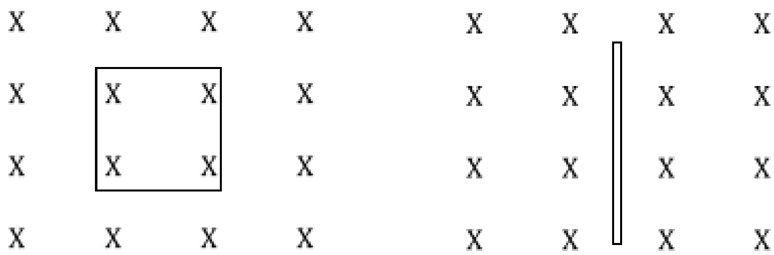
Worksheet - Electromagnetic Induction

1. A magnetic field ($B=3.2x10^{-3}$ T) passes perpendicular through a circular loop of wire (radius = 5.0 cm). What is the magnetic flux through the loop?

2. A circular coil (200 turn radius of 6.0 cm) is rotated in a uniform magnetic field ($B = 3.6x10^{-4}$ T) At t = 0 the coil is perpendicular to the field and at t = 0.015s the coil is parallel to the field what is the average emf induced in the coil?

3. A square loop of wire with an area of $2.5x10^{-3}$ m^2 is perpendicular to a uniform magnetic field ($B = 2.2x10^{-2}$ T). If the square collapsed to an area of essentially 0 m^2 in a time of 0.100 s as shown in the diagram what is the average induced emf as it is collapsed and what is the direction of the induced current? (Remember to use conventional current)



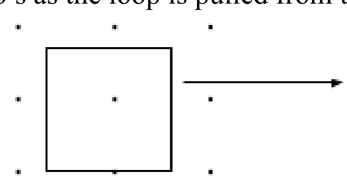
4. Find the average emf induced in a circular coil (50 turns radius of 0.050 m) if the magnetic flux through the loops is changing at a rate of 15.0 Wb/s?

5. A square coil (100 turns area of each square loop = $4.0x10^{-3}m^2$) is perpendicular to a uniform magnetic field. When the coil is rotated through 90º in 0.12 s, the average induced emf is 0.92 V. What is the magnetic field strength?

6. A circular coil (10 turns, diameter = 25 cm) is placed perpendicular to a uniform magnetic field ($B = 2.7 \times 10^{-3}$ T). If the direction of the magnetic field is reversed in 0.30s, what is the average emf induced in the coil?

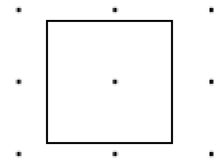
7. A magnet is quickly removed from a circular coil (25 turns, area = 5.0×10^{-3} m^2) changing the magnetic field within the coil at a rate of 0.40 T/s. What is the average emf induced in the coil?

8. A square loop of wire (area= 7.2×10^{-3} m^2) has a resistance of 12.0Ω. Assume that the magnetic field drops uniformly from 1.6 T to zero in 0.050 s as the loop is pulled from the magnetic field.



a) What is the average emf induced in the loop?
b) What is the current induced in the loop?
c) What is the direction of the **electron flow** in the loop?

9. A square loop of wire (4.0 cm per side) is placed in a magnetic field (B= 0.20 T). The magnetic field is increased to 0.50 T in 0.30 s.



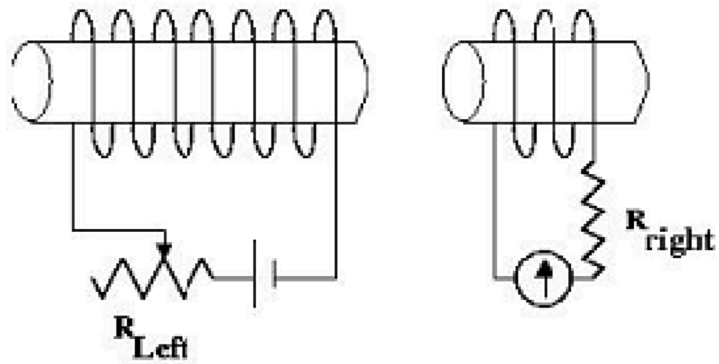
a. Find the current through the loop if the resistance of the loop is 2.0 Ω.
b. Find the direction of the **electron flow** through the loop.

