Physics 142 - November 30, 2010

- Presentations begin Thursday, Dec. 2
  - Rail Guns
  - Superconductivity

December 7
- Electrical musical instruments
- Relativity

December 9
- Em in Chem + medicine
- Lasers

Eval sheets . . .

- Exam 2 graded

  Mean = 74

Nice job!

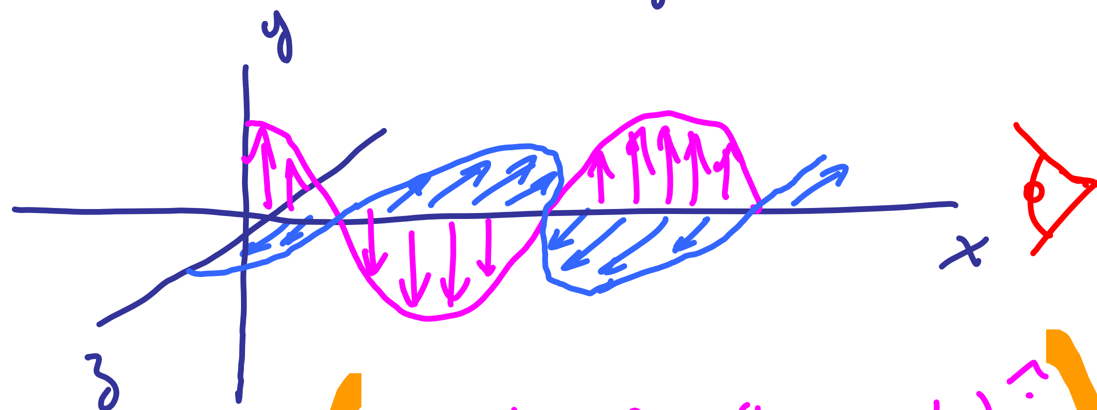
- Workshops this week

  + Next

Last Time

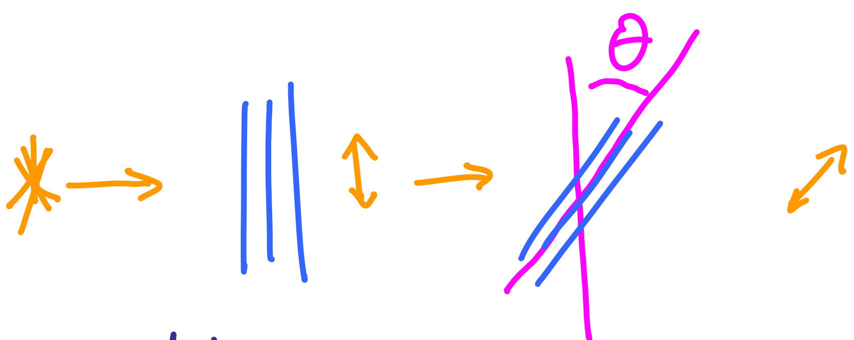
Polarization

general — two orthogonal solutions for plane waves



$$\vec{E}_y = E_{0y} \cos(kx - \omega t)\,\hat{j}$$
$$\vec{E}_z = E_{0z} \cos(kx - \omega t)\,\hat{k}$$

