CHAPTER 16 Review

REFLECTING ON CHAPTER 16

- Magnets are always found as a dipole with both an N-pole and an S-pole. Breaking a magnet into two parts results in each part being a dipole.
- For magnetic poles, like poles repel each other while unlike pole attract. The force of attraction or repulsion varies inversely as the square of the separation of the poles.
- Domain theory is used to explain why ferromagnetic materials can be induced to display magnetic behaviour.
- Oersted discovered the existence of magnetic fields near a current-carrying conductor. A right-hand rule is used to determine the direction of the field relative to the direction of the current.
- Ampère developed the laws describing the force exerted on a current carrying-conductor by the magnetic field in which it is located. He used the magnetic force exerted between parallel current-carrying conductors to define the ampere.
- The motor effect states that when a current passes through a magnetic field at right angles to the field, the magnetic field exerts a force on the current at right angles to both the current and the field. The direction of the motor force is found using a right-hand rule.
- Electric motors use a split-ring commutator to convert the DC current from the battery to an AC current so that the coil on the armature would always experience a force driving it in the same direction. The forces exerted on the opposite edges of the coil are in opposite directions. This results in a twisting action or torque on the coil.
- The *emf* induced by the motion of a conductor through a magnetic field varies directly as the speed v of the conductor, the field strength B, and the length L of the conductor in the field.
- When a coil rotates inside a magnetic field an alternating current is induced in the coil. A slip-ring commutator takes this current off as an AC current and a split-ring commutator takes the current off as a rectified DC current.
- Lenz's law is based on the law of conservation of energy. It states that the induced current, produced when any part of an electric circuit or magnetic field around the circuit changes, must be in a direction that opposes the change.
- Lenz's law states that a motor must generate a back *emf* that opposes the applied *emf*.

Knowledge/Understanding

1. Describe the two ways to use right hand rules to find the direction of the magnetic field inside a loop of wire.
2. A compass needle is placed at the centre of a loop of wire. When a strong current is passed through the loop, the compass needle shows no change in position. What can you state about the orientation of the loop and the direction of the current through the loop?
3. A conductor lies in an east-to-west orientation across a table. Assume that the lines of force for Earth's magnetic field point due north across the conductor, and that two compasses are placed so that one is above and the other is below the conductor. When the circuit is closed, a very strong electric current moves from west to east through the conductor. Use the right-hand rule to analyze what you should observe in the compass needles and why.
4. A conductor lies parallel to the lines of force from the Earth's magnetic field. A compass lies on top of the conductor so that its needle lies parallel to the conductor. As the current in the conductor is gradually increased, the compass needle gradually deflects to the west. (a) Is the current flowing north or south through the conductor? Explain. (b) At what angle would the compass needle be deflected when the magnetic field from the current is equal in magnitude to the Earth's magnetic field? Explain.

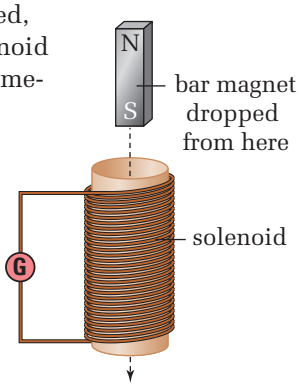
5. A solenoid is set up so that its axis is parallel to Earth's magnetic lines of force. A compass is placed at the geographic south end of the solenoid so that the N-pole of the compass points into the solenoid. When the current is turned on, the needle makes a 180° reversal in direction. Assume you are looking through the coil from its north end (due south along the axis of the coil). From your point of view, is the current moving around the coil in a clockwise or counter-clockwise direction? Explain your answer.
6. In a generator, what is the orientation of the coil with respect to the magnetic field when the generator output is at its peak?
7. What is the purpose of the commutator in a DC generator?

Inquiry

8. Design and build an electromagnet that, when powered by a single D-cell (flashlight battery), will support at least 2.0 kg. Connect your electromagnet to a variable voltage power supply and an ammeter. Make a graph of the weight your magnet can support versus the current. Does the strength of the electromagnet increase in direct proportion to the current? From your graph predict whether the magnet has an upper limit for the load it can support. Explain.
9. In an automobile, every time you come to a stop the brakes convert the car's kinetic energy into heat. The energy saved would be enormous if the work done to stop the motion of a car could somehow be recycled. In fact, electric trains can do just that. Investigate how the kinetic energy is transformed and recycled.
10. When a coil is connected to an AC power source, a phenomenon called self-inductance occurs. Investigate this phenomenon and how it affects the function of the coil.

