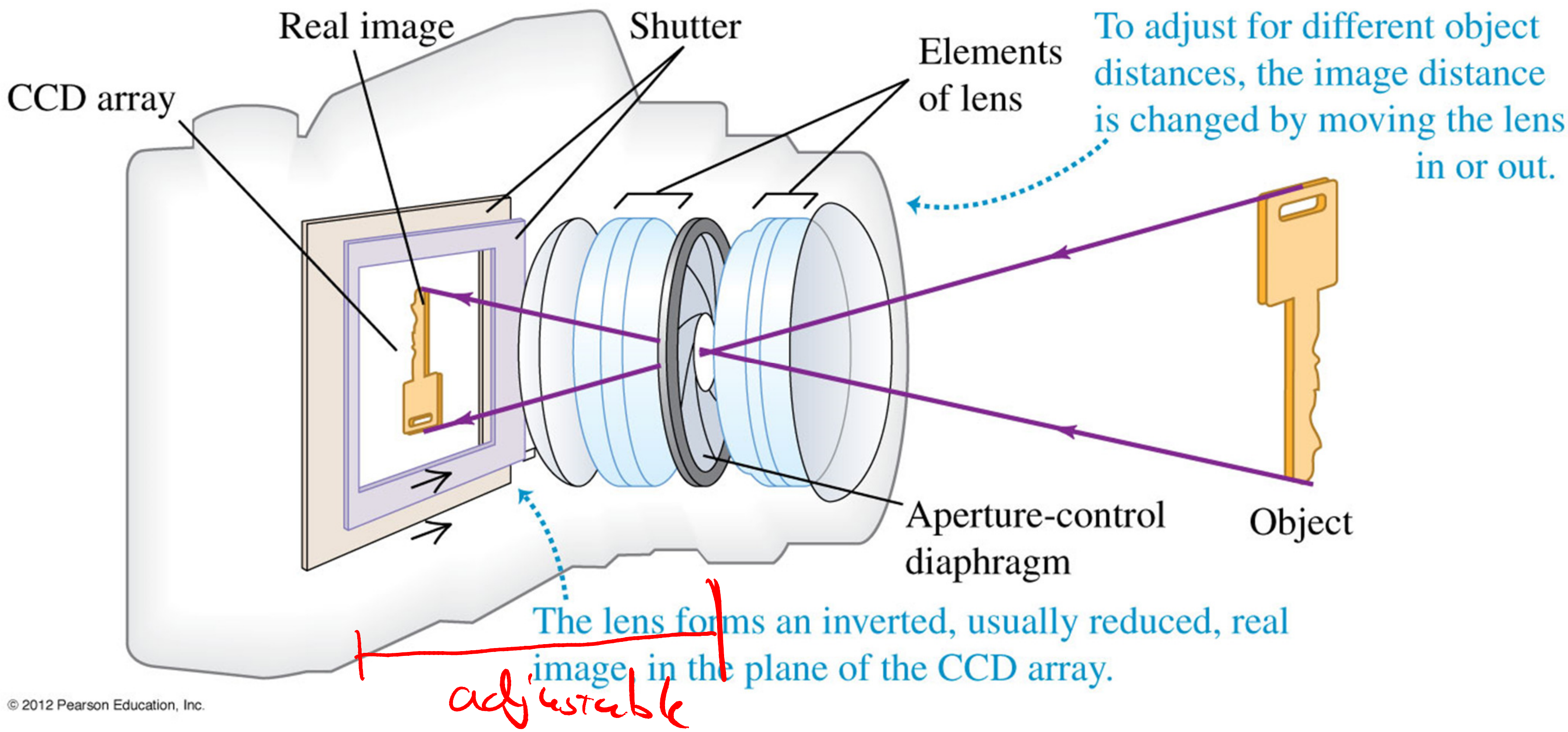
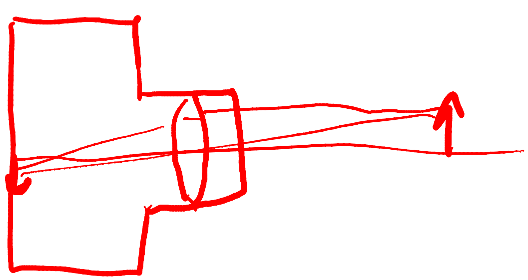
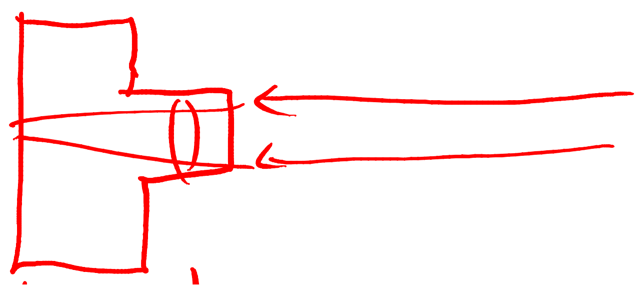
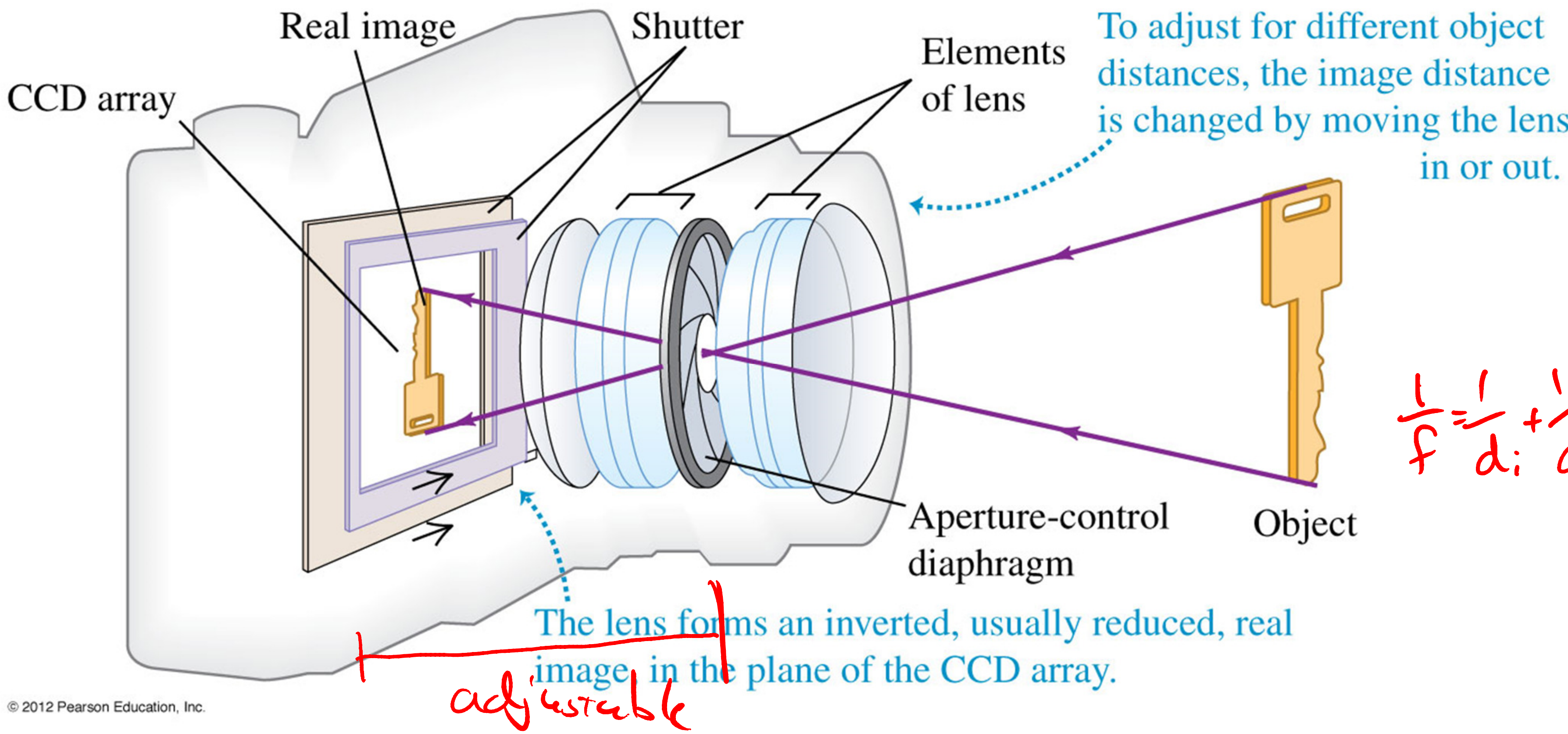


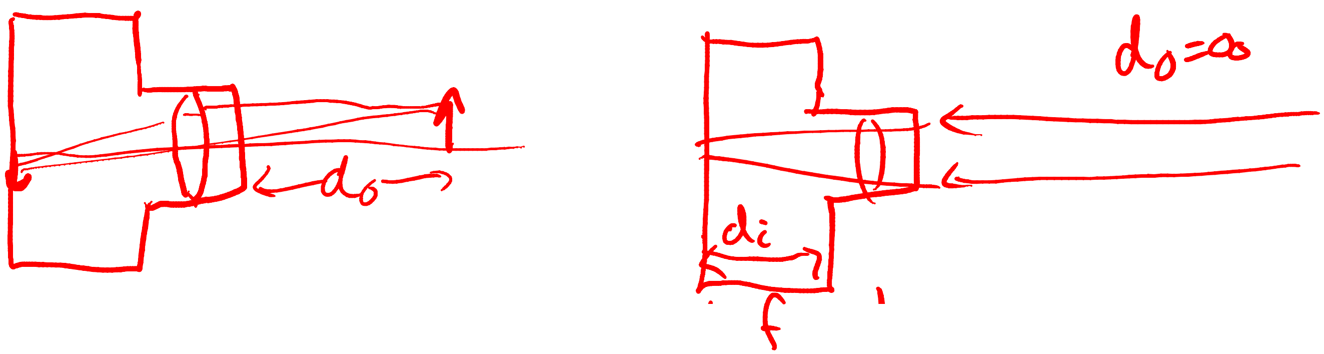
Real image
Shutter
CCD array
Elements of lens
To adjust for different object distances, the image distance is changed by moving the lens in or out.
Aperture-control diaphragm
Object
The lens forms an inverted, usually reduced, real image in the plane of the CCD array.
adjustable





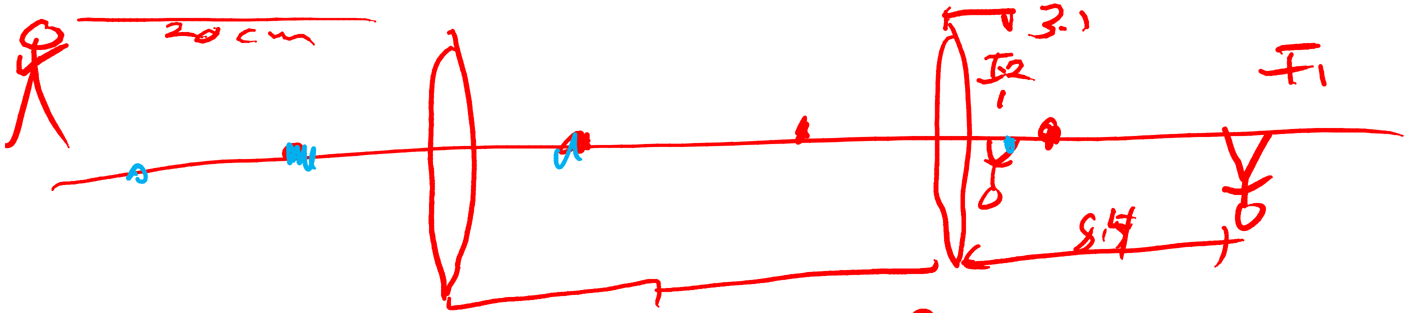


$$\frac{1}{f}=\frac{1}{d_i}+\frac{1}{d_o}$$



A two-lens problem

- Two thin lenses are placed 8 cm apart. The first has a focal length of +9 cm, the second +5 cm.
- An object is placed 20 cm in front of the first lens. Where is the final image formed, and what's its total magnification? Is it a virtual or real image?
- Method: break it up into two problems with one lens each. Use the image produced by the first lens as the object for the second lens.



