Chapter 15
Magnetism and Electromagnetic Induction
15.1 Magnetic Force on a Current-Carrying Wire Homework # 127

I

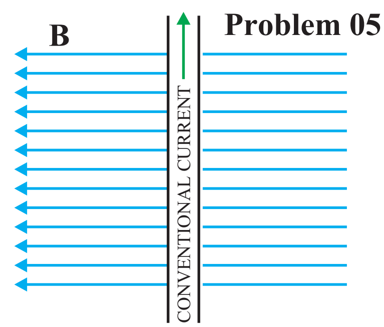
01. A wire carrying a 2.45-A current wire passes through a 1.60-T magnetic field. What is the force per meter on this wire if its length is oriented __________ to the direction of the magnetic field?
a.) perpendicular b.) at a 35.0° angle

02. A wire carrying a current of 22.5 A is placed between the opposite pole faces of two rectangular magnets. The pole faces are 12.0 cm in length. When this wire is parallel to the pole faces (perpendicular to the field) the magnetic force on the wire is 2.75 N. What is the approximate strength of the magnetic field?

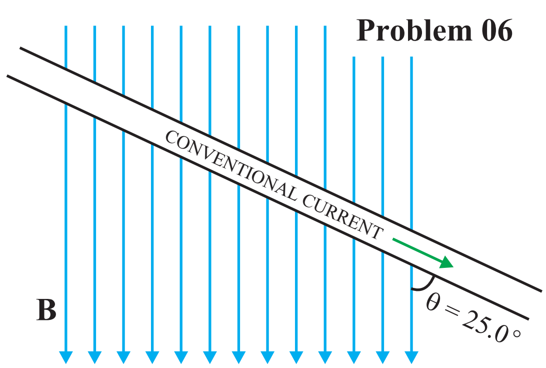
03. A 2.65-m long wire is placed in uniform magnetic field of 0.130 T. If length of this wire is oriented at right angles to the direction of the magnetic field, the force on the wire is 1.45 N. What is the current in the wire?

04. A 210-m length of electric power transmission wire stretched between two towers carries a 345-A current. The earth's magnetic field is 0.500 G (5.00×10^{-5} T) and directed at an angle of 60.0° with the wire at this location of the earth. What is the magnetic force on this wire?

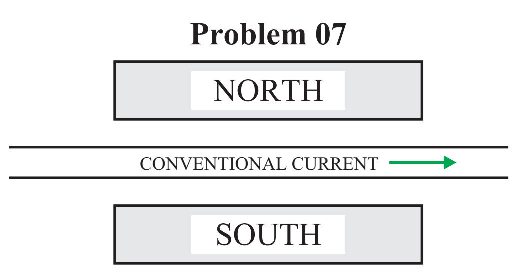
II



05. A conducting wire carries a current 4.20 A and is oriented perpendicular to a uniform magnetic field as shown in the diagram to the right. The strength of the magnetic field is 0.850 T and the length of wire exposed to the magnetic field is 25.0 cm.
a.) What is the magnitude of the force on this wire?
b.) What is the direction of the force on this wire?
c.) How could this wire be oriented such that the magnetic force on it is zero?



06. A wire, that is 32.0 cm long and carries a current of 2.85 A, is placed in a 0.60-T uniform magnetic field. The wire is oriented, as shown in the diagram to the right, such that it makes a 25.0° angle with the direction of the magnetic field.
a.) What is the magnitude of the force on this wire?
b.) What is the direction of the force on this wire?



07. A wire carrying a current of 4.75 A passes between the opposite poles of two permanent rectangular magnets as shown in the diagram to the right and below. The magnets are 3.20 cm wide. The wire experiences a force of 0.0245 N from the magnetic field.
a.) What is the direction of the magnetic field between the pole faces?
b.) What is the strength of the magnetic field between the pole faces?
c.) What is the direction of the magnetic force on the wire?

III

08. A copper wire ($\rho = 8900\ kg/m^3$) with a diameter of 2.05 mm (Gauge 12) is positioned horizontally above the earth in the presence of a magnetic field and released. If the current in the wire is 3.25 A towards the east, determine the __________ of the magnetic field if the wire remains suspended in midair.
a.) direction b.) magnitude

ANSWERS: **01.** a.) 3.92 N b.) 2.25 N **02.** 1.02 T **03.** 4.21 A **04.** 3.14 N
05. a.) 0.893 N b.) out of the page c.) parallel to field **06.** a.) 0.231 N b.) into the page
07. a.) down b.) 0.161 T c.) into the page **08.** a.) north b.) 0.0886 T

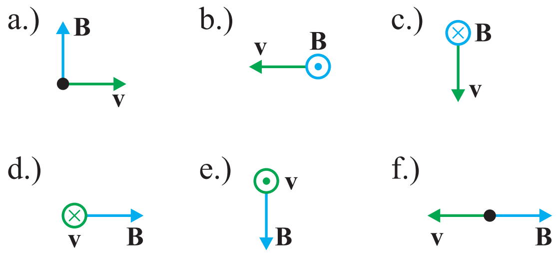
Chapter 15
Magnetism and Electromagnetic Induction
15.2 Magnetic Force on a Moving Charged Particle   Homework # 128

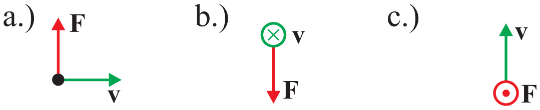
See Homework #95 in "Chapter 12-Electrostatics" for the table of "Useful Information" on atomic particles.

I

01. An electron travels eastward at 3.43×10^6 m/s into a 1.35-T magnetic field directed vertically upward.
   a.) What is the magnitude of the magnetic force on the moving electron?
   b.) What is the direction of the magnetic force on the electron the moment it enters the magnetic field?
   c.) Describe the path of the electron in this field.

02. For each diagram shown to the right, the green arrow, labeled **v**, shows the direction of the velocity of a positively charged particle, while the blue arrow, labled **B**, shows the direction of a magnetic field. What is the direction of the force, **F**, from the magnetic field on each particle?



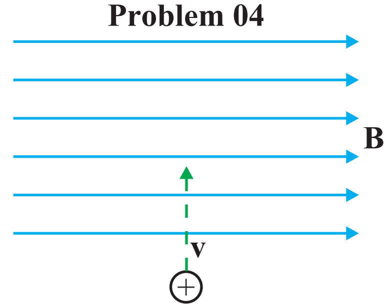


03. What is the direction of the magnetic field, **B**, in each diagram shown to the left, where **F** is the force on a positively charged particle with a velocity of **v**.

