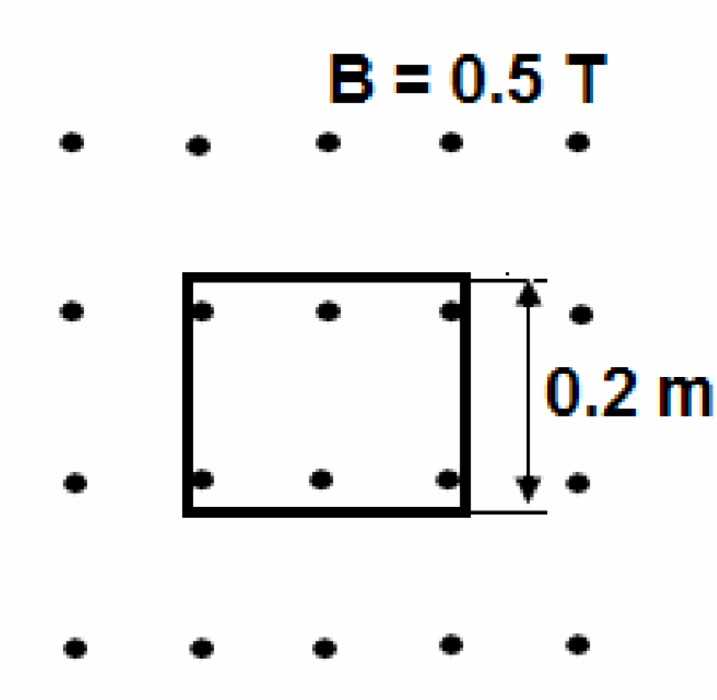
Electromagnetic Induction
Practice Problems

Multiple Choice

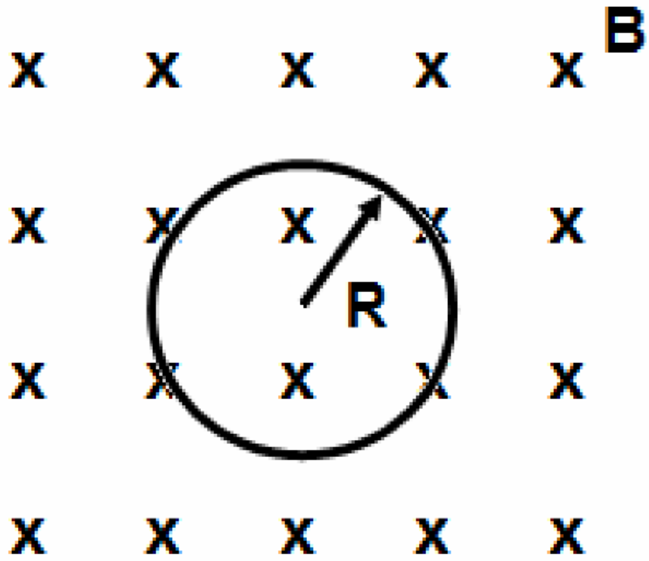
1 A square loop of wire is placed in a uniform magnetic field perpendicular to the magnetic lines. The strength of the magnetic field is 0.5 T and the side of the loop is 0.2 m. What is the magnetic flux in the loop?

- A 0.02 Wb
- B 0.04 Wb
- C 0.06 Wb
- D 0.08 Wb
- E 0.10 Wb



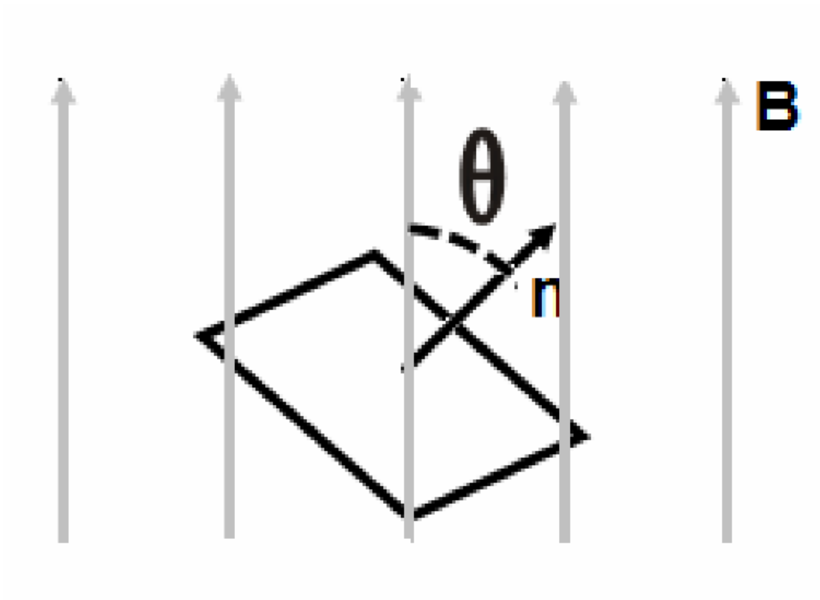
2 A circular loop of wire is placed in a uniform magnetic field perpendicular to the magnetic lines. The strength of the magnetic field is B and the radius of the loop is R. What is the magnetic flux in the loop?

- A π B/R2
- B π BR2
- C π B/R
- D π BR
- E B/R2



3 A square loop of wire with one side of 0.4 m is placed in a uniform magnetic field B = 2 T. The normal line to the loop makes 60º with the magnetic field lines. What is the magnetic flux in the loop?

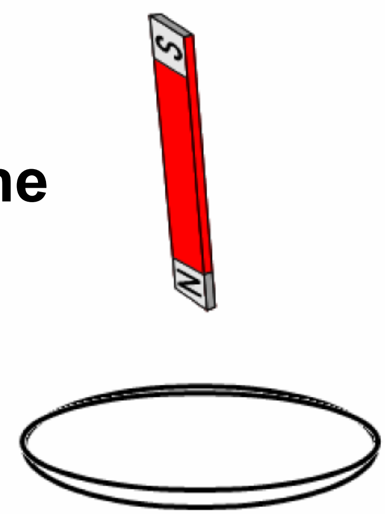
- A 0.12 Wb
- B 0.14 Wb
- C 0.16 Wb
- D 0.18 Wb
- E 0.20 Wb



4 **A circular loop is initially placed in a uniform magnetic field perpendicular to the field lines and then removed quickly from the field. The induced emf causes the electric charge flow in the loop. Which of the following explains the force on the induced current due to the original field?**