independent — Could have different Amplitudes + relative phases



see java applet

unpol. light I_0

$I' = \frac{1}{2} I_0$

$I'' = I' \cos^2\theta = \frac{1}{2} I_0 \cos^2\theta$

EM waves + laws of optics

Vacuum

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

Material

$$v = \frac{1}{\sqrt{\epsilon \mu}}$$

n = index of Refraction $= \frac{c}{v}$

Vacuum

$$\lambda_0 \nu = c$$

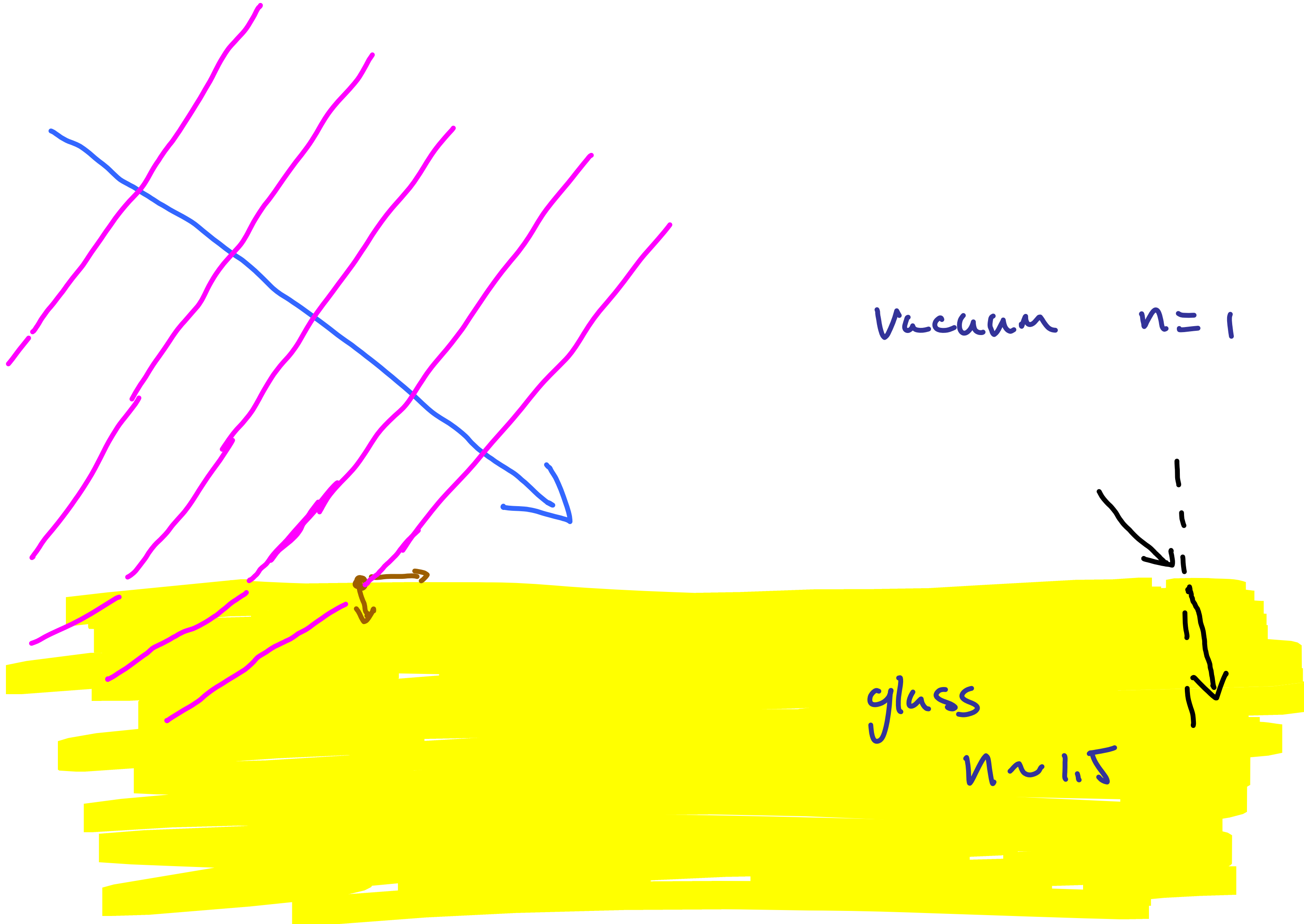
Material

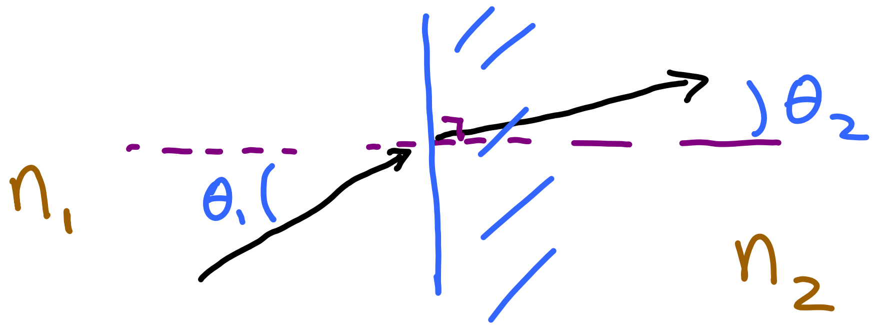
$$\lambda \nu = v$$

$$\lambda \nu = \frac{c}{n}$$

$$\lambda_{material}\, n = \frac{c}{\nu} = \lambda_0$$

$$\lambda_0 = \lambda_{material}\, n$$

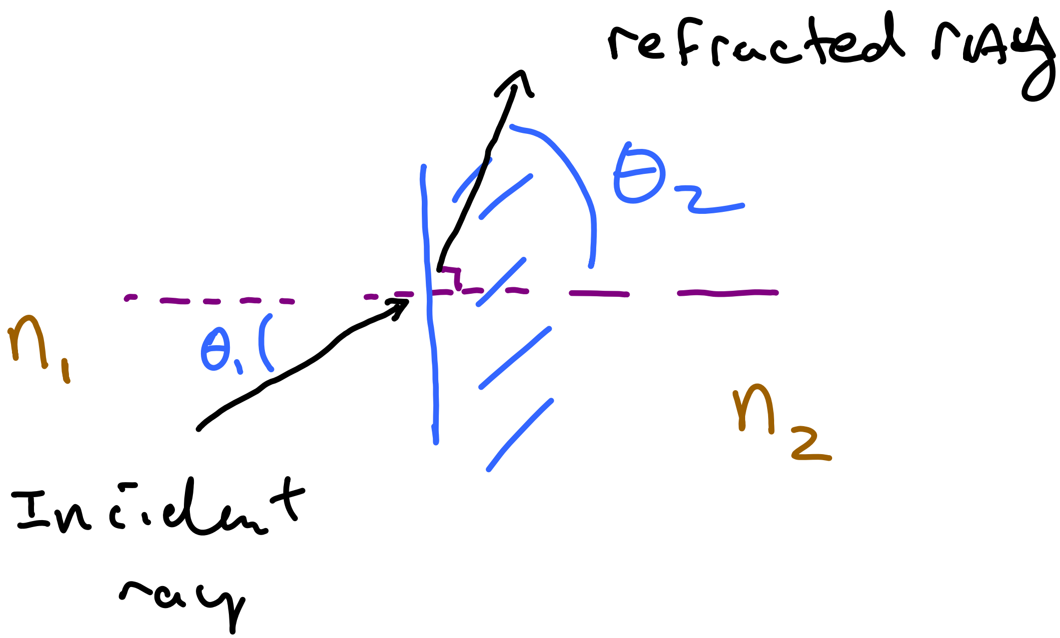

vacuum n = 1
glass
n ~ 1.5



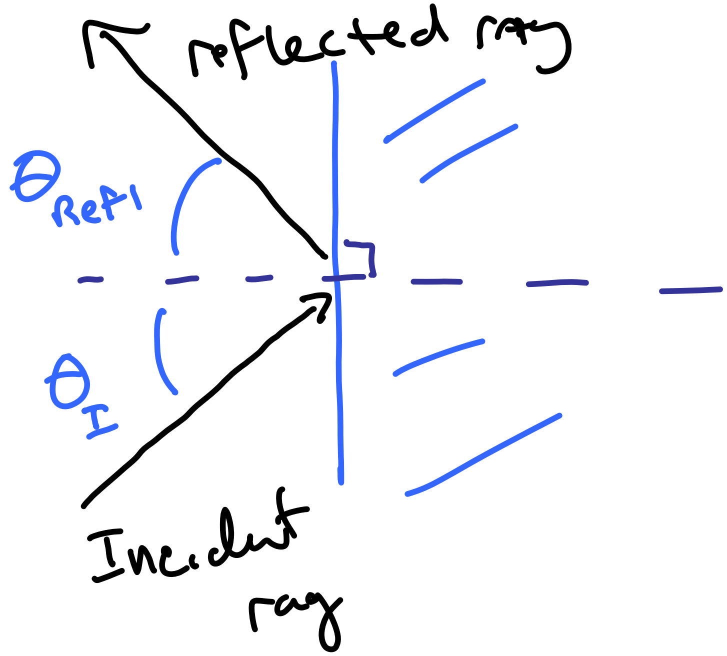
$n_2 > n_1$

Refraction

$$n_1 \sin\theta_1 = n_2 \sin\theta$$

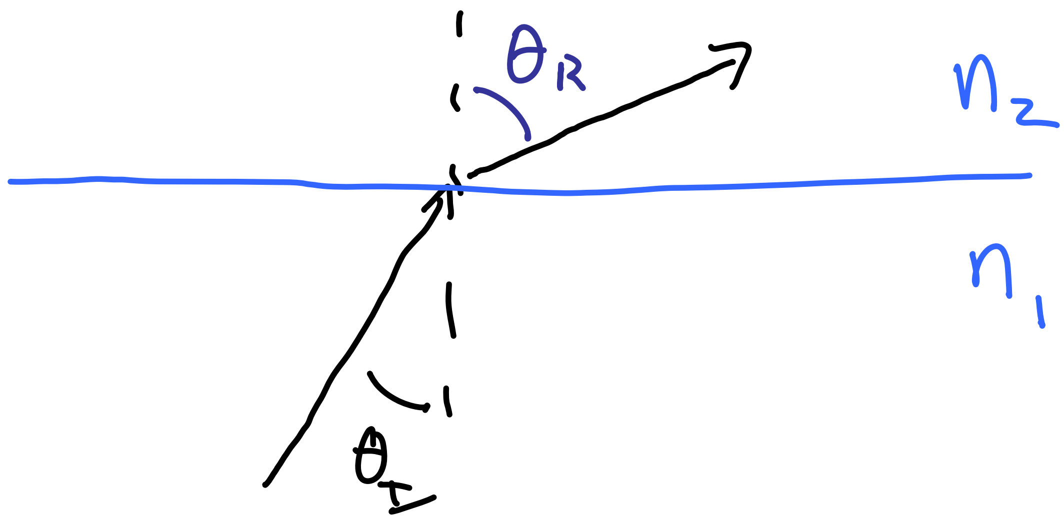


$n_2 < n_1$



$$\theta_I = \theta_{Reflection}$$

Law of Reflection



$$n_1 > n_2$$

When $\theta_R = 90^\circ$

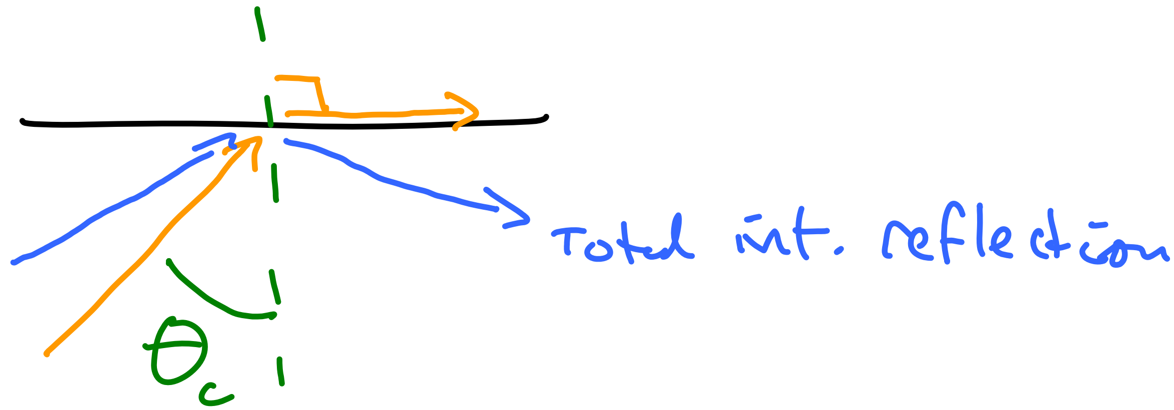
$\theta_I = \theta_c \equiv$ critical angle

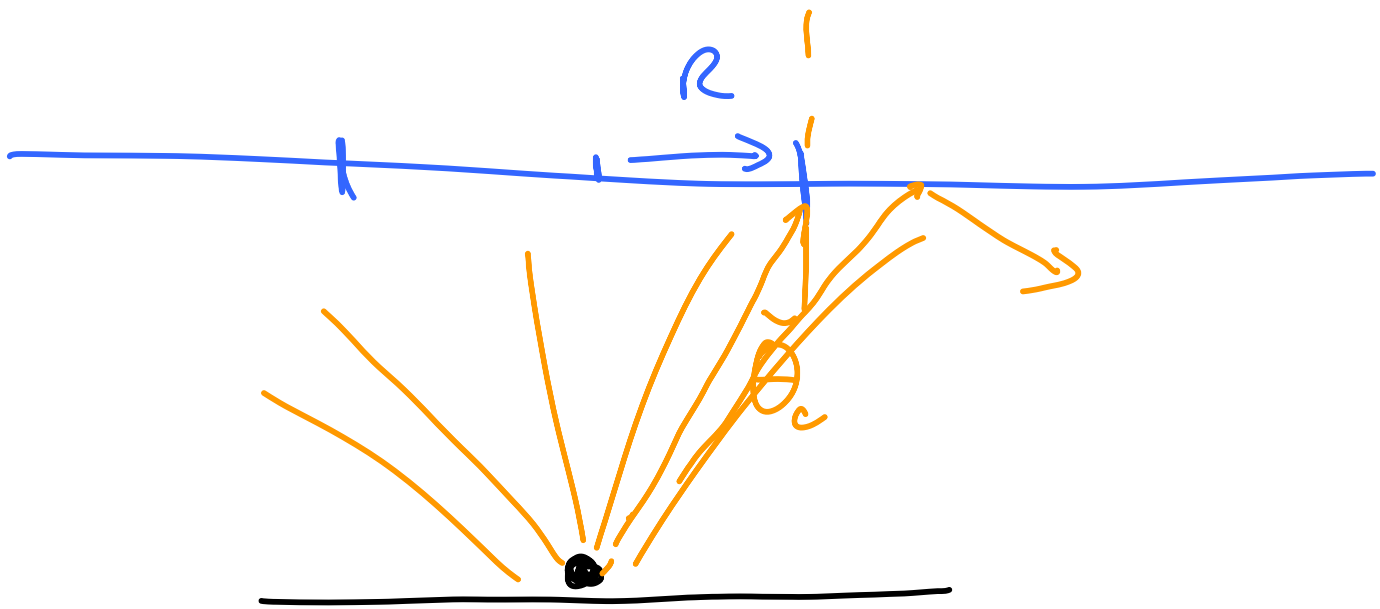
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$n_I \sin\theta_c = n_R \sin 90$$

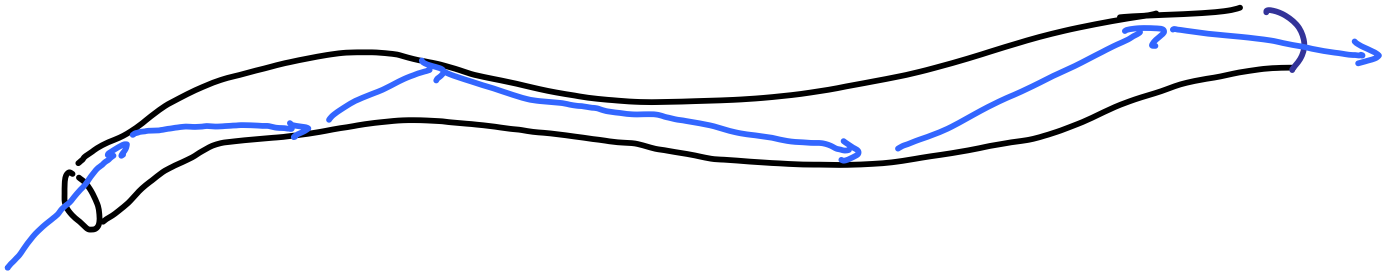
$$\boxed{\sin\theta_c = \frac{n_2}{n_1}}$$

