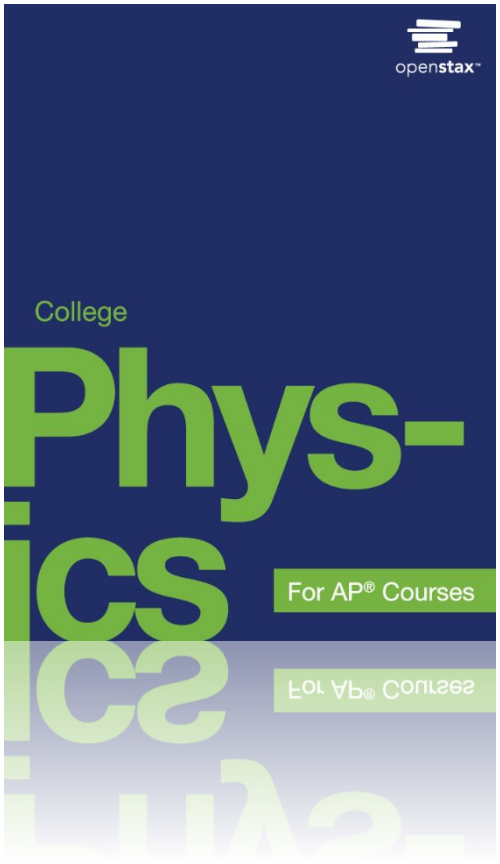
COLLEGE PHYSICS FOR AP® COURSES

Chapter 24 ELECTROMAGNETIC WAVES

PowerPoint Image Slideshow



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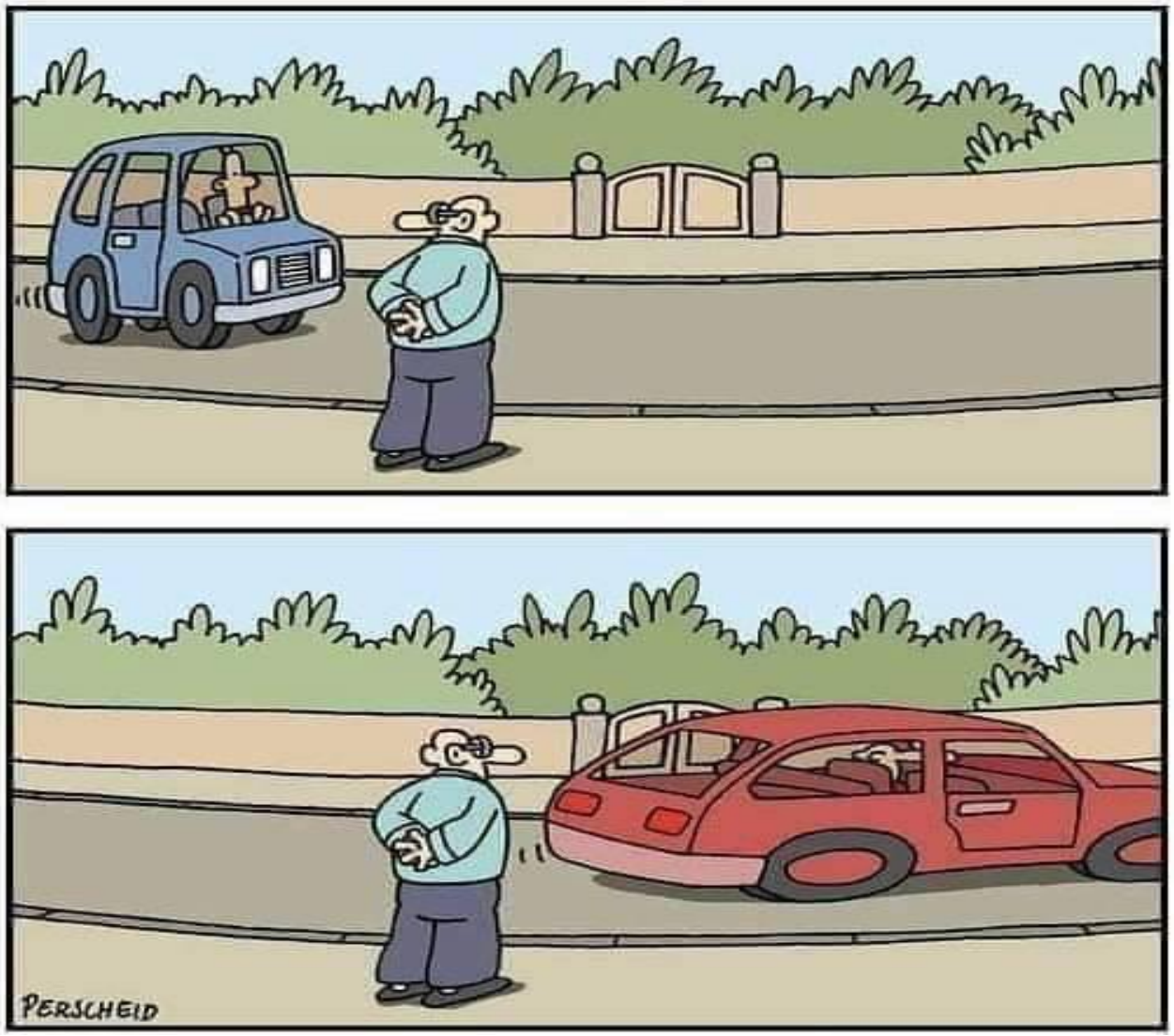
New Quarter, New You.

There is always a different POV.

Ice Breaker



Well, that's awkward.

FIGURE 24.1

Human eyes detect these orange “sea goldie” fish swimming over a coral reef in the blue waters of the Gulf of Eilat (Red Sea) using visible light. (credit: Daviddarom, Wikimedia Commons)

