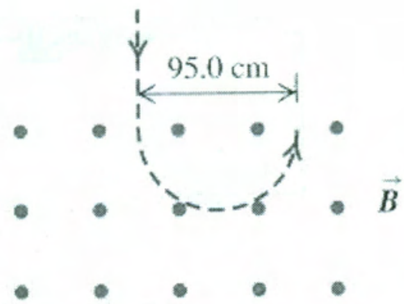
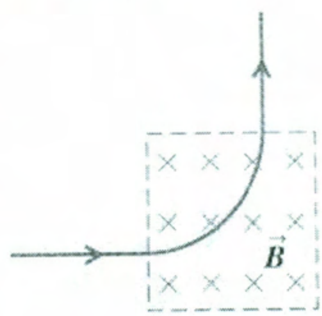
27.22. In an experiment with cosmic rays, a vertical beam of particles that have charge of magnitude $3e$ and mass 12 times the proton mass enters a uniform horizontal magnetic field of 0.250 T and is bent in a semicircle of diameter 95.0 cm, as shown in Fig. 27.47. (a) Find the speed of the particles and the sign of their charge. (b) Is it reasonable to ignore the gravity force on the particles? (c) How does the speed of the particles as they enter the field compare to their speed as they exit the field?

Figure **27.47** Exercise 27.22.



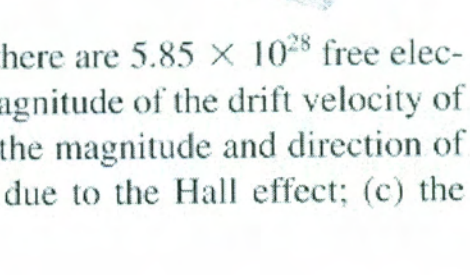
27.24. A beam of protons traveling at 1.20 km/s enters a uniform magnetic field, traveling perpendicular to the field. The beam exits the magnetic field, leaving the field in a direction perpendicular to its original direction (Fig. 27.48). The beam travels a distance of 1.18 cm *while in the field.* What is the magnitude of the magnetic field?

Figure **27.48** Exercise 27.24.



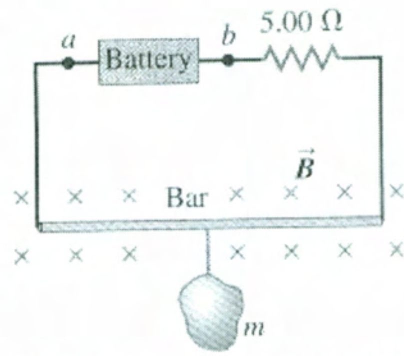
***27.51.** Figure 27.57 shows a portion of a silver ribbon with $z_1 = 11.8$ mm and $y_1 = 0.23$ mm, carrying a current of 120 A in the $+x$-direction. The ribbon lies in a uniform magnetic field, in the y-direction, with magnitude 0.95 T. Apply the simplified model of the Hall effect presented in Section 27.9. If there are 5.85×10^{28} free electrons per cubic meter, find (a) the magnitude of the drift velocity of the electrons in the x-direction; (b) the magnitude and direction of the electric field in the z-direction due to the Hall effect; (c) the Hall emf.

Figure **27.57** Exercises 27.51 and 27.52.



27.40. Magnetic Balance. The circuit shown in Fig. 27.52 is used to make a magnetic balance to weigh objects. The mass m to be measured is hung from the center of the bar that is in a uniform magnetic field of 1.50 T, directed into the plane of the figure. The battery voltage can be adjusted to vary the current in the circuit. The horizontal bar is 60.0 cm long and is made of extremely light-weight material. It is connected to the battery by thin vertical wires that can support no appreciable tension; all the weight of the suspended mass m is supported by the magnetic force on the bar. A resistor with $R = 5.00\ \Omega$ is in series with the bar; the resistance of the rest of the circuit is much less than this. (a) Which point, a or b, should be the positive terminal of the battery? (b) If the maximum terminal voltage of the battery is 175 V, what is the greatest mass m that this instrument can measure?

