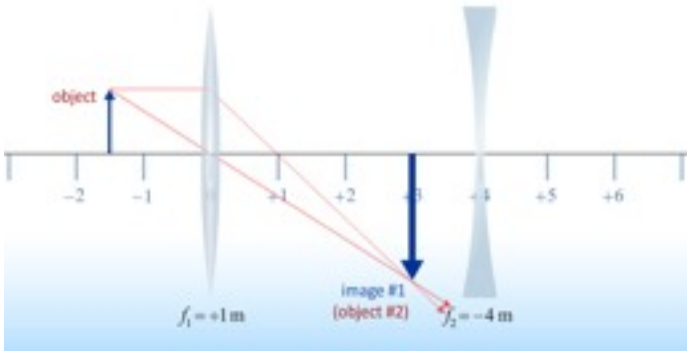
Physics 141
Lecture 28

Today's Concept:

A) Optical Devices



Executive Summary - Mirrors & Lenses:

$S > 2f$ — real, inverted, smaller

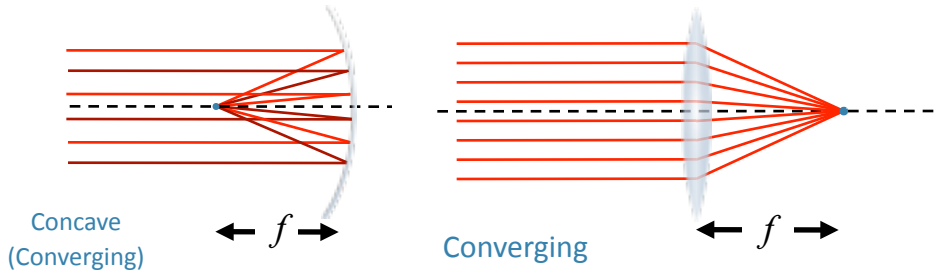
$2f > S > f$ — real, inverted, bigger

$f > S > 0$ — virtual, upright, bigger

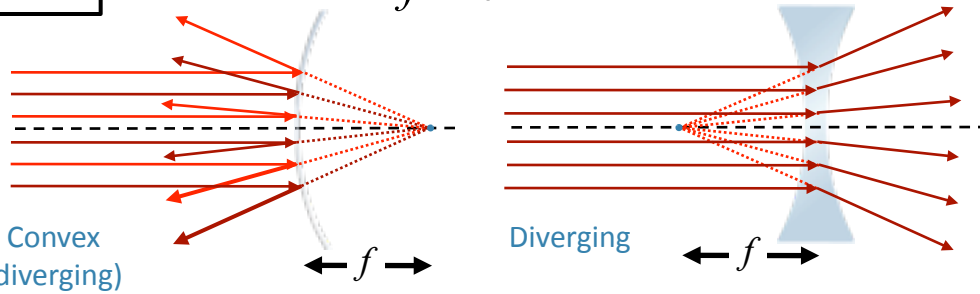
$S > 0$ — virtual, upright, smaller

$$\frac{1}{S} + \frac{1}{S'} = \frac{1}{f} \qquad M = -\frac{S'}{S}$$

$f > 0$



$f < 0$



It's Always the Same:

$$\frac{1}{S}+\frac{1}{S'}=\frac{1}{f} \qquad M=-\frac{S'}{S}$$

You just have to keep the signs straight:

s' is positive for a real image

f is positive when it can produce a real image

Lens sign conventions

S: positive if object is "upstream" of lens

S': positive if image is "downstream" of lens

f: positive if converging lens

Mirrors sign conventions

S: positive if object is "upstream" of mirror

S': positive if image is "upstream" of mirror

f: positive if converging mirror (concave)

