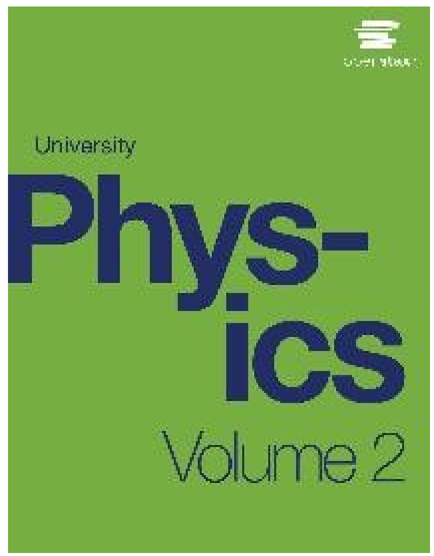
UNIVERSITY PHYSICS

Chapter 11 MAGNETIC FORCES AND FIELDS

PowerPoint Image Slideshow



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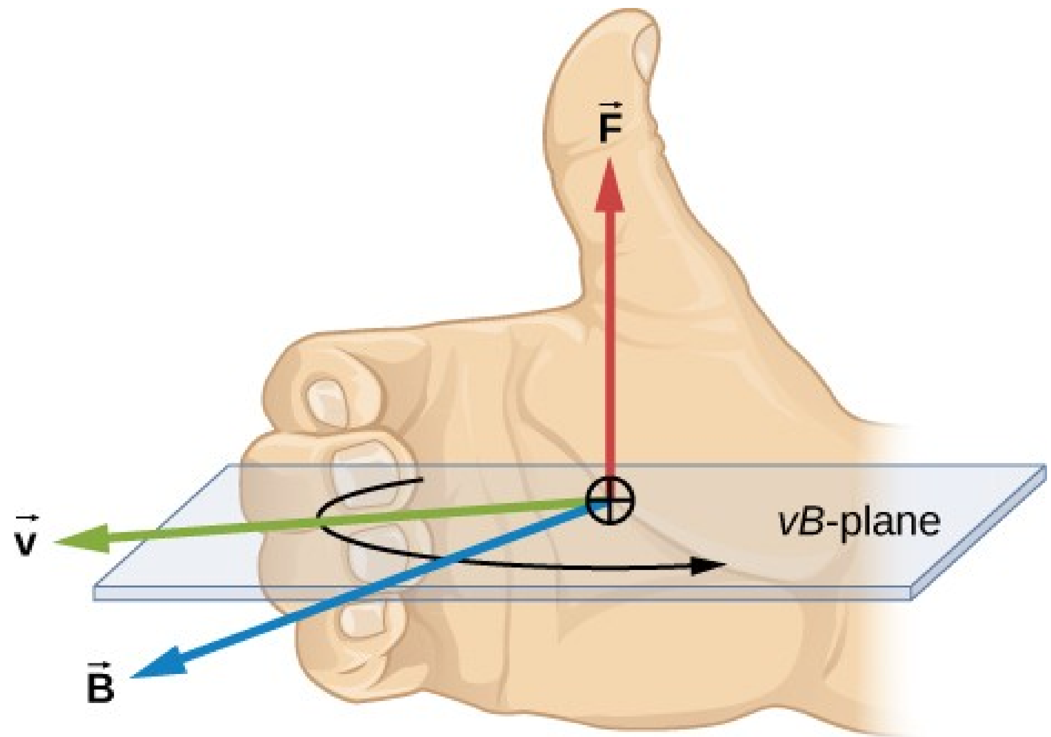
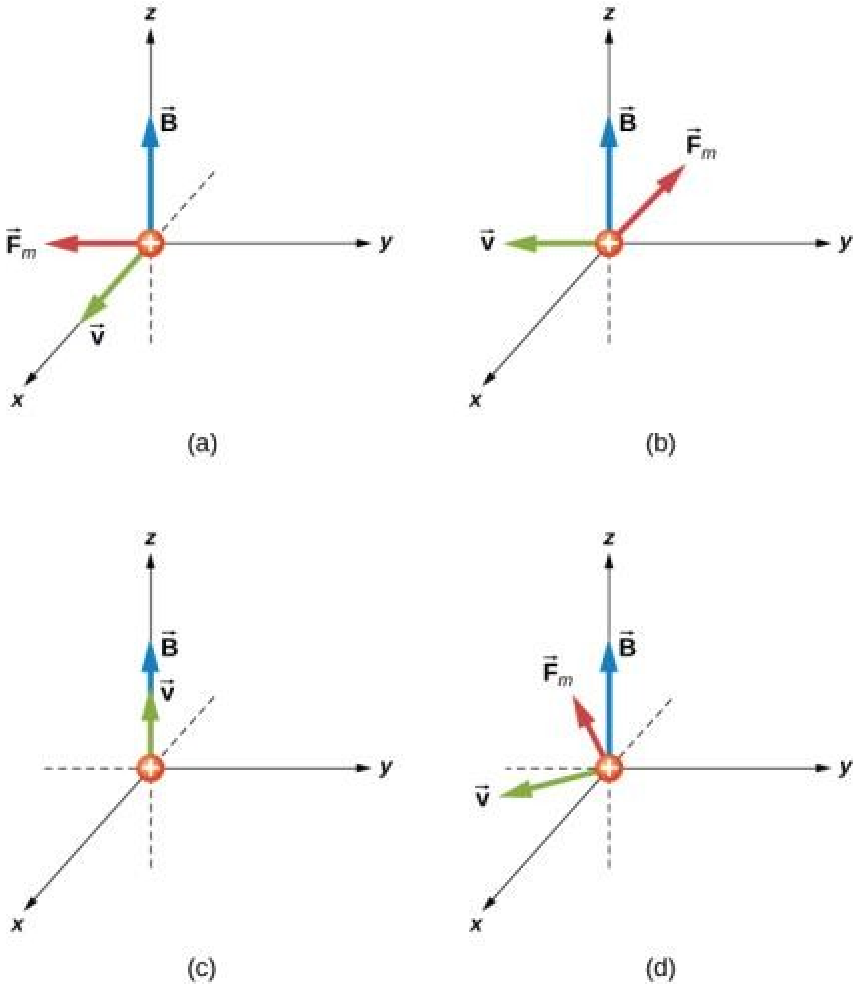
Right hand rule

FIGURE 11.4



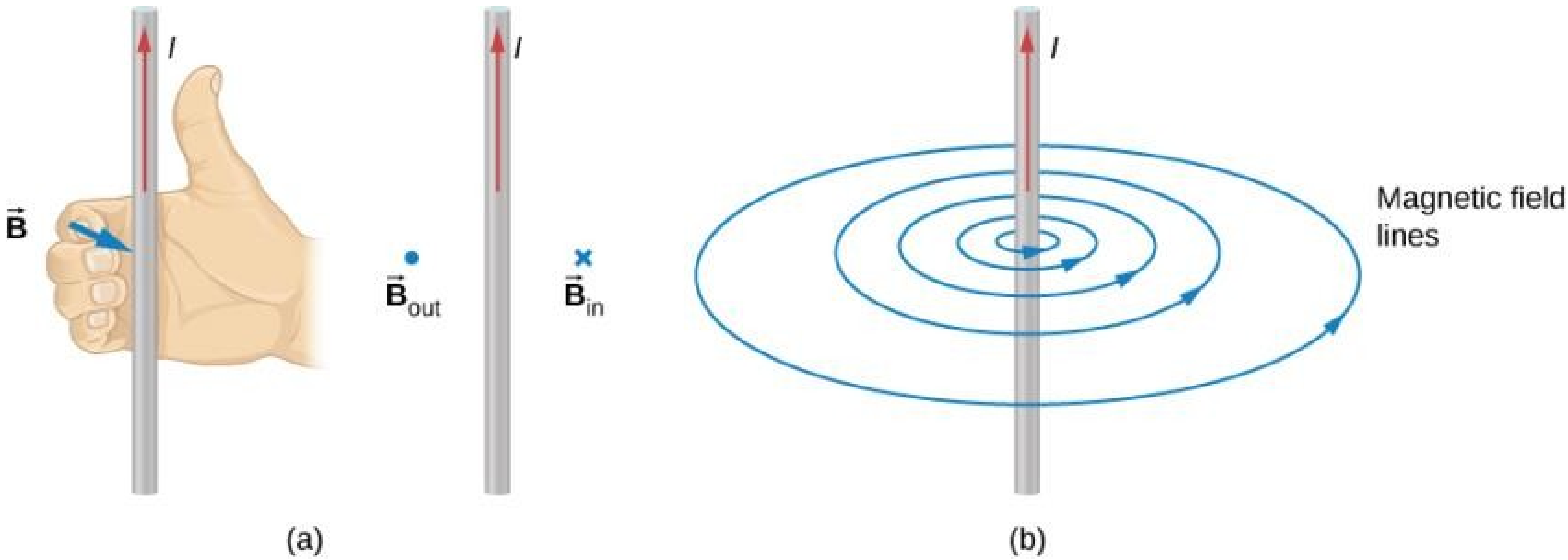
Magnetic fields exert forces on moving charges. The direction of the magnetic force on a moving charge is perpendicular to the plane formed by and and follows the right-hand rule-1 (RHR-1) as shown. The magnitude of the force is proportional to *q*, *v*, *B*, and the sine of the angle between and .

FIGURE 11.5



The magnetic forces on an alpha-particle moving in a uniform magnetic field. The field is the same in each drawing, but the velocity is different.

