PHYSICS HOMEWORK #127 MAGNETISM
MAGNETIC FLUX AND FARADAY'S LAW

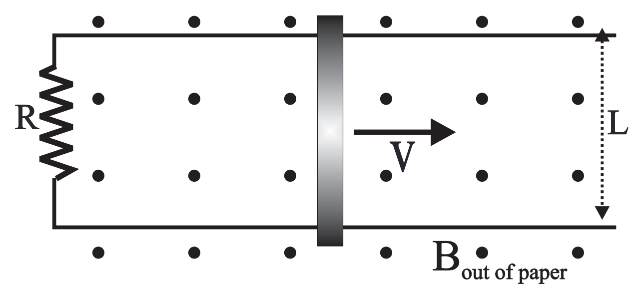
$$EMF = -N \cdot \frac{\Delta \phi}{\Delta t}$$

1. Consider a single loop of wire which is 25 cm by 25 cm. Passing through this loop is a magnetic field which has a magnitude of B = 0.220 Tesla.
   a. Assuming that the magnetic field is parallel to the normal to the loop, what will be the total magnetic flux passing through the loop?
   b. Assuming that the magnetic field meets the normal to the loop at an angle of $\Theta = 35.0^o$, what will be the total magnetic flux passing through the loop?
   c. Assuming that the magnetic field is perpendicular to the normal to the loop, what will be the total magnetic flux ϕ passing through the loop?

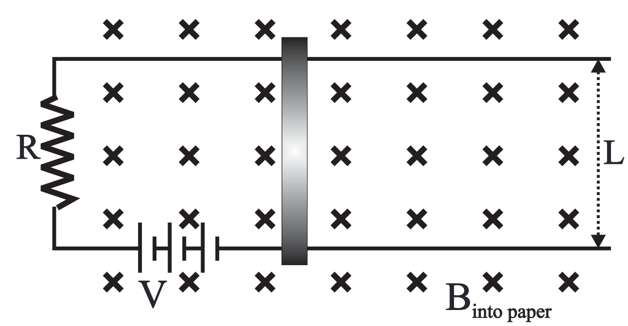
2. Consider a single loop of wire which encloses an area of A = 50.0 square centimeters. A magnetic field, which is parallel to the normal of this loop, initially has an intensity of B = 0.220 Tesla. Over a time period of Δt = 0.200 seconds the magnetic field strength B drops to zero.
   a. What will be the resulting EMF in the loop?
   b. What will be the EMF in this circuit if the loop consists of 1000 turns rather than a single turn as above?

3. Consider a coil of wire which has N = 1200 turns, encloses an area of A = 18.0 cm^2 and contains a magnetic field of B = 3.50 Tesla oriented parallel to the normal to the loop. What will be the induced EMF in this coil if the magnetic field B drops to zero in t = 0.0167 seconds?

4. Two parallel rails are connected together at one end by a resistance of R = 20.0 Ω as shown in the diagram to the right. Across these two rails, which are L = 45.0 cm apart, there lies a conducting metal bar. The magnetic field is uniform, has a strength of B = 2.20 Tesla and is directed out of the paper as shown. A force is applied to the metal bar so as to push the bar to the right with a velocity v = of 8.40 m/s.
   a. What will be the resulting EMF in this circuit?
   b. What will be the direction of the resulting conventional current flowing through this circuit?
   c. What will be the magnitude of the resulting current?
   d. At what rate is electrical energy being generated?
   e. How much force is being applied to this bar?
   f. At what rate is mechanical energy being consumed?

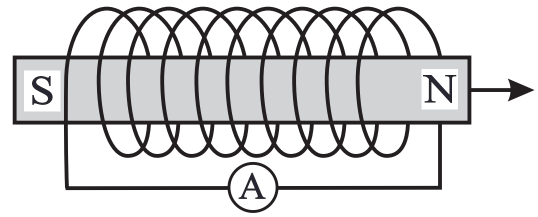


5. Consider the inverse of problem #22 above. Suppose that instead of pushing the metal bar through the magnetic field a battery, which has an EMF of V = 6.00 Volts, is inserted into the circuit as shown. The magnetic field has an intensity of B = 2.20 Tesla and is directed into the paper as shown and the resistance has a value of 20.0 Ω. A current of I = 0.20 Amperes is measured to be flowing through the circuit.
   a. What will be the resulting velocity of the bar?
   b. How much force is being applied to the bar by the the magnetic field as it moves through the field?



