PHYS 202

Lecture 16

Professor Stephen Thornton

March 28, 2006

Reading Quiz:
The near point is the

1. position a magnifying glass should be for maximum magnification.
2. closest a person can focus with a relaxed eye.
3. closest a person can focus their eye.
4. position glasses should be placed for a nearsighted person.
5. position glasses should be placed for a farsighted person.

Answer: 3

Last Time

Refraction of light

Snell's Law

Total internal reflection

Brewster's angle

Ray tracing for lenses

Thin-lens equation

Rainbows

Today – Chapter 27
Optical Instruments

The human eye

Vision correction

Camera

Magnifier

Microscopes, telescopes

Remember that Exam 3 has been postponed until Thursday, April 27.

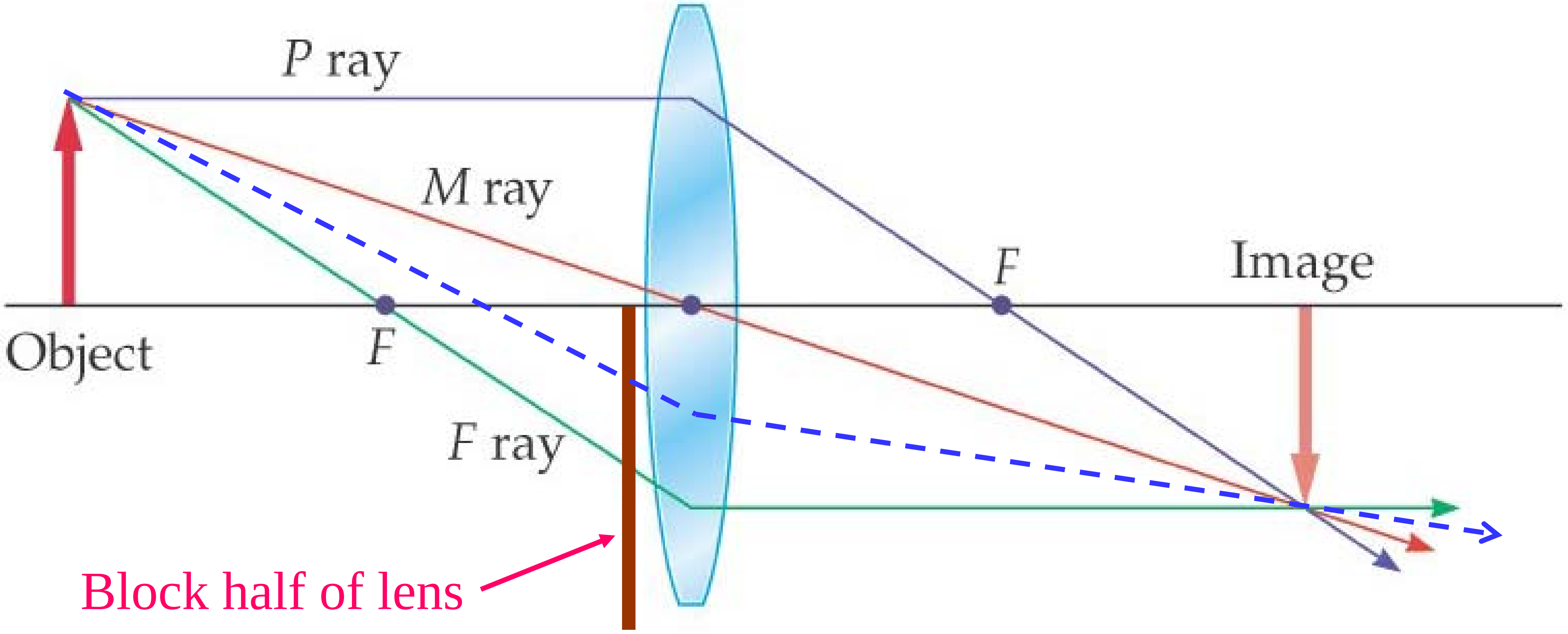
Exam 2 average: 78.7 ± 14.7

Let's look at a couple of the problems.

Conceptual Quiz last lecture:

A lens is used to image an object onto a screen. If the right half of the lens is covered,

1. the left half of the image disappears.
2. the right half of the image disappears.
3. the entire image disappears.
4. the image becomes blurred.
5. the image becomes fainter.



(a)

When we block half of the lens, we simply block half of the rays passing through the lens. We still receive a full image; it is just fainter.

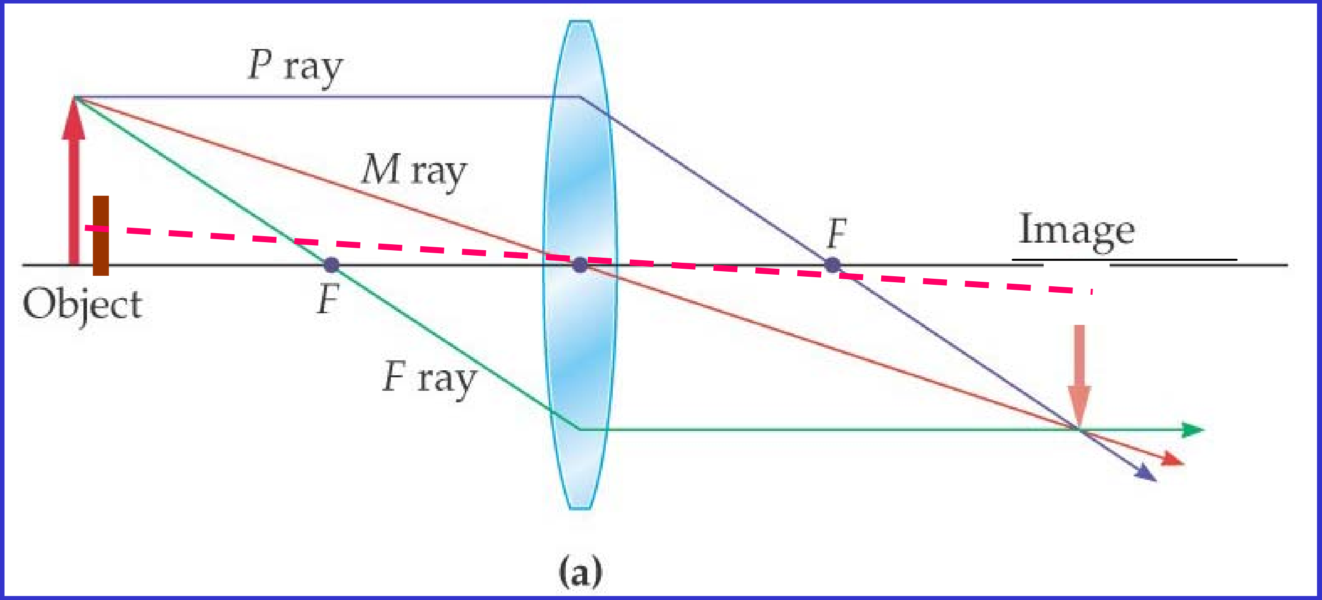
Conceptual Quiz:

A lens is used to image an object onto a screen. If the bottom half of the *object* is covered,

1. the bottom half of the image disappears.
2. the top half of the image disappears.
3. the entire image disappears.
4. the image becomes blurred.
5. the image becomes fainter.

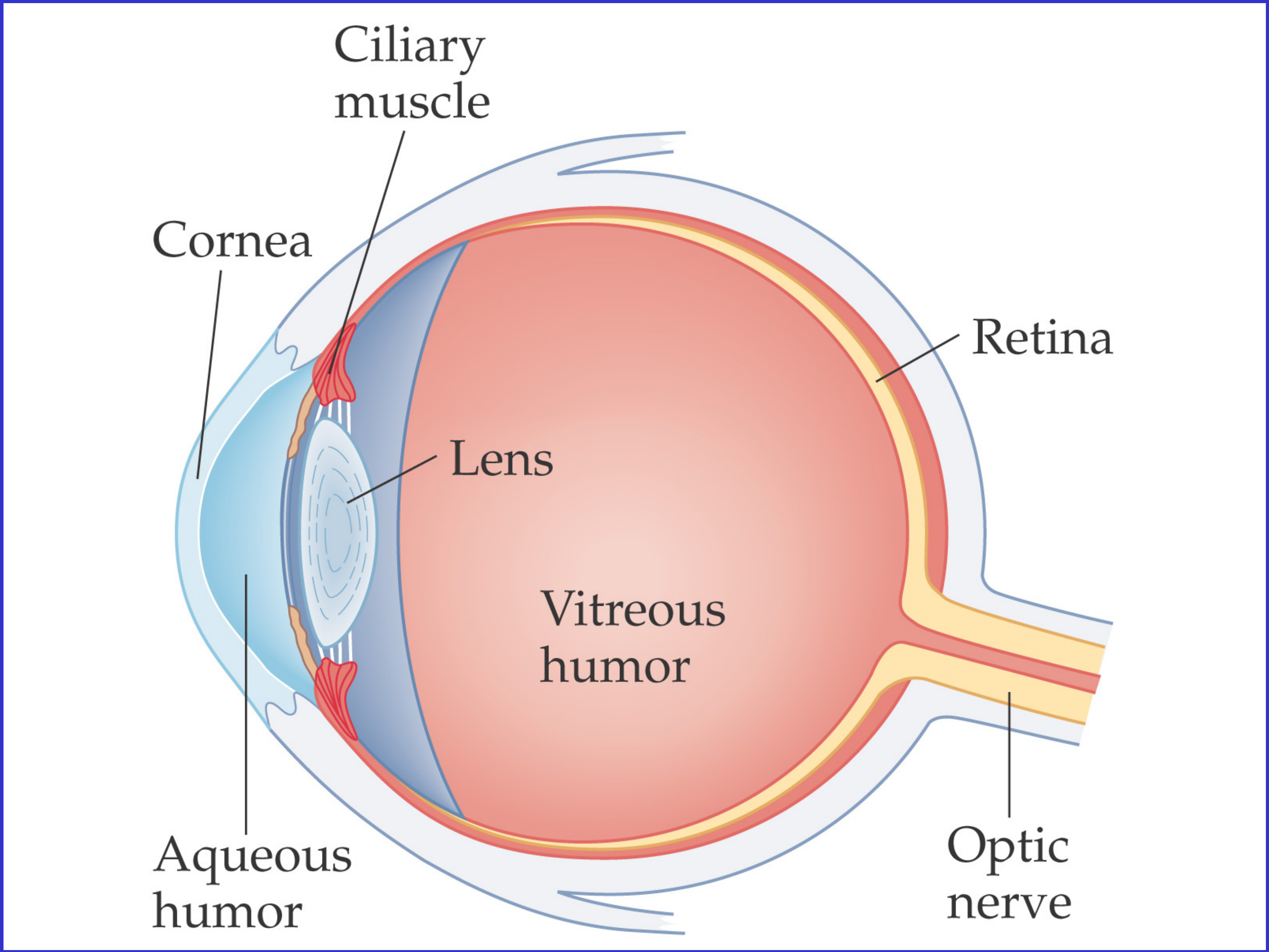
Answer: 1

Now the situation is much different. The light rays from the bottom half of the object are blocked, and they can go nowhere.