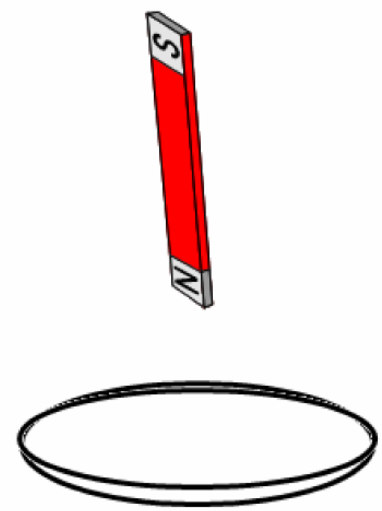
- A Force causes the loop to turn around its axis
- B Force causes the loop to turn around its diameter
- C Force causes the loop to accelerate in the field direction
- D Force causes the loop to accelerate perpendicular to the field direction
- E Force opposes to any motion of the loop

5 A magnet bar with the north pole down is held above a horizontal aluminum ring. Which of the following is true about the induced current in the ring? (View from above)



- A There is no current in the ring
- B There is a clockwise current in the ring
- C There is a counterclockwise current in the ring
- D There is an AC current in the ring
- E More information is required

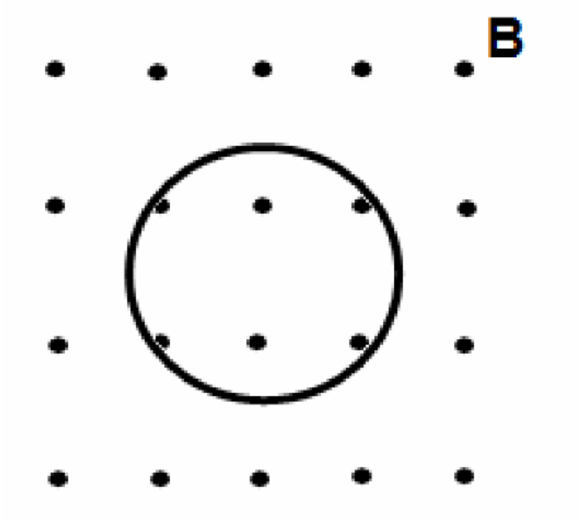
6 **A magnet bar with the north pole down is held above a horizontal aluminum ring. Which of the following is true about the induced current in the ring? (View from above)**



- **A** There is no current in the ring
- **B** There is a clockwise current in the ring
- **C** There is a counterclockwise current in the ring
- **D** There is an AC current in the ring
- **E** More information is required

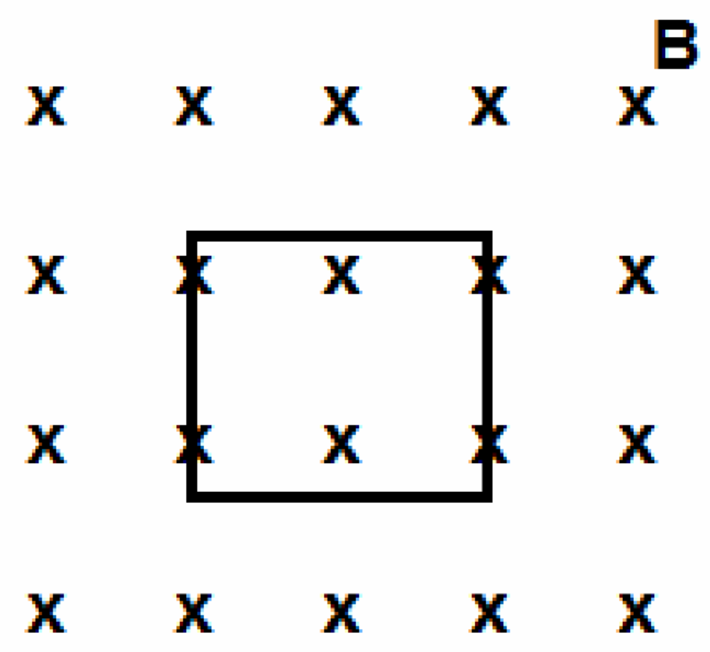
7 A circular loop of wire is placed in a uniform magnetic field directed out of the page. Suddenly the magnetic field disappears. What is the direction of the induced current in the loop?

- A Clockwise
- B Counterclockwise
- C No current in the coil
- D Into the page
- E Out of the page

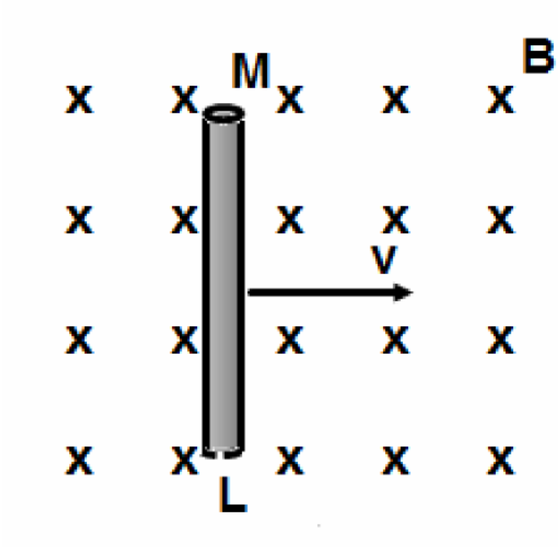


8 A square loop of wire is placed in a uniform magnetic field directed into the page. Suddenly the magnetic field grows stronger. What is the direction of the induced current in the loop?

- A Clockwise
- B Counterclockwise
- C No current in the coil
- D Into the page
- E Out of the page



9 A copper rod ML moves at a constant speed in a uniform magnetic field perpendicular to the magnetic lines. Which statement is true about the electric potential in the rod?



- A Point M is at higher potential
- B Point L is at higher potential
- C Potential is higher at the surface of the rod
- D Potential is higher at the center of the rod
- E More information is required

10 A copper rod ML moves at a constant speed in a uniform magnetic field perpendicular to the magnetic lines. Which statement is true about the electric potential in the rod?