if $\theta_R > \theta_c \Rightarrow$ Total internal reflection


Total int. reflection
θ_c

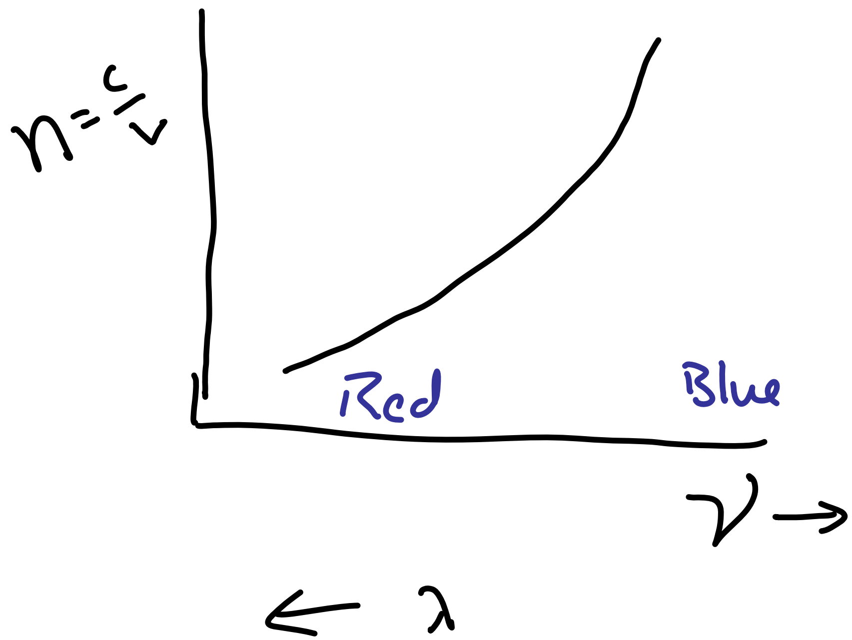

R
θ_c

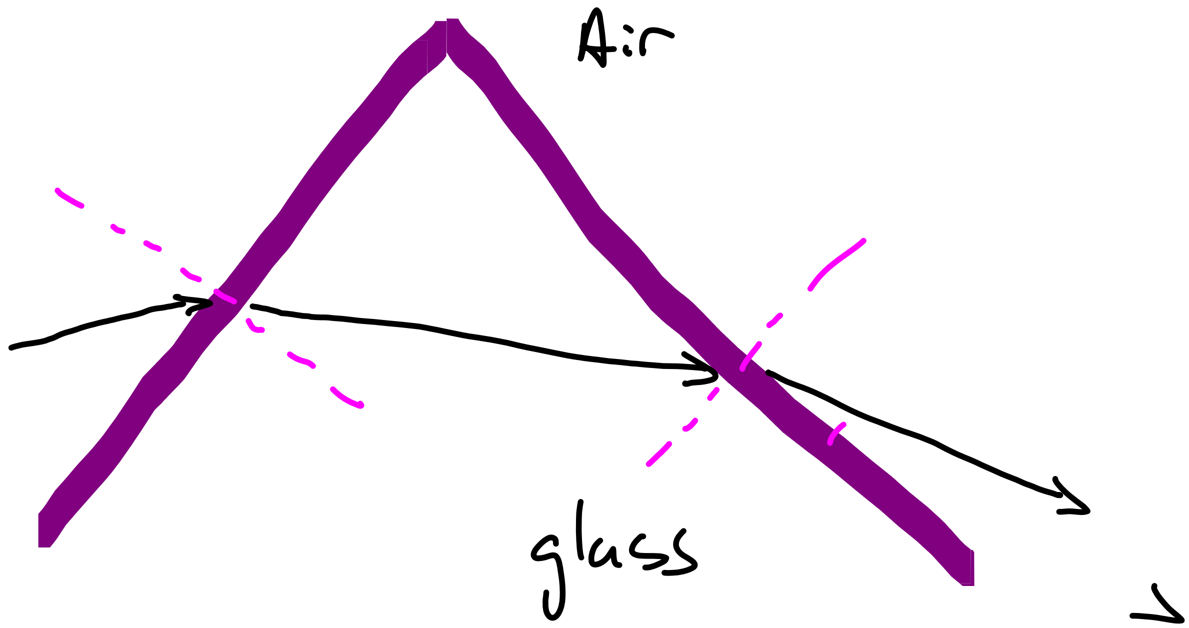
Optical fiber

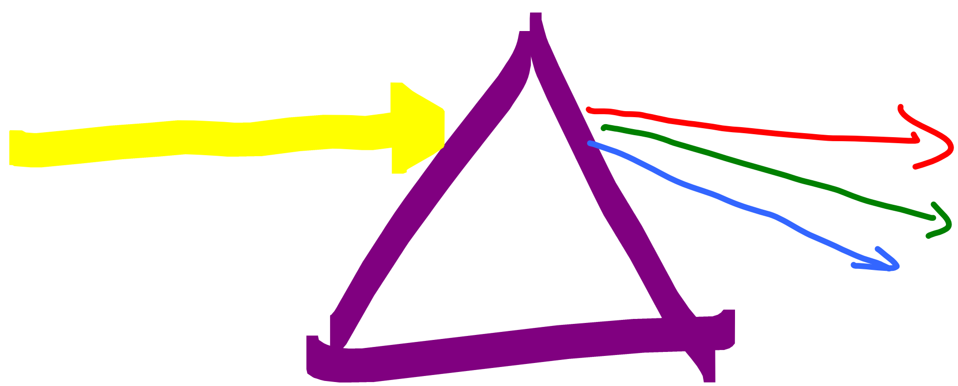


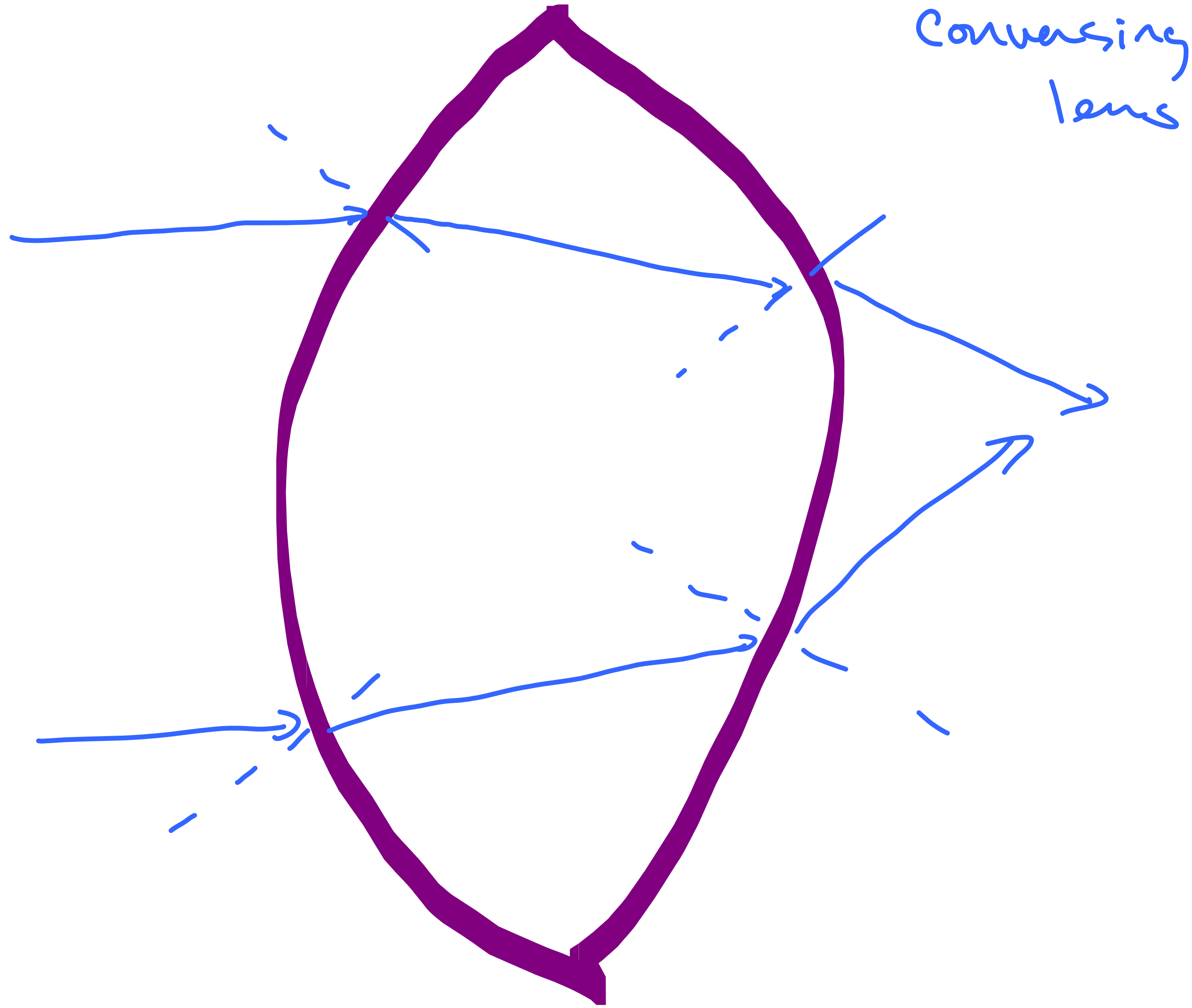
Dispersion

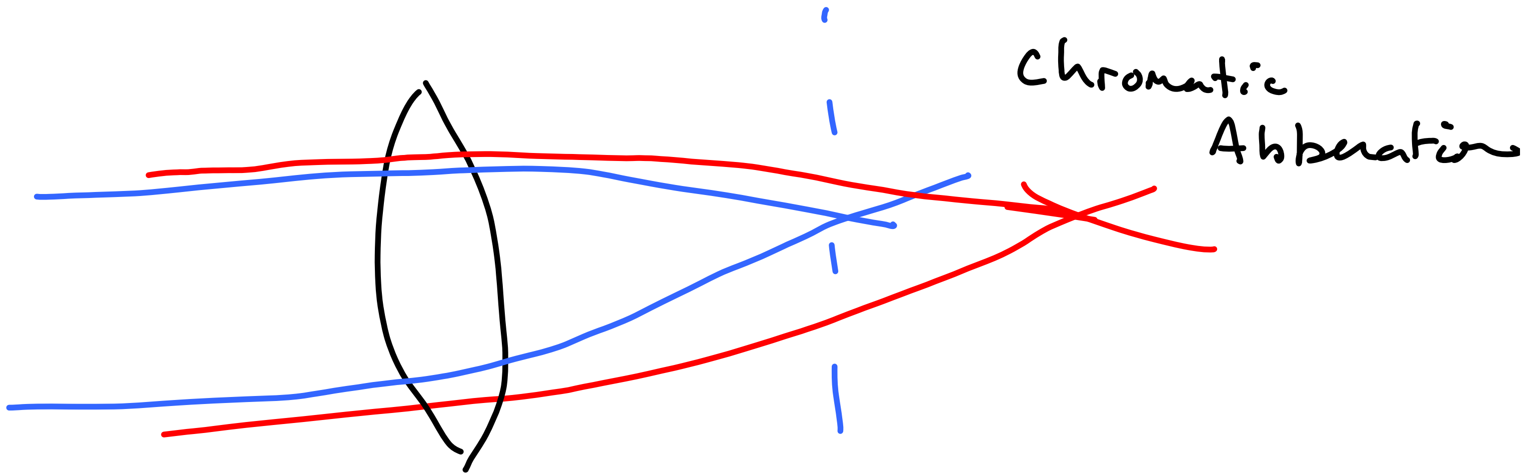
$$n = n(\lambda_0 \text{ or } \nu)$$




Air
glass




Converging
lens


Chromatic
Abberation

Thin lenses and optical instruments

Physics 142

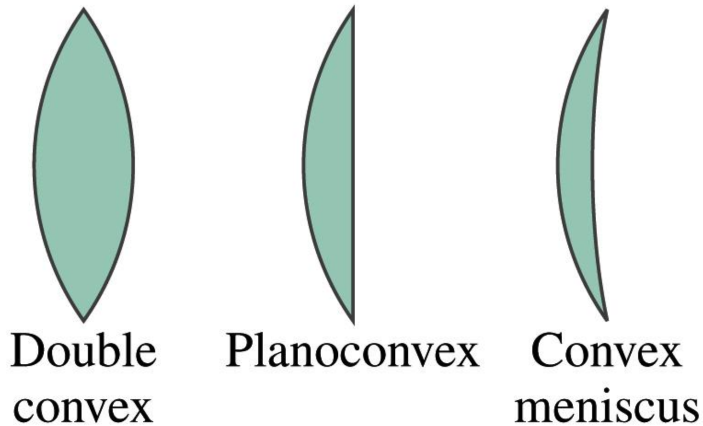
Fall 2010 - S. Manly

References and photo sources:

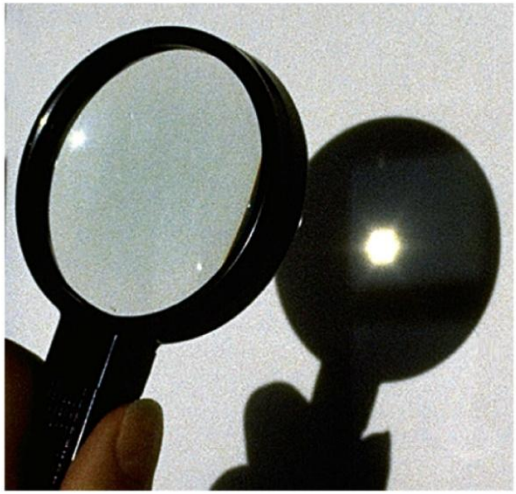
D. Giancoli, Physics for Scientists and Engineers, 3rd ed., 2000, Prentice-Hall

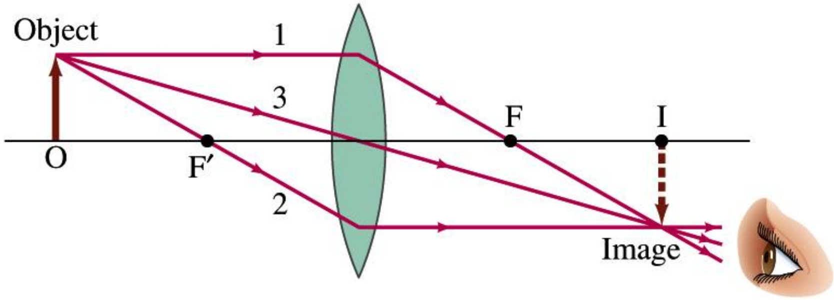
http://cvs.anu.edu.au (D. Denning and M. Kirk)