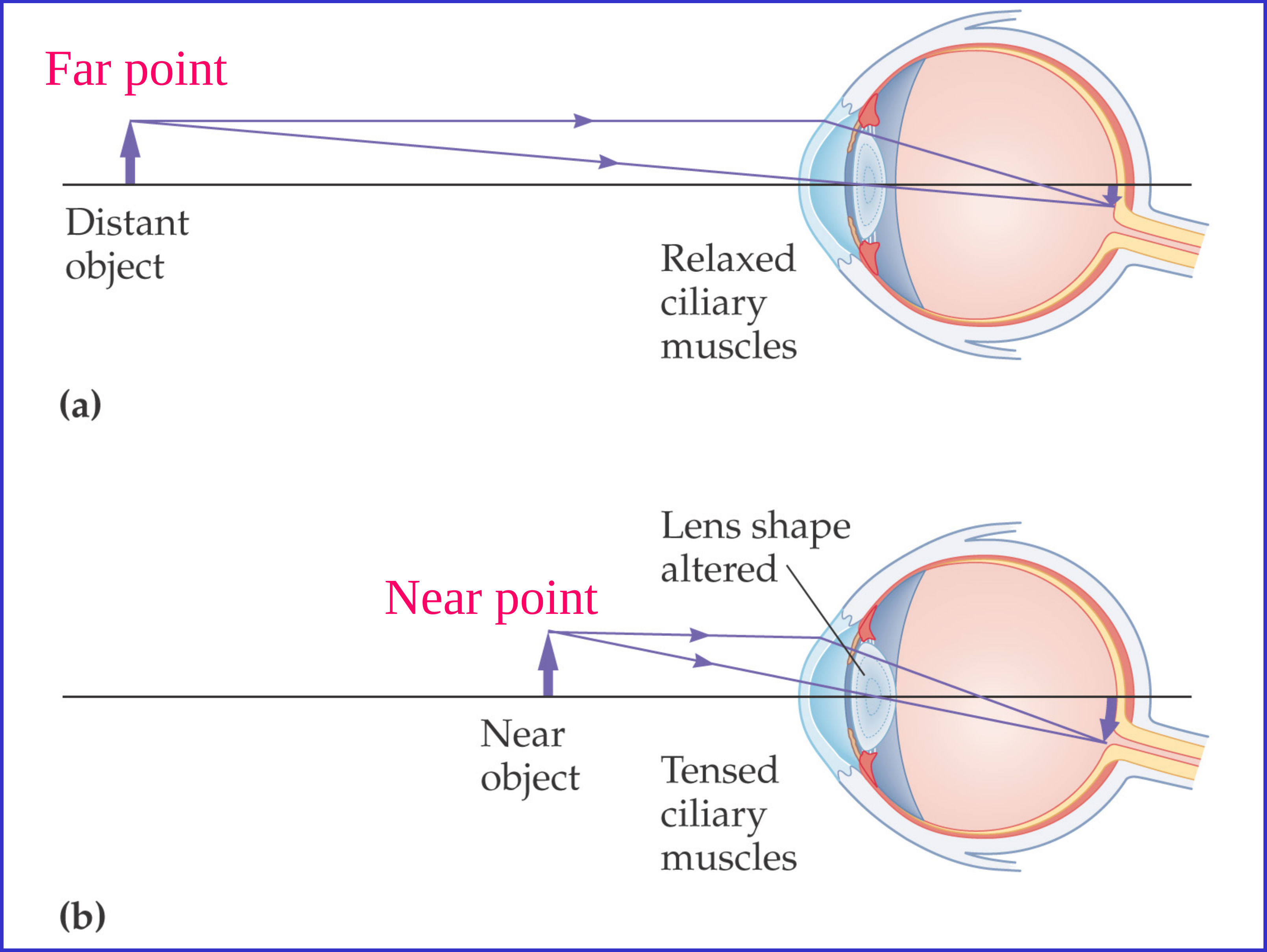


Work Problem 26-93

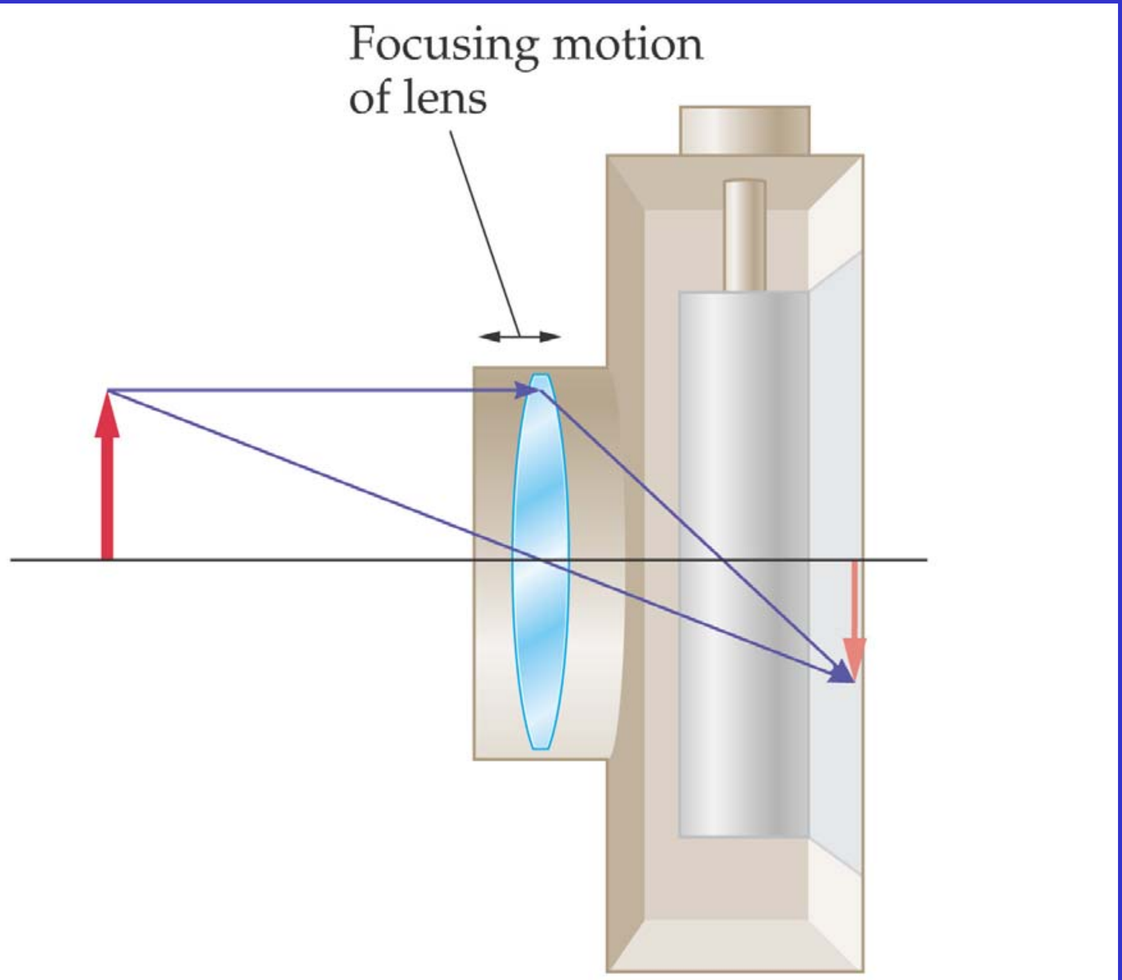
Basic Elements of the Human Eye



Accommodation in the Human Eye



Basic Elements of a Camera



$$f-\text{number}=\frac{\text{focal length}}{\text{aperture dia.}}=\frac{f}{D}$$

f-NUMBER - (*f*-number) A number that expresses a lens' light-transmitting ability - i.e. the size of the lens opening. Usually found on the barrel of a lens, f-numbers indicate the size of the aperture in relation to the focal length of the lens. A smaller number indicates a larger lens diameter. *f*/1.4 signifies that the focal length of the lens is 1.4 times as great as the diameter. All lenses set at the same f-number transmit the same amount of light.

***f*-stop** - (f-stop) A lens aperture setting calibrated to an f-number.

Conceptual Quiz:

When your eye focuses on something far away, the lens in the eye has a radius of curvature *R*. What is the radius of curvature when you focus on something at your eye's near point? (The near point is the minimum distance from your eye for an object to be in focus.)

1. It is still *R*.
2. It is less than *R*.
3. It is greater than *R*.

Answer: 2

To focus at the near point, we have to squeeze our eye muscles, which squeezes the lens to make it thicker. This makes the radius of curvature smaller.

Conceptual Test (too hard):

You have a manual camera with a focal length of 50 mm. It is "focused" at infinity, but you want to take a picture of an object that is only 0.30 m away. What should you do?

1. Increase the distance between the lens and the film by 10 mm (move the lens out)
2. Increase the distance between the lens and the film by 50 mm (move the lens out more)
3. Decrease the distance between the lens and the film by 10 mm (move the lens in)
4. Decrease the distance between the lens and the film by 50 mm (move the lens in more)
5. None of the above.

