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College of Optical Sciences

1.0 Measurement of Paraxial Properties of Optical Systems

Necessary to measure the exact location of its cardinal points, that is, its nodal points, focal points, and principal points

Topics

- 1.1 Thin Lenses
- 1.2 Thick lenses

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1.1 Thin Lenses

- 1.1.1 Measurements Based on Image Equation
- 1.1.2 Autocollimation Technique
- 1.1.3 Geneva Gauge
- 1.1.4 Neutralization Test
- 1.1.5 Focometer

1.1.1 Measurements Based on Image Equation

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

p is the object distance from the lens (positive if the object is before the lens), q is the image distance from the lens (positive if the image is after the lens), and f is the focal length of the lens.

Obtaining rough measurement of focal length of positive lens

$$zz' = f^2,$$

z is the distance of the object from the first focal point, and z' is the distance to the image from the second focal point.

If the object and image distances are measured in units of the focal length, then they are reciprocals of each other

$$z' = \frac{1}{z}.$$

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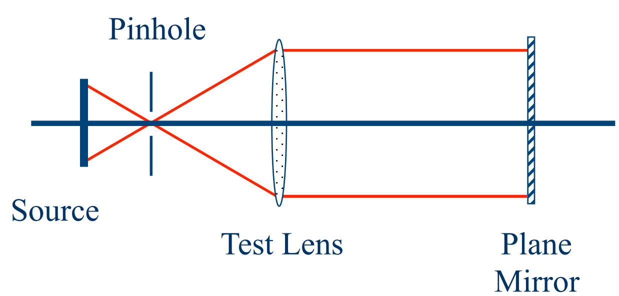
1.1.2 Autocollimation Technique

Locating the focal length



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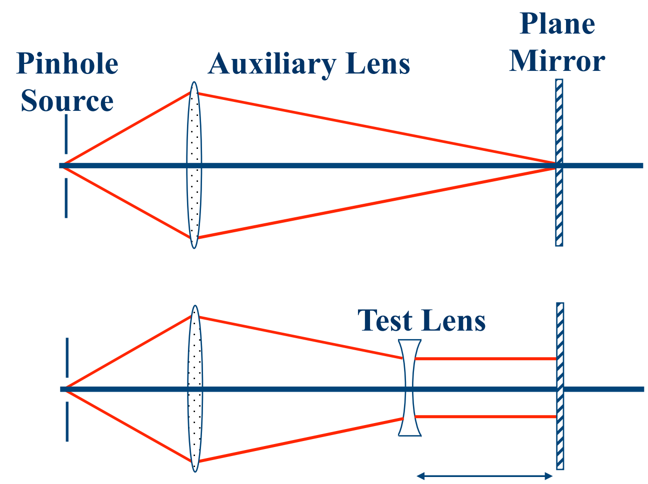
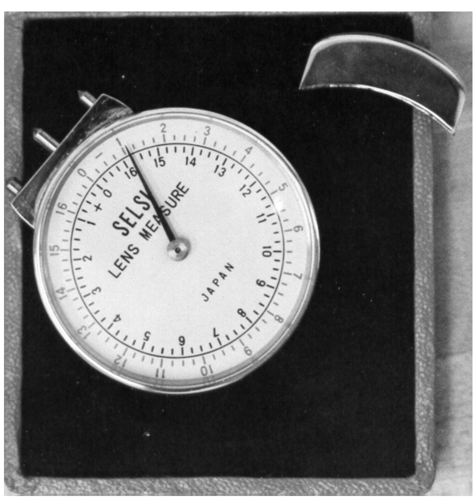
Use of Auxiliary Positive Lens to Find Focal Length of Negative Lens



