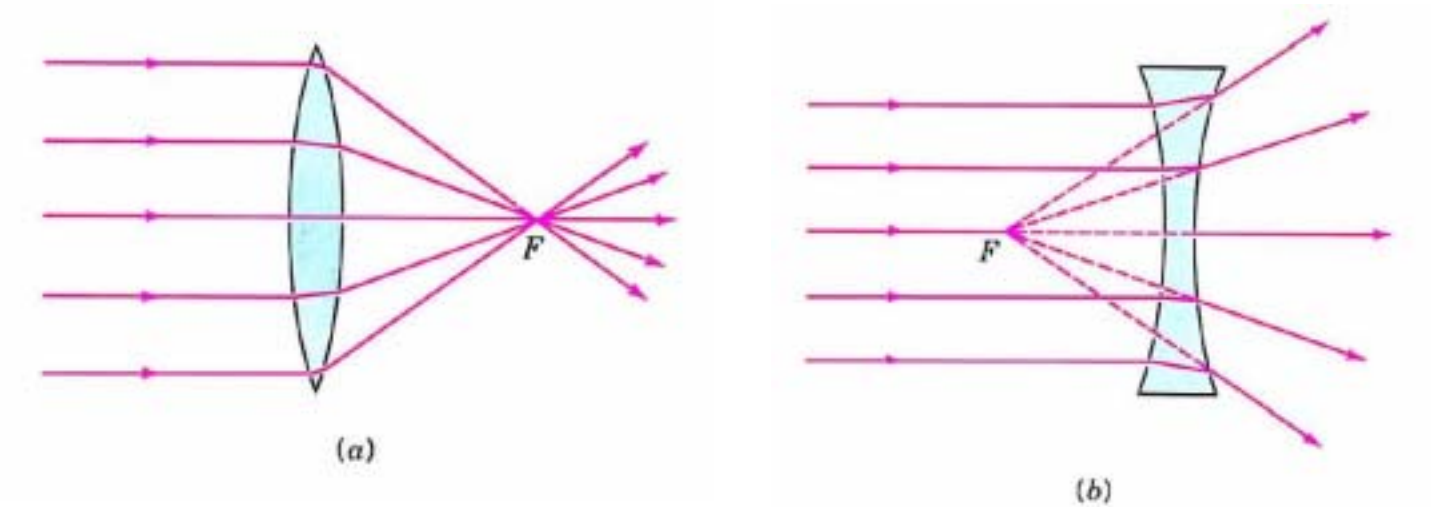
Chapter 36 Lenses and Optical Instruments

36.1 Lenses

An optical lens is a sample of some transparent material, such as glass, that usually has spherical or cylindrical surfaces.

Converging lens: the central section is thicker than the rim.

Diverging lens: the central section is thinner than the rim.



