Write the symbol and units for the following:

(a) electric field intensity

(b) magnetic field intensity

(c) electric flux density

(d) magnetic flux density

(e) volume charge density

(f) current density

(g) polarization field

(h) permittivity

(i) permeability

(j) electric scalar potential

(k) capacitance

(l) inductance

(m) magnetic flux

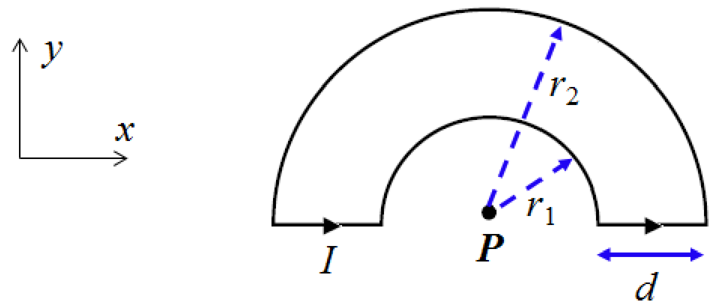
In free space, a magnetic field intensity is given by $\left(10^6/r\right)\sin\phi\,\hat{\mathbf{r}}$ A/m.

Calculate the magnetic flux crossing the surface defined by $0 \le \phi \le \pi/3, 0 \le z \le 2$ m.

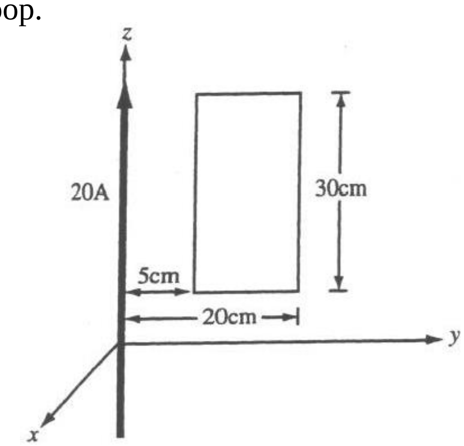
A wire loop is bent into the shape depicted, with two semicircles of radius $r_1 = 5$ mm and $r_2 = 10$ mm, and two straight edges of length $d = 5$ mm. A current $I = 1.6$ A flows around the loop in the direction shown.

Determine the magnetic flux density at point P.

Assume $\mu = \mu_0$. Express your answer in Wb/m^2, in the appropriate direction.

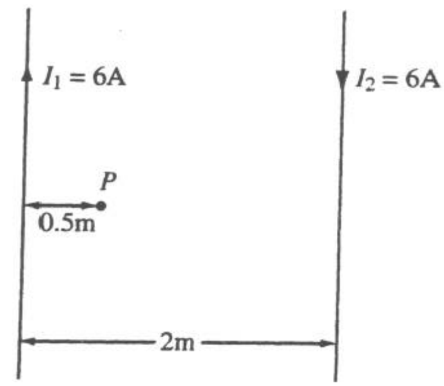


The rectangular loop shown in the figure is coplanar with the long, straight wire carrying the current I = 20 A. Determine the magnetic flux through the loop.



The y and z axes, respectively, carry filamentary currents of 10 A in the $+y$ direction and 20 A in the $-z$ direction. Find the magnetic field intensity at (–3 m, 4 m, 5 m).

Two infinitely-long, parallel wires carry 6-A currents in opposite directions. Determine the magnitude of the magnetic flux density at point P in the figure.



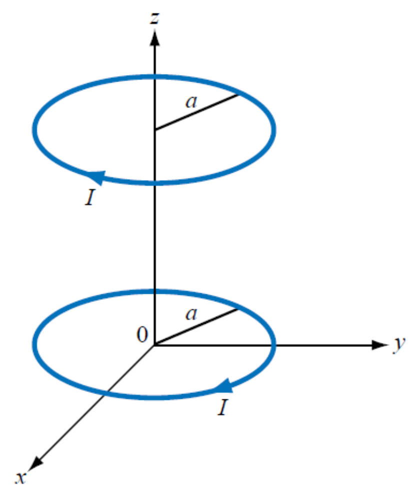
The line $x = 0, y = 0, 0 \le z \le 10\ \text{m}$ carries current 2 A in the +*z* direction.

