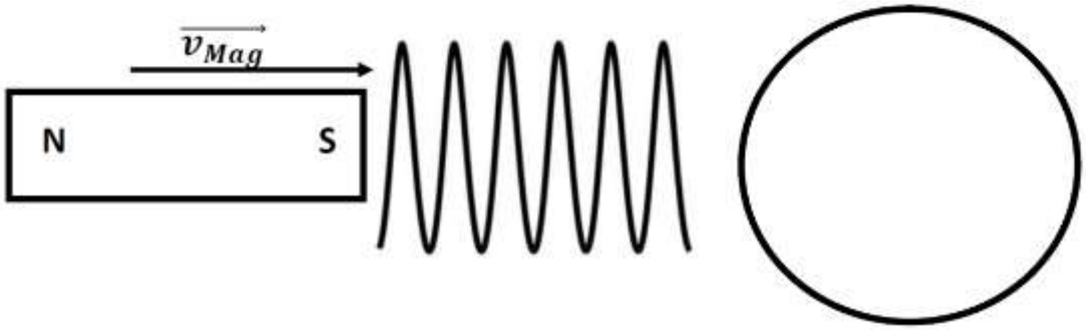
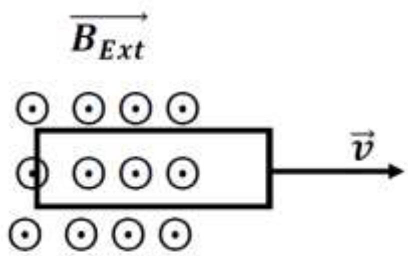
PH 221 Homework Assignment Chapter on Faraday & Induction – 22 Problems Total

1. As shown below a bar magnetic is being inserted into a coil with the "South" pole leading the way. On the right below this is the coil as the bar magnetic is being pushed into it. Which direction (Clockwise or Counter-Clockwise) is the current induced in the coil?



Solution for Problem 1

2. As shown below, a wire loop is being moved to the right out of the magnetic field which is coming out of the paper. In which direction will the induced current be created in the loop?



Solution for Problem 2

3. A circular loop of wire has a radius $(\mathrm{R} = 1.50 \text{ x } 10^{-2} \text{ m})$ is located inside a magnetic field which has a field strength $(\mathrm{B} = 0.850 \text{ T})$ which is directed perpendicular to the plane of the loop. The magnetic field strength is increased at a constant rate $\left(\frac{dB}{dt} = +0.020 \ {}^{T}/_{s}\right)$. At what rate should the radius of the loop be changed in order to make the induced emf within the loop to be zero? Is this increasing or decreasing the radius?

Solution for Problem 3

4. A circular coil of wire has a radius $(R_{Coil} = 1.80 \text{ x } 10^{-2} \text{ m})$ and 300 turns of wire in the coil. The coil is inside a magnetic field with a field strength $(B_{Ext} = 0.900 \text{ T})$.

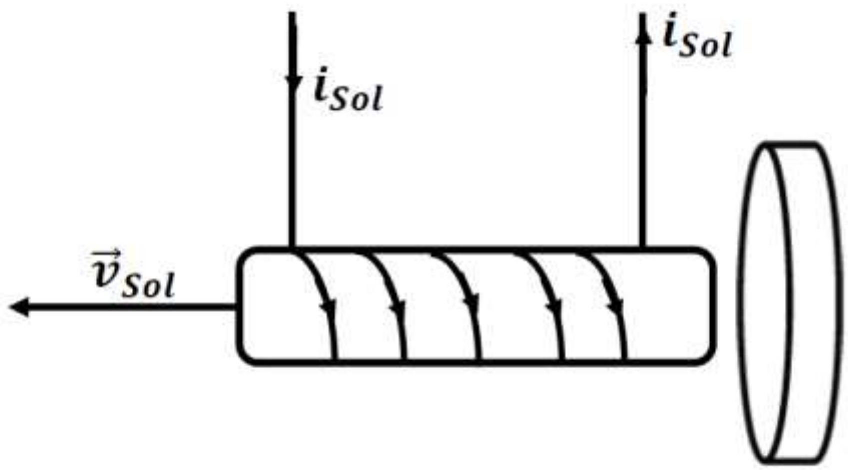
(a) When the direction of the magnetic field lines is perpendicular to the face of the coil, what is the magnetic flux through the coil?

