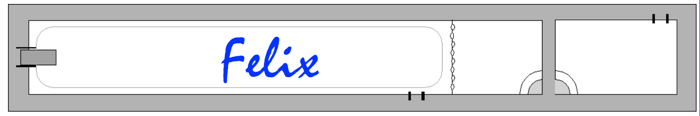
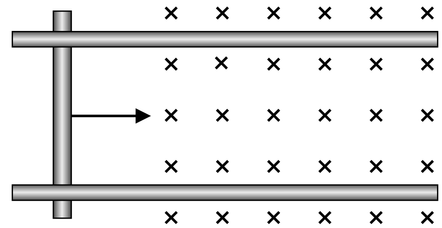
PhyzSpringboard: Faraday's Law X



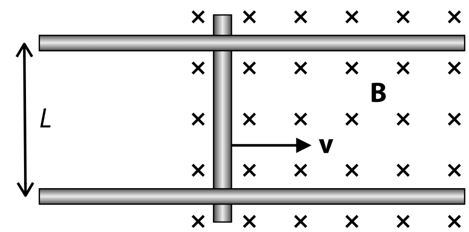
THE ELECTRIC SLIDE

Consider a metal rod sliding along two metal rails.



1. What happens when the rod moves into the magnetic field?

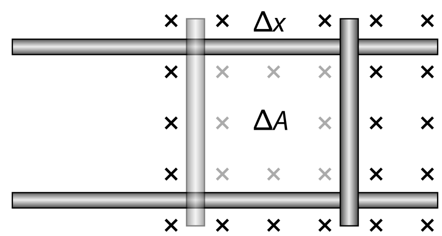
   Voltage (emf) is induced in the rod. The top rail gains a positive charge; the bottom rail gains a negative charge.



2. Suppose the rails are a distance L apart, the rod slides with a speed of v, and the magnetic field has a strength B.

a. Then...

   $\mathcal{E} = BLv$



b. How far Δx does the rod move in an interval of time Δt?

   Since $v = \Delta x/\Delta t$, $\Delta x = v\Delta t$

c. Eliminate v from the equation in part a.

   $\mathcal{E} = BL\Delta x/\Delta t$

d. What is the area ΔA swept through by the rod in the interval Δt?

   $\Delta A = L\Delta x$

e. Eliminate L and Δx from the equation in part c.

   $\mathcal{E} = B\Delta A/\Delta t$

f. What is the change in flux $\Delta\Phi$ that the loop undergoes in the interval Δt?

   $\Delta\Phi = B\Delta A$

g. Eliminate B and ΔA from the equation in part e.

   $\mathcal{E} = \Delta\Phi/\Delta t$

3. Write a verbal interpretation of this equation.

The voltage induced in a loop of wire is the rate at which flux changes.

FINISHING TOUCHES

Although this equation describes the voltage induced in a rod moving along a rail, it also describes the voltage induced in a loop of wire that undergoes a change of flux.

4. a. How can the number of loops be accounted for in the equation?

$\mathcal{E} = N\Delta\Phi/\Delta t$

b. Lenz's law reflects the fact that the induced voltage creates a current whose magnetic field opposes the change in flux that produced it. How is Lenz's law incorporated into Faraday's Law?

$\mathcal{E} = -N\Delta\Phi/\Delta t$

DO THE MATH

5. Consider a loop of wire turning in a magnetic field. If the magnetic field is 0.06 T, the area of the loop is 0.04 m^2, and the time for the loop to rotate 90° is 0.02 s,

a. how much voltage is induced in the loop?

$\mathcal{E} = N\Delta\Phi/\Delta t$

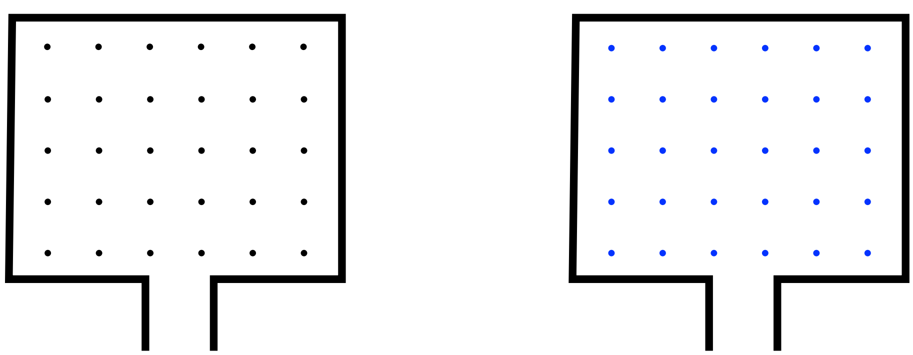
$\mathcal{E} = 1 \cdot 0.06\ T \cdot 0.04\ m^2 / 0.02\ s = 0.12\ V$

b. how much voltage would be induced in the loop if two loops were used instead of one?

$\mathcal{E} = 2 \cdot 0.06\ T \cdot 0.04\ m^2 / 0.02\ s = 0.24\ V$

c. how much voltage would be induced if 50 loops of wire were used?

$\mathcal{E} = 50 \cdot 0.06\ T \cdot 0.04\ m^2 / 0.02\ s = 6.0\ V$



DIRECTIONS

6. Consider a loop of wire immersed in a magnetic field that diminishes to zero over some period of time as shown. The change in flux will induce a voltage in the loop. ***But which way will the current flow?***

a. It flows in the direction so that the resulting magnetic field will

Oppose the change in flux that created it.

b. Since the change in the field in this case was a decreasing outward field, the current in the wire will create

an outward field inside the loop.

c. This kind of field will be generated inside the loop if the current flows counterclockwise.