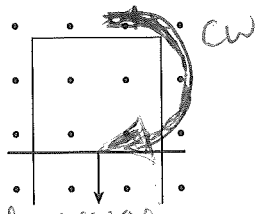
34 Electromagnetic Induction

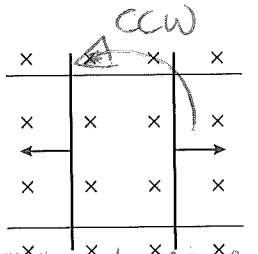
34.1 Induced Currents

34.2 Motional emf

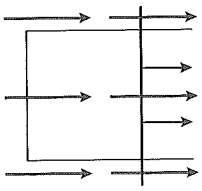
1. The figures below show one or more metal wires sliding on fixed metal rails in a magnetic field. For each, determine if the induced current flows clockwise, flows counterclockwise, or is zero. Show your answer by drawing it.

a. 

upward, increasing

b. 

down, increasing

c. 
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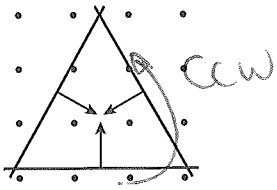
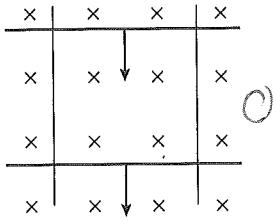
d. 

upward, decreasing

e. 
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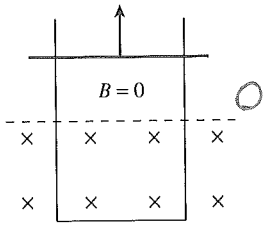
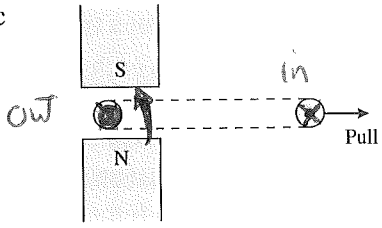
f. 

0

2. A loop of copper wire is being pulled from between two magnetic poles.

a. Show on the figure the current induced in the loop. Explain your reasoning.

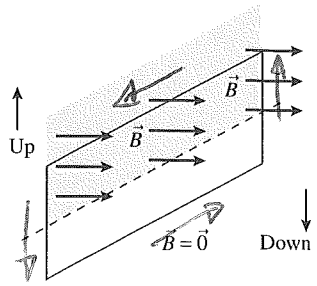


Flux upward, decreasing

b. Does either side of the loop experience a magnetic force? If so, draw and label a vector arrow or arrows on the figure to show any forces.

yes, left side, F is to left. $I\vec{\ell} \times \vec{B}$

3. A vertical, rectangular loop of copper wire is half in and half out of a horizontal magnetic field. (The field is zero beneath the dotted line.) The loop is released and starts to fall.

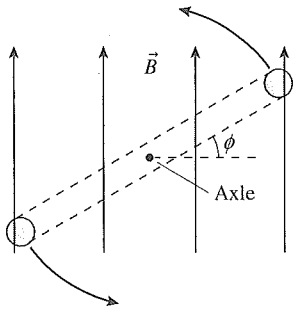


   a. Add arrows to the figure to show the direction of the induced current in the loop. Flux right, decreasing

   b. Is there a net magnetic force on the loop? If so, in which direction? Explain.

$I\vec{L} \times \vec{B}$ on top of loop is up. (Side cancel)

8. A circular loop rotates at constant speed about an axle through the center of the loop. The figure shows an edge view and defines the angle ϕ, which increases from 0° to 360° as the loop rotates.



   a. At what angle or angles is the magnetic flux a maximum?

$\phi = 0, 180^\circ$ ϕ cosine function

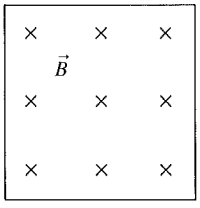
   b. At what angle or angles is the magnetic flux a minimum?

$\phi = 90^\circ, 270^\circ$

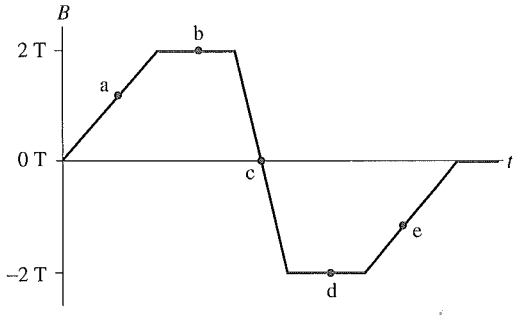
   c. At what angle or angles is the magnetic flux *changing* most rapidly? Explain your choice.

