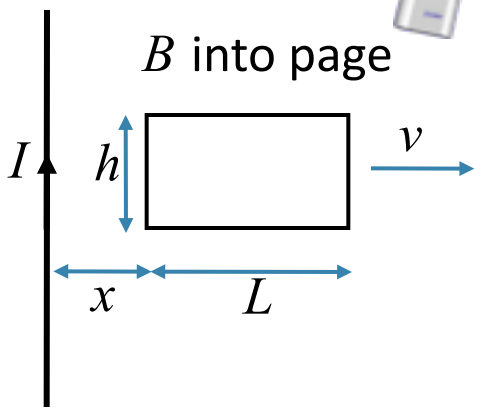
A) $\varepsilon_{loop} = \dfrac{\mu_o I}{2\pi x} hv + \dfrac{\mu_o I}{2\pi (L + x)} hv$

B) $\varepsilon_{loop} = \dfrac{\mu_o I}{2\pi x} hv - \dfrac{\mu_o I}{2\pi (L + x)} hv$

C) $\varepsilon_{loop} = 0$

Example Problem

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ m$) with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



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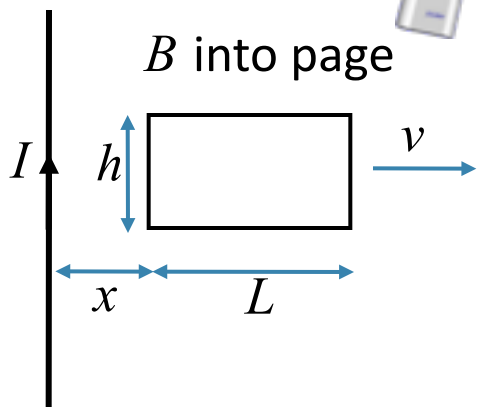
Example Problem

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ m$) with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



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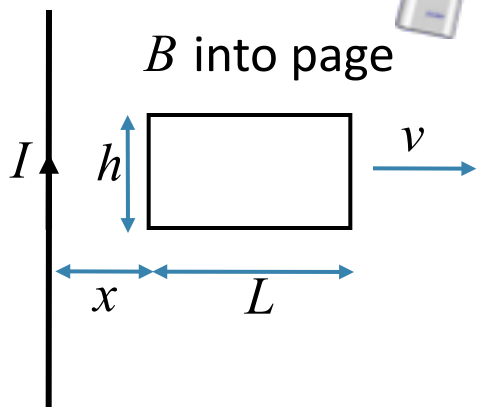
C) $\varepsilon_{loop} = 0$

$$I_{loop} = \frac{\varepsilon_{loop}}{R}$$

Example Problem

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ m$) with total resistance of $5\ \Omega$ is moving away from a long straight wire carrying total current 8 amps. What is the induced current in the loop when it is a distance $x = 0.7$ m from the wire?



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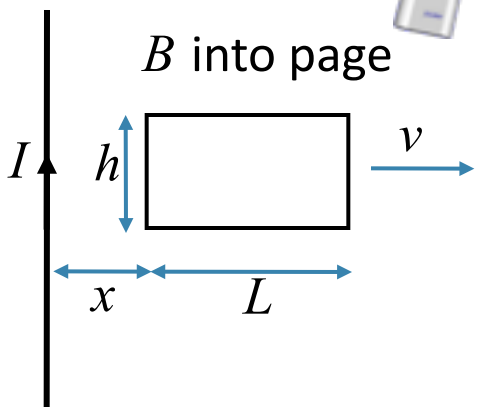
C) $\varepsilon_{loop} = 0$

$$I_{loop} = \frac{\varepsilon_{loop}}{R}$$

$$I_{loop} = \frac{\mu_o I}{2\pi R} hv \left(\frac{1}{x} - \frac{1}{L+x} \right)$$

Follow-Up

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ \text{m})$ with total resistance of 5Ω is moving away from a long straight wire carrying total current 8 amps.



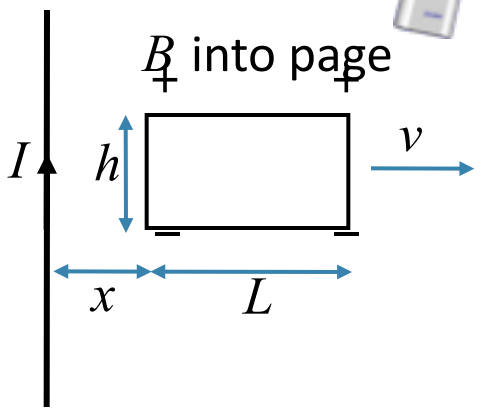
What is the direction of the induced current?

