A3

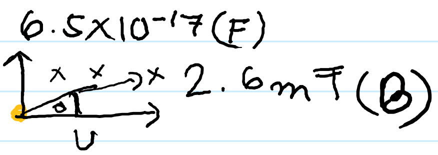
Friday, April 29, 2022 10:57 PM

chapter- 28

•1 A proton traveling at 23.0° with respect to the di-
rection of a magnetic field of strength 2.60 mT experiences
a mag-
netic force of 6.50 $ 10%o17 N. Calculate (a) the proton's
speed and
(b) its kinetic energy in electron-volts

Module 28-1 Magnetic Fields and the Definition of $\vec{B}$

•1 SSM ILW A proton traveling at 23.0° with respect to the direction of a magnetic field of strength 2.60 mT experiences a magnetic force of 6.50×10^{-17} N. Calculate (a) the proton's speed and (b) its kinetic energy in electron-volts.



(a)

We know,

$$F = qvB\sin\theta$$

$$v = \frac{F}{qB\sin\theta}$$

$$= \frac{6.5 \times 10^{-17}}{1.602 \times 10^{-19} \times 2.6 \times 10^{-3} \times \sin(23)}$$

$$= 399.39 \times 10^{3}\ ms^{-1}$$ (Ans)

$q = +1.602 \times 10^{-19}$ C

$\theta = 23$

(b)

We know

$$K = \frac{1}{2}mv^2$$

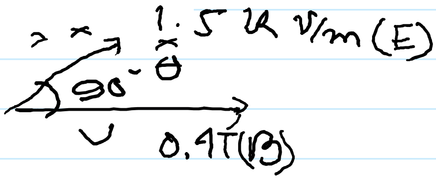
$$= 0.5 \times 1.67 \times 10^{-27} \times 399.39 \times 10^{3}$$

$$= 1.334 \times 10^{-16}\ J$$ (Ans)

$m = 1.67 \times 10^{-27}$ kg

•8 An electric field of 1.50 kV/m and a perpendicular magnetic
field of 0.400 T act on a moving electron to produce no net force.
What is the electron's speed?

•8 An electric field of 1.50 kV/m and a perpendicular magnetic field of 0.400 T act on a moving electron to produce no net force. What is the electron's speed?



We know

$$E = vB\sin\theta$$

$$v = \frac{E}{B\sin\theta}$$

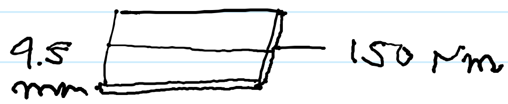
$$v = \frac{1.5 \times 1000}{0.40 \sin 90^\circ}$$

$$v = 3750\ ms^{-1}$$ (Ans)

•13 A strip of copper 150 mm thick and 4.5 mm wide is placed in
a uniform magnetic field of magnitude 0.65 T, with perpendi-
cular to the strip. A current i ! 23 A is then sent through the strip
such that a Hall potential difference V appears across the width of
the strip. Calculate V. (The number of charge carriers per unit vol-
ume for copper is 8.47 10 28 electrons/m3.)

Module 28-3 Crossed Fields: The Hall Effect

•13 A strip of copper 150 μm thick and 4.5 mm wide is placed in a uniform magnetic field $\vec{B}$ of magnitude 0.65 T, with $\vec{B}$ perpendicular to the strip. A current $i = 23$ A is then sent through the strip such that a Hall potential difference V appears across the width of the strip. Calculate V. (The number of charge carriers per unit volume for copper is 8.47×10^{28} electrons/m^3.)



$$n = \frac{q}{\omega} = \frac{\text{charge}}{\text{volume}}$$

we know,

$$v = \frac{iB}{nle}$$

$$= \frac{23 \times 0.65}{8.47 \times 10^{28} \times 150 \times 10^{-6} \times 1.6 \times 10^{-19}}$$

$$= 7.35 \times 10^{-6}\ V$$ (Ans)

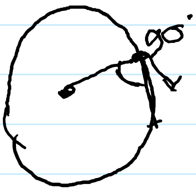
•21 An electron of kinetic energy 1.20 keV circles in a plane perpendicular to a uniform magnetic field. The orbit radius is 25.0 cm. Find (a) the electron's speed, (b) the magnetic field magnitude, (c) the circling frequency, and (d) the period of the motion.