1st lens $f_1 = +9\text{cm}$ 8cm $f_2 = +5\text{cm}$

$$\frac{1}{f_1} = \frac{1}{s_1} + \frac{1}{s_1'} \Rightarrow s_1' = \left(\frac{1}{f_1} - \frac{1}{s_1}\right)^{-1} = \left(\frac{1}{9\text{cm}} - \frac{1}{20\text{cm}}\right)^{-1}$$

$$s_1' = +16.4\text{ cm}$$

2nd Lens:

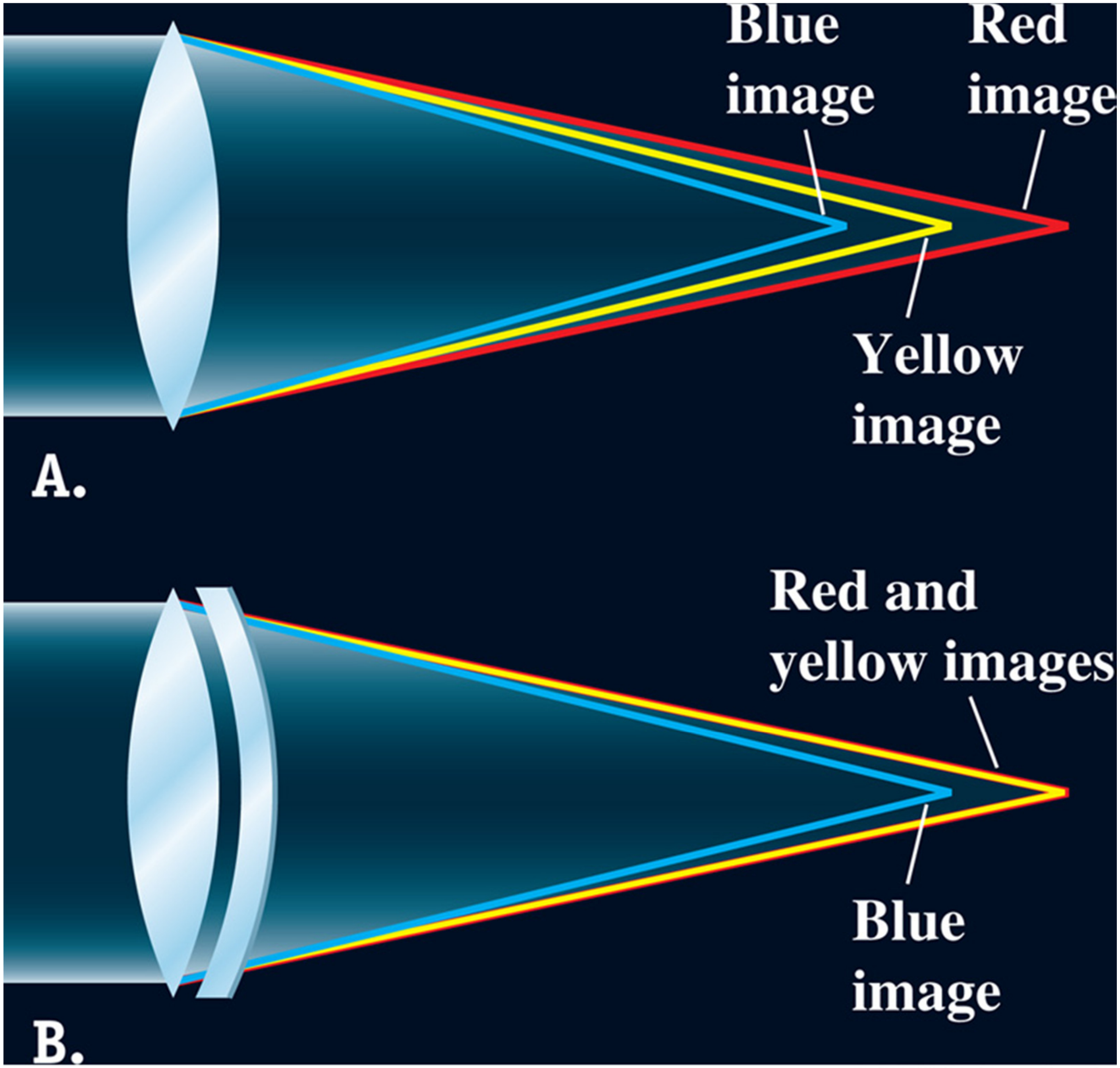
$$\frac{1}{f_2} = \frac{1}{s_2} + \frac{1}{s_2'} = \frac{1}{-8.4\text{cm}} + \frac{1}{s_2'}$$

$$s_2' = \left(\frac{1}{f_2} - \frac{1}{s_2}\right)^{-1} = \left(\frac{1}{5\text{cm}} - \frac{1}{-8.4\text{cm}}\right)^{-1} = +3.1\text{ cm}$$

to right of #2

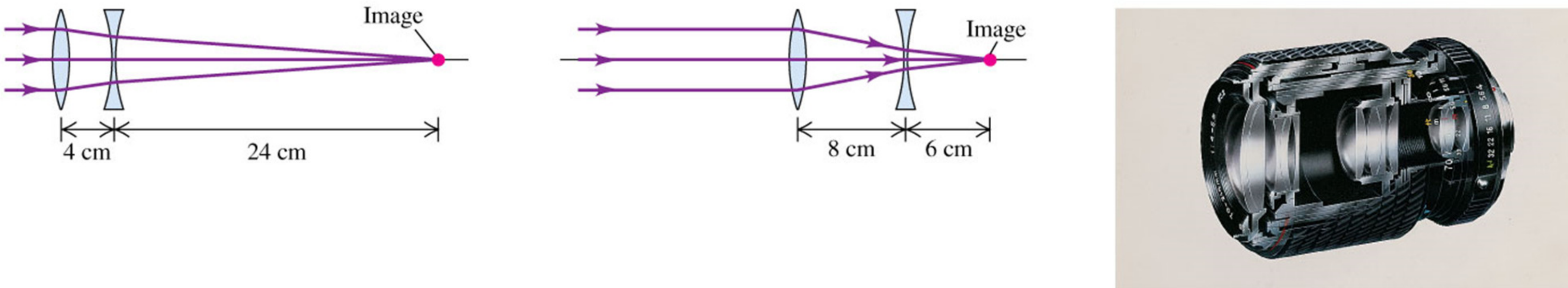
$$M_{TOT} = M_1 M_2 = \left(-\frac{s_1'}{s_1}\right)\left(-\frac{s_2'}{s_2}\right) = \left(-\frac{16.4}{20}\right)\left(-\frac{3.1}{-8.4}\right) = -0.31$$

Fig.38.42



Charles D. Winters/Cengage Learning

(a) Zoom lens set for long focal length (b) Zoom lens set for short focal length (c) A practical zoom lens

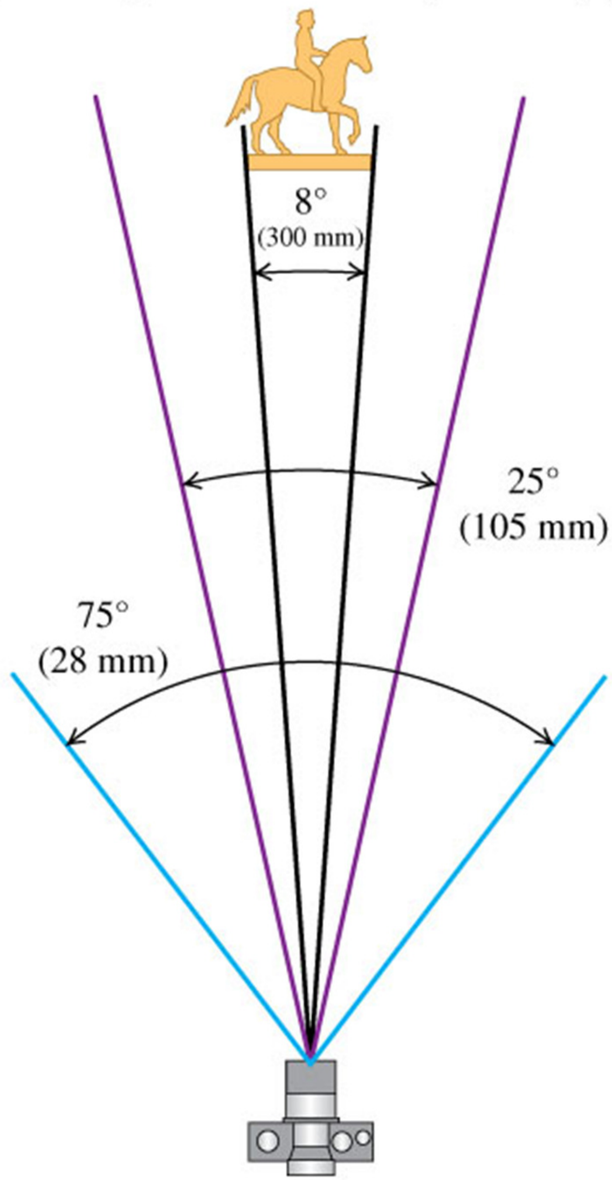


(a) $f = 28$ mm

(b) $f = 105$ mm

(c) $f = 300$ mm

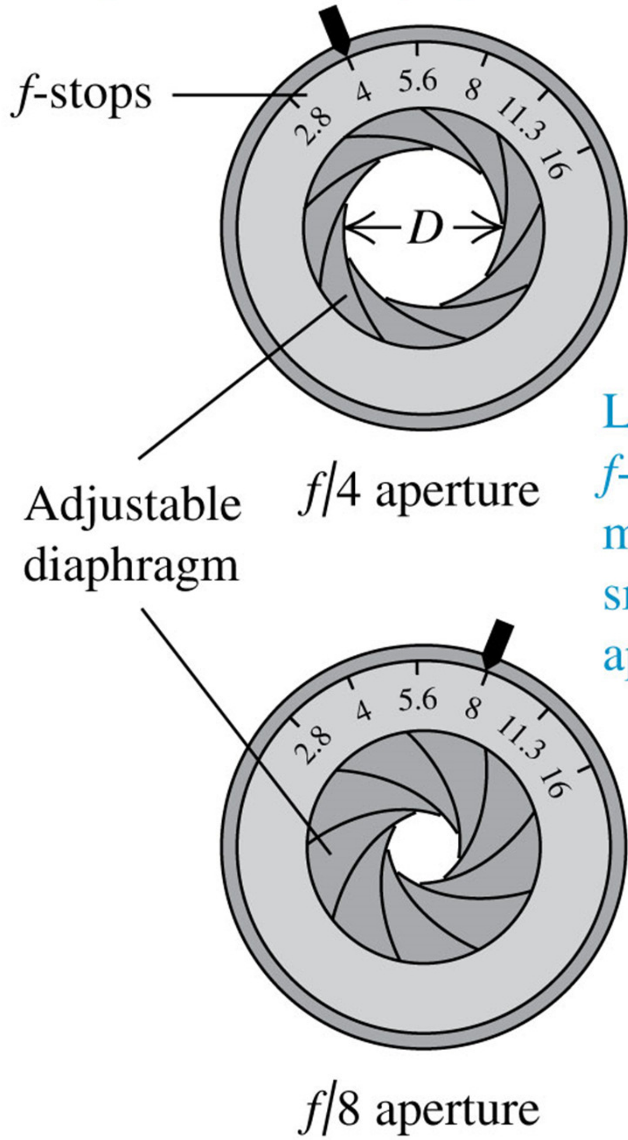
(d) The angles of view for the photos in (a)–(c)



$$\text{f.o.f} \propto \frac{1}{f^2}$$

$$I \propto \frac{1}{f^2}$$

Changing the diameter by a factor of $\sqrt{2}$ changes the intensity by a factor of 2.



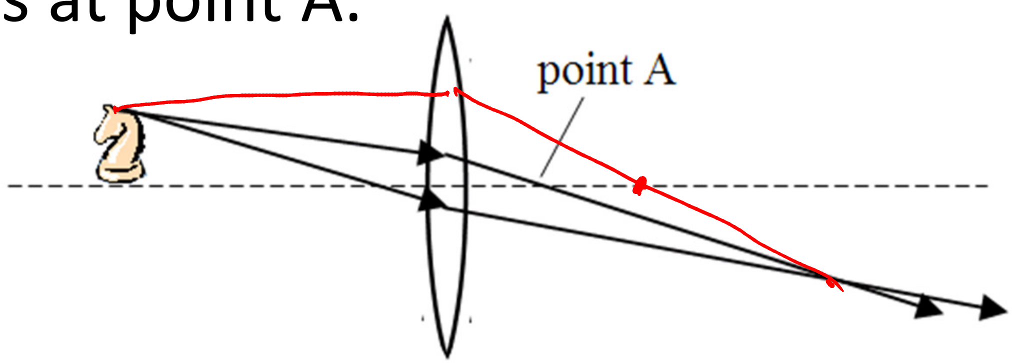
Larger *f*-numbers mean a smaller aperture.

