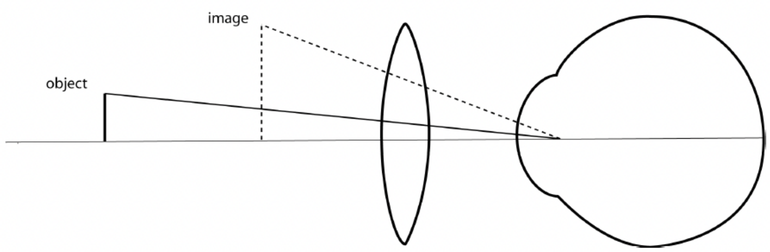
Optical Instruments
Simple Magnifier

Consists of a single plus lens
Magnification is angular magnification
Assumes Minimum Distance of Distinct Vision (Near Point) of 25cm

With object at focal point, distance between eye and magnifier not important
Magnification stays the same
FOV will vary

Magnification

M = F / 4 with object at focal point (no accommodation)
M = (F / 4) +1 with object slightly inside focal length (accommodation required)



Examples

What is the magnification of a simple magnifier with a power of +8.00D if the object if located at the primary focal point of the lens?

Magnification = F/4   M = +8.00 /4 = 2.0x

Where is the image located in this case?

The image of an object at the primary focal point is at infinity.

What lens power is required for a simple magnifier to produce 3.0x (assume object is at focal point)?

Magnification = F / 4
M = 3.0x
F = (3.0x) x (4) = +12.00D

Afocal Telescopes (TS)

General Concepts

Afocal means no accommodation is required for clear vision

Assumes object is at optical infinity

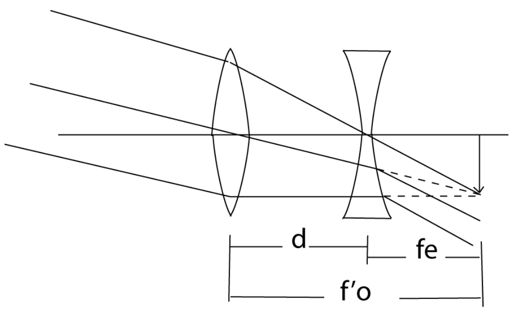
Creates angular magnification

Objective Lens is the Aperture Stop & Entrance Pupil for both TS types

Eyepiece (Ocular) Lens is the Field Stop for both TS types

Galilean Telescope

Also called Terrestrial Telescope



Galilean Telescope

Consists of a plus objective lens and a negative eyepiece (ocular) lens

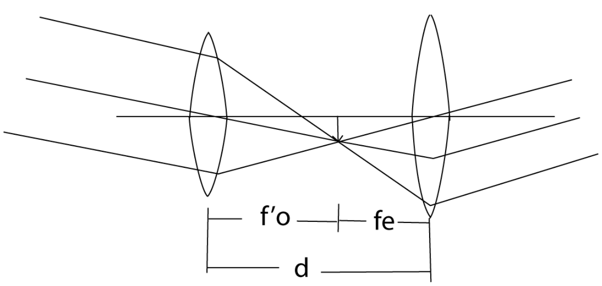
Angular magnification = -Fe / Fo

Separation of Lenses (tube length) = f'o + fe

Creates an erect image

Keplerian Telescope

Also called Astronomical Telescope



Keplerian Telescope

An astronomical (Keplerian) telescope consists of 2 plus lenses. The eyepiece (ocular lens) is higher in power than the objective (closer to the object) lens.
The astronomical telescope creates an inverted image (minus sign for magnification).

Afocal Telescope Optics

$$Magnification = \frac{-F_{eyepiece}}{F_{objective}}$$

$$\text{telescope length } = f'_o - f_e$$

Characteristic	**Galilean**	**Keplerian**
Objective	Positive	Positive
Eyepiece	Negative	Positive
Image Orientation	Erect	Inverted
Location of Exit Pupil	Within the device	Outside the device

Compound Microscopes

Like a telescope, in the simplest form a compound microscope contains two lenses: an objective lens and an eyepiece (or ocular) lens.

Both lenses are plus powered with the objective lens being of higher power than the eyepiece.

Unlike the telescopes we are studying, the compound microscope is not an afocal system.