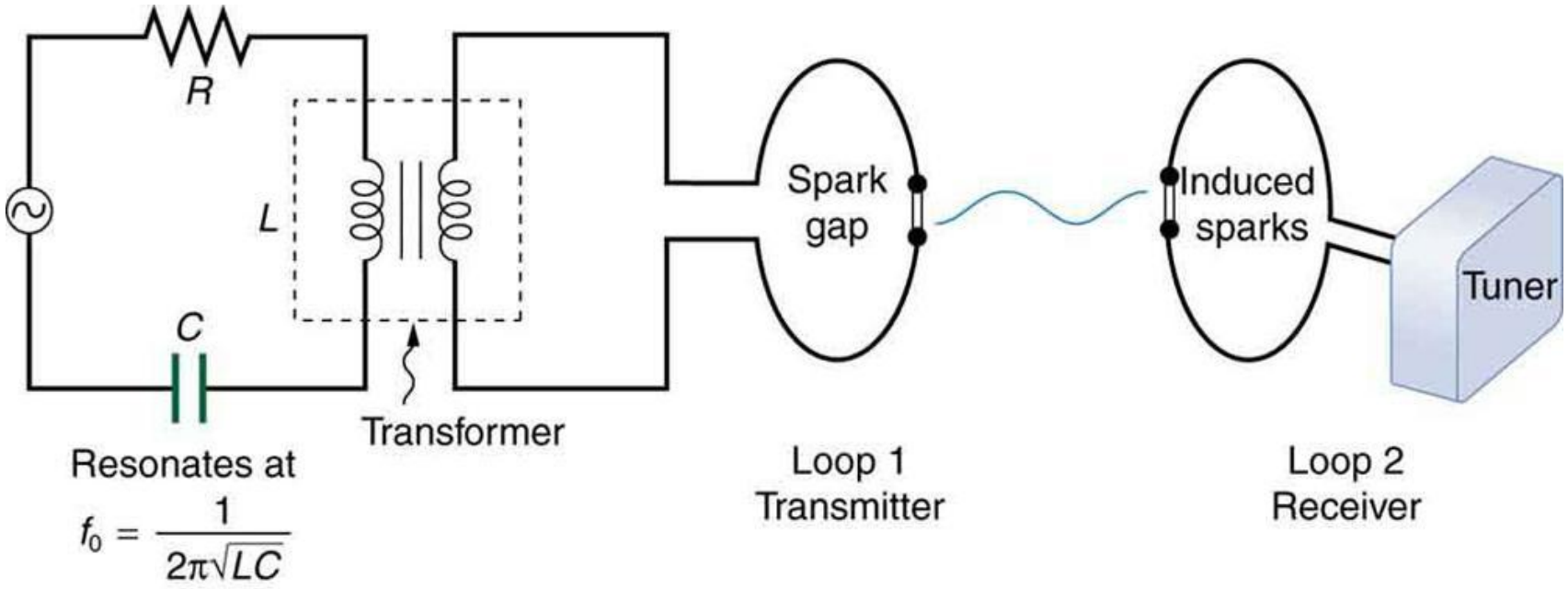
FIGURE 24.2

The electromagnetic waves sent and received by this 50-foot radar dish antenna at Kennedy Space Center in Florida are not visible, but help track expendable launch vehicles with high-definition imagery. The first use of this C-band radar dish was for the launch of the Atlas V rocket sending the New Horizons probe toward Pluto. (credit: NASA)

FIGURE 24.3

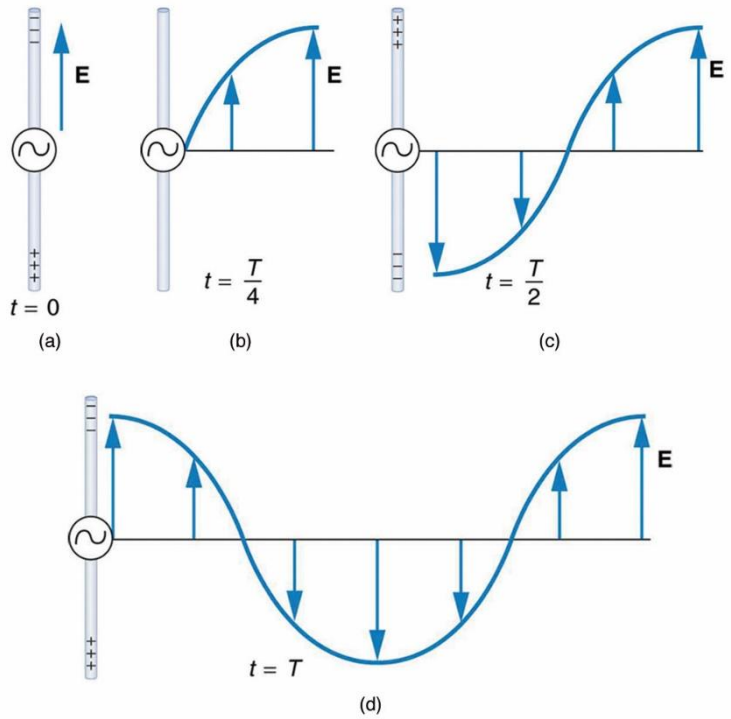
James Clerk Maxwell, a 19th-century physicist, developed a theory that explained the relationship between electricity and magnetism and correctly predicted that visible light is caused by electromagnetic waves. (credit: G. J. Stodart)

FIGURE 24.4



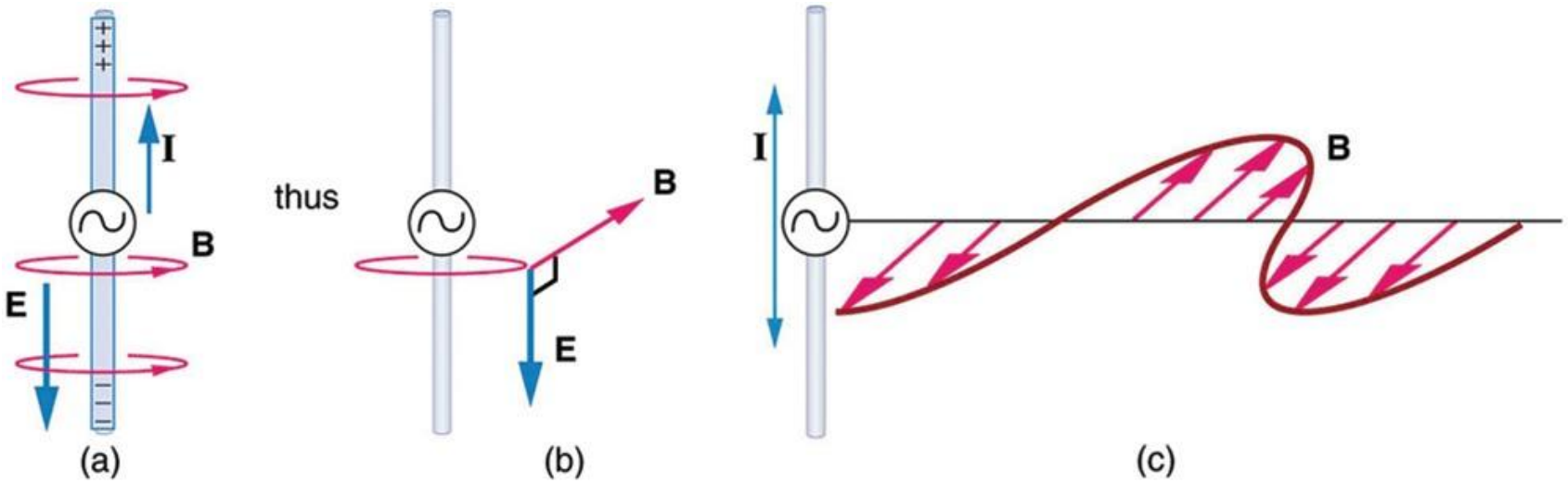
The apparatus used by Hertz in 1887 to generate and detect electromagnetic waves. An RLC circuit connected to the first loop caused sparks across a gap in the wire loop and generated electromagnetic waves. Sparks across a gap in the second loop located across the laboratory gave evidence that the waves had been received.

FIGURE 24.5



This long straight gray wire with an AC generator at its center becomes a broadcast antenna for electromagnetic waves. Shown here are the charge distributions at four different times. The electric field (**E**) propagates away from the antenna at the speed of light, forming part of an electromagnetic wave.

