Exercise 29.7 - Enhanced - with Solution

1 of 15

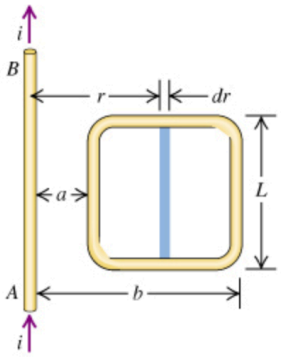
The current in the long, straight wire *AB* shown in the figure (Figure 1)is upward and is increasing steadily at a rate $\frac{di}{dt}$.

You may want to review (Page) .

For related problemsolving tips and strategies, you may want to view a Video Tutor Solution of Emf and current induced in a loop.

Figure

1 of 1



Review | Constants

Part A

At an instant when the current is i, what are the magnitude of the field $\vec{B}$ at a distance r to the right of the wire?

Express your answer in terms of the variables i, r, and magnetic constant μ_0.

$B =$

Submit Request Answer

Part B

At an instant when the current is i, what are the direction of the field $\vec{B}$ at a distance r to the right of the wire?

- into the page
- out of the page

Submit Request Answer

Part C

What is the flux $d\Phi_B$ through the narrow shaded strip?

Express your answer in terms of the variables i, L, r, dr, and magnetic constant μ_0.

$d\Phi_B =$ $\dfrac{\mu_0 i L dr}{2\pi r}$

Submit Previous Answers

Correct

$$d\Phi_B = BdA = \frac{\mu_0 i}{2\pi r} L dr.$$

Part D

What is the total flux through the loop?

Express your answer in terms of the variables i, L, a, b, and magnetic constant μ_0.

Part E

What is the induced emf in the loop?

Express your answer in terms of the variables di, dt, L, a, b, and magnetic constant μ_0.

$\mathcal{E}$ =

Submit Request Answer

Part F

Evaluate the numerical value of the induced emf if $a = 12.0\ \text{cm}$, $b = 36.0\ \text{cm}$, $L = 24.0\ \text{cm}$, and $di/dt = 9.60\ \text{A/s}$.

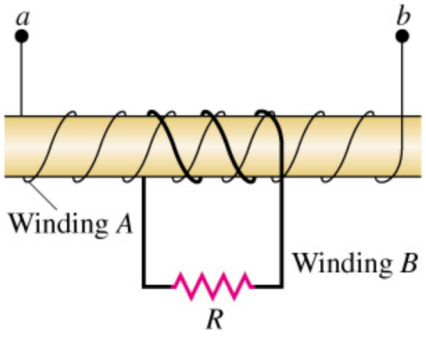
Express your answer in volts.

$\mathcal{E}$ = V

Exercise 29.20

A cardboard tube is wrapped with two windings of insulated wire wound in opposite directions, as in the figure (Figure 1). Terminals *a* and *b* of winding *A* may be connected to a battery through a reversing switch. State whether the induced current in the resistor *R* is from left to right or from right to left in the following circumstances.

Figure 1 of 1



Review | Constants

Part A

The current in winding *A* is from *a* to *b* and is increasing.

- from left to right
- from right to left

Submit Request Answer

Part B

The current in winding *A* is from *b* to *a* and is decreasing.

- from left to right
- from right to left

Submit Request Answer

Part C

Part C

The current in winding *A* is from *b* to *a* and is increasing.

- from left to right
- from right to left

Submit

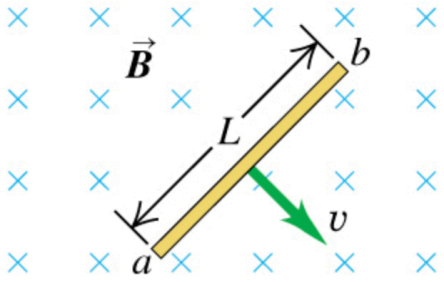
Request Answer

Exercise 29.25 - Enhanced - with Feedback

In the figure (Figure 1) a conducting rod of length $L = 40.0\ \text{cm}$ moves in a magnetic field $\vec{B}$ of magnitude $0.470\ \text{T}$ directed into the plane of the figure. The rod moves with speed $v = 5.70\ \text{m/s}$ in the direction shown.

Figure

1 of 1



Review | Constants

Part A

What is the potential difference between the ends of the rod?

Express your answer in volts.

$V =$ V

Submit Request Answer

Part B

Which point, **a** or **b**, is at higher potential?

