LENS ABERRATIONS

One of the basic problems of lenses and lens systems is the imperfect quality of the images. The simple theory of mirrors and lenses assumes that rays make small angles with the principal axis and that all rays reaching the lens or mirror from a point source are focused at a single point, producing a sharp image. Clearly, this is not always true in the real world. Where the approximations used in this theory do not hold, imperfect images are formed.

As with spherical mirrors, *spherical aberration* occurs for lenses also. It results from the fact that the focal points of light rays far from the principal axis of a spherical lens are different from the focal points of rays with the same wavelength passing near the axis. Rays near the middle of the lens are focused farther from the lens than rays at the edges.

Another type of aberration, called **chromatic aberration,** arises from the wavelength dependence of refraction. Because the index of refraction of a material varies with wavelength, different wavelengths of light are focused at different focal points by a lens. For example, when white light passes through a lens, violet light is refracted more than red light, as shown in **Figure 14;** thus, the focal length for red light is greater than that for violet light. Other colors' wavelengths have intermediate focal points. Because a diverging lens has the opposite shape, the chromatic aberration for a diverging lens is opposite that for a converging lens. Chromatic aberration can be greatly reduced by the use of a combination of converging and diverging lenses made from two different types of glass.

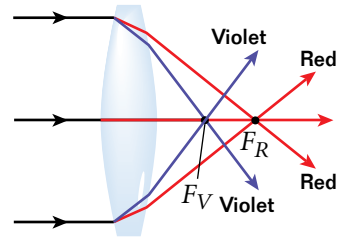

Figure 14
Because of dispersion, white light passing through a converging lens is focused at different focal points for each wavelength of light. (The angles in this figure are exaggerated for clarity.)

chromatic aberration

the focusing of different colors of light at different distances behind a lens

SECTION REVIEW

1. Find the critical angle for light traveling from water ($n = 1.333$) into ice ($n = 1.309$).
2. Which of the following describe places where a mirage is likely to appear?
   - **a.** above a warm lake on a warm day
   - **b.** above an asphalt road on a hot day
   - **c.** above a ski slope on a cold day
   - **d.** above the sand on a beach on a hot day
   - **e.** above a black car on a sunny day
3. When white light passes through a prism, which will be bent more, the red or green light?
4. **Critical Thinking** After a storm, a man walks out onto his porch. Looking to the east, he sees a rainbow that has formed above his neighbor's house. What time of day is it, morning or evening?