FIGURE 11.11

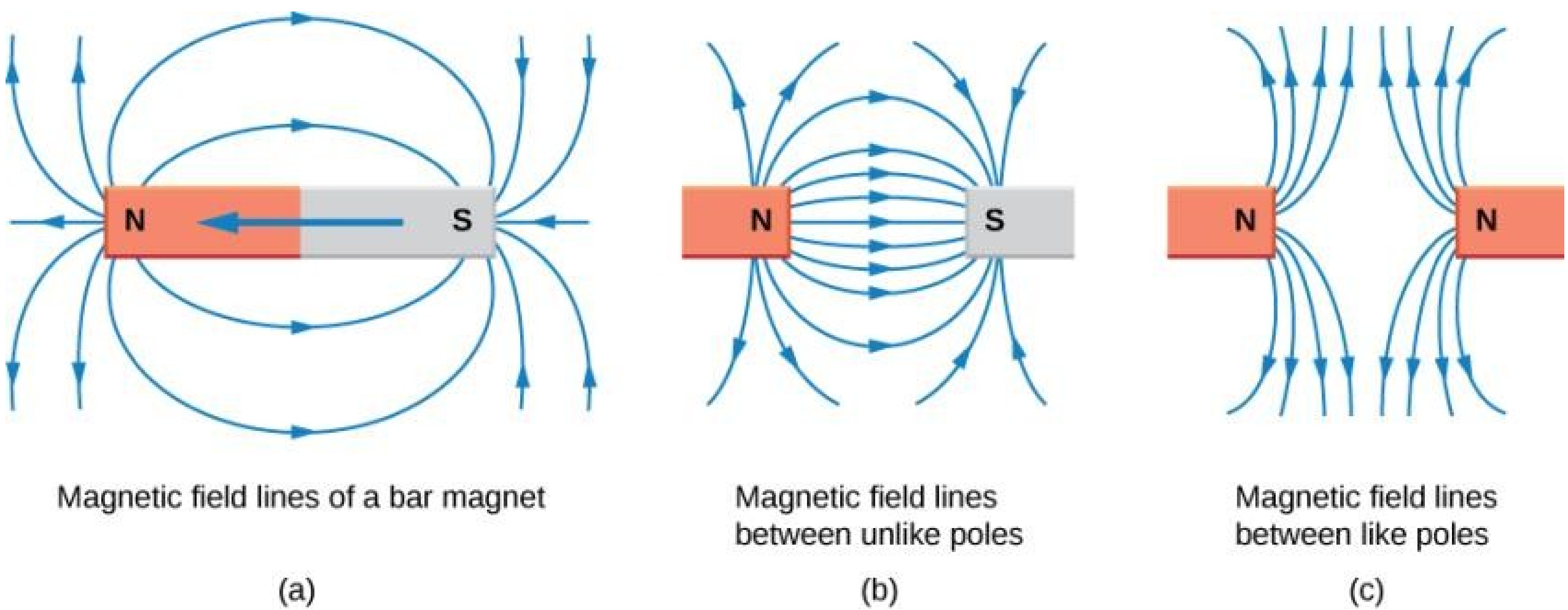


a) When the wire is in the plane of the paper, the field is perpendicular to the paper. Note the symbols used for the field pointing inward (like the tail of an arrow) and the field pointing outward (like the tip of an arrow).

b) A long and straight wire creates a field with magnetic field lines forming circular loops.

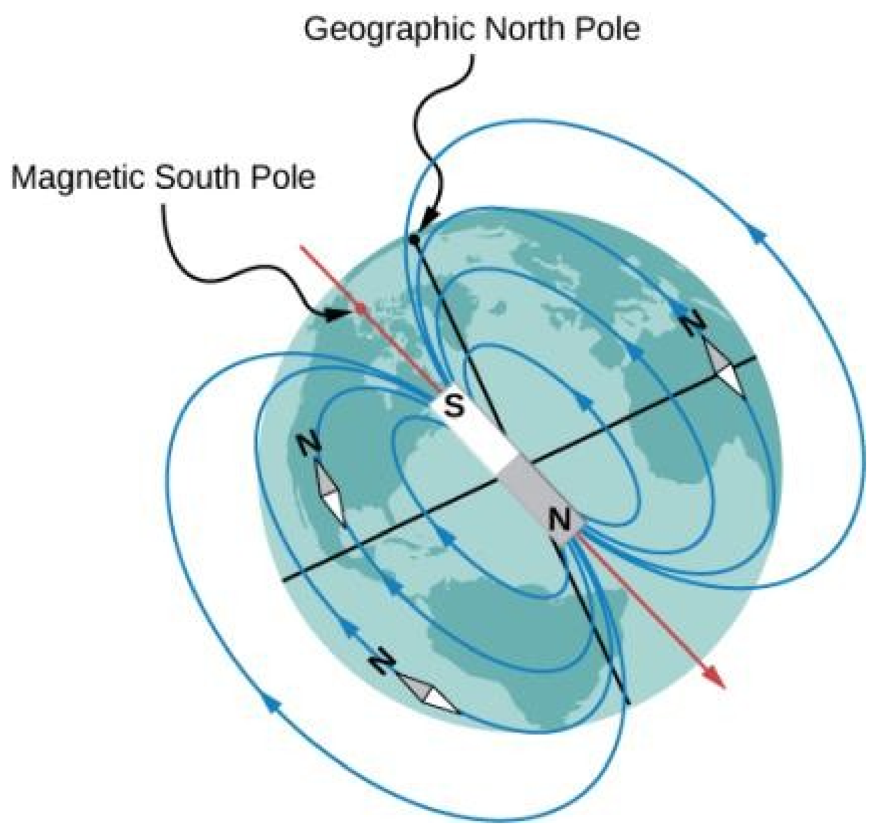
Magnet orientation

FIGURE 11.6



Magnetic field lines are defined to have the direction in which a small compass points when placed at a location in the field. The strength of the field is proportional to the closeness (or density) of the lines. If the interior of the magnet could be probed, the field lines would be found to form continuous, closed loops. To fit in a reasonable space, some of these drawings may not show the closing of the loops; however, if enough space were provided, the loops would be closed.

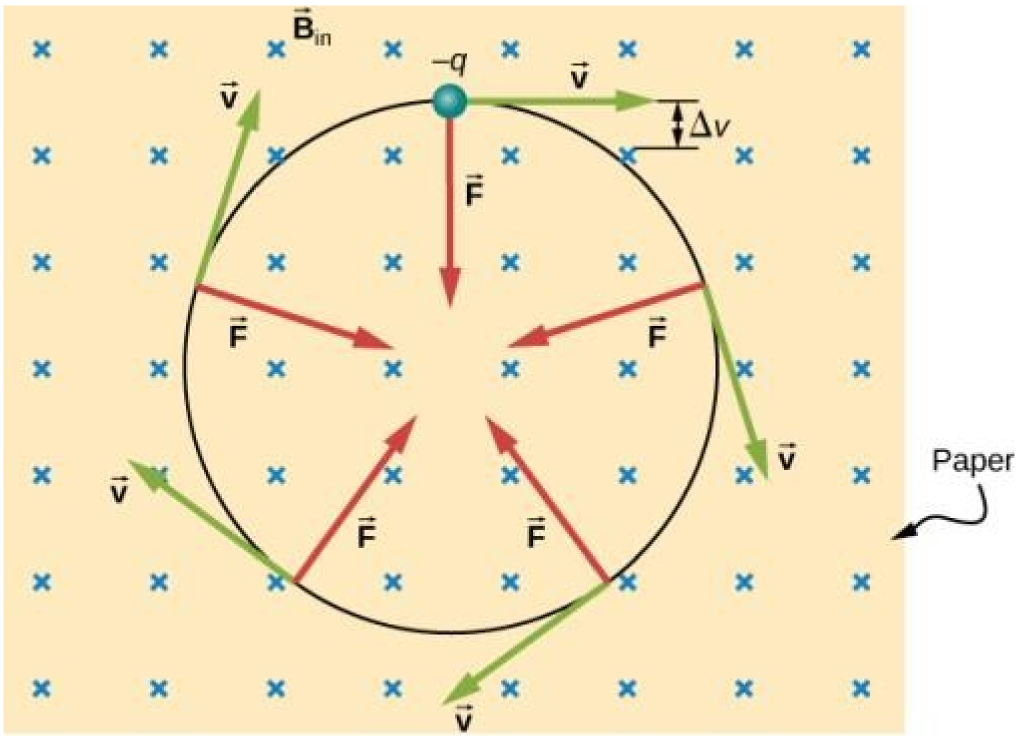
FIGURE 11.2



The north pole of a compass needle points toward the south pole of a magnet, which is how today's magnetic field is oriented from inside Earth. It also points toward Earth's geographic North Pole because the geographic North Pole is near the magnetic south pole.