Figure **27.52** Exercise 27.40.



27.62. A long, straight wire containing a semicircular region of radius 0.95 m is placed in a uniform magnetic field of magnitude 2.20 T as shown in Fig. 27.60. What is the net magnetic force acting on the wire when it carries a current of 3.40 A?

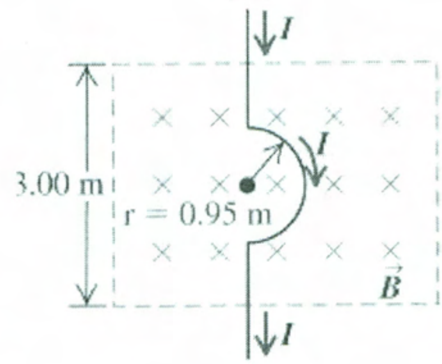
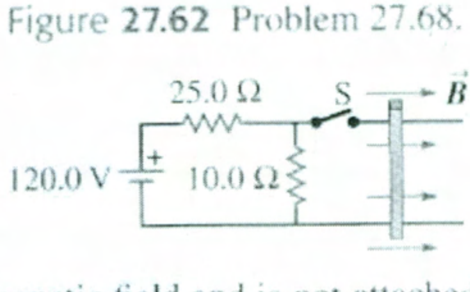


Figure **27.60** Problem 27.62.

27.68. A 3.00-N metal bar, 1.50 m long and having a resistance of 10.0 Ω, rests horizontally on conducting wires connecting it to the circuit shown in Fig. 27.62. The bar is in a uniform, horizontal, 1.60-T magnetic field and is not attached to the wires in the circuit. What is the acceleration of the bar just after the switch S is closed?

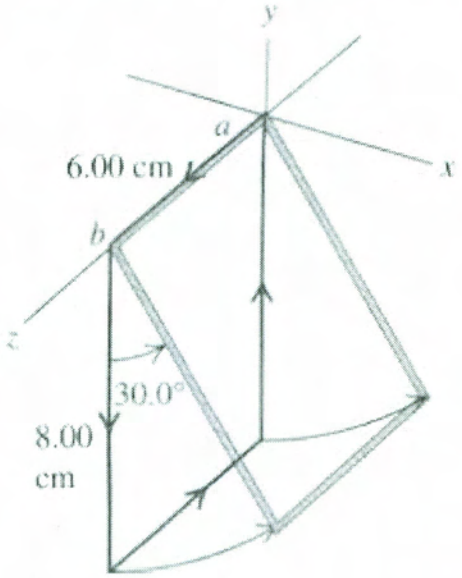
Figure **27.62** Problem 27.68.



27.1. A particle with a charge of -1.24×10^{-8} C is moving with instantaneous velocity $\vec{v} = (4.19 \times 10^4 \text{ m/s})\hat{\imath} + (-3.85 \times 10^4 \text{ m/s})\hat{\jmath}$. What is the force exerted on this particle by a magnetic field (a) $\vec{B} = (1.40 \text{ T})\hat{\imath}$ and (b) $\vec{B} = (1.40 \text{ T})\hat{k}$?

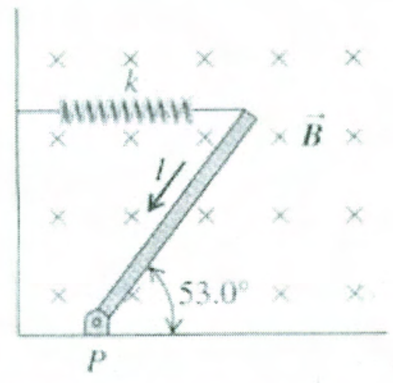
27.75. The rectangular loop of wire shown in Fig. 27.65 has a mass of 0.15 g per centimeter of length and is pivoted about side *ab* on a frictionless axis. The current in the wire is 8.2 A in the direction shown. Find the magnitude and direction of the magnetic field parallel to the *y*-axis that will cause the loop to swing up until its plane makes an angle of 30.0° with the *yz*-plane.