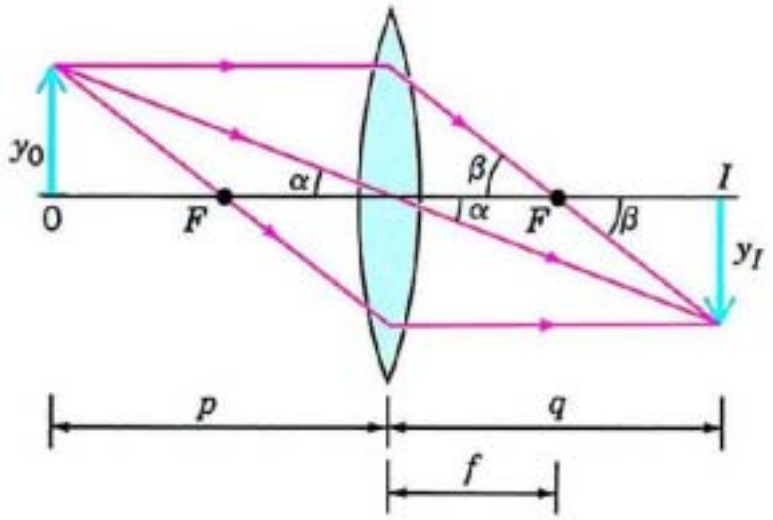
Principal Ray Diagrams

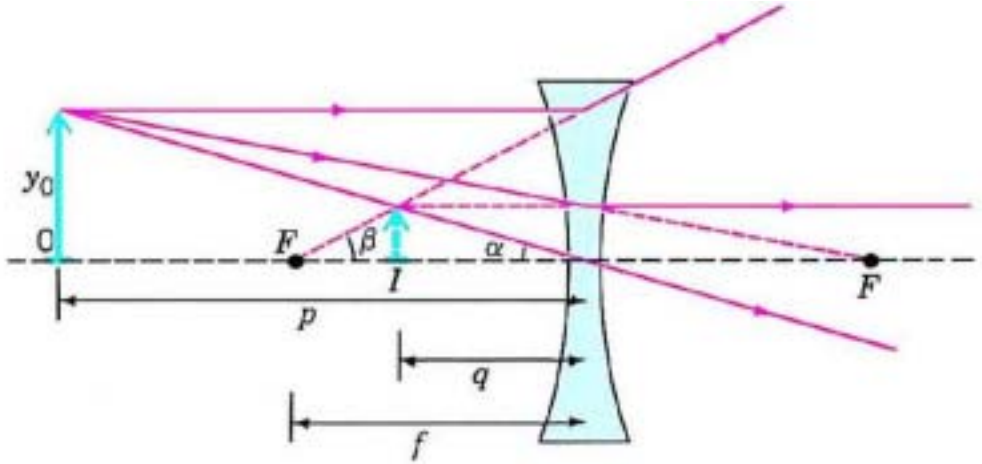
Ray diagrams are useful in locating images due to lenses.

1. A ray passing through the center of the lens is undeviated.

2. A ray directed parallel to the axis passes through a focal point.

3. A ray directed toward, or away from, a focal point emerges parallel to the axis.





The Thin Lens Formula

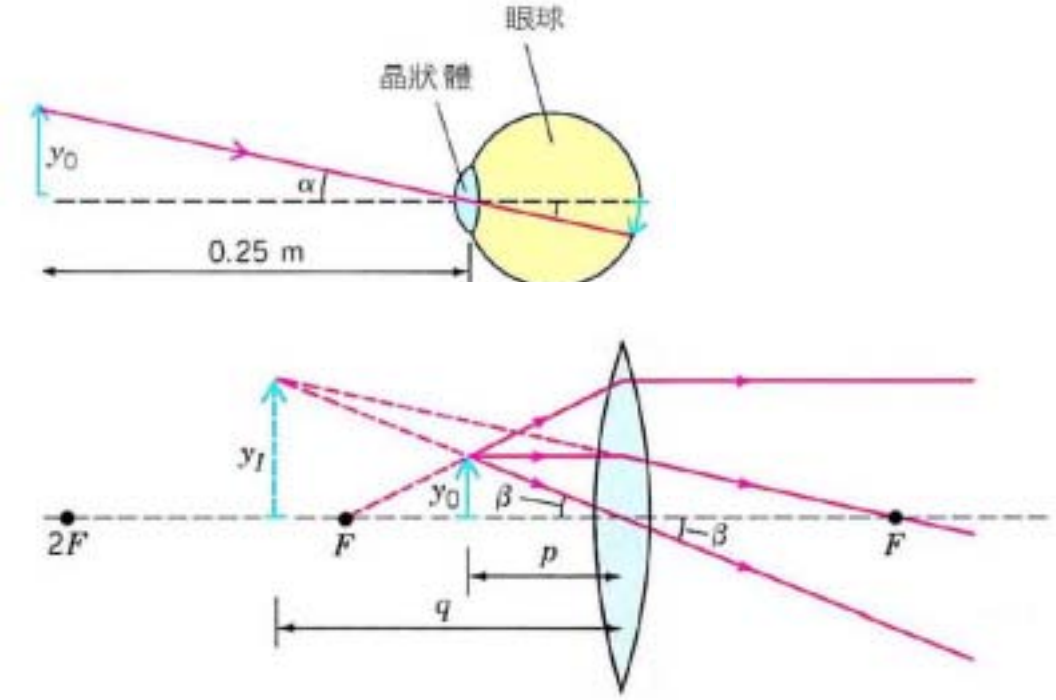
$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

Sign convention: p is positive (real) on the left, negative (virtual) on the right. q is positive on the right, negative on the left. f is positive for converging lens, negative for a diverging lens.