- A Point M is at higher potential
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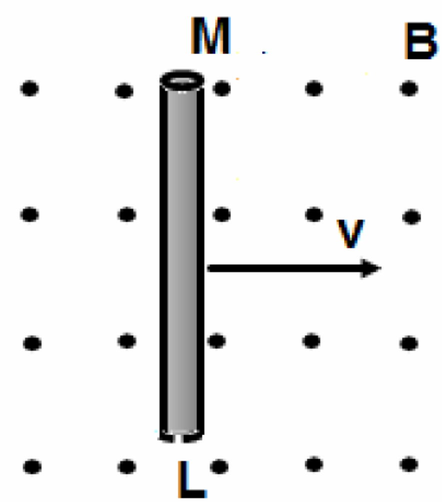
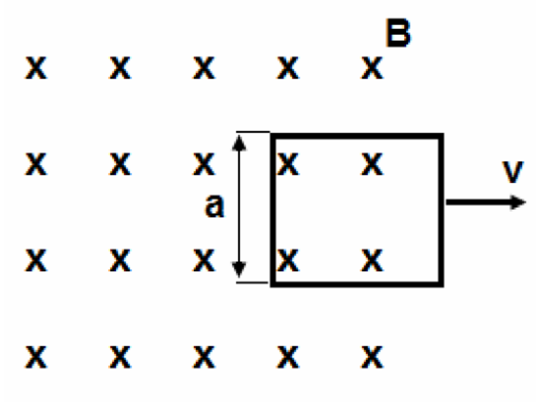
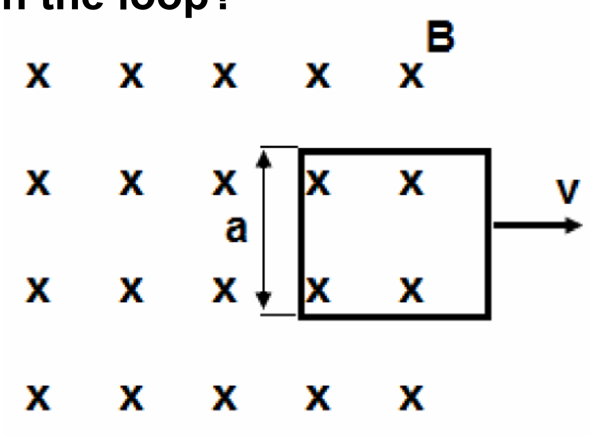


11 A square loop of wire with one side of a and resistance R is pulled out the field with a constant speed of v. The strength of the field is B. Which statement is true about the magnitude and direction of the induced current?

	Magnitude	Direction
A	Bav/R	Counterclockwise
B	Bav/R	Clockwise
C	BavR	Counterclockwise
D	BavR	Clockwise
E	Ba/vR	Counterclockwise



12 A square loop of wire with one side of a and resistance R is pulled out the field with a constant speed of v. The strength of the field is B. Which statement is true about the magnitude and direction of the magnetic force on the loop?



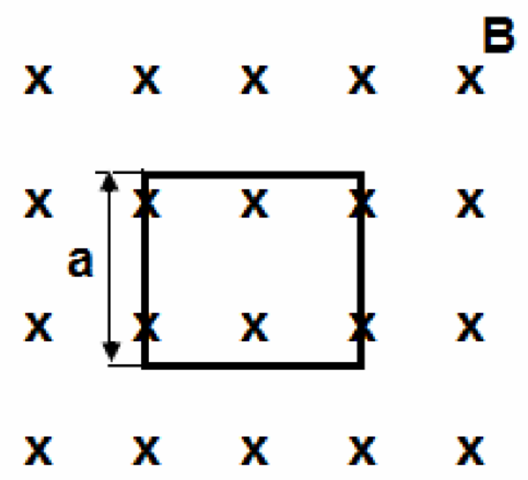
- A Bav/R In the direction of the loop's motion
- B Bav/R In opposite direction to the loop's motion
- C B^2a^2v/R In the direction of the loop's motion
- D B^2a^2v/R In opposite direction to the loop's motion
- E B^2a^2vR In the direction of the loop's motion

13 **A square loop of aluminum wire is initially placed perpendicular to the lines of a constant magnetic field of 0.5 T. The area enclosed by the loop is 0.2 m^2. The loop is then turned through an angle of 90° so that the plane of the loop is parallel to the field lines. The turn takes 0.1 s. What is the induced emf in the loop?**

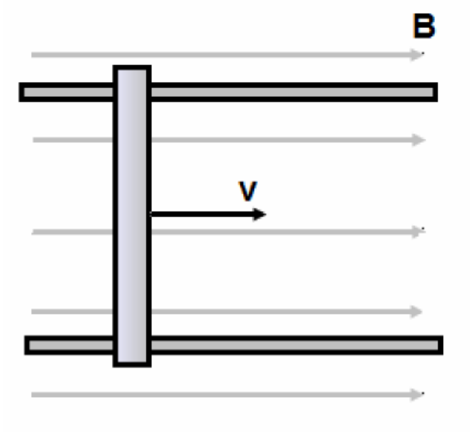
- A 0.5 V
- B 1.0 V
- C 1.5 V
- D 1.2 V
- E 0.8 V

14 **A square loop of wire with one side of a and resistance R is placed in a uniform magnetic field of strength B. The field vanishes and results an induced current I in the loop. What is the rate of change of magnetic field?**

- A IR/a
- B IR/a^2
- C IRa^2
- D IRa
- E Ia/R

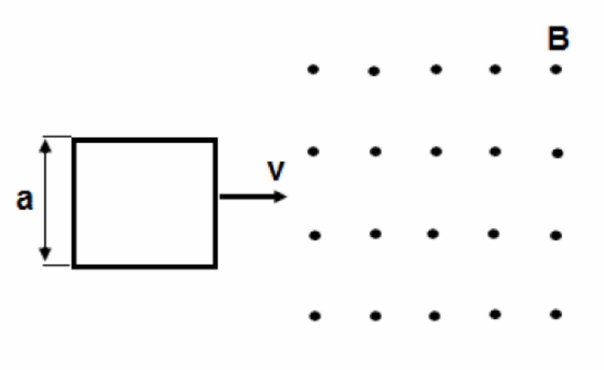


15 **A metallic bar with ends lying on two parallel conducting rails moves at a constant speed v in the direction of the uniform magnetic field B. The induced emf in the bar is:**



- A **Directed to the left side of the page**
- B **Directed to the right side of the page**
- C **Directed to the top of the page**
- D **Directed to the bottom of the page**
- E **Zero**

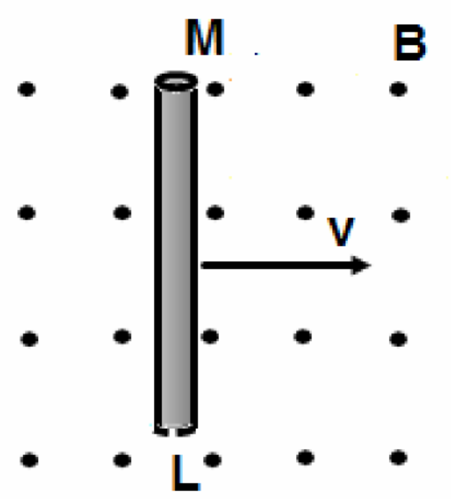
16 A loop of wire is pulled with constant velocity v to the right through a region of space where there is a uniform magnetic field B directed into the page, as shown above. The magnetic force on the loop is