Magnification

The overall magnification of a compound microscope is the product of:

The linear magnification of the objective lens
The angular magnification of the eyepiece

Tube Length of Compound Microscope

The tube length is the distance between the focal points F’o and Fe

Example
An object is 1.4cm from the +80.00D objective lens of a compound microscope. The eyepiece power is +40.00D.

What is the total magnification of the microscope?

M_{TOTAL} = LMo x AMe

LMo = l'/l

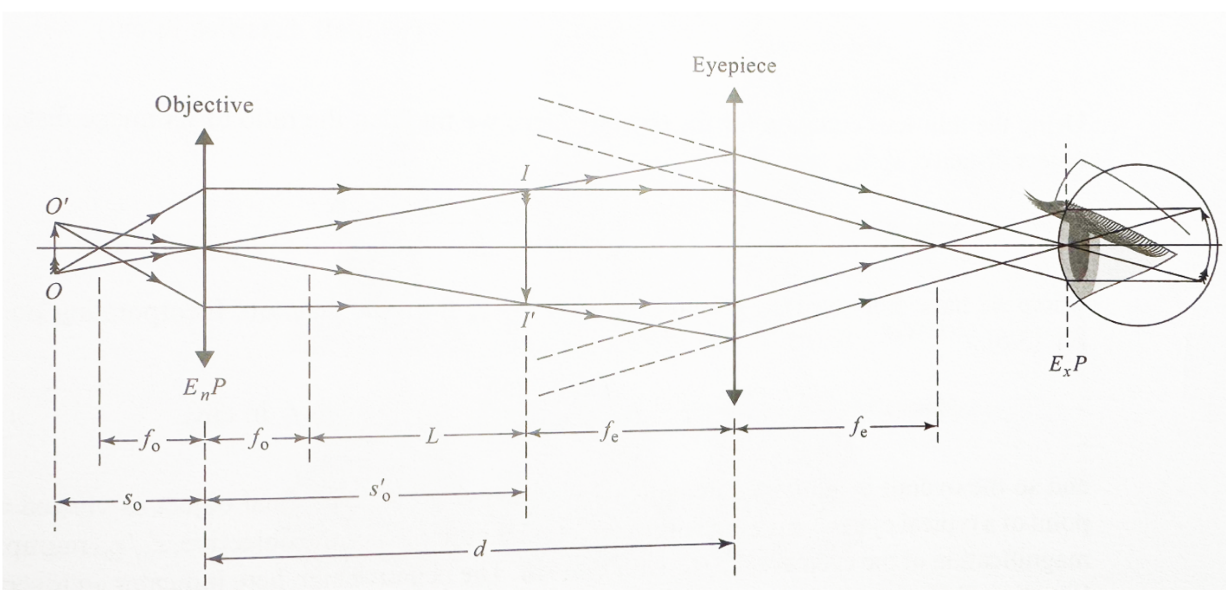
l = -0.014m (given)
l' = +0.117m

L' = L + F   L' = -71.43 + +80.00   L' = +8.57   l' = 0.117m

LMo = +0.117 / -0.014 = -8.33x

AMe = F/4
AMe = +40.00D / 4 = 10.0x

M_{TOTAL} = (-8.33 x +10.00) = **-83.3x** (inverted image)

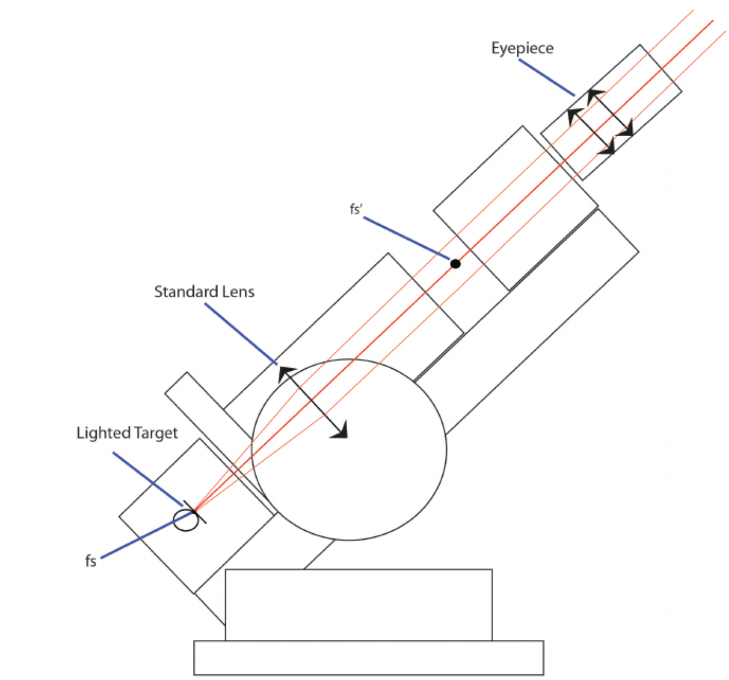


(from Pedrottis 2025)