Answer: 1

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{i_1} \quad \text{because } o = \infty$$

$$i_1 = f = 50 \text{ mm} = 5.0 \text{ cm}$$

$$\frac{1}{5.0 \text{ cm}} = \frac{1}{o_2} + \frac{1}{i_2} = \frac{1}{30 \text{ cm}} + \frac{1}{i_2}$$

$$\frac{1}{i_2} = \frac{1}{5.0 \text{ cm}} - \frac{1}{30 \text{ cm}} = 0.20 - 0.033 \text{ cm}^{-1}$$

$$i_2 = 6.0 \text{ cm} \quad \text{further out by}$$

6.0 cm - 5.0 cm = 1 cm = 10 mm

You have a manual camera with a focal length of 50 mm. It is "focused" at infinity, but you want to take a picture of an object that is only 0.30 m away. What should you do?
Answer: Increase the distance between the lens and the film by 10 mm (move the lens out)

$$\frac{1}{f} = \frac{1}{o_1} + \frac{1}{i_1} = \frac{1}{i_1} \quad \text{because } o_1 = \infty$$

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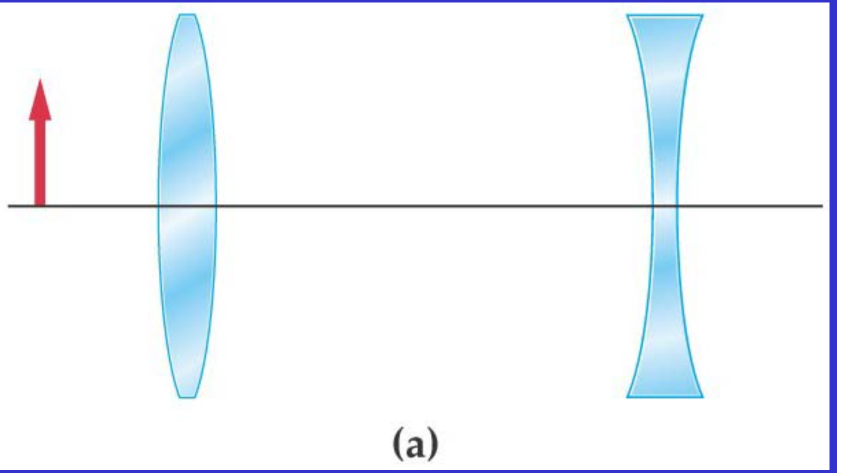
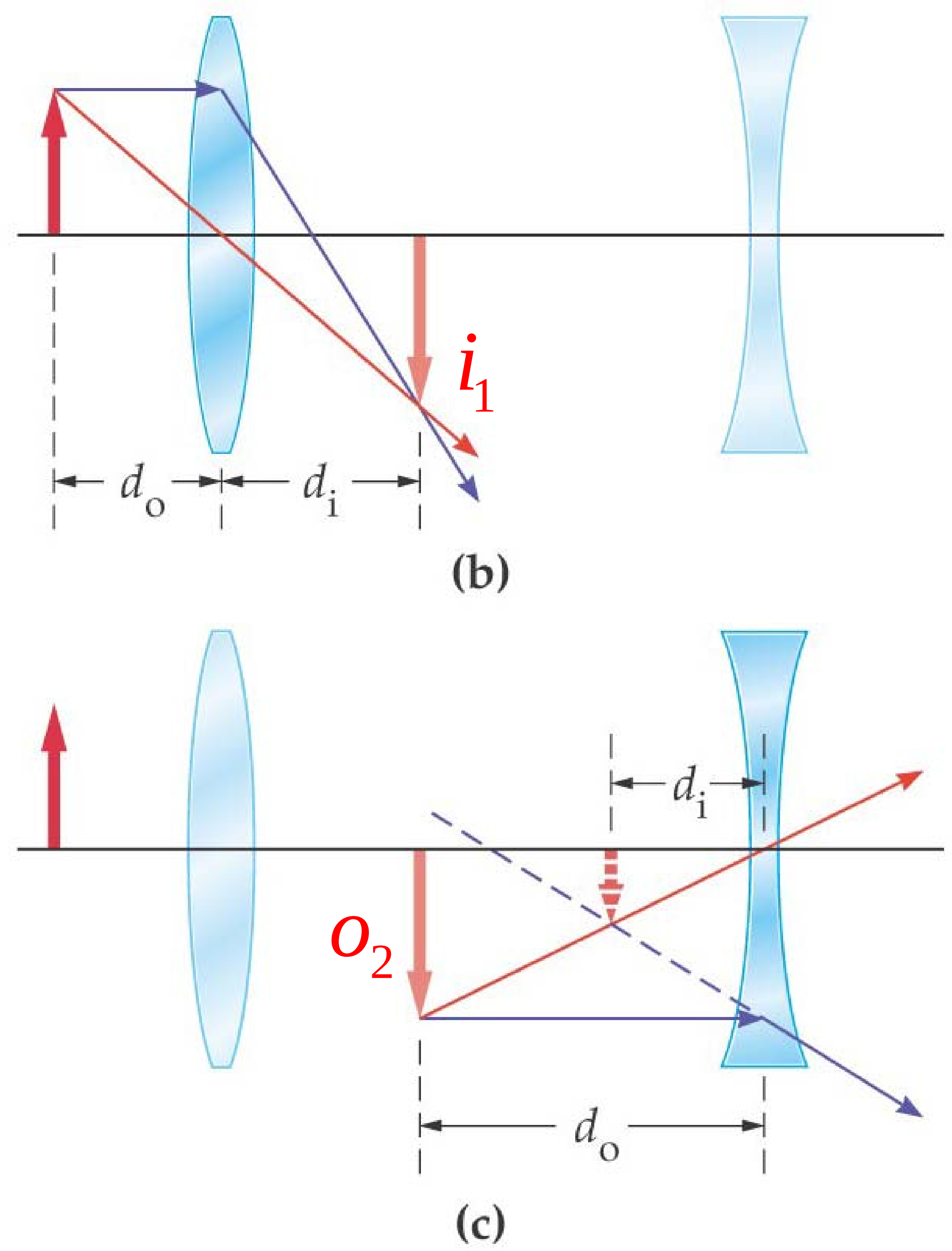
Two-Lens System

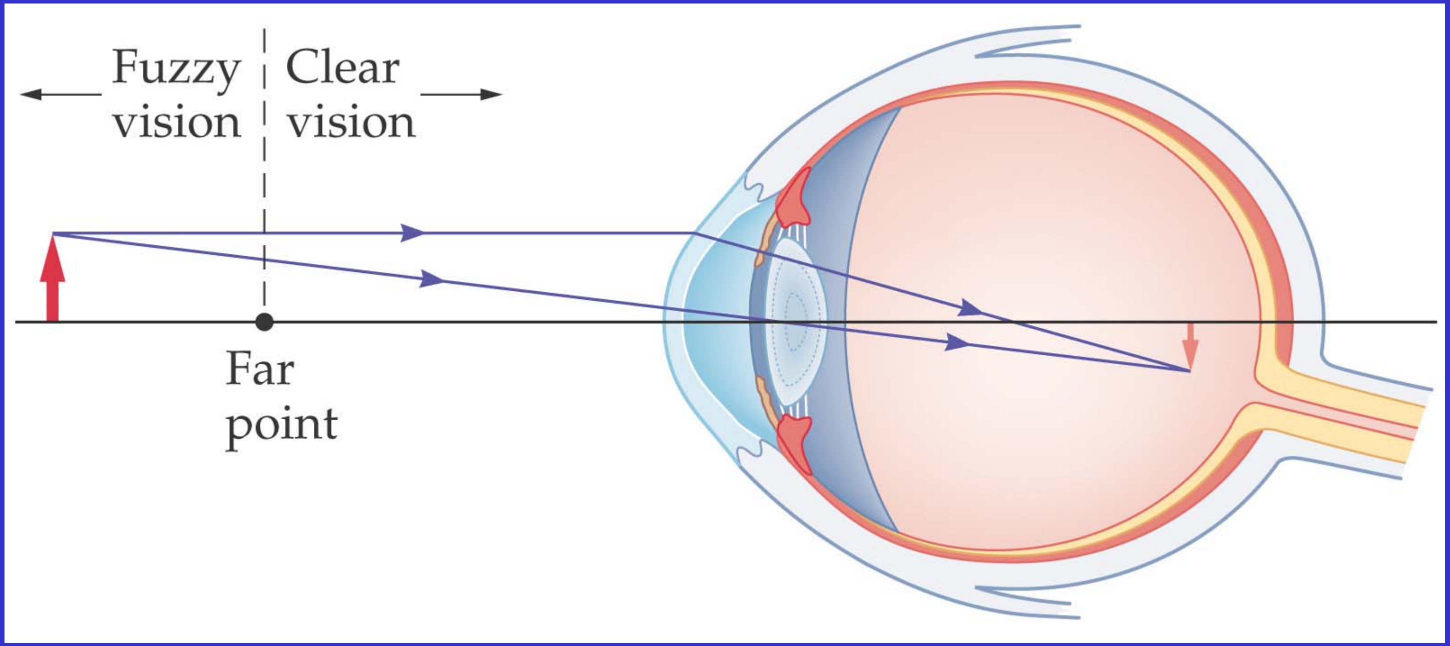


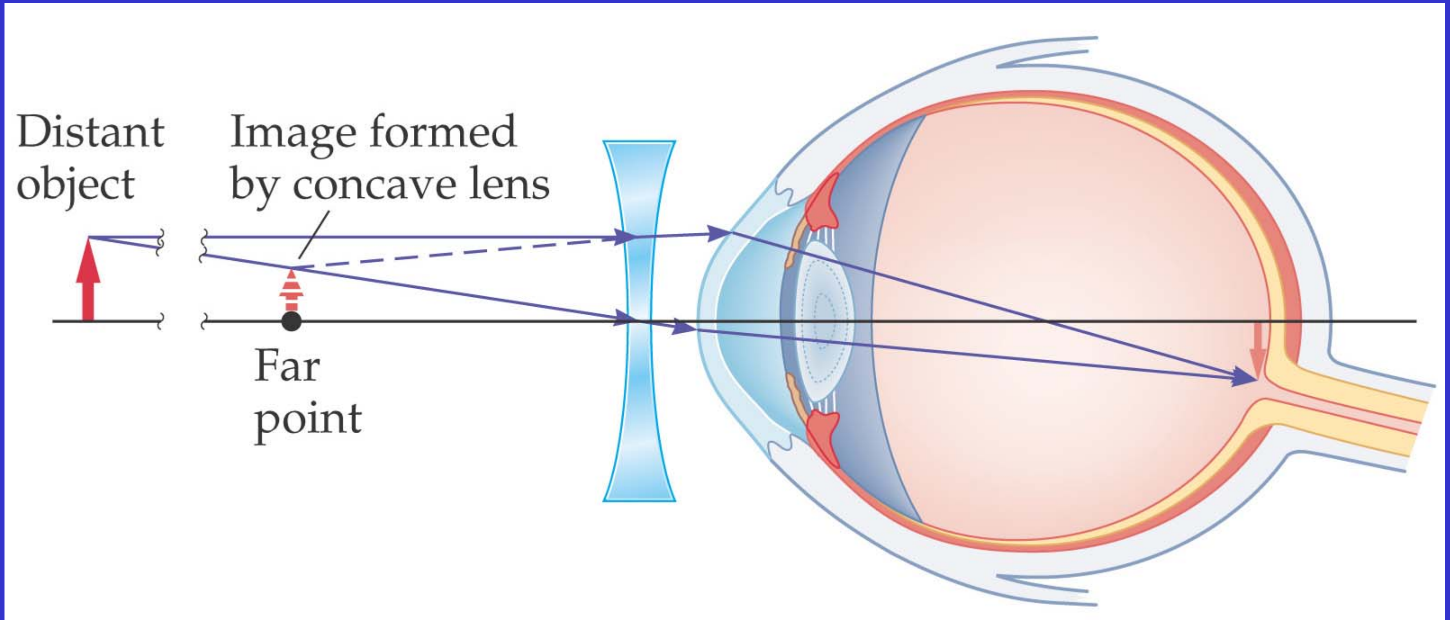


Remember that the image of the first lens becomes the object of the second.