- A Directed to the left both as it enters and as it leaves the region
- B Directed to the right both as it enters and as it leaves the region
- C Directed to the left as it enters the region and to the right as it leaves
- D Directed to the right as it enters the region and to the left as it leaves
- E zero at all times

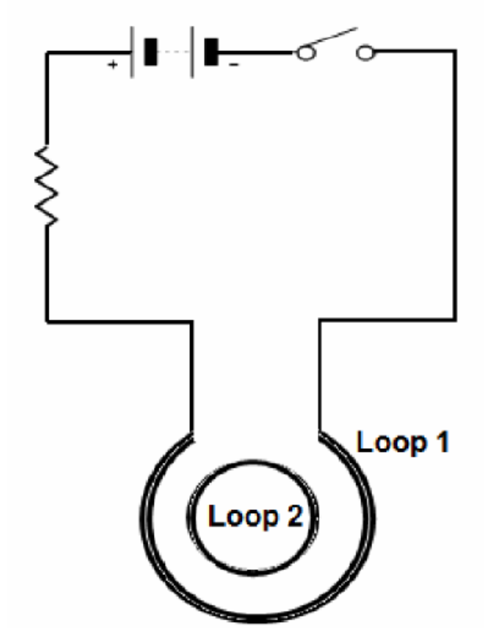
17 A vertical length of copper wire moves to the right with a constant speed v in the perpendicular direction of a constant horizontal magnetic field B. Which of the following describes the induced charges on the ends of the wire?

	Point M	Point L
A	Positive	Negative
B	Negative	Positive
C	Negative	Zero
D	Zero	Negative
E	Zero	Zero

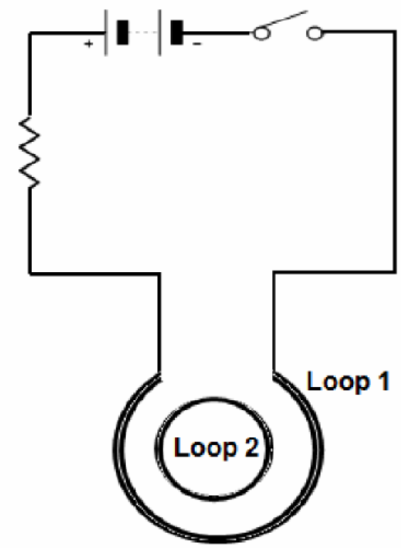


18 When the switch is closed the direction of the electric current is:

	Loop 1	Loop 2
A	Clockwise	Counterclockwise
B	Counterclockwise	Clockwise
C	Clockwise	Clockwise
D	Counterclockwise	Counterclockwise
E	Zero	Zero



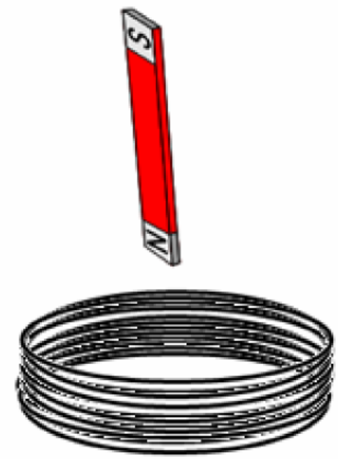
19 **Which of the following procedures will not produce an induced current in the loop 2:**



- A Closing the switch
- B Opening the switch
- C Rotating loop 2 with respect to its axis when switch is close for a long time
- D Rotating loop 2 with respect to its diameter when switch is close for a long time
- E Removing loop 2 from loop 1 when the switch is closed for a long time

20 A magnet bar with a north pole down is dropped from a certain height and on the way down passes through a closed coil of wire. Which statement is true about the magnet's acceleration?

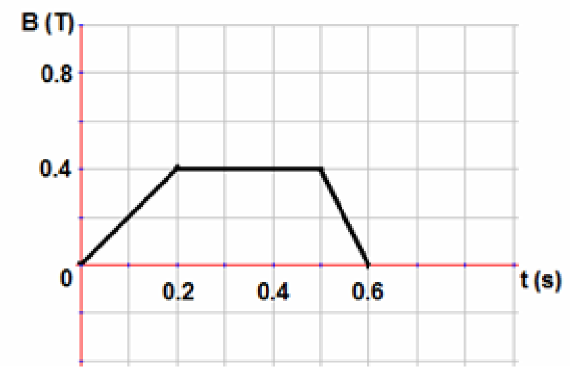
- A Greater than g
- B Less than g
- C g
- D Zero acceleration
- E More information is required



Free Response

1. A 0.2 Ω rectangular loop of wire has an area of 0.5 m^2 and placed in a region where magnetic field changes as shown on the diagram.

a. What is the magnetic flux in the loop at 0.4 s?



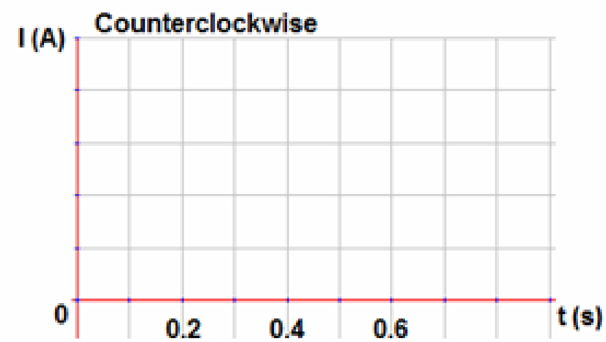
b. What is the induced emf for the following time?

i. ____ 0.1 s ii. ____0.3 s iii. ____ 0.5 s

c. What is the induced current for the following time?

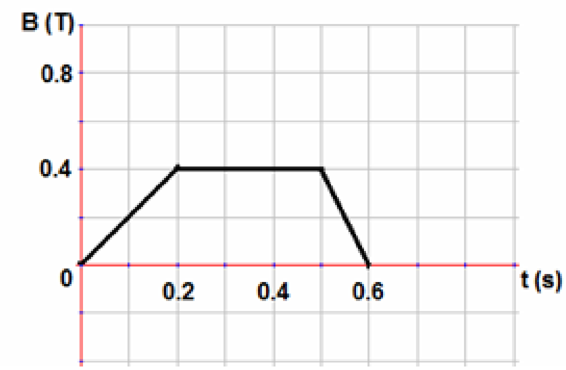
i. ____ 0.1 s ii. ____0.3 s iii. _____ 0.5 s

d. On the diagram below graph the induced current as a function of time.