System of Lenses

Trace rays through lenses, beginning with most upstream lens

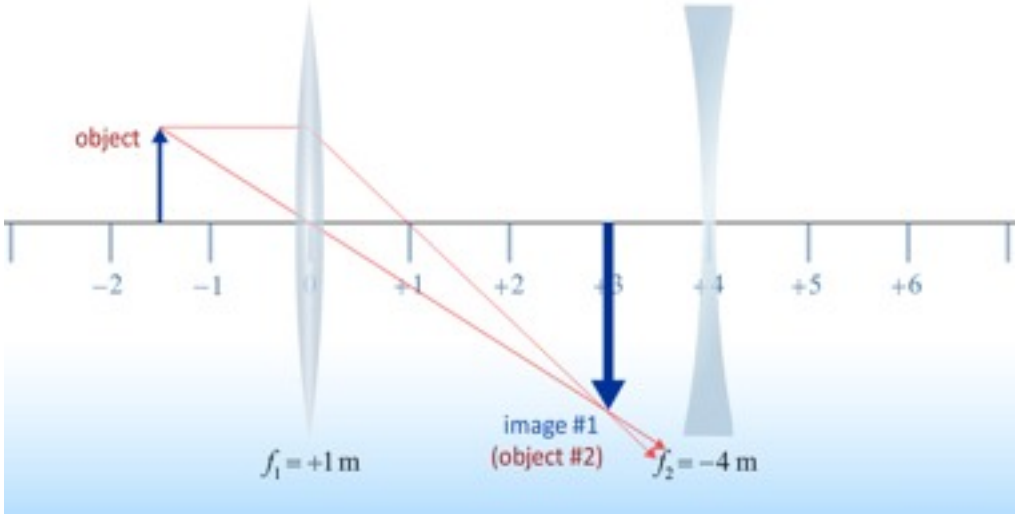
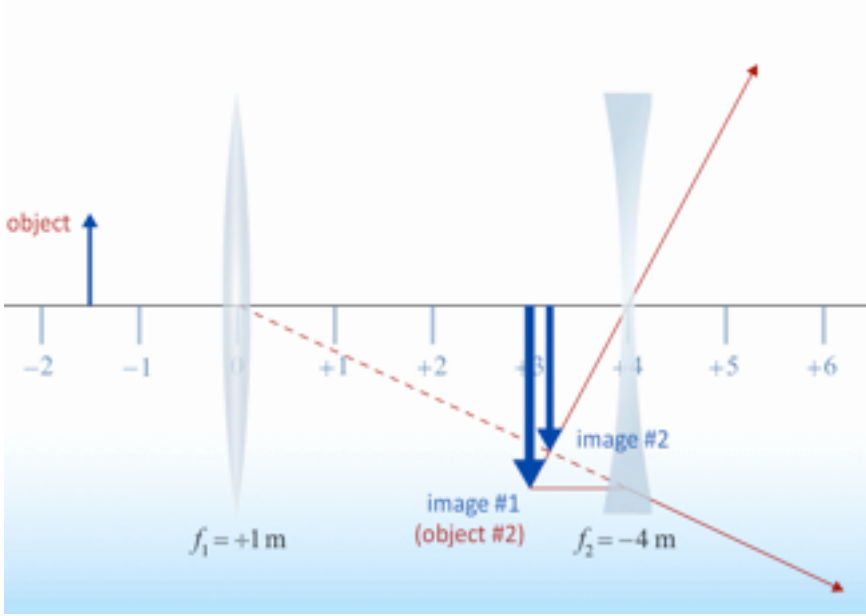


Image from first lens
Becomes object for second lens



System of Lenses

Virtual Objects are Possible !!