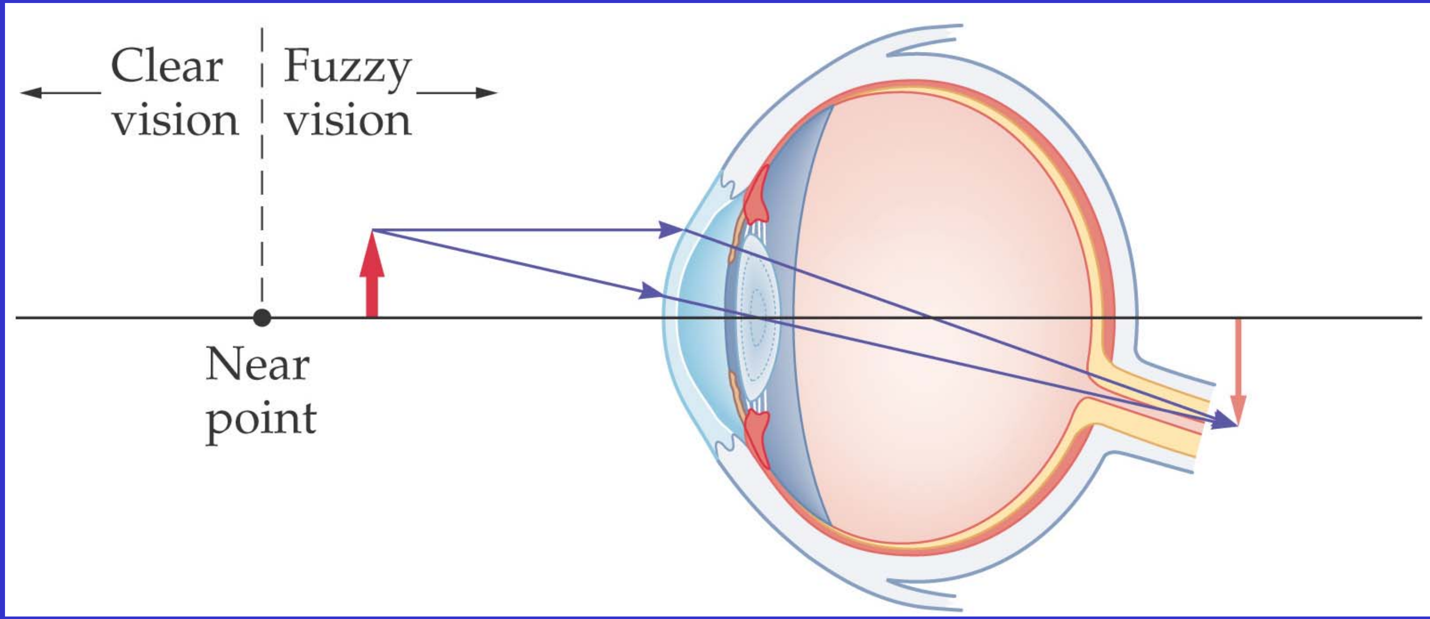
Total $m = m_1 m_2$

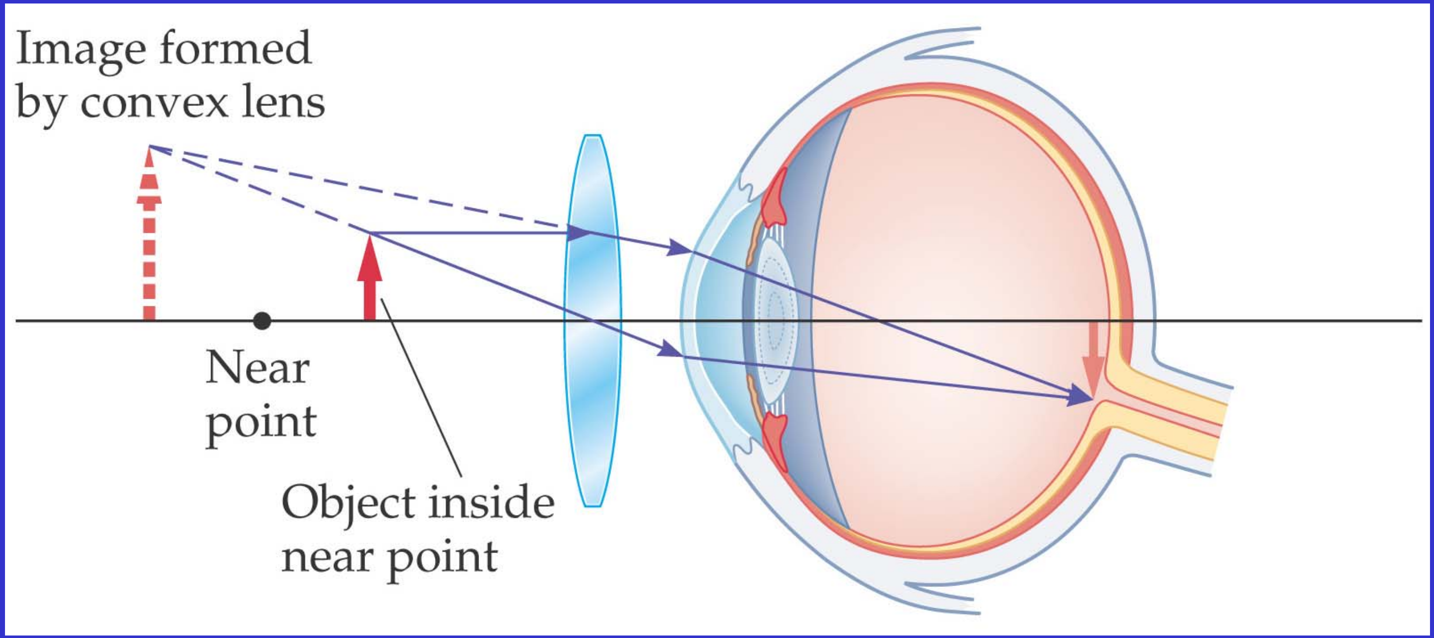
Eye Shape and Nearsightedness





Farsightedness



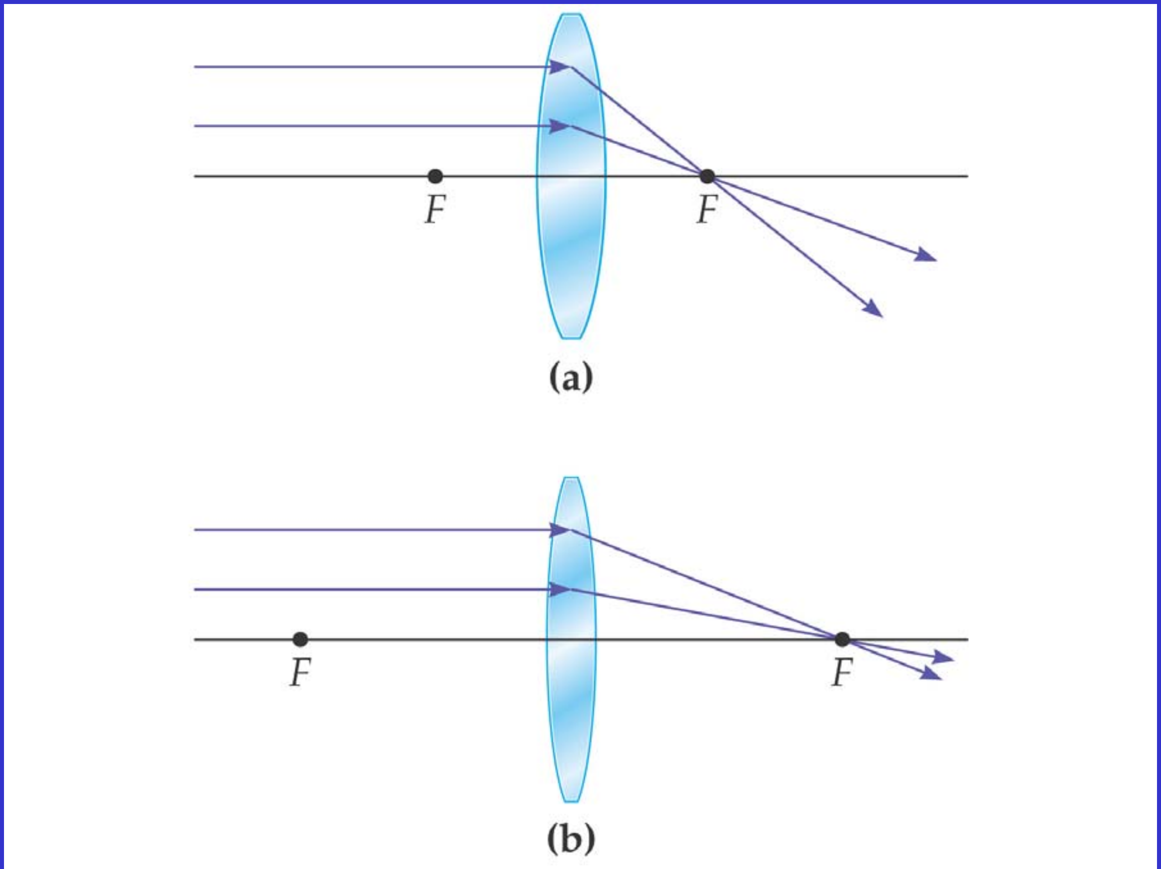


Model to see how glasses affect

Nearsightedness:
http://qbx6.ltu.edu/s_schneider/physlets/main/nearsighted.shtml

Farsightedness:
http://qbx6.ltu.edu/s_schneider/physlets/main/farsighted.shtml

Refractive Power



$$\text{Refractive power} = \frac{1}{f}$$

+ converging lens
- diverging lens

SI unit: diopter = m^{-1}

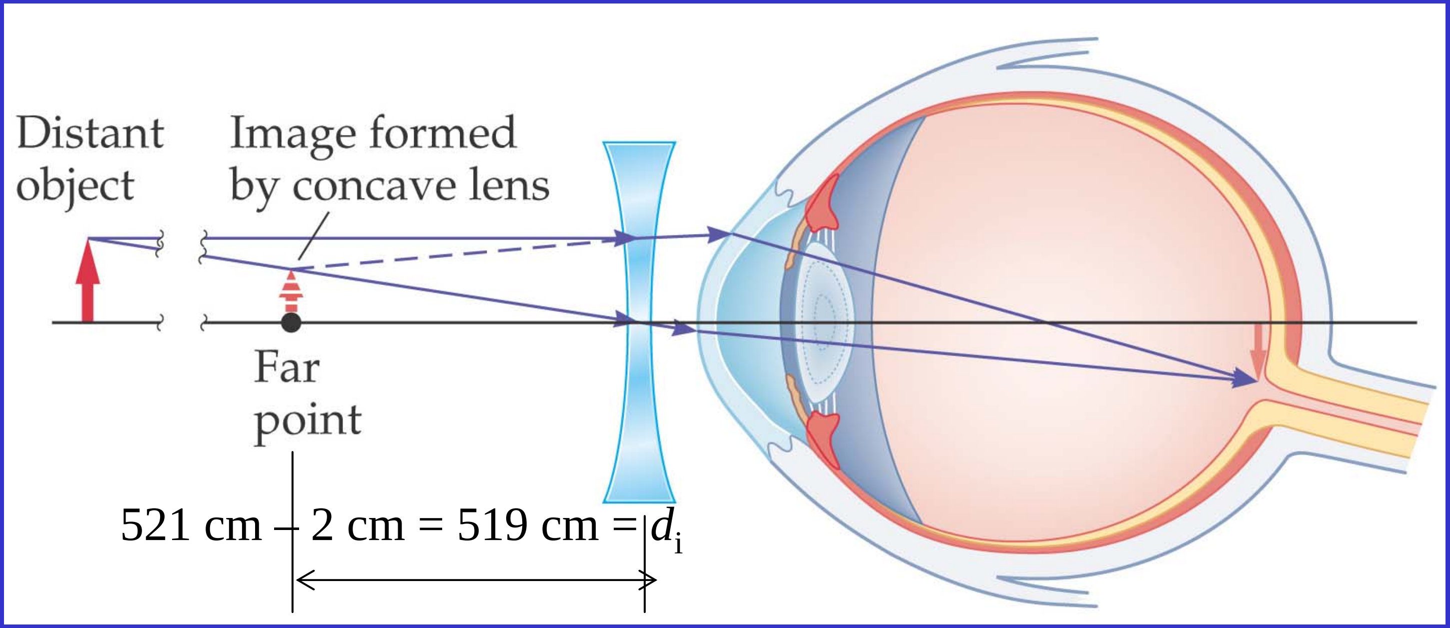
limit of clear vision	normal distance	vergence
near point	25 cm = 0.25 m	4 diopters
far point	∞	0 diopters

Range of accommodation is then 4 diopters.

Nearsighted Example – find RP

Far point: 521 cm

Eyeglasses worn 2 cm from eye.



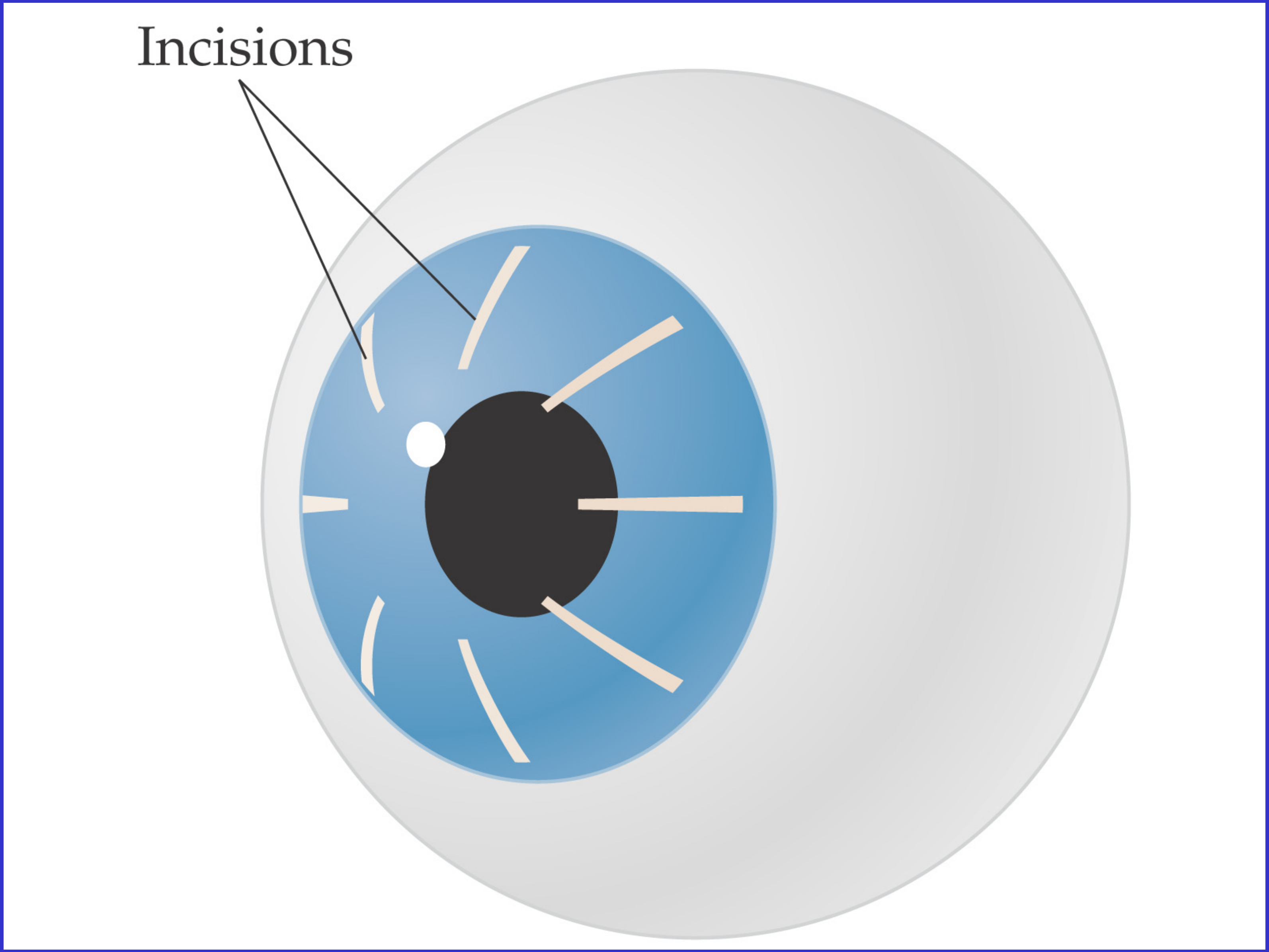
We want to see far away: $d_0 = \infty$; d_i = -519 cm (virtual)

$$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i} = \frac{1}{\infty} + \frac{1}{-519\text{ cm}}$$

