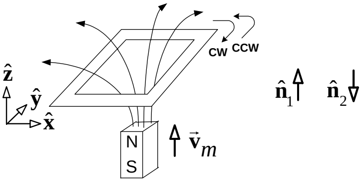
Problem 1

Problem 1 *Faraday's Law*

- Magnet is *moving up* into a square planar loop of copper wire.

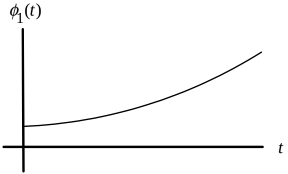


(a) Using the normal $\hat{\mathbf{n}}_1$, roughly sketch the flux $\phi_1(t) = \int_S \vec{\mathbf{B}} \cdot (\hat{\mathbf{n}}_1 dS)$ as a function of t while the magnet is below the copper loop.

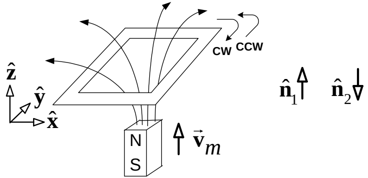
Is the flux in the loop produced by the magnet increasing or decreasing?

With normal $\hat{\mathbf{n}}_1$, $\phi_1(t) = \int_S \vec{\mathbf{B}} \cdot (\hat{\mathbf{n}}_1 dS)$ is **positive** and **increasing**.

So $\xi_m \triangleq -\dfrac{d\phi_1(t)}{dt} < 0.$



Problem 1 *Faraday's Law* (continued)

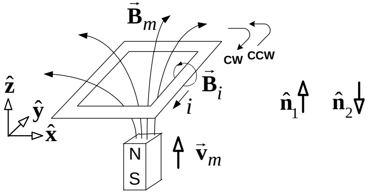


(b) Using the normal $\hat{\mathbf{n}}_1$, what is the direction of positive travel around the surface whose boundary is the loop (clockwise or counterclockwise)?

With the normal $\hat{\mathbf{n}}_1$, the positive direction of travel around the surface is **CCW**.

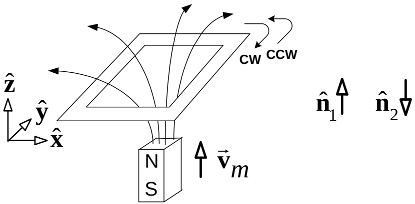
(c) What is the direction of the **induced** current (clockwise or counterclockwise)?
Let $\psi_1(i)$ be the flux in the loop due to the induced current.
Is $\psi_1(i)$ positive or negative while the magnet is below the loop?
Is $\psi_1(i)$ increasing or decreasing while the magnet is below the loop, but moving up?

As $\xi_m \triangleq -d\phi_1(t)/dt < 0$ the induced current flows in the **CW** direction.
$\psi_1(i) = \int_S \vec{\mathbf{B}}_i \cdot (\hat{\mathbf{n}}_1 dS) < 0$ is the flux in the loop due to the **induced** current.
$\phi_1(t) > 0$ and *increasing* while $\psi_1(i) < 0$.
So $\psi_1(i) < 0$ is opposing the increasing flux $\phi_1(t) > 0$



- The arrow ($\longrightarrow$) next to i is the actual direction of i and *not* a sign convention.

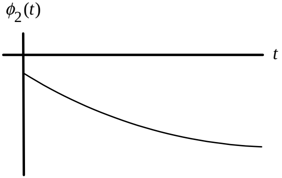
Problem 1 *Faraday's Law* (continued)



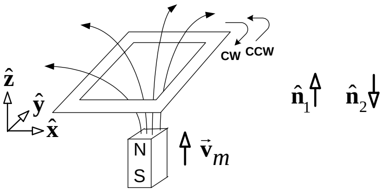
(d) Using the normal $\hat{\mathbf{n}}_2$, roughly sketch the flux $\phi_2(t) = \int_S \vec{\mathbf{B}} \cdot (\hat{\mathbf{n}}_2 dS)$ as a function of t while the magnet is below the copper loop.
Is the flux in the loop produced by the magnet increasing or decreasing?

With the normal $\hat{\mathbf{n}}_2$, $\phi_2(t) = \int_S \vec{\mathbf{B}} \cdot (\hat{\mathbf{n}}_2 dS)$ is **negative** and **decreasing**.

That is, $\xi_m = -\dfrac{d\phi_2(t)}{dt} > 0$.



Problem 1 *Faraday's Law* **(continued)**



(e) Using the normal $\hat{\mathbf{n}}_2$, what is the direction of positive travel around the surface whose boundary is the loop (clockwise or counterclockwise)?

With $\hat{\mathbf{n}}_2$, the positive direction of travel around the surface is **CW**.

(f) What is the direction of the induced current (clockwise or counterclockwise)?

Let $\psi_2(i)$ be the flux in the loop due to the induced current.

Is $\psi_2(i)$ positive or negative while the magnet is below the loop?

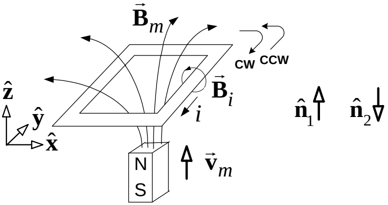
Is $\psi_2(i)$ increasing or decreasing while the magnet is below the loop, but moving up?

$\xi_m = -d\phi_2(t)/dt > 0 \Longrightarrow$ Induced current flows in the **CW** direction.

Same induced voltage/current as computed using $\vec{\mathbf{n}}_1$ in part (c)!

$\phi_2(t) < 0$ and decreasing (becoming more negative)

$\psi_2(i) = \int_S \vec{\mathbf{B}}_i \cdot (\hat{\mathbf{n}}_2 dS) > 0$ opposes the *negative and decreasing* flux $\phi_2(t)$



- The arrow ($\longrightarrow$) next to i is the actual direction of i and *not* a sign convention.