As is the case with mirrors, the **transverse** (or **linear**) **magnification**, m, is defined as the ratio of image height to object height.

$$m=\frac{y_I}{y_O}=-\frac{q}{p}$$

36.2 The Simple Magnifier



$$\alpha_{25} = \frac{y_o}{0.25}$$

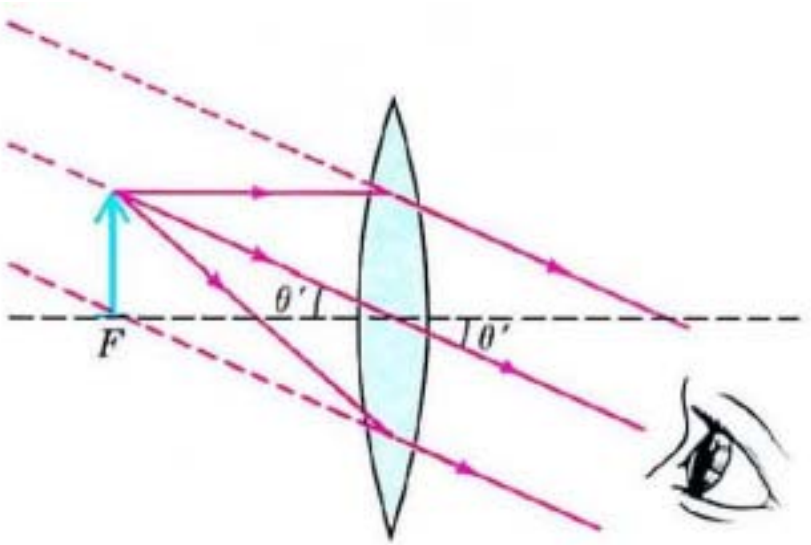
$$\beta = \frac{y_I}{q} = \frac{y_o}{p}$$

The **angular magnification,** M, of single lens, called a simple magnifier, is defined as the ratio of the angle subtended by the image produced by the lens to the angle subtended when the object itself is at 25 cm.

$$M = \frac{\beta}{\alpha_{25}} = \frac{0.25}{p}$$

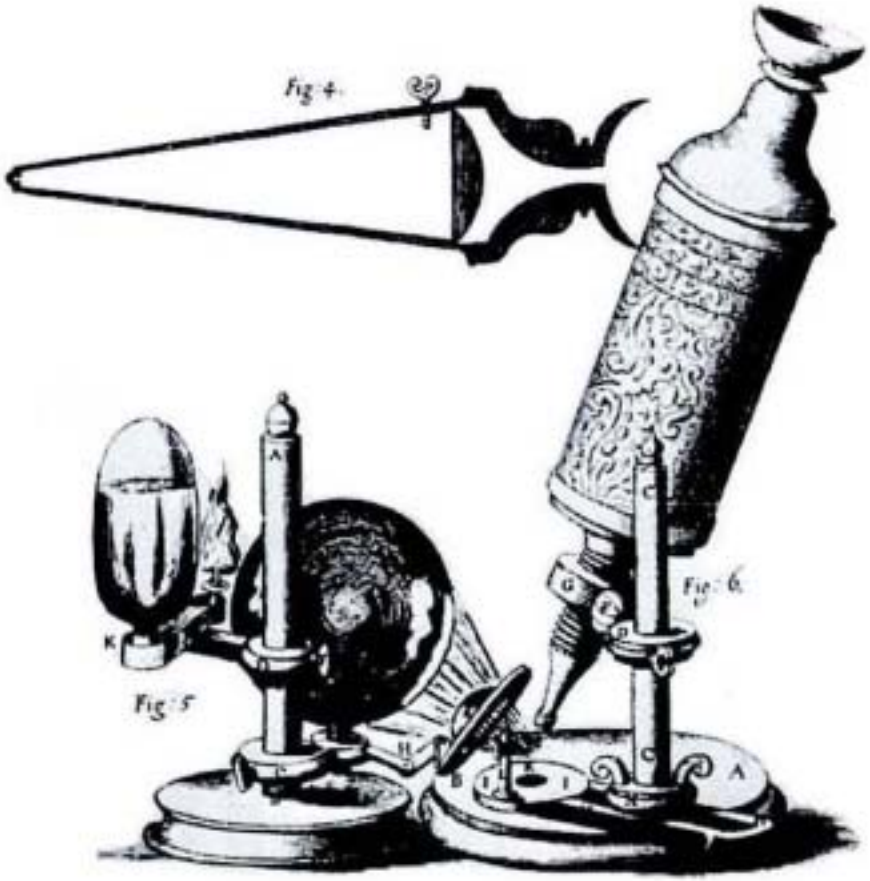
The Simple Magnifier

When an object is placed at the focal point of a converging lens, the imagine is at infinity.