$$\text{RP} = \frac{1}{-5.19} = -0.193 \text{ diopters}$$

Do demo on light retention

Radial Keratotomy



LASIK – laser eye surgery

Earlier versions:

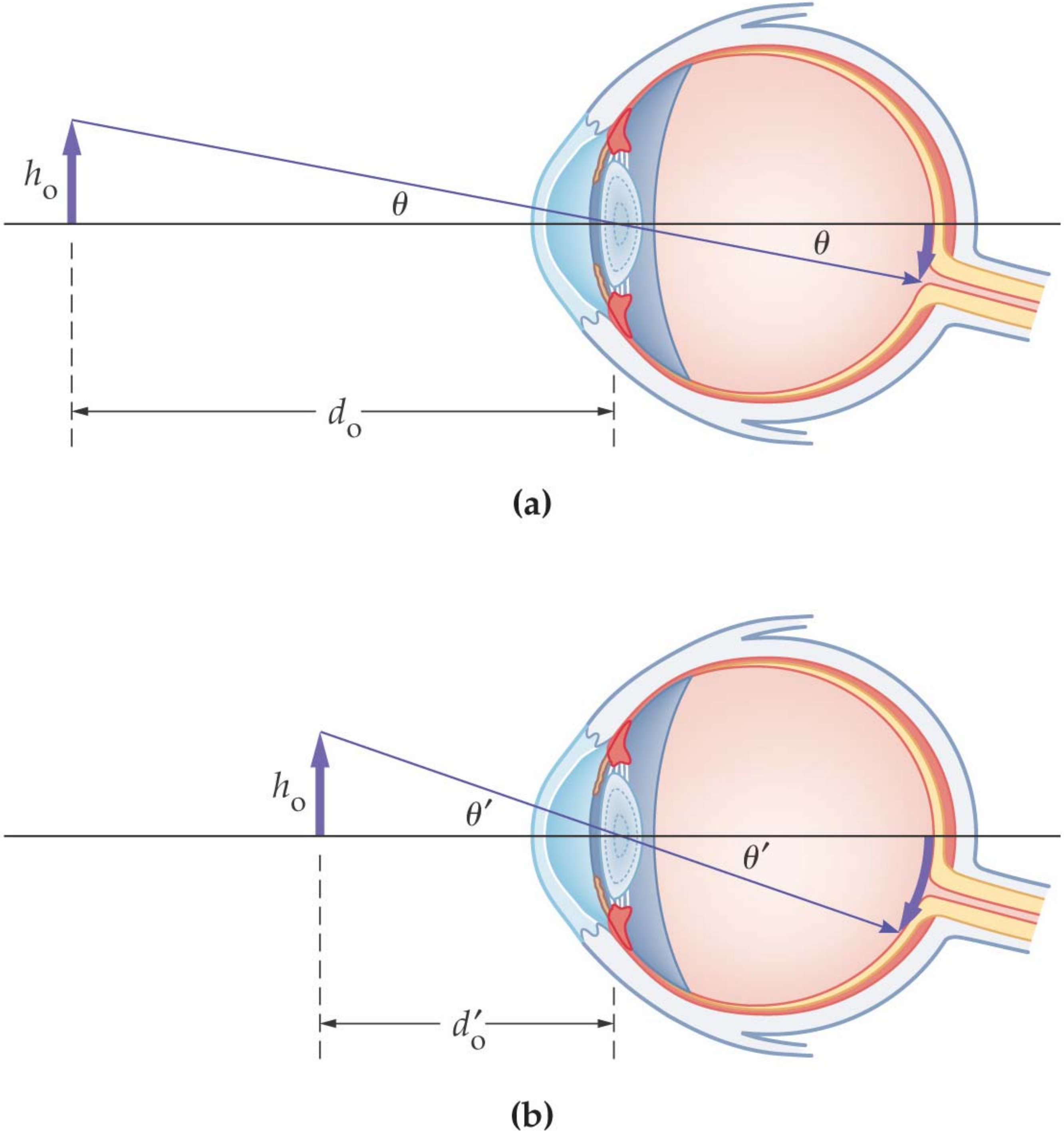
http://www.bausch.com/us/vision/concerns/surgery/history.jsp

Description:

http://www.lasik1.com/index.html

LASIK is the most commonly performed refractive surgery procedure. The name is short for "laser-assisted in situ keratomileusis." An instrument called a microkeratome is used in LASIK eye surgery to create a thin, circular flap in the cornea. The surgeon folds the flap back out of the way, then removes some corneal tissue underneath using an excimer laser. The laser uses a cool ultraviolet light beam to precisely remove ("ablate") very tiny bits of tissue from the cornea to reshape it. When the cornea is reshaped in the right way, it works better to focus light into the eye and onto the retina, providing clearer vision than before. The flap is then laid back in place, covering the area where the corneal tissue was removed.