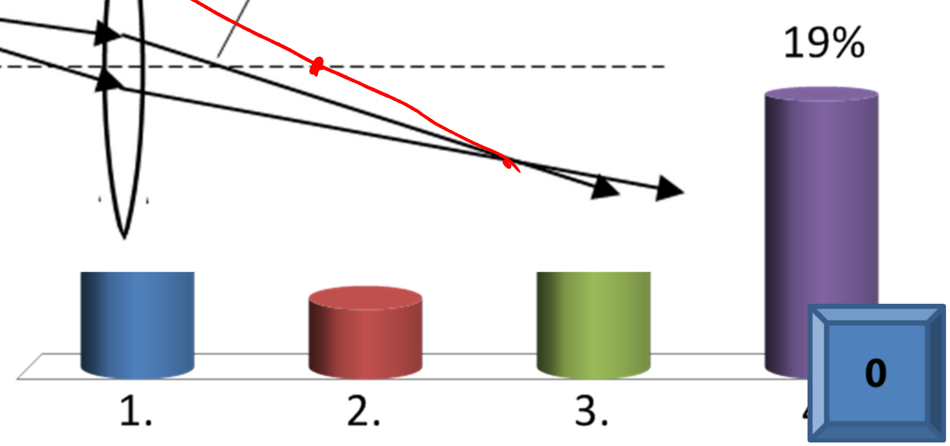
$I \propto D^2$

$\frac{f}{D}$ = f-number

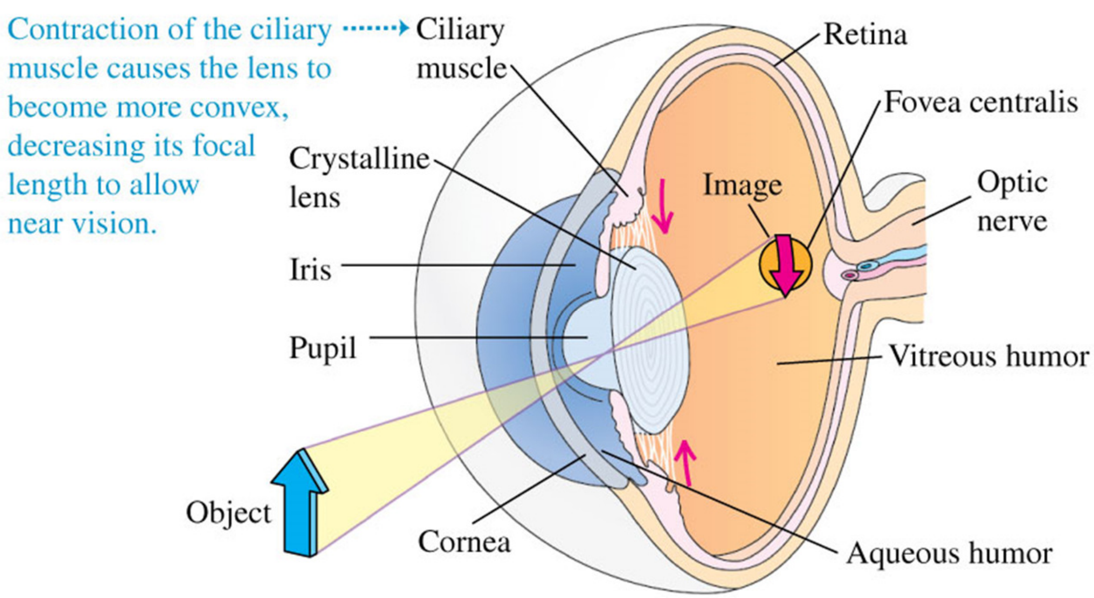
Two rays are drawn from the top of an object. One of the rays crosses the principle axis at point A as shown. Which one of the following statements best describes the location of the focal point on the right side of the converging lens:

1. The focal point is a short distance left of point A
2. The focal point is a large distance right of point A, where the rays converge.
3. ✓ The focal point is a short distance right of point A.
4. The focal point is at point A.

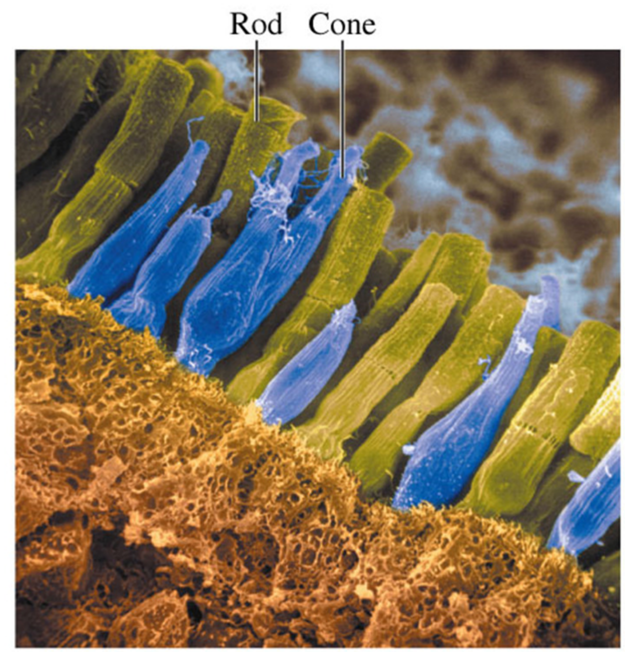


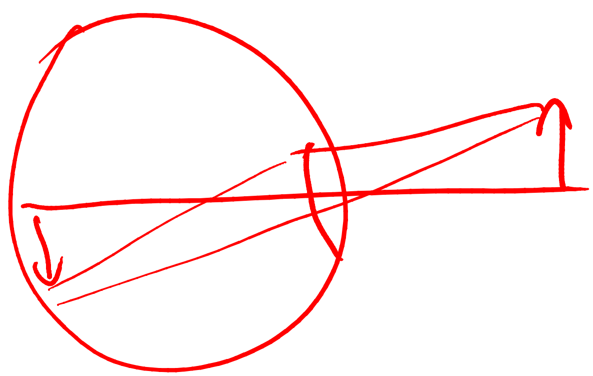


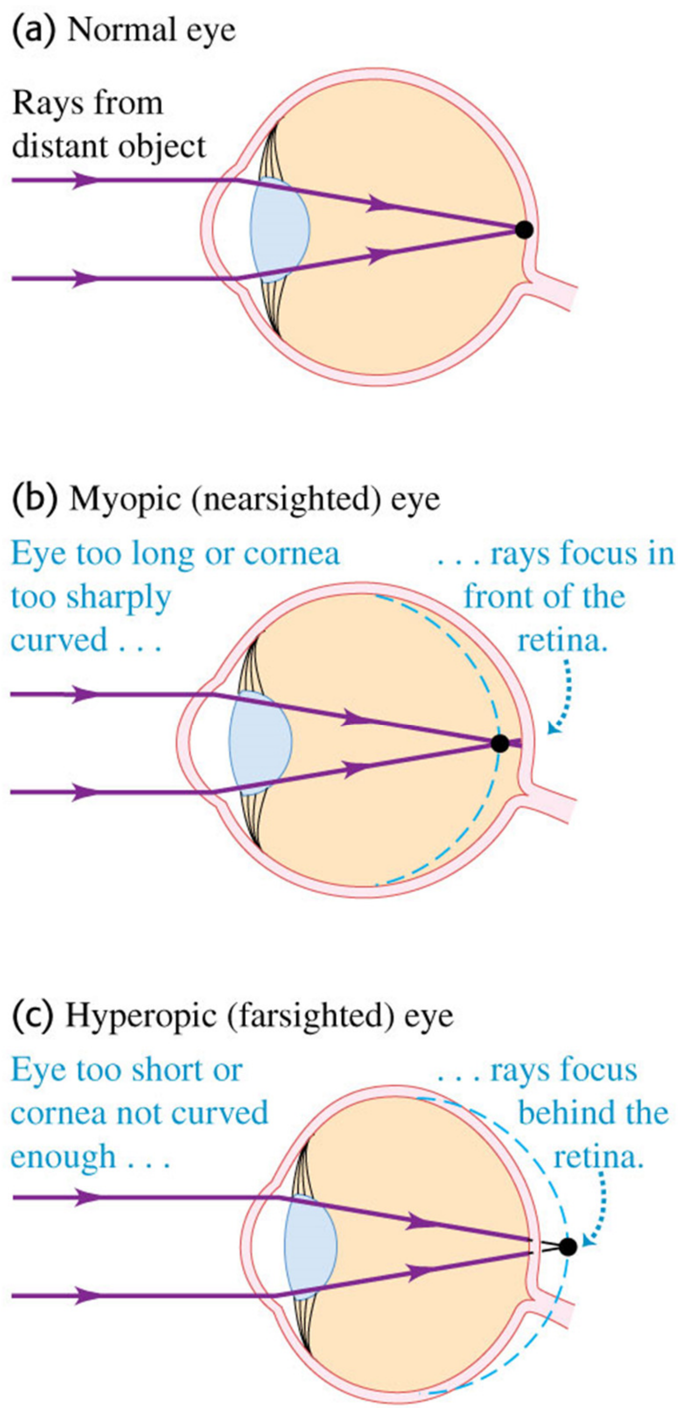
(a) Diagram of the eye



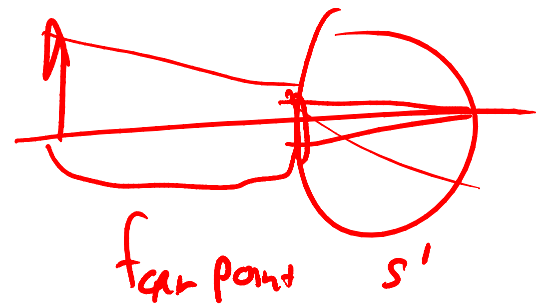
(b) Scanning electron micrograph showing retinal rods and cones in different colors







far point = ∞



near point → further than you'd like

Table 34.1 Receding of Near Point with Age

Age (years)	Near Point (cm)
10	7
20	10
30	14
40	22
50	40
60	200

25 cm "Normal"

a) Where is the near point for an eye which needs a contact lens of power +2.75 diopters?

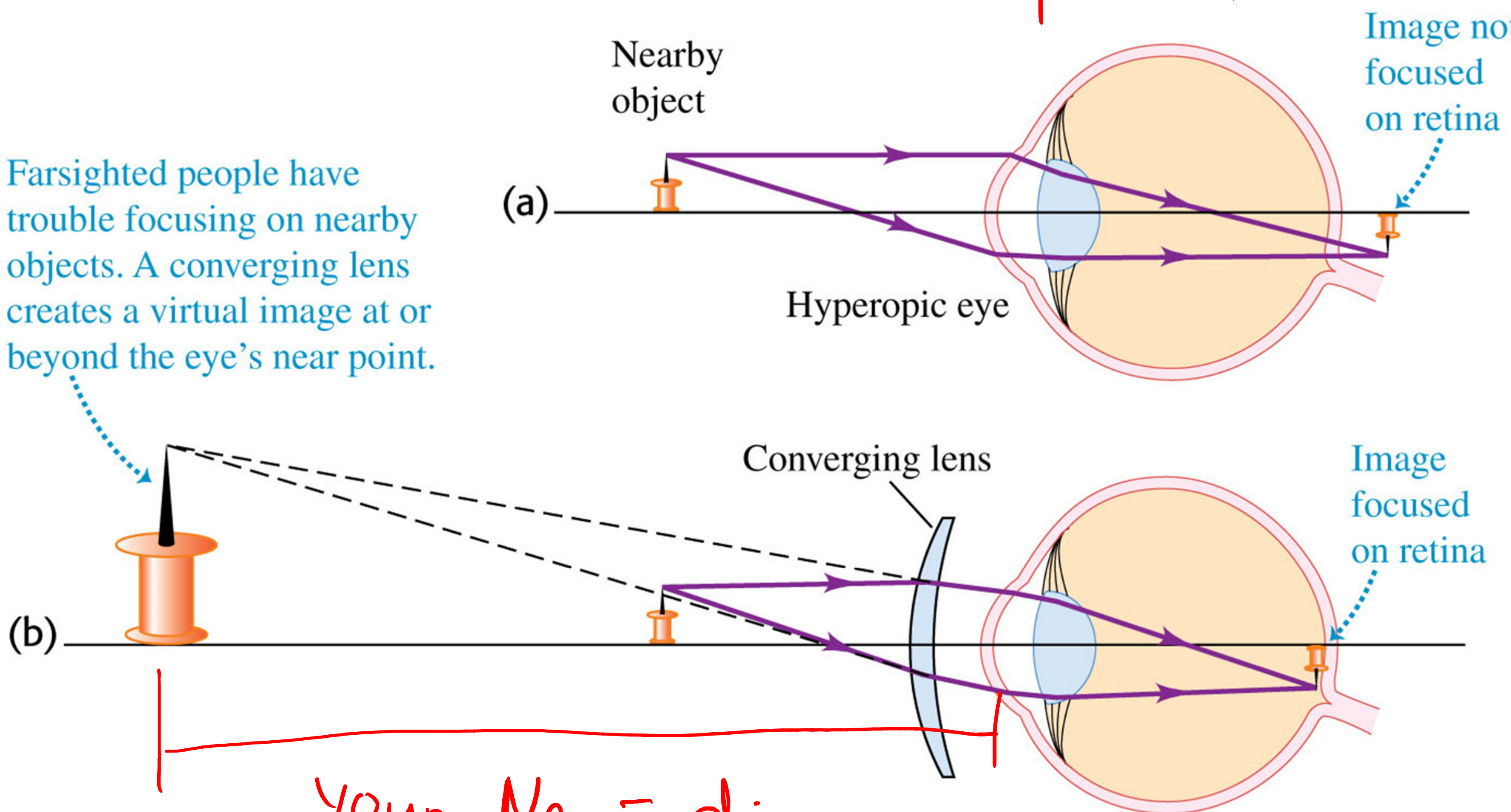
b) Where is the far point for an eye which needs a contact lens of power -1.30 diopters?