1. A 0.2 Ω rectangular loop of wire has an area of 0.5 m^2 and placed in a region where magnetic field changes as shown on the diagram.

a. What is the magnetic flux in the loop at 0.4 s?



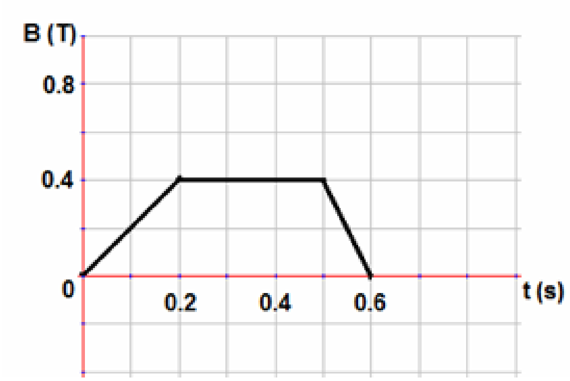
F = B^A

F = (0.4 T)(0.5 m^2)

F = 0.2 Wb

1. A 0.2 Ω rectangular loop of wire has an area of 0.5 m^2 and placed in a region where magnetic field changes as shown on the diagram.

b. What is the induced emf for the following time?



i. ____ 0.1 s ii. ____0.3 s iii. ____ 0.5 s

i. $E = -A\Delta B/\Delta t = -(0.5\ m^2)(0.4\ T)/(0.2\ s) = -1V$

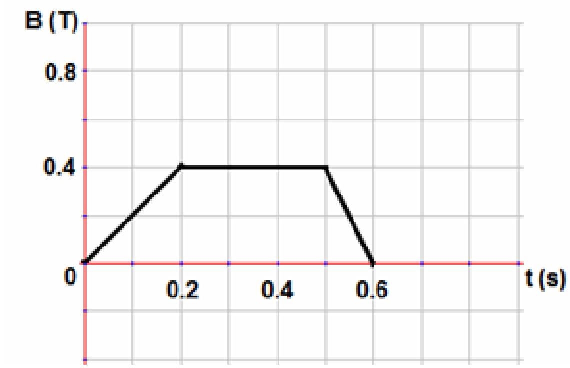
ii. $E = 0$

iii. $E = -A\Delta B/\Delta t = -(0.5\ m^2)(-0.4\ T)/(0.1\ s) = -1V$

1. A 0.2 Ω rectangular loop of wire has an area of 0.5 m^2 and placed in a region where magnetic field changes as shown on the diagram.

c. What is the induced current for the following time?

i. ____ 0.1 s ii. ____0.3 s iii. _____ 0.5 s



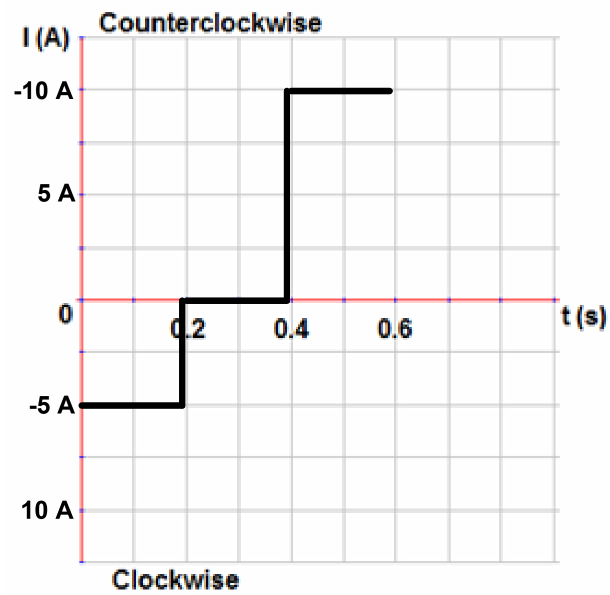
i. I = V/R = (1 V)/(0.2 Ω) = 5 A

ii. I = 0

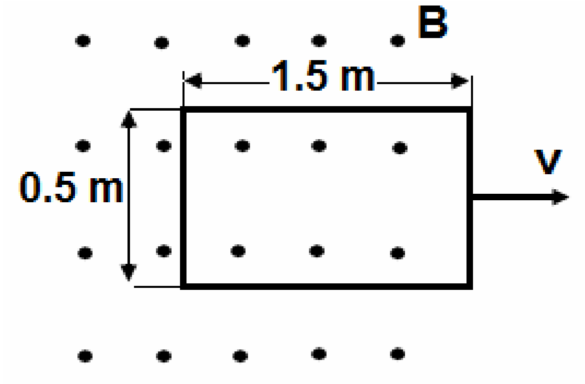
iii. I = V/R = (2 V)/(0.2 Ω) = 10 A

1. A 0.2 Ω rectangular loop of wire has an area of 0.5 m^2 and placed in a region where magnetic field changes as shown on the diagram.

d. On the diagram below graph the induced current as a function of time.



2. A rectangular loop of wire 0.5 m wide and 1.5 m long is moving out of a uniform magnetic field B = 2 T at a constant speed of 2m/s. The left side of the loop stays inside the field when the right side is out. The resistance of the loop is 0.5 Ω.



a. What is the direction of the induced current in the loop?

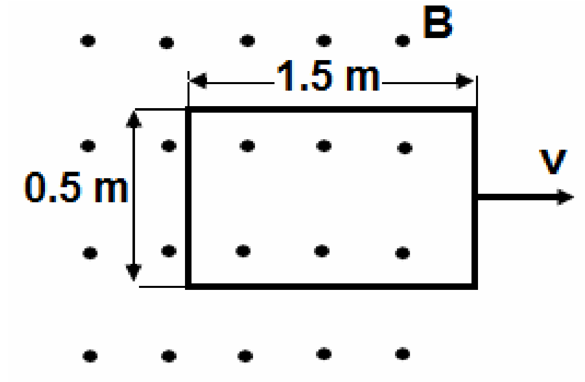
b. Calculate the induced emf in the loop.

c. Calculate the induced current in the loop.

d. Calculate the applied force required to move the loop at the constant speed.

e. Calculate the power developed by the force.