(b) When the face of the coil makes an angle of $28.0°$ with the magnetic field lines, what is the angle from the dot product in the magnetic flux expression?

(c) What is the magnetic flux through the coil when the face of the coil makes the $28.0°$ angle with the magnetic field lines?

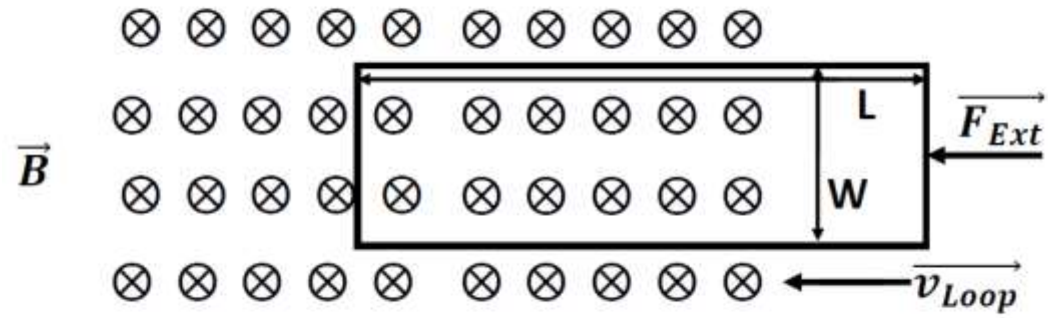
<u>Solution for Problem 4</u>

5. As shown below a solenoid is moving away from a circular loop. In which direction is the current induced into the circular loop because of this?



<u>Solution for Problem 5</u>

6. A rectangular loop $(L = 0.875\text{ m}, W = 0.346\text{ m})$ is being pushed into a magnetic field $(B = 0.680T)$which is directed out of the paper as shown. The loop is moving with a constant velocity $\left(\overrightarrow{v_{Loop}} = 4.98\ {}^{m}/_{s}\ \widehat{(Left)}\right)$. The loop has an electrical resistance $\left(R_{Loop} = 0.198\ \Omega\right)$. What is the magnitude and direction of the external force $\left(\overrightarrow{F_{Ext}}\right)$ needed to keep the loop moving at the constant velocity into the magnetic field?