http://www.ebiomedia.com

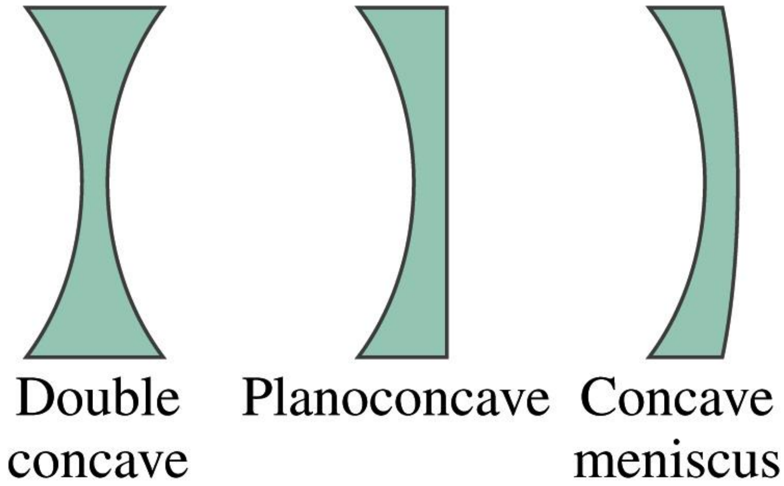


(a) Converging lenses

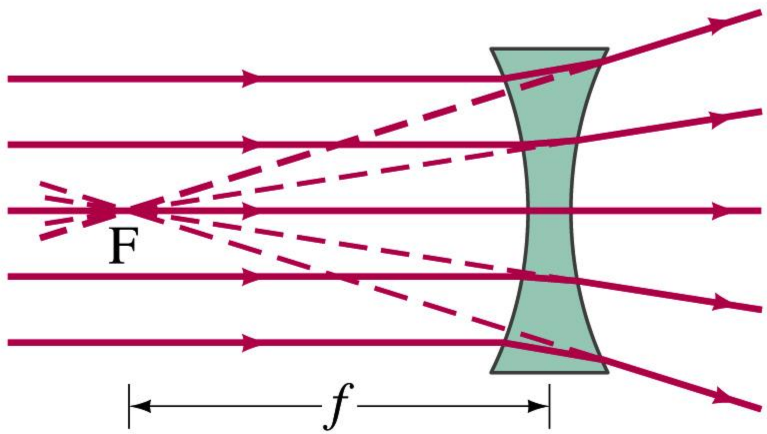


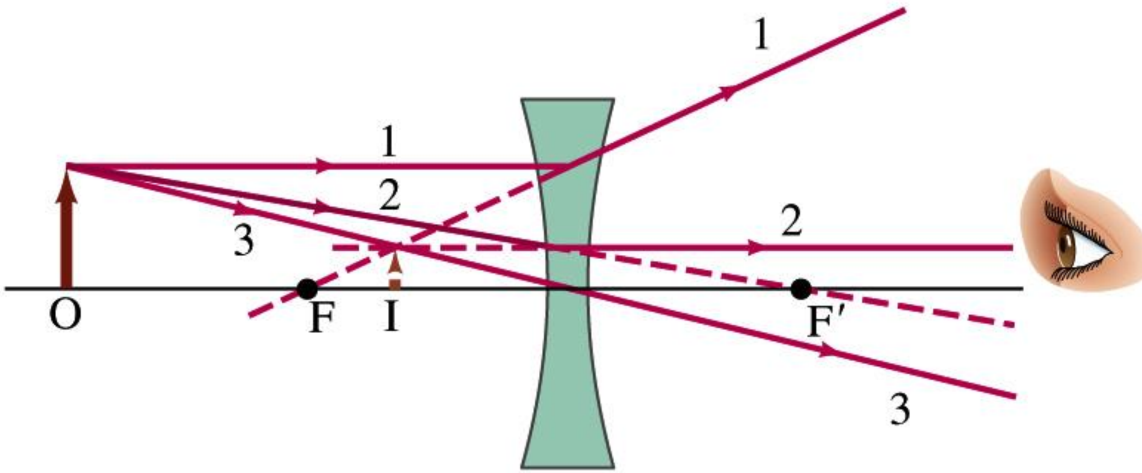


(c) Ray 3 passes straight through the center of the lens (assumed very thin).



(b) Diverging lenses

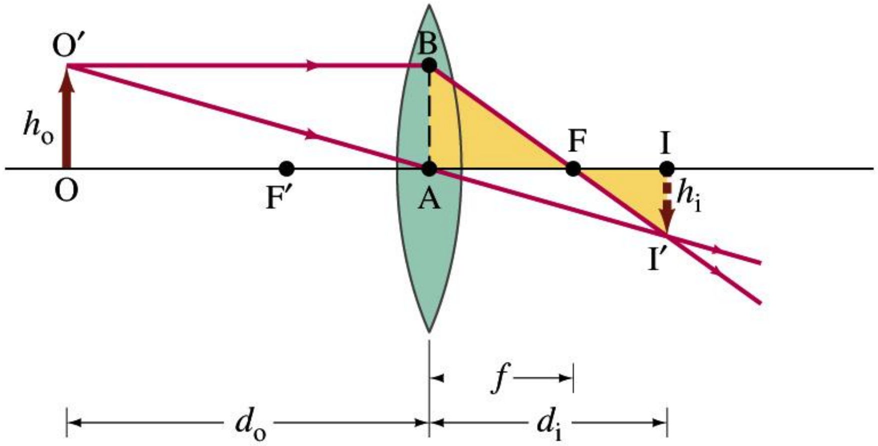



1
1
2
2
3
3
O
F
I
F′

Power of lens measured in diopters

$$P = \frac{1}{f}$$ where f is focal length in meters

Power is positive for converging lenses
and negative for diverging lenses

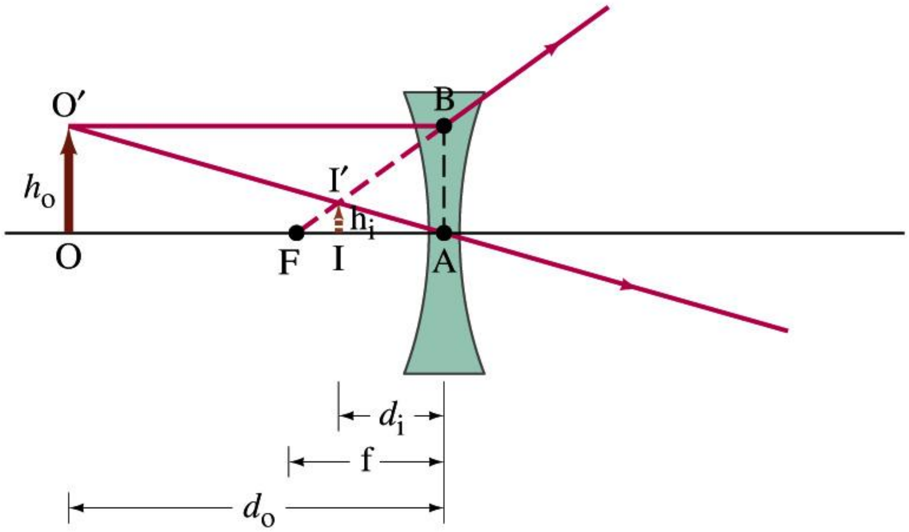


Magnification:

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

Lens equation:

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



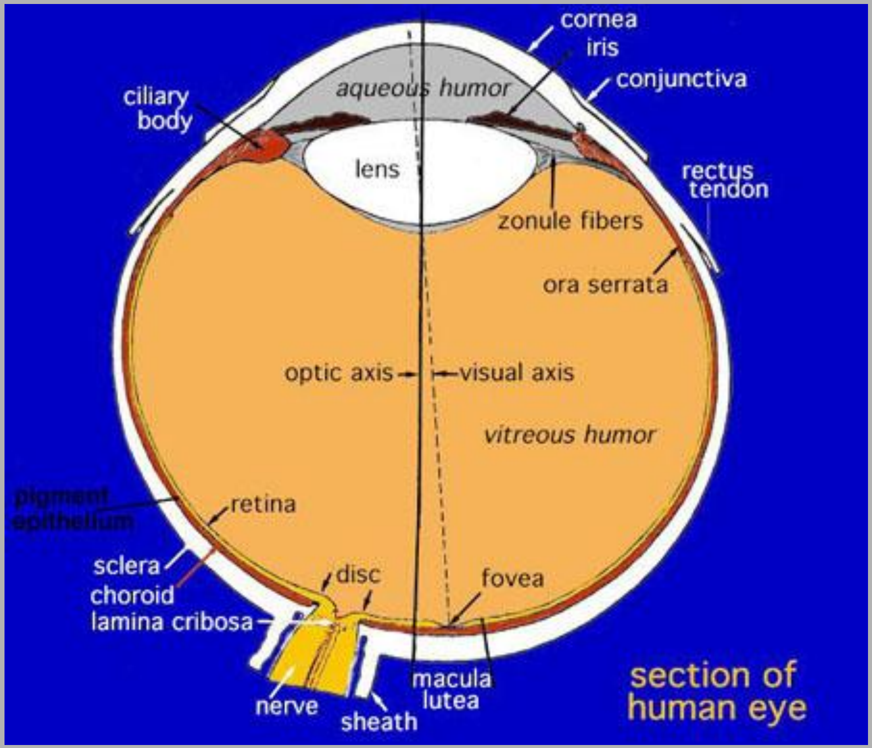
Real image: rays actually pass thru image

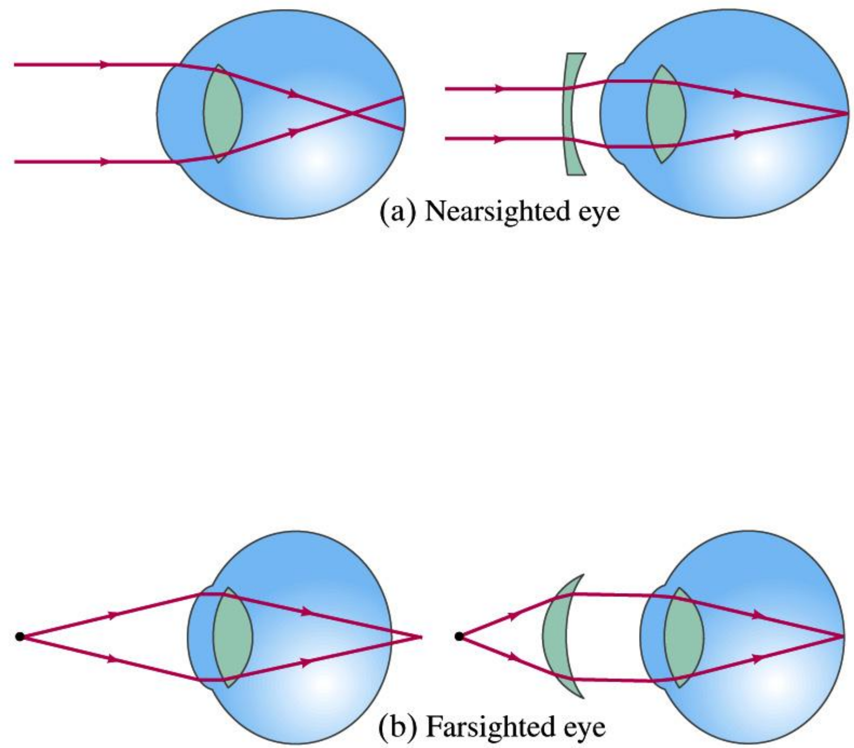
Virtual image: rays do not actually pass thru image

Sign convention is the tricky part, especially in multiple lens systems

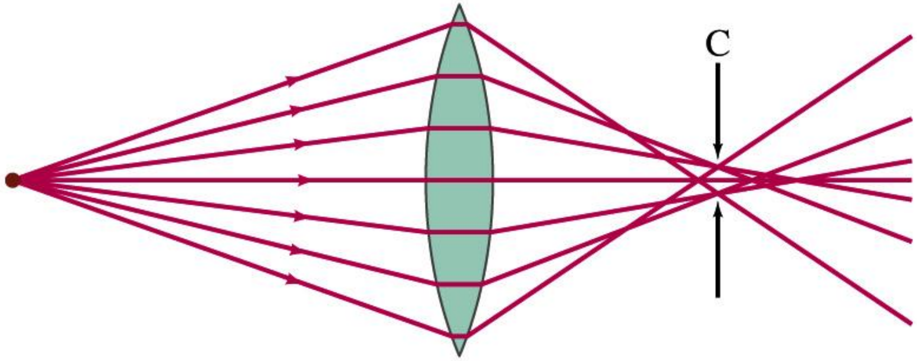
Convention from Giancoli p. 841:

- **Focal length is + for converging lens and - for diverging lens**
- **Object distance is + if on the side of the lens from which the light is coming (usual, unless in multi-lens system)**
- **Image distance is + if on the opposite side of the lens from where the light is coming, if on same side, image distance is –**
- **Image distance is + for real images and – for virtual images**
- **Height of image is + if image is upright and – if image is inverted. Height of object is always taken to be +.**

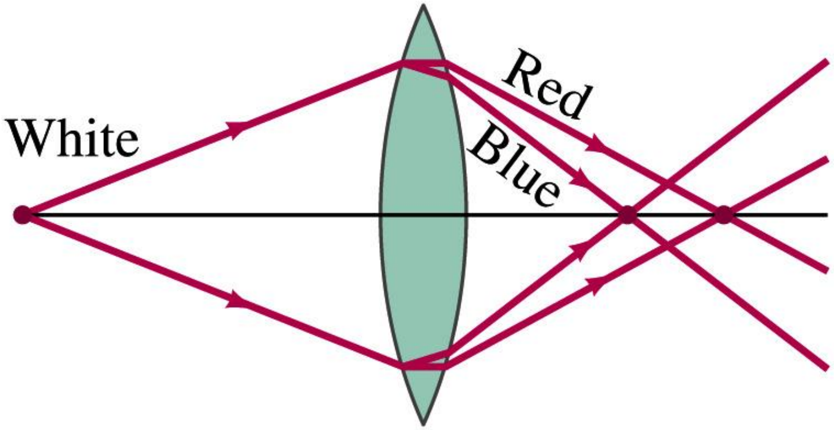

cornea
iris
conjunctiva
ciliary body
aqueous humor
lens
rectus tendon
zonule fibers
ora serrata
optic axis
visual axis
vitreous humor
pigment epithelium
retina
sclera
choroid
lamina cribosa
disc
fovea
macula lutea
nerve
sheath
section of human eye


