APPROACH We find the angles for violet and red light from the distances given and the diagram of Fig. 24–10. Then we use Eq. 24–2a to obtain the wavelengths. Because 3.5 mm is much less than 2.5 m, we can use the small-angle approximation.

SOLUTION We use Eq. 24–2a with $m = 1$ and $\sin\theta \approx \tan\theta \approx \theta$. Then for violet light, $x = 2.0\text{ mm}$, so (see also Fig. 24–10)

$$\lambda = \frac{d\sin\theta}{m} \approx \frac{d\theta}{m} \approx \frac{d}{m}\frac{x}{L} = \left(\frac{5.0\times10^{-4}\text{ m}}{1}\right)\left(\frac{2.0\times10^{-3}\text{ m}}{2.5\text{ m}}\right) = 4.0\times10^{-7}\text{ m},$$

or 400 nm. For red light, $x = 3.5\text{ mm}$, so

$$\lambda = \frac{d}{m}\frac{x}{L} = \left(\frac{5.0\times10^{-4}\text{ m}}{1}\right)\left(\frac{3.5\times10^{-3}\text{ m}}{2.5\text{ m}}\right) = 7.0\times10^{-7}\text{ m} = 700\text{ nm}.$$

EXERCISE A For the setup in Example 24–3, how far from the central white fringe is the first-order fringe for green light $\lambda = 500\text{ nm}$?

Coherent Light

The two slits in Fig. 24–7 act as if they were two sources of radiation. They are called **coherent sources** because the waves leaving them have the same wavelength and frequency, and bear the same phase relationship to each other at all times. This happens because the waves come from a single source to the left of the two slits in Fig. 24–7. An interference pattern is observed only when the sources are coherent. If two tiny lightbulbs replaced the two slits, an interference pattern would not be seen. The light emitted by one lightbulb would have a random phase with respect to the second bulb, and the screen would be more or less uniformly illuminated. Two such sources, whose output waves bear no fixed phase relationship to each other, are called **incoherent sources**.

Coherent and incoherent sources

Interference patterns occur only if sources are coherent

24–4 The Visible Spectrum and Dispersion

The two most obvious properties of light are readily describable in terms of the wave theory of light: intensity (or brightness) and color. The **intensity** of light is the energy it carries per unit area per unit time, and is related to the square of the amplitude of the wave, just as for any wave (see Section 11–10, or Eqs. 22–7 and 22–8). The **color** of the light is related to the frequency f or wavelength λ of the light. (Recall $\lambda f = c = 3.0\times10^{8}\text{ m/s}$, Eq. 22–4.) Visible light—that to which our eyes are sensitive—consists of frequencies from 4×10^{14} Hz to 7.5×10^{14} Hz, corresponding to wavelengths in air of about 400 nm to 750 nm.[†] This is known as the **visible spectrum**, and within it lie the different colors from violet to red, as shown in Fig. 24–12. Light with wavelength shorter than 400 nm is called **ultraviolet** (UV), and light with wavelength longer than 750 nm is called **infrared** (IR).[‡] Although human eyes are not sensitive to UV or IR, some types of photographic film and other detectors do respond to them.

[†] Sometimes the angstrom (Å) unit is used when referring to light: $1\text{ Å} = 1\times10^{-10}\text{ m}$. Visible light has wavelengths in air of 4000 Å to 7500 Å.

[‡] The complete electromagnetic spectrum is illustrated in Fig. 22–8.

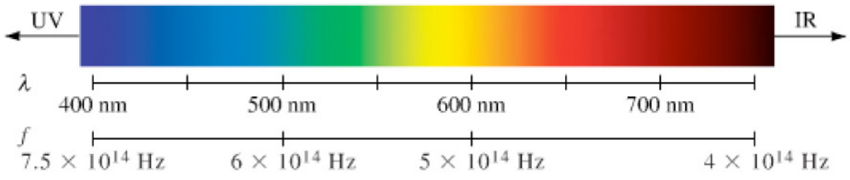

FIGURE 24–12 The spectrum of visible light, showing the range of frequencies and wavelengths (in air) for the various colors.