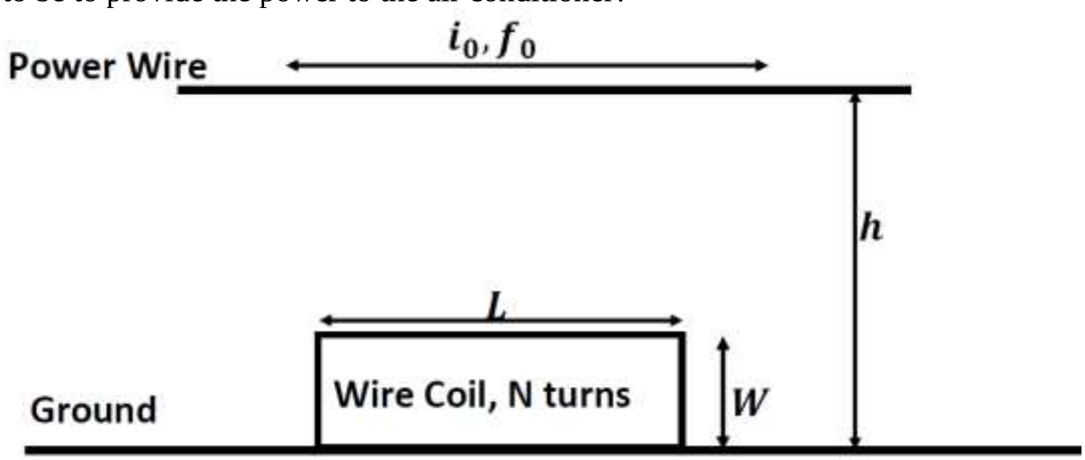


Solution for Problem 6

7. A home owner has a high-power electrical cable that runs over their large back yard. The electrical cable carries a current $(i_0 = 75.0 \times 10^3\text{ A})$ at a frequency $(f_0 = 60.0\text{ hz})$. The current is most appropriately expressed as:

$$i = i_0 \sin(2\pi f_0 t)$$

The power wire lies at a distance $(h = 8.76\text{ m})$ above the ground. The home owner would like to use this time varying current to power an air conditioner. They construct a vertical rectangular wire coil $(W = 2.50\text{ m}, N = 50.0\text{ turns})$ on the ground as shown below. The air conditioner runs on a standard wall outlet $(110.\text{ V}, 60.0\text{ hz})$. This means the peak voltage of the signal will need to be $V_0 = 156.\text{ V}$ at a frequency $f = 60.0\text{ hz}$. How long (L) will the coil need to be to provide the power to the air conditioner?



Solution for Problem 7

8. A coil of wire has 150 turns of wire. A single loop of wire has a magnetic flux expressed by:

$$\Phi_B = (3.92t^2 - 8.88t + 92.3) \text{ x } 10^{-3} \text{ T m}^2$$

Where time t is given in seconds.

(a) Derive an expression for the emf induced as a function of time.

(b) Calculate the emf when $t = 1.05$ s.

(c) Calculate the emf when $t = 4.24$ s.

Solution for Problem 8

9. A square coil of wire has 55.0 turns of wire and has sides of length $(S = 0.340 \text{ m})$. The loop has a magnetic field that makes an angle $(\theta = 37.0°)$ between the normal to the area of the coil and the direction of the magnetic field in which the coil is sitting at rest. The magnetic field is a constant field of strength $(B = 1.41 \text{ T})$. The area of the square loop has the ability to change size at a constant rate $\left({dA}/{dt} = +5.67 \text{ x } 10^{-3} \text{ m}^2/\text{s}\right)$.

(a) Derive an expression for the emf induced as a function of time.

(b) Calculate the emf when $t = 2.53$ s.

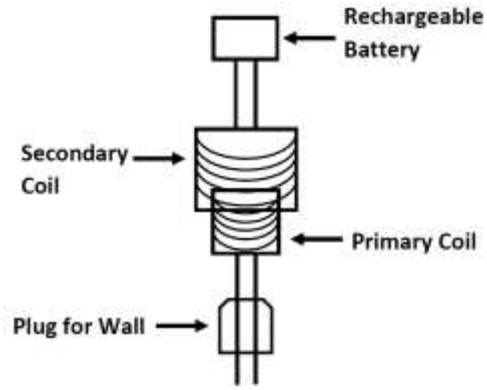
(c) Calculate the emf when $t = 6.27$ s.

Solution for Problem 9

10. A circular coil has (N_C) turns of wire, a radius (R_C) and is located inside a solenoid. The solenoid has turns per length (n_s) and a radius $(R_S > R_C)$. The coil and solenoid are concentric sharing the same center point. The solenoid has a current $(i_S = i_0 \cos(\omega t))$ flowing in its wire. What is the magnitude of the EMF developed in the circular coil?