0 $V_s^{1/2}$

$V^{1/2}$ ($V^{1/2}$)

Figure 28-38 Problem 20.

•21 SSM An electron of kinetic energy 1.20 keV circles in a plane perpendicular to a uniform magnetic field. The orbit radius is 25.0 cm. Find (a) the electron's speed, (b) the magnetic field magnitude, (c) the circling frequency, and (d) the period of the motion.



$$F = \frac{mv^2}{r}$$

$$F = qvB\sin\theta$$

(a)

We know,

$$K = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2\times 1.2\times 10^3 \times e}{9.11\times 10^{-31}}}$$

$$= 20.596\times 10^6 \ ms^{-1} \text{ (Ans)}$$

(b)

we get,

$$F_e = F_B$$

So, $$\frac{mv^2}{r} = qvB\sin\theta$$

$$B = \frac{mv}{q\sin\theta r} = \frac{9.11\times 10^{-31}\times 20.596\times 10^6}{1.6\times 10^{-19}\times \sin 90^\circ \times 25\times 10^{-2}}$$

$$= 4.679\times 10^{-3} T \text{ (Ans)}$$

(c)

we know,

$$\omega = \frac{v}{r} = 2\pi f$$

So, $$f = \frac{v}{2\pi r}$$

$$= \frac{20.526\times 10^6}{2\pi\times 25\times 10^{-2}} = 13.078\times 10^6 Hz \text{ (Ans)}$$

(d)

we know.

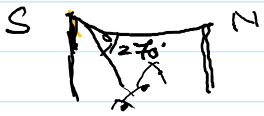
$$T = \frac{1}{f} = \frac{1}{13.078\times 10^6} = 76.453\times 10^{-9} s \text{ (Ans)}$$

$$T = \frac{1}{f} = \frac{1}{13.0787\times10^{6}} = 76.453\times10^{-9}\ \text{s} \quad \text{(Ans)}$$

•39 A horizontal power line carries a current of 5000 A from south to north. Earth's magnetic field (60.0 mT) is directed
toward the north and inclined downward at 70.0° to the horizontal.
Find the (a) magnitude and (b) direction of the magnetic force on
100 m of the line due to Earth's field.

Module 28-6 Magnetic Force on a Current-Carrying Wire

•39 SSM A horizontal power line carries a current of 5000 A from south to north. Earth's magnetic field (60.0 μT) is directed toward the north and inclined downward at 70.0° to the horizontal. Find the (a) magnitude and (b) direction of the magnetic force on 100 m of the line due to Earth's field.



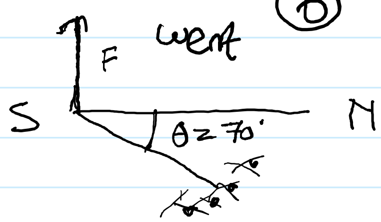
(a)

We know,

$$F = i\vec{L}\times\vec{B}$$
$$= iLB\sin\theta$$

$$= 5000 \times 100 \times 60\times10^{-6} \times \sin 70^\circ$$
$$= 28.19\ \text{N} \quad \text{(Ans)}$$

(b)



So the direction is in west.

●●50 An electron moves in a circle
of radius r ! 5.29 $ 10 %11 m with
speed 2.19 $ 10 6 m/s. Treat the circular path as a current loop
with a constant current equal to the ratio of the electron's charge
magnitude to the period of the motion. If the circle lies in a uni-
form magnetic field of magnitude B ! 7.10 mT, what is the maxi-
mum possible magnitude of the torque produced on the loop by
the field?

••50 An electron moves in a circle of radius $r = 5.29 \times 10^{-11}$ m with speed 2.19×10^6 m/s. Treat the circular path as a current loop with a constant current equal to the ratio of the electron's charge magnitude to the period of the motion. If the circle lies in a uniform magnetic field of magnitude $B = 7.10$ mT, what is the maximum possible magnitude of the torque produced on the loop by the field?