- a
- b

Submit Request Answer

Part C

When the charges in the rod are in equilibrium, what is the magnitude of the electric field within the rod?

Express your answer in volts per meter.

$E =$ [ ] $\mathrm{V/m}$

Submit Request Answer

Part D

What is the direction of the electric field within the rod?

- From **b** to **a**
- From **a** to **b**

Submit Request Answer

Part E

When the charges in the rod are in equilibrium, which point, **a** or **b**, has an excess of positive charge?

- ○ **a**
- ○ **b**

Submit Request Answer

Part F

What is the potential difference across the rod if it moves parallel to **ab**?

Express your answer in volts.

$V =$ [ ] V

Part G

What is the potential difference across the rod if it moves directly out of the page?

Express your answer in volts.

$V =$ V

Exercise 29.27 - Enhanced - with Solution

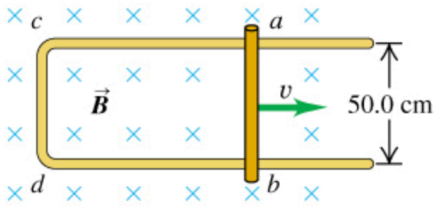
The conducting rod *ab* shown in the figure (Figure 1)makes contact with metal rails *ca* and *db*. The apparatus is in a uniform magnetic field 0.800 T, perpendicular to the plane of the figure.

You may want to review (Page) .

For related problemsolving tips and strategies, you may want to view a Video Tutor Solution of Motional emf in the slidewire generator.

Figure

1 of 1



Review | Constants

Part A

Find the magnitude of the emf induced in the rod when it is moving toward the right with a speed 7.50 $\mathrm{m/s}$.

Express your answer in volts.

$\mathcal{E}$ = V

Submit Request Answer

Part B

In what direction does the current flow in the rod?

- clockwise
- counterclockwise

Submit Request Answer

Part C

If the resistance of the circuit *abdc* is 1.50 Ω (assumed to be constant), find the magnitude of the force required to keep the rod moving to the right with a constant speed of 7.50 $\mathrm{m/s}$. You can ignore friction.

Express your answer in newtons.

F = N to the right

Submit Request Answer

Part D

Find the direction of the force required to keep the rod moving to the right with a constant speed of 7.50 $\mathrm{m/s}$.

- upward
- downward
- to the right
- to the left

Part E

Compare the rate at which mechanical work is done by the force (Fv) with the rate at which thermal energy is developed in the circuit (I^2R).

- equal
- nonequal

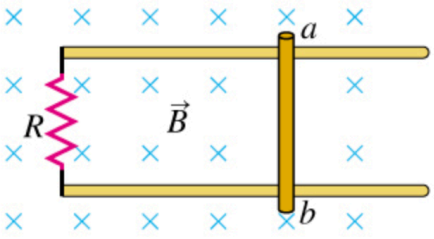
Submit Request Answer

Exercise 29.28 - Enhanced - with Feedback

A 0.750-m-long metal bar is pulled to the right at a steady 6.00 $\mathrm{m/s}$ perpendicular to a uniform, 0.550 T magnetic field. The bar rides on parallel metal rails connected through a 25.0 Ω resistor (Figure 1), so the apparatus makes a complete circuit. Ignore the resistance of the bar and the rails.

Figure

1 of 1



Review | Constants

Part A

Calculate the magnitude of the emf induced in the circuit.

Express your answer with the appropriate units.

$\mathcal{E}$ = Value Units

Submit Request Answer

Part B

Find the direction of the current induced in the circuit by using the magnetic force on the charges in the moving bar, Faraday's law or Lenz's law.

- clockwise
- counterclockwise

Submit Request Answer

Part C

Calculate the current through the resistor.

Express your answer with the appropriate units.

I = Value | Units

Submit

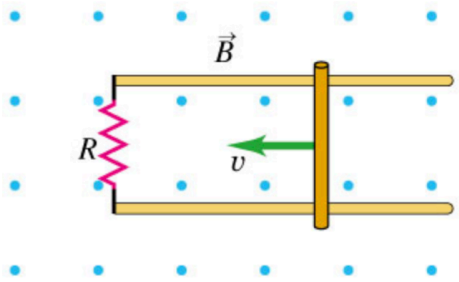
Request Answer

Exercise 29.29 - Enhanced - with Feedback

A 0.370-m-long metal bar is pulled to the left by an applied force F. The bar rides on parallel metal rails connected through a 41.0 Ω resistor, as shown in (Figure 1), so the apparatus makes a complete circuit. You can ignore the resistance of the bar and rails. The circuit is in a uniform 0.670 T magnetic field that is directed out of the plane of the figure.

