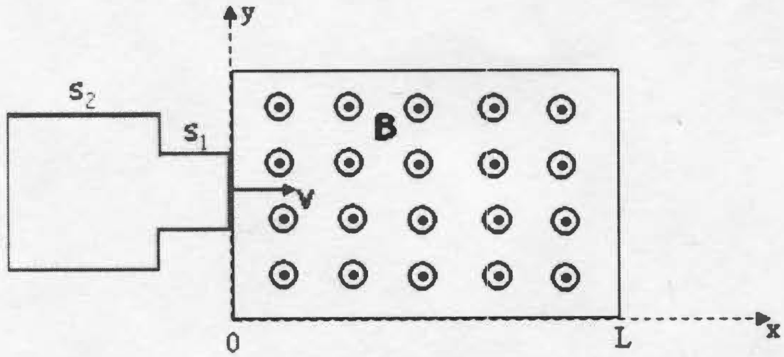
The next six questions pertain to the situation described below.

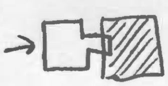


A conducting loop is made in the form of two squares of sides s_1 = 2.5cm and s_2 = 5.1 cm as shown. At time t = 0, the loop enters a region of length L = 15.1 cm that contains a uniform magnetic field B = 1.6 T, directed in the positive z-direction. The loop continues through the region with constant speed v = 41 cm/s. The resistance of the loop is R = 2.6 Ω.

1) At time $t = t_1 = 0.02$ s, what is I_1, the induced current in the loop? I_1 is defined to be positive if it is in the counterclockwise direction.

✓-0.00630769230769231 A

at $t = t_1 \rightarrow$



$d = .82$ cm

The emf is induced by the right side s_1 moving into the field

$\mathcal{E} = vBL = vB(s_1) = (.41\ m/s)(1.6T)(.025\ m)$

$\mathcal{E} = .0164$ V

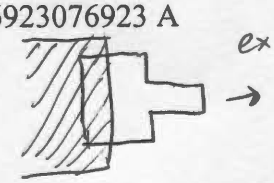
$I = V/R = \frac{.0164V}{2.6\Omega}$ $\qquad I = .00631$ A

Direction is determined so that induced current creates a magnetic field that opposes the change in flux. Flux is increasing out of page so current is clockwise. (creates field into page) - so negative

2) At time $t = t_2 = 0.471$ s, what is I_2, the induced current in the loop? I_2 is defined to be positive if it is in the counterclockwise direction.

✓0.0128676923076923 A

$t = t_2$



$d = 19$ cm

$\rightarrow$ exiting field

same process - s_2 is now length moving in field

$\mathcal{E} = vB(s_2) = (.41)(1.6)(.051)$

$\mathcal{E} = .0335$ V

$I = V/R = .0129$ A

Changing flux through loop is now decreasing, so induced current is ~~[illegible]~~ counter-clockwise (positive)

3)What is $F_x(t_2)$, the x-component of the force that must be applied to the loop to maintain its constant velocity v = 41 cm/s at t = t_2 = 0.471 s?

✓0.00105000369230769 N

$$\text{Power} = F \cdot v = \frac{V^2}{R}$$

(mechanics) velocity (electric)

physical power applied must equal the electric power being dissipated

$$F = \frac{1}{v}\frac{(vBL)^2}{R} = \frac{vB^2(s_2)^2}{R}$$

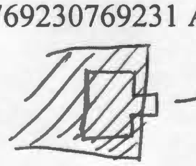
$$F = \frac{(.41)(1.6)^2(.051)^2}{(2.6)}$$

$\underline{F = .00105\ N}$ → direction

4)At time t = t_3 = 0.389 s, what is I_3, the induced current in the loop? I_3 is defined to be positive if it is in the counterclockwise direction.