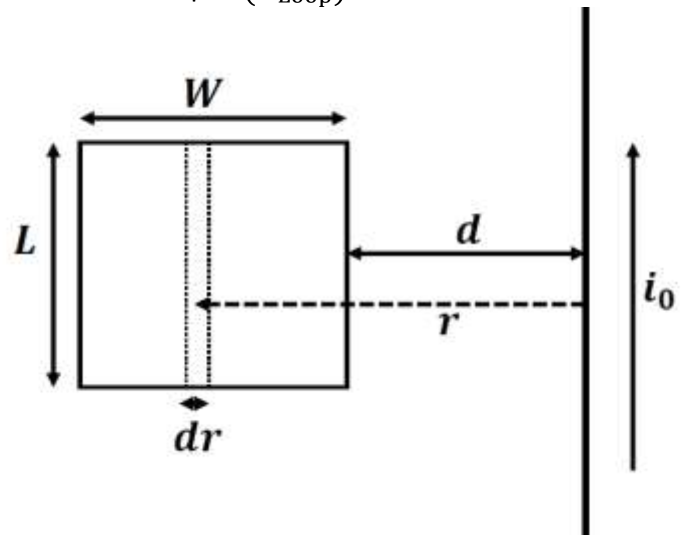
Solution for Problem 10

11. Inductive charging devices allows electronics to be recharged without connecting wires. Pictured on the right is a basic circuit idea. The primary coil is connected to a standard plug for a wall which will allow a current $(i_P = i_0 \sin(2\pi f_0 t))$ to flow through the primary coil (essentially a solenoid) which has (n_P) turns of wire per unit length, and a radius (R_P). The device to be charged (think toothbrush) has secondary coil (N_S) turns of wire around a radius $(R_S \sim R_P = R)$ which is just slightly bigger than the primary, so that the secondary can fit snugly over the primary. The secondary and primary coil are co-centered. The secondary coil will have an emf induced which can then recharge a battery within the device. What is the magnitude of the induced emf in the secondary coil?



<u>Solution for Problem 11</u>

12. A rectangular loop has dimensions of length (L) and width (W) and sits initially a distance (d) from a long straight wire which carries current (i_0) along the wire in the direction shown. The total resistance of the wire loop is $(\mathrm{R}_{\mathrm{Loop}})$



(a) Determine the magnetic flux passing through the Loop due to the current flowing in the long straight wire.

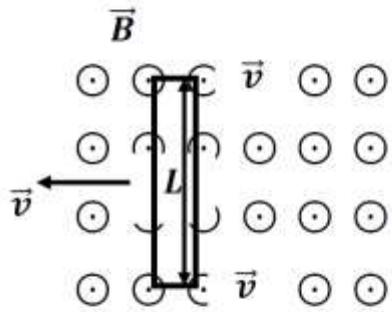
(b) Now consider the loop is being pulled away from the wire with a constant speed. Replace the distance (d) with an expression $(\mathrm{d} = \mathrm{d}_0 + \mathrm{vt})$. Determine the magnitude of the emf induced in the loop.

(c) In which direction (Clockwise or Counter-Clockwise) does the induced current flow in the loop?

(d) What is the magnitude and direction of the force that must be used to make the loop move away from the wire at constant speed?

<u>Solution for Problem 12</u>

13. As shown below a bar of length $(\mathrm{L} = 0.346\ \mathrm{m})$ is moving to the left with a velocity $\left(\vec{\mathrm{v}} = 0.245\ {}^{\mathrm{m}}/_{\mathrm{s}}\ \widehat{(\mathrm{Left})}\right)$ in a magnetic field $\left(\vec{\mathrm{B}} = 0.967\ \mathrm{T}\ \widehat{(\odot)}\right)$.