A) Clockwise

B) Counterclockwise

Follow-Up

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ \text{m})$ with total resistance of 5Ω is moving away from a long straight wire carrying total current 8 amps.



What is the direction of the induced current?

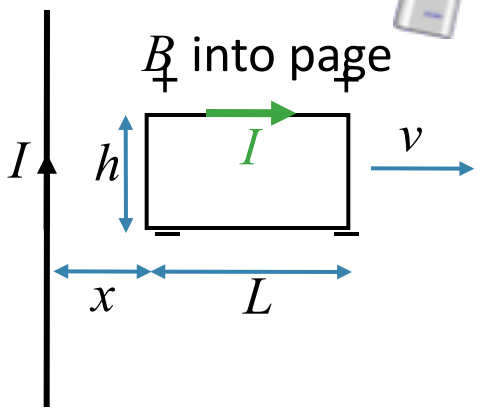
A) Clockwise

B) Counterclockwise

$\varepsilon_{left} > \varepsilon_{right}$

Follow-Up

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ \text{m}$) with total resistance of 5Ω is moving away from a long straight wire carrying total current 8 amps.



What is the direction of the induced current?

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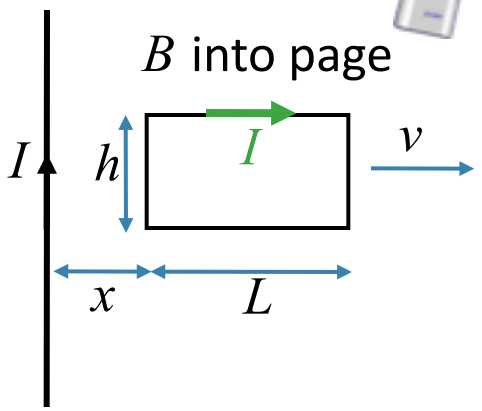
Clockwise current

Follow-Up

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ \text{m}$) with total resistance of 5Ω is moving away from a long straight wire carrying total current 8 amps.



What is the direction of the force exerted by the magnetic field on the loop?

A) UP

B) DOWN

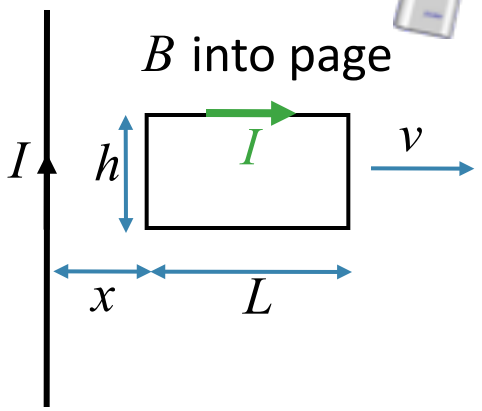
C) LEFT

D) RIGHT

E) $F = 0$

Follow-Up

A rectangular loop $(h = 0.3\text{m}\ L = 1.2\ \text{m})$ with total resistance of 5Ω is moving away from a long straight wire carrying total current 8 amps.



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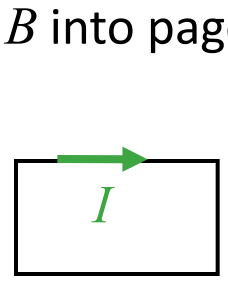
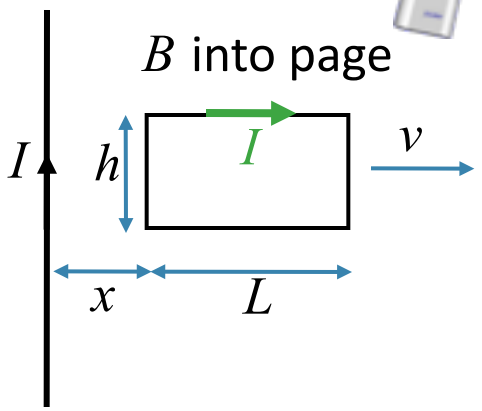


Follow-Up

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ \text{m}$) with total resistance of 5Ω is moving away from a long straight wire carrying total current $8\ \text{amps}$.