(a) Nearsighted eye
(b) Farsighted eye

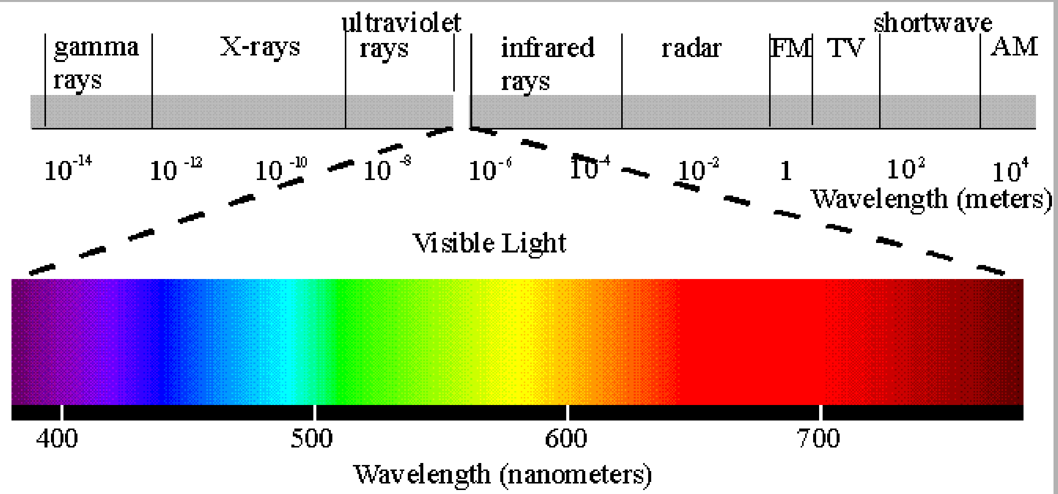
Aberrations



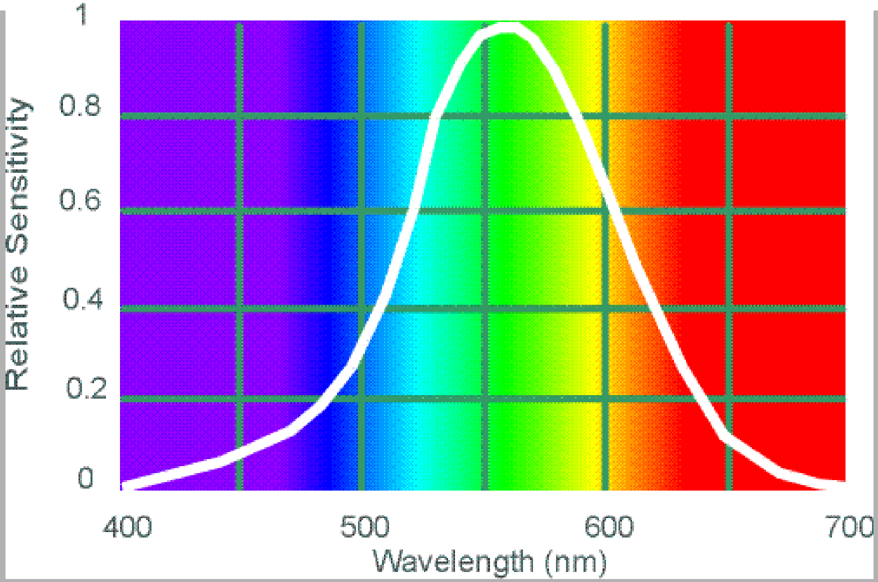
Spherical aberration

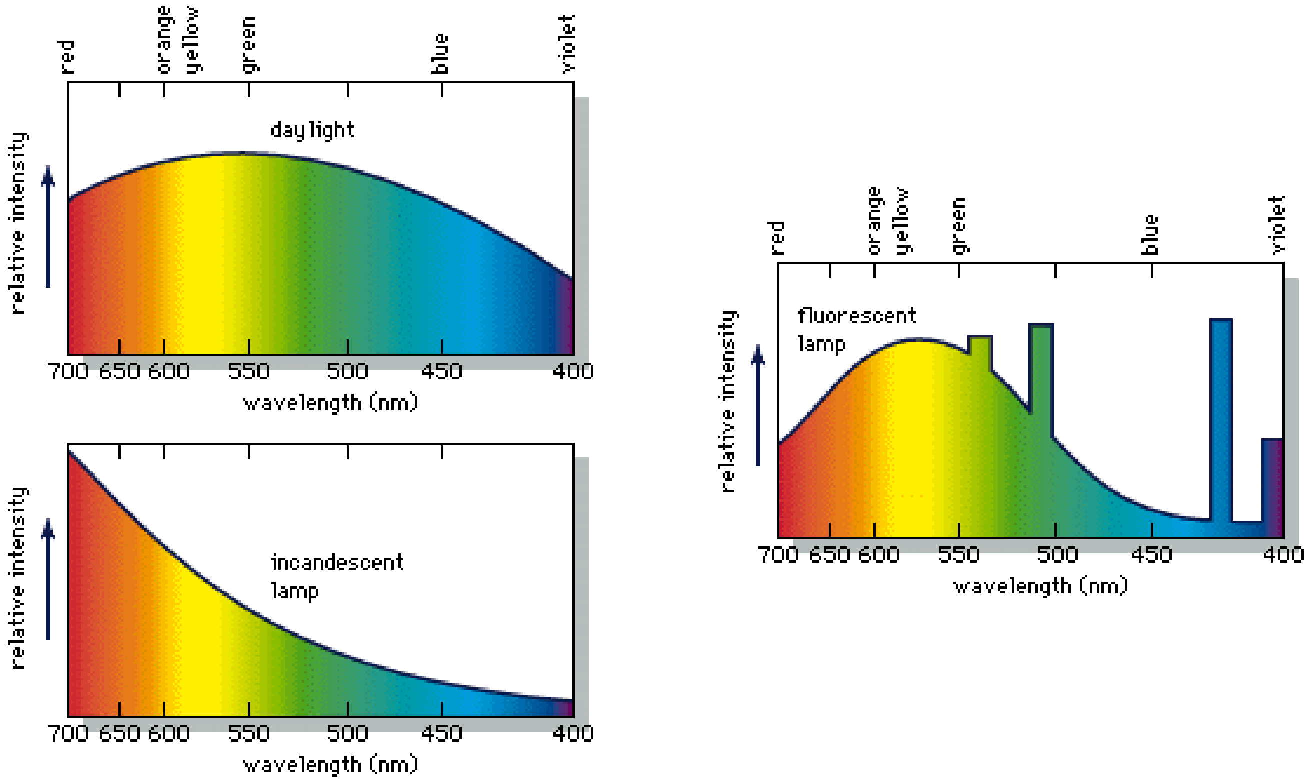


Chromatic aberration

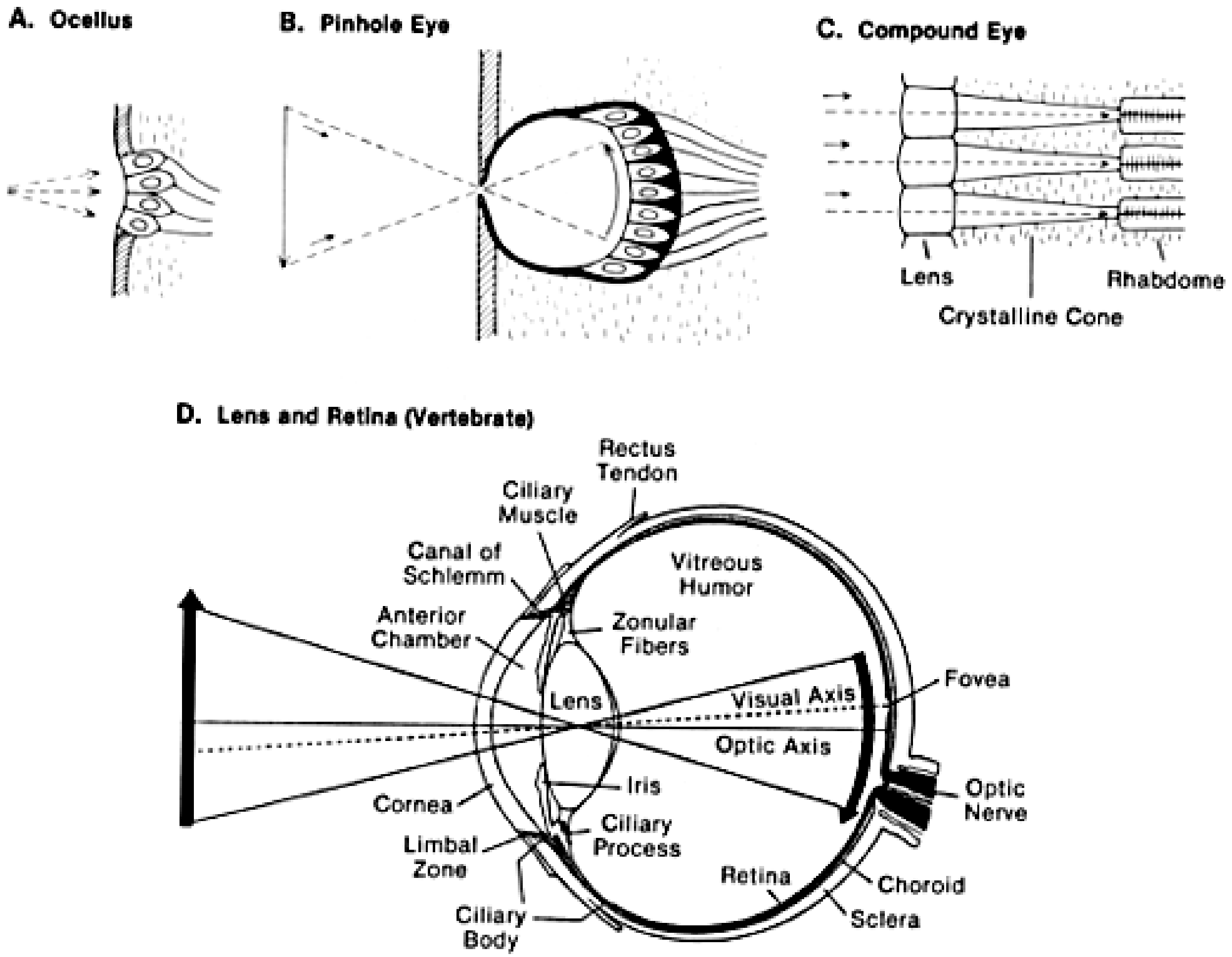


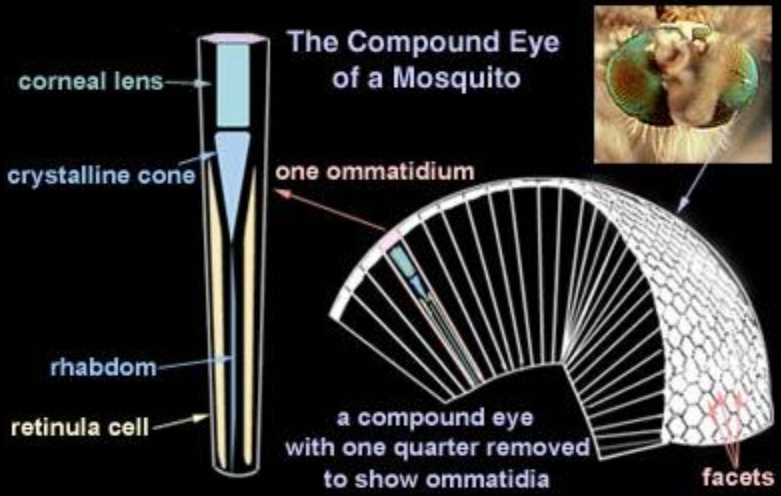
The electromagnetic spectrum
from "The Joy of Visual Perception: A Web Book"
http://www.yorku.ca/eye/



