12. A positively charged particle in a nonuniform magnetic field follows the trajectory shown in Fig. 20–49. Indicate the direction of the magnetic field at points near the path, assuming the path is always in the plane of the page, and indicate the relative magnitudes of the field in each region. Explain your answers.

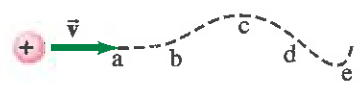

FIGURE 20–49 Question 12.

13. Explain why a strong magnet held near a CRT television screen (Section 17–10) causes the picture to become distorted. Also, explain why the picture sometimes goes completely black where the field is the strongest. [But don't risk damage to your TV by trying this.]

14. Suppose you have three iron rods, two of which are magnetized but the third is not. How would you determine which two are the magnets without using any additional objects?

15. Can you set a resting electron into motion with a magnetic field? With an electric field? Explain.

16. A charged particle is moving in a circle under the influence of a uniform magnetic field. If an electric field that points in the same direction as the magnetic field is turned on, describe the path the charged particle will take.

17. A charged particle moves in a straight line through a particular region of space. Could there be a nonzero magnetic field in this region? If so, give two possible situations.

18. If a moving charged particle is deflected sideways in some region of space, can we conclude, for certain, that $\vec{\mathbf{B}} \neq 0$ in that region? Explain.

19. Two insulated long wires carrying equal currents I cross at right angles to each other. Describe the magnetic force one exerts on the other.

20. A horizontal current-carrying wire, free to move in Earth's gravitational field, is suspended directly above a parallel, current-carrying wire. (*a*) In what direction is the current in the lower wire? (*b*) Can the lower wire be held in stable equilibrium due to the magnetic force of the upper wire? Explain.

21. What would be the effect on B inside a long solenoid if (*a*) the diameter of all the loops was doubled, (*b*) the spacing between loops was doubled, or (*c*) the solenoid's length was doubled along with a doubling in the total number of loops?

22. A type of magnetic switch similar to a solenoid is a **relay** (Fig. 20–50). A relay is an electromagnet (the iron rod inside the coil does not move) which, when activated, attracts a strip of iron on a pivot. Design a relay to close an electrical switch. A relay is used when you need to switch on a circuit carrying a very large current but do not want that large current flowing through the main switch. For example, a car's starter switch is connected to a relay so that the large current needed for the starter doesn't pass to the dashboard switch.

FIGURE 20–50 Question 22.

*23. Two ions have the same mass, but one is singly ionized and the other is doubly ionized. How will their positions on the film of a mass spectrometer (Fig. 20–41) differ? Explain.

*24. Why will either pole of a magnet attract an unmagnetized piece of iron?

*25. An unmagnetized nail will not attract an unmagnetized paper clip. However, if one end of the nail is in contact with a magnet, the other end *will* attract a paper clip. Explain.

MisConceptual Questions

1. Indicate which of the following will produce a magnetic field:
   (*a*) A magnet.
   (*b*) The Earth.
   (*c*) An electric charge at rest.
   (*d*) A moving electric charge.
   (*e*) An electric current.
   (*f*) The voltage of a battery not connected to anything.
   (*g*) An ordinary piece of iron.
   (*h*) A piece of any metal.

2. A current in a wire points into the page as shown at the right. In which direction is the magnetic field at point A (choose below)?

   $I\otimes$ •A
   •B

   → ← ↓ ↑
   (*a*) (*b*) (*c*) (*d*) (*e*) None of these.

3. In which direction (see above) is the magnetic field at point B?

4. When a charged particle moves parallel to the direction of a magnetic field, the particle travels in a
   (*a*) straight line.
   (*b*) circular path.
   (*c*) helical path.
   (*d*) hysteresis loop.

5. As a proton moves through space, it creates
   (*a*) an electric field only.
   (*b*) a magnetic field only.
   (*c*) both an electric field and magnetic field.
   (*d*) nothing; the electric field and magnetic fields cancel each other out.

6. Which statements about the force on a charged particle placed in a magnetic field are true?
   (*a*) A magnetic force is exerted only if the particle is moving.
   (*b*) The force is a maximum if the particle is moving in the direction of the field.
   (*c*) The force causes the particle to gain kinetic energy.
   (*d*) The direction of the force is along the magnetic field.
   (*e*) A magnetic field always exerts a force on a charged particle.