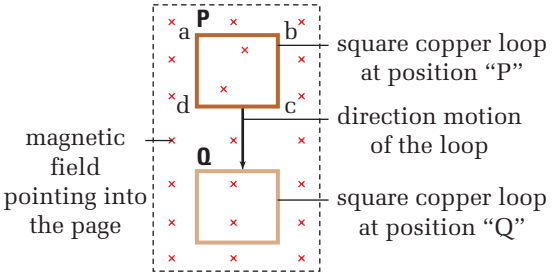
Communication

11. Describe how Domain theory explains the difference between a permanent and a temporary magnet.
12. Explain how to apply a right-hand rule(s) to determine whether the force one long straight conductor exerts on a second conductor that runs parallel to it is an attractive or a repulsive force.
13. Draw a circular loop of wire that lies in the plane of the page. Draw an arrow to indicate that the current in the loop flows in the counter-clockwise direction. Draw "dots" and "crosses" to indicate the lines of force magnetic field inside and outside the loop as they pass through the plane of the page.
14. A solenoid lies in the plane of the page with its axis parallel to the edge of the page. The magnetic lines of force flow through the loop towards the bottom of the page. Draw a diagram of the solenoid, showing windings and the direction of the current through the windings.
15. A simple electric meter can be made by placing a compass at the centre of a coil of wire. How should the coil and compass be aligned so that the deflection of the compass can be used to indicate the size and direction of the current in the coil? Explain how this system could be used to indicate the size of the current.
16. Describe the role of the commutator in a DC motor. Support your description with diagrams to illustrate the function of the commutator.
17. A coil of wire, which is free to turn, is suspended so that its plane is parallel to Earth's magnetic field. When a current flows in the coil, it turns so that its plane is perpendicular to Earth's magnetic field. Explain why this happens.
18. A bar magnet is dropped, S-pole first, into a solenoid connected to a galvanometer. Discuss the nature of the induced current in the solenoid as the magnet passes through and out the other end. As a frame of reference, use the view looking down into the solenoid.



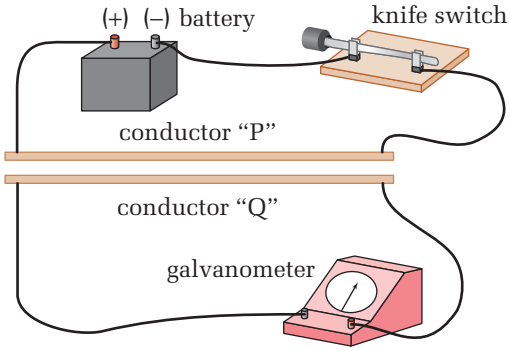
19. At the same instant as the bar magnet in Question 9 is dropped, a second bar magnet is dropped from the same height above the floor. The second magnet falls parallel to the first magnet, but does not pass through the solenoid. Explain why the second magnet would hit the floor before the first magnet.

20. Study the diagram below. The square loop of wire is moved inside the magnetic field from position P to position Q. Discuss the induced *emf* in the loop along each of it edges: **ab**, **bc**, **cd**, **da**. What is the net *emf* for the complete loop? Explain.



21. It has been said that "every motor is a generator". Explain why this is true. Is it also true that "every generator is a motor"? Explain.

22. The diagram below shows two conductors, P and Q, side by side. Describe the induced current in the conductor Q, connected to the galvanometer, when the switch connecting the conductor P to the battery is closed. Does the induced current in conductor Q flow to the left or to the right? Explain how to find the direction of induced current using right-hand rule for (a) the generator effect and (b) Lenz's law.



Making Connections

23. The solenoid is often described as a linear motor. If a rod is placed so that one of its ends is in a solenoid, the magnetic field of the solenoid will draw the rod into the solenoid (See Question 10). This action is employed in many industrial and home appliances. Prepare a list of the devices in the home that use solenoids. For each device, describe the purpose of the solenoid.

24. Investigate and report on the method by which information is recorded on a magnetic audio or video tape or a computer disk.

25. When you board an aircraft you are not allowed to use certain electronic devices during take off and landing. Investigate and report on which devices are not to be used and why this is so.

26. A 24 V DC motor runs at a speed of 3 600 rpm. At that speed, it draws 1.0 A from the battery. The resistance of the coil, measured when the motor is at rest, is found to be 6.0 Ω. Explain why the motor does not draw a current of 4.0 A when it is running. Evaluate the dangers of running at speeds much lower than its ideal operating speed.

Problems for Understanding

27. Two parallel conductors carry current in opposite directions as shown in Figure 16.19. Describe the change in magnitude of the force for each of the following scenarios.
    (a) The current in one conductor is doubled.
    (b) The current in both conductors is tripled.
    (c) The distance between the conductors is halved.