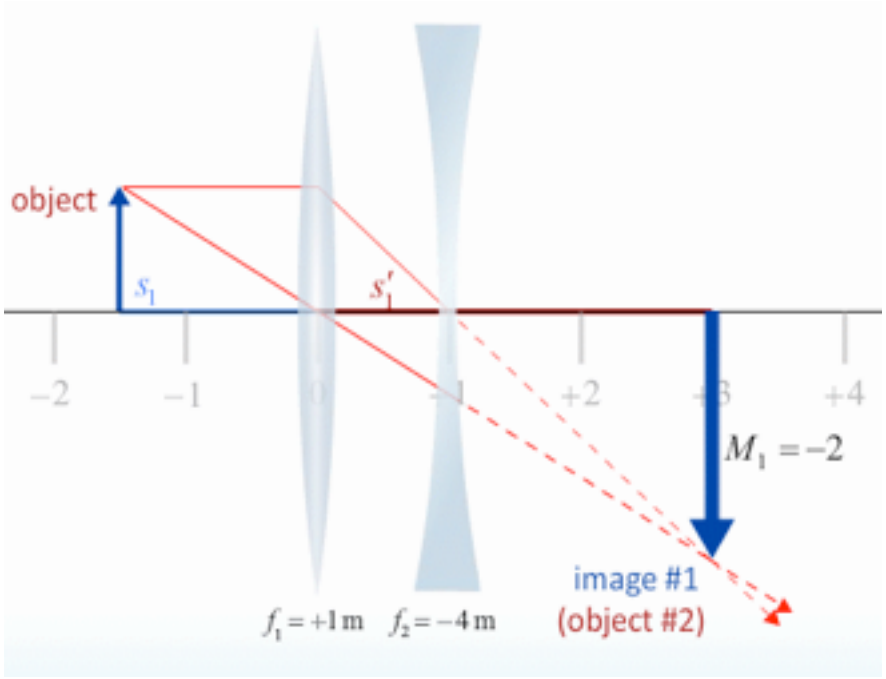
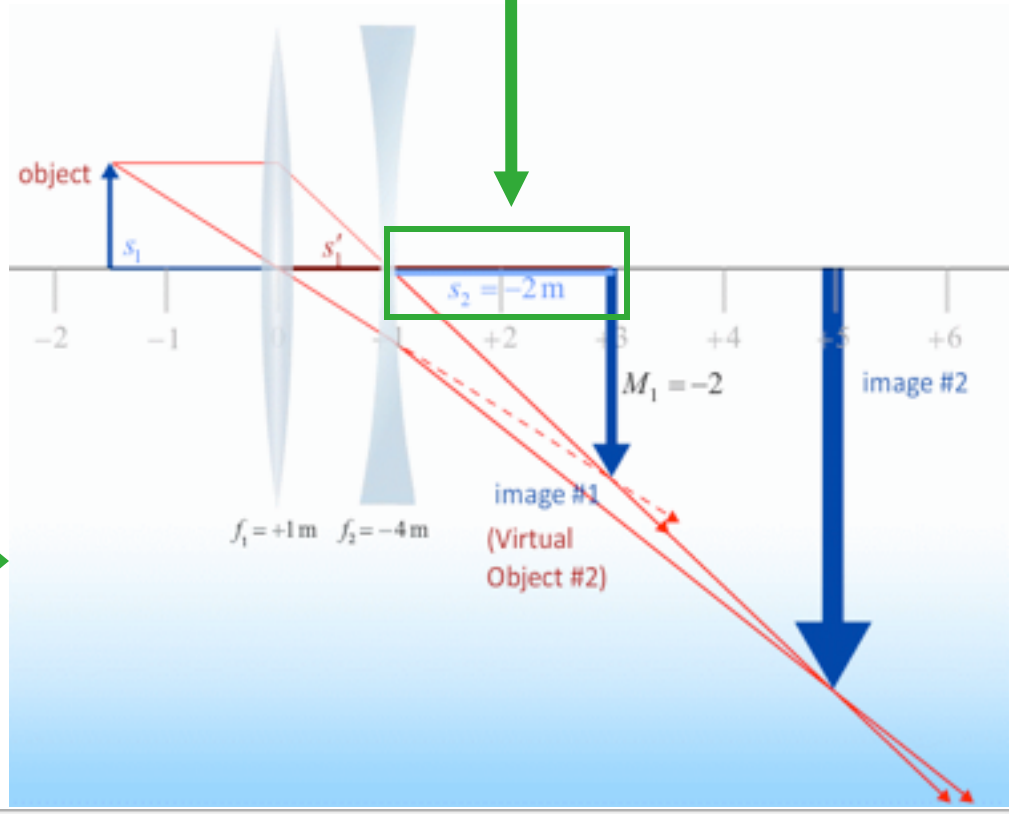