FIGURE 24.6

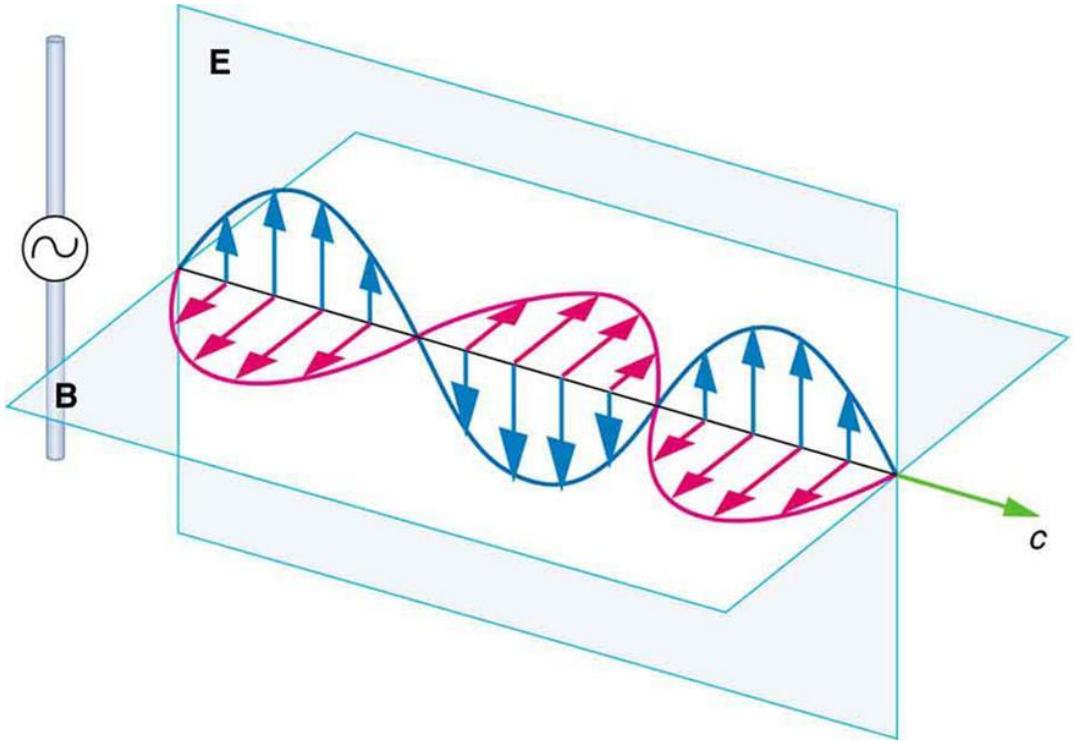


(a) The current in the antenna produces the circular magnetic field lines. The current (I) produces the separation of charge along the wire, which in turn creates the electric field as shown.

(b) The electric and magnetic fields (**E** and **B**) near the wire are perpendicular; they are shown here for one point in space.

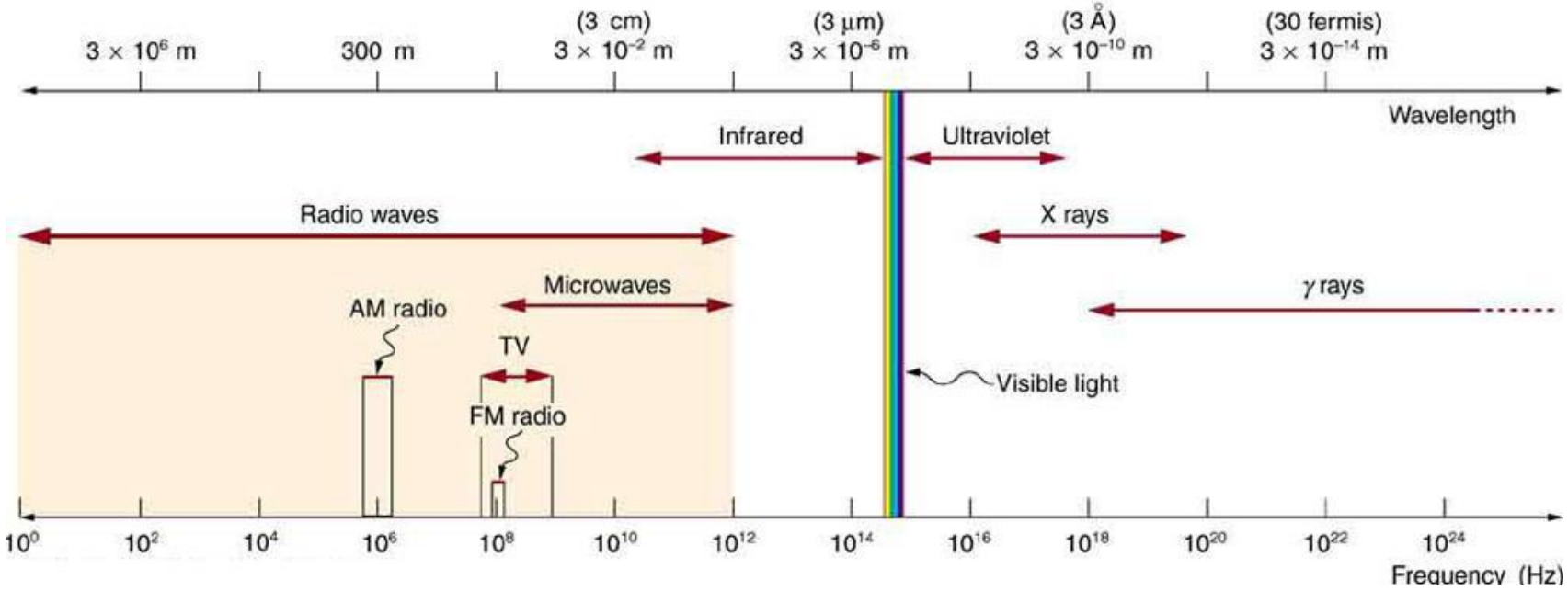
(c) The magnetic field varies with current and propagates away from the antenna at the speed of light.

FIGURE 24.7



A part of the electromagnetic wave sent out from the antenna at one instant in time. The electric and magnetic fields (**E** and **B**) are in phase, and they are perpendicular to one another and the direction of propagation. For clarity, the waves are shown only along one direction, but they propagate out in other directions too.

FIGURE 24.9

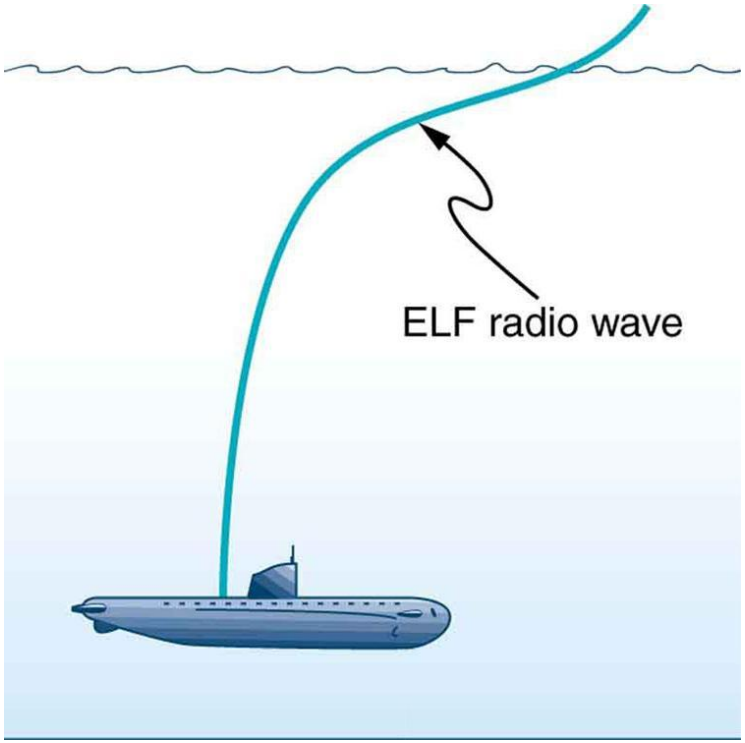


The electromagnetic spectrum, showing the major categories of electromagnetic waves. The range of frequencies and wavelengths is remarkable. The dividing line between some categories is distinct, whereas other categories overlap.