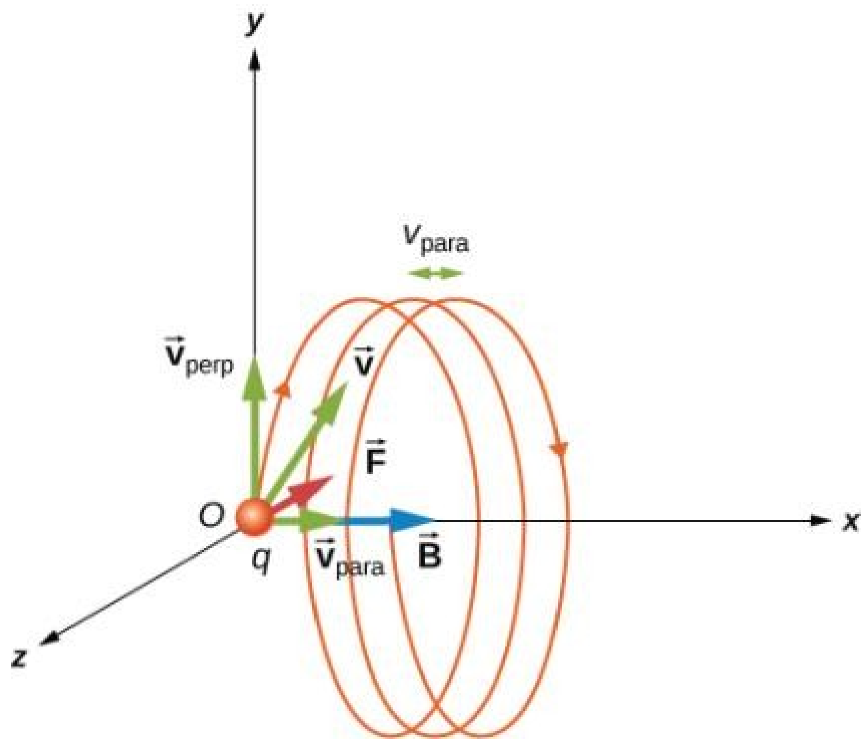
Charged particle in magnetic field

FIGURE 11.7



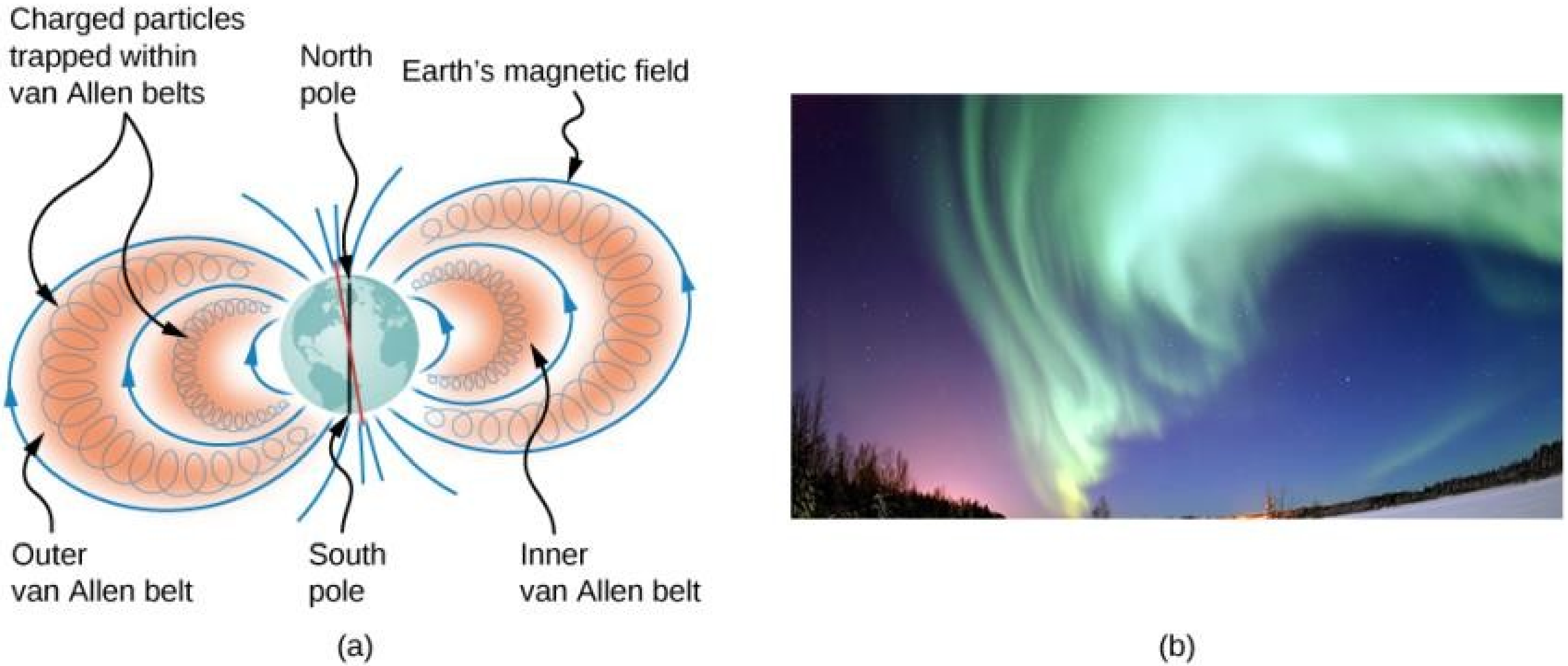
A negatively charged particle moves in the plane of the paper in a region where the magnetic field is perpendicular to the paper (represented by the small $\times$'s—like the tails of arrows). The magnetic force is perpendicular to the velocity, so velocity changes in direction but not magnitude. The result is uniform circular motion. (Note that because the charge is negative, the force is opposite in direction to the prediction of the right-hand rule.)

FIGURE 11.8



A charged particle moving with a velocity not in the same direction as the magnetic field. The velocity component perpendicular to the magnetic field creates circular motion, whereas the component of the velocity parallel to the field moves the particle along a straight line. The pitch is the horizontal distance between two consecutive circles. The resulting motion is helical.

FIGURE 11.9



a) The Van Allen radiation belts around Earth trap ions produced by cosmic rays striking Earth's atmosphere.

b) The magnificent spectacle of the aurora borealis, or northern lights, glows in the northern sky above Bear Lake near Eielson Air Force Base, Alaska. Shaped by Earth's magnetic field, this light is produced by glowing molecules and ions of oxygen and nitrogen. (credit b: modification of work by USAF Senior Airman Joshua Strang)

FIGURE 11.10

Top view of the beam deflector setup.

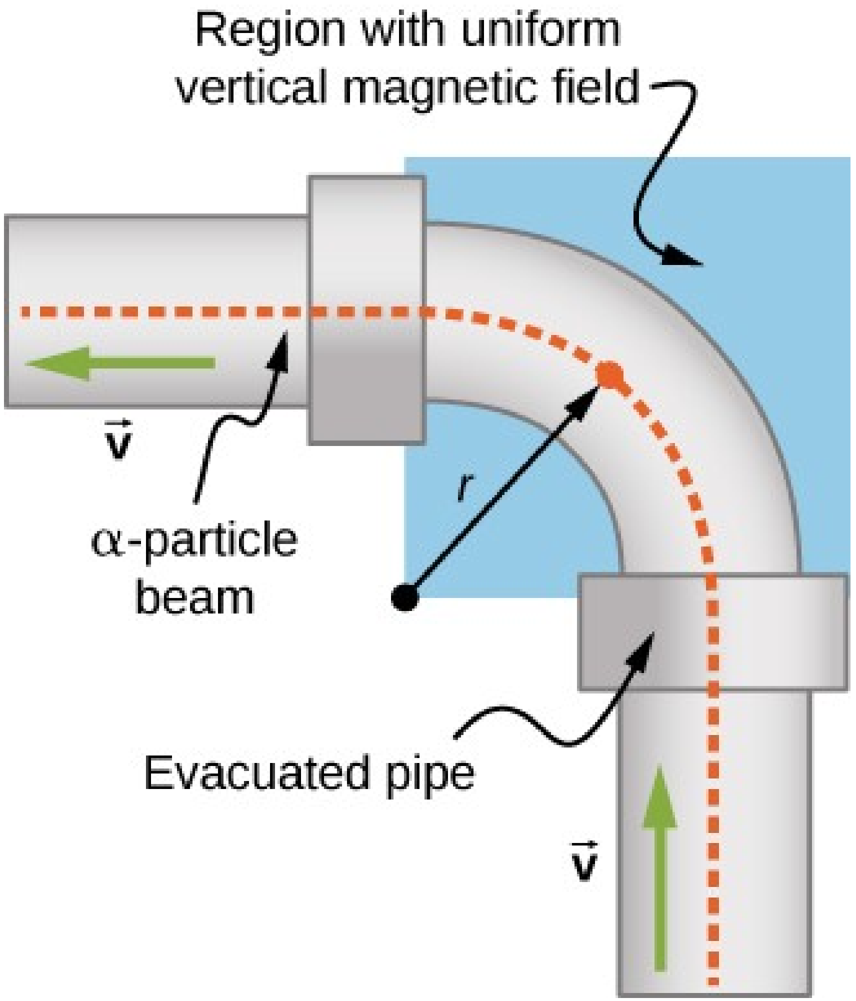
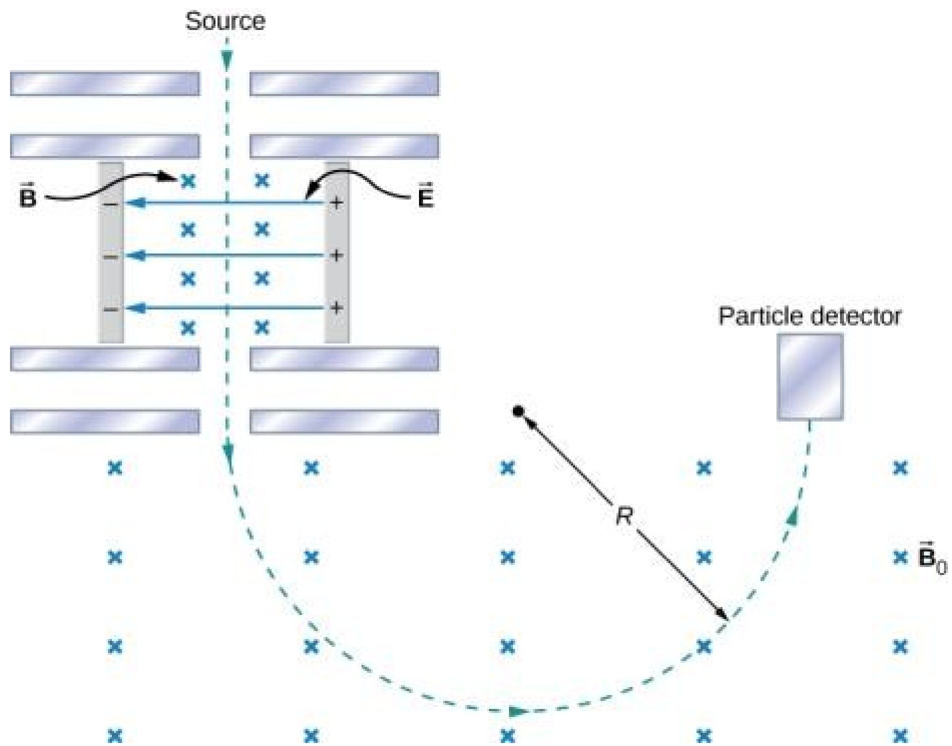
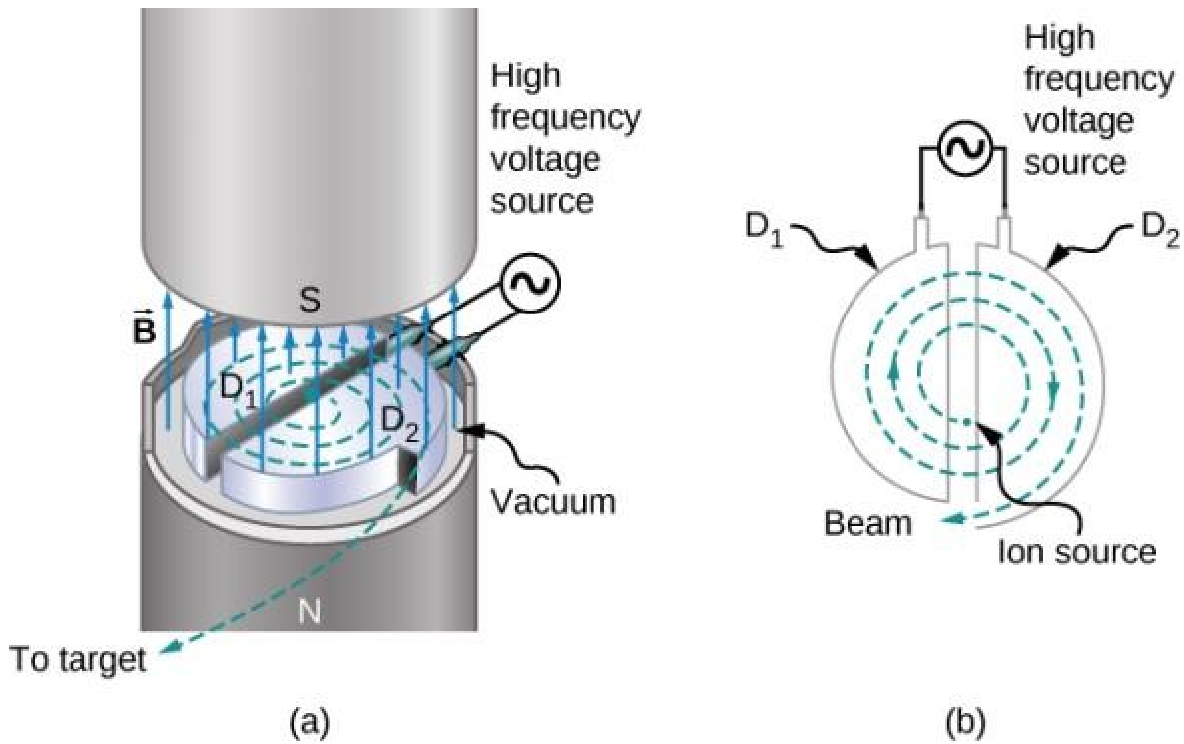