Both nearsighted and farsighted people can benefit from the LASIK procedure. With nearsighted people, the goal is to flatten the too-steep cornea; with farsighted people, a steeper cornea is desired. Also, excimer lasers can correct astigmatism, by smoothing an irregular cornea into a more normal shape.

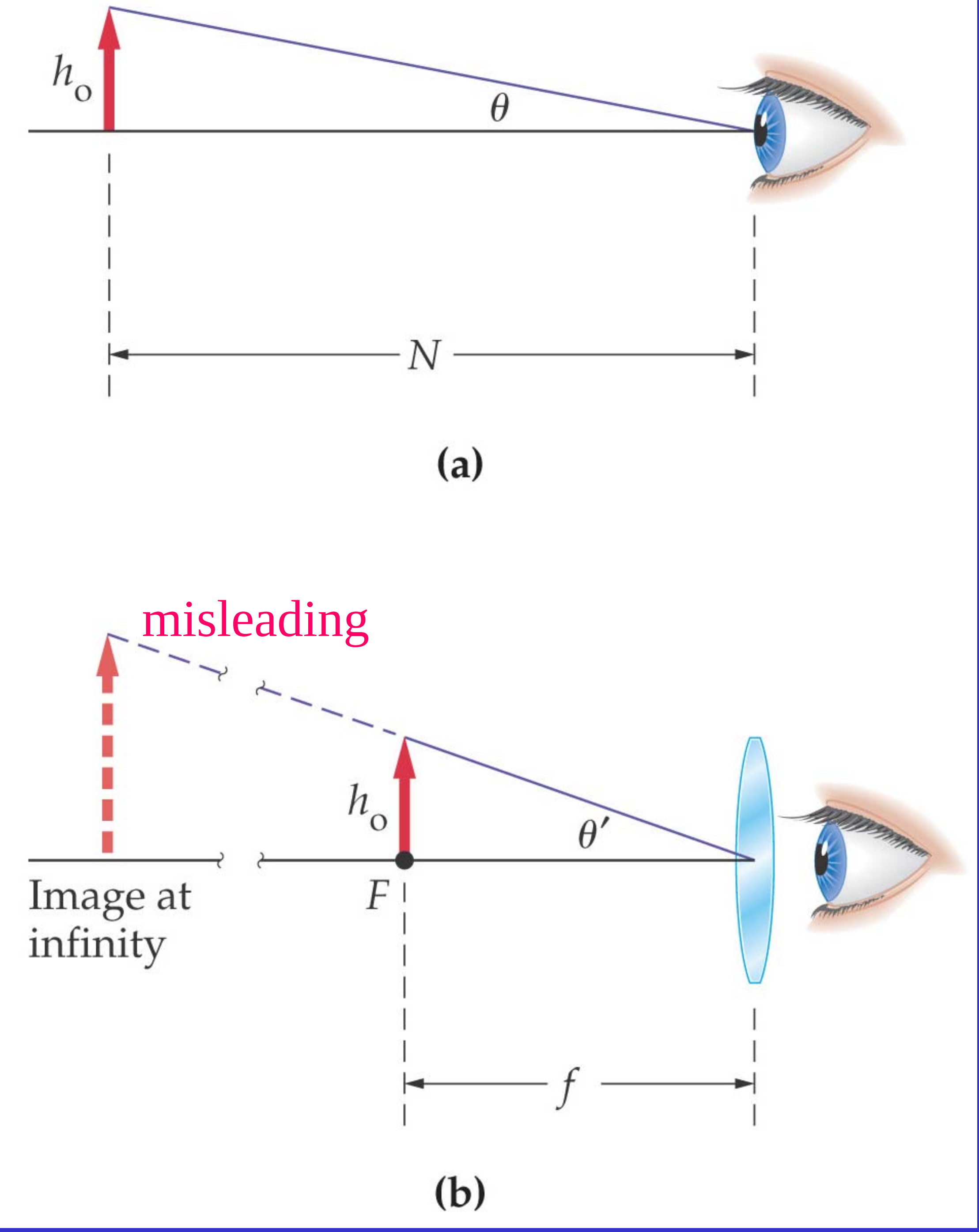


Angular Size and Distance

$$\theta \approx \frac{h_0}{d_0}$$

$$\theta' \approx \frac{h_0}{d_0^{'}}$$

Angular size θ determines size on retina.