✓0.00630769230769231 A

t_2 t_3



exiting field

same process - length s_1

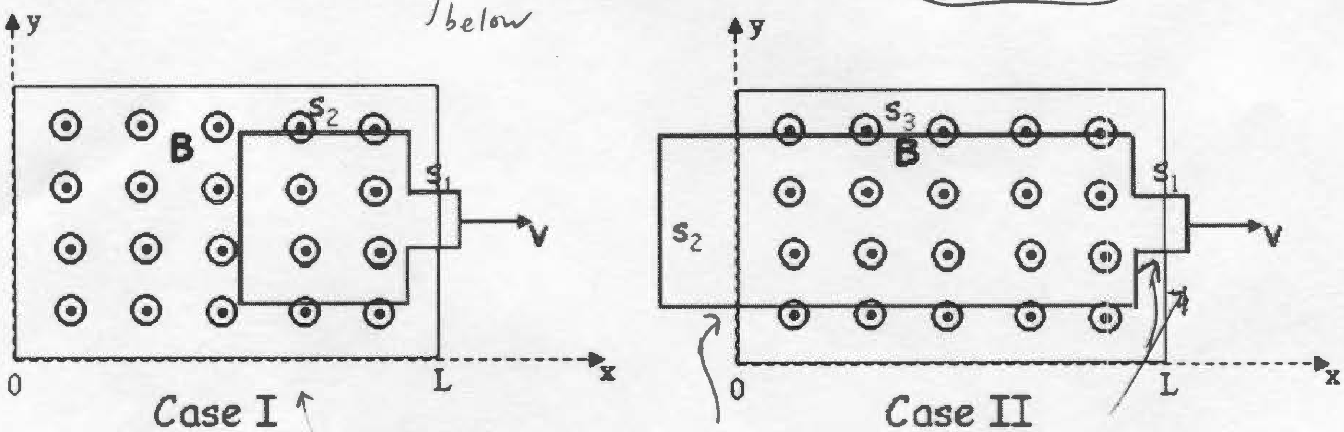
$\mathcal{E} = vBs_1 = (.41)(1.6)(.025)$

$\mathcal{E} = .0164$

$\underline{I = V/R = .00631\ A}$

decreasing flux creates ~~clock~~ $\underline{\text{counter-clockwise}}$ current

5)Consider the two cases shown ~~above~~ below. How does I_I, the magnitude of the induced current in Case I, compare to I_{II}, the magnitude of the induced current in Case II? Assume $s_2 = 3s_1$.



length of side exiting field (changing flux)

1. $I_I > I_{II}$
2. $I_I = I_{II}$
3. ✓ $I_I < I_{II}$

~~exiting (changing~~ [illegible]

Case I

s_1

$\mathcal{E} = vBs_1$

Case II

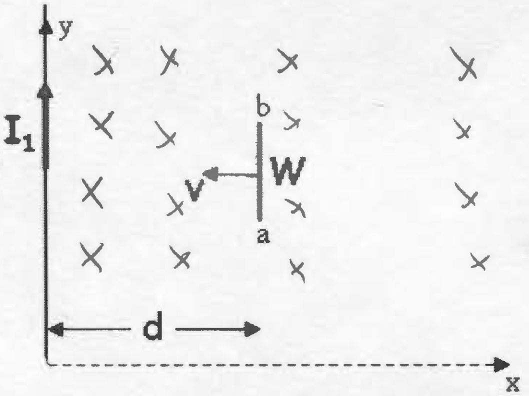
s_2 entering, s_1 exiting

so $\mathcal{E} = vBs_2 - vBs_1$

since $s_2 - s_1 > s_1$

$\boxed{I_{II} > I_I}$

The next six questions pertain to the situation described below.



An infinite straight wire carries current I_1 = 4.4 A in the positive y-direction as shown. At time t = 0, a conducting wire, aligned with the y-direction is located a distance d = 42 cm from the y-axis and moves with velocity v = 15 cm/s in the negaitve x-direction as shown. The wire has length W = 15 cm.