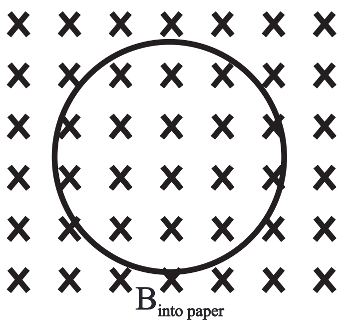
Answers to opposite side: 6a. left to right b. left to right c. zero d. left to right e. left to right
7. counterclockwise 8. counterclockwise 9. counterclockwise 10. clockwise 11a. right to left
11b. zero c. counterclockwise d. clockwise

PHYSICS HOMEWORK #128 MAGNETISM
MAGNETIC INDUCTANCE AND LENZ'S LAW



6. Consider a coil of wire formed into a solenoid [a solenoid is a coil whose length is much greater than its diameter] as shown to the right. Initially, a bar magnet is sitting at rest within the solenoid with the polarity as shown. The bar magnet is then quickly removed to the right.
   a. What will be the direction of the magnetic field within the solenoid BEFORE the permanent magnet is removed from the solenoid?
   b. What will be the direction of the magnetic field within the solenoid IMMEDIATELY after removing the permanent magnet?
   c. What will be the direction of the magnetic field within the solenoid a long time after the permanent magnet has been removed from the solenoid?
   d. What will be the direction of the resulting current through the ammeter? Explain!
   e. Suppose, instead, that the magnet is removed quickly to the left. What will be the direction of the resulting current through the ammeter? Explain!

7. A single loop of wire is lying in the plane of the paper as shown to the right. A bar magnet is approaching the loop from in front of the paper with the North end of the magnet entering the loop first. What will be the direction of the induced current flowing in the loop? Explain!

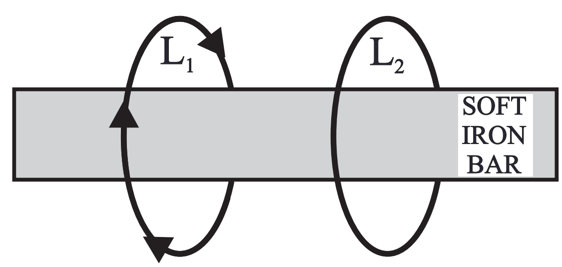


Each of the following 3 problems refers to the diagram to the left which represents a single coil of wire sitting in a uniform magnetic field B directed into the paper.

8. Suppose that this coil is quickly flipped over. What will be the direction of the induced current in the loop immediately after it has been flipped? Explain!

9. Suppose that the magnetic field B is slowly getting stronger with time. What will be the direction of the induced current? Explain!

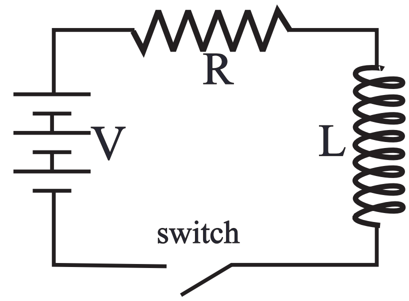
10. Suppose that the magnetic field B is slowly getting weaker with time. What will be the direction of the induced current? Explain!