FIGURE 11.19



A schematic of the Bainbridge mass spectrometer, showing charged particles leaving a source, followed by a velocity selector where the electric and magnetic forces are balanced, followed by a region of uniform magnetic field where the particle is ultimately detected.

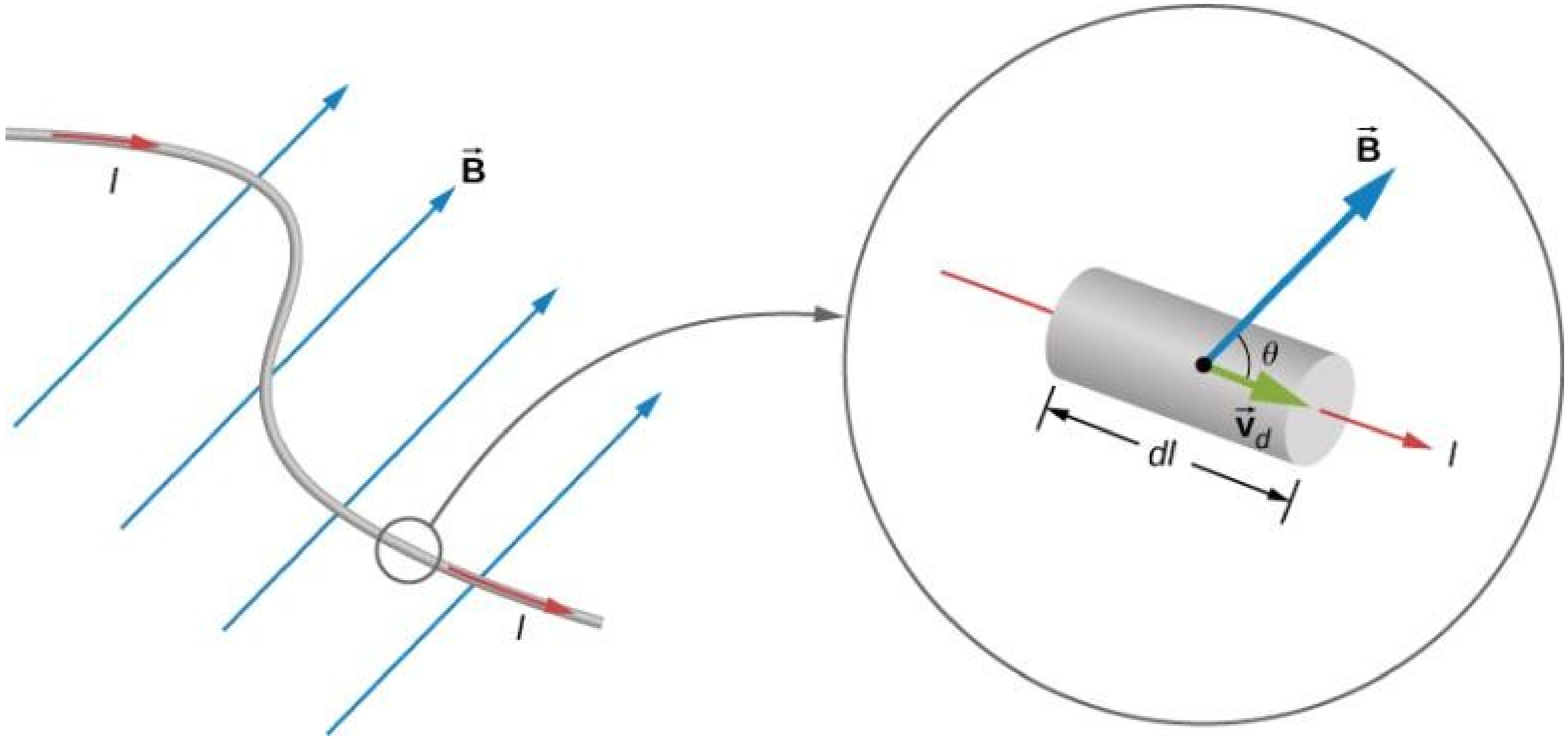
FIGURE 11.20



The inside of a cyclotron. A uniform magnetic field is applied as circulating protons travel through the dees, gaining energy as they traverse through the gap between the dees.

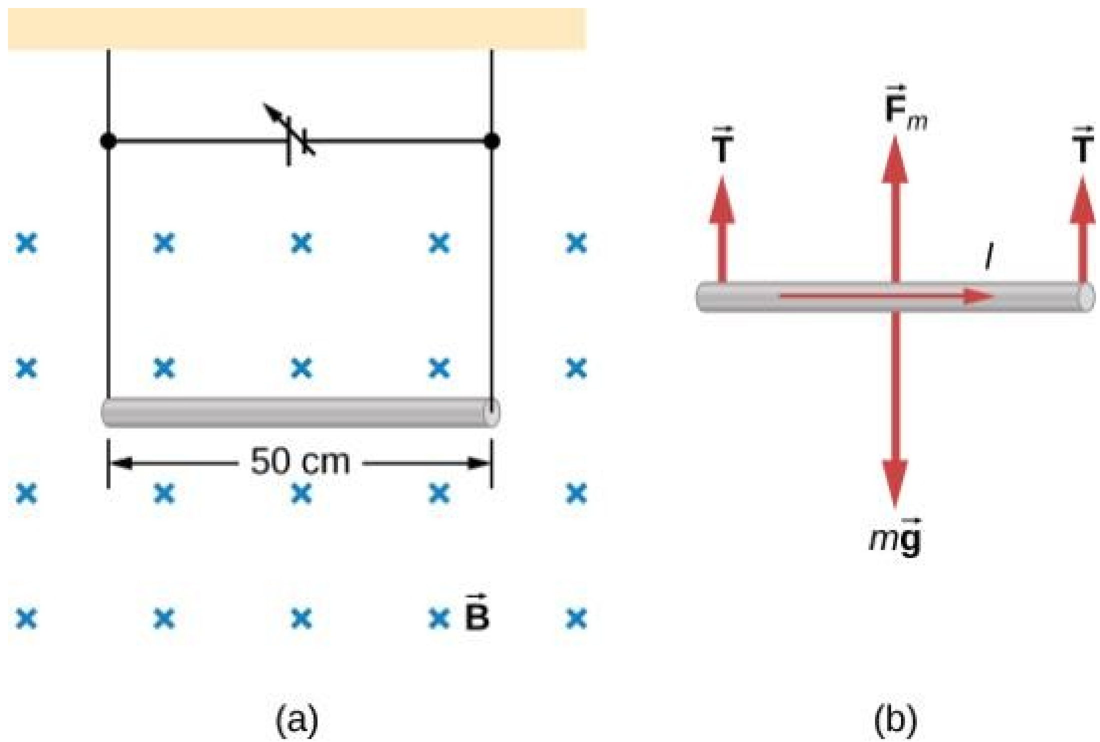
Fields near wires

FIGURE 11.12



An infinitesimal section of current-carrying wire in a magnetic field.