$$M_{\infty} = \frac{0.25}{p} = \frac{0.25}{f}$$

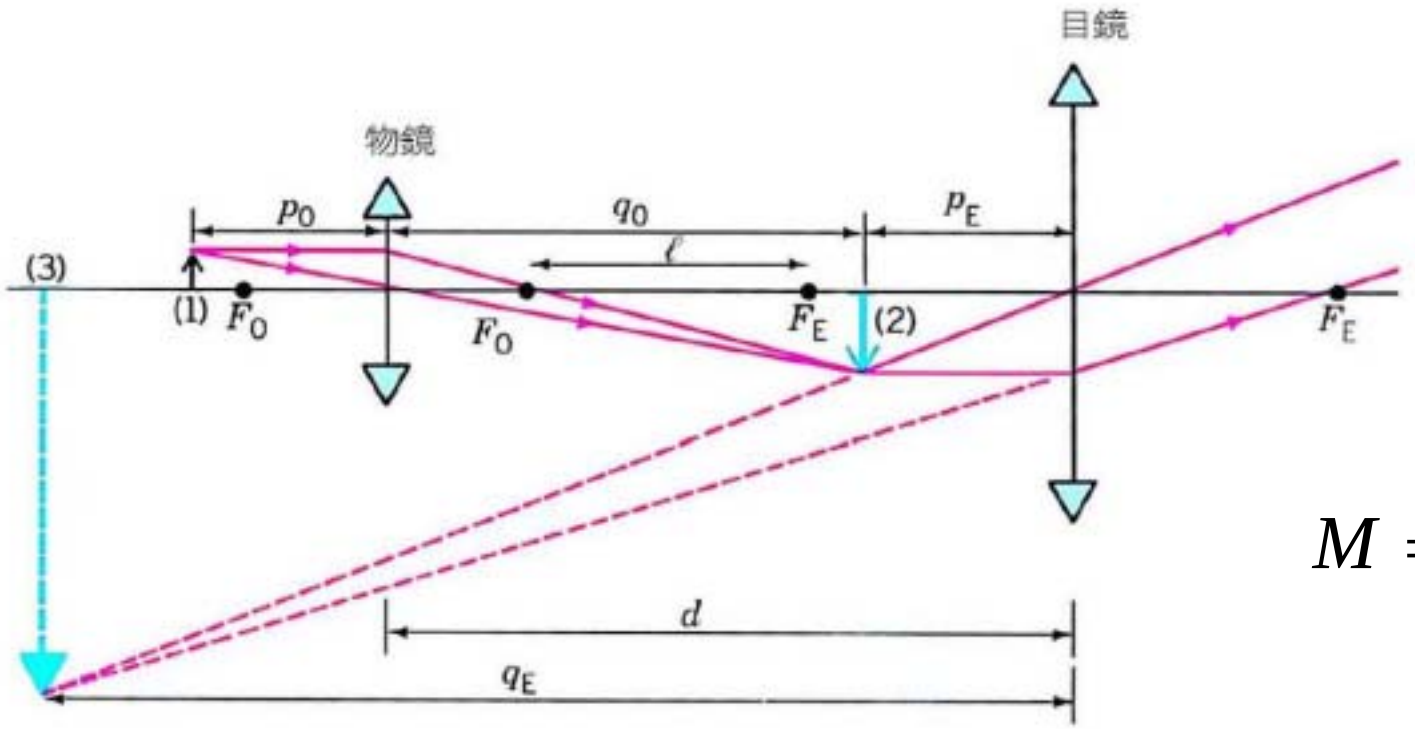
36.3 The Compound Microscope



The Compound Microscope

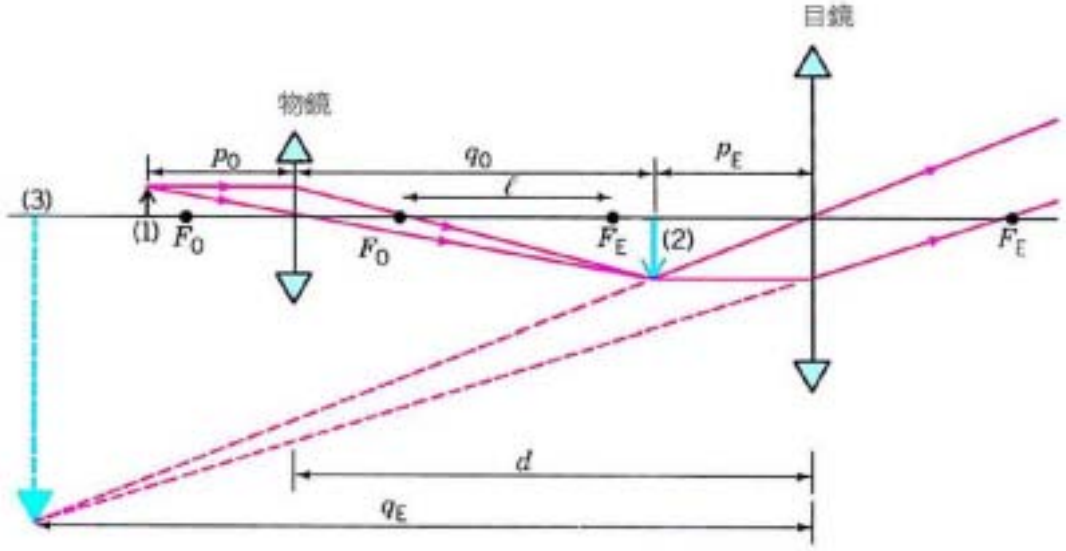
The object just beyond the focal point of the objective ($P_0 > f_0$).
The enlarged image produced by the objective ($q_0 > l + f_0$) acts as a real object for the eyepiece.

