Self Reflection

Remember Narcissus, the beautiful but self-absorbed young boy of Greek mythology? Wandering through the forest one day, he comes across a deep pool of liquid with refractive index 1.33 (normal people would call this a pond). Narcissus bends over to drink and sees his reflection for the first time. The child he beholds is beautiful, and Narcissus falls in love. Of course, the boy soon realizes that he is seeing himself, and that he will never be able to act on his infatuation. He tears at his clothes and body and collapses and dies on the shore of the pond. The legend concludes with the Narcissus flower, commonly known as the daffodil, springing up from the point where he expired.

Had young Narcissus spent more time at the faceting machine, rather than hunting stags and prancing about with nymphs, he would have immediately realized that the dim figure visible in the pool was the result of partial surface reflection, and not a viable object of affection.

Interestingly, Narcissus and his problems of self-reflection live on in the modern optics industry. Ghosts and double images caused by the partial surface reflection of bright objects off the film (or nowadays the CCD) in a camera are known as "Narcissus ghosts."

Figure 11-18 Narcissus struggling with surface reflections (painting by Caravaggio, ca. 1595).

As with refraction and TIR, the refractive index is the key. The amount of light reflected from a surface depends on the index of refraction on each side of the interface. Specifically, the fraction R of light reflected is:

$$R = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2$$

where n_1 and n_2 are the two indices of refraction. This is known as the *Fresnel reflection law*, after the French physicist Augustin-Jean Fresnel, who correctly derived the equations governing the effect. Figure 11-19 plots the amount of surface reflection for light entering a gemstone from air (n_1=1).

Technically speaking, this formula only holds for light that strikes the surface of the gem nearly perpendicularly – that is, the incident angle in Snell's law is near zero degrees. It turns out that with real-world materials and non-perpendicular incidence, one polarization of the light experiences a greater surface reflection while the other experiences less. This explains the situation with the afternoon sunlight and asphalt described in Section 11.2.2. Neverthe-