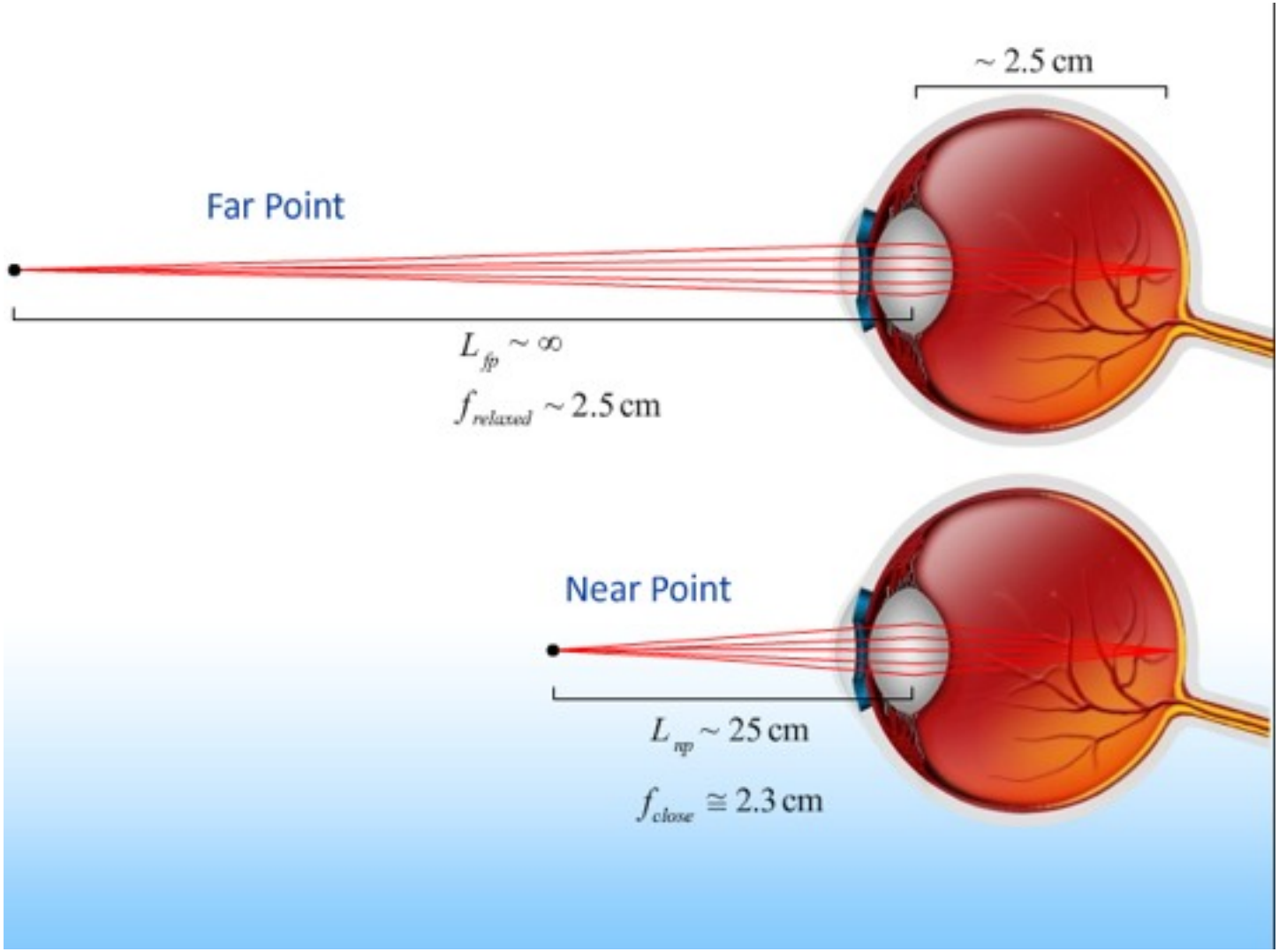