Figure 28-45 Problem 49.

$R = 5.29 \times 10^{-11} m$

$v = 2.19 \times 10^{6} ms^{-1}$

$B = 7.10 \times 10^{-3} T$

we know, $N = 1$

$$\tau = \vec{\mu} \times \vec{B}$$
$$= \mu B$$
$$= NiAB = i\pi r^2 B$$
$$= \frac{qv}{\cancel{r}2\cancel{\pi}} \cancel{\pi} \cancel{r^2}^{r} B$$
$$= \frac{qvB}{} \frac{r}{2} =$$
$$= \frac{1.6\times10^{-19} \times 2.19\times10^{6} \times 7.1\times10^{-3} \times 5.29\times10^{-11}}{2}$$
$$= 6.58\times10^{-26} \text{ N.m}$$ (Ans)

$$i = \frac{q}{t} = qf$$
we know,
$$\omega = 2\pi f = \frac{v}{r}$$
$$f = \frac{v}{r2\pi}$$
So,
$$i = \frac{qv}{r2\pi}$$

•57 A circular coil of 160 turns has a radius of 1.90 cm.
(a) Calculate the current that results in a magnetic dipole moment

of magnitude 2.30 A)m2
. (b) Find the maximum magnitude of the
torque that the coil, carrying this current, can experience in a
uni-
form 35.0 mT magnetic field.

•57 SSM A circular coil of 160 turns has a radius of 1.90 cm. (a) Calculate the current that results in a magnetic dipole moment of magnitude 2.30 $A \cdot m^2$. (b) Find the maximum magnitude of the torque that the coil, carrying this current, can experience in a uniform 35.0 mT magnetic field.

$n = 160$
$r = 1.9 \times 10^{-2} m$

(a)

We know,

$\mu = NiA$

$i = \frac{\mu}{NA} = \frac{\mu}{N\pi r^2}$

$= \frac{2.30}{160 \times \pi \times (1.9 \times 10^{-2})^2}$

$= 12.675\ A$ Ans

(b)

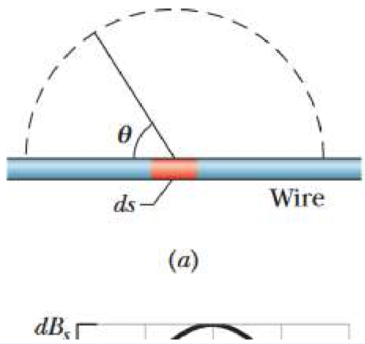
$\tau = \mu . B$
$= 2.3 \times 35 \times 10^{-3}$
$= 80.5 \times 10^{-3}\ N.m$ Ans

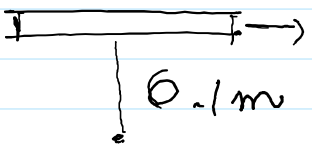
Chapter - 29

•1 A surveyor is using a magnetic compass 6.1 m below a power line in which there is a steady current of 100 A. (a) What is the magnetic field at the site of the compass due to the power line? (b) Will this field interfere seriously with the compass reading? The horizontal component of Earth's magnetic field at the site is 20 mT.

Module 29-1 Magnetic Field Due to a Current

•1 A surveyor is using a magnetic compass 6.1 m below a power line in which there is a steady current of 100 A. (a) What is the magnetic field at the site of the compass due to the power line? (b) Will this field interfere seriously with the compass reading? The horizontal component of Earth's magnetic field at the site is 20 μT.





(a)

We know,

$$B = \frac{\mu_0 i}{2\pi r} = \frac{4\pi \times 10^{-7} \times 100}{2\pi \times 6.1}$$

$$= 3.28 \times 10^{-6}\ T$$

(b)

As the earth magnatic feild is 60μT The magnatic feild is $n = \frac{B_E}{B_C} = 18.3$ times smaller which shouldn't effect much.