II

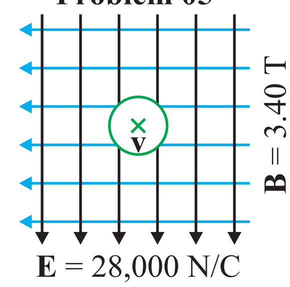
04. A 2.10-T magnetic field is directed to the right as shown in the diagram to the right. A proton is moving at a speed of 5.80×10^5 m/s from the bottom of the page to the top of the page.
   a.) What is the magnitude of the magnetic force acting on the proton?
   b.) Describe **exactly** the path of the proton once it enters the magnetic field.
   c.) What is the radius of the proton's path?

Problem 04



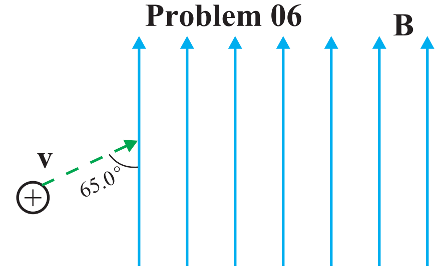
05. A charged particle moves into the page in a region of space where both an electric field, with a strength of 28,000 N/C, and a magnetic field, with a strength of 3.40 T are present. The two fields are perpendicular to each other and in the plane of the page as shown in the diagram to the right. The charged particle passes straight through the fields undeflected.
   a.) What is the velocity of the charge?
   b.) Does the magnitude or sign of the charge affect the answer? If yes what magnitude and sign should the charge have to travel through this region of space undeflected?

Problem 05



06. An alpha particle (helium nucleus) is traveling at 26,350 m/s when it enters a magnetic field, with a strength of 0.0165 T, directed toward the top of the page as shown in the diagram to the right. The initial direction of the alpha particle's path makes a 65.0° angle with the direction of the magnetic field.
   a.) Describe **exactly** the path of the alpha particle after it enters the field.
   b.) What is the radius of the alpha particle's path after it enters the field?
   c.) What is the pitch of the alpha particle's path after it enters the field

Problem 06



ANSWERS: **01.** a.) 7.41×10^{-13} N b.) north c.) circular **02.** a.) out of the page b.) top of the page
02. c.) right d.) bottom of the page e.) right f.) no force **03.** a.) into the page b.) right c.) left
04. a.) 1.95×10^{-13} N b.) clockwise circular path when viewed from the right c.) 2.88 mm **05.** 8235 m/s
06. a.) clockwise spiral (when viewed from above) toward the top of the page b.) 3.02 cm c.) 8.85 cm

Chapter 15
Magnetism and Electromagnetic Induction

15.3 Magnetic Force Applications: Galvanometers-Motors (Torque) Homework # 129

I

01. A galvanometer has a full-scale deflection of 50 μA. If the magnetic field were to weaken to 0.800 of its original strength, what current would produce full-scale deflection?

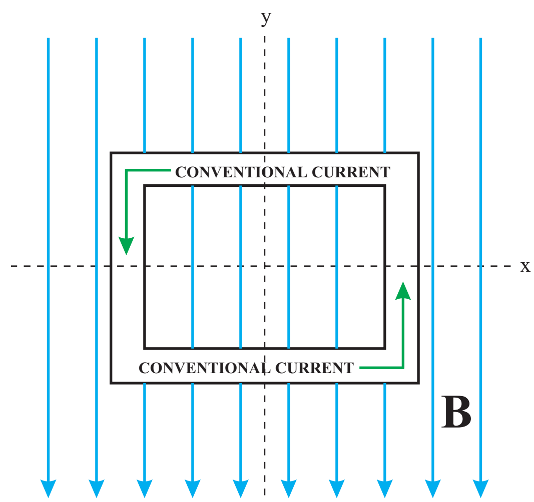
02. If the restoring spring of a galvanometer (originally with a full-scale deflection current of 80.0 μA) weakens by 15.0% through years of use, what minimum current will now give full-scale deflection?

03. If the current to a motor drops by 8.00%, by what factor will the output torque change?

II

04. A rectangular coil, which is 16.0 cm wide and 12.0 cm high and consists of 1200 turns, is initially sitting in a magnetic field with a magnitude of B = 4.60 T as shown in the diagram to the right. A conventional current of 8.75 A is flowing counterclockwise through the coil as shown.
   a.) Describe **exactly** the direction of the torque acting on this coil while oriented as shown?
   b.) What will be the magnitude of the torque acting on this coil while oriented as shown?
   c.) What will be the magnitude of the torque acting on this coil when it has rotated 90.0° so that the normal to the face of the coil is parallel to the magnetic field?

Problem 04

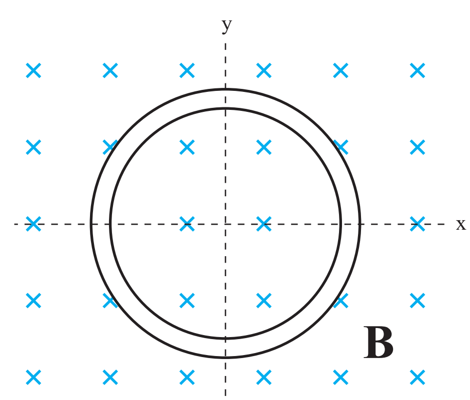


When the frequency of rotation of the coil reaches 5.20 revolutions per second, the coil no longer angularly accelerates due to a counter torque that makes the net torque zero. The coil then rotates at a constant rate of 5.20 revolutions per second. Assume the moment it reaches this state of equilibrium, the coils are oriented as shown in the diagram. Assume the current changes direction every half a turn.
   d.) Write an equation that describes the torque created by the magnetic field as a function of time.
   e.) What will be the torque after 12.0 s?

05. The circular coil consisting of 6 turns has a diameter of 14.0 cm and is sitting in a 1.65-T magnetic field as shown in the diagram to the right. The current in the wire is 2.80 A and is clockwise.
   a.) What would be the resulting magnetic effect on the loop? Explain!!!
   b.) If the current were reversed, what would be the resulting magnetic effect on the loop? Explain!!!