$$\frac{1}{d_i} - \frac{1}{d_o} = \frac{1}{f}$$

25 cm

$$\frac{1}{f} = +2.75$$

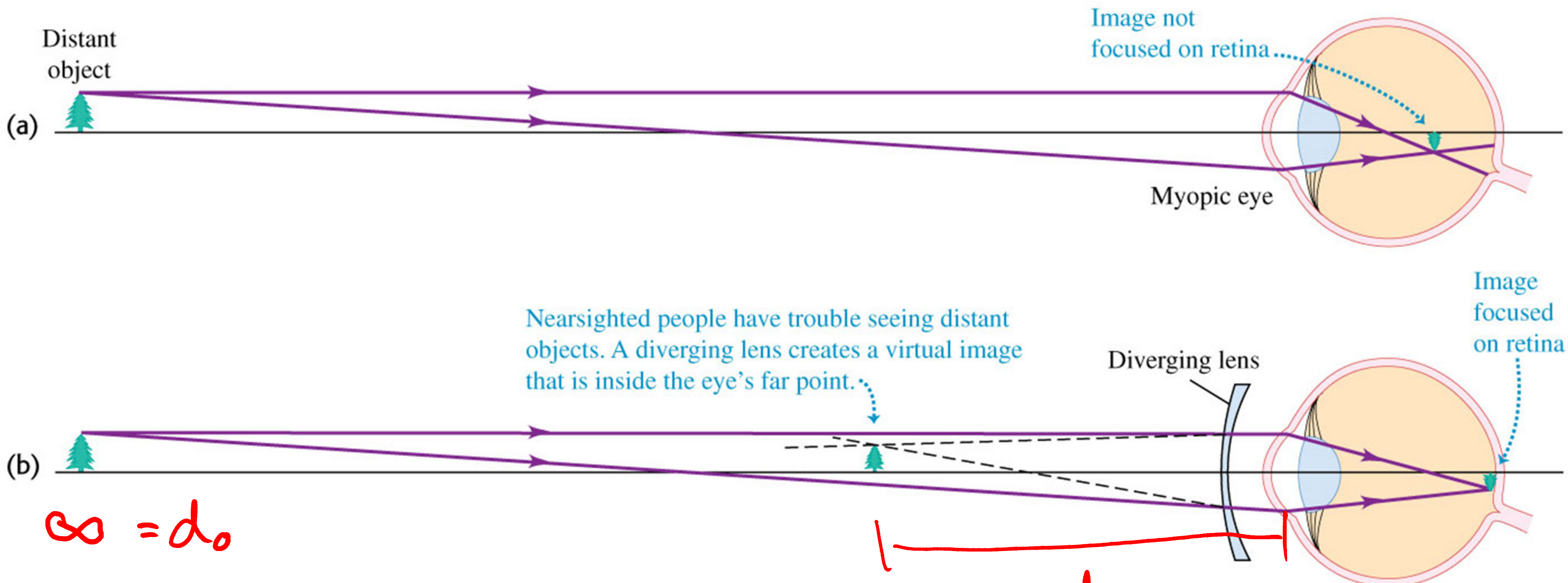
$$f = 36\text{ cm}$$



your N.p. $= d_i = -81$ cm

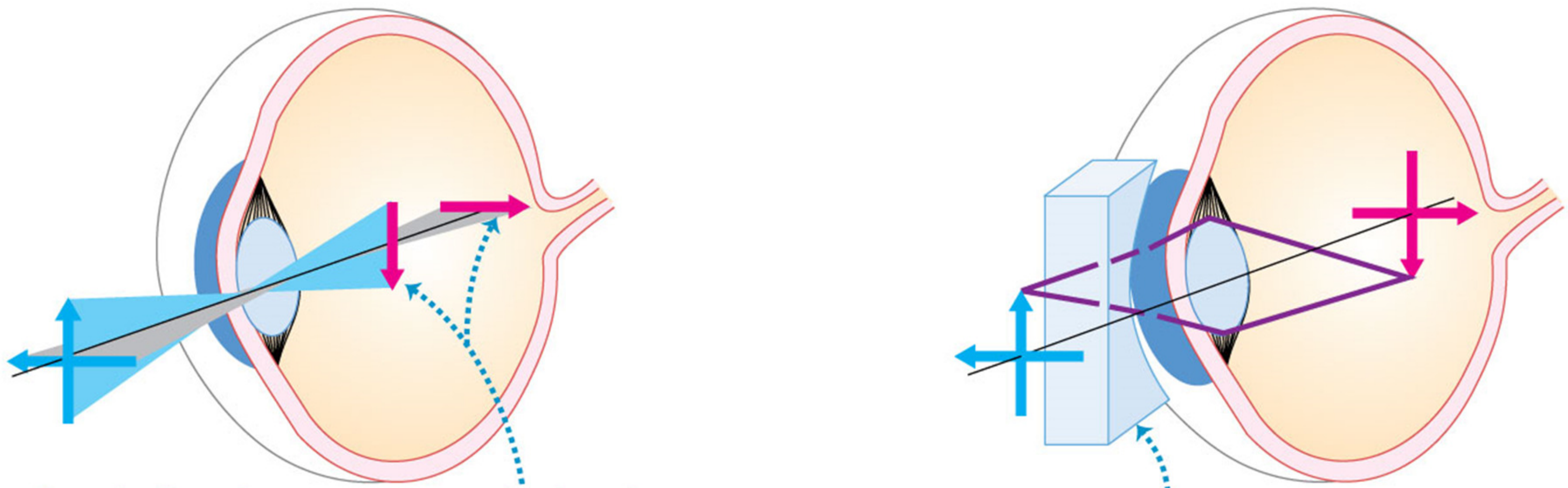
$$\frac{1}{d_i} + \frac{1}{d_o} = \frac{1}{f}$$

$$\frac{1}{f} = -1.30 \quad f = -0.769\,m$$



$d_i = F_p$

solve for $d_i = 76.9$ cm



(a) Vertical lines are imaged in front of the retina.

Shape of eyeball or lens causes vertical and horizontal elements to focus at different distances.

(b) A cylindrical lens corrects for astigmatism.

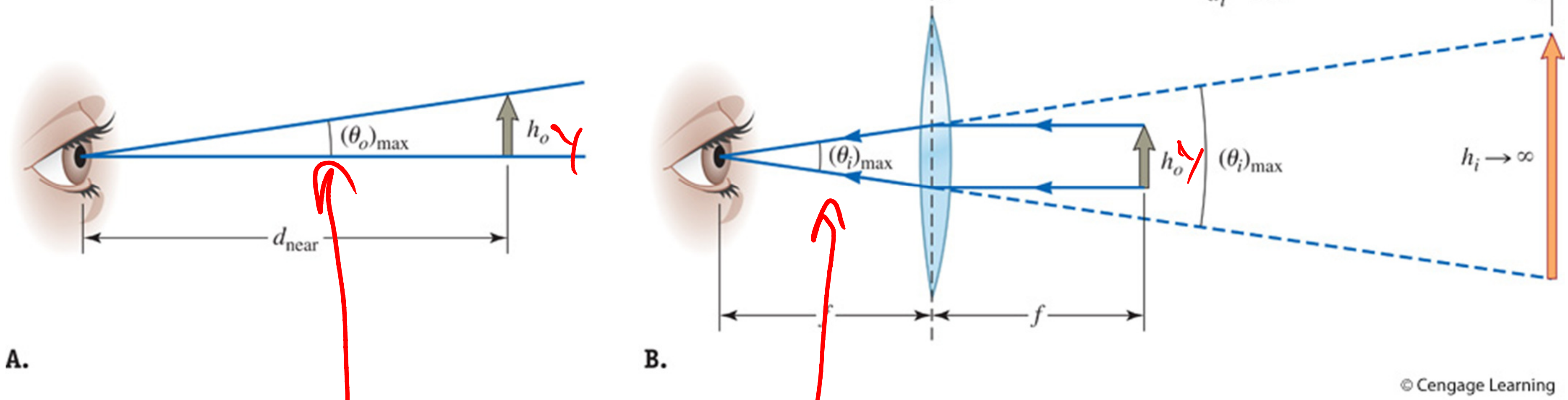
This cylindrical lens is curved in the vertical, but not the horizontal, direction; it changes the focal length of vertical elements.

A.

Fig.38.43

Christian Musat/Shutterstock.com

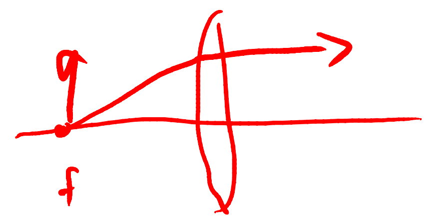
Fig.38.44



$$\sin\theta = \frac{y}{N.P.}$$

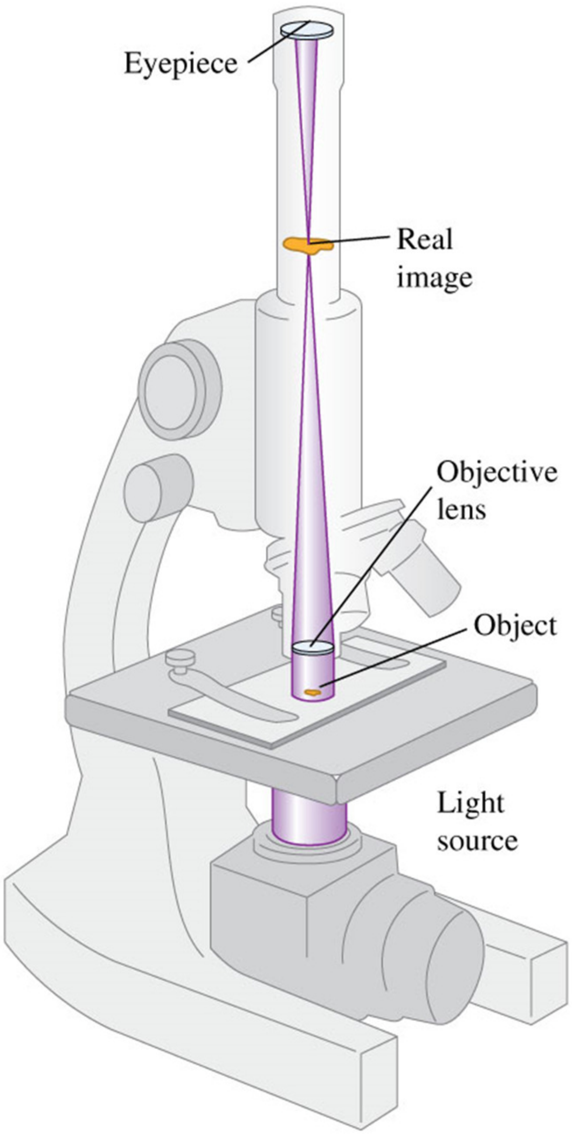
$$\sin\theta \sim \theta = \frac{y}{N.P.}$$