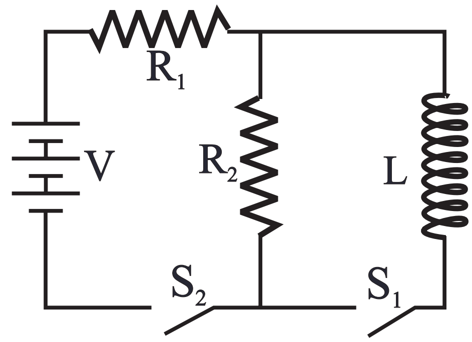
11. A soft iron bar is sitting surrounded by two separate loops of wire. The loop on the left, L_1, initially has a current flowing clockwise as viewed from the right and as shown.
   a. What will be the direction of the magnetic field in the soft iron bar? Explain!
   b. What will be the direction of the initial current flowing through the right hand loop L_2? Explain!
   c. The current flowing through loop L_1 is slowing increasing with time. What will be the direction of the resulting current flow in loop L_2? Explain!
   d. The current flowing through loop L_1 is slowing decreasing with time. What will be the direction of the resulting current flow in loop L_2? Explain!

Answers to opposite side: 1a. 0.01375 Webers b. 0.0113 Webers c. 0.0 Webers
2a. 0.0055 Volts b. 5.50 Volts 3. 453 Volts 4a. 8.32 Volts b. clockwise c. 0.416 Amperes
4d. 3.46 Watts e. 0.412 Newtons f. 3.46 Watts 5a. 2.02 m/s b. 0.198 Newtons

PHYSICS HOMEWORK #129 MAGNETISM
MAGNETIC INDUCTANCE & SIMPLE CIRCUITS

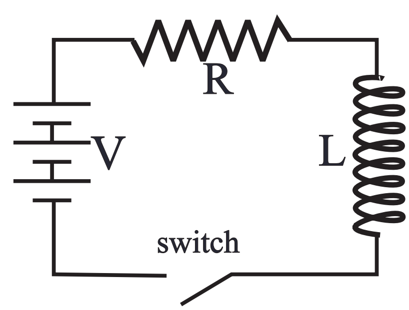


1. An induction coil, which has an inductance of L = 250.0 milliHenrys, is connected in series with a resistance of R = 20.0 Ω and with a battery which has a DC voltage of V = 36.0 Volts. Initially, the switch has been closed for a long time but at t = 0 sec. the switch is opened.
   a. What will be the current I_o is this circuit **immediately before** the switch is opened? Explain!
   b. What will be the current through the circuit **immediately after** the switch has been opened? Explain!
   b. What is the inductive time constant t_c for this circuit?
   c. What will be the current I_t flowing through this circuit t = 15.0 millisec after the switch has been opened?
   d. What will be the current I_f flowing in this circuit a long time after the switch has been opened?



2. An induction coil, which has an inductance of L = 22.0 milliHenrys, is connected with two resistors, R_1 = 100 Ω and R_2 = 1500 Ω, and a battery V = 32.0 Volts as shown in the diagram to the right. At t = 0 seconds both switches are closed simultaneously.
   a. What will be the **current** flowing in the inductor L **immediately** after the switches have been closed?
   b. What will be the **current** flowing through resistor R_2 **immediately** after the switches have been closed?
   c. What will be the **current** flowing through resistor R_2 **a long time** after the switches have been closed?
   d. What will be the **current** flowing through resistor R_1 **a long time** after the switches have been closed?
   e. What will be the **current** flowing through the inductor L **a long time** after the switches have been closed?

   After a long time switch S_2 is re-opened. [S_1 remains closed.]
   f. What will be the **current** flowing through the inductor **L immediately** after switch **S_2** has been re-opened?
   g. What will be the **current** flowing through the resistor **R_1 immediately** after switch **S_2** has been re-opened?
   h. What will be the **potential difference** across resistor **R_2 immediately** after switch **S_2** has been re-opened?
   i. What will be the **potential difference** across the inductor **L immediately** after switch **S_2** has been re-opened?
   j. What will be the **current flowing** through the inductor **L** a **long time** after switch **S_2** has been re-opened?



3. An induction coil, which has an inductance of L = 12.0 milliHenrys, is connected in series with a resistance of R = 50 Ω and with a battery which has a DC voltage of V = 24.0 Volts. At t= 0 seconds the switch is closed.
   a. What will be the current is this circuit **immediately** after the switch is closed? Explain!
   b. What will be the inductive time constant t_c for this circuit?
   c. What will be the current I_t flowing through this circuit t = 50 μsec after the switch has been closed?
   d. What will be the current I_f flowing in this circuit a long time after the switch has been closed?