This magnetic field is removed and replaced with one directed to the right which creates a torque with a magnitude of 0.957 m·N when the coil is in the plane of the page as shown. The current is still 2.80 A clockwise.
   c.) Describe **exactly** the direction of the torque acting on this coil while oriented as shown?
   d.) What is the magnitude of the magnetic field?

Problem 05



ANSWERS: **01.** 62.5 μA **02.** 68.0 μA **03.** 92.0% τ_{Original} **04.** a.) counterclockwise when viewed from the right **04.** b.) 927 m·N c.) 0 m·N d.) $\tau = (927)\cdot\sin(32.7t)$ e.) 546 m·N (273 m·N - rounding) **05.** a.) expand **05.** b.) collapse c.) clockwise when viewed from above d.) 3.70 T

Chapter 15
Magnetism and Electromagnetic Induction

15.4 Electron Properties/Thermionic Emission and Cathode-Ray Tube (CRT) Homework # 130

See Homework #95 in "Chapter 12-Electrostatics" for the table of "Useful Information" on atomic particles.

Electron Properties

I

01. A charged particle moves in a circle of radius 12.0 cm when it enters a 0.319-T magnetic field. A crossed 300-V/m electric field causes the path of moving charges to be straight. (Note: a crossed electric field is one that has a direction that is perpendicular to the directions of both the magnetic field and the velocity of the moving charges)
    a.) What is the velocity of this particle? b.) What is the value of q/m for this particle?

02. A beam of protons, initially traveling west, encounter a 0.285-T magnetic field that is directed vertically downward into the earth causing the beam to move in a circle with a radius of 4.80 cm.
    a.) What is the velocity of the protons?
    b.) What is the direction of the electric field that will straighten this path out?
    c.) What is the strength of the electric field that will straighten this path out?

03. A beam of electrons goes undeflected when passing through crossed magnetic (B = 1.35 x 10^{-3} T) and electric (E = 7250 N/C) fields.
    a.) What is the velocity of the beam of electrons?
    b.) What is the radius of the beam of electrons if the electric field is removed?

II

04. An oil drop with a mass determined to be 4.46 x 10^{-15} kg is held at rest between two large plates, separated by a gap of 1.00 cm, when the potential difference between them is 390 V. How many excess electrons does this drop have?

Thermionic Emission & the CRT

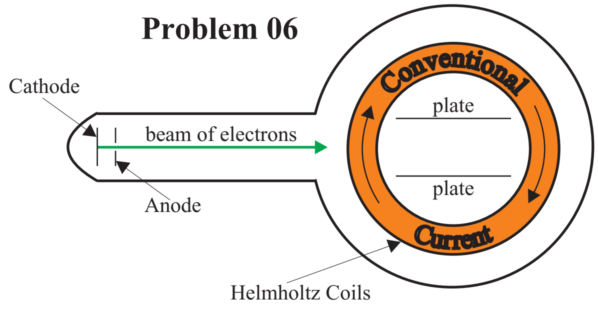
I

05. Use the ideal gas model ($KE_{ave} = \frac{3}{2}kT$) to estimate the *rms* speed of a free electron in a metal at __________.
    a.) 300 K b.) 2500 K (the typical temperature of the cathode in a tube)

II

06. The potential difference between the cathode and anode in a CRT is 3500 V creating a beam of electrons directed to the right as shown in the diagram to the right and below. The beam passes through a 32.5-G magnetic field created by two Helmholtz coils causing the beam to bend. This bent beam will strike one of two horizontal metal plates that are 5.00 cm apart. The original path of the beam is at a height exactly halfway between the two plates. The Helmholtz coils have a clockwise current.
    a.) What is the speed of the electrons in the beam as they pass through the hole in the anode?
    b.) What is the direction of the magnetic field created by the Helmholtz coils? Draw this field direction in the diagram.
    c.) Which plate will the beam of electrons hit?
    d.) What is the radius of the path of electrons once they enter the magnetic field?
    e.) What horizontal distance from the entry of the magnetic field will the beam travel before hitting the plate?

Problem 06

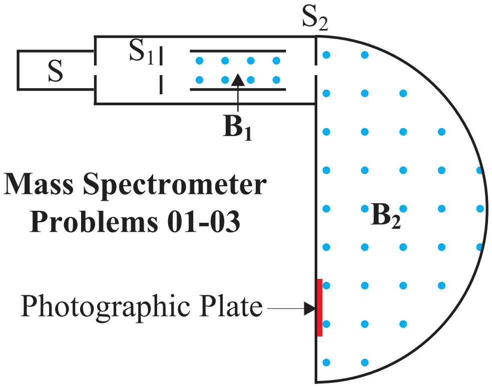


ANSWERS: **01.** a.) 940 m/s b.) 2.46 x10^4 C/kg **02.** a.) 1.31 x10^6 m/s b.) north c.) 3.74 X10^5 N/C
03. a.) 5.37 x 10^6 m/s b.) 2.27 cm **04.** 7 **05.** a.) 1.17 x 10^5 m/s b.) 3.37 x 10^5 m/s
06. a.) 3.51 x 10^7 m/s b.) into the page c.) bottom plate d.) 6.14 cm e.) 4.95 cm

Chapter 15
Magnetism and Electromagnetic Induction
15.5 Mass Spectrometer/Magnetic Field Strength (Ampere's Law) Homework # 131

See Homework #95 **in "Chapter 12-Electrostatics"** **for the table of "Useful Information" on atomic particles.**

Mass Spectrometer



Mass Spectrometer Problems 01-03

I

01. In a mass spectrometer, carbon atoms have radii of curvature equal to 3.30 cm, 3.60 cm, 3.90 cm, 4.20 cm. The largest radius corresponds to a mass of 14.0 u. What are the atomic masses of the other isotopes?

II

02. Suppose the electric field between the electric plates of a mass spectrometer is 2.82 x 10^4 V/m and the magnetic fields in each chamber are identical ($B_1 = B_2 = 0.850$ T). The source contains neon with mass numbers of 20 (19.992435 u) and 22 (21.991383 u). How far apart are the lines, formed by the singly-charged positive ions of each isotope, on the photographic film?

III

03. A mass spectrometer is being used to monitor air pollutants. It is difficult, however, to separate molecules with nearly equal mass such as CO (28.0106 u) and N_2 (28.0134 u). If these two molecules are to be separated on the film by a distance of 0.365 mm, how large a radius of curvature must a spectrometer have?