$$\theta' = \frac{y}{f}$$



$$M = \frac{\theta'}{\theta} = \frac{y/f}{y/N.P.} = \frac{NP}{f}$$

(a) Elements of a microscope



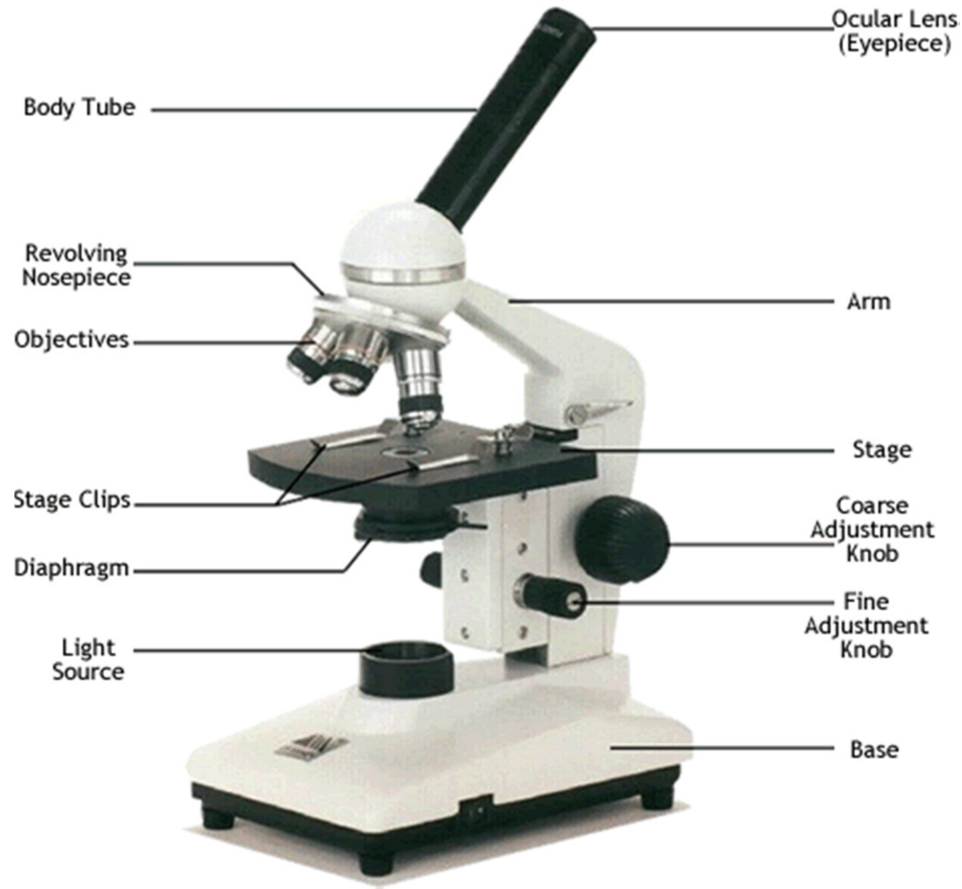
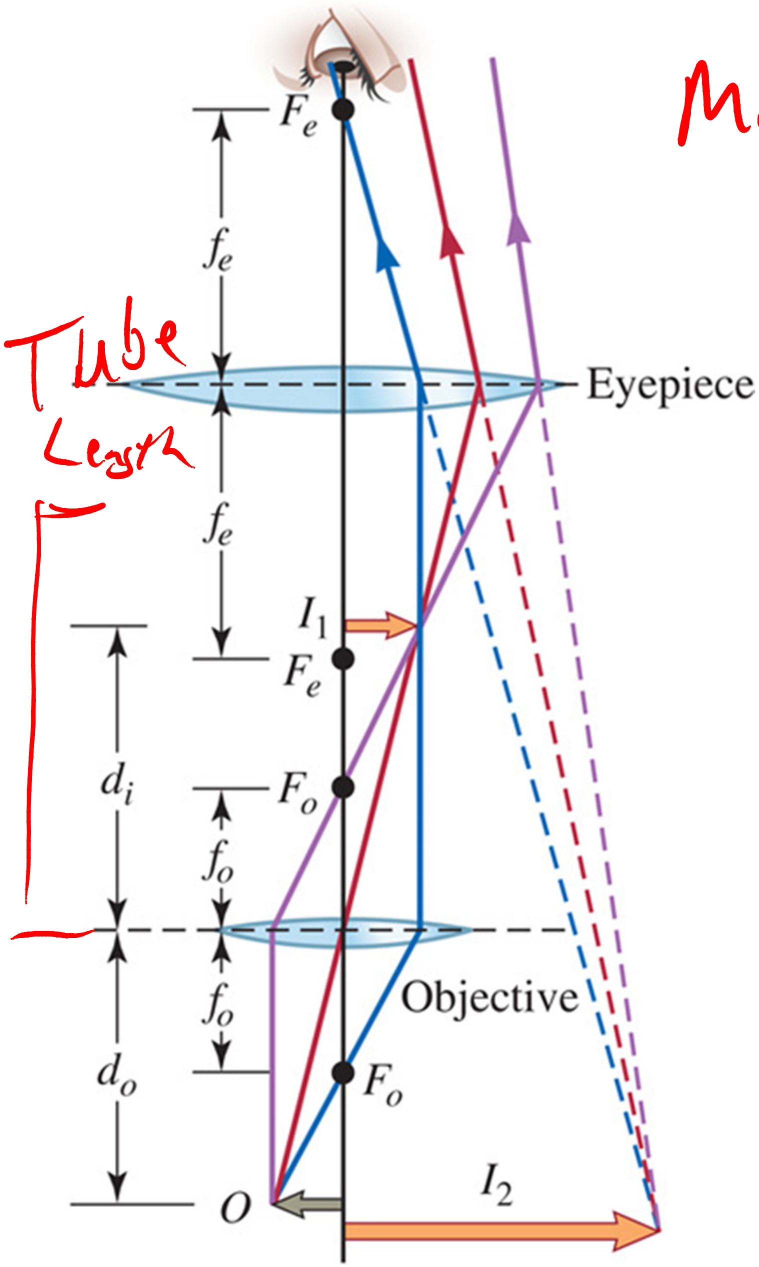


Fig.38.45



$$M_{obj} := -\frac{s_1'}{s_1}$$

$$M_{eye} := \frac{N.P.}{f_{eye}}$$

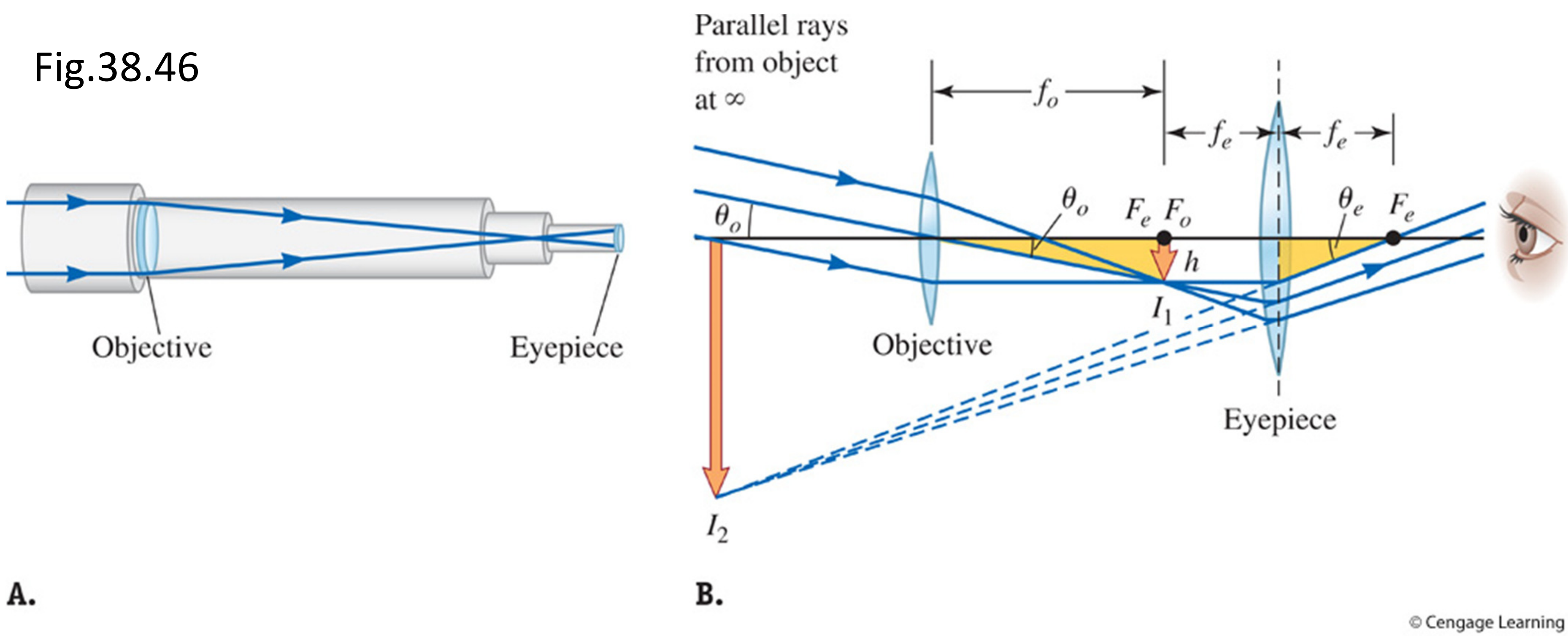
$$M_{TOT} = M_{obj} \cdot M_{eye} = -\frac{Np}{f_{eye}} \frac{s_1'}{s_1}$$

what's s_1? $\sim f_{obj}$

$$M_{TOT} \approx -\frac{Np\ s_1'}{f_{eye} f_{obj}}$$

$$s_1' = (\text{Tube length} - f_{eye})$$

Fig.38.46



$s_1 = \infty$, $\therefore s_1' = f_{obj}$ $\quad$ $s_2 = @ f$ $\therefore s_2' = \infty$

$\theta = \frac{-y'}{f_{obj}}$ $\quad$ $\theta' = \frac{y'}{f_2}$ $\quad$ $M = \theta'/\theta = \frac{y'/f_{eye}}{y'/f_{obj}} = -\frac{f_{obj}}{f_{eye}}$

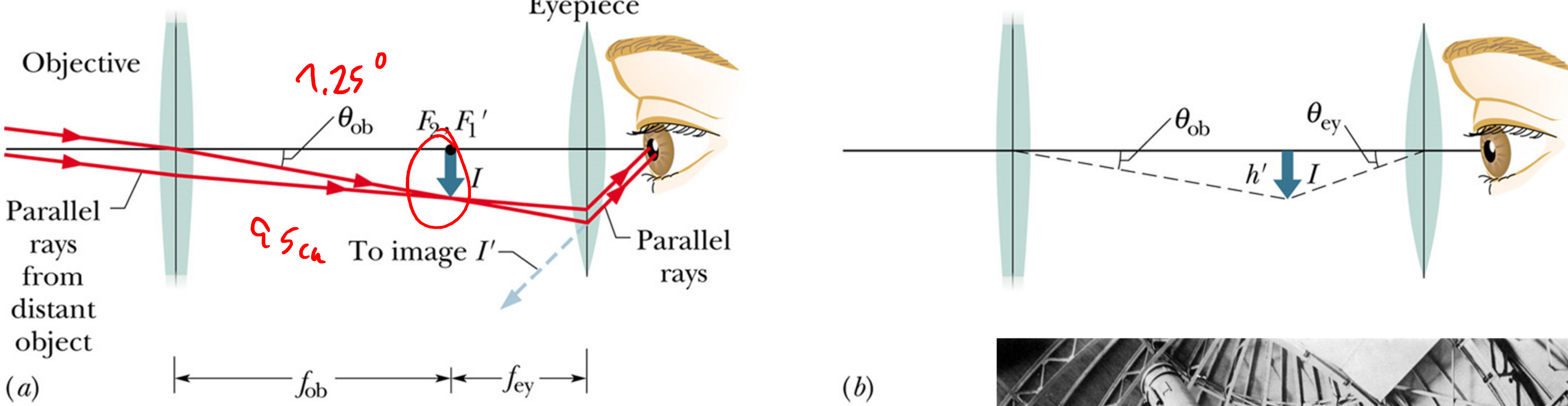
A telescope as a 95.0 cm focal length objective, and a 15.0 cm focal length eyepiece.

a) Find the angular magnification of the telescope.

b) Find the height of the image made by the objective of a building that's 60.0 m tall and 3 km away.

c) What is the angular size of the final image as seen through the eyepiece?