7)What is ε(0), the emf induced in the moving wire at t = 0? Define the emf to be positive if the potential at point a is higher than that at point b.
✓4.71428571428571 × 10^{-8} V

The induced emf is $\mathcal{E} = vBL$ so we need to find B at distance d

$$B(d) = \frac{\mu_0 I_1}{2\pi d} = \frac{(4\pi \times 10^{-7})(4.4\,A)}{2\pi(.42)} = 2.095 \times 10^{-6}\,T$$

So $\mathcal{E} = (.15\,m/s)(2.095 \times 10^{-6}\,T)(.15\,m)$

$\mathcal{E} = 4.71 \times 10^{-8}\,V$

only electrons are mobile, so using right-hand rule $\vec{F} = q\vec{v} \times \vec{B}$ shows they are pulled towards b, so positive V is at a (positive)

8)What is ε(t_1), the emf induced in the moving wire at t = t_1 = 1.9 s? Define the emf to be positive if the potential at point a is higher than that at point b.
✓1.46666666666667 × 10^{-7} V

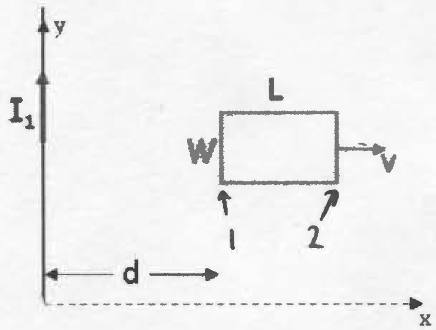
at t_1 d_1 = 13.5cm from wire

- B field is stronger closer to wire with current

$$B(d_1) = \frac{\mu_0 I_1}{2\pi d_1} = 6.52 \times 10^{-6}\,T$$

$\mathcal{E} = vBL = (.15)(6.52 \times 10^{-6})(.15)$

$\mathcal{E} = 1.47 \times 10^{-7}\,V$ positive as before



- Both the left and right sides moving create an emf, ~~m~~ opposing each other

$\mathcal{E} = vB_1L - vB_2L$

9)

$d_1 = .42\,m$ $\quad B_1 = \frac{\mu_0 I_1}{2\pi d_1} = 2.095 \times 10^{-6}\,T$

The wire is now replaced by a conducting rectangular loop as shown. The loop has length L = 56 cm and width W = 15 cm. At time t = 0, the loop moves with velocity v = 15 cm/s with its left end located a distance d = 42 cm from the y-axis. The resistance of the loop is R = 1.7 Ω. What is i(0), the induced current in the loop at time t = 0? Define the current to be positive if it flows in the counter-clockwise direction.

$d_2 = 98\,cm$ $\quad B_2 = \frac{\mu_0 I_1}{2\pi d_2} = 8.98 \times 10^{-7}\,T$

[ ] A

✓ -1.58463385354142 × 10^{-8} A

(L = W here)

$\mathcal{E} = vL(B_1 - B_2) = (.15\,m/s)(.15\,m)(B_1 - B_2)$

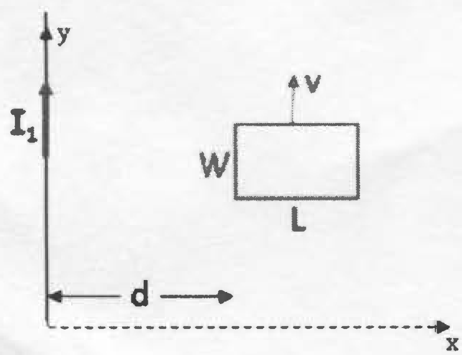
$\mathcal{E} = 2.69 \times 10^{-8}\,V$

$I = V/R = \mathcal{E}/R = \frac{2.69 \times 10^{-8}\,V}{1.7\,\Omega}$

$\underline{I = 1.58 \times 10^{-8}\,A}$

As it moves away from the wire flux is decreasing into the page, so the current will flow clockwise to create an induced field into the page

negative

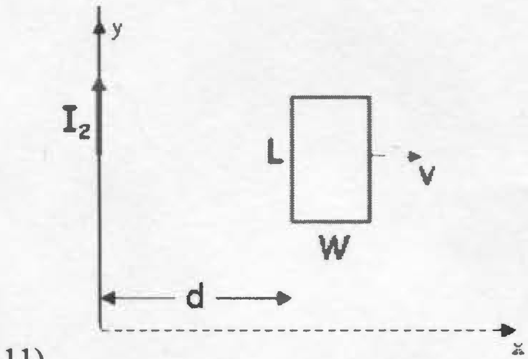


10)

Suppose the loop now moves in the positive y-direction as shown. What is the direction of the induced current now?