1.1.3 Geneva Gauge



The dial of the gauge is calibrated under the assumption that the refractive index of the glass is 1.523. The power of the surface is

$$\varphi = \frac{n-1}{R} = \frac{0.523}{R}.$$

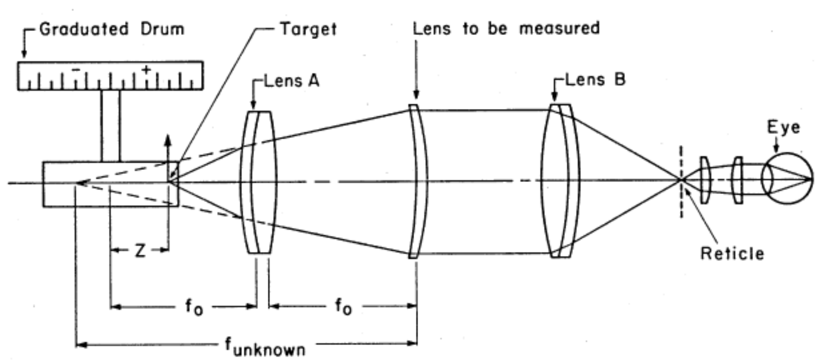
The true focal length of the lens is

$$f_{true} = \frac{0.523}{n_{lens} - 1} f_{measured}.$$

1.1.4 Neutralization Test

- Unknown lens is placed in contact with a lens that has a power equal in magnitude, but opposite in sign, to that of the unknown.
- Unknown lens and known lens are placed in contact, and a distant scene is viewed through the combination.
- The total system power is determined by observing the motion of the scene as the observer moves his head from side to side.
  - Total system power is positive
    - If scene moves in the same direction as head motion, the total system power is positive
  - Total system power is negative
    - If scene moves in the opposite direction to head motion, the total system power is negative

1.1.5 Focometer

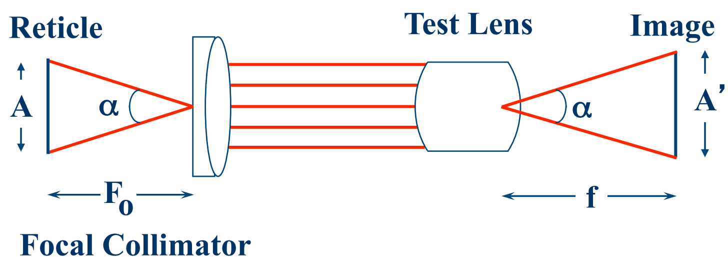


$$z(f_{unknown}) = f_o^2 \qquad \varphi_{unknown} = \left(\frac{1}{f_o}\right)^2 z.$$

1.2 Thick Lenses

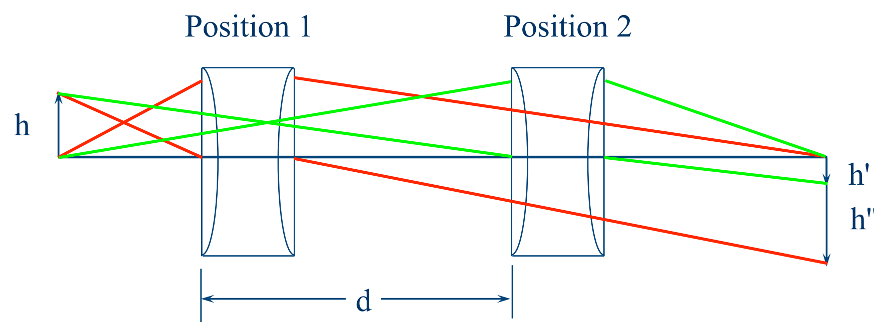
- 1.2.1 Focal Collimator
- 1.2.2 Reciprocal Magnification
- 1.2.3 Nodal-Slide Lens Bench