FIGURE 24.10

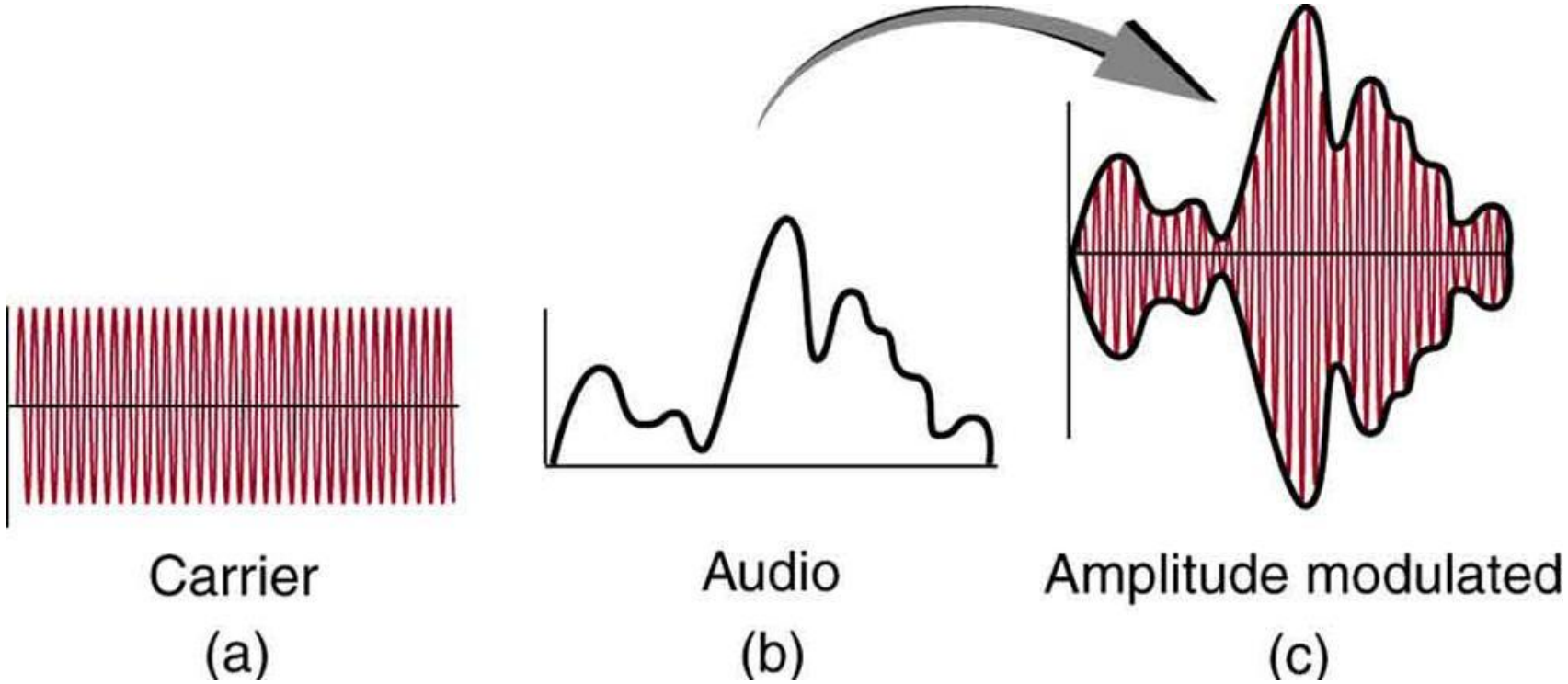
This high-voltage traction power line running to Eutingen Railway Substation in Germany radiates electromagnetic waves with very long wavelengths. (credit: Zonk43, Wikimedia Commons)

FIGURE 24.11



Very long wavelength radio waves are needed to reach this submarine, requiring extremely low frequency signals (ELF). Shorter wavelengths do not penetrate to any significant depth.

FIGURE 24.12



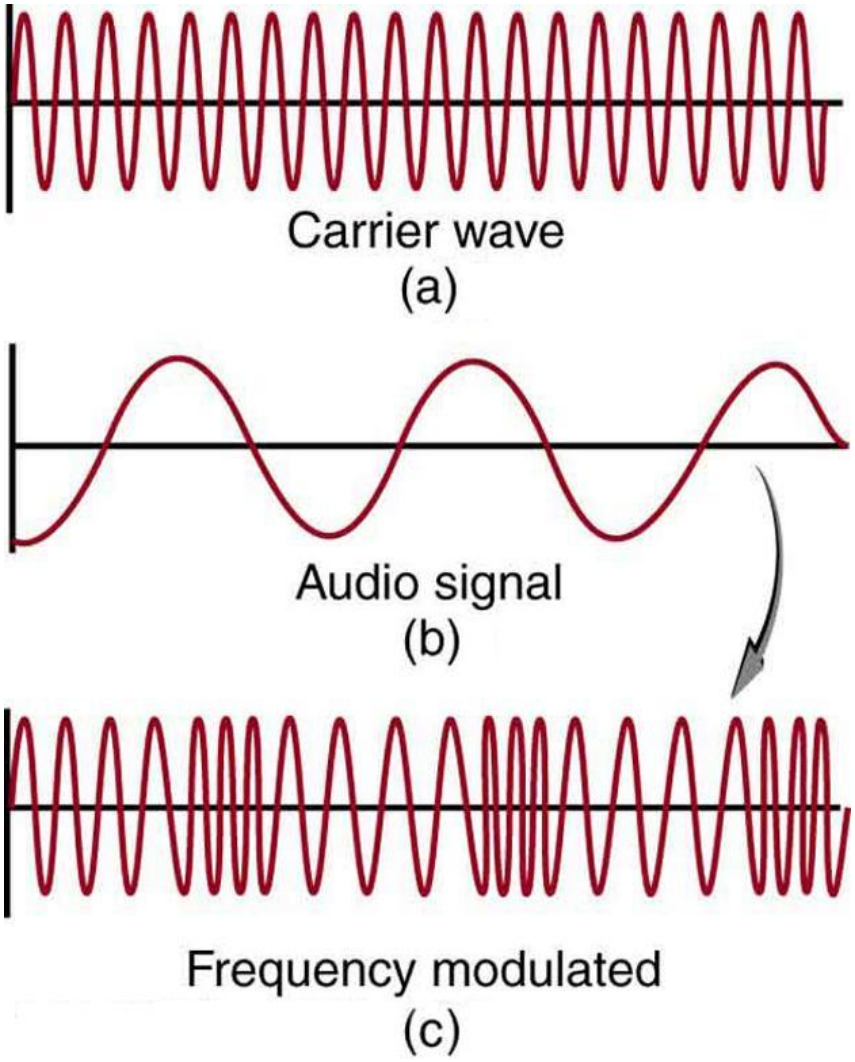
Amplitude modulation for AM radio.

