5.1 Single-lens systems

To see how the analytical tools developed in the previous chapter may be applied to the design of some simple optical systems, we study first systems formed by a single lens. You may find it useful to reproduce these examples using our virtual optical bench.

5.1.1 A magnifying glass

Angular size

What we perceive as the "size" of an object is the angle that it subtends in our field of vision. (See Figure 5.1). Clearly, to increase the angular size of a small object in order to see it better, we need

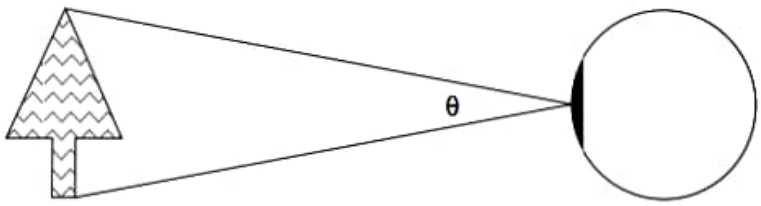

Figure 5.1: Angular size

to bring it as close to the eye as possible. But there is a limit to how close we can bring it: Beyond a certain distance, called the **near-point distance**, we can no longer focus the eye to create a sharp image on the retina. A magnifying glass is a converging lens which creates an image of an object very close to the eye at the near point, or slightly beyond it, so that the image may be seen sharply in focus.

Since the image is formed behind the lens, it is a virtual image. A ray-tracing analysis of the magnifying glass is shown in Figure 5.2. If the height of the original object is y, its angular size in the small-angle approximation is essentially the same as the tangent of the angle,

$$\theta = \frac{y}{p} \tag{5.1}$$

The eye is most relaxed when it is focused at infinity, so we want to form the image with the glass as far away as possible. This means that p must be very slightly under the focal length f, so we may write equation 5.1 as

$$\theta = \frac{y}{f} \tag{5.2}$$

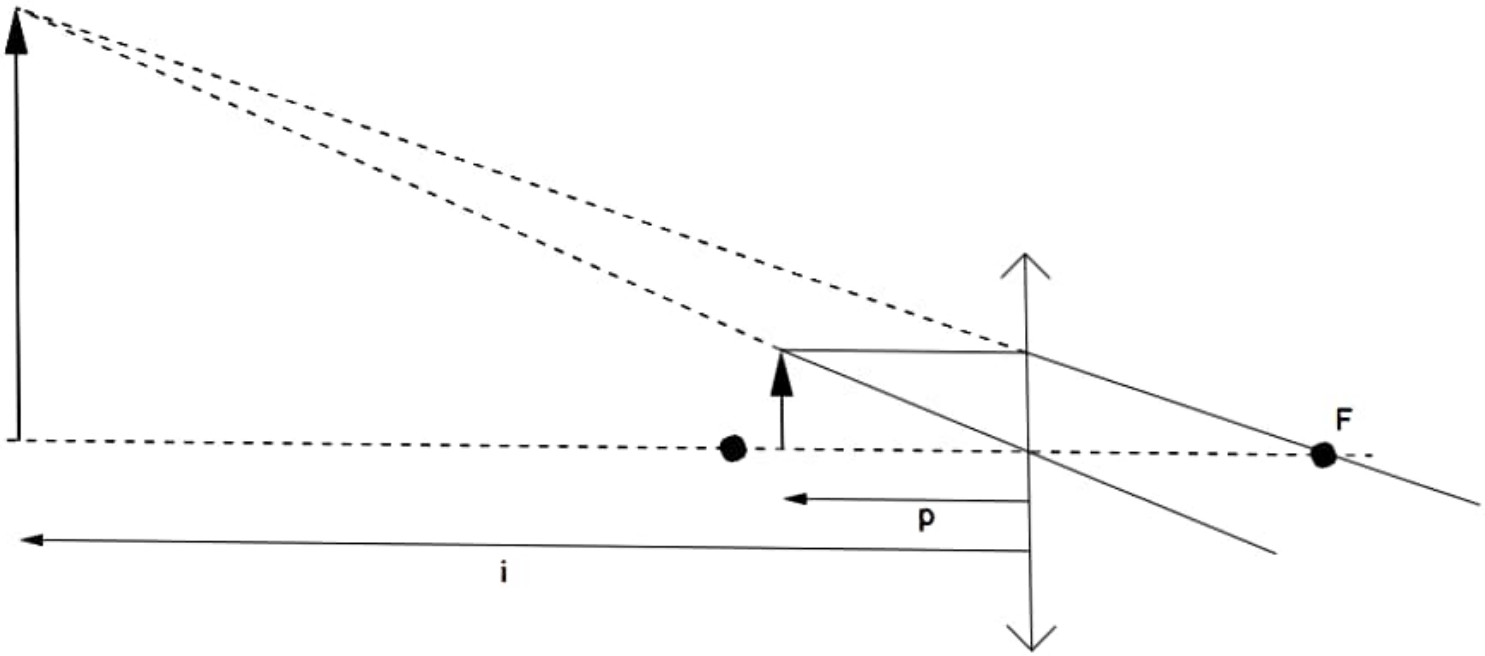

Figure 5.2: Image formation by a magnifying glass

and this is also the angular size of the image.

If we were obliged to look at the object at the near point distance d_N with the naked eye, its angular size would be

$$\theta' = \frac{y}{d_N} \tag{5.3}$$

so the angular magnification of the magnifying glass is

$$m_\theta = \frac{\theta}{\theta'} = \frac{d_N}{f}$$

Clearly, a magnifying glass should have a small focal length in comparison v
normally estimated as 25 cm.