The final virtual image is produced by the eyepiece.



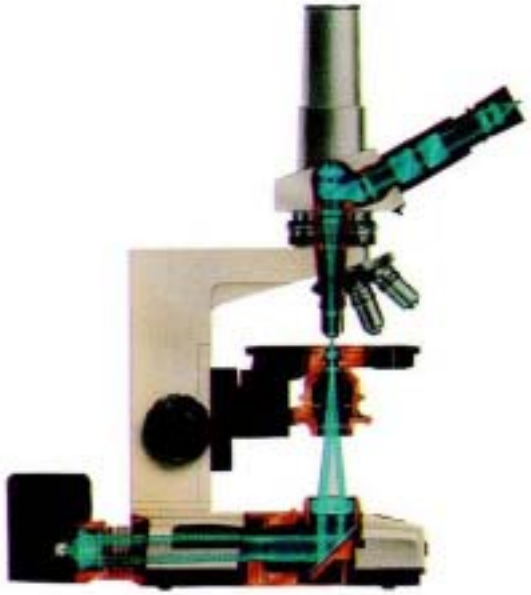
$$M = \frac{\beta}{\alpha_{25}}$$

The Compound Microscope (II)



$$M = -\frac{q_o}{p_o}\frac{0.25}{p_E}$$

$$= -\frac{q_o}{p_o}\frac{0.25}{f_E}$$



The optical system of a modern microscope.

36.4 Telescopes

A **telescope** is an optical instrument used to view object far away.