Image from first lens
Becomes object for second lens

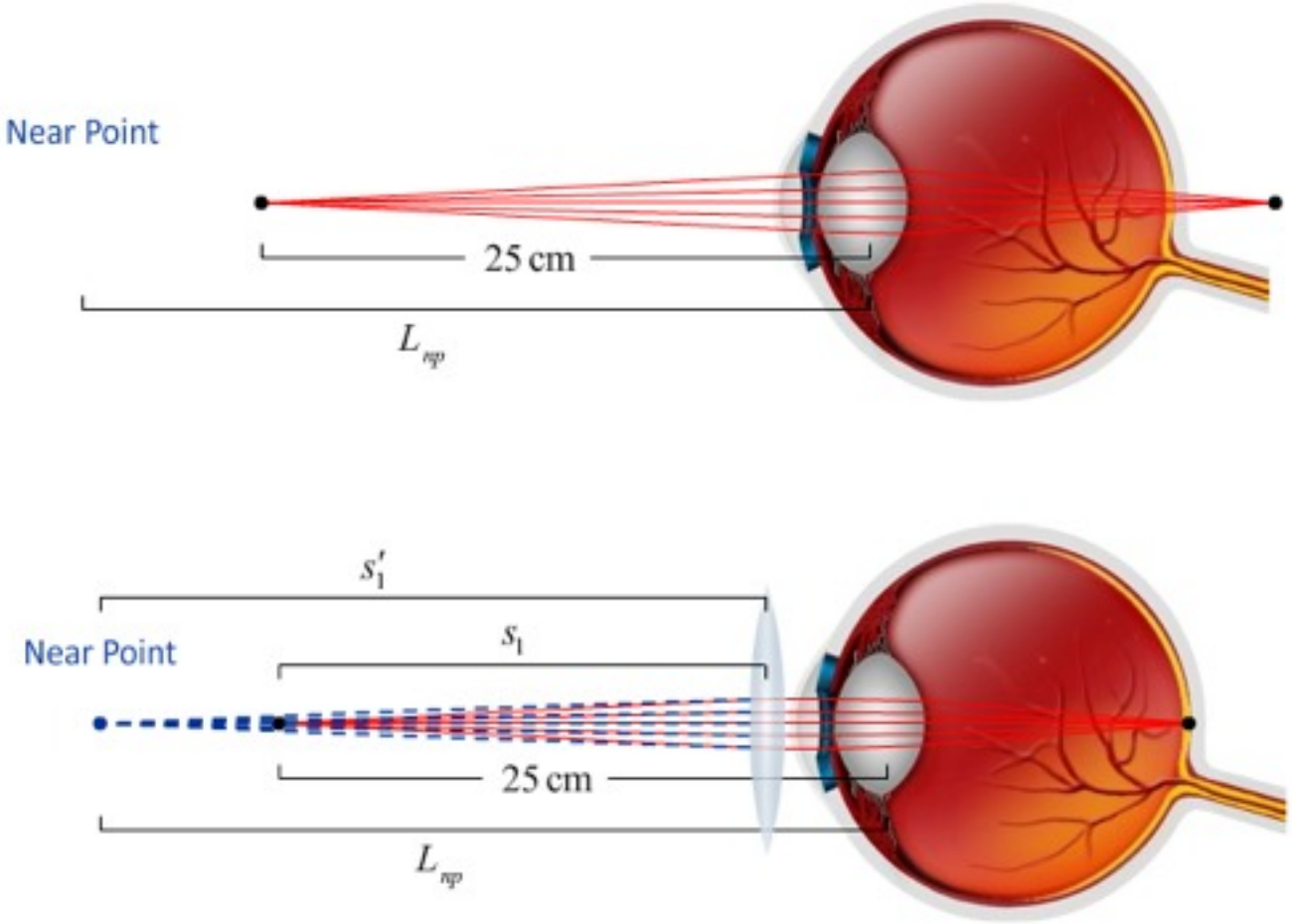
Object Distance is Negative!