Answers:

1. (2.5×10^{-5} Wb)`
2. (5.4×10^{-2} V)
3. (5.5×10^{-4} V clockwise)
4. (750 V)
5. (2.8×10^{-1} T)
6. (4.4×10^{-3} V)
7. (5.0×10^{-2} V)
8. a. (2.3×10^{-1} V) b. (1.9×10^{-2} A) c. (clockwise)
9. a. (8.0×10^{-4} A) b. (counter-clockwise)

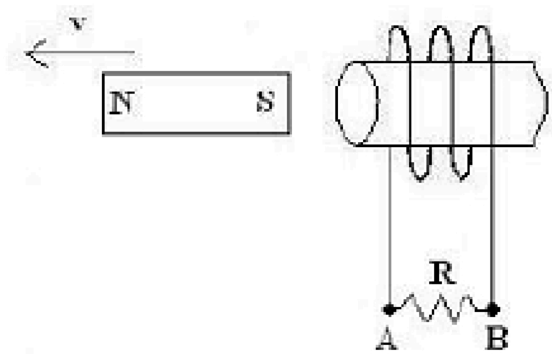
AP workbook

1. For the solenoids shown in the diagram (which are assumed to be close to each other), the resistance of the left-hand circuit is slowly increased. In which direction does the ammeter needle (indicating the direction of conventional current) in the right-hand circuit deflect in response to this change?
A) The needle deflects to the left.
B) The needle deflects to the right.
C) The needle oscillates back and forth.
D) The needle never moves.



2. A strong bar magnet is held very close to the opening of a solenoid as shown in the diagram. As the magnet is moved away from the solenoid at constant speed, what is the direction of conventional current through the resistor shown and what is the direction of the force on the magnet because of the induced current?

Current through resistor	Force on Magnet
A) From A to B	To the left
B) From B to A	To the left
C) From A to B	To the right
D) From B to A	To the right



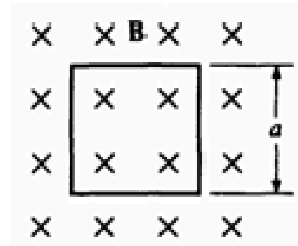
3. A magnet is dropped through a vertical copper pipe slightly larger than the magnet. Relative to the speed it would fall in air, the magnet in the pipe falls.
A) more slowly because it is attracted by the innate magnetic field of the pipe
B) more slowly because the currents induced in the pipe produce an opposing magnetic field
C) at the same rate
D) more quickly because the currents induced in the pipe produce an opposing magnetic field

4. A 0.20 m long copper rod has constant velocity 0.30 m/s traveling through a uniform magnetic field of 0.060 T. The rod, velocity, and magnetic field are all mutually perpendicular. What is the potential difference induced across the rod's length?
A) 0.0036 V B) 0.040 V C) 0.090 V D) 1.0 V E) 25 V

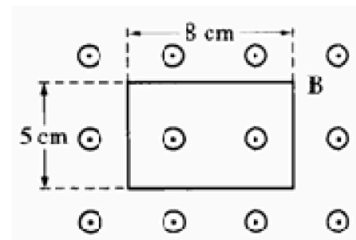
5. When a wire moving through a magnetic field has a voltage induced between the wire's ends, that voltage is
I. directly proportional to the strength of the magnetic field
II. directly proportional to the velocity of the wire
III. directly proportional to the diameter of the wire
A) I only B) II only C) III only D) I and II only

6. Lenz's law concerning the direction of an induced current in a conductor by a magnetic field could be considered a result of
A) Ampere's law B) Ohm's Law C) Tesla's Law
D) The Law of Conservation of Energy

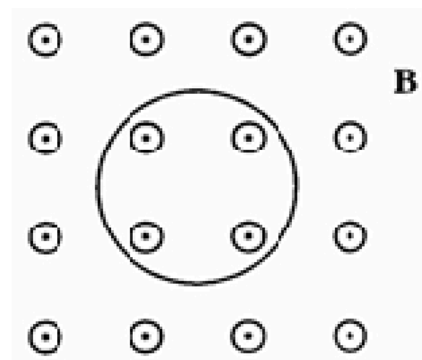
16. A square loop of wire of resistance R and side a is oriented with its plane perpendicular to a magnetic field **B**, as shown. What must be the rate of change of the magnetic field in order to produce a current I in the loop?
(A) IR/a^2 (B) Ia^2/R (C) Ia/R (D) Ira



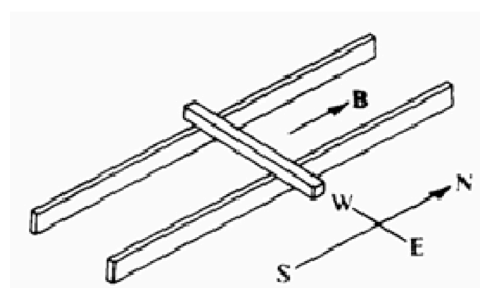
17. A rectangular wire loop is at rest in a uniform magnetic field **B** of magnitude 2 T that is directed out of the page. The loop measures 5 cm by 8 cm, and the plane of the loop is perpendicular to the field, as shown. The total magnetic flux through the loop is
(A) zero (B) 2×10^{-3} T-m^2 (C) 8×10^{-3} T-m^2
(D) 8×10^{-1} T-m