f=95 f=15

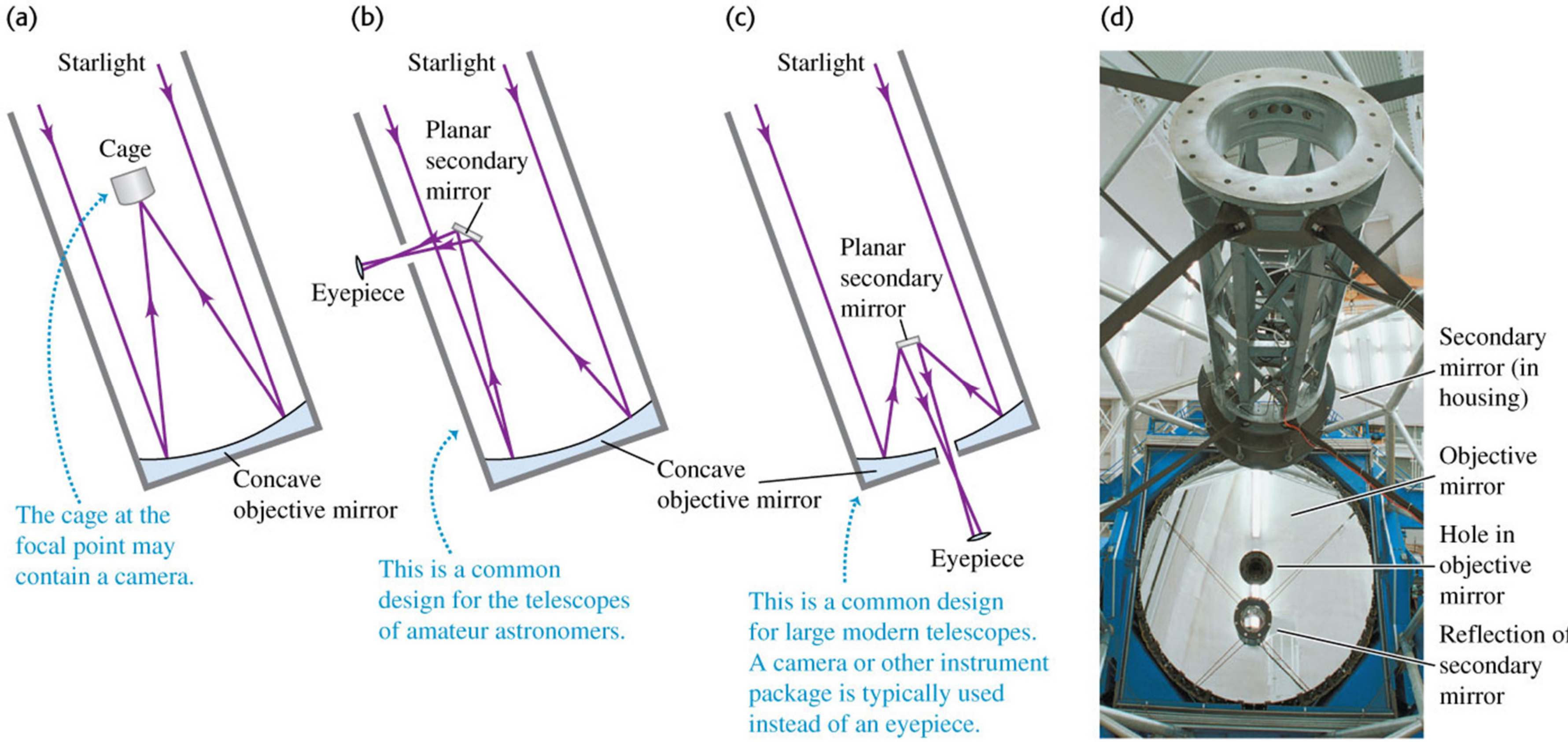


$\tan\theta = \frac{60}{3{,}000} \approx \theta = 1.15°$

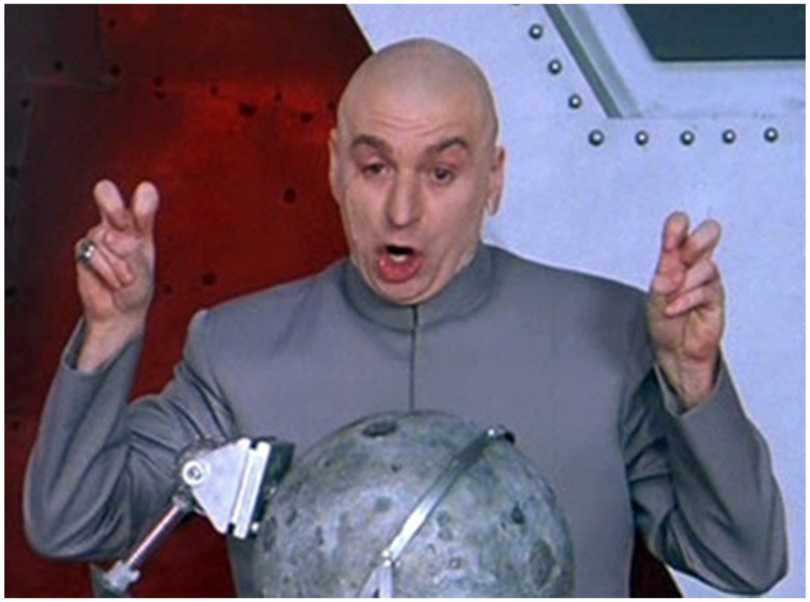
so "h" = -1.90cm

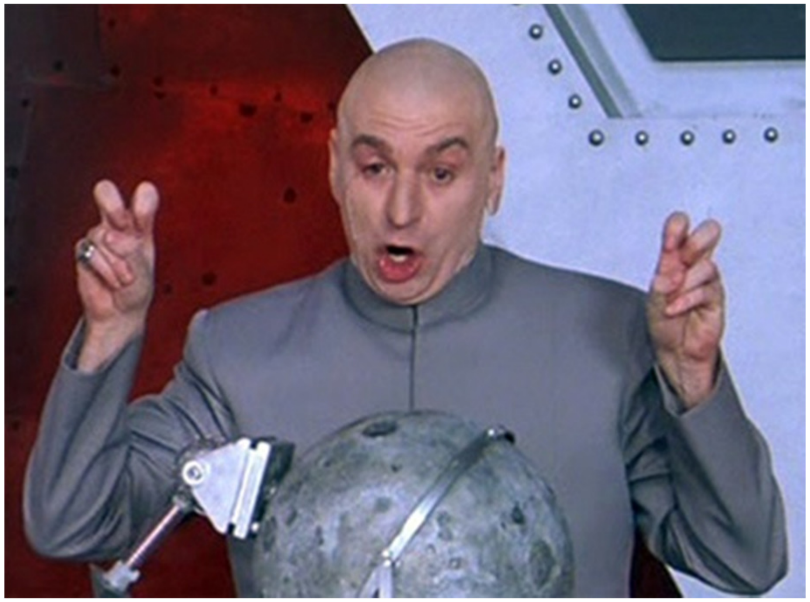
multiply by "M", get -7.25°

$M_\theta = -\frac{f_{obj}}{f_{eye}} = -\frac{95}{15} = -6.33$



(a)
Starlight
Cage
Concave objective mirror
The cage at the focal point may contain a camera.
(b)
Starlight
Planar secondary mirror
Eyepiece
Concave objective mirror
This is a common design for the telescopes of amateur astronomers.
(c)
Starlight
Planar secondary mirror
Eyepiece
This is a common design for large modern telescopes. A camera or other instrument package is typically used instead of an eyepiece.
(d)
Secondary mirror (in housing)
Objective mirror
Hole in objective mirror
Reflection of secondary mirror

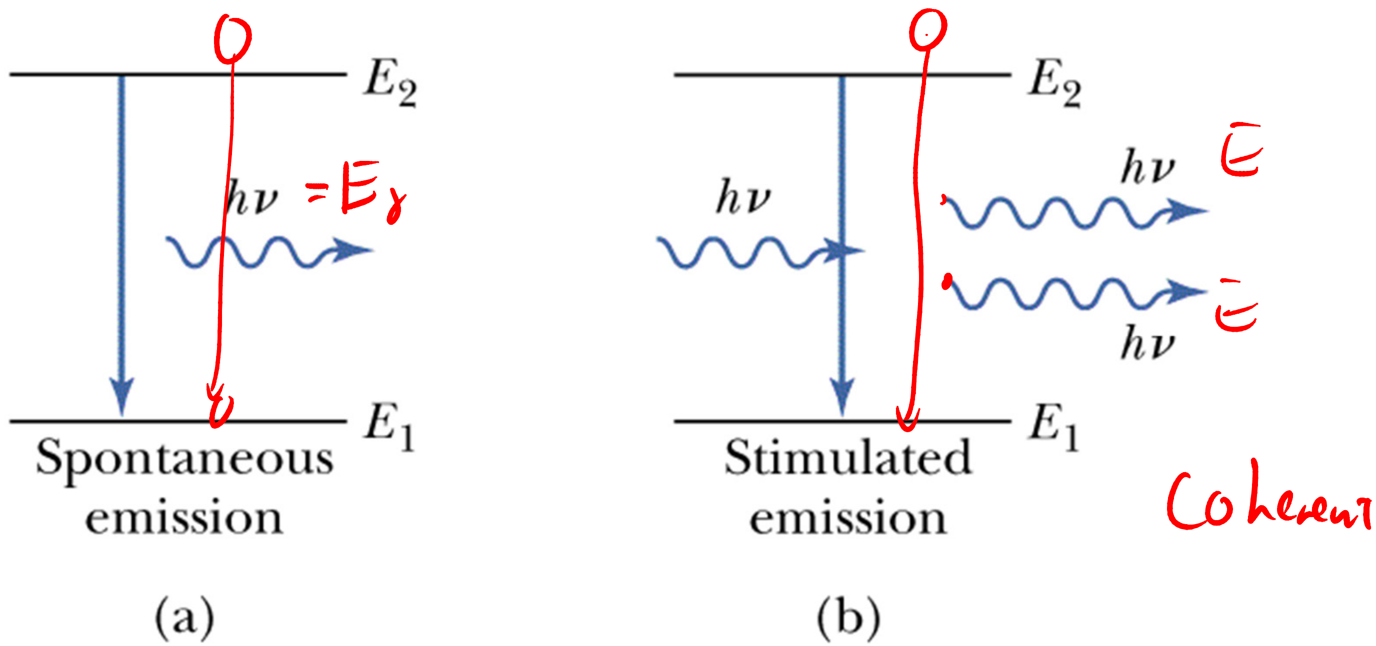




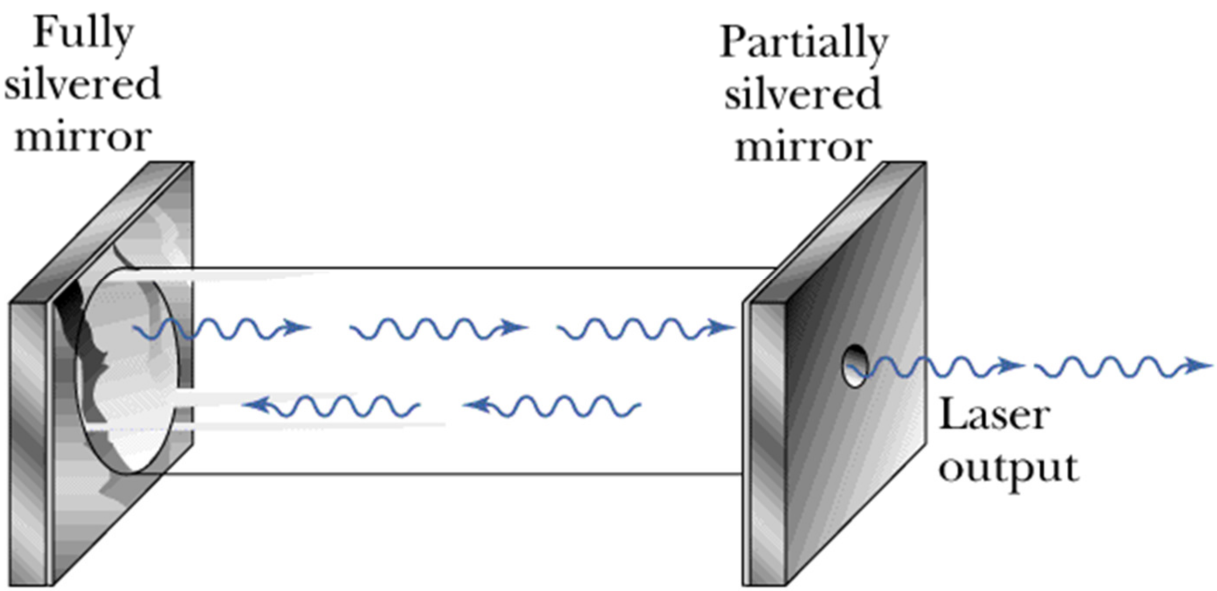
Light Amplification by
Stimulated Emission of Radiation