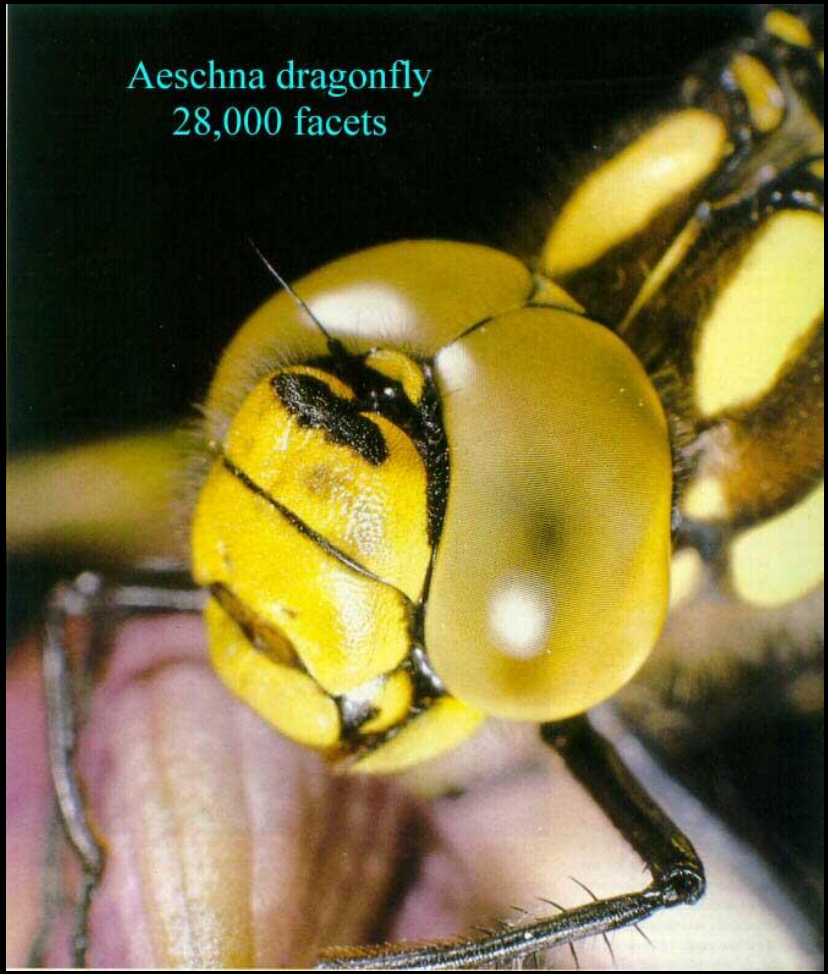

red
orange
yellow
green
blue
violet
relative intensity
daylight
700 650 600 550 500 450 400
wavelength (nm)
incandescent
lamp
fluorescent
lamp

Types of eyes in the animal kingdom



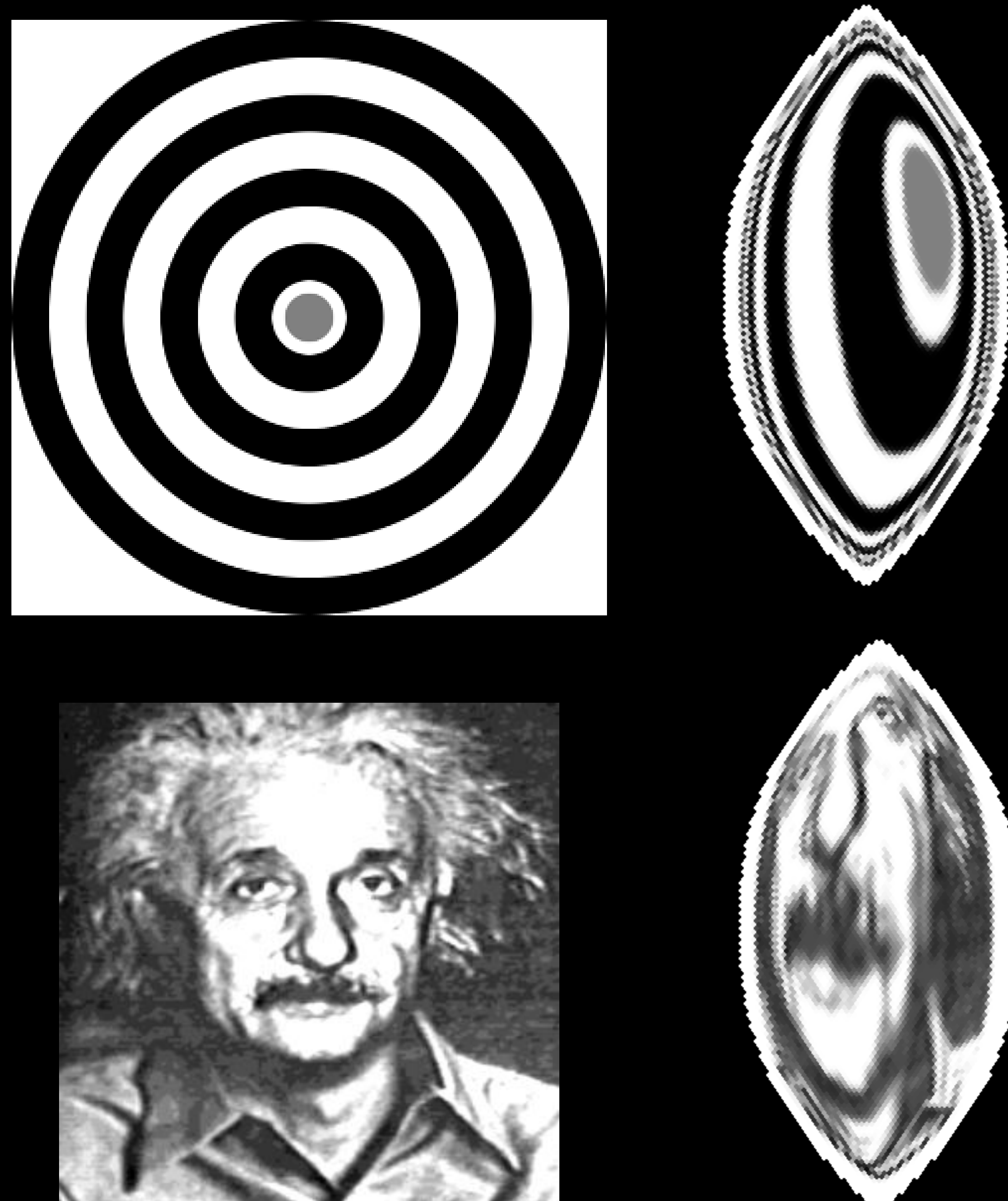


The Compound Eye
of a Mosquito
corneal lens
crystalline cone
one ommatidium
rhabdom
retinula cell
a compound eye
with one quarter removed
to show ommatidia
facets



Aeschna dragonfly
28,000 facets

A bee's eye view



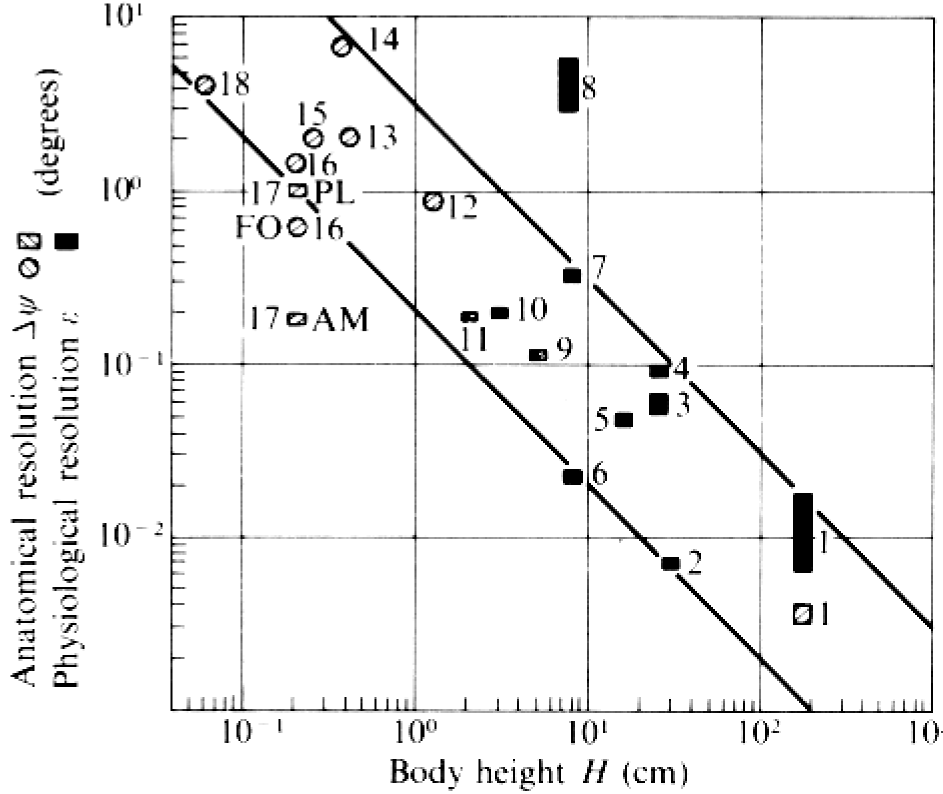
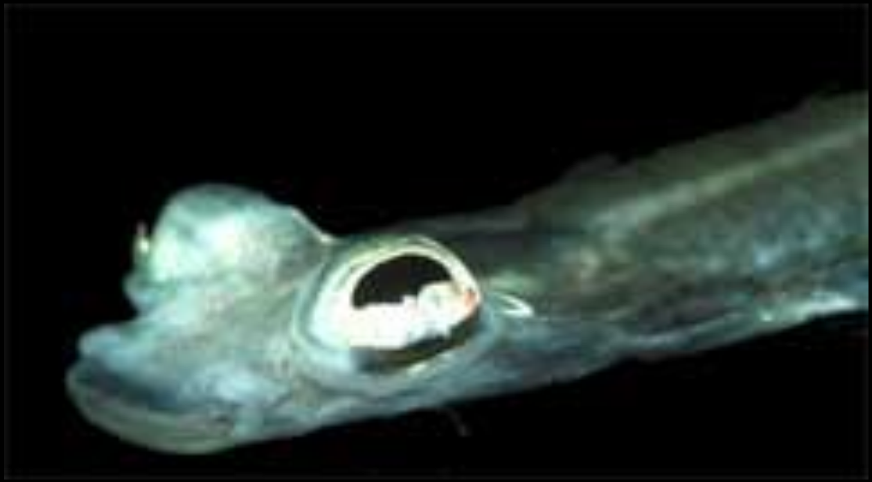
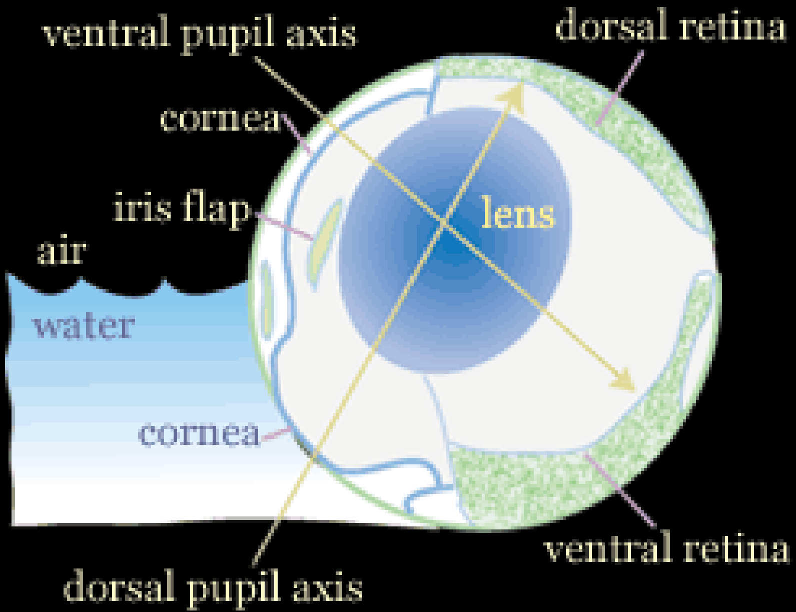


Fig. 2.9. Resolution of the eyes of various animals measured physiologically and deduced from anatomical criteria compared to body height: (1) man; (2) peregrine falcon; (3) hen; (4) cat; (5) pigeon; (6) chaffinch; (7) rat; (8) bat (*Myotis*); (9) frog; (10) lizard; (11) minnow; (12) dragonfly (*Aeschna*); (13) bee (Apis); (14) *Chlorophanus*; (15) housefly (*Musca*); (16) hover fly (*Syrrita*), frontal region FO; (17) jumping spider (*Methaphidippus*), anteromedian eye AM, postero-lateral eye PL; (18) fruit fly, *Drosophila*. (From Kirschfeld 1976.)