Lensometer

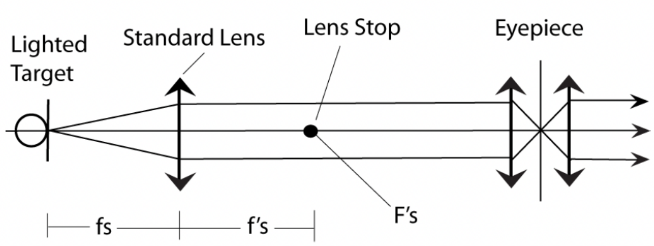
Used to measure vertex power of lenses (front or back).
An unknown lens (test lens) is placed at the lens stop and the lensometer drum is turned until a clear image of the lighted target is obtained.

Lensometer Optics



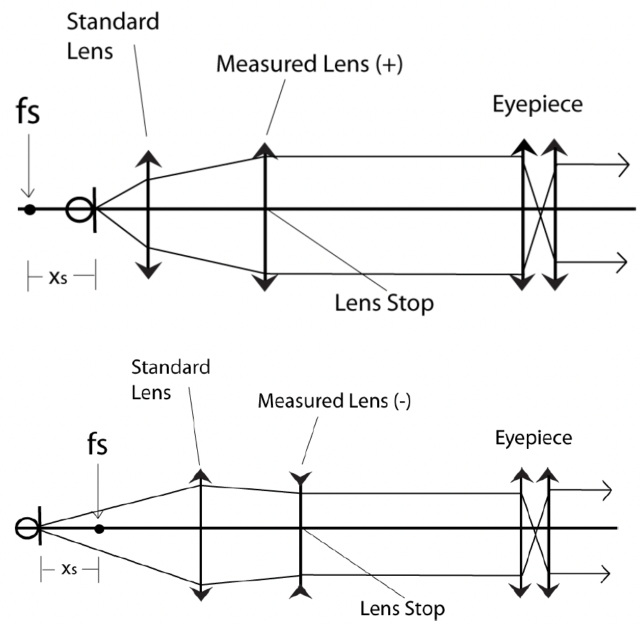
Important Elements

- Moveable Target (lighted)
- Standard Lens (+20D is typical)
- Lens Stop (position of lens to be measured)
- Eyepiece (Keplerian TS)



With the measuring drum set to plano (0.00D) the lensometer target is located at the focal point of the standard lens (which sets the limit the lens power can measure ± 20.00D). When the lens to be measured is placed at the secondary focal point of the standard lens, the target is moved (which changes the vergence of light incident on the tested lens) until parallel light emerges from the eyepiece (which provides a clear image of the target).

Lensometer Optics



These two diagrams illustrate the change in target position and resulting vergence incident at the test lens to measure the power of a plus powered lens and a minus powered lens.

To measure a plus lens, the target is moved closer to the standard lens which results in diverging light rays at the test lens.

To measure a minus lens, the target is moved farther from the standard lens which results in converging light rays at the test lens.

The amount of target movement required for lens “neutralization” is found using Newton’s relation:

$$x_s = f_s^2 \, F_v'$$

Where

x_s = target movement

f_s = focal length of standard lens

F_v' = back vertex power of test lens

Example

When an unknown lens is placed at the lens stop of a lensometer with a +20D standard lens the target moves closer to the standard lens 5mm. What is the power of the test lens?

$$x_s = f_s^2 \, F_v'$$

$0.005 = (0.05)^2F'v$

$F'v = +2.00D$

When a -8.00D spectacle lens is placed at the lens stop of a lensometer, the image of the target is clear when the target is located 12.8mm farther from the standard lens. What is the power of the standard lens?

$$-0.0128 = f_s^2(-8.00D)$$

$$f_s = \sqrt{0.0016}$$

$$f_s = 0.04m$$

$$F_s = 25.00D$$