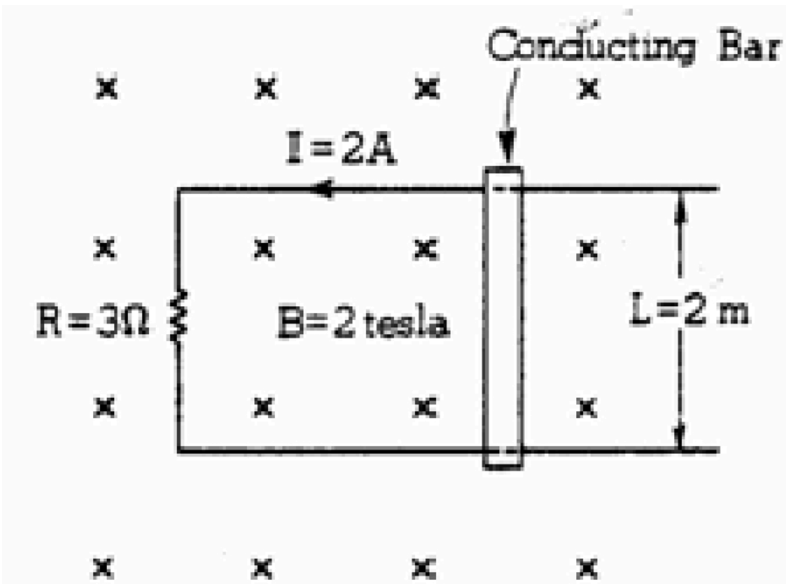


18. A single circular loop of wire in the plane of the page is perpendicular to a uniform magnetic field **B** directed out of the page, as shown. If the magnitude of the magnetic field is decreasing, then the induced current in the wire is
(A) directed out of the paper
(B) directed into the paper
(C) clockwise around the loop
(D) counterclockwise around the loop



22. The ends of a metal bar rest on two horizontal north-south rails as shown. The bar may slide without friction freely with its length horizontal and lying east and west as shown. There is a magnetic field parallel to the rails and directed north.If the bar is pushed northward on the rails, the electromotive force induced in the bar as a result of the magnetic field will
(A) be directed upward
(B) be zero
(C) produce a westward current
(D) stop the motion of the bar





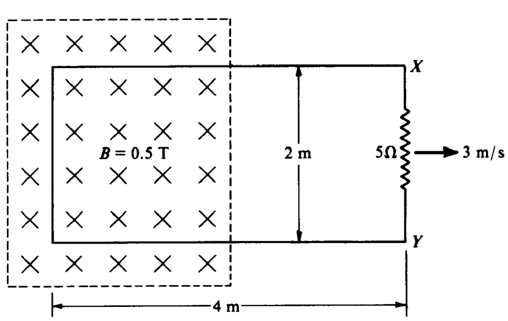
1978B4. Two parallel conducting rails, separated by a distance L of 2 meters, are connected through a resistance R of 3 ohms as shown above. A uniform magnetic field with a magnitude B of 2 tesla points into the page. A conducting bar with mass m of 4 kilograms can slide without friction across the rails.

(a) Determine at what speed the bar must be moved, and in what direction, to induce a counterclockwise current I of 2 amperes as shown.

(b) Determine the magnitude and direction of the external force that must be applied to the bar to keep it moving at this velocity.

(c) Determine the rate at which heat is being produced in the resistor, and determine the mechanical power being supplied to the bar.

(d) Suppose the external force is suddenly removed from the bar. Determine the energy in joules dissipated in the resistor before the bar comes to rest.



1986B4. A wire loop, 2 meters by 4 meters, of negligible resistance is in the plane of the page with its left end in a uniform 0.5-tesla magnetic field directed into the page, as shown above. A 5-ohm resistor is connected between points X and Y. The field is zero outside the region enclosed by the dashed lines. The loop is being pulled to the right with a constant velocity of 3 meters per second. Make all determinations for the time that the left end of the loop is still in the field, and points X and Y are not in the field.

a. Determine the potential difference induced between points X and Y.

b. On the figure above show the direction of the current induced in the resistor.

c. Determine the force required to keep the loop moving at 3 meters per second.

d. Determine the rate at which work must be done to keep the loop moving at 3 meters per second.