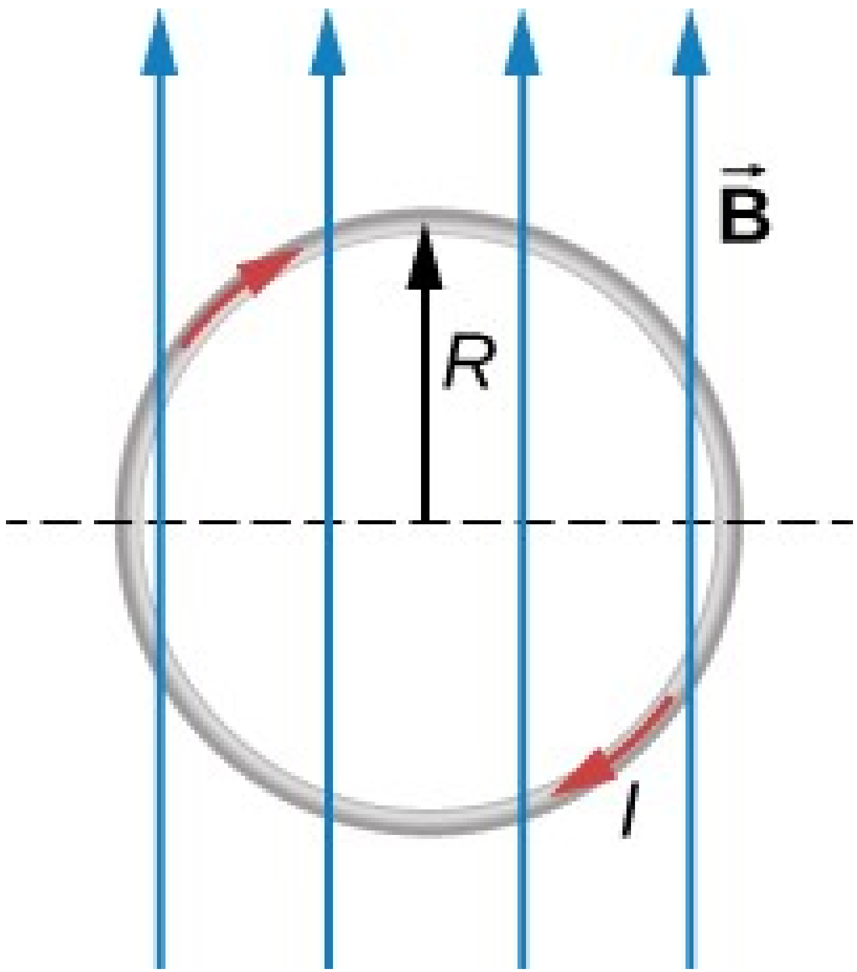
FIGURE 11.13



a) A wire suspended in a magnetic field.

b) The free-body diagram for the wire.

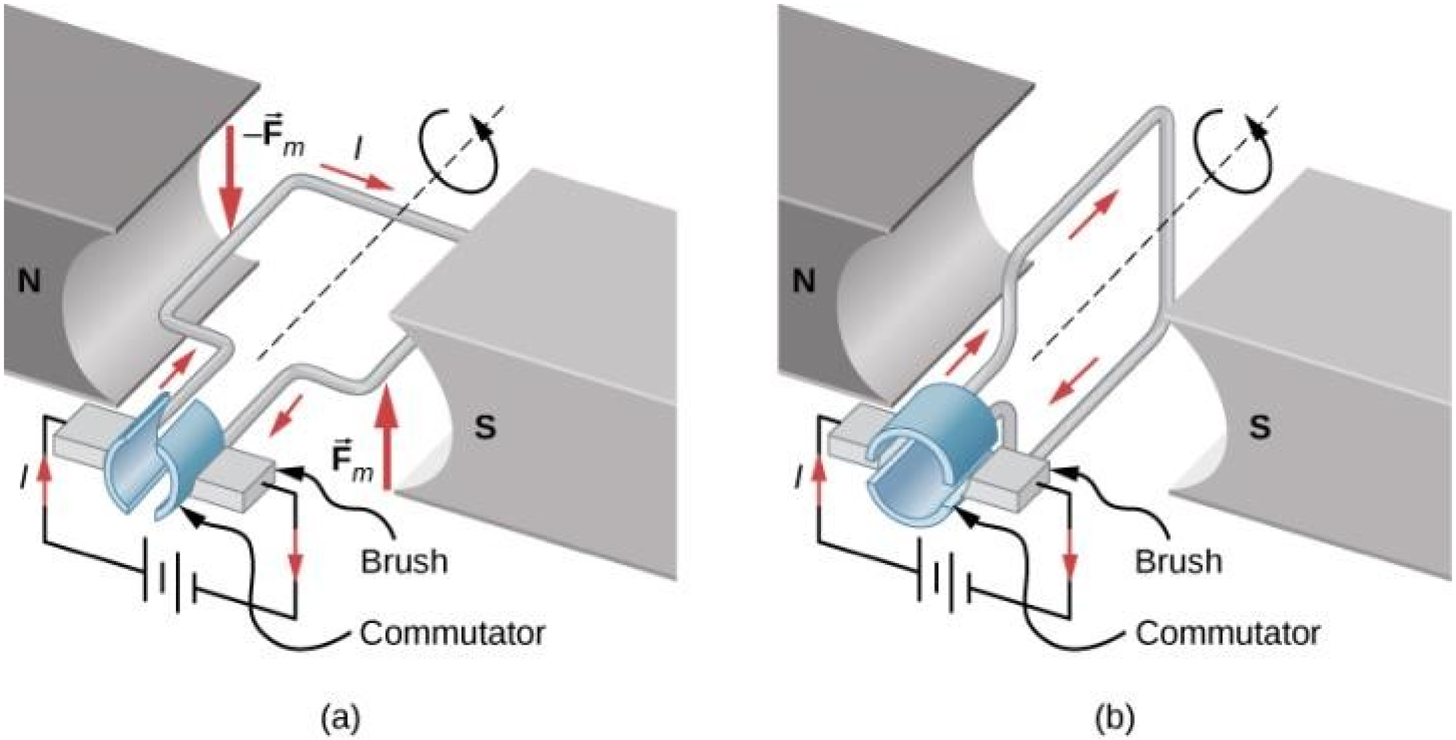
FIGURE 11.14



A loop of wire carrying a current in a magnetic field.

Motors and generators

FIGURE 11.15

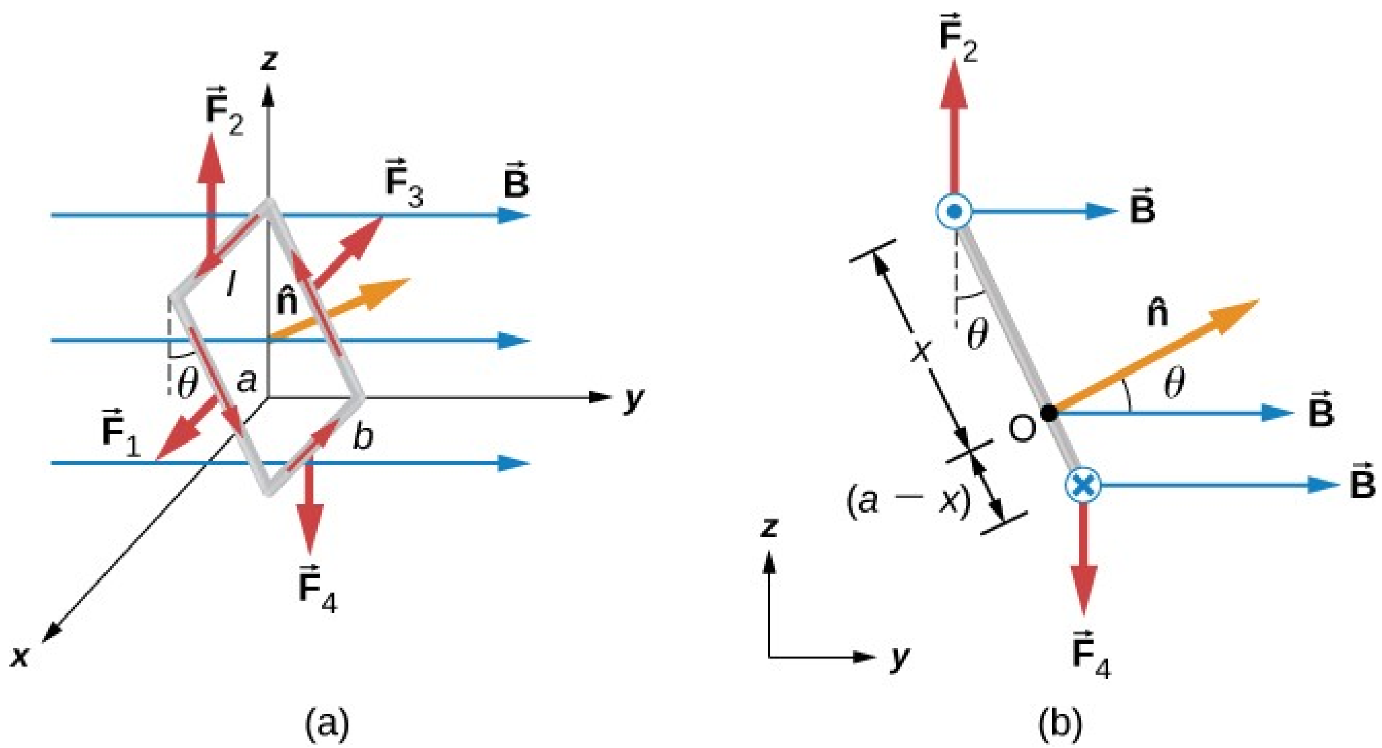


A simplified version of a dc electric motor.

a) The rectangular wire loop is placed in a magnetic field. The forces on the wires closest to the magnetic poles (N and S) are opposite in direction as determined by the right-hand rule-1. Therefore, the loop has a net torque and rotates to the position shown in (b).

b) The brushes now touch the commutator segments so that no current flows through the loop. No torque acts on the loop, but the loop continues to spin from the initial velocity given to it in part (a). By the time the loop flips over, current flows through the wires again but now in the opposite direction, and the process repeats as in part (a). This causes continual rotation of the loop.

