

KEY IDEAS

Section 1 Refraction

- According to Snell's law, as a light ray travels from one medium into another medium where its speed is different, the light ray will change its direction unless it travels along the normal.
- When light passes from a medium with a smaller index of refraction to one with a larger index of refraction, the ray bends toward the normal. For the opposite situation, the ray bends away from the normal.

Section 2 Thin Lenses

- The image produced by a converging lens is real and inverted when the object is outside the focal point and virtual and upright when the object is inside the focal point. Diverging lenses always produce upright, virtual images.
- The location of an image created by a lens can be found using either a ray diagram or the thin-lens equation.

Section 3 Optical Phenomena

- Total internal reflection can occur when light attempts to move from a material with a higher index of refraction to one with a lower index of refraction. If the angle of incidence of a ray is greater than the critical angle, the ray is totally reflected at the boundary.
- Mirages and the visibility of the sun after it has physically set are natural phenomena that can be attributed to refraction of light in Earth's atmosphere.

KEY TERMS

refraction (p. 488)

index of refraction (p. 490)

lens (p. 494)

total internal reflection
(p. 506)

critical angle (p. 506)

dispersion (p. 509)

chromatic aberration
(p. 511)

PROBLEM SOLVING

See **Appendix D: Equations** for a summary of the equations introduced in this chapter. If you need more problem-solving practice, see **Appendix I: Additional Problems**.

Variable Symbols

Quantities		Units	
θ_i	angle of incidence	$^\circ$	degrees
θ_r	angle of refraction	$^\circ$	degrees
n	index of refraction		
p	distance from object to lens	m	meters
q	distance from image to lens	m	meters
h'	image height	m	meters
h	object height	m	meters
θ_c	critical angle	$^\circ$	degrees