Calculate the magnetic field intensity at points (a) (5 m, 0, 0), (b) (5 m, 5 m, 0), (c) (5 m, 15 m, 0), and (d) (5 m, –15 m, 0).

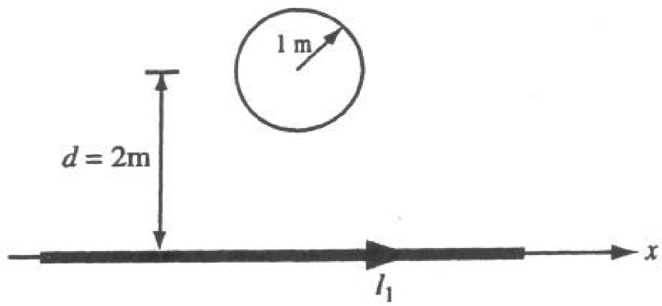
An infinitely long conductor is bent into an L shape along the x and y axes: $0 \le x < \infty, 0 \le y < \infty$. If a direct current of 5 A flows in the $-x$ direction and the $+y$ directions, find the magnetic field intensity at (a) (2 m, 2 m, 0), (b) (0, –2 m, 0), and (c) (0, 0, 2 m) .

Two parallel, circular loops carrying a current of 450 mA each are arranged as shown. The first loop is in the x-y plane with its center at the origin, and the second loop's center is at $z = 2$ cm. If the two loops have the same radius $a = 2$ cm, determine the magnetic field intensity at $(0, 0, 1.5\text{ cm})$. Assume $\mu = \mu_0$.

Express your answer in A/m, in the appropriate direction.



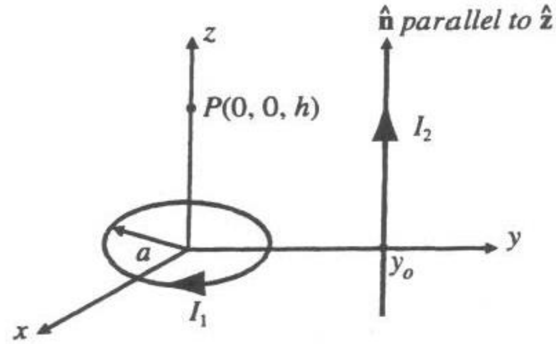
An infinitely-long wire carrying 50 A of current in the positive x direction is placed along the x axis in the vicinity of a 10-turn circular loop located in the x-y plane as shown in the figure. If the magnetic field intensity at the center of the loop is zero, determine the direction and magnitude of the current flowing in the loop.



A circular loop of radius a carrying current I_1 is located in the x-y plane as shown in the figure. In addition, an infinitely-long wire carrying current I_2 in a direction parallel with the z axis is located at $y = y_0$.

(a) Determine the magnetic field intensity at $P(0, 0, h)$.

(b) Evaluate this intensity for $a = 3$ cm, $y_0 = 10$ cm, $h = 4$ cm, $I_1 = 10$ A, and $I_2 = 20$ A.



A magnetic field intensity is given by $k_0 (r/a)\hat{\boldsymbol{\phi}}$, $r < a$ where k_0 is a constant.

(a) Determine the current density in this region for $r < a$.

(b) Determine the magnetic field intensity for $r > a$.

An electron beam forms a current density $\begin{cases} J_0\left(1-r^2/a^2\right)\hat{\mathbf{z}} & r<a \\ 0 & r\geq a \end{cases}$.

(a) Determine the total current.

(b) Find the magnetic field intensity everywhere.

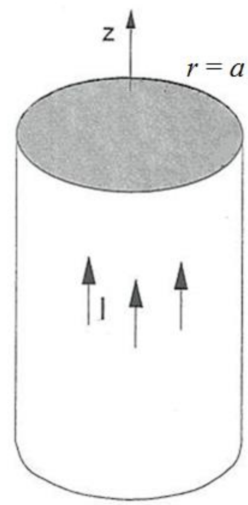
In a certain conducting region, the magnetic field intensity is $4\left[1-\left(1+2r\right)e^{-2r}\right]/r\,\hat{\boldsymbol{\phi}}$.