FIGURE 11.16

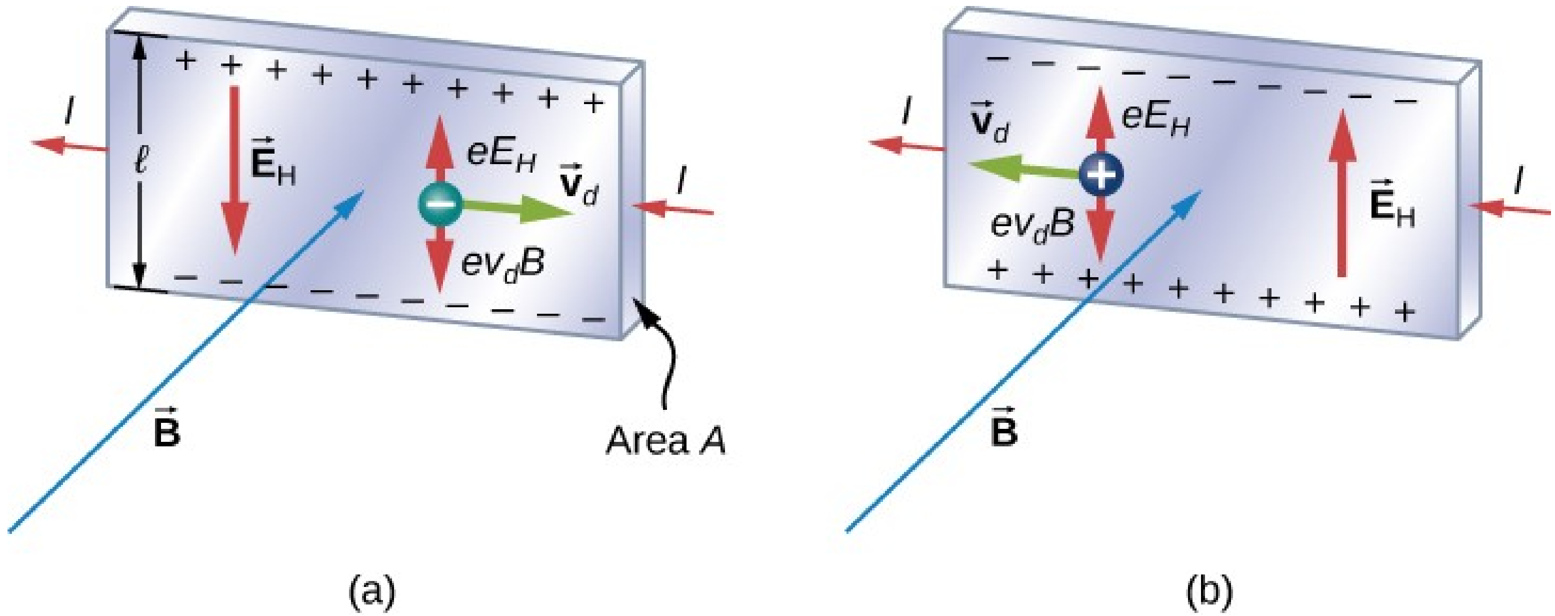


a) A rectangular current loop in a uniform magnetic field is subjected to a net torque but not a net force.

b) A side view of the coil.

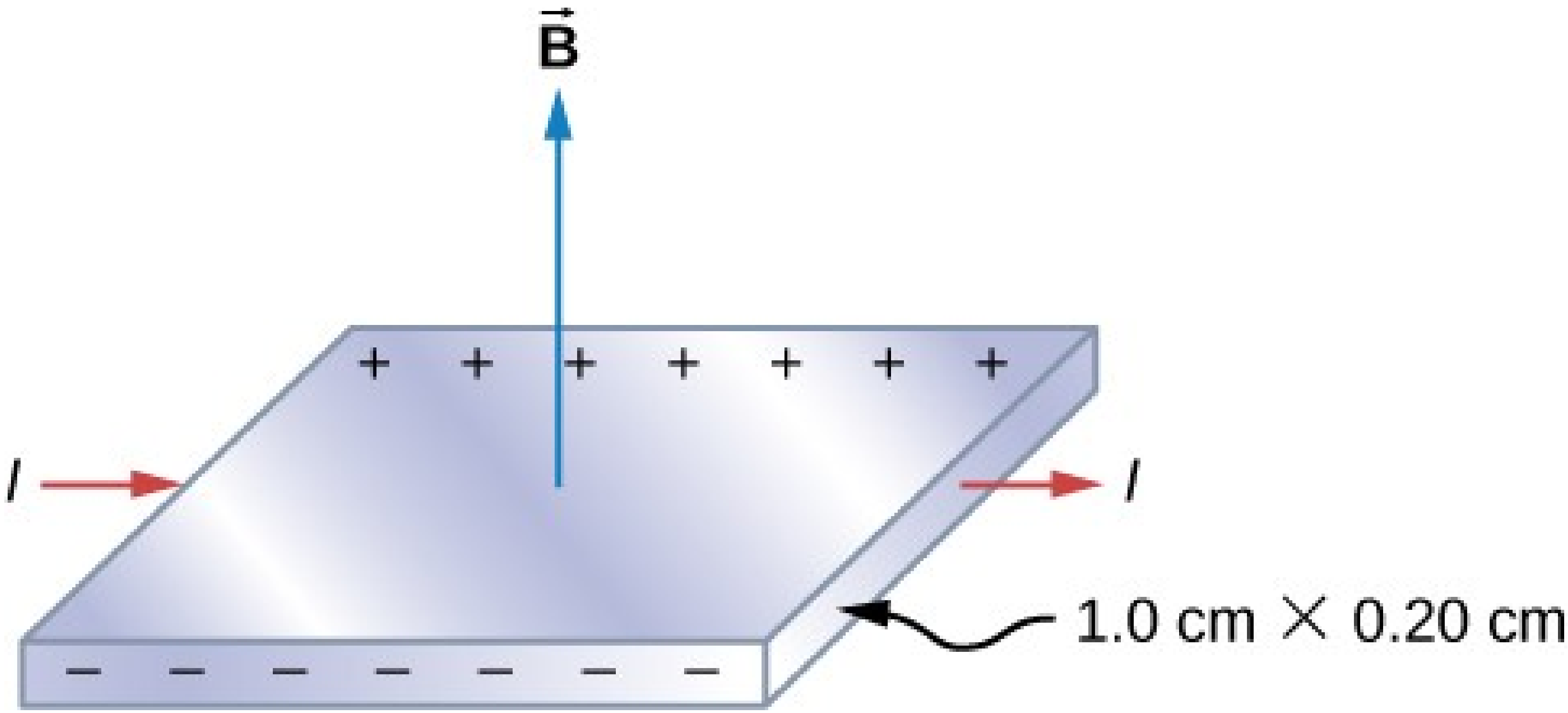
Hall effect

FIGURE 11.17



In the Hall effect, a potential difference between the top and bottom edges of the metal strip is produced when moving charge carriers are deflected by the magnetic field. (a) Hall effect for negative charge carriers; (b) Hall effect for positive charge carriers.

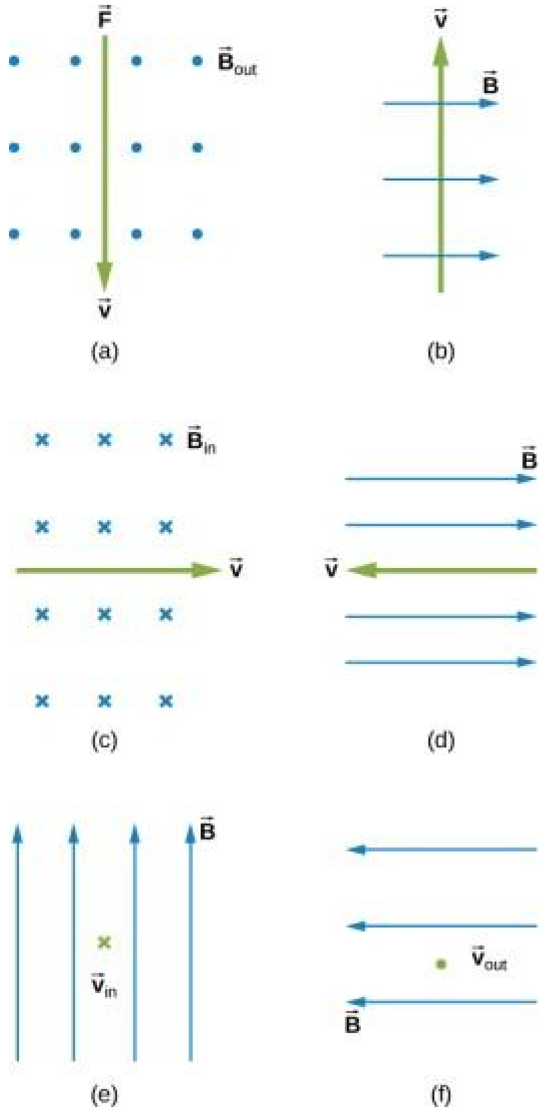
FIGURE 11.18



Finding the Hall potential in a silver ribbon in a magnetic field is shown.