Figure

1 of 1



Review | Constants

Part A

At the instant when the bar is moving to the left at 5.90 m/s, is the induced current in the circuit clockwise or counterclockwise?

- counterclockwise
- clockwise

Submit | Previous Answers

✔ Correct

Part B

What is the rate at which the applied force is doing work on the bar?

Express your answer with the appropriate units.

$P =$ Value | Units

Problem 29.47 - Enhanced - with Feedback

A very long, straight solenoid with a cross-sectional area of 2.20 cm^2 is wound with 86.0 turns of wire per centimeter. Starting at $t = 0$, the current in the solenoid is increasing according to $i\,(t) = (0.162\ \text{A/s}^2)t^2$. A secondary winding of 5.0 turns encircles the solenoid at its center, such that the secondary winding has the same cross-sectional area as the solenoid.

Review | Constants

Part A

What is the magnitude of the emf induced in the secondary winding at the instant that the current in the solenoid is 3.2 A?

Express your answer with the appropriate units.

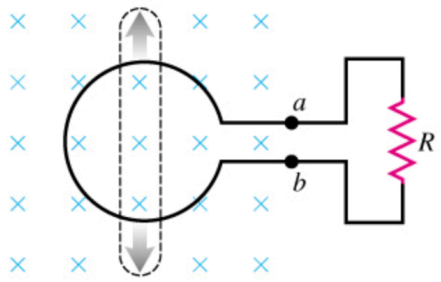
$|\mathcal{E}|$ = *Value* *Units*

Submit Request Answer

Problem 29.51

A flexible circular loop 6.10 cm in diameter lies in a magnetic field with magnitude 1.03 T , directed into the plane of the page in the figure (Figure 1). The loop is pulled at the points indicated by the arrows, forming a loop of zero area in 0.210 s .

Figure



Review | Constants

Part A

Find the average induced emf in the circuit.

Express your answer in volts.

$\mathcal{E}_{av}$ = V

Submit Request Answer

Part B

What is the direction of the current in R?

- from point *a* to point *b*
- from point *b* to point *a*

Submit Request Answer

Part C

Explain your reasoning.

Drag the terms on the left to the appropriate blanks on the right to complete the sentences.

Reset Help

b

decreasing

a

out of

into

increasing

Since the magnetic flux through the loop is **decreasing** , the induced current must produce a field that goes **into** the page.

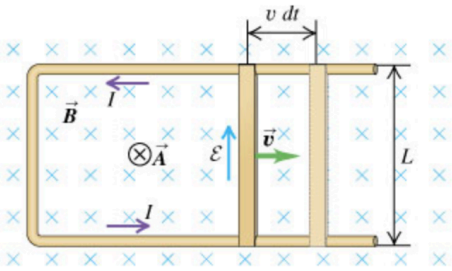
Therefore, the current flows from point a through the resistor to point b .

Problem 29.52

A conducting rod with length 0.153 m , mass 0.150 kg , and resistance 82.4 Ω moves without friction on metal rails as shown in the following figure(Figure 1). A uniform magnetic field with magnitude 1.50 T is directed into the plane of the figure. The rod is initially at rest, and then a constant force with magnitude 1.90 N and directed to the right is applied to the bar.

Figure

1 of 1



Review I Constants

Part A

How many seconds after the force is applied does the bar reach a speed of 28.2 $\mathrm{m/s}$?

Express your answer with the appropriate units.

t = Value Units

Submit Request Answer

Provide Feedback

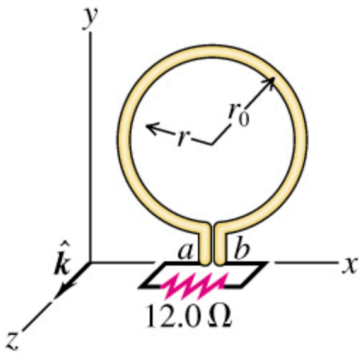
Next >

Problem 29.56

A circular conducting ring with radius $r_0 = 0.0420\ \text{m}$ lies in the *xy*-plane in a region of uniform magnetic field $\vec{B} = B_0[1 - 3(t/t_0)^2 + 2(t/t_0)^3]\hat{k}$. In this expression, $t_0 = 0.0100\ \text{s}$ and is constant, t is time, $\hat{k}$ is the unit vector in the $+z$-direction, and $B_0 = 0.0800\ \text{T}$ is constant. At points *a* and *b* (see the figure (Figure 1)) there is a small gap in the ring with wires leading to an external circuit of resistance $R = 12.0\ \Omega$. There is no magnetic field at the location of the external circuit.