(a) A carrier wave at the station's basic frequency.

(b) An audio signal at much lower audible frequencies.

(c) The amplitude of the carrier is modulated by the audio signal without changing its basic frequency.

FIGURE 24.13



Frequency modulation for FM radio.

(a) A carrier wave at the station's basic frequency.

(b) An audio signal at much lower audible frequencies.

(c) The frequency of the carrier is modulated by the audio signal without changing its amplitude.

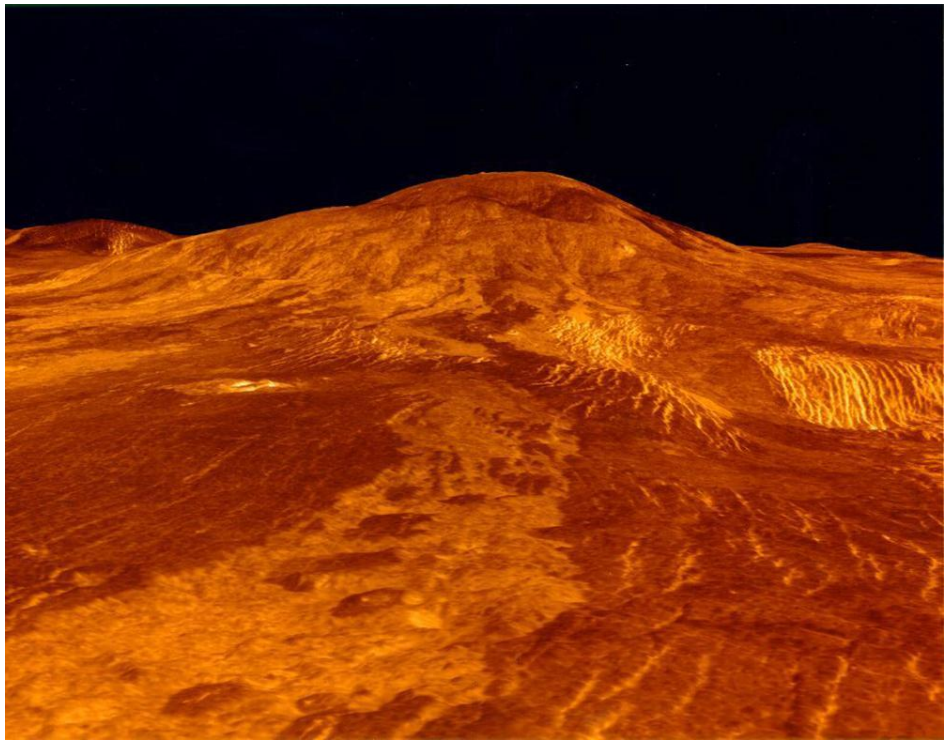
FIGURE 24.14

(a) (b)

(a) A large tower is used to broadcast TV signals. The actual antennas are small structures on top of the tower—they are placed at great heights to have a clear line of sight over a large broadcast area. (credit: Ozizo, Wikimedia Commons)

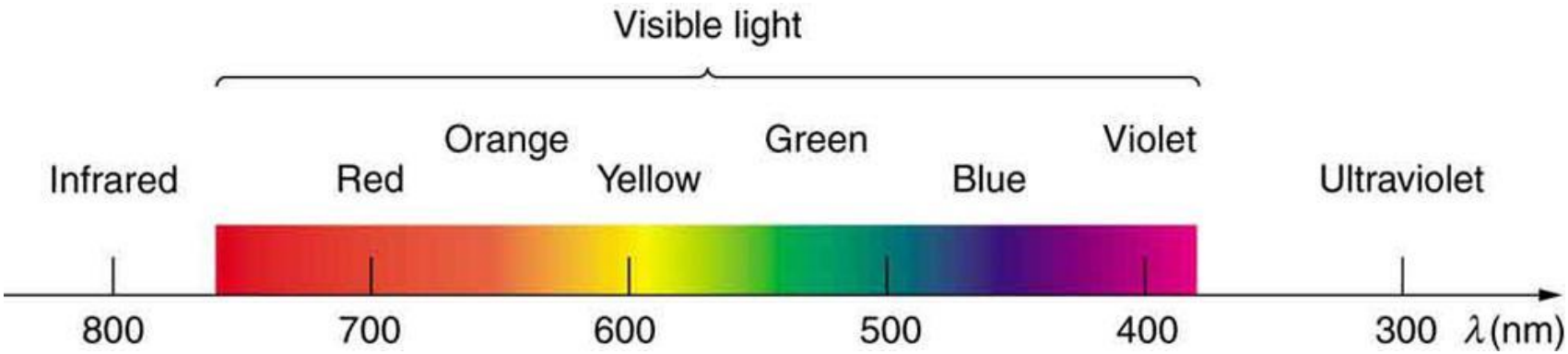
(b) The NTT Dokomo mobile phone tower at Tokorozawa City, Japan. (credit: tokoroten, Wikimedia Commons)

FIGURE 24.15



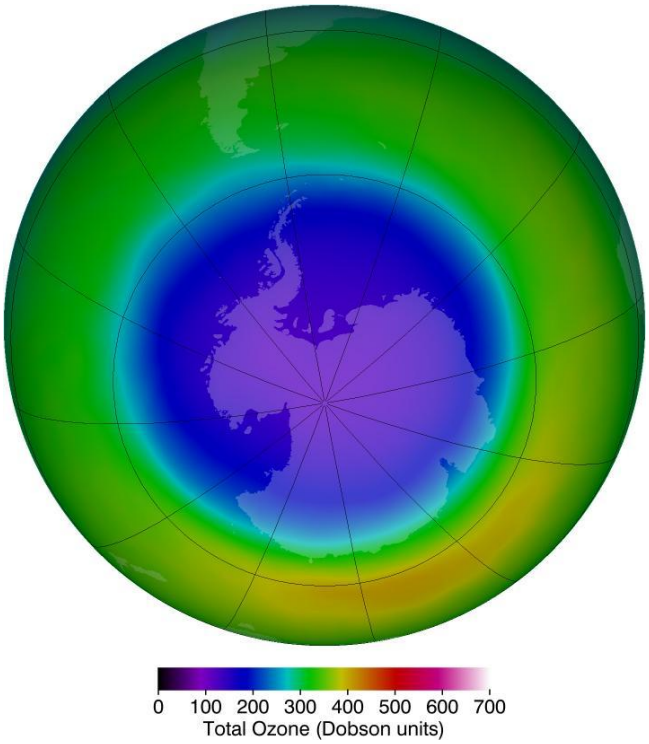
An image of Sif Mons with lava flows on Venus, based on Magellan synthetic aperture radar data combined with radar altimetry to produce a three-dimensional map of the surface. The Venusian atmosphere is opaque to visible light, but not to the microwaves that were used to create this image. (credit: NSSDC, NASA/JPL)

FIGURE 24.16



A small part of the electromagnetic spectrum that includes its visible components. The divisions between infrared, visible, and ultraviolet are not perfectly distinct, nor are those between the seven rainbow colors.