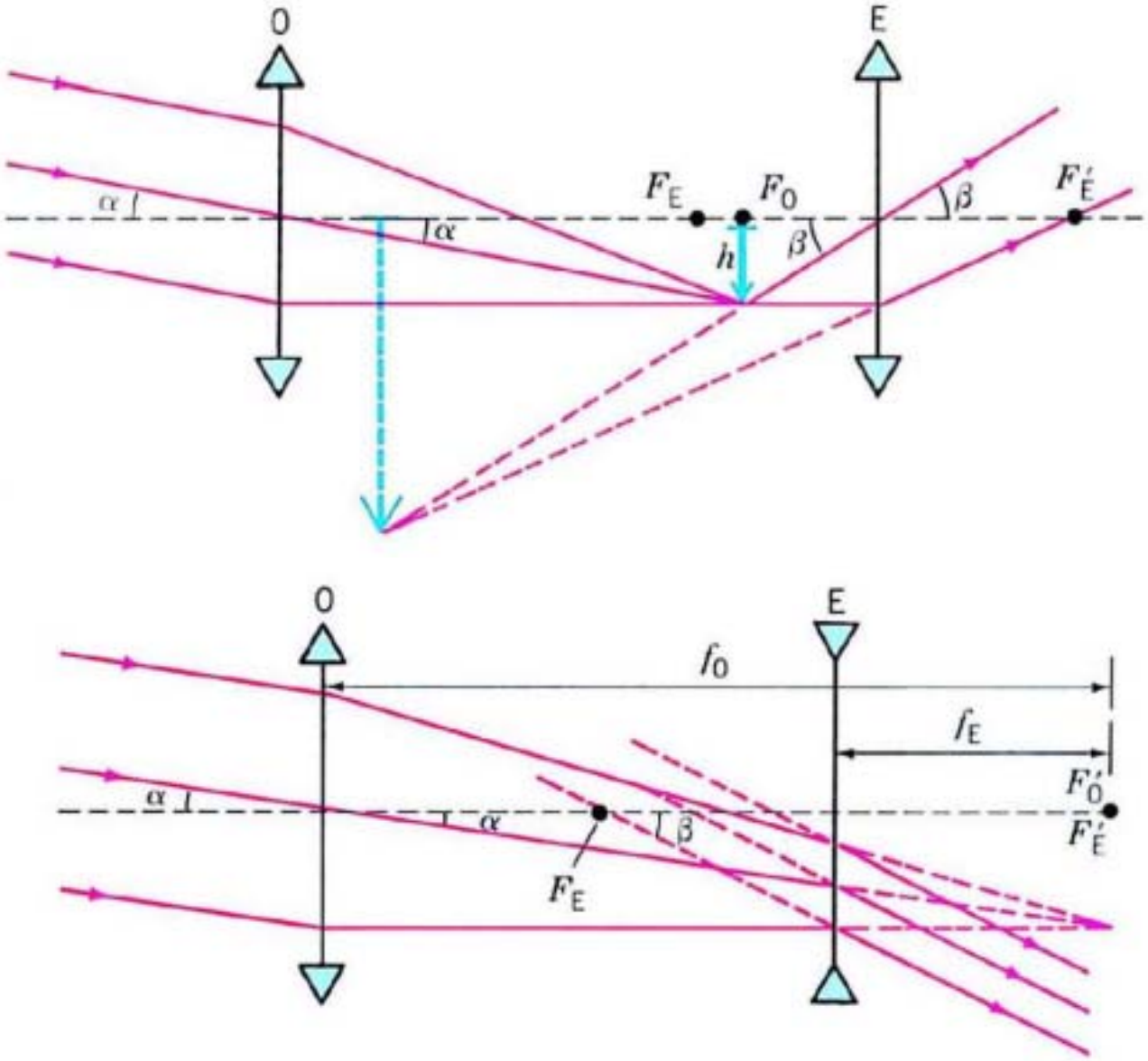
The image in the telescope subtends an angle β, so the angular magnification of the telescope is