Magnetic Field Strength

I

04. How strong is the magnetic field 6.00 cm from a long straight wire carrying 4.25 A of current?

05. If a magnetic field of no more than 10.0 G is allowed 30.0 cm from an electric wire, what is the maximum current the wire can carry?

II

06. What is the acceleration (magnitude and direction) of a 345-g model airplane charged to -9.15 C and traveling 1.85 m/s as it passes 8.25 cm from a wire, essentially parallel to its path, carrying a current of 37.5 A? Give the answer in *g*'s. Assume the lift force on the wings is exactly equal but opposite to the force of gravity.

07. An electron is moving 7.25 x 10^5 m/s towards the north. The electron is moving parallel to and directly above a straight wire carrying a 22.5-A current to the north. Initially, the electron is 8.50 cm from the wire.
a.) What is the direction of the magnetic field created by the current-carrying wire in the vicinity of the electron?
b.) What is the direction of the initial (maximum) force on the electron from the magnetic field?
c.) What is the magnitude of the initial (maximum) force on the electron from the magnetic field?

08. A 24.0-cm-long solenoid, 2.50 cm in diameter, is to produce a 0.250 T magnetic field at its center. If the maximum current is 7.95 A, how many turns must the solenoid have?

III

09. At a certain location, the earth's magnetic field has a horizontal component of 0.475 G and has a magnetic declination of 0° (magnetic north is in the exact direction of geographical or, "true", north). A horizontal compass is placed 14.00 cm due north of a straight vertical wire carrying 25.0 A of current straight up from the ground.
a.) In what direction will the compass needle point? b.) What is the magnitude of B_{net} at the compass?

ANSWERS: **01.** 11.0 u, 12.0 u, 13.0 u **02.** 1.63 mm **03.** 1.83 m **04.** 1.42 x 10^{-5} T (0.142 G) **05.** 1500 A **06.** 4.55 x 10^{-4} *g* up **07.** a.) east b.) up c.) 6.14 x 10^{-18} N **08.** 6006 turns **09.** a.) 53.1° N of W b.) 0.594 G

Chapter 15
Magnetism and Electromagnetic Induction
15.6 Magnetic Force Between Two Parallel Wires Homework # 132

I

01. Two horizontal straight and parallel wires 65.0 m long and 9.75 cm apart each carry 27.5 A of current directed toward the north. The two wires are at the same height so that one wire is further east than the other (by 9.75 cm).
a.) What is the magnitude and direction of the force on the eastern-most wire by the western-most wire?
b.) What is the magnitude and direction of the force on the western-most wire by the eastern-most wire?
c.) Are the forces on each of the two wires by the other wire attractive or repulsive?

02. A vertical wire carrying 11.5 A of current straight up exerts an attractive force per unit length of 8.45×10^{-4} N/m on a second parallel wire 12.75 cm away. What current (magnitude and direction) flows in the second wire?

03. Describe the direction of the magnetic field created by each of the current-carrying wires below.

a.)

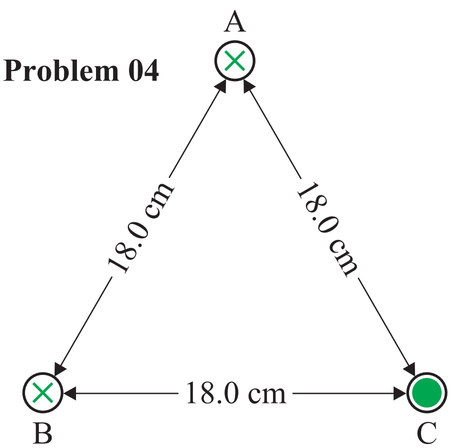
b.)

c.)

II

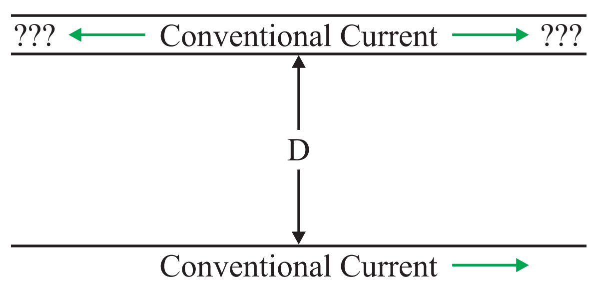
04. Three long parallel wires are 18.0 cm apart from one another so that they are at the three corners of an equilateral triangle as shown in the diagram to the right. The current in each wire is 5.00 A, but the current in wires A and B are into the page, while the current in wire C is out of the page. Assume North is toward the top of the page.
a.) What is the **NET** magnetic force per unit length (magnitude and direction) on wire A from wires B and C?
b.) What is the **NET** magnetic force per unit length (magnitude and direction) on wire B from wires A and C?
c.) What is the **NET** magnetic force per unit length (magnitude and direction) on wire C from wires A and B?

Problem 04



05. Two horizontal straight and parallel wires are oriented such that one is directly above the other as shown in the diagram to the right. The upper wire is made of copper ($\rho = 8900$ kg/m^3) with a diameter 2.05 mm (Gauge 12) and is a distance of $D = 3.45$ cm above the lower wire. The lower wire is a power transmission wire with a current of 2450 A to the right. The current in the upper wire is such that it is suspended above the lower wire due to the magnetic repulsive force from the lower wire.
a.) What is the magnitude and the direction of the magnetic field at the location of the upper wire created by the lower wire?
b.) What is the current (magnitude and direction) in the upper wire to create repulsive forces between the wires?
c.) What is the **NET** magnetic field (magnitude and direction) 3.25 cm above the bottom wire?
d.) What is the **NET** magnetic field (magnitude and direction) 3.25 cm above the top wire?

Problem 05



ANSWERS: **01.** a.) 0.101 N west b.) 0.101 N east c.) attractive **02.** 46.8 A straight up
03. a.) counterclockwise b.) clockwise c.) counterclockwise (viewed from the right)
04. a.) 2.78×10^{-5} N/m due West b.) 2.78×10^{-5} N/m 60.0° N of W c.) 4.81×10^{-5} N/m 30.0° S of E
05. a.) 1.42×10^{-2} T out of page b.) 20.3 A left c.) 1.71×10^{-2} T out of page d.) 7.19×10^{-3} T out of page

Chapter 15
Magnetism and Electromagnetic Induction
15.7 Faraday's Law of Electromagnetic Induction Homework # 133

I

01. A 16.0-cm diameter circular loop of wire is positioned such that a 0.750-T magnetic field is passing through the face of the loop (parallel to the normal to the loop). The loop is physically removed from the field in 0.125 s.
    a.) Initially, what is the magnetic flux through the loop?
    b.) Once removed from the field, what is the magnetic flux through the loop?
    c.) What is the average induced emf?