Normal Eye

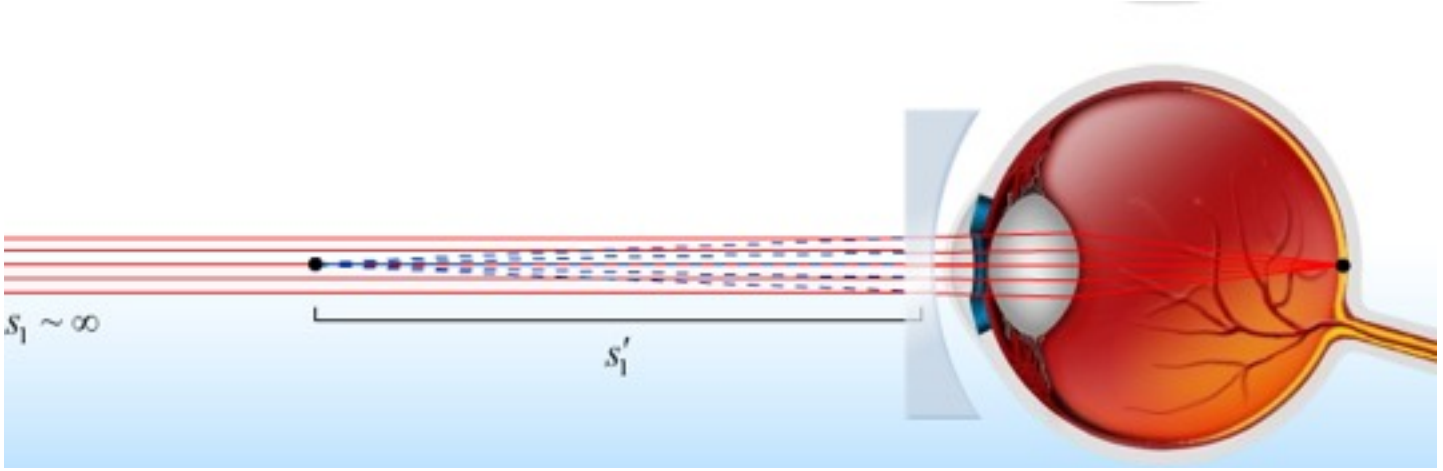

~ 2.5 cm
Far Point
$L_{fp} \sim \infty$
$f_{relaxed} \sim 2.5\,\text{cm}$
Near Point
$L_{np} \sim 25\,\text{cm}$
$f_{close} \cong 2.3\,\text{cm}$

Far-Sighted



Converging Lens creates virtual image at person's near point

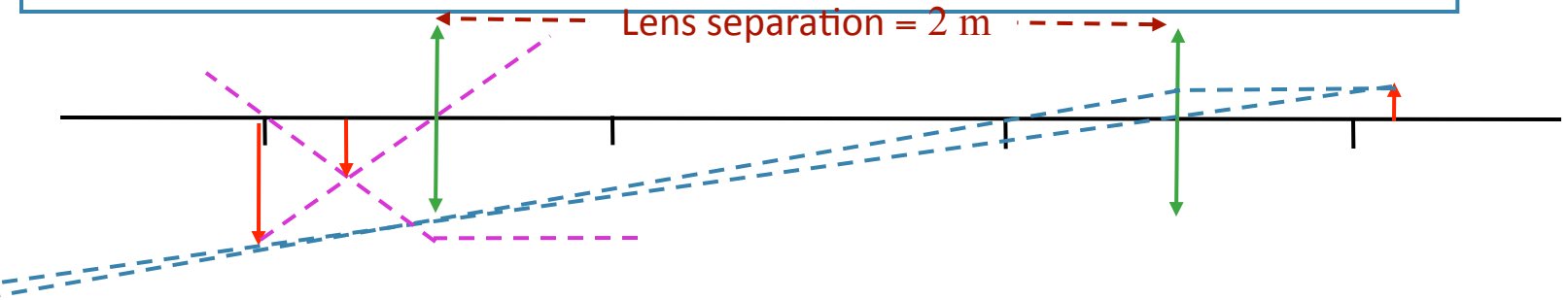
Near-Sighted



Fix with diverging lens that creates virtual image at far point.

Multiple Lenses Exercises

Suppose we now decrease the initial object distance to 58 cm. Applying the lens equation, we find $s_1' = 2.48\text{m}$



$s_1 = 58$ cm
$f = 47$ cm
$s_1' = 2.48$ m
$s_2 = -0.48$ m

What is the nature of the final image in terms of the original object?

A) REAL UPRIGHT

B) REAL INVERTED

C) VIRTUAL UPRIGHT

D) VIRTUAL INVERTED

EQUATIONS

$$S_2' = \frac{fs_2}{s_2 - f}$$

$s_2 < 0 \rightarrow s_2' > 0 \rightarrow$ real image

$$M_2 = -\frac{S_2'}{S_2}$$

$M_2 > 0 \rightarrow M = M_1 M_2 < 0 \rightarrow$ inverted image

PICTURES

Draw Rays as above.