FIGURE 24.17



This map of ozone concentration over Antarctica in October 2011 shows severe depletion suspected to be caused by CFCs. Less dramatic but more general depletion has been observed over northern latitudes, suggesting the effect is global. With less ozone, more ultraviolet radiation from the Sun reaches the surface, causing more damage. (credit: NASA Ozone Watch)

FIGURE 24.18

Artist's conception of an electron ionizing an atom followed by the recapture of an electron and emission of an X-ray.
An energetic electron strikes an atom and knocks an electron out of one of the orbits closest to the nucleus. Later, the atom captures another electron, and the energy released by its fall into a low orbit generates a high-energy EM wave called an X-ray.

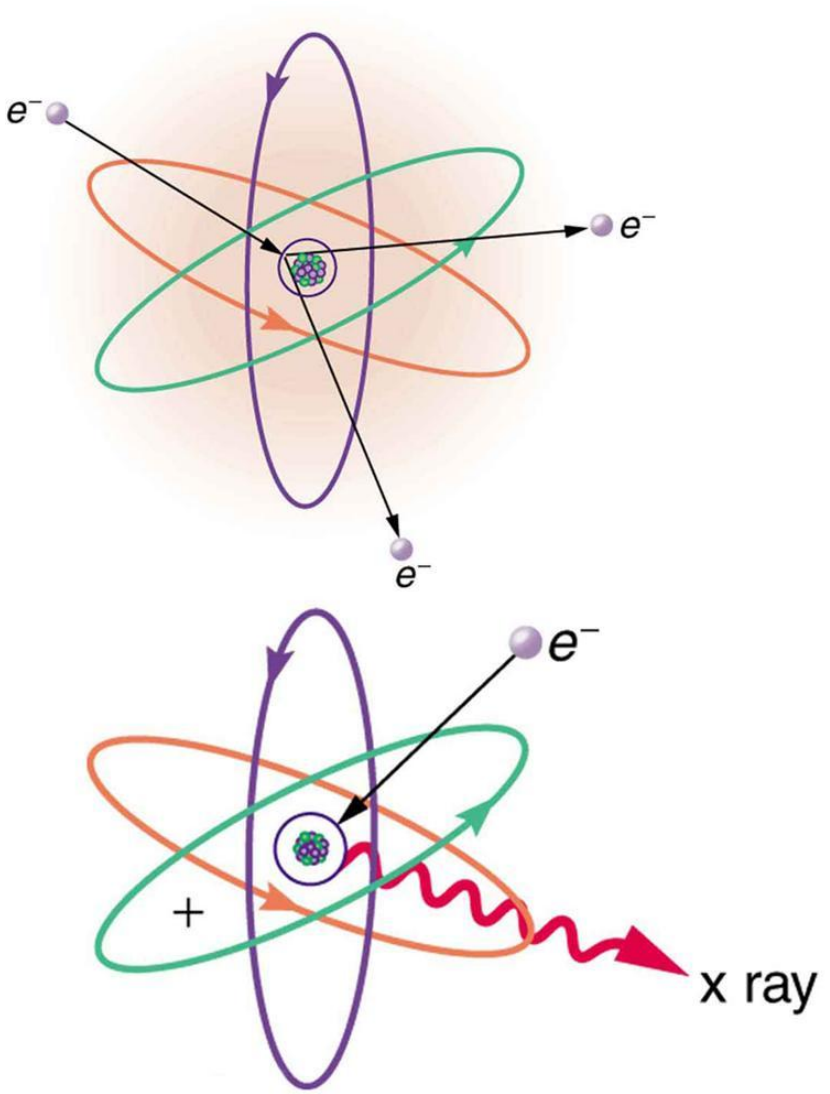
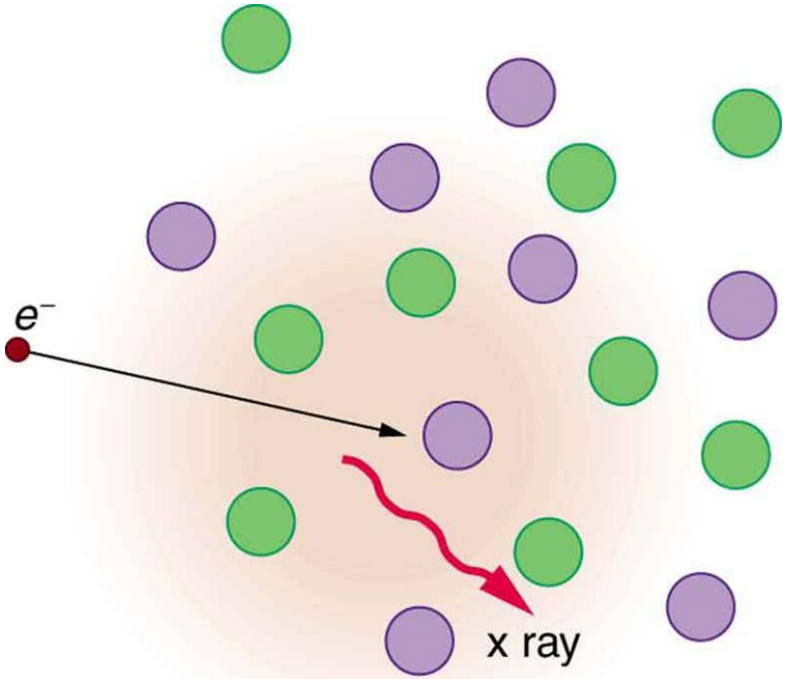
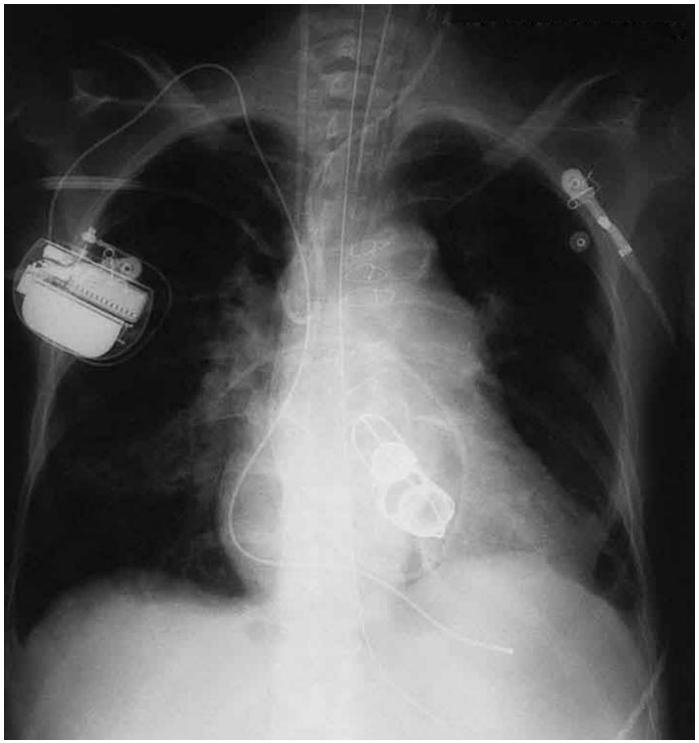


FIGURE 24.19



Artist's conception of an electron being slowed by collisions in a material and emitting X-ray radiation. This energetic electron makes numerous collisions with electrons and atoms in a material it penetrates. An accelerated charge radiates EM waves, a second method by which X-rays are created.