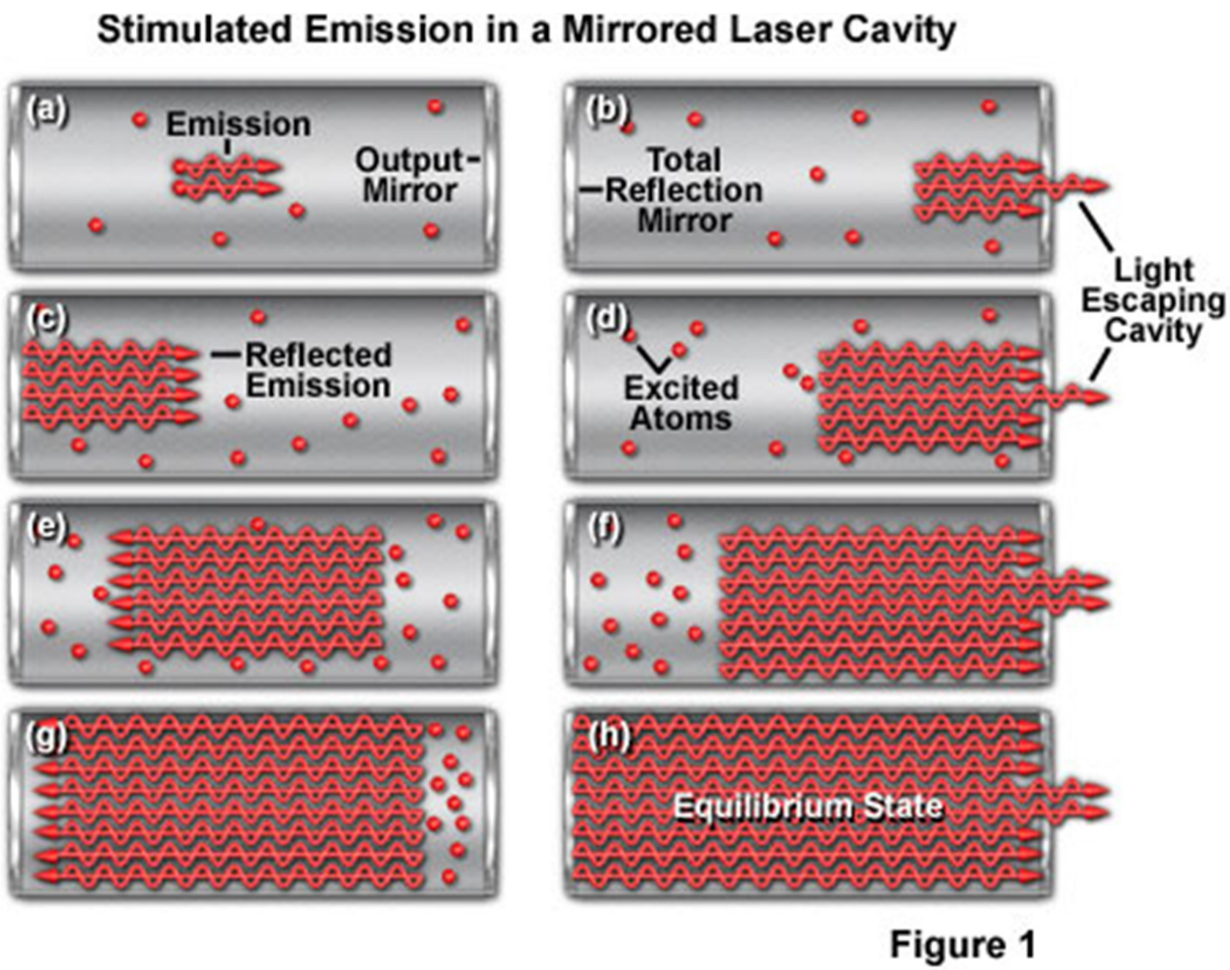
$f = \nu$

Thornton/Rex, Modern Physics for Scientists and Engineers, 2/e
Figure 10.11

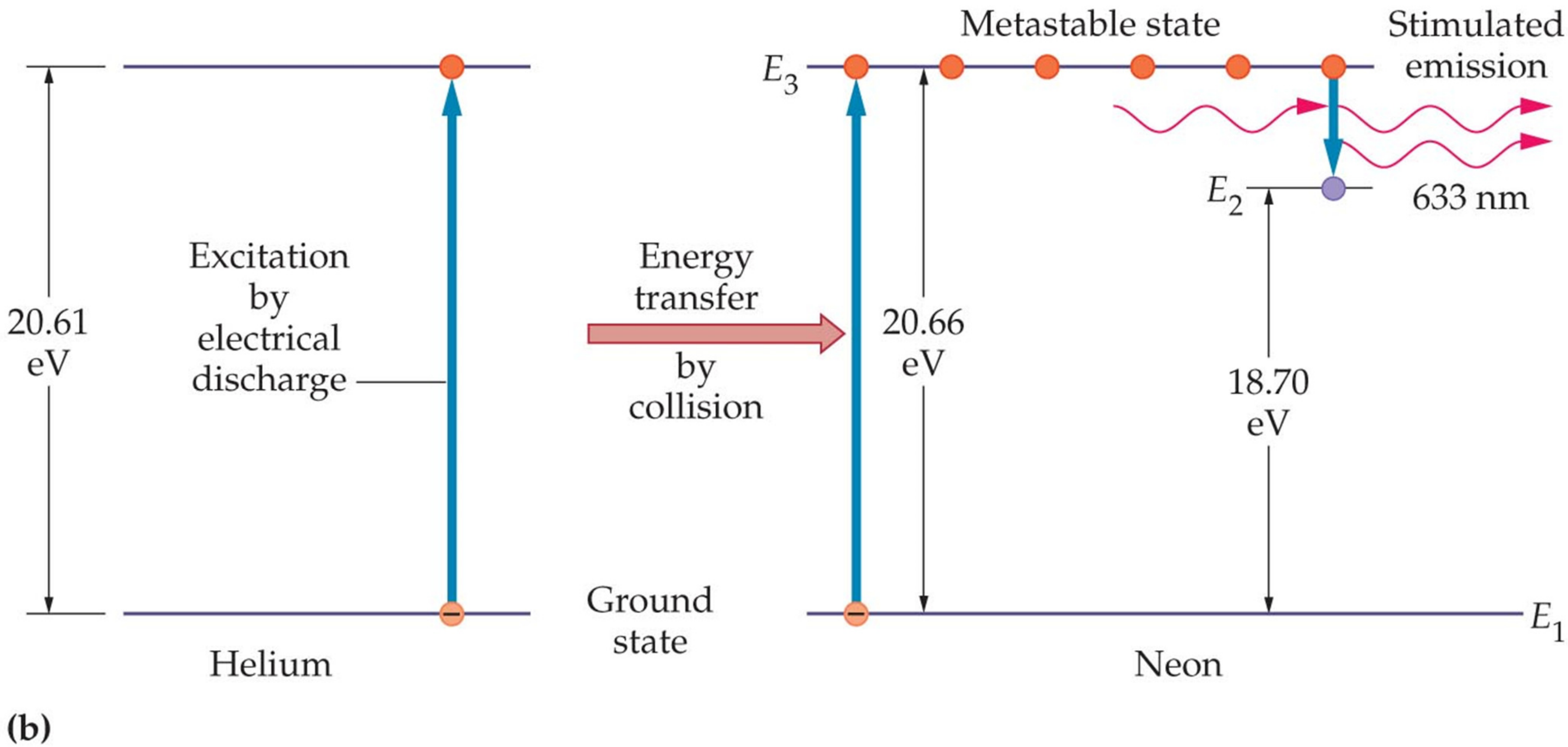


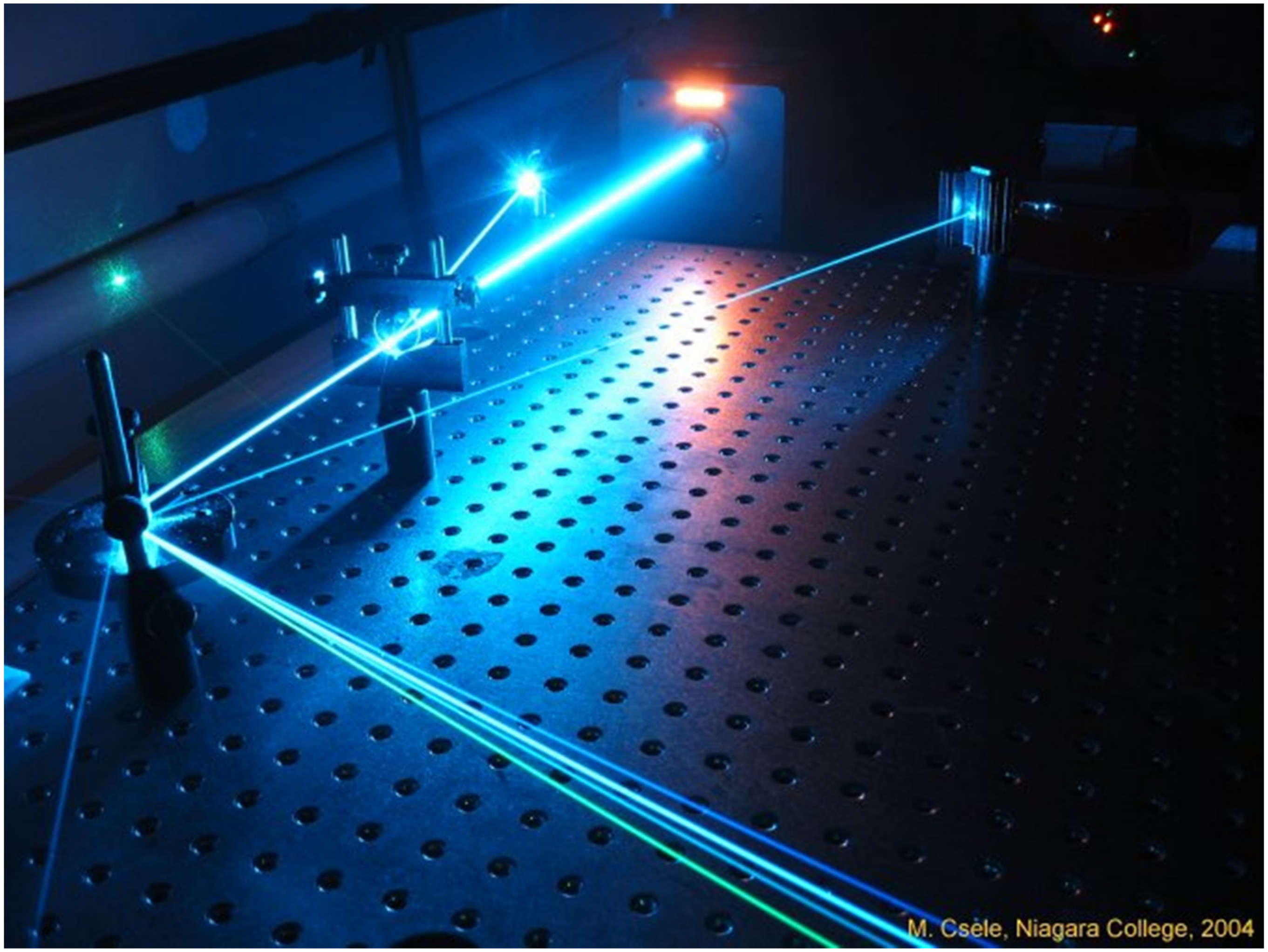
Thornton/Rex, Modern Physics for Scientists and Engineers, 2/e
Figure 10.12





Cool figure from “Molecular Expressions”


Metastable state
Stimulated emission
E_3
E_2
633 nm
20.61 eV
Excitation by electrical discharge
Energy transfer by collision
20.66 eV
18.70 eV
Ground state
E_1
Helium
Neon
(b)