Determine the current density in this region.

A cylindrical conductor whose axis is coincident with the z axis has an internal magnetic field intensity given by $2\left[1-(4r+1)e^{-4r}\right]/r\ \hat{\boldsymbol{\phi}}\ \mathrm{A/m},\ r \le a$, where a is the conductor's radius.

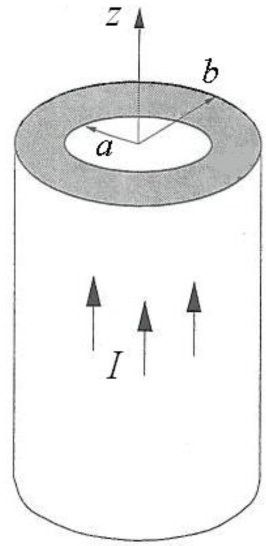
If a = 5 cm, determine the total current flowing in the conductor.

A cylindrical conductor (a = 4 mm) carries 5 A in a uniform current distribution. Calculate the magnetic field intensity vector that is observed at the cylindrical point (3 mm, 45°, 0).



Given a magnetic field intensity $3y^2\,\hat{\mathbf{x}} + 4x\,\hat{\mathbf{y}} + 7\,\hat{\mathbf{z}}$ A/m, calculate the current density at the point (1 m, 2 m, 3 m).

A cylindrical (infinitely-long) conductor carries a current I , uniformly distributed between inner radius a and outer radius b , along the z axis.



(a) Determine the magnetic field intensity everywhere in terms of I , a , b , and spatial coordinates. Assume $\mu = \mu_0$.

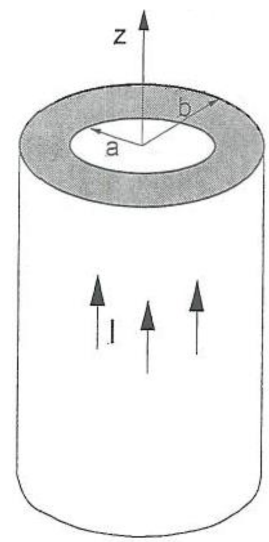
(b) Sketch the magnitude of the magnetic field intensity vs. radial distance away from the z axis.

Clearly label your axes, points of discontinuity/transition, and maxima/minima.

A hollow cylindrical metal shell illustrated below with a = 10 cm and b = 15 cm carries 3 A of current in the $+z$ direction.

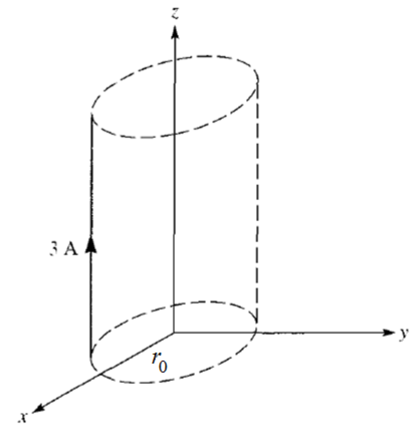
(a) Determine the current density in the conductive region.

(b) Determine the magnetic field intensity as a function of r for all values of r .



A charged particle (m = 1.673 x 10^{-27} kg) exists in a region with an electric field intensity of 10$\mathbf{x}$ kV/m and a magnetic flux density of 1$\mathbf{y}$ Wb/m^2. If the particle moves without being deflected, calculate its kinetic energy.

A conductor 2 meters long carrying a current of 3 A is placed parallel to the z axis at a distance r_0 = 10 cm as shown in the figure. If the field in the region is $\cos(\phi/3)\hat{\mathbf{r}}$ Wb/m^2, determine the work required to rotate the conductor one revolution about the z axis.



Three infinite lines L_1, L_2, and L_3 defined by $x = 0, y = 0$; $x = 0, y = 4\text{ m}$; $x = 3\text{ m}, y = 4\text{ m}$, respectively, carry filamentary currents –100 A, 200 A, and 300 A in the $+z$ direction.

