8

PHYS 122 HW 8

1

Assume that the rod in the figure below has a length of $0.86m$, the resistor has value 2.2Ω, and a magnetic field of $8.0T$ is directed into the page. The rod and rails have negligible resistance. The rod is pulled to the left at constant speed.

a

What speed will produce a current of $1.5A$ in the resistor?

Answer

$\epsilon = vBd$
$\epsilon = v(8.0)(0.86)$
$V = IR$
$V = (1.5)(2.2)$
$(1.5)(2.2) = v(8.0)(0.86)$
$\frac{(1.5)(2.2)}{(8.0)(0.86)} = v$
$v = 0.4797\ \frac{m}{s}$
$\square$

b

In what direction does the current flow?

Answer

Counterclockwise, as it's induced field opposes the original field.

c

What pulling force must be applied to maintain a steady current?

Answer

$F = IdB$
$F = 10.32\ N$

□

2

A long rectangular conducting loop of width $25cm$ is partially in a region of a horizontal magnetic field of $1.8T$ perpendicular to the loop as shown in the figure below. The mass of the loop is $12g$, and its resistance is 0.17Ω. If the loop is released, what is its terminal velocity? Assume that the top of the loop stays in the magnetic field. (Hint: The terminal velocity occurs when the magnetic force on the induced current is equal in magnitude to the gravitational force.)

Answer

$F_g = mg$
$F_l = IwB$
$I = \frac{mg}{wB}$

$V = IR$
$V = \frac{mgR}{wB}$
$vBw = \frac{mgR}{wB}$
$v = \frac{mgR}{w^2B^2}$
$v = 0.09883\ \frac{m}{s}$
□

3

A circular loop of wire is placed in a magnetic field of $0.30T$ while the free ends of the wire are attached to a 15Ω resistor as shown in the figure below. When you squeeze the loop, the area of the loop is reduced at a constant rate from 200 to $100\ cm^2$ in $0.020s$. What are the magnitude and direction of the current in the resistor?

Answer

$\epsilon = -\frac{BdA}{dt} = B\frac{0.01}{0.02}$
$V = IR$
$I = B\frac{0.01}{0.02R}$
$I = 0.01\ A$
□

4

A square loop of wire with side length $12cm$ is placed in a uniform magnetic field of strength $2T$. Initially $\vec{B}$ and $\vec{A}$ are parallel. At $t=0$ the loop begins to spin about its axis with angular velocity $\omega = 1rad/s$ (see below). Plot the EMF through this loop from $t=0$ to $t=7$ seconds.

✓ **Answer**

$\epsilon = -\frac{AB\hat{n}\cdot\hat{B}}{dt}$

$\hat{n}\cdot\hat{B} = \cos t$

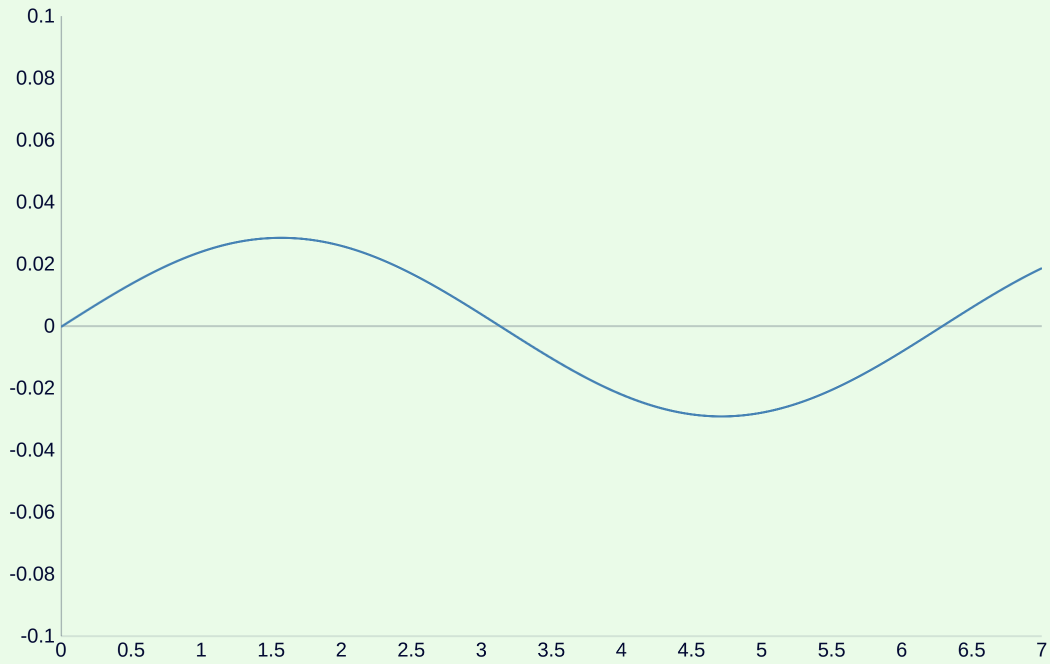
$\epsilon = -\frac{AB\cos t}{dt}$

$\epsilon = AB\sin t$

$\epsilon = (0.12)^2(2)\sin t$

$\epsilon = 0.0288\sin t$

□



5

A circular wire loop of radius r and total resistance R is placed inside a region of uniform magnetic field that has magnitude given by $B = B_0\sin(\omega t)$. $\vec{B}$ and $\vec{A}$ are parallel. Find the induced magnetic field (the magnetic field only from the wire loop) produced at the center of the wire loop at any given time t. Describe the phase offset between the two fields.

✓ **Answer**

$B = B_0\sin(\omega t)$

$\epsilon = -\frac{d\Phi_B}{dt}$

$\epsilon = -\frac{AB_0\sin(\omega t)}{dt}$

$\epsilon = -\omega AB_0\cos(\omega t)$

$I = -\frac{\omega AB_0}{R}\cos(\omega t)$

$$\vec{B} = \frac{\mu_0}{4\pi}(-\frac{\omega A B_0}{R}\cos(\omega t)) \oint \frac{d\vec{l}\times\vec{r}}{r^3}$$

$$B = \frac{\mu_0}{4\pi}\left(-\frac{\omega A B_0}{R}\cos(\omega t)\right) \oint \frac{2\pi}{r^2}$$

$$B = \left(-\frac{\omega\mu_0 A B_0}{2Rr^2}\cos(\omega t)\right)$$

$$B = -\frac{\omega\mu_0\pi B_0}{2R}\cos(\omega t)$$

$\square$

In the direction opposite the original magnetic field.