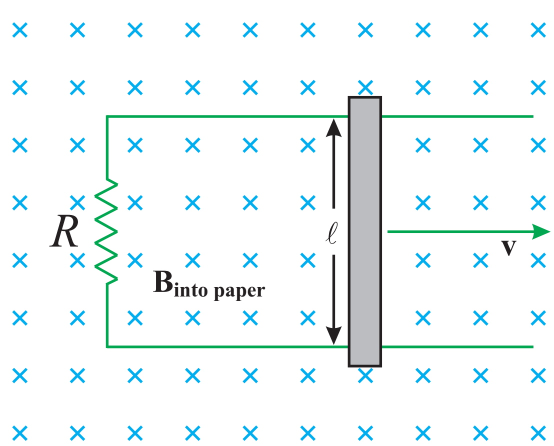
02. The magnetic flux through a loop of wire changes from -15.0 Wb to 32.5 Wb in 0.224 s. What is the induced emf?

03. The magnetic field strength through a 22.4-cm diameter circular coil of wire consisting of 24 turns (loops) changes from 1.450 T to 0.125 T in 0.480 s. The total resistance of the copper wire is 0.0150 Ω.
    a.) What is the induced emf in the coil?
    b.) What is the induced current flow in the coil?

II

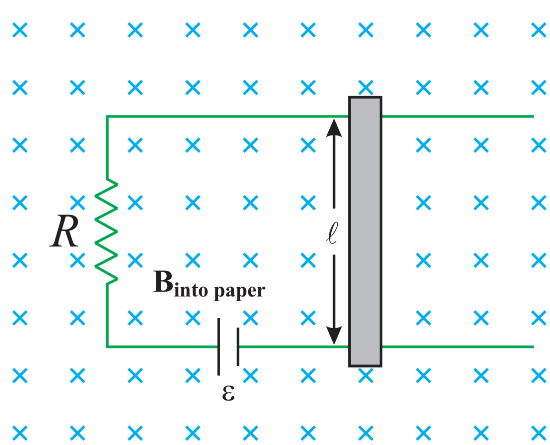
04. A U-shaped conductor consisting of two parallel conducting rails that are connected together by a resistor of $R = 40.0\ \Omega$ as shown to the right. A conducting bar, which is $\ell = 18.0$ cm long, is placed across these two rails and a force is applied to this bar so as to move it toward the right with a constant velocity of $v = 12.0$ m/s through a magnetic field of $B = 3.75$ Tesla.
    a.) What will be the EMF generated in this circuit?
    b.) What will be the magnitude and direction of the resulting electrical current in this circuit?
    c.) How much force would be required to push this bar along at a constant speed?
    d.) What will be the strength of the electric field within the moving bar?
    e.) At what rate is work being done on the moving bar?

Problem 04



05. The same U-shaped conducting apparatus (in the same magnetic field) as problem 04 above has a source of emf with a voltage of 8.00 V inserted in the bottom rail as shown in the diagram to the right. The same conducting bar as problem 04 is placed on the rails, but no outside object applies a force to the conducting bar.
    a.) What is the magnitude and direction of the conventional current in the conducting bar?
    b.) What force (magnitude and direction) is applied to the bar by the magnetic field?
    c.) What is the velocity (magnitude and direction) of the bar when equilbrium is established?

Problem 05

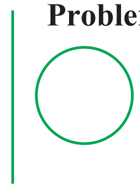


ANSWERS: **01.** a.) 0.0151 Wb b.) 0 Wb c.) 0.121 V **02.** 212 V **03.** a.) 2.61 V b.) 174 A
04. a.) 8.10 V b.) 0.203 A counterclockwise c.) 0.137 N d.) 45 N/C e.) 1.64 W
05. a.) 0.200 A toward the bottom of the page b.) 0.135 N to the right c.) 11.8 m/s to the right

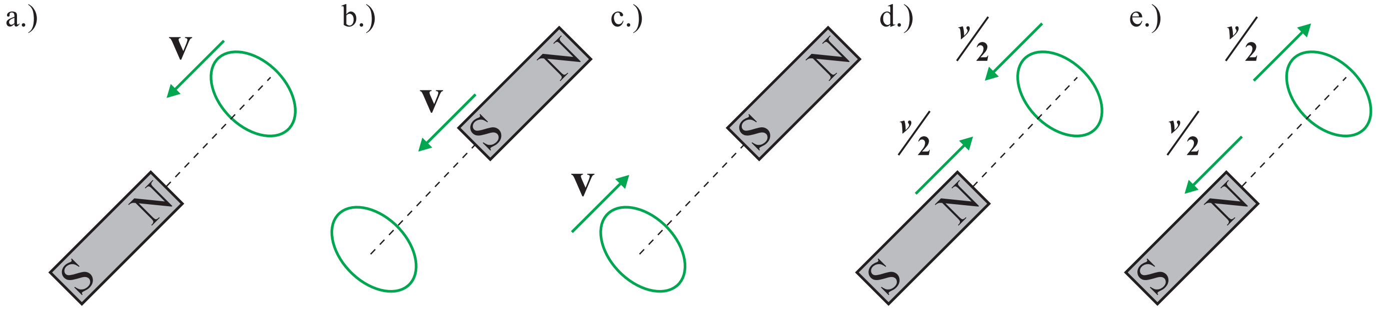
I

01. The diagram to the right shows a straight current-carrying wire near a circular loop of wire. Determine the direction of the induced current in the circular loop if the current in the straight wire is directed towards __________ of the page and is __________.
    a.) top, increasing b.) top, decreasing
    c.) bottom, increasing d.) bottom, decreasing

Problem 01

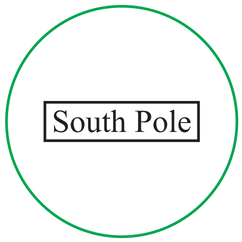


02. In each situation shown below, determine the direction of induced current when viewed from the pole of the magnet that is closest to the loop.