7. Which of the following statements is false? The magnetic field of a current-carrying wire
   (*a*) is directed circularly around the wire.
   (*b*) decreases inversely with the distance from the wire.
   (*c*) exists only if the current in the wire is changing.
   (*d*) depends on the magnitude of the current.

8. A wire carries a current directly away from you. Which way do the magnetic field lines produced by this wire point?
   (*a*) They point parallel to the wire in the direction of the current.
   (*b*) They point parallel to the wire opposite the direction of the current.
   (*c*) They point toward the wire.
   (*d*) They point away from the wire.
   (*e*) They make circles around the wire.

9. A proton enters a uniform magnetic field that is perpendicular to the proton's velocity (Fig. 20–51). What happens to the kinetic energy of the proton?
   (*a*) It increases.
   (*b*) It decreases.
   (*c*) It stays the same.
   (*d*) It depends on the velocity direction.
   (*e*) It depends on the B field direction.

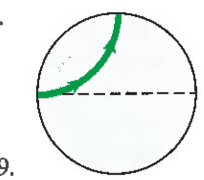

FIGURE 20–51 MisConceptual Question 9.

10. For a charged particle, a constant magnetic field can be used to change
    (*a*) only the direction of the particle's velocity.
    (*b*) only the magnitude of the particle's velocity.
    (*c*) both the magnitude and direction of the particle's velocity.
    (*d*) None of the above.

11. Which of the following statements about the force on a charged particle due to a magnetic field are not valid?
    (*a*) It depends on the particle's charge.
    (*b*) It depends on the particle's velocity.
    (*c*) It depends on the strength of the external magnetic field.
    (*d*) It acts at right angles to the direction of the particle's motion.
    (*e*) None of the above; all of these statements are valid.

12. Two parallel wires are vertical. The one on the left carries a 10-A current upward. The other carries 5-A current downward. Compare the magnitude of the force that each wire exerts on the other.
    (*a*) The wire on the left carries twice as much current, so it exerts twice the force on the right wire as the right one exerts on the left one.
    (*b*) The wire on the left exerts a smaller force. It creates a magnetic field twice that due to the wire on the right; and therefore has less energy to cause a force on the wire on the right.
    (*c*) The two wires exert the same force on each other.
    (*d*) Not enough information; we need the length of the wire.

For assigned homework and other learning materials, go to the MasteringPhysics website.

Problems

20–3 Force on Electric Current in Magnetic Field

1. (I) (*a*) What is the force per meter of length on a straight wire carrying a 6.40-A current when perpendicular to a 0.90-T uniform magnetic field? (*b*) What if the angle between the wire and field is 35.0°?

2. (I) How much current is flowing in a wire 4.80 m long if the maximum force on it is 0.625 N when placed in a uniform 0.0800-T field?

3. (I) A 240-m length of wire stretches between two towers and carries a 120-A current. Determine the magnitude of the force on the wire due to the Earth's magnetic field of 5.0×10^{-5} T which makes an angle of 68° with the wire.

4. (I) A 2.6-m length of horizontal wire carries a 4.5-A current toward the south. The dip angle of the Earth's magnetic field makes an angle of 41° to the wire. Estimate the magnitude of the magnetic force on the wire due to the Earth's magnetic field of 5.5×10^{-5} T.

5. (I) The magnetic force per meter on a wire is measured to be only 45% of its maximum possible value. What is the angle between the wire and the magnetic field?

6. (II) The force on a wire carrying 6.45 A is a maximum of 1.28 N when placed between the pole faces of a magnet. If the pole faces are 55.5 cm in diameter, what is the approximate strength of the magnetic field?

7. (II) The force on a wire is a maximum of 8.50×10^{-2} N when placed between the pole faces of a magnet. The current flows horizontally to the right and the magnetic field is vertical. The wire is observed to "jump" toward the observer when the current is turned on. (*a*) What type of magnetic pole is the top pole face? (*b*) If the pole faces have a diameter of 10.0 cm, estimate the current in the wire if the field is 0.220 T. (*c*) If the wire is tipped so that it makes an angle of 10.0° with the horizontal, what force will it now feel? [*Hint*: What length of wire will now be in the field?]

8. (II) Suppose a straight 1.00-mm-diameter copper wire could just "float" horizontally in air because of the force due to the Earth's magnetic field $\vec{\mathbf{B}}$, which is horizontal, perpendicular to the wire, and of magnitude 5.0×10^{-5} T. What current would the wire carry? Does the answer seem feasible? Explain briefly.