*Television*

A television receiver does similar things to both the audio and the video signals. The audio signal goes finally to the loudspeaker, and the video signal to the monitor, such as a *cathode ray tube* (CRT) or LCD screen (Sections 17–10 and 24–11).

*Antennas*

One kind of antenna consists of one or more conducting rods; the electric field in the EM waves exerts a force on the electrons in the conductor, causing them to move back and forth at the frequencies of the waves (Fig. 22–17a). A second type of antenna consists of a tubular coil of wire which detects the magnetic field of the wave: the changing $B$ field induces an emf in the coil (Fig. 22–17b). A satellite dish (Fig. 22–18) consists of a parabolic reflector that focuses the EM waves onto a "horn," similar to a concave mirror telescope (Fig. 25–21).

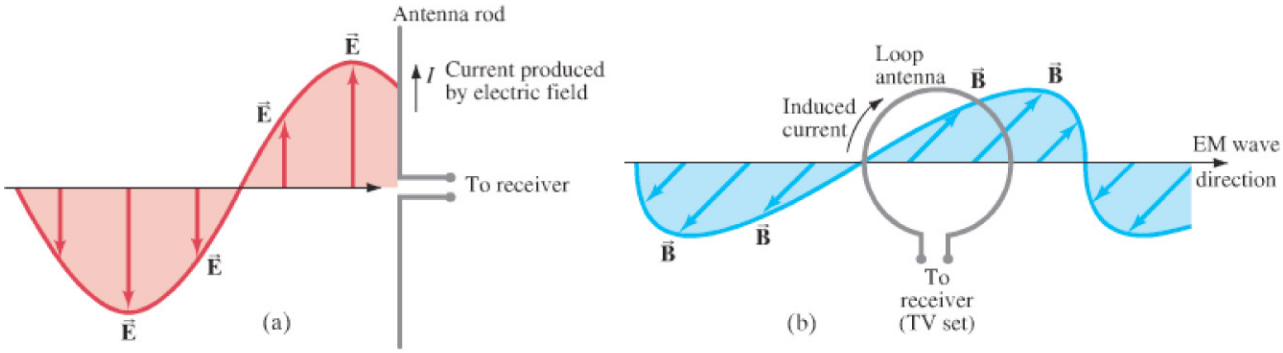


**FIGURE 22–17** Antennas. (a) Electric field of EM wave produces a current in an antenna consisting of straight wire or rods. (b) Changing magnetic field induces an emf and current in a loop antenna.

**FIGURE 22–18** A satellite dish.


**EXAMPLE 22–6** **Tuning a station.** Calculate the transmitting wavelength of an FM radio station that transmits at 100 MHz.

**APPROACH** Radio is transmitted as an EM wave, so the speed is $c = 3.0 \times 10^8\,\text{m/s}$. The wavelength is found from Eq. 22–4, $\lambda = c/f$.

**SOLUTION** The carrier frequency is $f = 100\,\text{MHz} = 1.0 \times 10^8\,\text{s}^{-1}$, so

$$\lambda = \frac{c}{f} = \frac{(3.0 \times 10^8\,\text{m/s})}{(1.0 \times 10^8\,\text{s}^{-1})} = 3.0\,\text{m}.$$

**NOTE** The wavelengths of other FM signals (88 MHz to 108 MHz) are close to the 3.0-m wavelength of this station. FM antennas are typically 1.5 m long, or about a half wavelength. This length is chosen so that the antenna reacts in a resonant fashion and thus is more sensitive to FM frequencies. AM radio antennas would have to be much too long to be either $\frac{1}{2}\lambda$ or $\frac{1}{4}\lambda$.

## Other EM Wave Communications

PHYSICS APPLIED

*Cell phones, radio control, remote control, cable TV, and satellite TV and radio*

The various regions of the radio-wave spectrum are assigned by governmental agencies for various purposes. Besides those mentioned above, there are "bands" assigned for use by ships, airplanes, police, military, amateurs, satellites and space, and radar. Cell phones, for example, are complete radio transmitters and receivers which in the U.S. function on two different bands: 800 MHz and 1900 MHz (= 1.9 GHz), whereas in Europe and Asia 900-MHz and 1800-MHz bands are used in the international standard called GSM (Global System for Mobile Communication). Radio-controlled toys (cars, sailboats, robotic animals, etc.) can use various frequencies from 27 MHz to 75 MHz. Automobile remote (keyless) entry may operate around 300 MHz or 400 MHz.

Cable TV channels are carried as electromagnetic waves along a coaxial cable (see Fig. 22–9) rather than being broadcast and received through the "air." The channels are in the same part of the EM spectrum, hundreds of MHz, but some are at frequencies not available for TV broadcast. Digital satellite TV and radio are carried in the microwave portion of the spectrum (12 to 14 GHz and 2.3 GHz, respectively).