Determine the force per unit length on

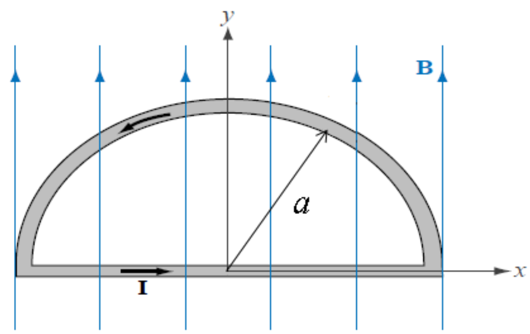
(a) L_2 due to L_1, (b) L_1 due to L_2, (c) L_3 due to L_1, (d) L_3 due to L_1 and L_2.

Also state whether each force is repulsive or attractive.

A semicircular wire loop (in the x-y plane) carries a current $I = 4$ A .

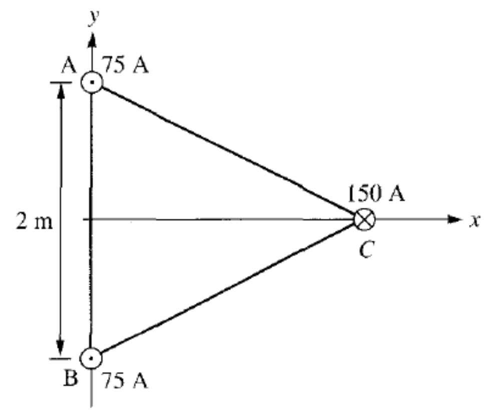
The radius of the semicircle is $a = 8$ cm .

The closed loop is exposed to a magnetic flux density of $50\,\mathbf{y}$ mWb/m^2 .



(a) Determine the force on the straight section of the wire.
(b) Determine the force on the curved section of the wire.
(c) Determine the magnetic torque experienced by the loop.

A three-phase transmission line consists of three conductors that are supported at points *A*, *B*, and *C* to form an equilateral triangle as shown in the figure. At one instant, conductors *A* and *B* both carry a current of 75 A while conductor *C* carries a return current of 150 A. Determine the force per meter on conductor *C* at that instant.



The magnetic flux density in a certain region is $40\mathbf{x}$ mWb/m^2. A conductor that is 2 m in length lies on the z axis and carries a current of 5 A in the $+z$ direction. Calculate the force on the conductor.

A rectangular coil of area 10 cm^2 carrying a current of 50 A lies on a plane $2x+6y-3z=7$ such that the magnetic moment of the coil is directed away from the origin. The coil is surrounded by a uniform magnetic flux density of $0.6\,\hat{\mathbf{x}}+0.4\,\hat{\mathbf{y}}+0.5\,\hat{\mathbf{z}}\ \ \text{Wb/m}^2$.

(a) Calculate the magnetic moment of the coil.
(b) Find the torque on the coil.

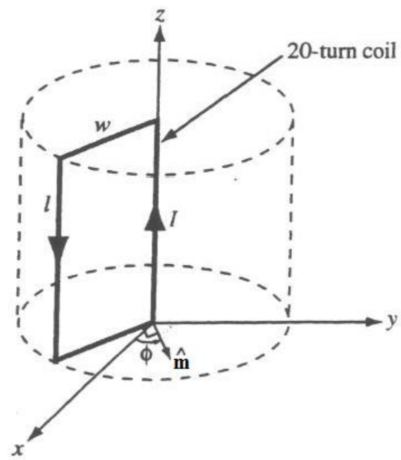
A 60-turn coil carries a current of 2 A and lies in the plane $x+2y-5z=12$ such that the magnetic moment of the coil is directed away from the origin. Calculate the magnetic moment, assuming that the area of the coil is 8 cm^2.

A 20-turn rectangular coil with side l = 15 cm and w = 5 cm is placed as shown in the figure. The magnetic flux density in this region is $\left(2\cdot 10^{-2}\right)\left(\hat{\mathbf{x}}+2\hat{\mathbf{y}}\right)\ \mathrm{Wb/m^2}$.

(a) If the coil carries a current I = 10 A, determine the torque acting on the coil as a function of ϕ.