FIGURE 24.20

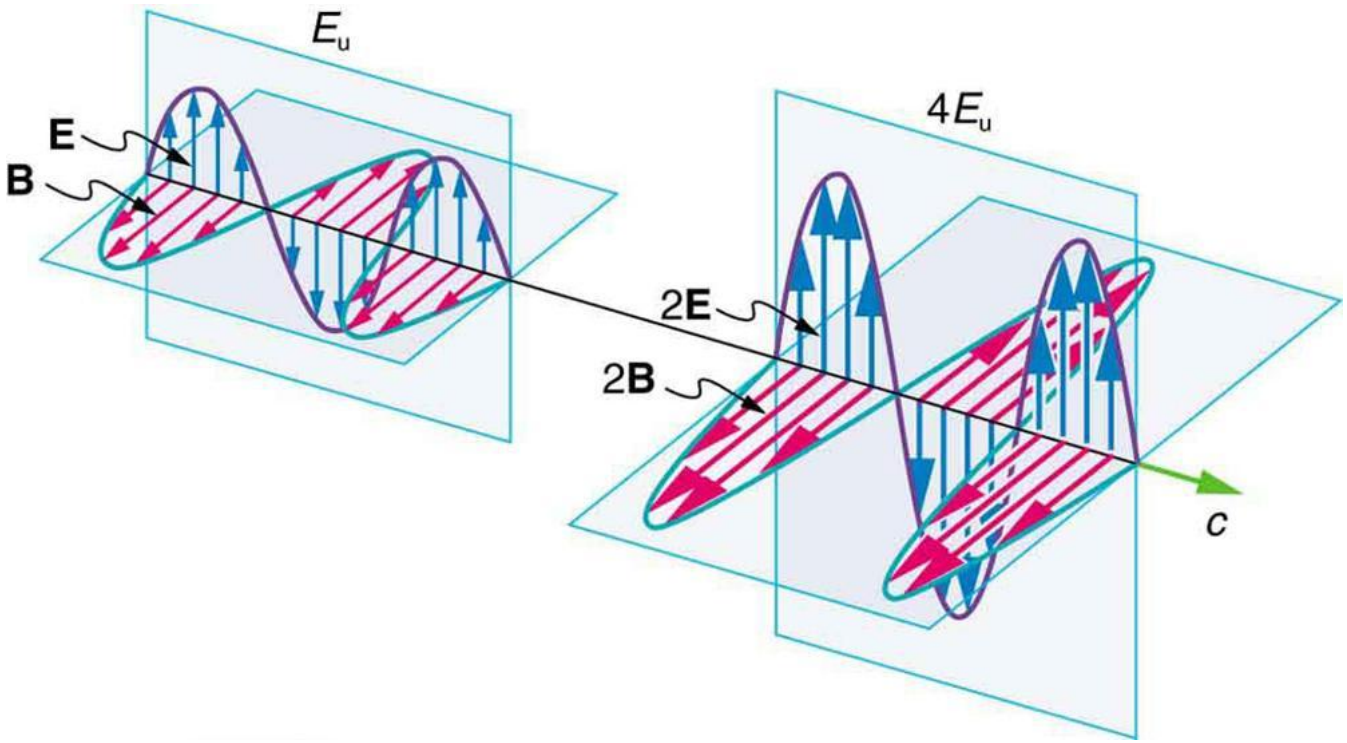


This shadow X-ray image shows many interesting features, such as artificial heart valves, a pacemaker, and the wires used to close the sternum. (credit: P. P. Urone)

FIGURE 24.21

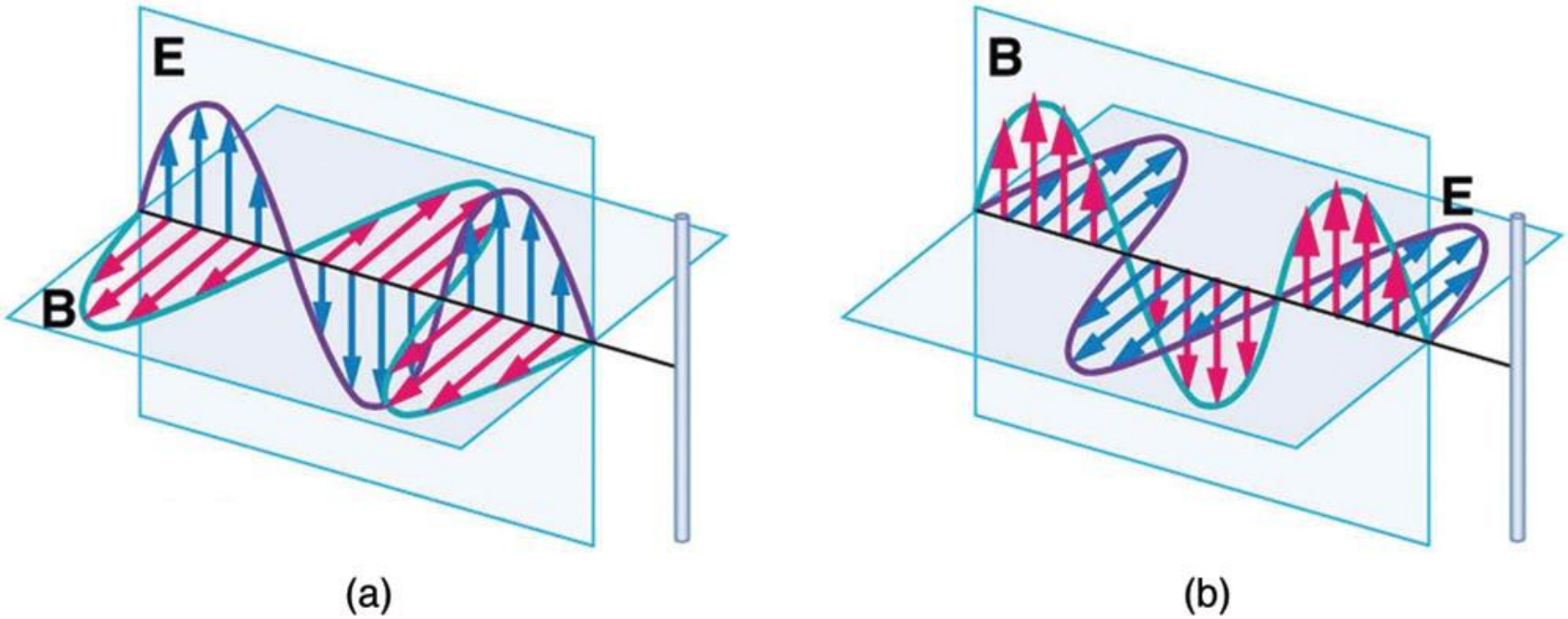
This is an image of the γ rays emitted by nuclei in a compound that is concentrated in the bones and eliminated through the kidneys. Bone cancer is evidenced by nonuniform concentration in similar structures. For example, some ribs are darker than others. (credit: P. P. Urone)