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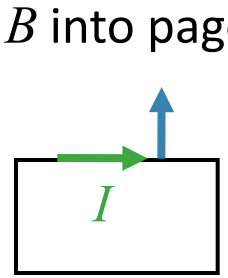
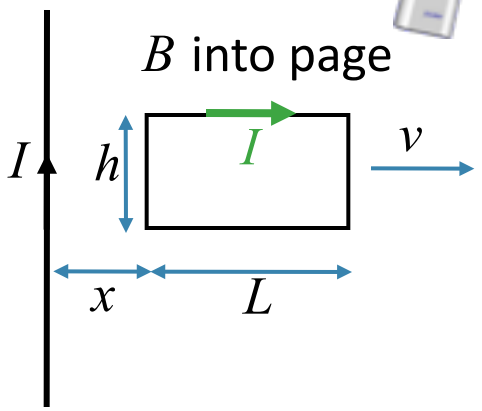


Follow-Up

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ \text{m}$) with total resistance of 5Ω is moving away from a long straight wire carrying total current 8 amps.



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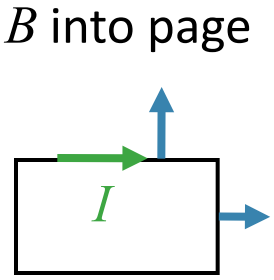

Follow-Up

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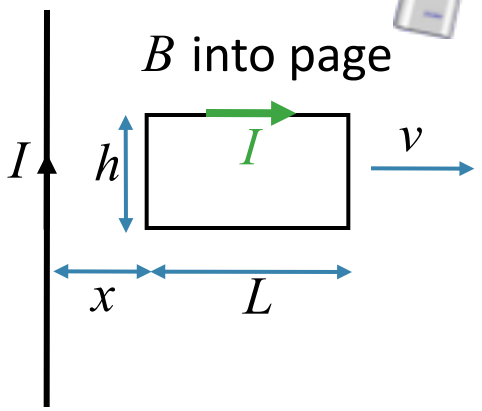

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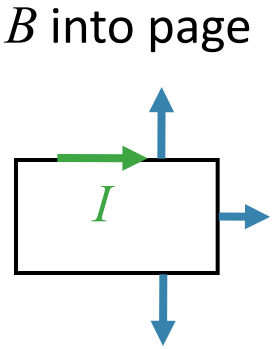
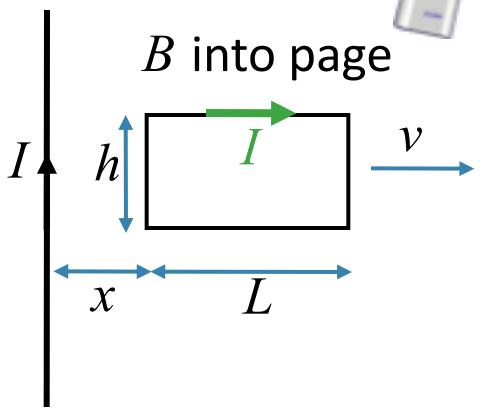


Follow-Up

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ \text{m}$) with total resistance of 5Ω is moving away from a long straight wire carrying total current 8 amps.



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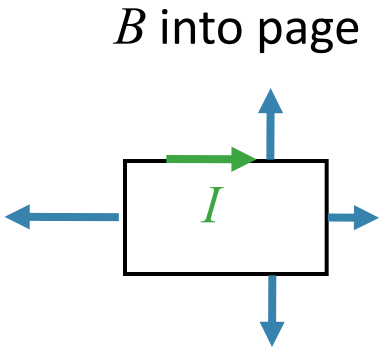
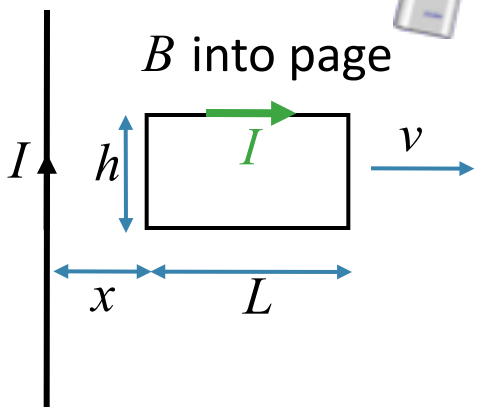


Follow-Up

A rectangular loop ($h = 0.3\text{m}\ L = 1.2\ \text{m}$) with total resistance of 5Ω is moving away from a long straight wire carrying total current $8\ \text{amps}$.



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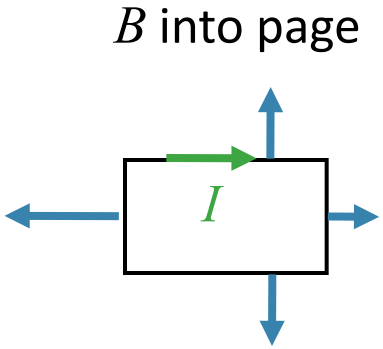

Total force from B
Points to the left !