•10 In Fig. 29-41, a wire forms a semi-circle of radius R ! 9.26 cm and two (radial) straight segments each of length L ! 13.1 cm. The wire carries current i ! 34.8 mA. What are the (a) magnitude and (b) direction (into or

out of the page) of the net magnetic field at the semicircle's cen-
ter of curvature C?

•10 In Fig. 29-41, a wire forms a semicircle of radius $R = 9.26$ cm and two (radial) straight segments each of length $L = 13.1$ cm. The wire carries current $i = 34.8$ mA. What are the (a) magnitude and (b) direction (into or out of the page) of the net magnetic field at the semicircle's center of curvature C?

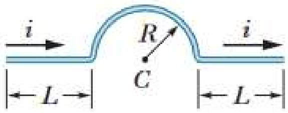


Figure 29-41 Problem 10.

(a)

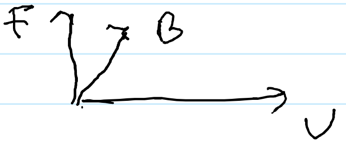
We Know $\qquad \phi = \pi$ for Half circil

$$B = \frac{\mu_0 i \cancel{\phi}}{4 \cancel{\pi} R} = \frac{4\pi \times 10^{-7} \times 34.8}{4 \times 9.26 \times 10^{-2}}$$

$= 118.06 \times 10^{-6}$ T (Ans)

(b)

As for Right hand rule



× × ×
into page

(Ans)

••25 A wire with current
i ! 3.00 A is shown in Fig. 29-53. Two semi-infinite straight sections, both tangent to the same circle, are connected by a circular arc that has a central angle u and runs along the circumference of the circle. The arc and the two straight sections all lie in the same plane. If B ! 0 at the circle's center, what is u?

••25 SSM A wire with current $i = 3.00$ A is shown in Fig. 29-53. Two semi-infinite straight sections, both tangent to the same circle, are connected by a circular arc that has a central angle θ and runs along the circumference of the circle. The arc and the two straight sections all lie in the same plane. If $B = 0$ at the circle's center, what is θ?

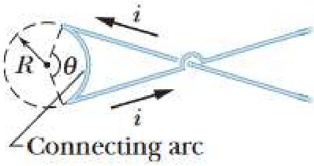


Figure 29-53 Problem 25.

$$B_L = \frac{\mu_0 i}{4\pi R} \longrightarrow \text{lines}$$

$$B_A = \frac{\mu_0 i \phi}{4\pi R}$$

$$B = 2B_C - B_A = 2 \times \frac{\mu_0 i}{4\pi r} - \frac{\mu_0 i \phi}{4\pi r}$$

$$0 = \frac{\mu_0 i}{4\pi}(2 - \phi)$$

$$2 - \phi = 0$$

$$\phi = 2 \text{ rad}$$ (Ans)

•35 Figure 29-63 shows wire
1 in cross section; the wire is long
and straight, carries a current of 4.00 mA out of the page,
and is
at distance d 1 ! 2.40 cm from a surface. Wire 2, which is
parallel
to wire 1 and also long, is at horizontal distance d 2 ! 5.00 cm
from wire 1 and carries a current of 6.80 mA into the page.
What
is the x component of the magnetic force per unit length on

wire
2 due to wire 1?

positioned such that, at the origin, the net magnetic field due to the two currents has magnitude 80.0 nT?

Module 29-2 Force Between Two Parallel Currents

•35 **SSM** Figure 29-63 shows wire 1 in cross section; the wire is long

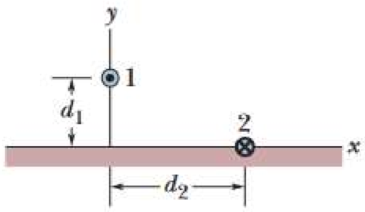


Figure 29-63 Problem 35.

and straight, carries a current of 4.00 mA out of the page, and is at distance $d_1 = 2.40$ cm from a surface. Wire 2, which is parallel to wire 1 and also long, is at horizontal distance $d_2 = 5.00$ cm from wire 1 and carries a current of 6.80 mA into the page. What is the x component of the magnetic force *per unit length* on wire 2 due to wire 1?