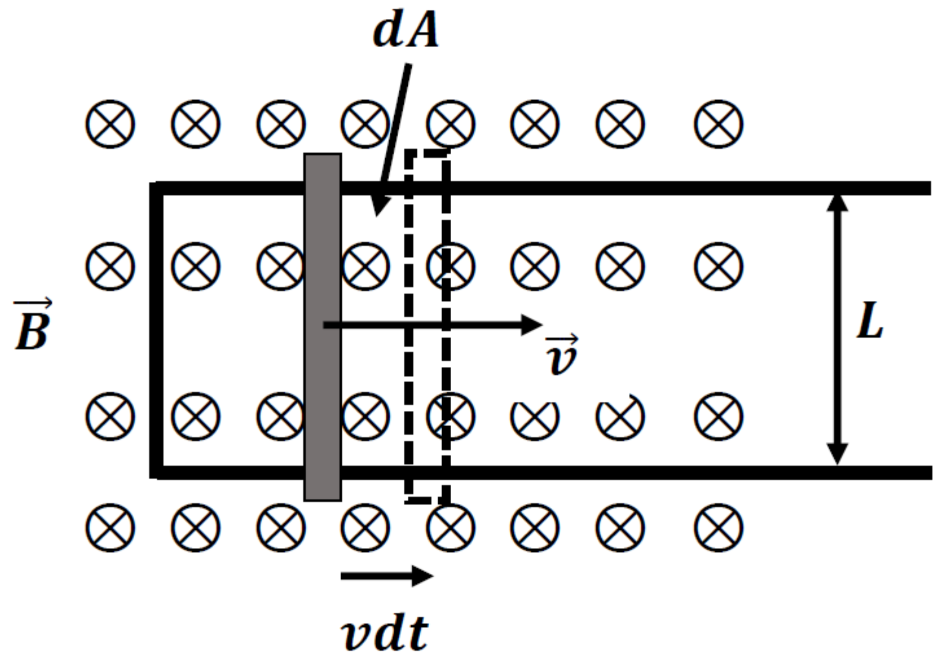


(a) Determine the motional emf created by the bar moving through the magnetic field.

(b) Which end of the bar (top or bottom) is more positive?

Solution for Problem 13

14. A bar moves to the right with a speed $(v = 3.76\ ^{m}/_{s})$. The bar slides along conducting rails which are a distance $(L = 0.475\ m)$ apart and have a resistance $(R_{Rails} = 16.0\ \Omega)$. The magnetic field $(\vec{B} = 0.676\ T\ \widehat{(\otimes)})$ is going into the plane of the paper.



(a) What is the magnitude of the motional emf across the bar?

(b) Which end (top or bottom) of the bar is more positive?

(c) What is the induced current along the rails?

(d) Which direction (Clockwise or Counter-Clockwise) does the induced current flow in the rails?

(e) What is the external force needed to keep the bar moving at constant speed to the right?

(f) How much power is dissipated by the current in the rails?

(g) How much power must the external force provide to keep the bar moving at constant speed?

Solution for Problem 14

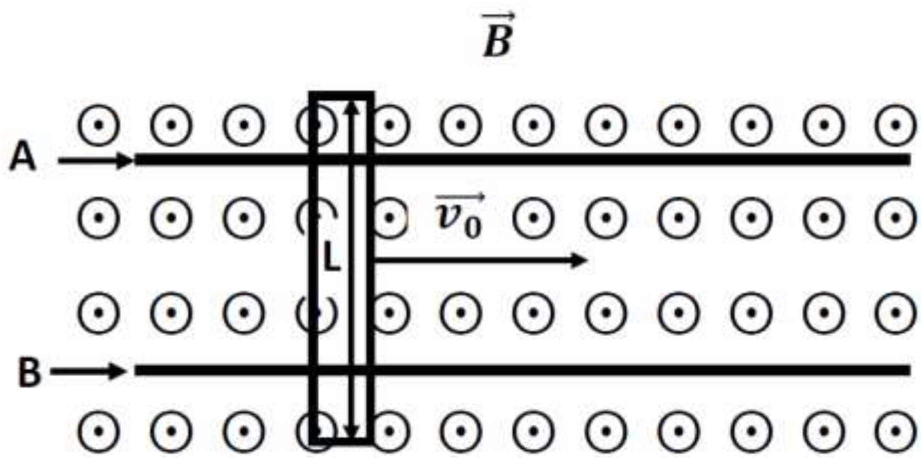
15. A sports car has an antenna which extends a distance $(\mathrm{L} = 0.860 \text{ m})$ above the body of the car. The car is traveling with a speed $(\mathrm{v} = 35.8 \ ^{\mathrm{m}}/_{\mathrm{s}})$ along a horizontal road which passes through the Earth's magnetic field $\left(\overrightarrow{\mathrm{B}_{\mathrm{Earth}}} = 5.50 \text{ x } 10^{-5} \text{ T } (\widehat{\text{North}}) \text{ @ } 37.0° \text{ below the horizontal}\right)$.

