PRACTICE A

Electromagnetic Waves

1. Gamma-ray bursters are objects in the universe that emit pulses of gamma rays with high energies. The frequency of the most energetic bursts has been measured at around 3.0×10^{21} Hz. What is the wavelength of these gamma rays?
2. What is the wavelength range for the FM radio band (88 MHz–108 MHz)?
3. Shortwave radio is broadcast between 3.50 and 29.7 MHz. To what range of wavelengths does this correspond? Why do you suppose this part of the spectrum is called shortwave radio?
4. What is the frequency of an electromagnetic wave if it has a wavelength of 1.0 km?
5. The portion of the visible spectrum that appears brightest to the human eye is around 560 nm in wavelength, which corresponds to yellow-green. What is the frequency of 560 nm light?
6. What is the frequency of highly energetic ultraviolet radiation that has a wavelength of 125 nm?

Waves can be approximated as rays

Consider an ocean wave coming toward the shore. The broad crest of the wave that is perpendicular to the wave's motion consists of a line of water particles. Similarly, another line of water particles forms a low-lying trough in the wave, and still another line of particles forms the crest of a second wave. In any type of wave, these lines of particles are called *wave fronts.*

All the points on the wave front of a plane wave can be treated as point sources, that is, coming from a source of neglibible size. A few of these points are shown on the initial wave front in **Figure 3.** Each of these point sources produces a circular or spherical secondary wave, or *wavelet.* The radii of these wavelets are indicated by the blue arrows in **Figure 3.** The line that is tangent to each of these wavelets at some later time determines the new position of the initial wave front (the new wave front in **Figure 3**). This approach to analyzing waves is called *Huygens' principle,* named for the physicist Christian Huygens, who developed it.

Huygens' principle can be used to derive the properties of any wave (including light) that interacts with matter, but the same results can be obtained by treating the propagating wave as a straight line perpendicular to the wave front. This line is called a *ray,* and this simplification is called the *ray approximation.*

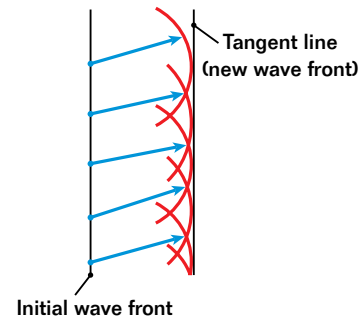

Figure 3
According to Huygens' principle, a wave front can be divided into point sources. The line tangent to the wavelets from these sources marks the wave front's new position.