03. A single loop of wire is positioned in the plane of the paper as shown in the diagram to the right. A bar magnet is approaching the loop from above the page leading with the south end of the magnet (i.e. the south end of the magnet is approaching the loop from above the page).
    a.) What is the direction of the induced current in the loop?
    b.) What is the direction of the induced current in the loop if the magnet is later pulled in the opposite direction (upward away from the coil)?

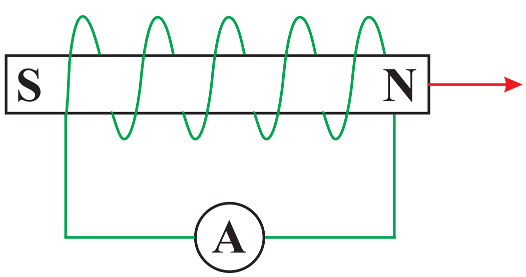
Problem 03



II

04. A coil of wire (solenoid) is connected to an ammeter as shown in the diagram to the right. Initially, a bar magnet is sitting inside the coil oriented as shown. This magnet is then quickly withdrawn to the right.
    a.) What will be the direction of the magnetic field before the magnet is removed from the solenoid?
    b.) What will be the direction of the magnetic field **IMMEDIATELY** after the magnet is removed from the solenoid?
    c.) What will be the direction of the magnetic field a long period of time after the magnet is removed from the solenoid?
    d.) What will be the direction of the induced current through the ammeter?
    e.) What would be the direction of the induced current through the ammeter if the magnet were withdrawn quickly to the left?

Problem 04



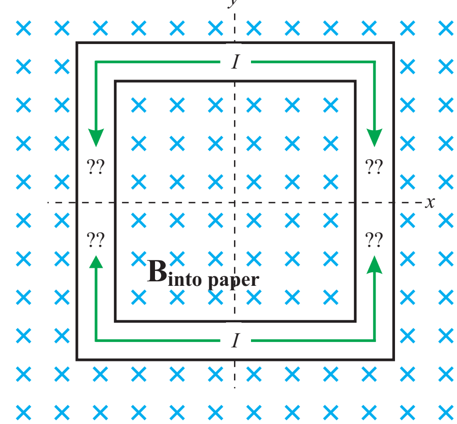
ANSWERS: **01.** a.) counterclockwise b.) clockwise c.) clockwise d.) counterclockwise
02. a.) counterclockwise b.) clockwise c.) clockwise d.) counterclockwise e.) clockwise
03. a.) clockwise b.) counterclockwise
04. a.) right b.) right c.) 0 d.) right e.) right

Chapter 15
Magnetism and Electromagnetic Induction
15.8 Lenz's Law — Homework # 135

II

05. The diagram to the right shows a rectangular coil of wire sitting in magnetic field directed into the page. A torque is applied to the coil so as to rotate it around the x-axis in a clockwise fashion when view from the right. What is the direction of the induced current during the first ¼ of a turn. Even though the coil is rotating, use the current orientation of the coil to describe the direction of the induced current.

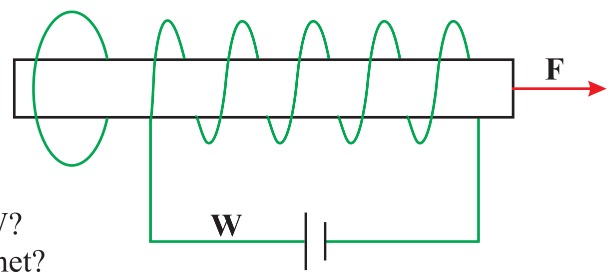
Problem 05



III

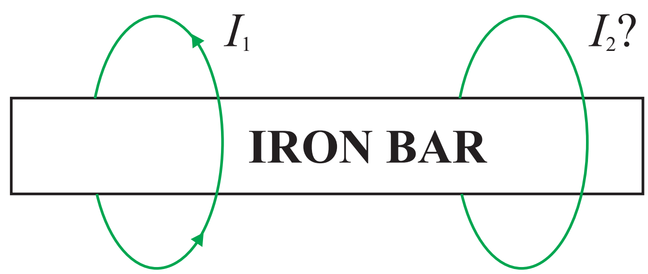
06. An electromagnet (solenoid with an iron bar through the center) is wired to a power supply as shown in the diagram to the right. A loop of wire with no power supply is placed around the part of the iron bar that extends outside the solenoid on the left. The bar is being pulled to the right, away from the loop of wire, with a force of *F*.
   a.) What is the direction of the current in the wire segment labeled W?
   b.) What is the direction of the magnetic field within the electromagnet?
   c.) What is the direction of the induced current in the loop of wire when viewed from the right?

Problem 06



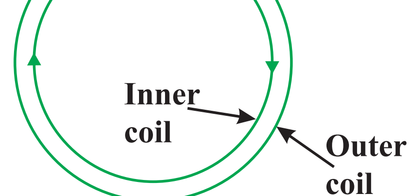
07. Two loops of wire are arranged as shown to the right around a common bar of soft iron. Initially, there is a conventional current I_1 flowing counterclockwise through the left hand loop as shown in the diagram to the right. What will be the resulting effect on the right hand loop if the current in this loop is gradually __________ with time?
   a.) increasing b.) decreasing

Problem 07



08. Two concentric coils are arranged as shown in the diagram to the right. At $t = 0$ the inner coil has a clockwise current flowing through it. What will be the direction of the induced current in the outside coil if the current in the inner coil is __________ in magnitude as a function of time? [Assume any changes in flux in the small area between the coils are insignificant]
   a.) increasing b.) decreasing

Problems 08 and 09



09. What will be the resulting effect on the inner coil in each part of problem 08 above?

ANSWERS: **05.** clockwise **06.** a.) left b.) left c.) clockwise
07. a.) move away from left wire b.) move toward left wire
08. a.) counterclockwise b.) clockwise **09.** a.) collapse b.) expand

Chapter 15
Magnetism and Electromagnetic Induction
15.9 Electric Generators/Counter EMF and Torque   Homework # 136

Electric Generators

I

01. A car generator produces 12.0 V when the armature turns at 720 rev/min. Assuming no other changes what will its output voltage be at 1800 rev/min?

02. A simple generator has square armature windings that are 6.25 cm on a side. It has 145 loops and is positioned in a magnetic field with a strength of 0.589 T. If it rotates at a rate of 105 rev/s, what is the peak output voltage?

03. A simple generator has a 275-loop square coil 27.5 cm on a side. How fast must it turn in a 0.475-T field to produce a 170-V peak output?