$$F = \frac{\mu i_1 i_2}{2\pi r_0}$$

we know,

$$F_x = \frac{\mu i_1 i_2}{2\pi \cancel{r_0}} \times \cancel{r_0} \cdot \cos\theta$$

$$\cos\theta = \frac{d_2}{d_1^2 + d_2^2}$$

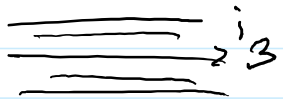
So $$F_x = \frac{\mu i_1 i_2 d_2}{d_1^2 + d_2^2}$$

$$= \frac{4\pi \times 10^{-7} \times 4 \times 10^{-3} \times 6.8 \times 10^{-3} \times 0.050}{2\pi\ (0.024)^2 + (0.050)^2}$$

$$= 8.84 \times 10^{-11}\ \mathrm{N\,m^{-1}}$$ (Ans)

••39 In Fig. 29-64, five long parallel wires in an xy plane
are
separated by distance d ! 50.0 cm. The currents into the
page
are i 1 ! 2.00 A, i 3 ! 0.250 A, i 4 ! 4.00 A, and i 5 ! 2.00 A;
the current out of the page is i 2 ! 4.00 A. What is the
magnitude
of the net force per unit length acting on wire 3 due to the
cur-
rents in the other wires?

••39 In Fig. 29-64, five long parallel wires in an *xy* plane are separated by distance $d = 50.0$ cm. The currents into the page are $i_1 = 2.00$ A, $i_3 = 0.250$ A, $i_4 = 4.00$ A, and $i_5 = 2.00$ A; the current out of the page is $i_2 = 4.00$ A. What is the magnitude of the net force *per unit length* acting on wire 3 due to the currents in the other wires?



We know

i_1 i_2 i_4 i_5

we know

$$F = \frac{\mu_0 i_3}{2\pi}\left(-\frac{i_1}{2} + \frac{i_2}{1} + \frac{i_4}{1} + \frac{i_5}{2}\right)$$

$$= 400 \times 10^{-9}\ N$$

$$\frac{F}{l} = \frac{400 \times 10^{-9}}{50 \times 10^{-2}}$$

$$= 800 \times 10^{-9}\ N\,m^{-1}$$ (Ans.)

•45 Each of the eight conductors in Fig. 29-69 carries 2.0 A
of
current into or out of the page. Two paths are indicated for

the line
integral . What is the value of the integral for (a) path 1
and
(b) path 2?

•45 SSM Each of the eight conductors in Fig. 29-69 carries 2.0 A of current into or out of the page. Two paths are indicated for the line integral $\oint \vec{B} \cdot d\vec{s}$. What is the value of the integral for (a) path 1 and (b) path 2?

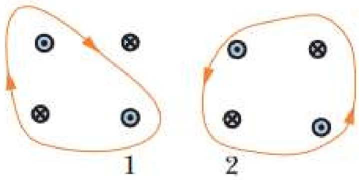


Figure 29-69 Problem 45.

(a)

$i_{Total} = (-2+2-2)$
$= -2$ A (As it oppose the magnetic feild)

we know,

$\oint B\, d\vec{s} = \mu_0 i$
$= 4\pi \times 10^{-7}$ Tm $\times (-2)$
$= 2.513 \times 10^{-6}$ Tm

(b)

$i_{total} = (-2+2-2+2)$
$= 0$

we know

$\oint B\, d\vec{s} = \mu_0 i$
$= 4\pi \times 10^{-7} \times 0$

20 Tm (Ans)

•50 A solenoid that is 95.0 cm long has a radius of 2.00 cm
and
a winding of 1200 turns; it carries a current of 3.60 A.
Calculate
the magnitude of the magnetic field inside the solenoid.