Figure

1 of 1



Review | Constants

Part A

Derive an expression, as a function of time, for the total magnetic flux Φ_B through the ring.

Express your answer in terms of the variables r_0, t_0, B_0, t, and magnetic constant μ_0.

$|\Phi_B| =$

Submit Request Answer

Part B

Determine the emf induced in the ring at time $t = 5.00 \times 10^{-3}\ \text{s}$.

Express your answer in volts.

$|\mathcal{E}| =$ V

Submit Request Answer

Part C

Determine the polarity of the emf in the ring at time $t = 5.00 \times 10^{-3}$ s.

- clockwise
- counterclockwise

Submit Request Answer

Part D

Because of the internal resistance of the ring, the current through R at the time given in part B is only 3.00 mA. Determine the internal resistance of the ring.

Express your answer in ohms.

$r =$ Ω

Submit Request Answer

Part E

Determine the emf in the ring at a time $t = 1.21 \times 10^{-2}$ s.

Express your answer in volts.

$|\mathcal{E}| =$ V

Submit Request Answer

Part F

Determine the polarity of the emf in the ring at a time $t = 1.21 \times 10^{-2}$ s.

- clockwise
- counterclockwise

Submit Request Answer

Part G

Determine the time at which the current through R reverses its direction.

Express your answer in seconds.

$t =$ s

Submit Request Answer

Problem 29.57

A slender rod with a length of 0.200 m rotates with an angular speed of 9.00 $\mathrm{rad/s}$ about an axis through one end and perpendicular to the rod. The plane of rotation of the rod is perpendicular to a uniform magnetic field with a magnitude of 0.700 T .

Review | Constants

Part A

What is the induced emf in the rod?

Express your answer in volts.

$\mathcal{E}$ = 0.126 V

Submit Previous Answers

Correct

Important: If you use this answer in later parts, use the full unrounded value in your calculations.

Part B

What is the potential difference between its ends?

Express your answer in volts.

V = 0.126 V

Submit Previous Answers

Part C

Suppose instead the rod rotates at 9.00 $\mathrm{rad/s}$ about an axis through its center and perpendicular to the rod. In this case, what is the potential difference between the ends of the rod?

Express your answer in volts.

$V = 0\ \mathrm{V}$

Submit Previous Answers

✔ Correct

Part D

Suppose instead the rod rotates at 9.00 $\mathrm{rad/s}$ about an axis through its center and perpendicular to the rod. In this case, what is the potential difference between the center of the rod and one end?

Express your answer in volts.

Problem 29.58 - Enhanced - with Feedback

A metal rod with a length of 23.0 cm lies in the xy-plane and makes an angle of 36.1° with the positive x-axis and an angle of 53.9° with the positive y-axis. The rod is moving in the $+x$-direction with a speed of 6.80 $\mathrm{m/s}$. The rod is in a uniform magnetic field $\vec{B} = (0.180\ \mathrm{T})\hat{i} - (0.250\ \mathrm{T})\hat{j} - (0.0700\ \mathrm{T})\hat{k}$.

Review | Constants

Part A

What is the magnitude of the emf induced in the rod?

Express your answer in volts.

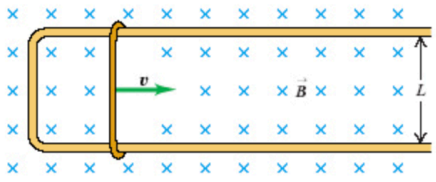
$\mathcal{E}$ = V

Submit Request Answer

Problem 29.59 - Enhanced - with Feedback

A rectangular loop with width L and a slidewire with mass m are as shown in (Figure 1). A uniform magnetic field $\vec{B}$ is directed perpendicular to the plane of the loop into the plane of the figure. The slidewire is given an initial speed of v_0 and then released. There is no friction between the slidewire and the loop, and the resistance of the loop is negligible in comparison to the resistance R of the slidewire.