$$M = \frac{\beta}{\alpha}$$

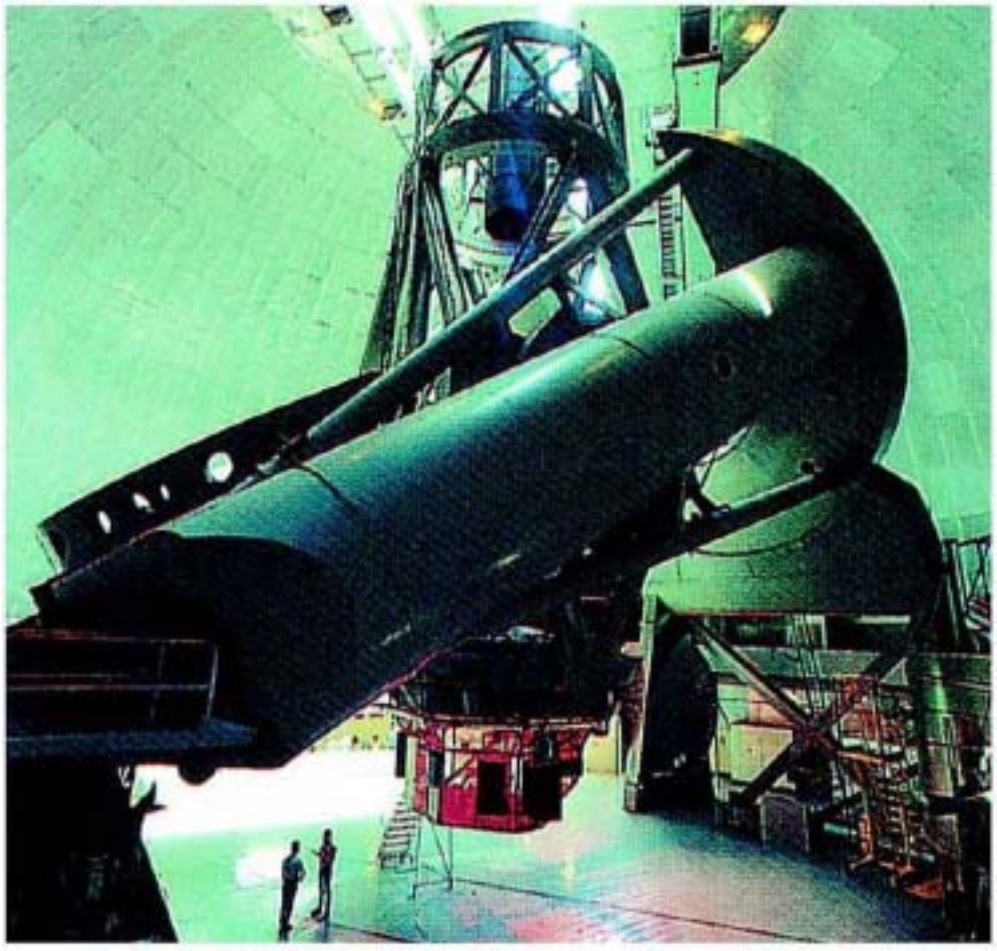
Since the angles are small, $\alpha \approx \frac{h}{f_o}$ and $\beta \approx \frac{h}{p_E}$