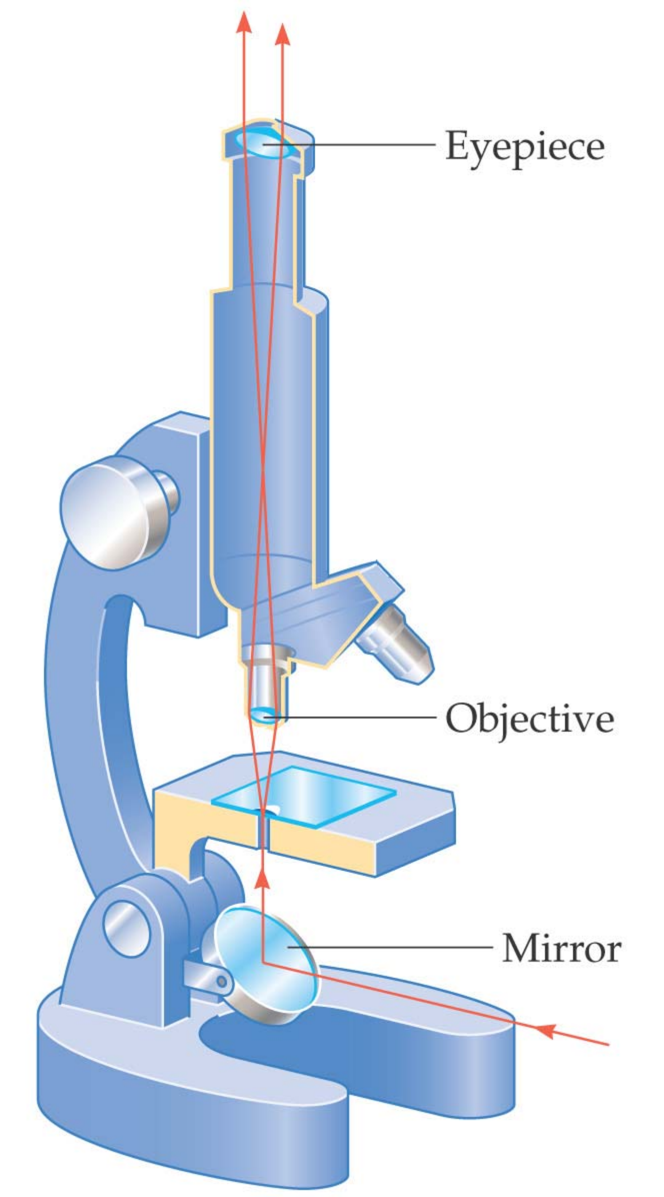
How a Simple Magnifier Works

$$\theta = \frac{h_0}{N}$$

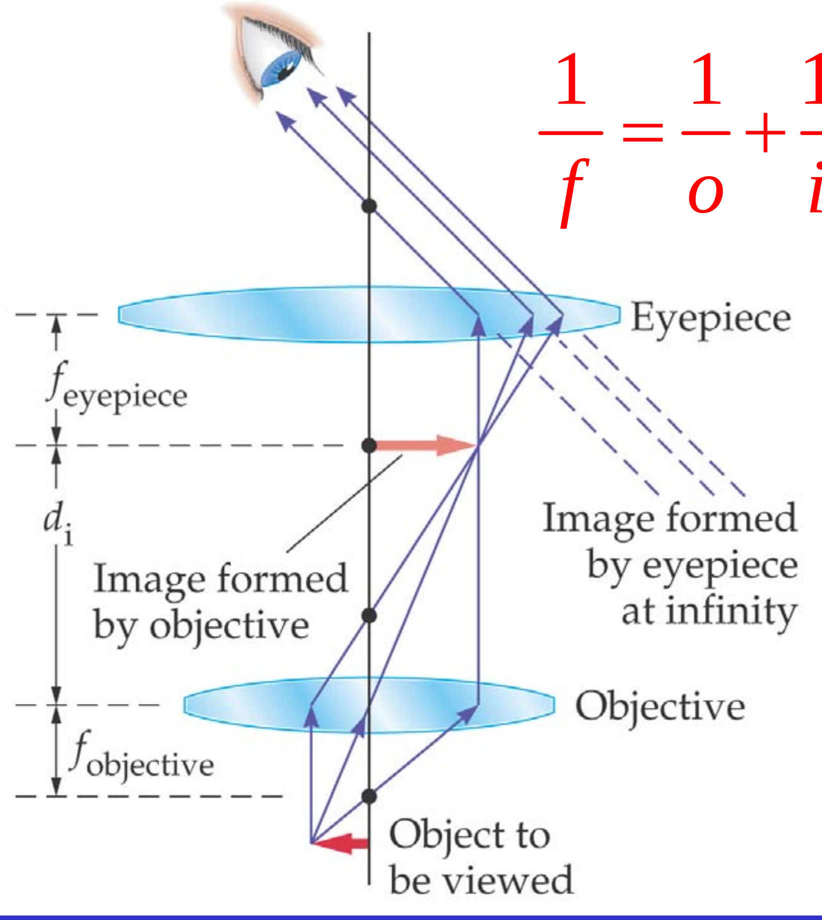
$$\theta' = \frac{h_0}{f} > \theta$$

$$M = \frac{\theta'}{\theta} = \frac{N}{f}$$ Angular magnification

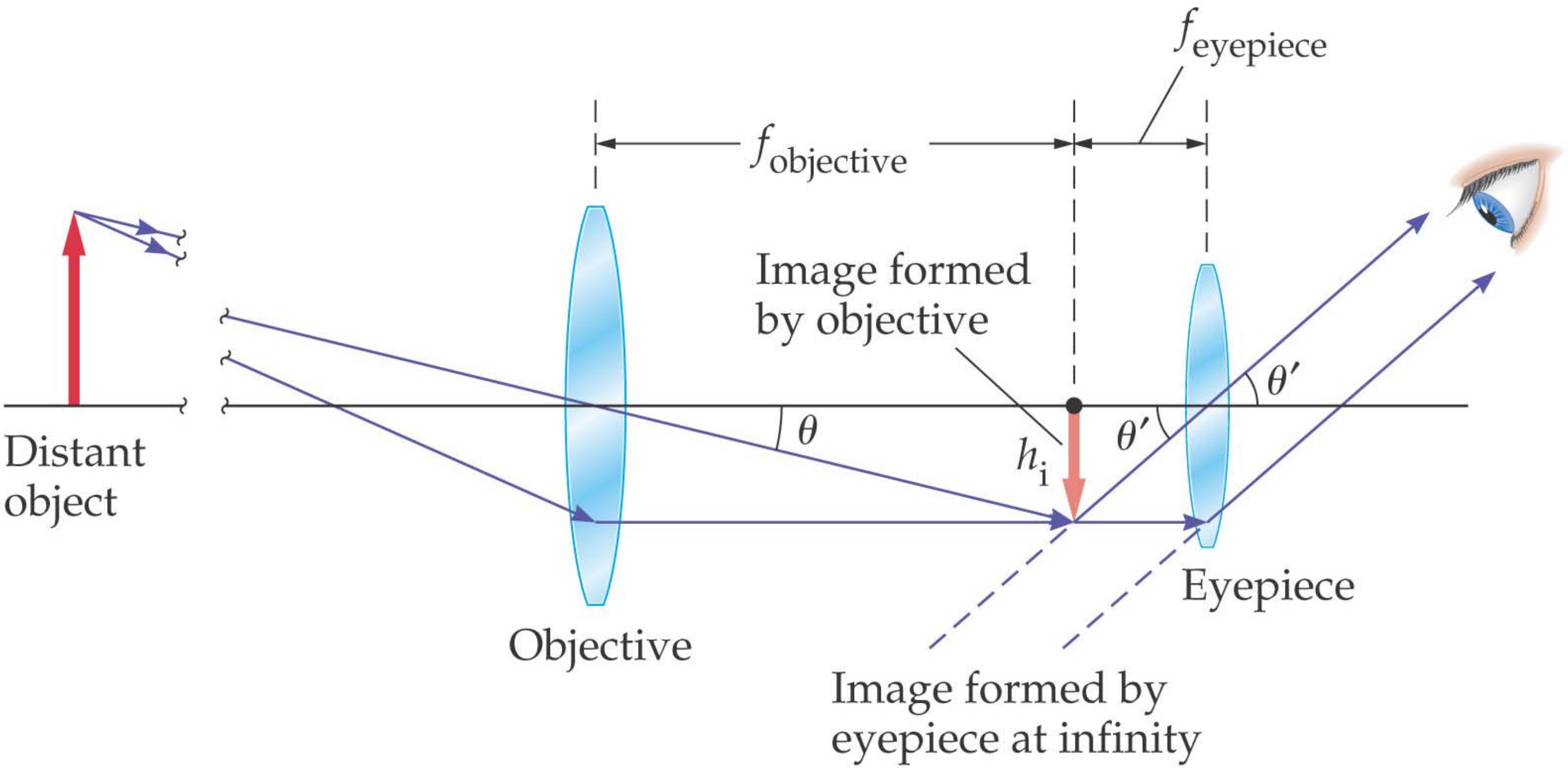
Basic Elements of a Compound Microscope



$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$

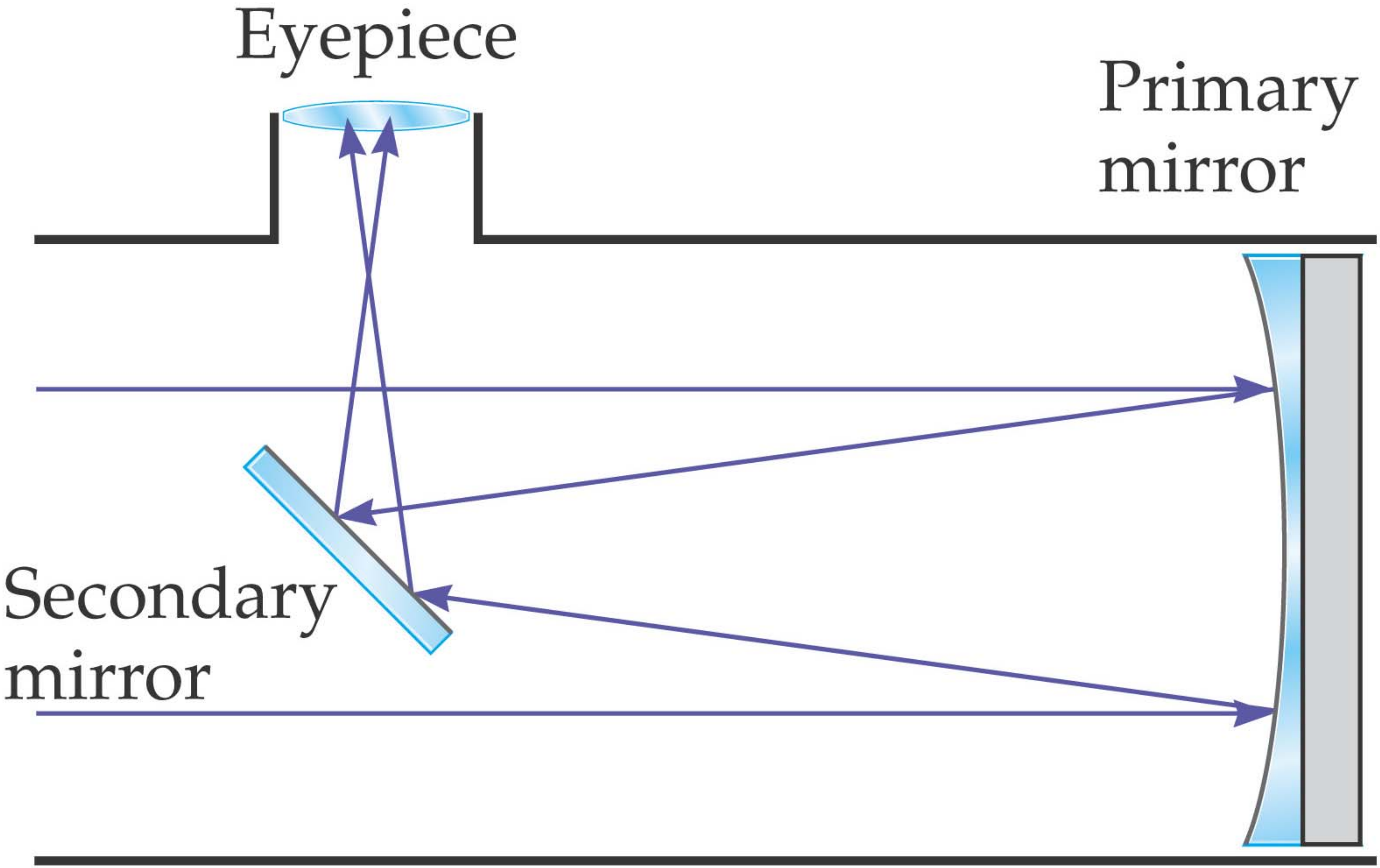


Basic Elements of a Telescope