Answers to opposite side: 4a. 0.437 Henrys b. 9.61 Volts c. 5.24 Henrys d. 115 Volts
5a. 0.91 Amperes b. 0.0174 s c. $I = 0.91\ e^{-t/.0174}$ Amperes d. 0.859 Amperes e. 0.0386 Amperes f. 0.080 sec
6a. 66.3 μH b. 0.445 Ω c. 0.667 Ω d. 0.802 Ω e. 29.9 Amperes f. $I = 29.9 \sin [1.01 \times 10^4 t]$
6g. $3.01 \times 10^5 \cos [1.01 \times 10^4 t]$ h. $-19.9 \cos [1.01 \times 10^4 t]$ i. 4.07 Volts 7a. 415 Ω b. 419 Ω
7c. 0.076 Amperes d. 82.5° e. 0.317 Watts

PHYSICS HOMEWORK #130 MAGNETISM
MAGNETIC INDUCTANCE & IMPEDANCE

4. A given solenoid consists of 7250 turns of wire, has a diameter of 4.4 cm and is 23 cm long.
   a. What is the self inductance of this solenoid?
   b. Suppose that the current flowing through this solenoid is initially 12.5 Amperes and is decreasing at a rate of 22.0 Amperes/second. What will be the EMF generated across this coil as a result of this changing current?
   c. Suppose that this coil is surrounded by a second coil which has the exact same length as the first coil, consists of 87,000 turns and has a radius that is only slightly larger than the first coil. What will be the mutual inductance of these two coils?
   d. What will be the induced EMF in the secondary coil?

5. Consider a coil which has a self inductance of 0.23 Henrys and a resistance of 13.2 Ω. A DC voltage of 12.0 Volts is applied to this coil until a steady state current is flowing through the coil.
   a. What will be the magnitude of this steady state current?
   b. What will be the time constant for this coil?
   c. Suppose that the supply of EMF is suddenly cut off. Write an equation describing the current flowing through this coil as a function of time.
   d. What will be the current flowing through this coil 1.0 milliseconds after the source of EMF is removed?
   e. What will be the current flowing through this coil 55.0 milliseconds after the source of EMF is removed?
   f. How long will it take for the current flowing through the coil to drop to 1.0% of its initial steady state value?

6. Consider a solenoid which consists of 210 turns of wire, has a diameter of 0.8 cm., and is 4.2 cm long. The solenoid is made of gauge 24 [diameter = 0.051cm] copper [r = 1.72×10^{-6} Ω cm] wire. An AC voltage of 24 Volts RMS at 1600 Hz. is applied to this solenoid.
   a. What is the self inductance of this solenoid?
   b. What is the resistance of this solenoid?
   c. What will be the inductive reactance of this solenoid?
   d. What will be the impedance of this solenoid at this frequency?
   e. Based on the applied voltage , what will be the peak current flowing through this solenoid?
   f. Write an equation describing the current flowing through this solenoid as a function of time.
   g. Write the equation describing the rate of change of current in this solenoid as a function of time?
   h. What will be the resulting EMF generated by this coil as a function of time?
   i. What will be the phase angle between the voltage across the solenoid and the current flowing through the solenoid?

7. An AC voltage of 45.0 Volts at a frequency of 880 Hz. is applied to a coil which has a resistance of 55.0 Ω and an inductance of L = 0.075 Henrys.
   a. What is the inductive reactance of this coil?
   b. What is the impedance of this coil at this frequency?
   c. What will be the RMS current flowing through this coil?
   d. What is the phase angle between the current and the voltage across this coil?
   e. At what rate is power being dissipated in this coil?

Answers to opposite side: 1a. 1.80 Amperes b. 1.80 Amperes c. 0.0125 seconds d. 0.542 Amperes 1e. zero 2a. zero b. 0.020 Amperes c. zero d. 0.320 Amperes e. 0.320 Amperes 2f. 0.320 Amperes g. 0.320 Amperes h. 480 Volts i. 480 Volts j. zero 3a. zero 3b. 2.40×10^{-4} seconds c. 0.0903 Amperes d. 0.480 Amperes