The Magnifier

The size of an object is determined by the size of its image on the retina, and this size depends upon the angle θ (angular size), subtended by the object at the eye. A magnifier is a converging lens that is used to form an image larger than the object. The angular magnification is

M (angular magnification)= $\frac{\theta'}{\theta}$

where

θ' = angle subtended with magnifier.

θ = angle subtended without magnifier.

For a simple single lens magnifier $M = \frac{25}{f}$, where f is the focal length in cm.

The Microscope

When we need greater magnification than we can get with a simple magnifier, we usually use a microscope (also known as a compound microscope). The image formed by the objective lens serves as the object for the eyepiece. Both the objective and the eyepiece of an actual microscope are compound lenses with several elements (not as simple as described herein). The overall angular magnification of the compound microscope is the product of two factors:

1. Lateral magnification of the objective lens, m_1.

2. Eyepiece magnification m_2.

Therefore, overall magnification

$$M = m_1 m_2 \qquad (1)$$

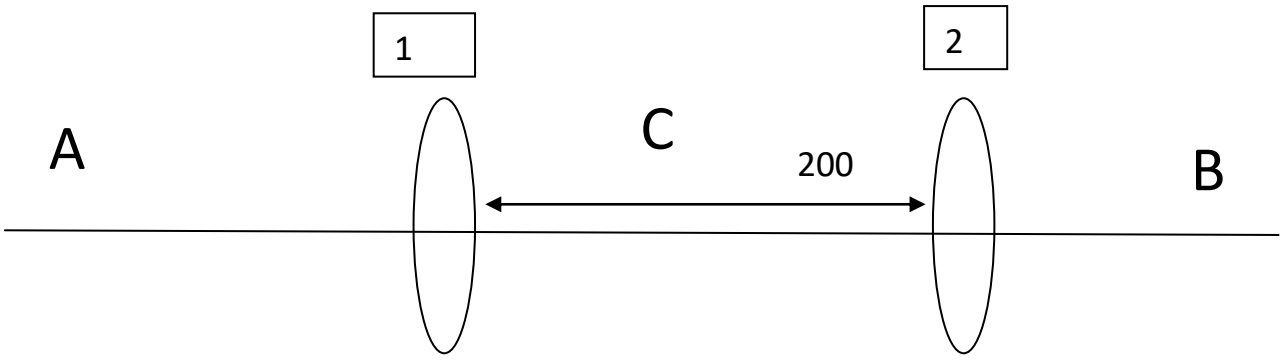
The final image is inverted with respect to the object.

Examples

1. In a compound microscope, the objective lens has a focal length of 8 mm, and the eyepiece has a focal length of 40 mm. The distance between the two lenses is 200 mm, and the final image appears to be at a distance 250mm from the eyepiece.

a. How far is the object from the objective lens?

b. What is the total magnification?



Telescopes

The optical system of a telescope is similar to that of a compound microscope. In both instruments, the image formed by an objective is viewed by an eyepiece. The key difference is that the telescope is used to view large objects at large distances and the microscope is used to view small objects close by. Another difference is that many telescopes use a curved mirror, not a lens, as the objective. The angular magnification M of a telescope is the ratio of the focal length of the objective to that of the eyepiece.

$$M = \frac{\theta}{\theta'} = -\frac{f_1\ (objective)}{f_2\ (eyepiece)}$$

The negative sign shows that the final image is inverted. The magnification of a telescope can be varied by using different eyepieces with different focal lengths f_2.

An important property of a telescope is its ability to distinctly identify two distant objects, close to each other. This property is known as the resolving power (RP) of a telescope. The RP of a telescope depends on the dimensions of the mirror and the colour of light reaching the observer's eye from the objects.

$$RP = \frac{1.22\lambda}{D}$$

where λ=wavelength of light, and D=diameter of mirror (objective)

Example

The focal length of a simple magnifier is 9.0 cm. Assume the magnifier to be a thin lens placed very close to the eye.

a. How far in front of the magnifier should an object be placed if the image is formed at the observer's near point, 25 cm in front of her eye?

b. If the object is 1.0mm high, what is the height of its image formed by the magnifier?