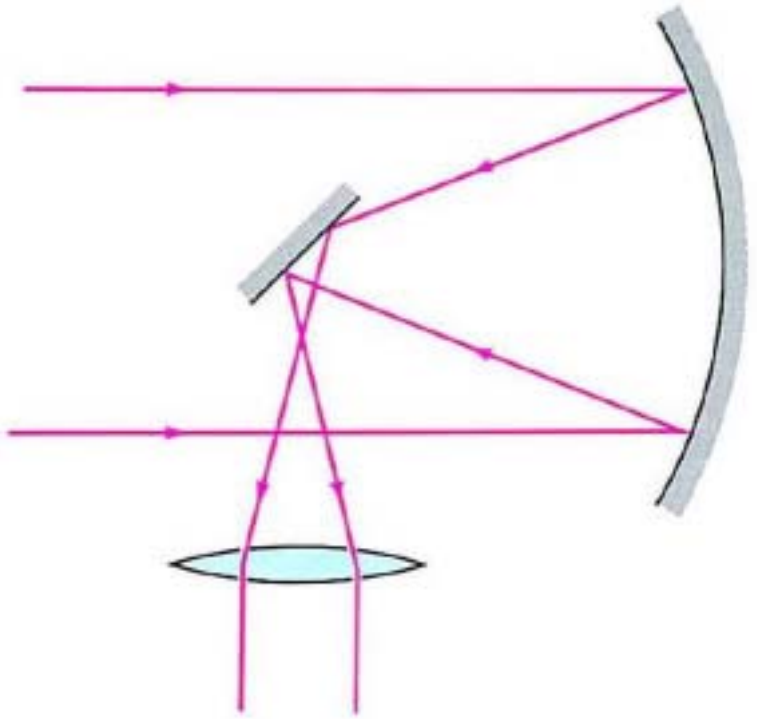
$$M = -\frac{f_0}{p_E}$$

Galilean Telescope



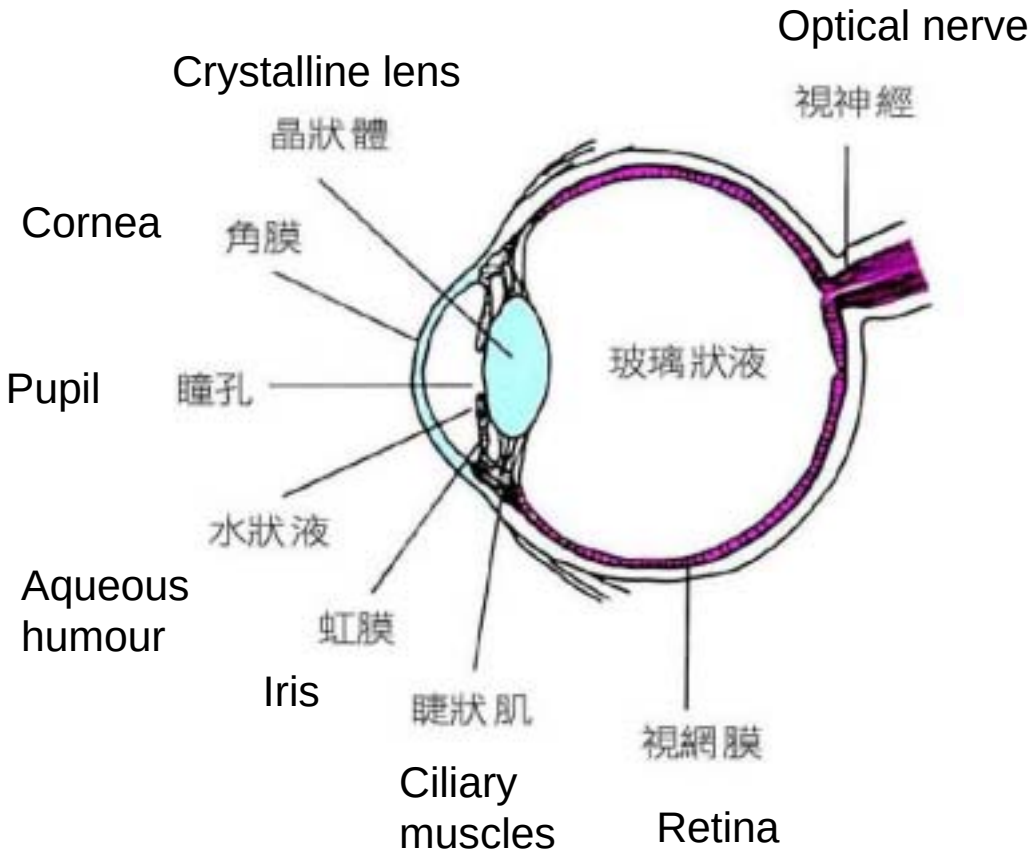
Reflecting Telescope





36.5 The Eye

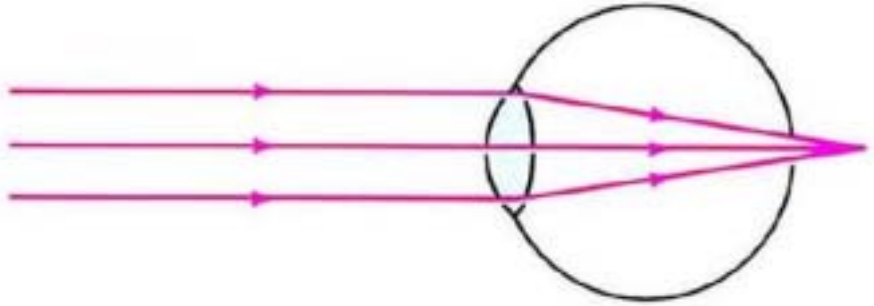
The human eye is a wonderfully refined optical instrument.



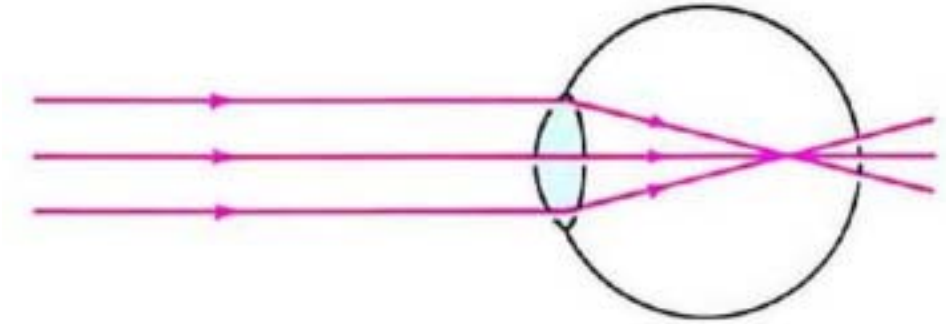
The Eye (II)

The human eye is a wonderfully refined optical instrument.

Farsighted



Nearsighted



The Eye (III)

Eyeglasses are specified in terms of the **power** of the lens. This is defined as the reciprocal of the focal length in meters:

$$Power = \frac{1}{f}$$

The unit of power is the dioptre (D).

Exercises and Problems

Ch.36:

Ex.

Prob.