Examples: charged particle in magnetic field

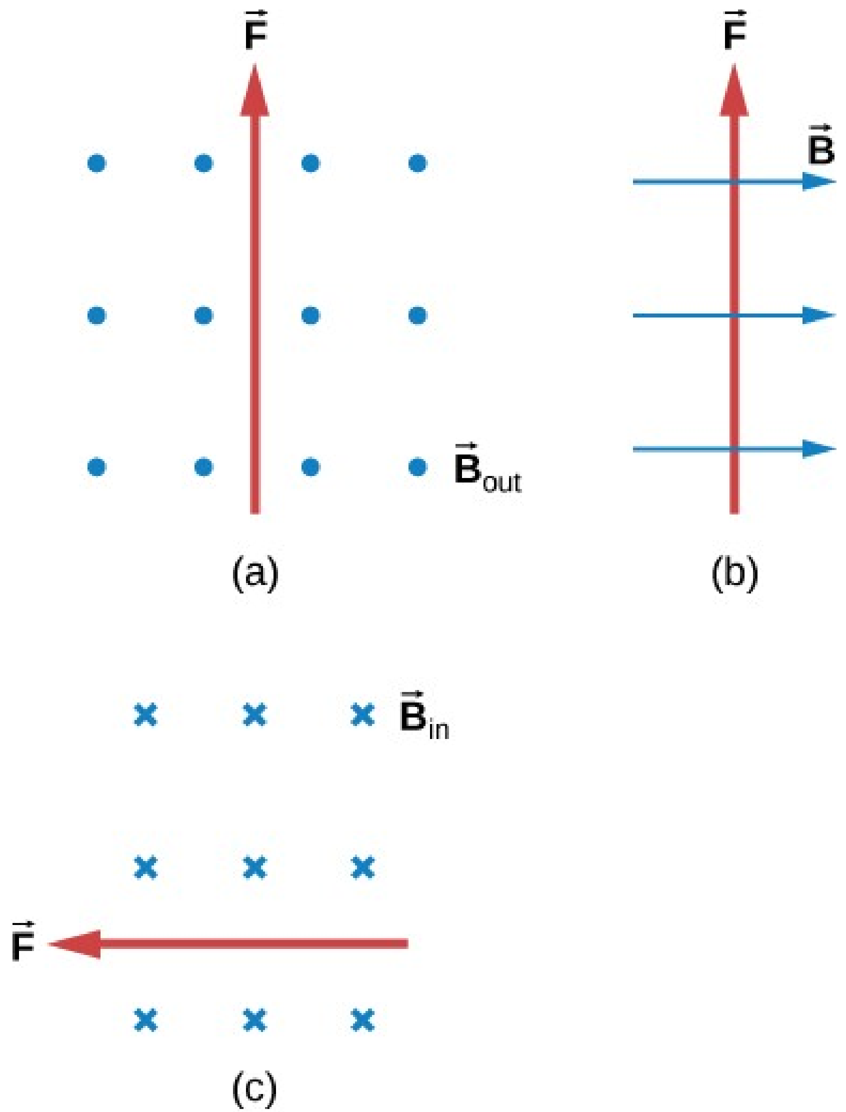
EXERCISE 15



What is the direction of the magnetic force on a positive charge that moves as shown in each of the six cases?

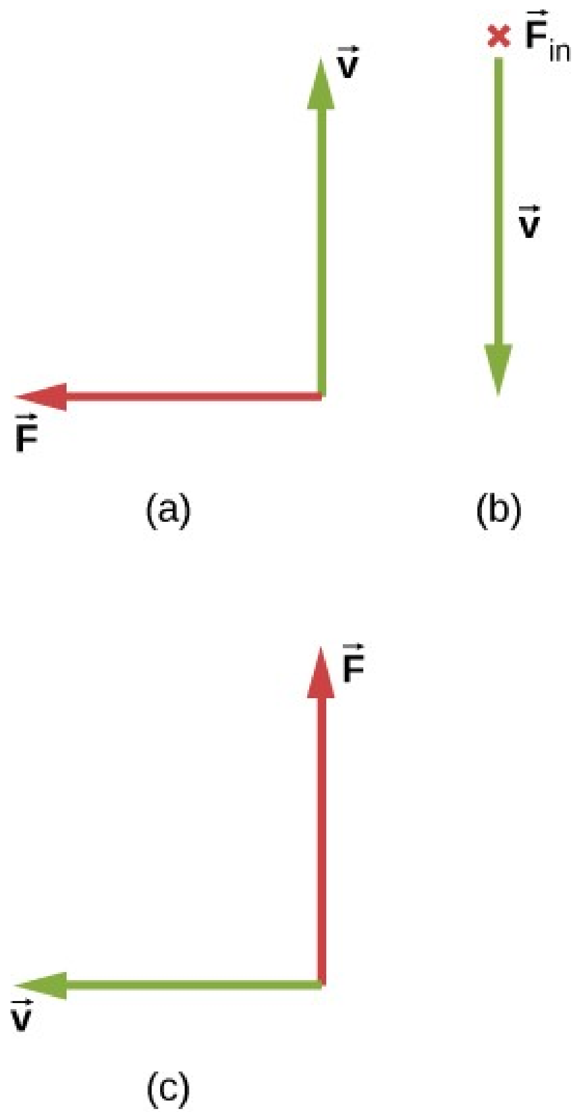
EXERCISE 17

What is the direction of the velocity of a negative charge that experiences the magnetic force shown in each of the three cases, assuming it moves perpendicular to *B*?

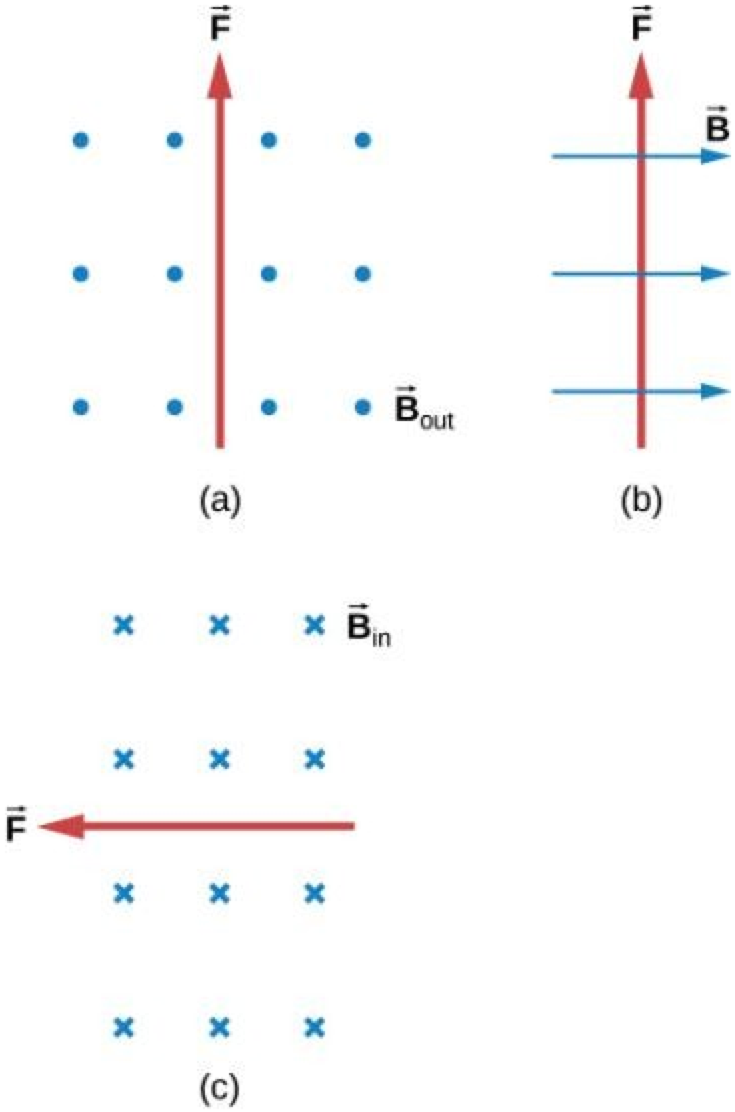


EXERCISE 19

What is the direction of the magnetic field that produces the magnetic force on a positive charge as shown in each of the three cases, assuming **B** is perpendicular to **v**?



EXERCISE 34

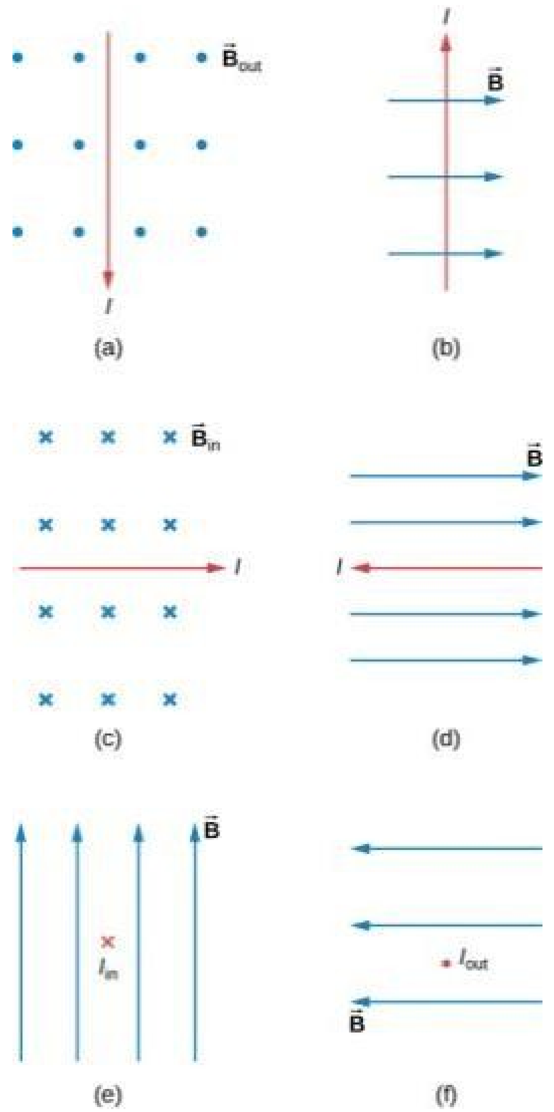


What is the direction of a current that experiences the magnetic force shown in each of the three cases, assuming the current runs perpendicular to **B**?