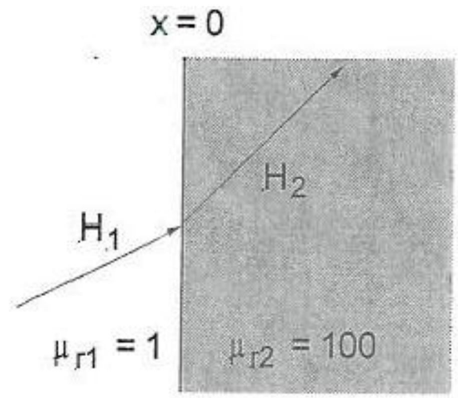
(b) Determine the angle ϕ at which the torque is zero.

(c) Determine the angle ϕ at which the torque is maximum.



The interface between two materials is $y = 0$. The magnetic field intensity in medium 1, $y < 0$, with permeability $\mu = 3\mu_0$, is $40\mathbf{x} + 120\mathbf{y} - 80\mathbf{z}$ mA/m. Medium 2, $y \geq 0$, has permeability $\mu = 60\mu_0$. Assuming that no surface current exists at the boundary, calculate the angle between the field intensity in region 1 and the field intensity in region 2.

As depicted in the figure, a magnetic field intensity $\mathbf{H}_1 = 5\,\hat{\mathbf{x}} + 3\,\hat{\mathbf{y}} - 1\,\hat{\mathbf{z}}\ \mathrm{A/m}$ strikes a magnetic material at x = 0. Assuming no surface current at the boundary, determine the magnetic field intensity vector in medium 2.



Region 1, described by $3x + 4y \geq 10$, is free space, whereas region 2, described by $3x + 4y \leq 10$, is a magnetic material for which $\mu = 10\mu_0$. Assuming that the boundary between the material and free space is current-free, find the magnetic flux density in region 2 if the magnetic flux density in region 1 is $0.1\,\hat{\mathbf{x}} + 0.4\,\hat{\mathbf{y}} + 0.2\,\hat{\mathbf{z}}\ \ \mathrm{Wb/m^2}$.

A unit normal vector from region 2 ($\mu = 2\mu_0$) to region 1 ($\mu = \mu_0$) is $\hat{\mathbf{n}} = \left(6\,\hat{\mathbf{x}} + 2\,\hat{\mathbf{y}} - 3\,\hat{\mathbf{z}}\right)/7$. If the magnetic field intensity in region 1 is $10\,\hat{\mathbf{x}} + 1\,\hat{\mathbf{y}} + 12\,\hat{\mathbf{z}}$ A/m and the field intensity in region 2 is $H_{2x}\hat{\mathbf{x}} - 5\,\hat{\mathbf{y}} + 4\,\hat{\mathbf{z}}$ A/m, determine (a) H_{2x}, (b) the current density on the interface, and (c) the angles that the magnetic flux densities make with the normal to the interface.

The interface $2x + y = 8$ between two media carries no current. Medium 1 ($2x + y \geq 8$) is nonmagnetic and contains a magnetic field intensity of $-4\,\hat{\mathbf{x}} + 3\,\hat{\mathbf{y}} - \hat{\mathbf{z}}$ A/m. Medium 2 ($2x + y < 8$) has a permeability $\mu = 10\mu_0$. Determine (a) the magnetic flux density in medium 2 and (b) the angles that the magnetic field intensities in each region make with the normal to the interface.

The plane $z = 0$ separates air ($z \geq 0$, $\mu = \mu_0$) from iron ($z \geq 0$, $\mu = 200\mu_0$). If the magnetic field intensity in air is $10\,\hat{\mathbf{x}} + 15\,\hat{\mathbf{y}} - 3\,\hat{\mathbf{z}}$ A/m, find (a) the magnetic flux density in iron and (b) the angle that the flux density vector makes with the interface.

The cylindrical surface r = 10 separates two homogeneous magnetic regions: region 1 ($r \le 10,\ \mu_{r1} = 2.5$) and region 2 ($r > 10,\ \mu_{r1} = 5$). If the magnetic field intensity in region 1 is $-10\,\hat{\mathbf{r}} + 20\,\hat{\boldsymbol{\phi}} + 40\,\hat{\mathbf{z}}$ $\mathrm{A/m}$, determine (a) the magnetic field intensity in region 2 and (b) the angle between the two field intensities.