II

04. An electric generator produces an rms output voltage of 220 V. The generator has 225 loops on a square armature coil that is 22.5 cm on a side and rotates at 60.0 rev/s. What is the strength of the magnetic field in which the armature is rotating?

05. A circular coil consisting of 245 turns and having a diameter of 6.18 centimeters is rotating in a uniform magnetic field of 4.65 Tesla. At $t = 0.00$ seconds the coil is oriented such that the normal to the plane of the coil is parallel to the direction of the magnetic field and the coil is rotating at 185 rev/s. The total resistance in the coil is 28.0 Ω.
    a.) What will be the angular velocity of this rotating coil?
    b.) Write an equation that describes the magnetic flux passing through this coil as a function of time.
    c.) What will be the EMF generated by this coil as a function of time?
    d.) What will be the EMF 35.0 s after rotations begin?
    e.) Write an equation that describes the power generated as a function of time.
    f.) What will be the resulting average power output of this coil?
    g.) What is the maximum torque that must be applied to this coil?

Counter EMF and Counter Torque

I

06. The counter emf of a dc motor wired to a 120-V line reaches 112 V when the motor is running at full speed. If the armature windings of the motor have a resistance of 5.25 Ω, what is the current into the motor when the motor is __________?
    a.) starting up   b.) running at full speed

II

07. At full speed, a motor draws 4.65 A when connected to a 120 V line. If it has an armature resistance of 4.85 Ω, how large is the counter emf?

08. A simple generator has square armature windings that are 5.75 cm on a side. It has 115 loops and is positioned in a magnetic field with a strength of 0.550 T and is it rotated at a rate of 137 rev/s. This generator is connected to a load with a resistance of 40.0 Ω.
    a.) What is the peak output voltage of this generator?
    b.) What is the maximum counter torque produced in the generator?

ANSWERS: **01.** 30.0 V **02.** 220 V **03.** 2.74 rev/s **04.** 0.0725 T **05.** a.) 1162 rad/s
05. b.) $\Phi_B = 3.42 \cos(1162 \cdot t)$ c.) $\varepsilon = 3970 \sin(1162 \cdot t)$ d.) -3460 V e.) $P = (5.64 \times 10^5) \sin^2(1162 \cdot t)$
05. f.) 2.82×10^5 W g.) 485 m·N **06.** a.) 22.9 A b.) 1.52 A **07.** 97.4 V **08.** a.) 180 V b.) 0.941 m·N

Chapter 15
Magnetism and Electromagnetic Induction
15.10 Transformers Homework # 137

I

01. A transformer, that has 11,200 turns in the secondary, converts 120 V to 21,000 V. Assuming 100 percent efficiency, how many turns must be in the primary?

02. An essentially 100-percent efficient transformer changes 60 V to 220 V.
    a.) What kind of transformer is this?
    b.) What is the ratio of the current in the secondary to that in the primary?

03. A Neon sign is wired to a 220-V line, but requires 12.0 kV for their operation.
    a.) What is the ratio of secondary to primary turns of the transformer?
    b.) What would be the voltage to the sign if the transformer were connected backwards?

II

04. A transformer has 1200 primary turns and 225 secondary turns. The input voltage is 120 V and the output current is 7.25 A.
    a.) What type of transformer is this?
    b.) What is the output voltage?
    c.) What is the primary current?

05. A 99-percent efficient transformer has 135 turns in the primary and 1400 turns in the secondary. If the current in the primary coils is 6.25 A, what is the current in the secondary?

III

06. An electric power plant must transmit 45.0 kW of electricity to a nearby town. The energy is delivered over two 0.120 Ω lines. The energy conglomerate that owns the power plant saves power by stepping up the voltage from 120 V to 1800 V to transmit it to the town and then stepping it back down to 120 V in the town. Both transformers are 99 percent efficient.

For parts a.) and b.), the power is to be transmitted at 120 V (not stepped up or down).
    a.) What is the current flow in the transmission lines?
    b.) What is the power loss to heat in the transmission lines?

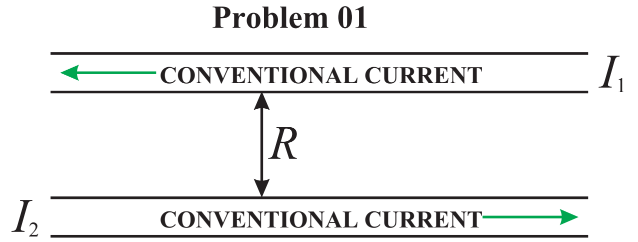
For parts c.) through g.), the power is to be transmitted at 1800 V by the step-up and step down process described above.
    c.) What is the current flow in the transmission lines?
    d.) What is the power loss to heat in the transmission lines?
    e.) How much power is delivered to the step-down transformer in the town?
    f.) How much power "leaves" the step-down transformer to be used in the town?
    g.) How much total power is lost in this system (from power generation to completion of the step-down process)?
    h.) How much power is saved by transmitting the power at 1800 V instead of 120 V?

ANSWERS: **01.** 64 **02.** a.) step-up b.) 0.273 **03.** a.) 55 b.) 4.0 V
04. a.) step-down b.) 22.5 V c.) 1.36 A **05.** 0.597 A
06. a.) 375 A b.) 33.75 kW c.) 24.75 A d.) 147 W e.) 44.4 kW f.) 44.0 kW g.) 1.0 kW (1041 W)
06. h.) 32.7 kW

Chapter 15
Magnetism and Electromagnetic Induction
Magnetism and Electromagnetic Induction Review   Homework # 138

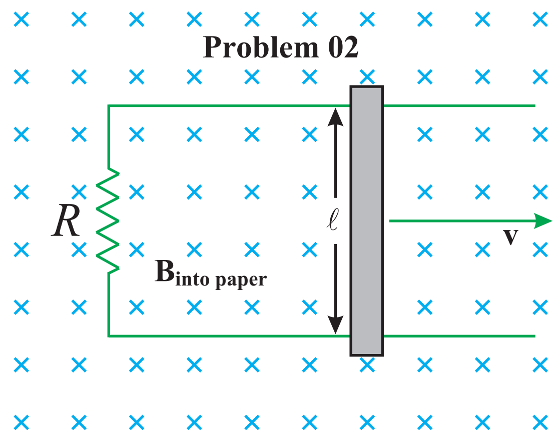
II

01. Two very long parallel wires are R = 1.85 cm apart and are carrying currents as shown below. The upper wire is carrying a current of I_1 = 3.50 A toward the left while the lower wire is carrying a current of I_2 = 2.50 A toward the right.