Examples: currents

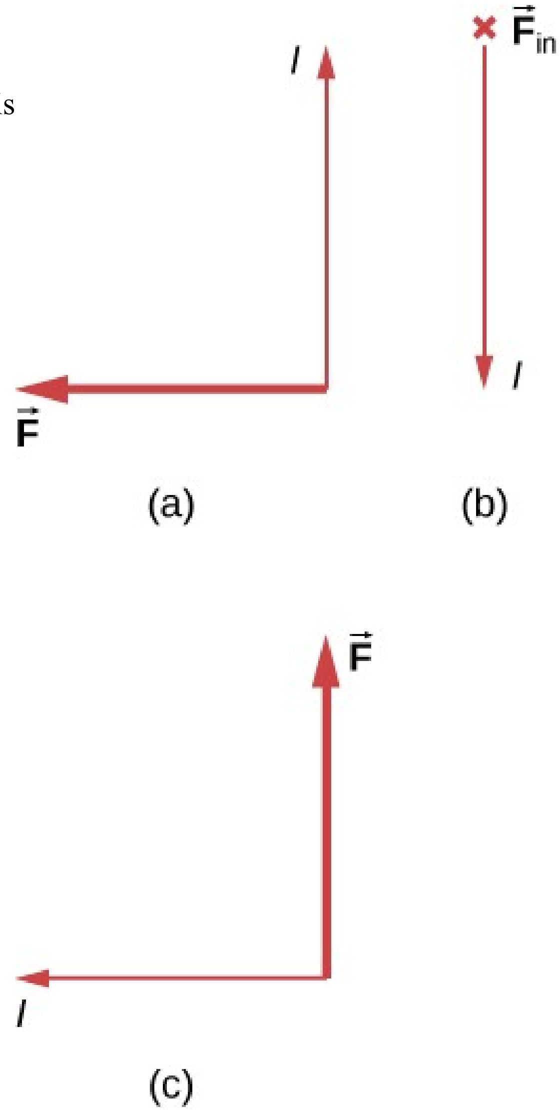
EXERCISE 33

What is the direction of the magnetic force on the current in each of the six cases?

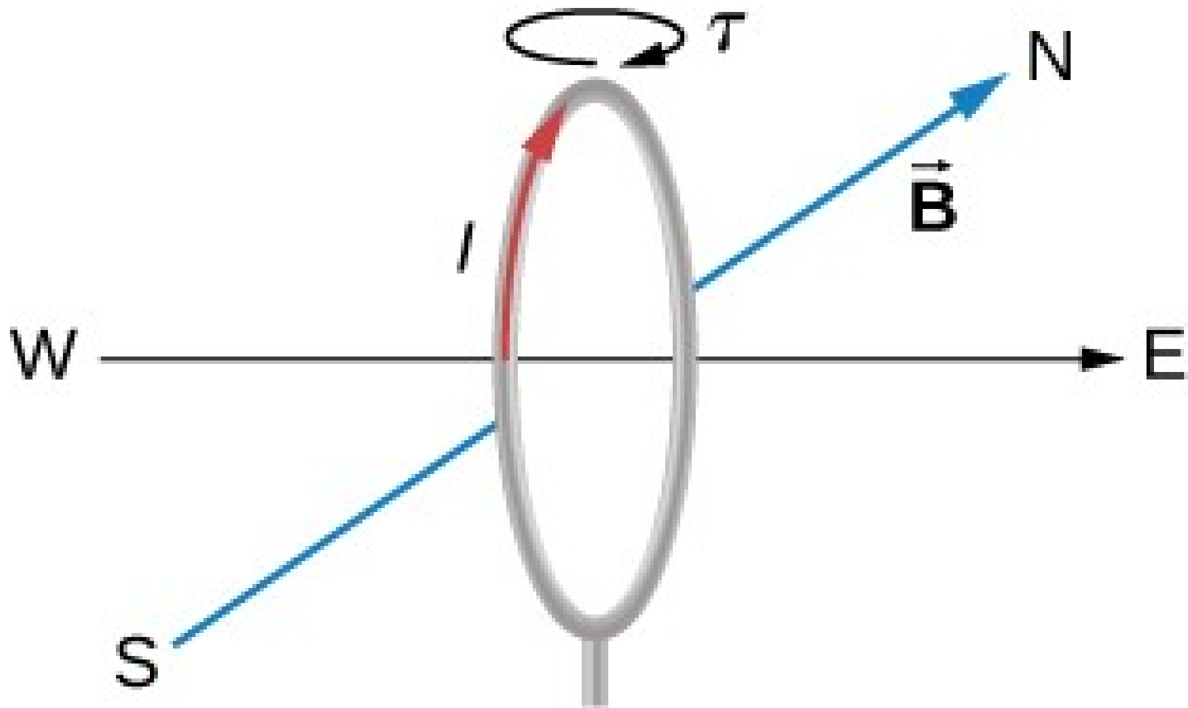


EXERCISE 35

What is the direction of the magnetic field that produces the magnetic force shown on the currents in each of the three cases, assuming **B** is perpendicular to *I*?

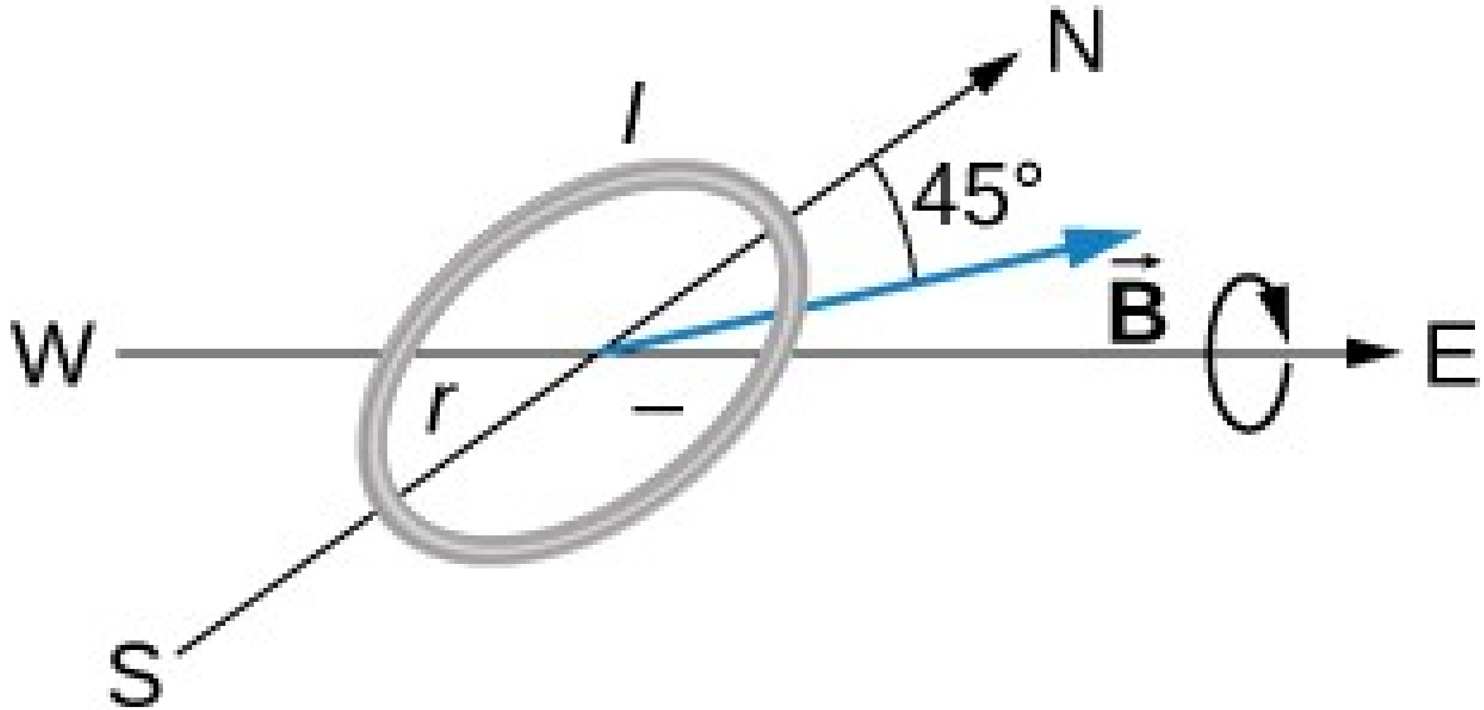


EXERCISE 46



(a) A 200-turn circular loop of radius 50.0 cm is vertical, with its axis on an east-west line. A current of 100 A circulates clockwise in the loop when viewed from the east. Earth's field here is due north, parallel to the ground, with a strength of 3e-5 T. What are the direction and magnitude of the torque on the loop? (b) Does this device have any practical applications as a motor?

EXERCISE 47



Repeat the previous problem, but with the loop lying flat on the ground with its current circulating counterclockwise (when viewed from above) in a location where Earth's field is north, but at an angle 45.0° below the horizontal and with a strength of
6e-5 T