18. A beam of electrons is directed toward a horizontal wire carrying a current from left to right (Fig. 20–49). In what direction is the beam deflected?

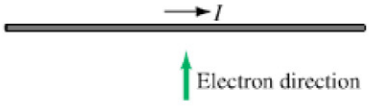

FIGURE 20–49 Question 18.

19. Describe electric and/or magnetic fields that surround a moving electric charge.
20. 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.
21. 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.
22. In a particular region of space there is a uniform magnetic field $\vec{\mathbf{B}}$. Outside this region, $B = 0$. Can you inject an electron from outside into the field perpendicularly so that it will move in a closed circular path in the field? What if the electron is injected near the center?
23. How could you tell whether moving electrons in a certain region of space are being deflected by an electric field or by a magnetic field (or by both)?
24. How can you make a compass without using iron or other ferromagnetic material?
25. Two long wires carrying equal currents I are at right angles to each other, but don't quite touch. Describe the magnetic force one exerts on the other.
26. A horizontal current-carrying wire, free to move in Earth's gravitational field, is suspended directly above a second, parallel, current-carrying wire. (*a*) In what direction is the current in the lower wire? (*b*) Can the upper wire be held in stable equilibrium due to the magnetic force of the lower wire? Explain.
27. Why will either pole of a magnet attract an unmagnetized piece of iron?
28. 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.
* 29. 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. 20–39) differ?
30. 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?
31. 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 piece 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 you do not want that large current flowing through the main switch. For example, the starter switch of a car is connected to a relay so that the large current needed for the starter doesn't pass to the dashboard switch.

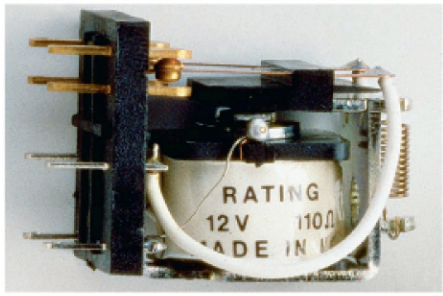

FIGURE 20–50 Question 31.

Problems

20–3 Force on Electric Current in Magnetic Field

1. (I) (*a*) What is the magnitude of the force per meter of length on a straight wire carrying an 8.40-A current when perpendicular to a 0.90-T uniform magnetic field? (*b*) What if the angle between the wire and field is 45.0°?
2. (I) Calculate the magnitude of the magnetic force on a 160-m length of straight wire stretched between two towers carrying a 150-A current. The Earth's magnetic field of 5.0×10^{-5} T makes an angle of 65° with the wire.
3. (I) How much current is flowing in a wire 4.80 m long if the maximum force on it is 0.750 N when placed in a uniform 0.0800-T field?
4. (II) A 1.5-m length of wire carrying 4.5 A of current is oriented horizontally. At that point on the Earth's surface, the dip angle of the Earth's magnetic field makes an angle of 38° 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 at this point.
5. (II) The force on a wire carrying 8.75 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?
6. (II) The magnetic force per meter on a wire is measured to be only 35% of its maximum possible value. Sketch the relationship of the wire and the field if the force had been a maximum, and sketch the relationship as it actually is, calculating the angle between the wire and the magnetic field.
7. (II) The force on a wire is a maximum of 6.50×10^{-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 0.16 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?
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.