1. The current flows counterclockwise
2. The current flows clockwise
3. ✓There is no induced current now

The net magnetic flux through the loop is 0, so no net emf is created, and no current flows.



we rewrite our expression for current in the loop, but now we don't know the magnetic field so we leave it as an ~~[illegible]~~ expression to let us solve for I_2

11)

Suppose now that the loop is rotated 90° and moves with velocity v = 15 cm/s in the positive x-direction as shown. What is I_2, the current in the infinite wire, if the induced current in the loop at the instant shown (d = 42 cm) is the same as it was in the third part of this problem (i.e., when the left end of loop was at a distance d = 42 cm from the y-axis)?

A

✓2.55918367346939 A

Now we have $d_1 = .42m$ $\quad B_1 = \frac{\mu_0 I_2}{2\pi d_1}$

$d_2 = .57cm$ $\quad B_2 = \frac{\mu_0 I_2}{2\pi d_2}$

$L = L = 56cm$

and $\mathcal{E} = vL(B_1 - B_2)$

and $I = \mathcal{E}/R$

so $I = \frac{vL}{R}\left(\frac{\mu_0 I_2}{2\pi d_1} - \frac{\mu_0 I_2}{2\pi d_2}\right)$

induced (loop) current

~~[illegible]~~ $I = \frac{vL\mu_0}{2\pi R} I_2 \left(\frac{1}{d_1} - \frac{1}{d_2}\right)$

I_2 is what we are solving for

$$I_2 = \frac{2\pi R I}{vL\mu_0\left(\frac{1}{d_1} - \frac{1}{d_2}\right)}$$

I is given $= 1.58 \times 10^{-8}$ A previous answer

$$I_2 = \frac{2\pi(1.7)(1.58 \times 10^{-8})}{(.15)(.56)(4\pi \times 10^{-7})\left(\frac{1}{.57} - \frac{1}{.42}\right)}$$

switched by mistake

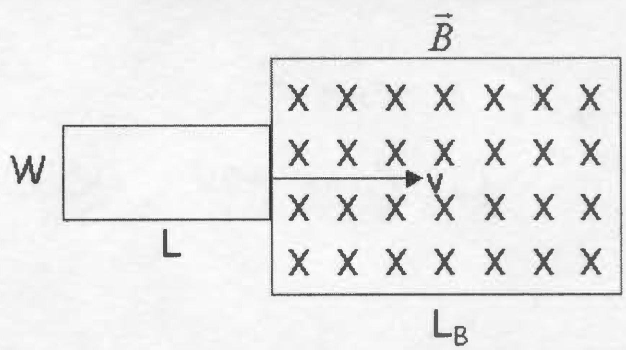
$I_2 = 2.56$ A

Moving Coil

MOVING COIL BASE

Welcome to this IE. You may navigate to any page you've seen already using the IE tab on the right.

Coil Moving through a Magnetic Field



At t=0, a rectangular coil of resistance R = 2 ohms and dimensions w = 3 cm and L = 8 cm enters a region of constant magnetic field B = 1.6 T directed into the screen as shown. The length of the region containing the magnetic field is L_B = 15 cm. The coil is observed to move at constant velocity v = 5 cm/s. What is the force required at time t = 0.8 sec to maintain this velocity? F(0.8 sec) =

5.76×10^{-5} N Submit Graph

while the loop is entering the field, the required force is constant.

We can find force using $F = IL \times B$, so first we need to find the current.

general equations: $\mathcal{E} = vBL$, $I = \mathcal{E}/R$ → in this case $\mathcal{E} = vBW$

$\mathcal{E} = (.05\ m/s)(.03\ m)(1.6\ T)$

$= .0024\ V$

$I = \dfrac{.0024\ V}{2\ \Omega}$

$I = .0012\ A$

Now we can calculate force on the right wire (no other segment feels a force)

$F = ILB = IWB$ (length perpendicular to motion)

$F = (.0012\ A)(.03\ m)(1.6\ T)$

$F = 5.76 \times 10^{-5}\ N$