RESULTS

$s_2' = 0.24$ m

$M = -2.1$

Magnifying Glass

The Magnifying Glass merely a lens which creates a virtual image!.

$$\theta = \frac{y}{f} \qquad \theta_o = \frac{y}{x_{np}}$$

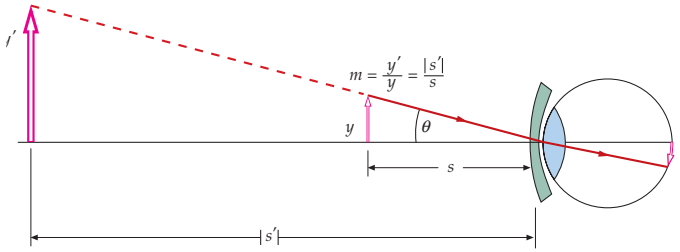
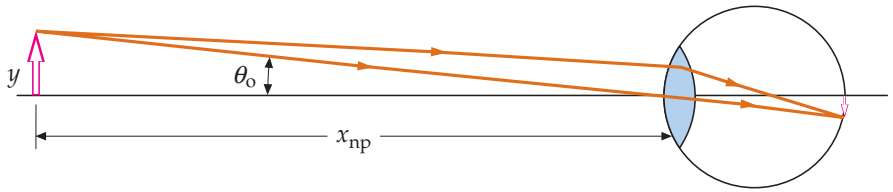
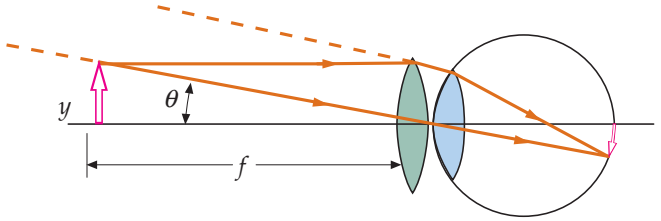


FIGURE 32-50

$$M = \frac{\theta}{\theta_o} = \frac{x_{np}}{f}$$



(a)



(b)

The Compound Microscope

A combination of two converging lens makes a Microscope.

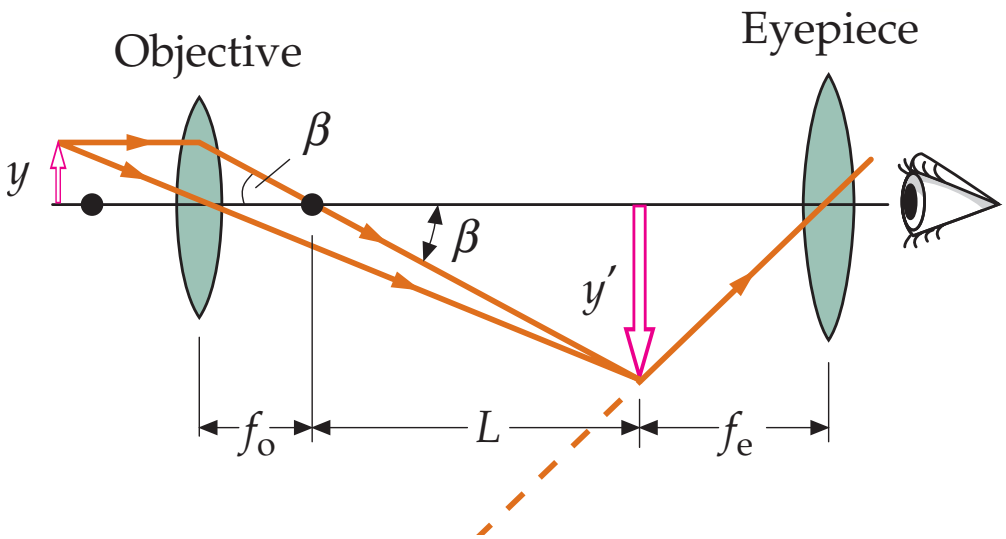
In a Microscope the distance between the two lens that is comparable to the focal length of the two lens.

The first lens is the Objective lens, the second one called Eyepiece.

$$m_o = \frac{y'}{y} = -\frac{L}{f_o}$$

$$M_e = \frac{x_{np}}{f_e}$$

$$M = m_o M_e = -\frac{L}{f_o}\frac{x_{np}}{f_e}$$



How to Make a Big Telescope Mirror

Melt it & Spin it.

Telescope

Like microscope, a telescope is also made of two converging lenses.

In a Microscope the distance between the two lens that is comparable to the focal length of the two lens.

Both object and image in telescope are at infinity.

$$\tan\theta_o = \frac{y}{s} = -\frac{y'}{f_o} \approx \theta_o$$

$$\tan\theta_e = \frac{y'}{f_e} \approx \theta_e$$

$$M = \frac{\theta_e}{\theta_o} = -\frac{f_o}{f_e}$$