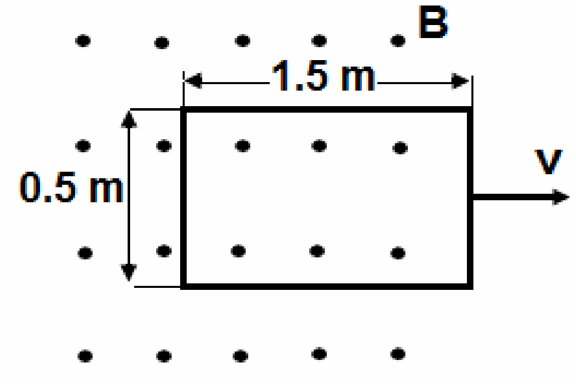
2. A rectangular loop of wire 0.5 m wide and 1.5 m long is moving out of a uniform magnetic field B = 2 T at a constant speed of 2m/s. The left side of the loop stays inside the field when the right side is out. The resistance of the loop is 0.5 Ω.



a. What is the direction of the induced current in the loop?

Counter clockwise

2. A rectangular loop of wire 0.5 m wide and 1.5 m long is moving out of a uniform magnetic field B = 2 T at a constant speed of 2m/s. The left side of the loop stays inside the field when the right side is out. The resistance of the loop is 0.5 Ω.



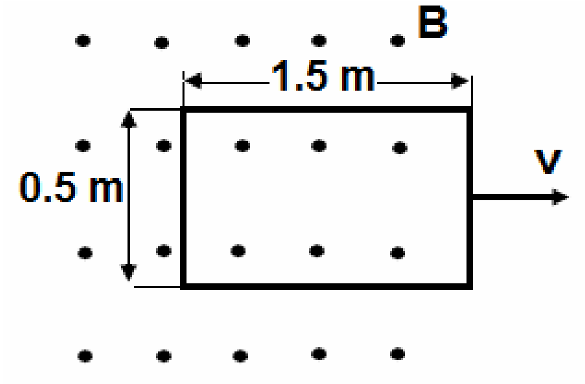
b. Calculate the induced emf in the loop.

E = Blv

E = (2 T)(0.5 m)(2 m/s)

E = 2 V

2. A rectangular loop of wire 0.5 m wide and 1.5 m long is moving out of a uniform magnetic field B = 2 T at a constant speed of 2m/s. The left side of the loop stays inside the field when the right side is out. The resistance of the loop is 0.5 Ω.



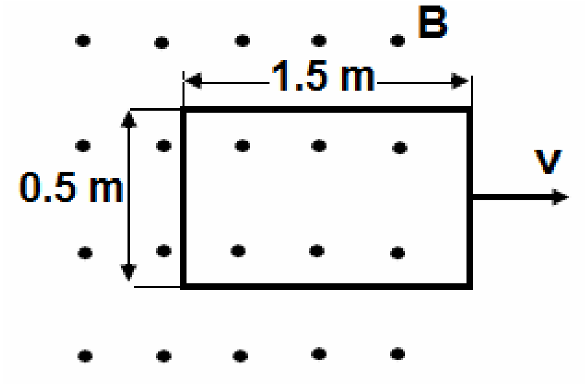
c. Calculate the induced current in the loop.

I = V/R

I = (2 V)/(0.5 Ω)

I = 4 A

2. A rectangular loop of wire 0.5 m wide and 1.5 m long is moving out of a uniform magnetic field B = 2 T at a constant speed of 2m/s. The left side of the loop stays inside the field when the right side is out. The resistance of the loop is 0.5 Ω.



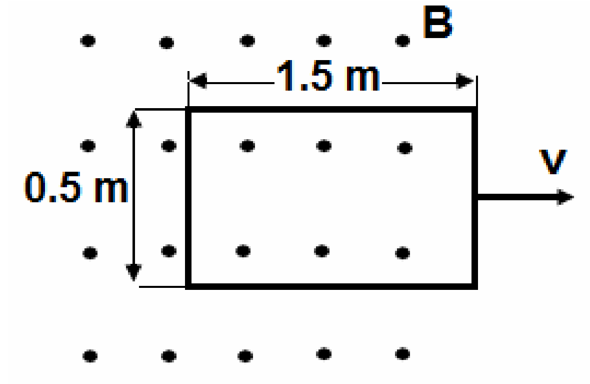
d. Calculate the applied force required to move the loop at the constant speed.

F = BIL

F = (2 T)(4 A)(0.5 m)

F = 4 N

2. A rectangular loop of wire 0.5 m wide and 1.5 m long is moving out of a uniform magnetic field B = 2 T at a constant speed of 2m/s. The left side of the loop stays inside the field when the right side is out. The resistance of the loop is 0.5 Ω.



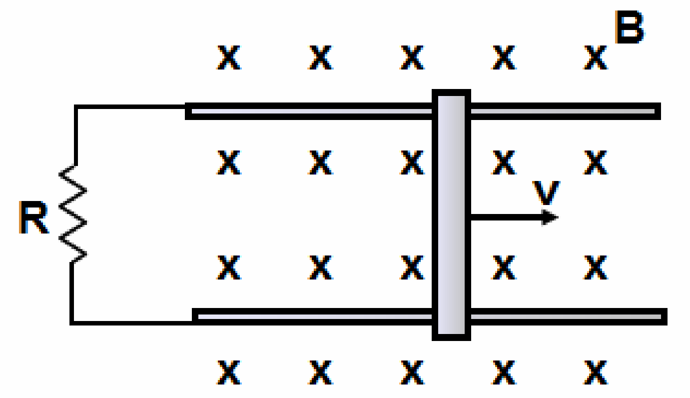
e. Calculate the power developed by the force.

$P = Fv$

$P = (4\ N)(2\ m/s)$

$P = 8\ W$

3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.



a. What is the direction of the induced current?

b. Determine the induced emf.

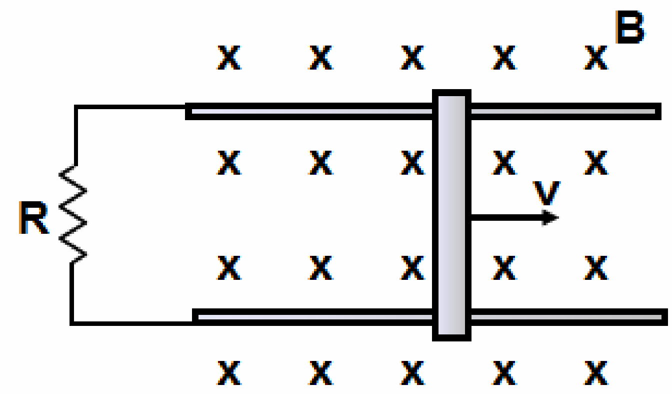
c. Determine the induced current in the circuit.

d. Determine the electric field E induced in the rod.

e. Determine the force required to move the rod at the constant speed.

f. Determine the power dissipated in the resistor when the rod crosses the magnetic field.