•50 A solenoid that is 95.0 cm long has a radius of 2.00 cm and a winding of 1200 turns; it carries a current of 3.60 A. Calculate the magnitude of the magnetic field inside the solenoid.

we know

$B = \mu_0 i n$

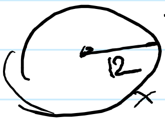
$= 4\pi \times 10^{-7} \times 3.6 \times 1200$

$= 5.43 \times 10^{-3}$ T (Ans)

Chapter - 30

•2 A certain elastic conducting material is stretched into a cir-
cular loop of 12.0 cm radius. It is placed with its plane perpendi-
cular to a uniform 0.800 T magnetic field. When released, the ra-
dius of the loop starts to shrink at an instantaneous rate of
75.0 cm/s. What emf is induced in the loop at that instant?

•2 A certain elastic conducting material is stretched into a circular loop of 12.0 cm radius. It is placed with its plane perpendicular to a uniform 0.800 T magnetic field. When released, the radius of the loop starts to shrink at an instantaneous rate of 75.0 cm/s. What emf is induced in the loop at that instant?



$\times .800T$

$v = 75 \text{ cm/s}$

$= 75 \times 10^{-2}$

We know,

$$V = \frac{-d\Phi_B}{dt}$$

$$= -B\frac{dA}{dt} = -2\pi r B \frac{dr}{dt}$$

$$= -2\pi(0.12)(0.8)(-0.75)$$

$$= 0.452V$$

Ans

•8 A uniform magnetic field is per-
pendicular to the plane of a circular loop
of diameter 10 cm formed from wire of
diameter 2.5 mm and resistivity 1.69 $
10 %8 1)m. At what rate must the magni-
tude of change to induce a 10 A current in the loop?

•8 A uniform magnetic field $\vec{B}$ is perpendicular to the plane of a circular loop of diameter 10 cm formed from wire of diameter 2.5 mm and resistivity $1.69 \times 10^{-8}\ \Omega\cdot\text{m}$. At what rate must the magnitude of $\vec{B}$ change to induce a 10 A current in the loop?

Figure 30-38 Problem 7.

we know

$$\rho = \frac{RA}{l}$$

Or, $$R = \frac{\rho l}{A} = \frac{\pi(0.1)}{\frac{\pi r^2}{4}} = 1.1\times10^{-3}\,\Omega$$

$$i = \frac{\mathcal{E}_{emf}}{R} = \frac{\frac{d\Phi_B}{dt}}{R} = \frac{\pi r^2}{R}\,\frac{dB}{dt}$$

So, $$\frac{dB}{dt} = \frac{iR}{\pi r^2} = \frac{10\times1.1\times10^{-3}}{\pi\times0.05}$$

$$= 1.4\ \text{T s}^{-1}$$ (Ans)

••23 Figure 30-47 shows two parallel loops of wire having a common axis. The smaller loop (radius r) is above the larger loop (radius R) by a distance $x R$. Consequently, the magnetic field due to the counterclockwise current i in the larger loop is nearly uniform throughout the smaller loop. Suppose that x is increasing at the constant rate dx/dt ! v. (a) Find an expression for the magnetic flux through the area of the smaller loop as a function of x. (Hint: See Eq. 29-27.) In the smaller loop, find (b) an expression for the induced emf and (c) the direction of the induced current

0.15 m^2) turns in a uniform magnetic field, $B = 0.20$ T. When the angle between the field and the normal to the plane of the loop is $\pi/2$ rad and increasing at 0.60 rad/s, what emf is induced in the loop?

••23 SSM Figure 30-47 shows two parallel loops of wire having a common axis. The smaller loop (radius r) is above the larger loop (radius R) by a distance $x \gg R$. Consequently, the magnetic field due to the counterclockwise current i in the larger loop is nearly uniform throughout the smaller loop. Suppose that x is increasing at the constant rate $dx/dt = v$. (a) Find an expression for the magnetic flux through the area of the smaller loop as a function of x. (*Hint:* See Eq. 29-27.) In the smaller loop, find (b) an expression for the induced emf and (c) the direction of the induced current.

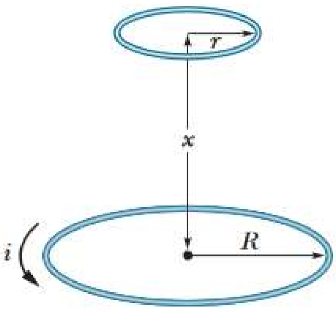


Figure 30-47 Problem 23.