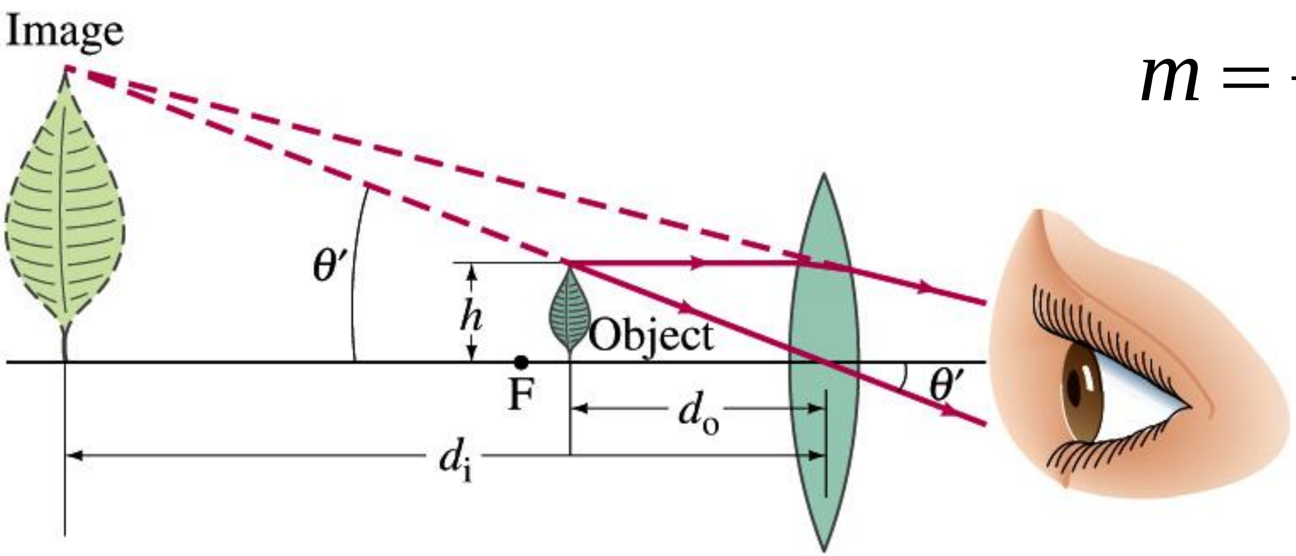
Anableps - minnow

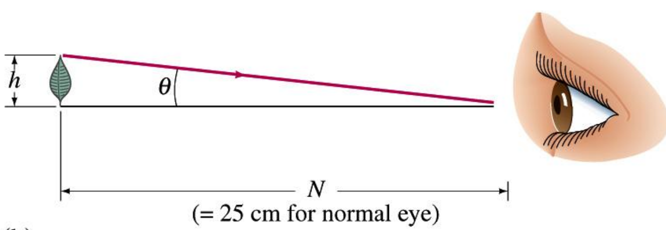




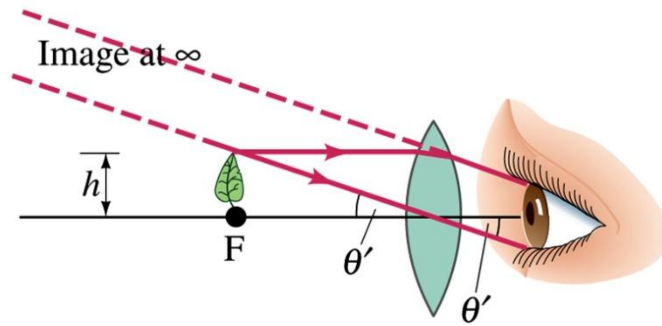
Magnifying glass

$$m = \frac{\theta'}{\theta} = \frac{N}{f}$$

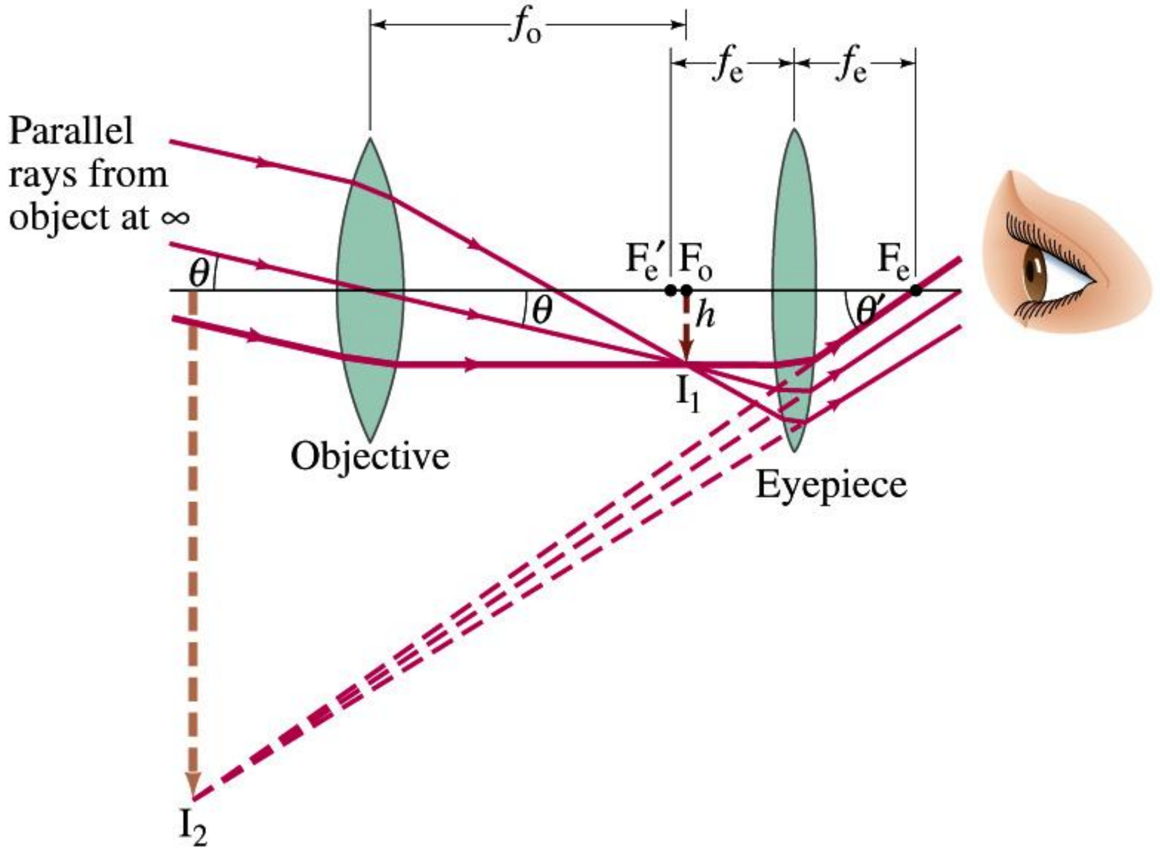




(b)

