

Homework 9

Angular magnification and simple magnifier.

The simple magnifier or “reading glass” is a convex lens which we place close to the object to create a magnified virtual image. The function of the simple magnifier is to assist the eye in examining small details of the object. The operation principle of a simple magnifier is shown in Figure 1.

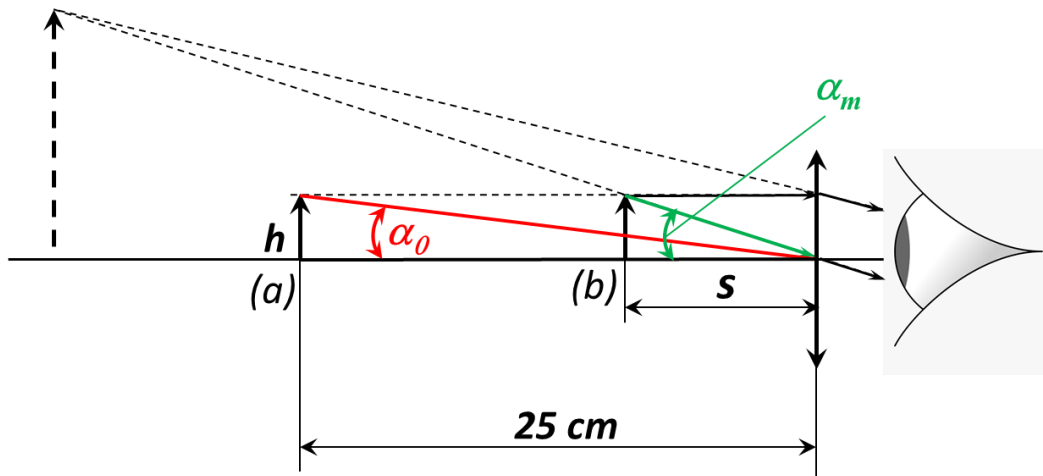


Figure 1. Operation principle of the simple magnifier.

A small object h being examined by the unaided eye is held at the *near point* of the normal eye, which is taken as 25cm away from the eye (position “a” in the Figure). This is a typical distance at which one can examine the object comfortably. At this position the object subtends an angle α_0 at the eye. To project a larger object to the retina, we place a simple magnifier between the eye and the object and move the object close to the eye, to position “b”, where it subtends a larger angle α_m . The angular magnification of a simple magnifier is defined to be the ratio $\frac{\alpha_m}{\alpha_0}$.

As long as the angles are small (paraxial approximation) we can replace the angles by their tangents:

$$\frac{\alpha_m}{\alpha_0} = \frac{h/s}{h/25} = \frac{25}{s} \quad (1)$$

As the object is close to the focal point f of the lens, the image is observed very far away (at infinity) and the angular magnification becomes:

$$M = \frac{25}{f} \quad (2)$$

At the other extreme, if the image is viewed at the near point of the eye, the distance to the image becomes:

$$s_i = -25cm \quad (3)$$

The “minus” sign is because the image is virtual. In this case, the angular magnification is:

$$M = \frac{25}{f} + 1 \dots\dots(4)$$

The actual angular magnification depends then on the particular viewer, who will move the simple magnifier until the virtual image is seen comfortably. For small focal lengths, the expressions (2) and (4) give similar values. Typical magnification of a simple magnifier is in the range from 2x to 10x. Higher magnification requires special lenses with aberration correction.

Problems:

1. Derive expression (4)
2. A camera uses a convex lens of focal length 15cm. How large an image is formed on the photo-sensitive chip of a 180cm-tall person 30m away?