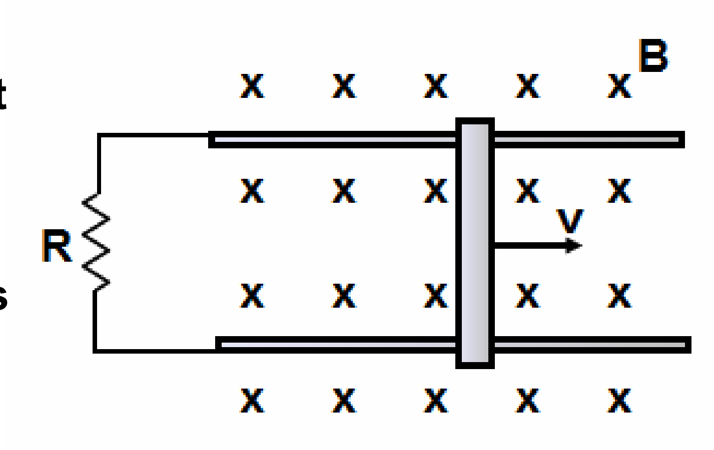
3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.



a. What is the direction of the induced current?

Counter clockwise

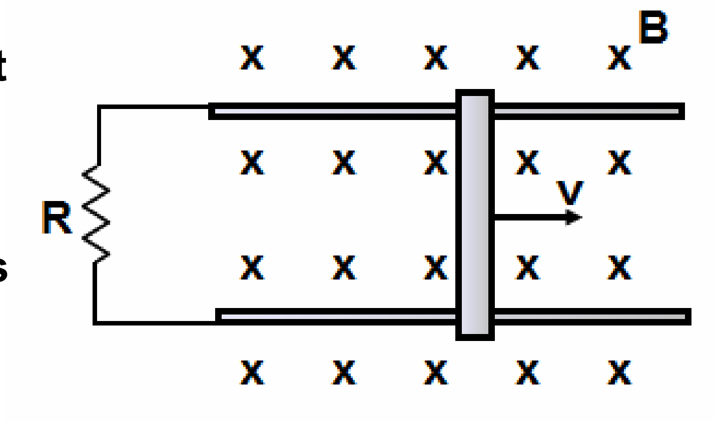
3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.



b. Determine the induced emf.

E = Blv = BLv

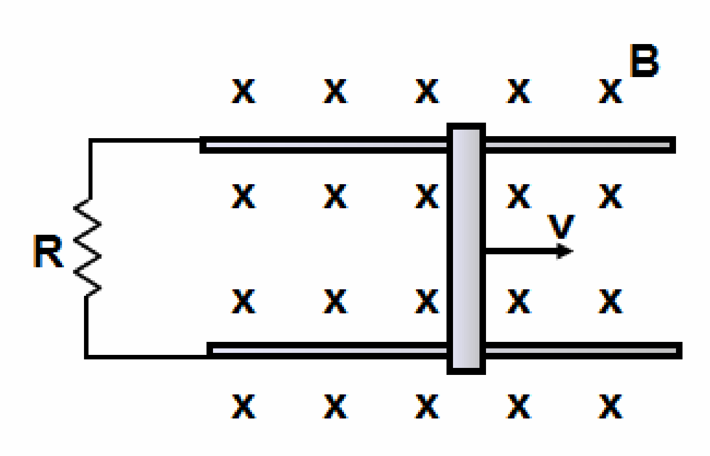
3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.



c. Determine the induced current in the circuit.

$I = E/R = BLv/R$

3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.



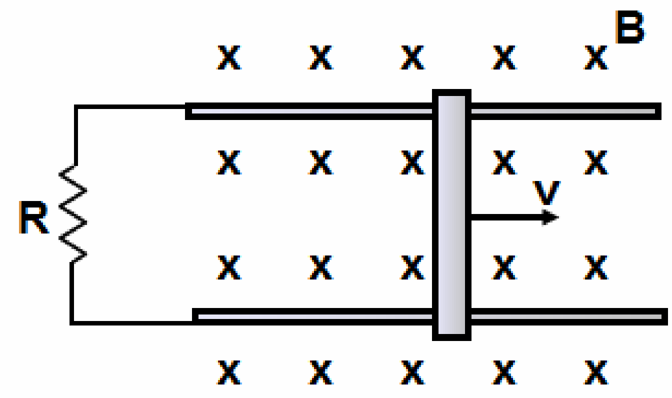
d. Determine the electric field E induced in the rod.

E = V/d

E = BLv/L

E = Bv

3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.



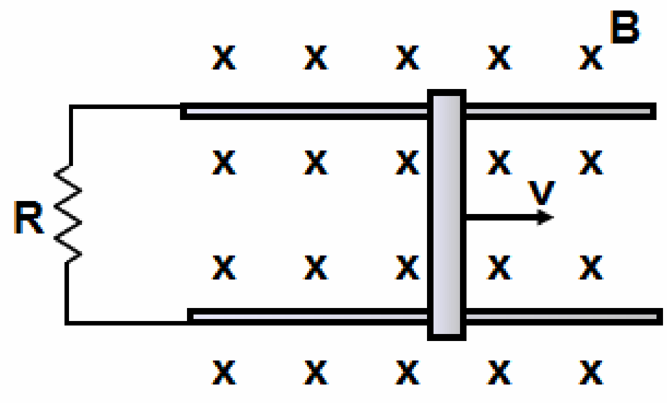
e. Determine the force required to move the rod at the constant speed.

$F = BIL$

$F = B(BLv/R)(L)$

$F = B^2L^2v/R$

3. A metallic rod has a length L and slides at a constant speed v on the top of two conducting parallel rails. The rails are connected to a resistor R. The apparatus is placed in a uniform magnetic field B which is perpendicular to the plane where rod is moving.