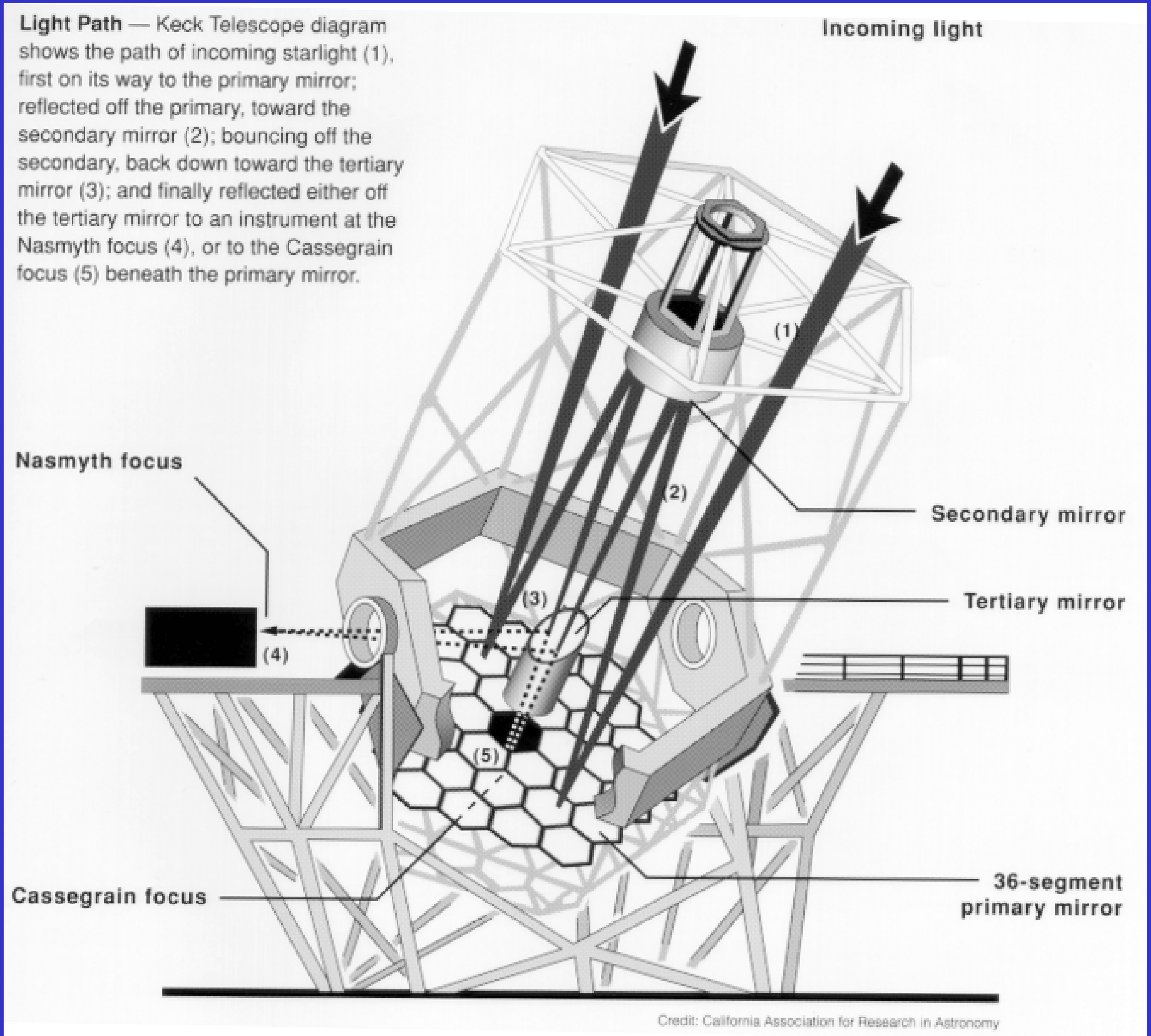


Refracting telescope

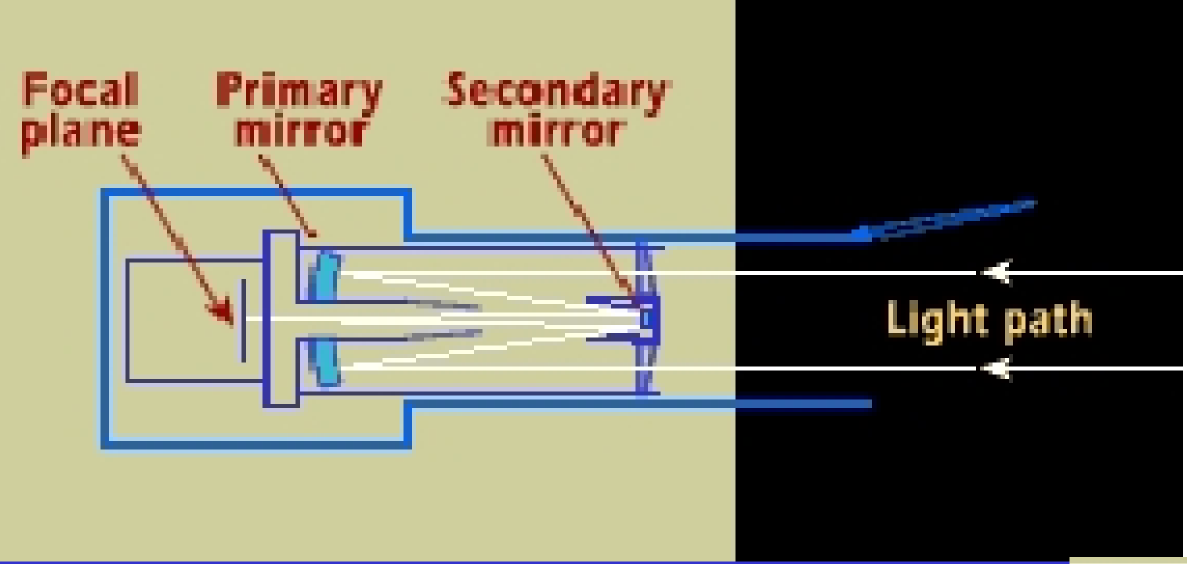
Newtonian Reflecting Telescope

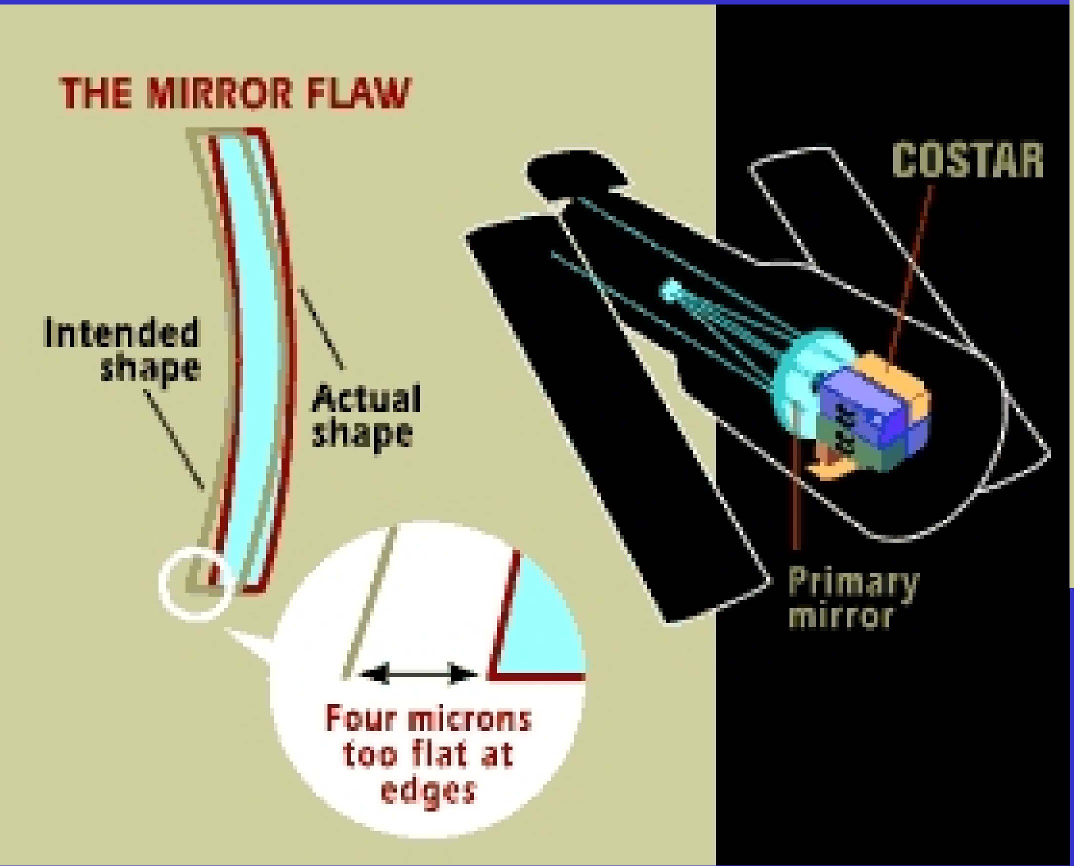


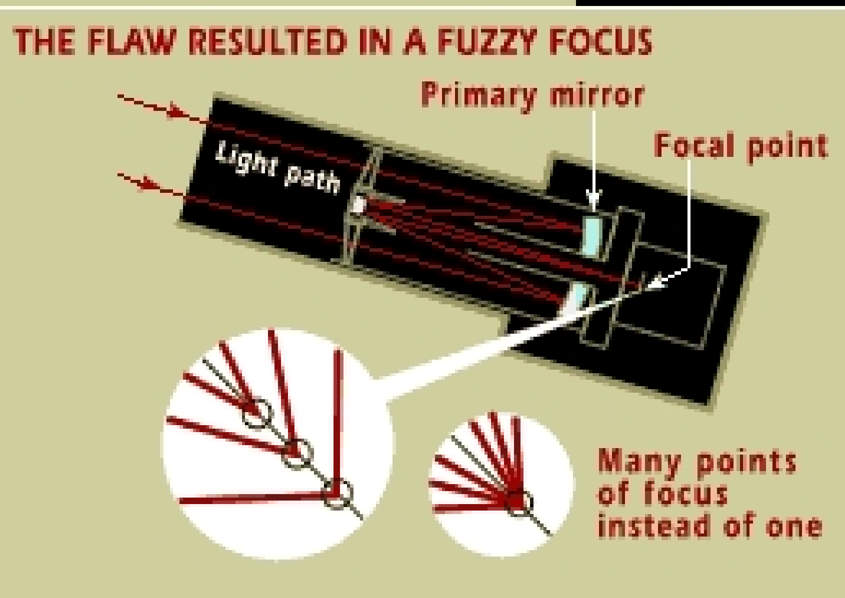
Cassegrain type telescopes – most large telescopes are like this – Keck, Hubble, Hale.



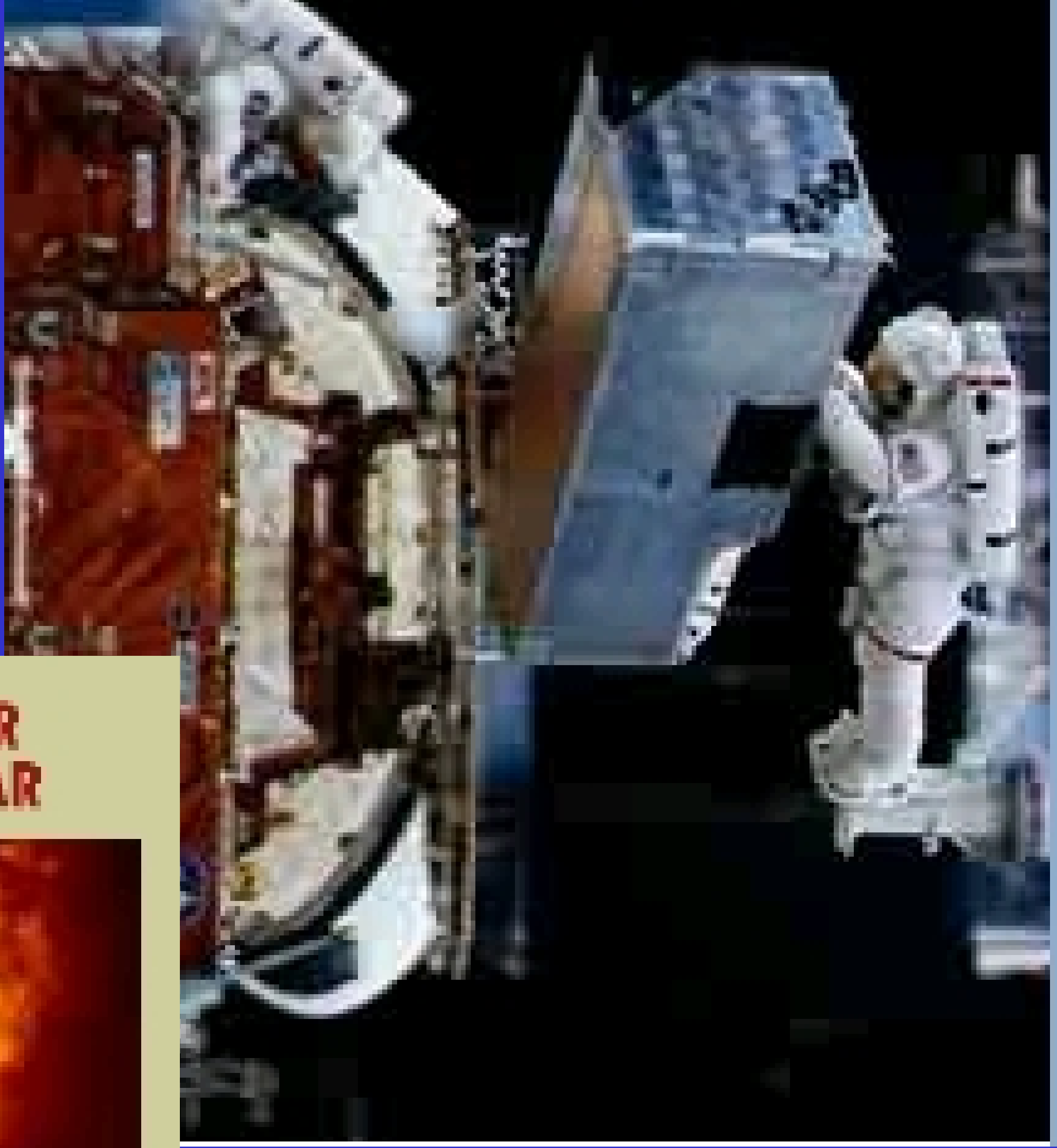
Hubble Space Telescope







Fixing Hubble Space Telescope



Work Problems 27-33, 27-68