(a)

we know

$$\Phi = \oint B\, dA = BA = \frac{\pi \mu_0 i r^2 R^2}{2x^3}$$

(Ans)

(b)

$$\mathcal{E} = \frac{-d\Phi_B}{dt} = \frac{-\pi \mu_0 i r^2 R^2}{2} \cdot \frac{-3}{x^4}$$

$$= \frac{3\pi \mu_0 i r^2 R^2 v}{2x^4}$$

(Ans)

(c)

The smaller loop would create induced current in the same direction of smaller loop.

•31 If 50.0 cm of copper wire (diameter ! 1.00 mm) is
formed into a circular loop and placed perpendicular to a
uniform
magnetic field that is increasing at the constant rate of
10.0 mT/s, at
what rate is thermal energy generated in the loop?

•31 SSM ILW If 50.0 cm of copper wire (diameter = 1.00 mm) is formed into a circular loop and placed perpendicular to a uniform magnetic field that is increasing at the constant rate of 10.0 mT/s, at what rate is thermal energy generated in the loop?

given

$$\frac{dB}{dt} = 10 \times 10^{-3} T$$

$$\rho = \frac{RA}{L}$$

$$\frac{\rho l}{A} = R$$

$$\varepsilon = -\frac{d\Phi_B}{dt} = \frac{-A\,dB}{dt} = \frac{\pi l^2}{4\pi^2}\frac{dB}{dt}$$

$$= \frac{-l^2}{4\pi}\frac{dB}{dt}$$

we know,

$$P = \frac{V_{emf}^2}{R} = \frac{\left(\frac{d^2}{4A} \times \frac{dB}{dt}\right)^2}{\frac{\rho l}{A}}$$

$$= 3.68 \times 10^{-6} \text{ watt} \text{ (Ans)}$$

•37 A long solenoid has a diameter of 12.0 cm. When a current i exists in its windings, a uniform magnetic field of

magni-
tude B ! 30.0 mT is produced in its interior. By decreasing i,
the
field is caused to decrease at the rate of 6.50 mT/s.
Calculate the
magnitude of the induced electric field (a) 2.20 cm and (b)
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•37 SSM ILW A long solenoid has a diameter of 12.0 cm. When a current i exists in its windings, a uniform magnetic field of magnitude $B = 30.0$ mT is produced in its interior. By decreasing i, the field is caused to decrease at the rate of 6.50 mT/s. Calculate the magnitude of the induced electric field (a) 2.20 cm and (b) 8.20 cm from the axis of the solenoid.

given

$$\frac{dB}{dt} = 6.5 \ mT/s$$

(a)

we know,

$$E \, 2\pi r = -(\pi r^2) \frac{dB}{dt}$$

$$|E| = \frac{1}{2} r \frac{dB}{dt}$$

$$= \frac{1}{2} (6.5 \times 10^{-3})(0.022)$$

$$= 7.15 \times 10^{-5} \ V/m$$ (Ans)

(b)

$$E(2\pi r) = -(\pi R^2) \frac{dB}{dt}$$

$$|E| = \frac{dB \, R^2}{2 \, dt \, r}$$

$$= \frac{1}{2} \times (6.5 \times 10^{-3}) \times \frac{0.06}{0.082}$$

$= 1.43 \times 10^{-9}$ V/m (Ans)

•40 The inductance of a closely packed coil of 400 turns is 8.0 mH. Calculate the magnetic flux through the coil when the
current is 5.0 mA

Module 30-4 Inductors and Inductance

•40 The inductance of a closely packed coil of 400 turns is 8.0 mH. Calculate the magnetic flux through the coil when the current is 5.0 mA.

$$\Phi_B = BA = \frac{Li}{N} = \frac{8 \times 10^{-3} \times 5 \times 10^{-3}}{400}$$

$$= 1 \times 10^{-7} \text{ Wb.}$$

(Ans)