$\phi = 90^\circ, 270^\circ$ $\frac{d\phi}{dt}$ 90° 270° -sine

9. A magnetic field is perpendicular to a loop. The graph shows how the magnetic field changes as a function of time, with positive values for B indicating a field into the page and negative values a field out of the page. Several points on the graph are labeled.



Field through loop



   a. At which lettered point or points is the flux through the loop a maximum? b, d

   b. At which lettered point or points is the flux through the loop a minimum? c

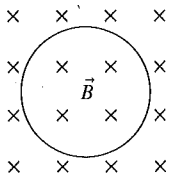
   c. At which point or points is the flux changing most rapidly? c

   d. At which point or points is the flux changing least rapidly? b, d

34.4 Lenz's Law

34.5 Faraday's Law

10. Does the loop of wire have a clockwise current, a counterclockwise current, or no current under the following circumstances? Explain.



a. The magnetic field points into the page and its strength is increasing.

CCW.

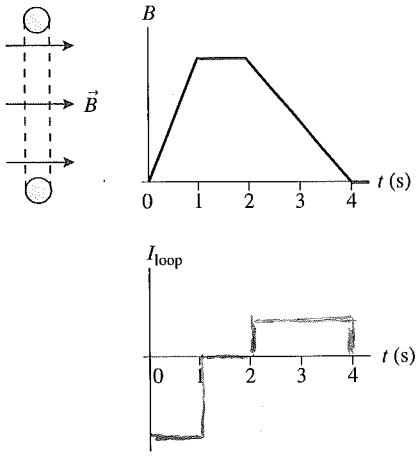
b. The magnetic field points into the page and its strength is constant.

0

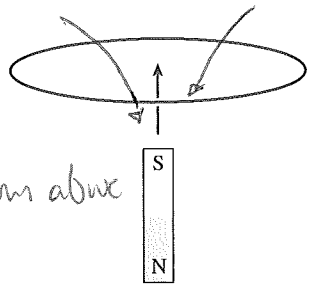
c. The magnetic field points into the page and its strength is decreasing.

CW.

11. A loop of wire is perpendicular to a magnetic field. The magnetic field strength as a function of time is given by the top graph. Draw a graph of the current in the loop as a function of time. Let a positive current represent a current that comes out of the top and enters the bottom. There are no numbers for the vertical axis, but your graph should have the correct shape and proportions.



12. A loop of wire is horizontal. A bar magnet is pushed toward the loop from below, along the axis of the loop.



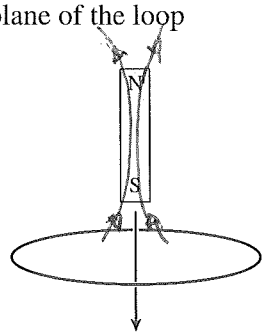
a. What is the current direction in the loop? Explain.

Flux is down & increasing. To oppose: ccw from above

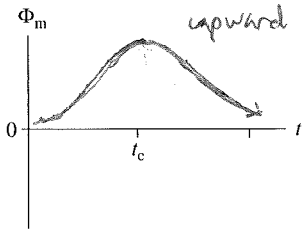
b. Is there a magnetic force on the loop? If so, in which direction? Explain.
Hint: A current loop is a magnetic dipole.

Repulsive, as S pole ⟷ S pole

13. A bar magnet is dropped, south pole down, through the center of a loop of wire. The center of the magnet passes the plane of the loop at time t_c.

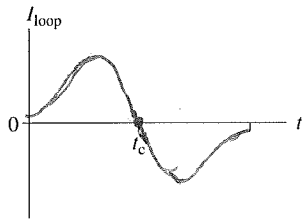


a. Sketch a graph of the magnetic flux through the loop as a function of time.

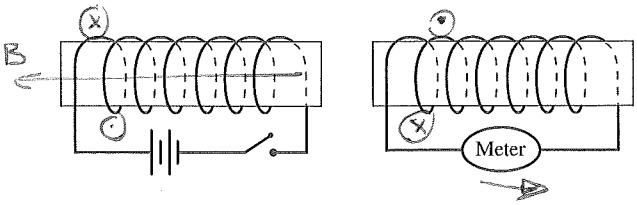


b. Sketch a graph of the current in the loop as a function of time. Let a clockwise current be a positive number and a counterclockwise current be a negative number.

from above



14. a. Just after the switch on the left coil is closed, does current flow right to left or left to right through the current meter of the right coil? Or is the current zero? Explain.



Flux is left & increasing.
To oppose Δ, i flows out of top & into bottom, Left to right

b. Long after the switch on the left coil is closed, does current flow right to left or left to right through the current meter of the right coil? Or is the current zero? Explain.

$i = 0$. $\frac{d\Phi_B}{dt} = 0$.