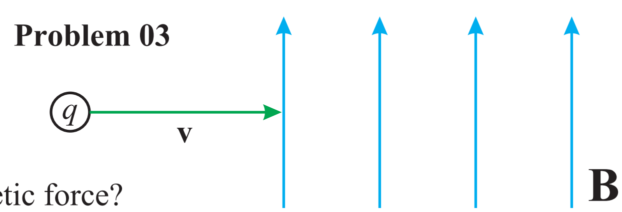
a.) What is the magnitude and direction of the magnetic field at the location of the upper wire as generated by the lower wire?
b.) What is the magnitude and direction of the magnetic force acting on 30.0 cm of the upper wire?
c.) What is the **NET** magnetic field (magnitude and direction) at a point exactly midway between these two wires?
d.) What is the magnitude and direction of the magnetic field 1.25 cm above the upper wire?
e.) What is the magnitude and direction of the magnetic force acting on 30.0 cm of the upper wire if the current flowing through the lower wire is reversed? Explain!

02. The diagram to the right shows two parallel conducting rails that are connected together by a resistor of R = 105.0 Ω. A conducting bar, which has a length of ℓ = 14.0 cm long, is placed across these two rails and a force is applied to this bar so as to move it toward the right with a constant velocity of v = 11.5 m/s through a magnetic field of B = 1.95 T.



a.) What will be the EMF generated in this circuit?
b.) What will be the magnitude and direction of the resulting electrical current in this circuit?
c.) How much force would be required to push this bar along at a constant speed?
d.) What will be the strength of the electric field within the moving bar?
e.) At what rate is work being done on the moving bar?

03. A particle, which has a charge of q = -14.5 μC and a mass of 3.45 x 10^{-12} kg, enters a magnetic field of B = 960 Gauss, as shown to the right, with a velocity of 5400 m/s perpendicular to the direction of the magnetic field.



a.) What will be the magnitude and direction of the resulting magnetic force?
b.) Describe, exactly, the path that this particle will follow as it moves through the magnetic field and determine the magnitude of the parameter which describes this path?
c.) What will be the direction and magnitude of an electric field which can be added to this magnetic field so that this charge passes through both fields undeflected?
d.) Suppose that instead of entering this magnetic field at a right angle, the particle enters at an angle of 56.0° relative to the magnetic field from the bottom of the page. What will be the magnitude of the resulting magnetic force? Assume the electric field added in part C is **NOT** present.
e.) Describe, exactly, the path that this particle from part D will now follow as it moves through the magnetic field and determine the magnitude of the two parameters [radius and pitch] which describe this path?

ANSWERS: **01.** a.) 2.70 x 10^{-5} T out of page b.) 2.84 x 10^{-5} N toward top of page c.) 1.30 x 10^{-4} T out of page
01. d.) 3.99 x 10^{-5} T into the page e.) 2.84 x 10^{-5} N toward bottom of page **02.** a.) 3.14 V
02. b.) 0.0299 A counterclockwise c.) 8.16 x 10^{-3} N d.) 22.4 N/C e.) 0.0939 W **03.** a.) 7.52 x 10^{-3} N into page
03. b.) counterclockwise circular path when viewed from above (r = 1.34 cm) c.) 518 N/C into page
03. d.) 6.23 x 10^{-3} N e.) counterclockwise spiral (view from above) toward top of page (r = 1.11 cm, p = 4.70 cm)

Chapter 15
Magnetism and Electromagnetic Induction
Magnetism and Electromagnetic Induction Review Homework # 139

II

04. A circular coil of conducting wire with a diameter of 0.300 m consists of 250 turns and is rotating at 75.0 rpm in the presence of a 1.35 T magnetic field. The coil has a total resistance of 30.0 Ω. The area of the loop is parallel to the field at time t = 0.00 s.
   a.) What is the angular velocity of this rotating coil?
   b.) Describe the magnetic flux as a function of time.
   c.) What is the maximum flux that will pass through this coil?
   d.) How long will it take to achieve this maximum flux the first time?
   e.) What is the minimum flux that will pass through this coil?
   f.) How long will it take to achieve this minimum flux the first time?
   g.) What will be the flux after 1.32 seconds?
   h.) Describe the induced EMF as a function of time.
   i.) What is the maximum induced EMF that will be created in this coil?
   j.) How long will it take to achieve this maximum EMF the first time?
   k.) What is the minimum induced EMF that will be created in this coil?
   l.) How long will it take to achieve this minimum EMF the first time?
   m.) What will be the EMF after 1.32 seconds?
   n.) What will be the current flow as a function of time?
   o.) What is the maximum current flow in this coil?
   p.) How long will it take to achieve this maximum current the first time?
   q.) What is the minimum current flow in this coil?
   r.) How long will it take to achieve this minimum current the first time?
   s.) What will be the current after 1.32 seconds?
   t.) Describe the power consumed as a function of time.
   u.) What will be the maximum power consumption for any instant?
   v.) What will be the minimum power consumption for any instant?
   w.) What is the average power consumed?
   x.) Describe the external torque as a function of time that would be required to maintain this **CONSTANT** angular velocity.
   y.) What would be the maximum torque required to maintain this angular velocity?
   z.) What would be the minimum torque required to maintain this angular velocity?

ANSWERS: **04.** a.) 7.85 rad/s b.) $\Phi_B = 23.86\ \cos\left(7.85\cdot t\right)$ c.) 23.86 Wb d.) 0 s, 0.400 s e.) 0 Wb
04. f.) 0.200 s g.) -14.1 Wb h.) $\varepsilon = 187.3\ \sin\left(7.85\cdot t\right)$ i.) 187.3 V j.) 0.200 s k.) 0 V l.) 0.400 s
04. m.) -150.9 V n.) $I = 6.24\ \sin\left(7.85\cdot t\right)$ o.) 6.24 A p.) 0.200 s q.) 0 A r.) 0.400 s s.) -5.03 A
04. t.) $P = 1168\ \sin^2\left(7.85\cdot t\right)$ u.) 1168 W v.) 0 W w.) 584 W x.) $\tau = 149\ \sin\left(7.85\cdot t\right)$
04. y.) 149 m·N z.) 0 m·N