# Summary

## 21.1 Magnets and Magnetic Fields

A magnet is the source of a magnetic force. This force is exerted on other magnets, on iron or a similar metal, or on moving charges. Magnetic force acts over a distance but weakens as you move farther away from the magnet. Poles are regions of a magnet where the force is strongest. All magnets have two poles. One end of a magnet is its north pole. The other end is its south pole. If you cut a magnet in half, each half will have a north pole and a south pole. No matter how many times you cut a magnet, each piece will still have both poles. Like magnetic poles repel one another. Opposite magnetic poles attract one another.

A magnetic field surrounds a magnet. The field can exert magnetic force. A magnetic field is strongest near a magnet's poles. The field will attract or repel other magnets that enter the field. Earth is like a giant magnet. Earth's magnetic poles are close to its geographic poles. Since Earth is like a magnet, a magnetic field surrounds the planet. Earth's magnetic field is called the magnetosphere.

Electrons in atoms have tiny magnetic fields. Sometimes the magnetic fields of many electrons in a material all line up the same way. An area where this occurs is called a magnetic domain. Materials with magnetic domains can be magnetized. This means they can be turned into magnets. A material that can be magnetized is called a ferromagnetic material. Iron is an example of a ferromagnetic material. A ferromagnetic material may remain magnetized briefly or for a long time, depending on the material.

## 21.2 Electromagnetism

Electricity and magnetism are two parts of electromagnetic force. Both forces are due to charged particles. Recall that pushing and pulling between charged particles produces electric force. Moving charged particles produce magnetic force. This is why electrons in atoms have magnetic fields. Electrons are constantly moving around the nucleus. In the 1820s, scientist Hans Oersted discovered that moving charges create a magnetic field. You can demonstrate this by passing a current through a straight wire. The current creates a magnetic field that circles around the wire.

A coil of wire carrying current also produces a magnetic field. A coil of wire acts like a bar magnet. Each end of the coil is a pole. A coil of wire that produces a magnetic field is called a solenoid. An electromagnet is a solenoid with a rod of ferromagnetic material inside the coil. Current flowing through the coil magnetizes the rod. The rod and coil together produce a stronger magnet than the solenoid alone. In a solenoid or electromagnet, you can easily control the magnetic field by controlling the current. You can turn the magnet on and off by turning the current on and off. You can increase or decrease the current to make the magnetic field stronger or weaker. The strength of an electromagnet also depends on the number of loops of wire in the coil and the type of rod inside the coil.

Electromagnetic devices change electrical energy into mechanical energy. Such devices include galvanometers, electric motors, and loudspeakers.

- A galvanometer measures small amounts of current. Galvanometers are used in car fuel gauges.

- An electric motor turns an axle. Electric motors are used in washing machines.
- A loudspeaker reproduces sounds. Loudspeakers are used in stereo systems.

## 21.3 Electrical Energy Generation and Transmission

You can produce an electric current by moving an electrical conductor relative to a magnetic field. Recall that an electrical conductor is a material, such as a metal wire, through which charge can easily flow. You can move a conductor back and forth over a magnet, or you can move a magnet back and forth over a conductor. Current will flow in the conductor whenever it moves relative to the magnet. This process is called electromagnetic induction. Scientist Michael Faraday discovered the process in the 1830s.

Power plants use generators to produce electric current. A generator produces current by turning a coil of wire in a magnetic field. There are two types of generators: AC generators and DC generators. AC generators produce alternating current. DC generators produce direct current. Most power plants today use AC generators. People can also buy small AC generators to provide electricity for their homes during power failures.

Power lines carry power from power plants to homes. The voltage is very high in the lines. The voltage must be lowered before it enters homes. A device called a transformer can decrease voltage. A transformer has two coils of wire, each with a different number of coils. Alternating current produces a changing magnetic field in one coil, called the primary coil. This changing field produces an alternating current in the other coil, called the secondary coil. There are two types of transformers: step-down and step-up.

- In a step-down transformer, the secondary coil has fewer loops than the primary coil. As a result, voltage decreases and current increases.
- In a step-up transformer, the secondary coil has more loops than the primary coil. As a result, voltage increases and current decreases.

There are six major sources of electrical energy used in the United States: coal, water, nuclear energy, wind, natural gas, and petroleum. A turbine uses the energy from one of these six sources to produce electricity. A turbine has blades like a fan. The blades turn when they are pushed by water, wind, or steam. Turning the blades of the turbine causes the coils of a generator to turn. This produces electricity. Water collected behind a dam, or blowing wind, can force the blades of a turbine to turn. Steam from water heated by burning coal or another fuel can also force the blades to turn.