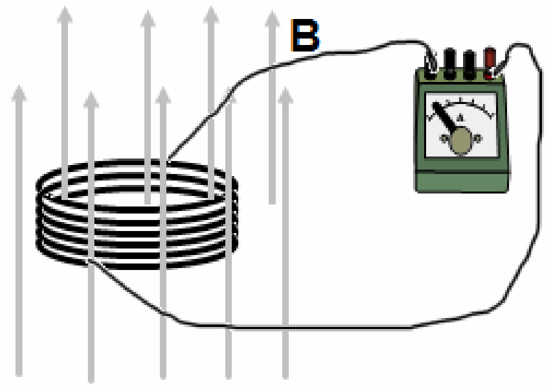
f. Determine the power dissipated in the resistor when the rod crosses the magnetic field.

$P = Fv$

$P = (B^2L^2v/R)v$

$P = B^2L^2v^2/R$

4. A coil 30 cm in diameter consist of 20 turns of circular copper wire 2 mm in diameter. The coil is connected to a low resistance galvanometer. Initially coil is placed in a uniform magnetic field perpendicular to its plane. During the experiment the magnetic field changes from 0.5 T to 2.5 T in 0.4 s. Ignore the resistance of the connecting wires. (copper resistivity $1.68 \times 10^{-8} \Omega \cdot m$)



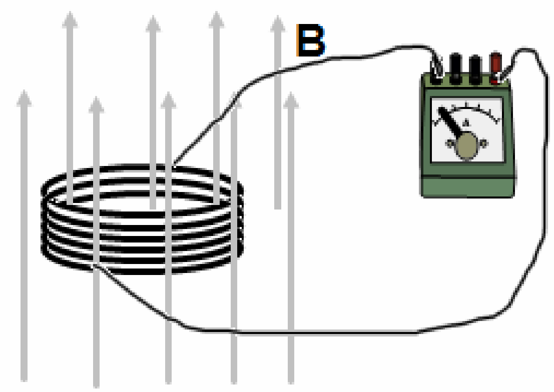
a. Calculate the initial flux in the coil.

b. Calculate the induced emf in the galvanometer.

c. Calculate the induced current in the coil.

d. Calculate the power dissipated in the coil as the field changes.

4. A coil 30 cm in diameter consist of 20 turns of circular copper wire 2 mm in diameter. The coil is connected to a low resistance galvanometer. Initially coil is placed in a uniform magnetic field perpendicular to its plane. During the experiment the magnetic field changes from 0.5 T to 2.5 T in 0.4 s. Ignore the resistance of the connecting wires. (copper resistivity $1.68 \times 10^{-8} \Omega \cdot m$)



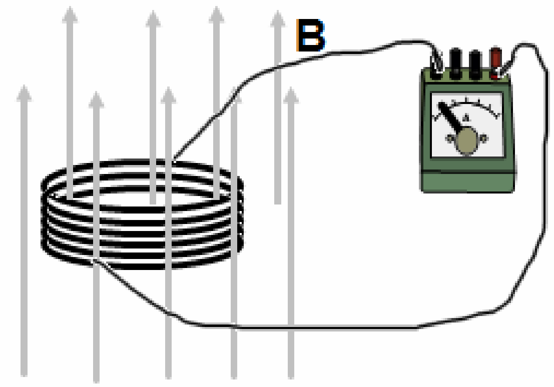
a. Calculate the initial flux in the coil.

$F = nB_{\wedge}A$

$F = (20)(0.5\ T)(À)(0.15\ m)^2$

$F = 0.71\ Wb$

4. A coil 30 cm in diameter consist of 20 turns of circular copper wire 2 mm in diameter. The coil is connected to a low resistance galvanometer. Initially coil is placed in a uniform magnetic field perpendicular to its plane. During the experiment the magnetic field changes from 0.5 T to 2.5 T in 0.4 s. Ignore the resistance of the connecting wires. (copper resistivity $1.68 \times 10^{-8} \Omega \cdot m$)



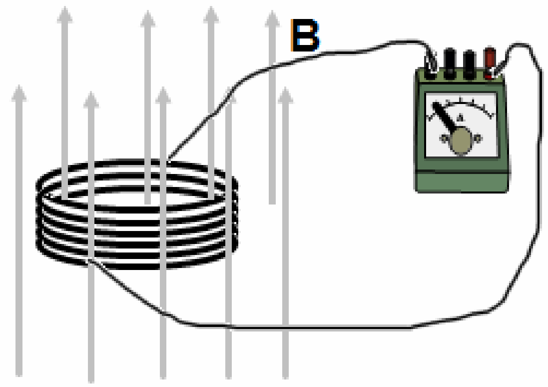
b. Calculate the induced emf in the galvanometer.

$E = -\Delta F / \Delta t$

$E = (0.36\ Wb)/(0.4\ s)$

$E = 0.9\ V$

4. A coil 30 cm in diameter consist of 20 turns of circular copper wire 2 mm in diameter. The coil is connected to a low resistance galvanometer. Initially coil is placed in a uniform magnetic field perpendicular to its plane. During the experiment the magnetic field changes from 0.5 T to 2.5 T in 0.4 s. Ignore the resistance of the connecting wires. (copper resistivity $1.68\times10^{-8}\,\Omega\cdot m$)



c. Calculate the induced current in the coil.

$R = pL/A$

$R = p(2\pi r)(20\ m)/(\pi r^2)$

$R = (1.68\times10^{-8}\ \Omega m)(20\ m)/(\pi)(0.001\ m)^2$

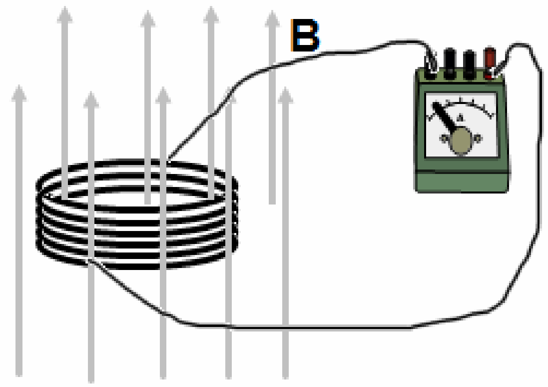
$R = 10.7\ \Omega$

$I = V/R$

$I = (0.9\ V)/(10.7\ \Omega)$

$I = 0.0841\ A$

4. A coil 30 cm in diameter consist of 20 turns of circular copper wire 2 mm in diameter. The coil is connected to a low resistance galvanometer. Initially coil is placed in a uniform magnetic field perpendicular to its plane. During the experiment the magnetic field changes from 0.5 T to 2.5 T in 0.4 s. Ignore the resistance of the connecting wires. (copper resistivity $1.68 \times 10^{-8} \Omega \cdot m$)



d. Calculate the power dissipated in the coil as the field changes.

P = IV

P = (0.09 A)(0.0841 V)

P = 0.0757 W