1.2.1 The Focal Collimator

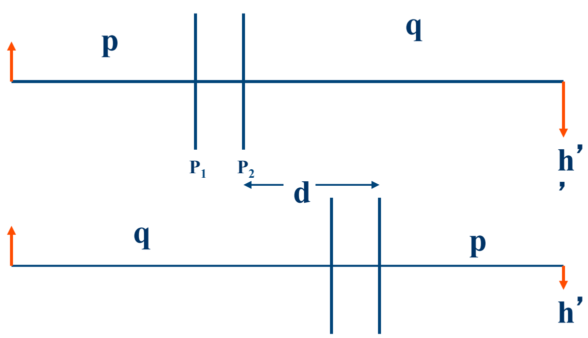


$$f = A'\left(\frac{F_o}{A}\right)$$

1.2.2 Reciprocal Magnification



Reciprocal Magnification Derivation



$$d = q - p$$

mag of magnification =

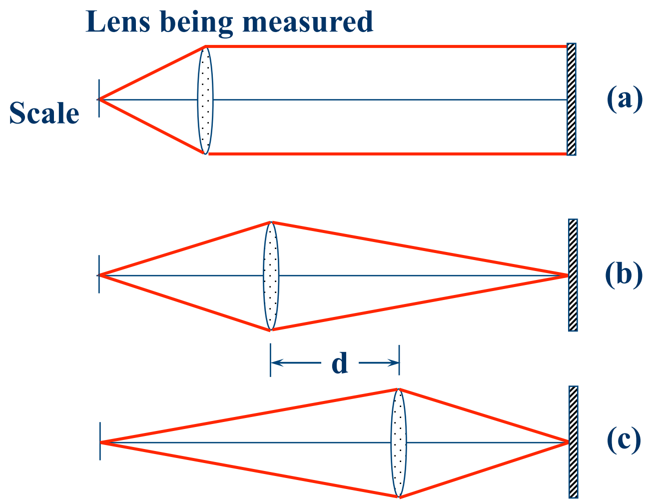
$$m = \frac{q}{p}$$

$$d = pm - p = p(m-1)$$

$$\frac{1}{f} = \frac{1}{p} - \frac{1}{q} \qquad \frac{1}{f} = \frac{m-1}{d}\left(\frac{m+1}{m}\right) = \frac{m^2-1}{md} \qquad f = \frac{d}{m - \frac{1}{m}}$$

$$p = \frac{d}{m-1} \qquad q = \frac{d}{1 - \frac{1}{m}}$$

Locating Principal Points by Reciprocal Magnification and Auto-Collimation



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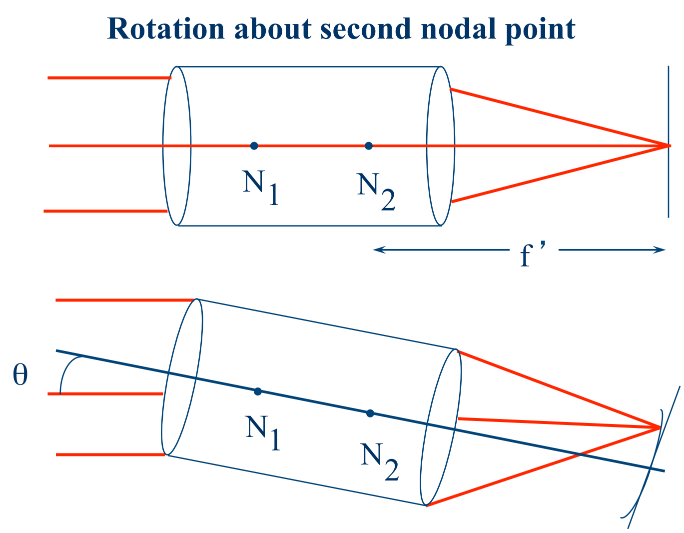
1.2.3 Nodal-Slide Lens Bench



$$\varepsilon_z = f'(\sec\theta - 1)$$

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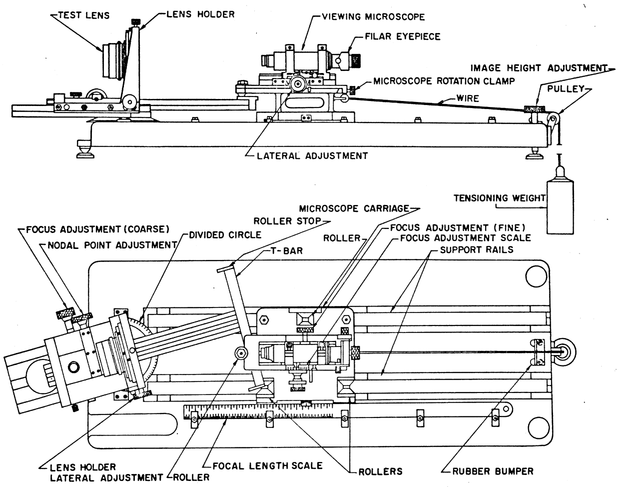
Kingslake Lens Bench



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