A coaxial cable consists of an inner conductor of radius 1.2 cm and an outer conductor of radius 1.8 cm. The two conductors are separated by an insulating medium ($\mu = 4\mu_0$). If the cable is 3 meters long and carries 25 mA current, calculate the energy stored in the medium.

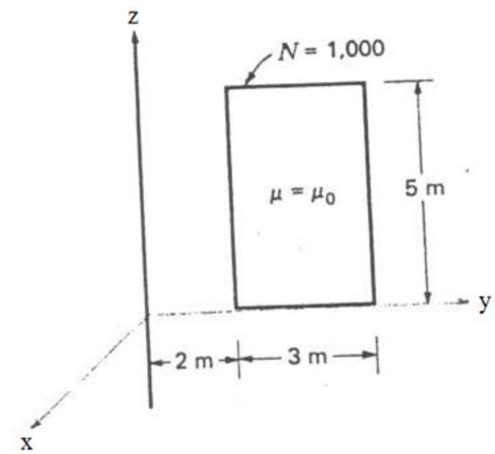
In a certain medium with $\mu = 4.5\mu_0$, the magnetic field intensity is $200\,\hat{\mathbf{x}} + 500\,\hat{\mathbf{y}}$ mA/m. Calculate the total magnetic energy stored in a 2x2x2 m^3 cubic region centered on the origin.

A very long solenoid with 2x2-cm cross section has an iron core ($\mu_r = 1000$) and 4000 turns per meter. It carries a current of 500 mA. Determine (a) its self-inductance per meter, and (b) the energy per meter stored in its magnetic field.

A square-cross-section, air-filled toroid has inner radius 3 cm, outer radius 5 cm, and height 2 cm. Determine the number of turns required to produce an inductance of 45 μH.

Two parallel cylindrical conductors are separated by 1.2 meters. If the conductors have an inductance per unit length of 1.37 μH/m, determine the conductor radius.

Determine (a) the mutual inductance between the infinite straight filament and the 1000-turn rectangular loop shown below, (b) the mutual inductance if the loop is moved to within 1 mm of the filament, and (c) the mutual inductance if all the dimensions were given in centimeters instead of meters.



The magnetic flux density in a particular region of space is
$0.90\cos(250t)\,\hat{\mathbf{x}} + 1.5\sin(200t)\,\hat{\mathbf{y}} + 2.4\cos(314t)\,\hat{\mathbf{z}}\ \ \mathrm{Wb/m^2}$.

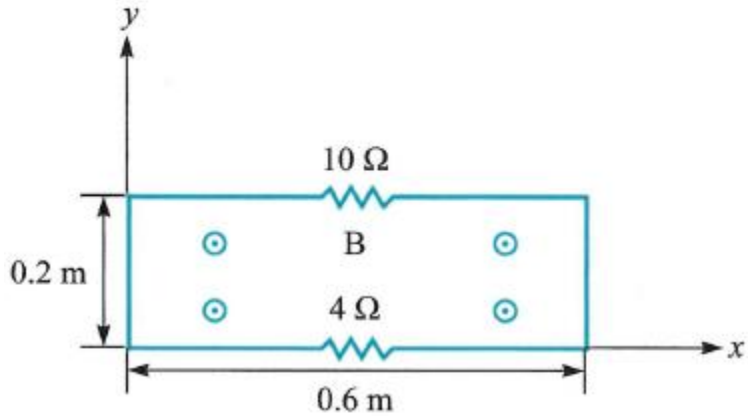
A circular wire loop, with radius $a = 2$ cm and resistance $R = 50\ \Omega$, is in the *x*-*y* plane.

Determine the root-mean-squared value of the current induced in the loop.

A conducting circular loop of radius 20 cm lies in the $z = 0$ plane in a magnetic flux density of $10\cos(377t)\hat{\mathbf{z}}$ $\mathrm{mWb/m^2}$. Calculate the voltage induced in the loop.