FIGURE 24.23



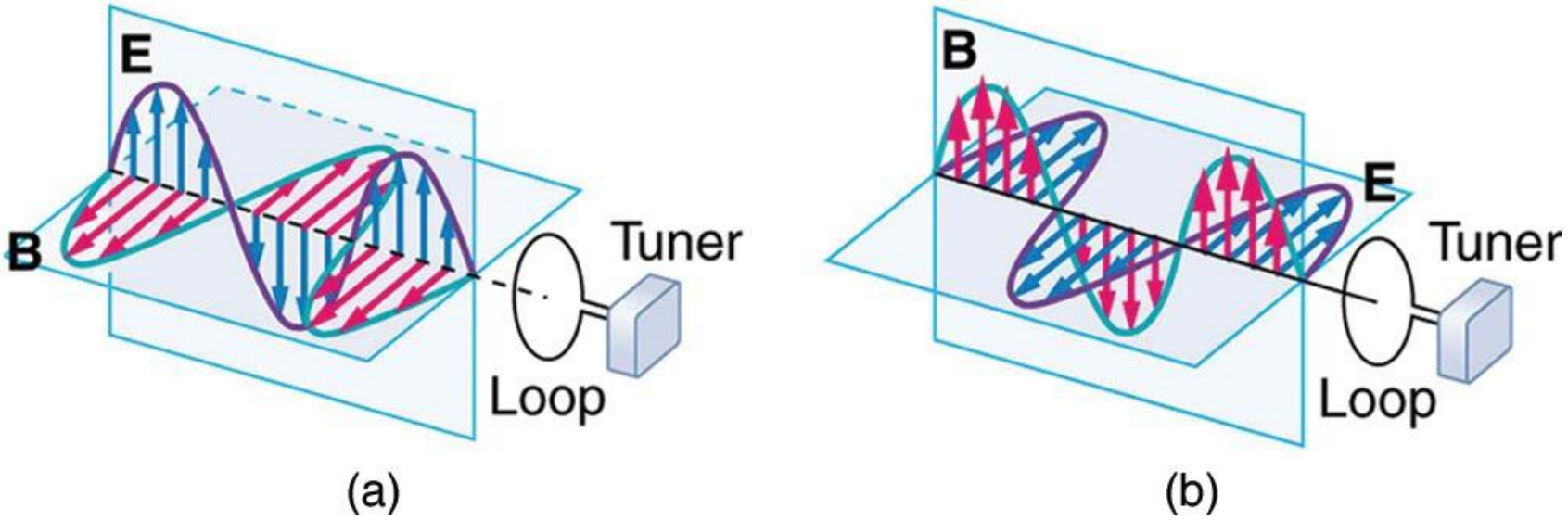
Energy carried by a wave is proportional to its amplitude squared. With electromagnetic waves, larger E -fields and B -fields exert larger forces and can do more work.

FIGURE 24.24



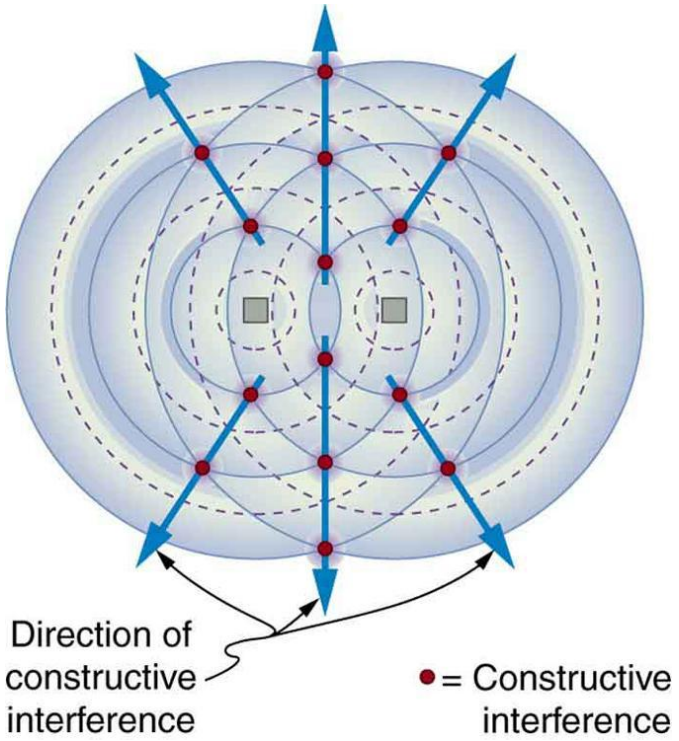
Electromagnetic waves approaching long straight wires.

FIGURE 24.25



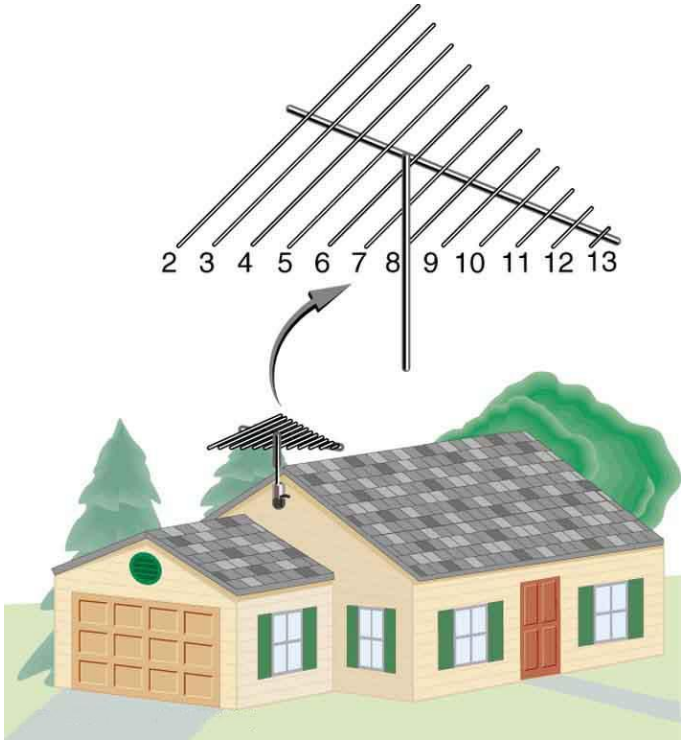
Electromagnetic waves approaching a wire loop.

FIGURE 24.26



An overhead view of two radio broadcast antennas sending the same signal, and the interference pattern they produce.

FIGURE 24.27



A television reception antenna has cross wires of various lengths to most efficiently receive different wavelengths.

FIGURE 24.28

Satellite dishes receive TV signals sent from orbit. Although the signals are quite weak, the receiver can detect them by being tuned to resonate at their frequency.

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