Figure **27.65** Problem 27.75.



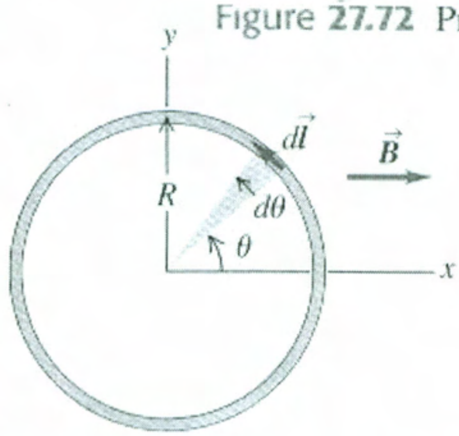
27.77. A thin, uniform rod with negligible mass and length 0.200 m is attached to the floor by a frictionless hinge at point *P* (Fig. 27.67). A horizontal spring with force constant $k = 4.80$ N/m connects the other end of the rod to a vertical wall. The rod is in a uniform magnetic field $B = 0.340$ T directed into the plane of the figure. There is current $I = 6.50$ A in the rod, in the direction shown. (a) Calculate the torque due to the magnetic force on the rod, for an axis at *P*. Is it correct to take the total magnetic force to act at the center of gravity of the rod when calculating the torque? Explain. (b) When the rod is in equilibrium and makes an angle of 53.0° with the floor, is the spring stretched or compressed? (c) How much energy is stored in the spring when the rod is in equilibrium?

Figure **27.67** Problem 27.77.



27.84. Derivation of Eq. (27.26) for a Circular Current Loop. A wire ring lies in the xy-plane with its center at the origin. The ring carries a counterclockwise current I (Fig. 27.72). A uniform magnetic field $\vec{B}$ is in the $+x$-direction, $\vec{B} = B_x\hat{\imath}$ (The result is easily extended to $\vec{B}$ in an arbitrary direction.) (a) In Fig. 27.72, show that the element $d\vec{l} = R\,d\theta(-\sin\theta\hat{\imath} + \cos\theta\hat{\jmath})$, and find $d\vec{F} = I\,d\vec{l} \times \vec{B}$. (b) Integrate $d\vec{F}$ around the loop to show that the net force is zero. (c) From part (a), find $d\vec{\tau} = \vec{r} \times d\vec{F}$, where $\vec{r} = R(\cos\theta\hat{\imath} + \sin\theta\hat{\jmath})$ is the vector from the center of the loop to the element $d\vec{l}$. (Note that $d\vec{l}$ is perpendicular to $\vec{r}$.) (d) Integrate $d\vec{\tau}$ over the loop to find the total torque $\vec{\tau}$ on the loop. Show that the result can be written as $\vec{\tau} = \vec{\mu} \times \vec{B}$, where $\mu = IA$. (*Note:* $\int\cos^2x\,dx = \frac{1}{2}x + \frac{1}{4}\sin 2x$, $\int\sin^2x\,dx = \frac{1}{2}x - \frac{1}{4}\sin 2x$, and $\int\sin x\cos x\,dx = \frac{1}{2}\sin^2x$.)

Figure 27.72 Problem 27.84.



27.1. A particle with a charge of -1.24×10^{-8} C is moving with instantaneous velocity $\vec{v} = (4.19 \times 10^4\ \text{m/s})\hat{\imath} + (-3.85 \times 10^4\ \text{m/s})\hat{\jmath}$. What is the force exerted on this particle by a magnetic field (a) $\vec{B} = (1.40\ \text{T})\hat{\imath}$ and (b) $\vec{B} = (1.40\ \text{T})\hat{k}$?