(a) Which direction does the car have to be traveling to produce the greatest motional emf along the antenna with the positive end being the car body?

(b) What is the magnitude of the motional emf of the antenna?

<u>**Solution for Problem 15**</u>

16. A conducting bar $(\mathrm{L} = 0.560 \text{ m})$ is given an initial velocity $(\overrightarrow{\mathrm{v}_0})$ to the right as shown below. The bar is sliding along two horizontal frictionless conducting rails which are initially unconnected to each other. A magnetic field $(\vec{\mathrm{B}})$ as shown is coming out of the page. The electrical resistance of the bar is $\mathrm{R}_{\mathrm{Bar}}$, while the resistance of the rails and any connecting wire is negligible.



(a) If the rails are not electrically connected, will the speed of the bar remain constant? Explain.

(b) If a conductive wire is attached at points A and B, find an expression for the speed as a function of time.

<u>**Solution for Problem 16**</u>

17. A square coil has sides $(\mathrm{S} = 0.0660 \text{ m})$is being rotated about its center at a rotational speed $\left(\omega = 100.0 \ ^{\mathrm{Rev}}/_{\mathrm{s}}\right)$ while immersed in a fixed magnetic field $(\mathrm{B} = 0.750 \text{ T})$. If this is to generate a peak voltage $(\varepsilon_0 = 27.0 \text{ V})$, how many turns of wire will be needed?

<u>**Solution for Problem 17**</u>

18. A circular coil $(R_{Coil} = 0.150\ m,\ N_{Coil} = 300\ Turns)$ has a rotation frequency $\left(f_0 = 240.\ {}^{Rev}/_{s}\right)$ is rotating inside a magnetic field $(B = 0.350\ T)$. This is used a simple electrical generator.

(a) What is the rms voltage output of the generator?

(b) If you wished to have half the rms voltage output, what should you change the rotating frequency of the coil to?

Solution for Problem 18

19. A motor is running off a wall outlet $\left(\varepsilon_{App} = 120.\ V\right)$. The motor is drawing a current $(i_{Run} = 6.80\ A)$. The back emf $(\varepsilon_{Back} = 96.7\ V)$ is created. What is the resistance of the motor's armature?

Solution for Problem 19

20. A motor is running with its armature making $1300.\ {}^{Rev}/_{min}$, as a result the back emf created is $93.0\ V$. If you could change the magnetic field of the motor, what is the fractional change $\left(\frac{B_f}{B_0}\right)$ which would produce a back emf $(79.0\ V)$ when the armature makes $2700.\ {}^{Rev}/_{min}$?

Solution for Problem 20

21. A bug zapper is powered by a standard wall outlet $(V_{Wall} = 120.\ V)$. This voltage is attached to the primary coil of the transformer used by the bug zapper. The bug zapper voltage $\left(V_{Zap} = 5500.\ V\right)$ is attached to the secondary coil of the transformer. If the primary coil has 500 turns, how many turns must be in the secondary coil?

Solution for Problem 21

22. The output voltage of a $125.$ W transformer is measured to be $17.5\ \mathrm{V}$. The input current is $27.5\ \mathrm{A}$.

(a) Is this a step-up or a step-down transformer?

(b) What is the turns ratio $\mathrm{N_S}/\mathrm{N_P}$ of the transformer?

Solution for Problem 22

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