Figure



Review | Constants

Part A

Obtain an expression for F, the magnitude of the force exerted on the wire while it is moving at speed v.

Express your answer in terms of some or all of the variables B, v, R, L, and m.

$F =$

Submit Request Answer

Part B

Find the distance x that the wire moves before coming to rest.

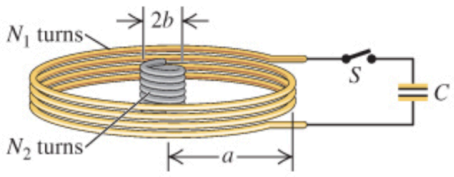
Express your answer in terms of some or all of the variables B, v_0, R, L, and m.

$x =$

Problem 29.60

A circular coil with $N_1 = 5000$ turns is made of a conducting material with resistance 0.0100 Ω/m and radius $a = 40.0$ cm. The coil is attached to a $C = 10.00$ μF capacitor as shown in (Figure 1). A second coil with radius $b = 4.00$ cm, made of the same wire, with $N_2 = 100$ turns, is concentric with the first coil and parallel to it. The capacitor has a charge of +100 μC on its upper plate, and the switch S is open. At time $t = 0$ the switch is closed.

Figure



Review | Constants

Part A

What is the magnitude of the current in the larger coil immediately after the switch is closed?

Express your answer with the appropriate units.

I_1 = 7.96×10^{-2} A

Submit Previous Answers

✔ Correct

Part B

What is the magnetic flux through each turn of the smaller coil immediately after the switch is closed? (Since $b << a$, we may treat the magnetic field in the smaller coil due to the larger coil as uniform.)

Express your answer with the appropriate units.

Φ_2 = 0 V • s

Part C

What is the direction of the current in the smaller coil immediately after the switch is closed?

- (•) clockwise
- ( ) counterclockwise

Submit | Previous Answers

Correct

Just after S is closed, I_1 is increasing to its maximum value and runs counterclockwise through the outer loop. This produces an increasing field in the inner circuit pointing out of the paper. I_2 flows to oppose this increase, so it flows clockwise.

Part D

What is the direction of the current in the smaller coil at t = 1.26 ms?

- ( ) clockwise
- ( ) counterclockwise

Submit | Request Answer

Part E

What is the magnitude of the current in the smaller coil at $t = 1.26\ \text{ms}$?

Express your answer with the appropriate units.

$I_2 =$ *Value* *Units*

Submit Request Answer

Challenge Problem 29.69

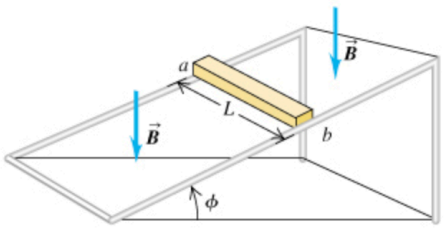
15 of 15

✔ Complete

A metal bar with length L, mass m, and resistance R is placed on frictionless metal rails that are inclined at an angle ϕ above the horizontal. The rails have negligible resistance. A uniform magnetic field of magnitude B is directed downward in the figure (Figure 1). The bar is released from rest and slides down the rails.

Figure

1 of 1



Review | Constants

Part A

✔

Is the direction of the current induced in the bar from *a* to *b* or from *b* to *a*?

- (•) from *a* to *b*
- ( ) from *b* to *a*

Submit | Previous Answers

✔ **Correct**

Part B

✔

What is the terminal speed of the bar?

Express your answer in terms some or all of of the variables R, m, ϕ, L, B, and acceleration due to gravity g.

$$v_t = \frac{Rmg}{B^2L^2}\frac{\tan\phi}{\cos\phi}$$

Part C

What is the induced current in the bar when the terminal speed has been reached?

Express your answer in terms some or all of of the variables R, m, ϕ, L, B, and acceleration due to gravity g.

$$i = \frac{mg\tan\phi}{BL}$$

Submit Previous Answers

✔ **Correct**

Part D

After the terminal speed has been reached, at what rate is electrical energy being converted to thermal energy in the resistance of the bar?

Express your answer in terms some or all of of the variables R, m, ϕ, L, B, and acceleration due to gravity g.

Part E

After the terminal speed has been reached, at what rate is work being done on the bar by gravity?

Express your answer in terms some or all of of the variables R, m, ϕ, L, B, and acceleration due to gravity g.