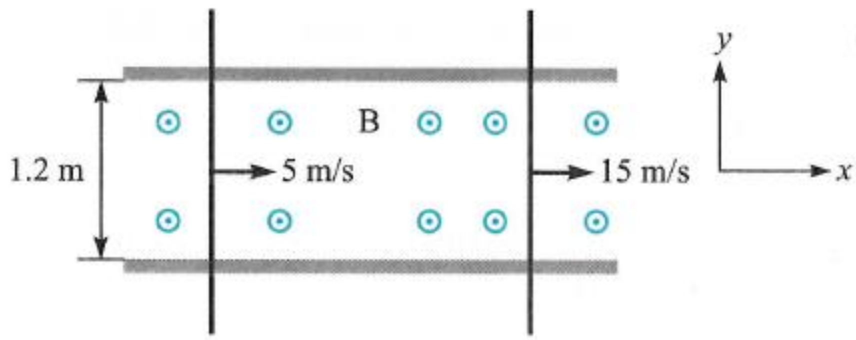
The circuit in the figure exists in a magnetic flux density of $40\cos(30\pi t - 2y)\hat{\mathbf{z}}$ Wb/m^2. Assume that the wires connecting the resistors have negligible resistances.

Determine the current in the circuit.

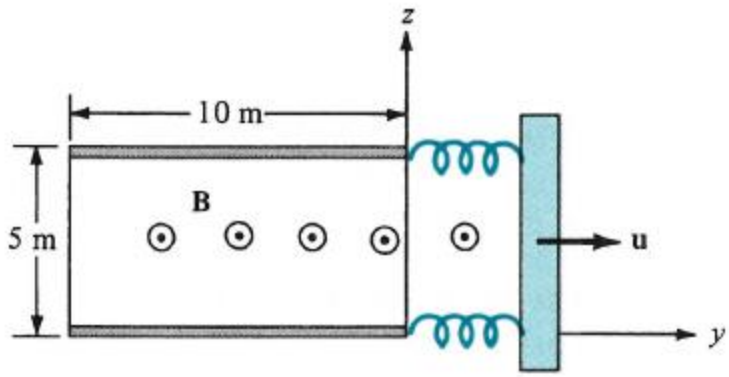


Two conducting bars slide over two stationary rails, as illustrated in the figure.

The magnetic flux density is $0.2\,\hat{\mathbf{z}}\ \mathrm{Wb/m^2}$. Determine the voltage induced in the loop.



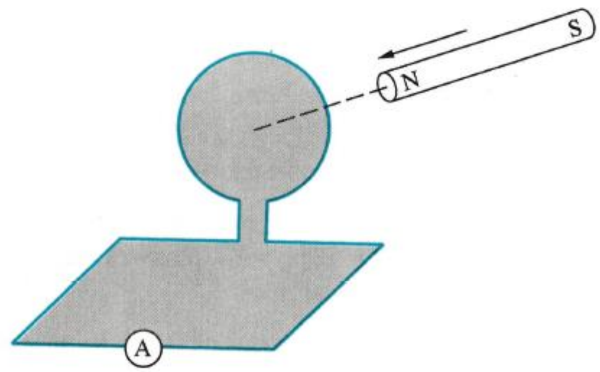
A conducting bar is connected via flexible leads to a pair of rails in a magnetic flux density of $6\cos(10t)\,\hat{\mathbf{x}}$ mWb/m^2 as illustrated in the figure. If the z axis is the equilibrium position of the bar and its velocity is $2\cos(10t)\,\hat{\mathbf{y}}$ m/s, find the voltage induced in it.



In the figure, a bar magnet is thrust toward the center of a coil of 10 turns and resistance 15 Ω .

The magnetic flux through the coil changes from 0.45 Wb to 0.64 Wb in 0.02 s.

Estimate the magnitude and direction (as viewed from the side near the magnet) of the induced current.



A 50-V voltage generator at 20 MHz is connected to the plates of an air-dielectric parallel-plate capacitor with a plate area of 2.8 cm^2 and a separation distance of 0.2 mm. Determine the maximum value of (a) the displacement current density and (b) the displacement current.

Assume that dry soil has a conductivity of 10^{-4} S/m, a dielectric constant of 3, and a magnetic permeability equal to that of free space. Determine the frequency at which the ratio of the magnitudes of the conduction current density and the displacement current density is unity.