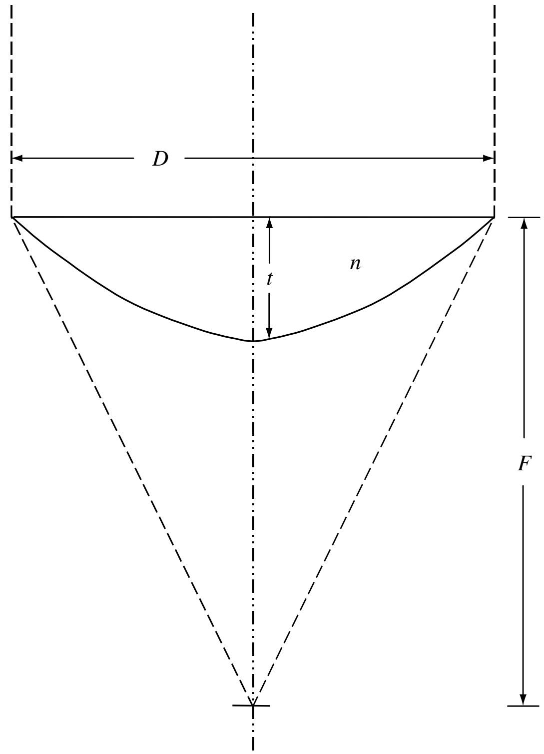

Figure 11.28 Refractive lens geometry

optical path length. (And hence, if they leave the source at the same time, they will arrive at the focus at the same time, regardless of where they strike the lens.) By equating the optical path length of the two rays shown in Figure 11.28, one obtains

$$F + (n - 1)t = \sqrt{(F - y)^2 + x^2} + ny$$

This is the equation of a hyperbola. Such a lens is called *aspheric* to differentiate it from the common spherical lens that is an approximation of the above for large F and small x. The thickness of the lens can be related to the f-number by setting $x = D/2$, the edge of the lens, giving

$$\frac{t}{D} = \frac{\sqrt{F^2/D^2 + 1/4} - F/D}{n - 1}$$

A serious problem with such a lens is that it becomes rather thick for short f-numbers. For example, for $F/D = 1$ and $n = 1.5$, one obtains $t/D = 0.24$. If the lens has a diameter of 10 cm, then the thickness will be 2.4 cm, resulting in a rather heavy, material-intensive structure. For small lenses on the order of several centimeters in diameter, the thickness is quite acceptable. Such "microlenses," accompanied by small cells at the focus, are an interesting avenue for possible development. This approach was explored by Wattsun [52].