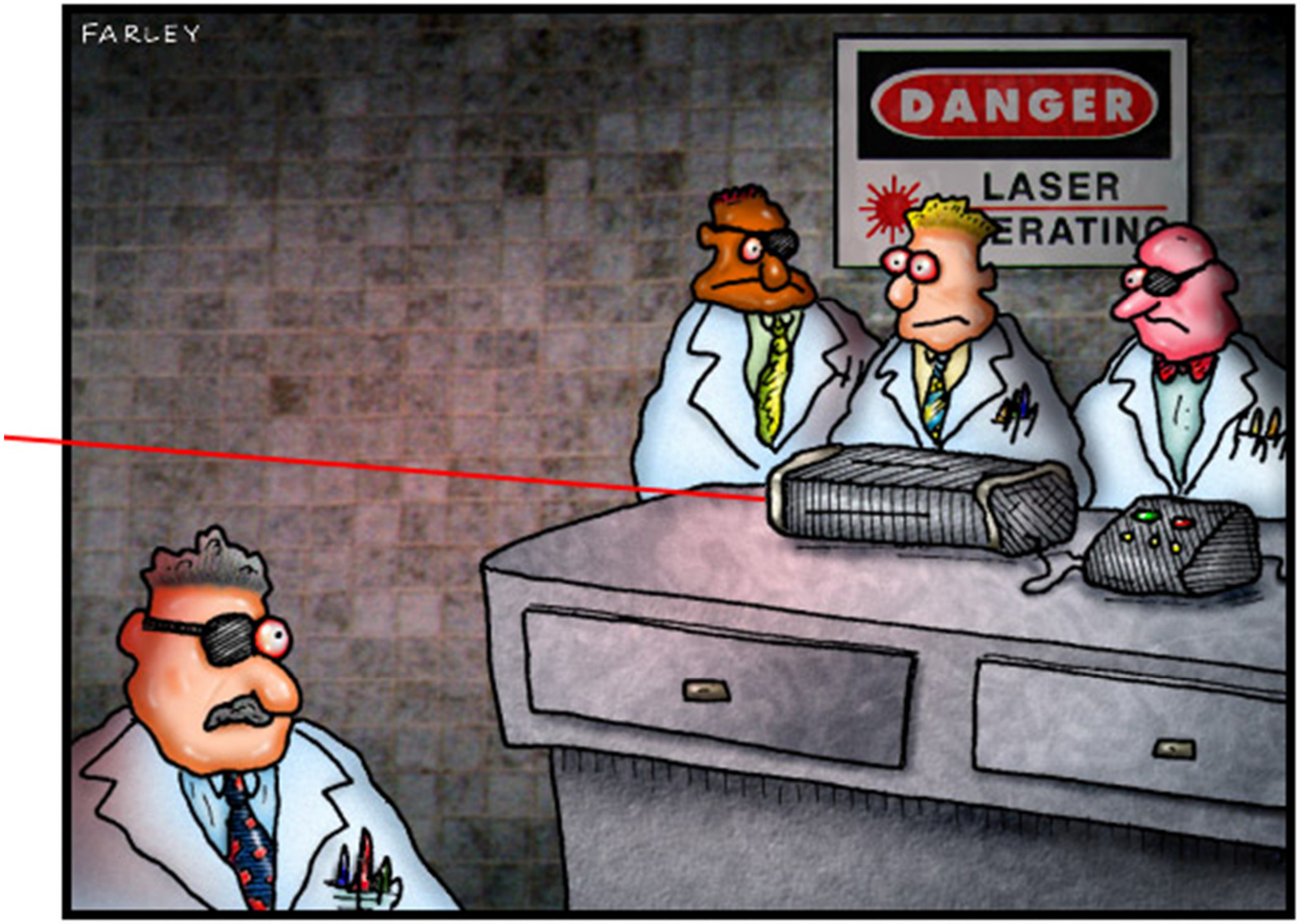

M. Csele, Niagara College, 2004

Laser guide star in use at the Keck 10m telescope on Mauna Kea


WARNING
Laser Radiation
Do Not Look At Laser
With Remaining Eye

DOCTOR FUN

26 June 97



Peer pressure in the laser lab

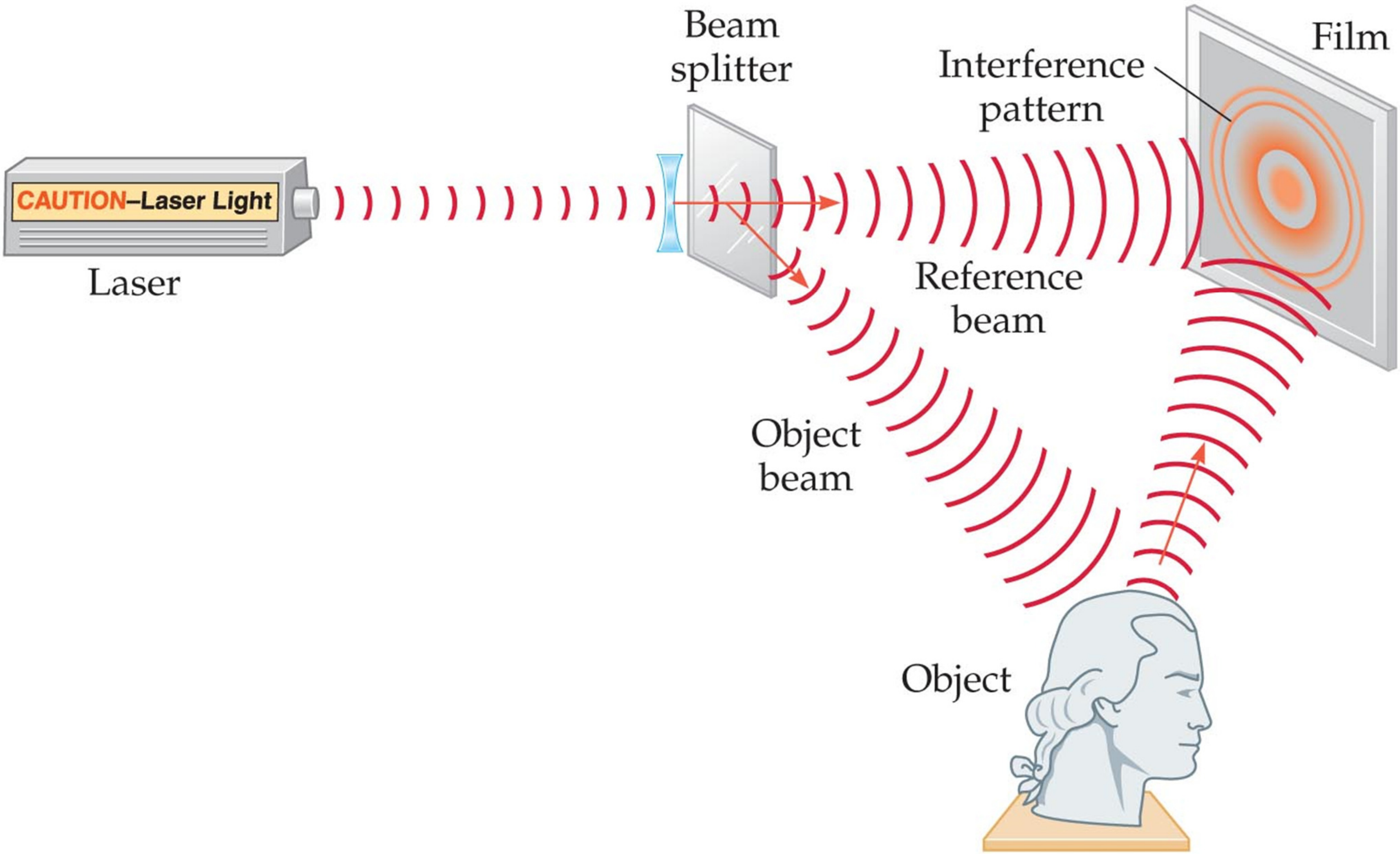
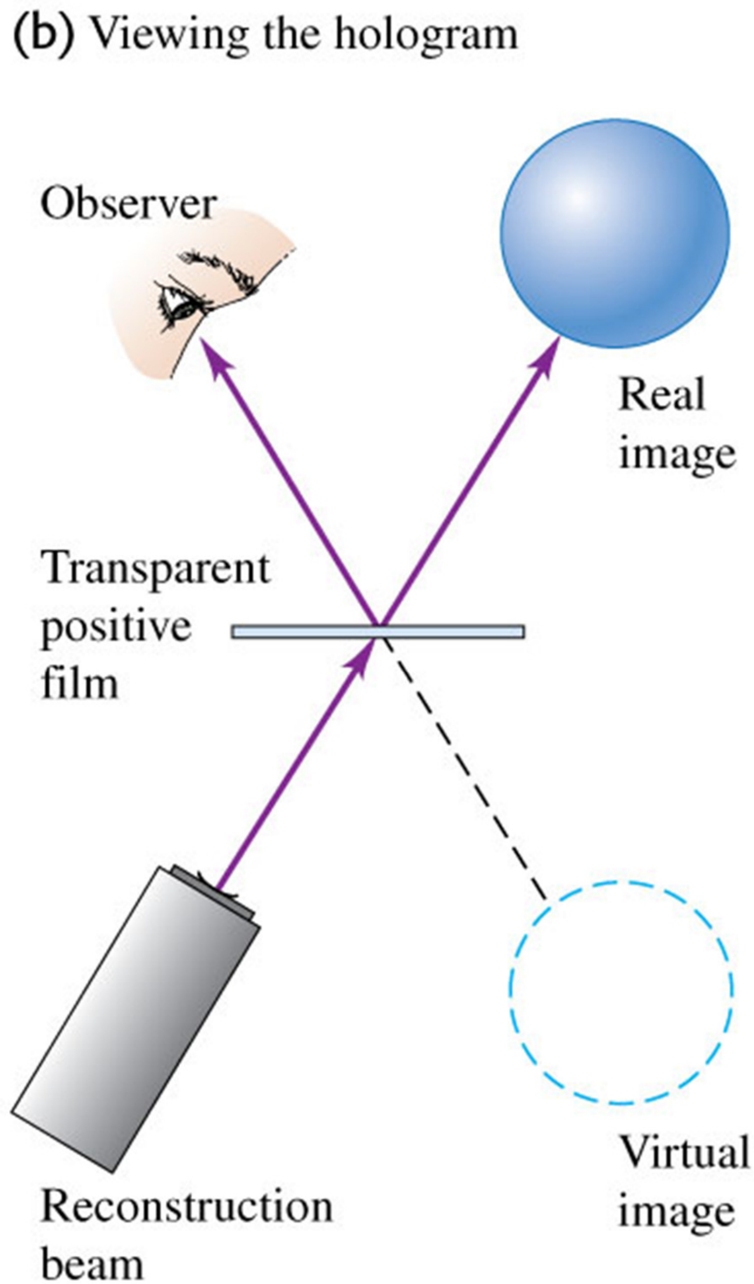

CAUTION–Laser Light
Laser
Beam splitter
Interference pattern
Film
Reference beam
Object beam
Object

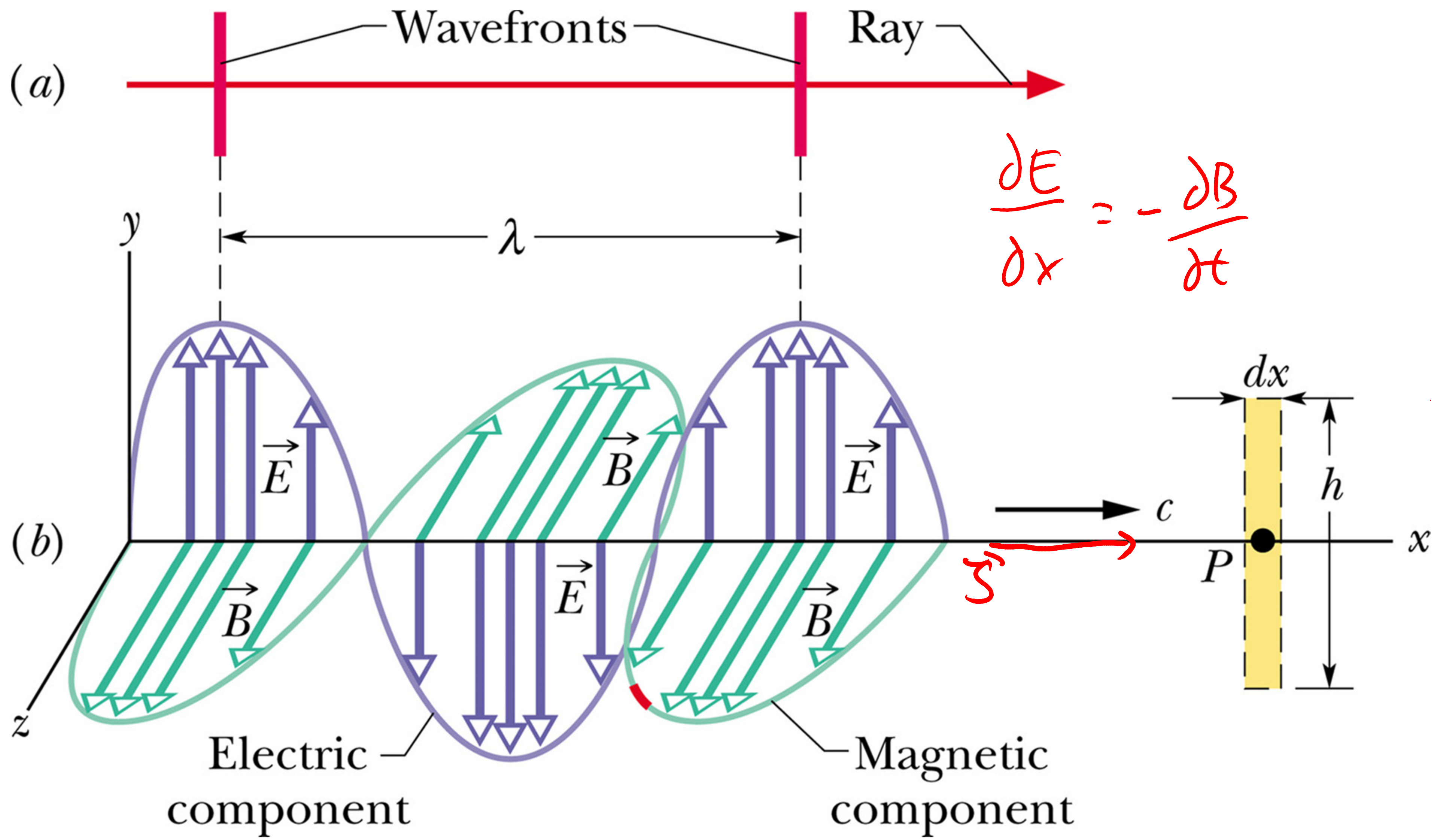
Fig.36.28b


(b) Viewing the hologram
Observer
Real image
Transparent positive film
Reconstruction beam
Virtual image

The End

$$E(x,t) = E_{max} \sin(kx - \omega t) \qquad B(x,t) = B_{max} \sin(kx - \omega t)$$

$$\frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t}$$



Waves, λ, f, c $\quad c = \lambda f$ $\quad |E| = c|B|$

$$c = \frac{1}{\sqrt{\varepsilon\mu}} \text{ in a vacuum } = 3\times10^8\,m/s$$

$$c_n = \frac{c}{n} \qquad \lambda = \lambda_0/n$$

$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B} \qquad I = S_{Av} = \frac{E_{max}B_{max}}{2\mu_0}$$

$$I = \frac{\text{Power}}{\text{Area}} = W/m^2 = \frac{J/s}{m^2}$$

etc..

Ch. 32

Cl. 33

Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

reflection: $\theta_i = \theta_R$

Total reflection: $\sin\theta_{crit} = \frac{n_b}{n_a}$

polarization: Unpolarized light ⇒ thru polarize $I = \frac{1}{2} I_0$

Polarized light " " $I = I_0 \cos^2\theta$

$\tan\theta_B = \frac{n_b}{n_a}$ Brewster angle Polarizes

Ch. 34

focal length f object distance s image distance s'

$m = -\frac{s'}{s}$ $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$ $m = \frac{y'}{y} = \frac{\theta'}{\theta}$

more than one element: use image from 1st thing as an "object" of the 2nd.

magnifiers, microscopes, telescopes, cameras, eyeballs

Ch.35 "interfere" constructively (add up) $m\lambda$

destructively (cancel) $(m+\frac{1}{2})\lambda$

racing 2 rays of light

two slits: $d\sin\theta = m\lambda$ (bright)

thin films

#1) reflection changes phase by $\frac{1}{2}\lambda$ if bounce off a "slower" thing

#2) rember that $\lambda_n = \frac{\lambda_0}{n}$

ch. 36

put wave throgh a hole, $a \sin\theta = m\lambda$ (Dark!!)

~~diffraction grating: $d \sin\theta = m\lambda$ (bright)~~

$\frac{1}{N}$

$$\sin\theta_R = 1.22 \frac{\lambda}{D}$$

(telling apart 2 points seen throgh said hole)

$$\sin\theta_R = 1.22 \frac{\lambda}{a}$$