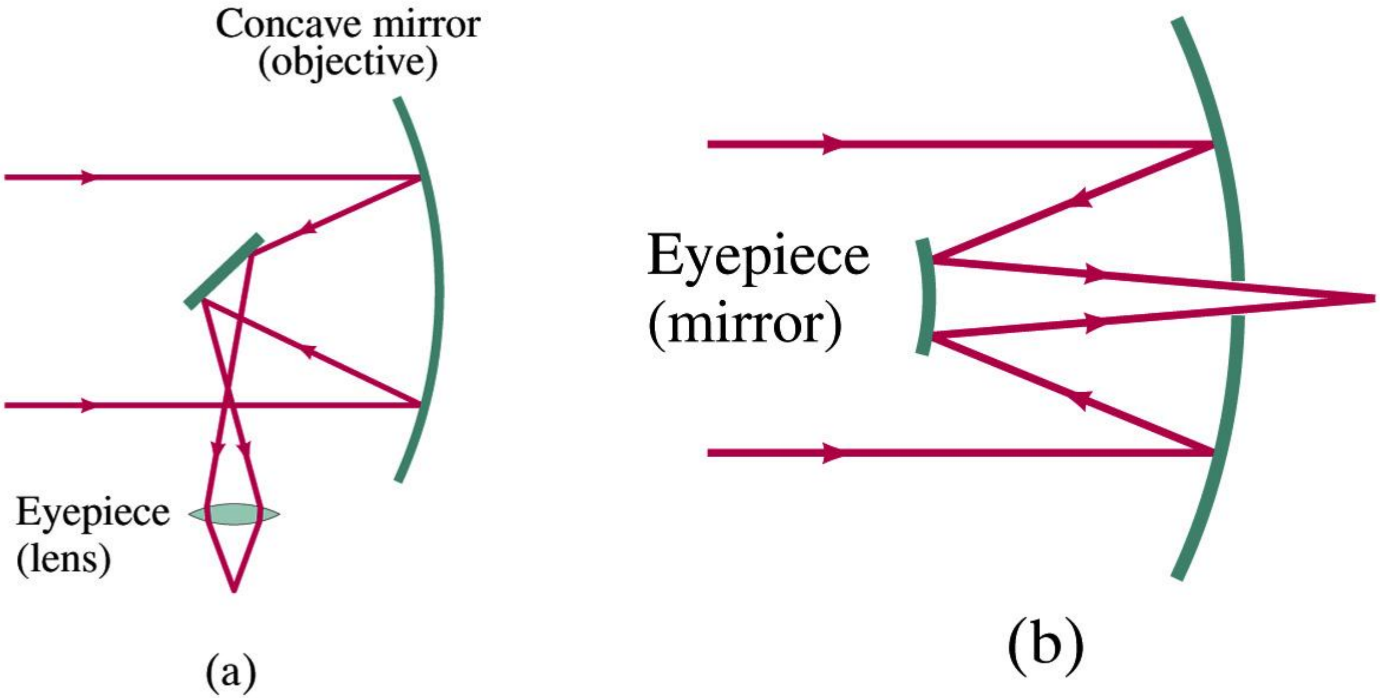


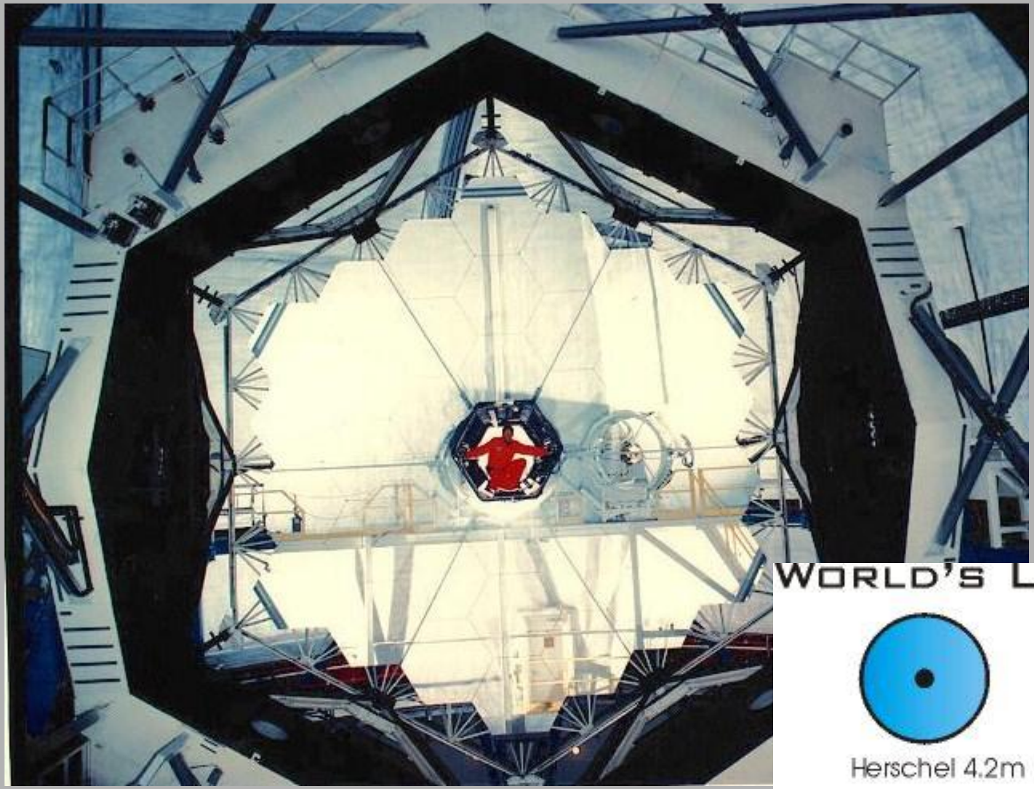
Refracting telescope

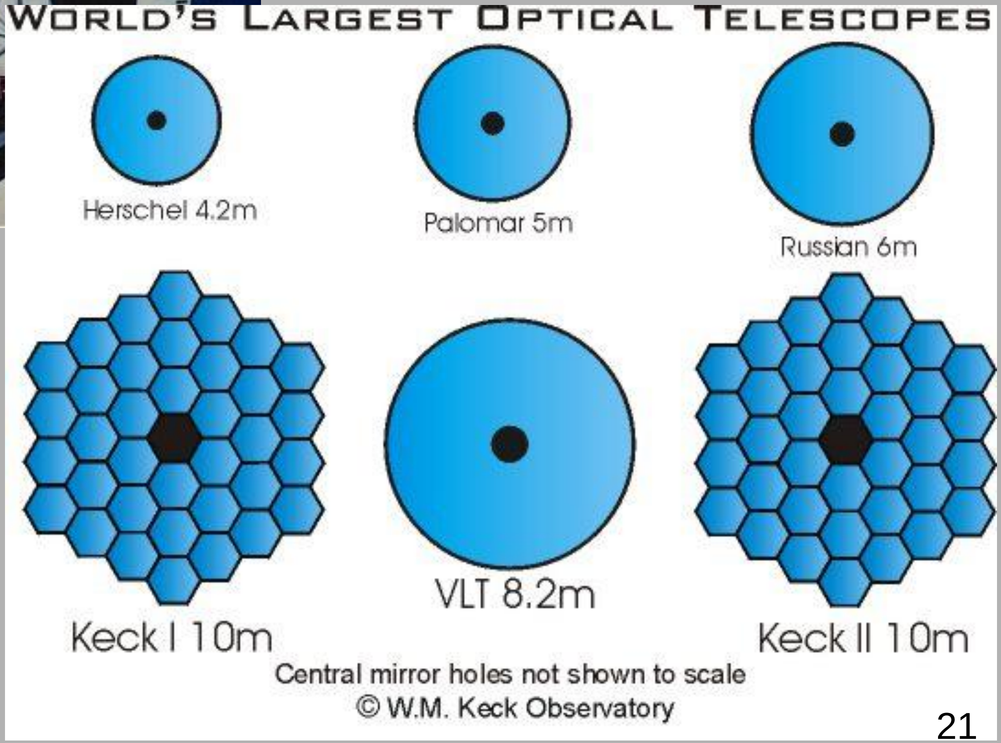


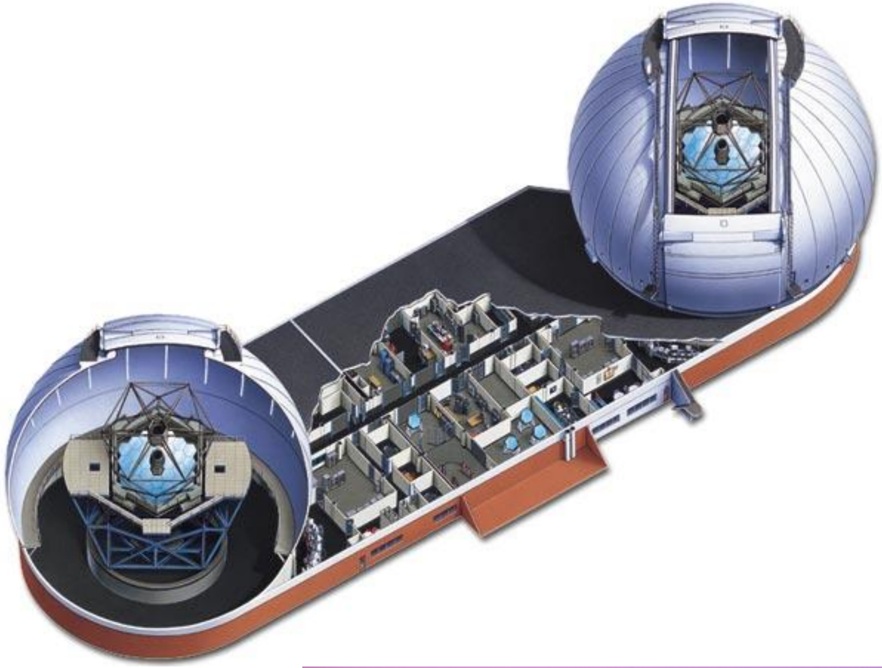
40 inch refractor – Yerkes Observatory

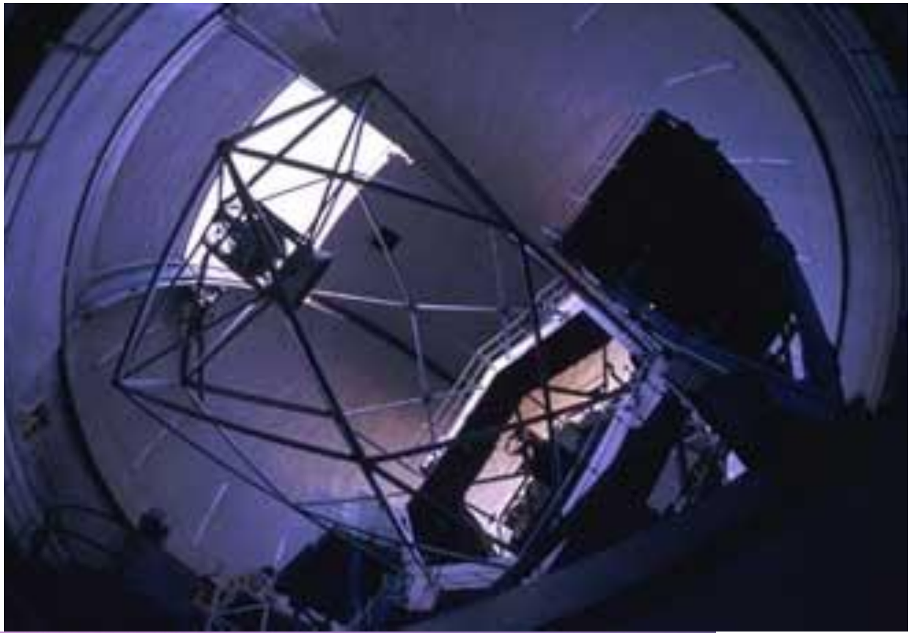
Reflecting telescope





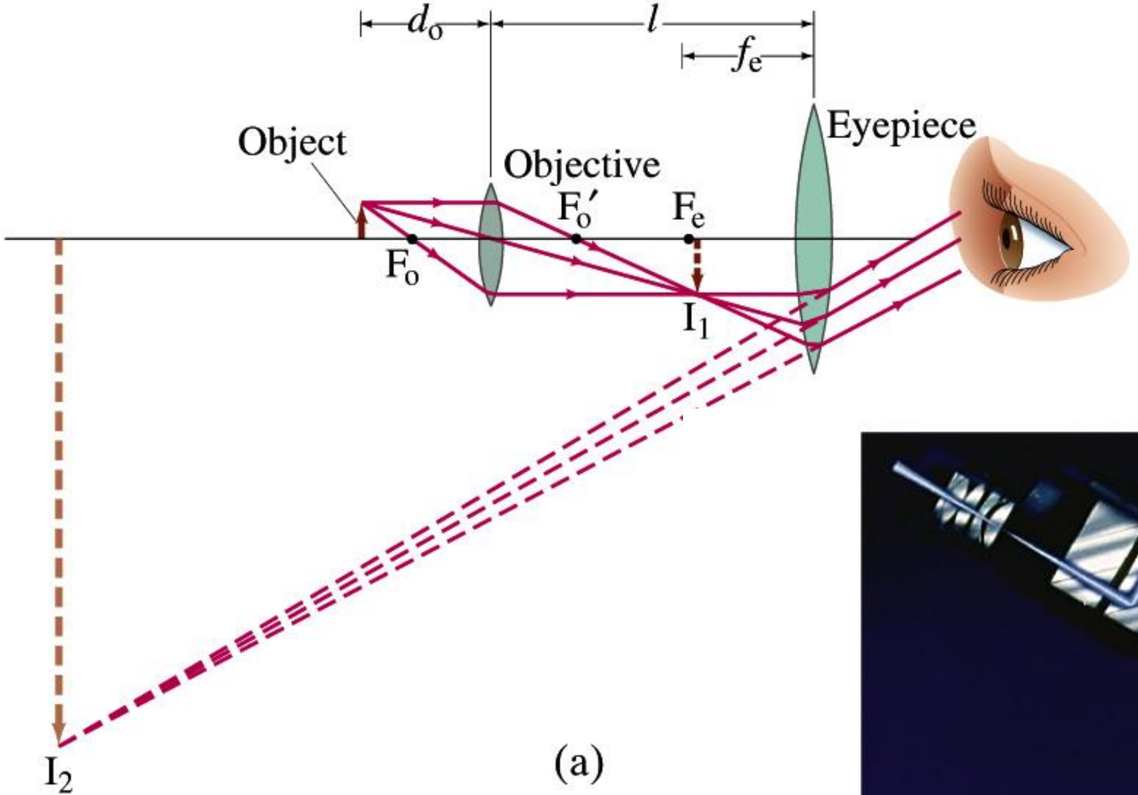

WORLD'S LARGEST OPTICAL TELESCOPES
Herschel 4.2m
Palomar 5m
Russian 6m
Keck I 10m
VLT 8.2m
Keck II 10m
Central mirror holes not shown to scale
© W.M. Keck Observatory





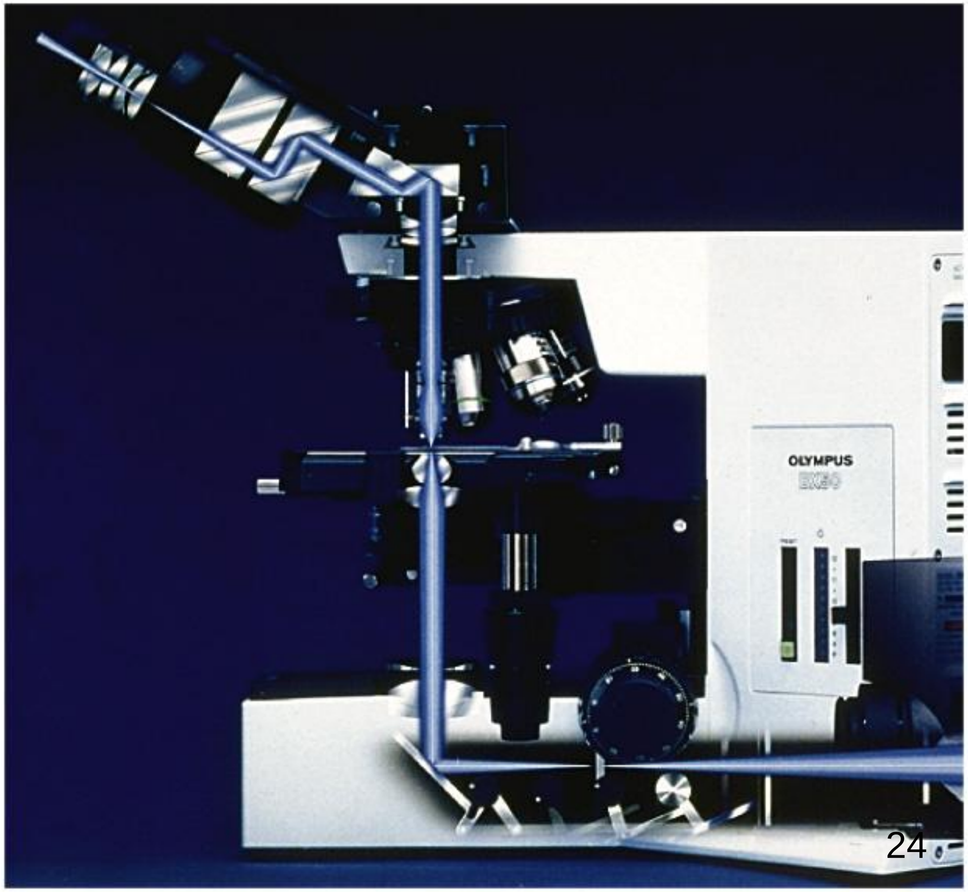
Keck Observatory


Hubble Space Telescope



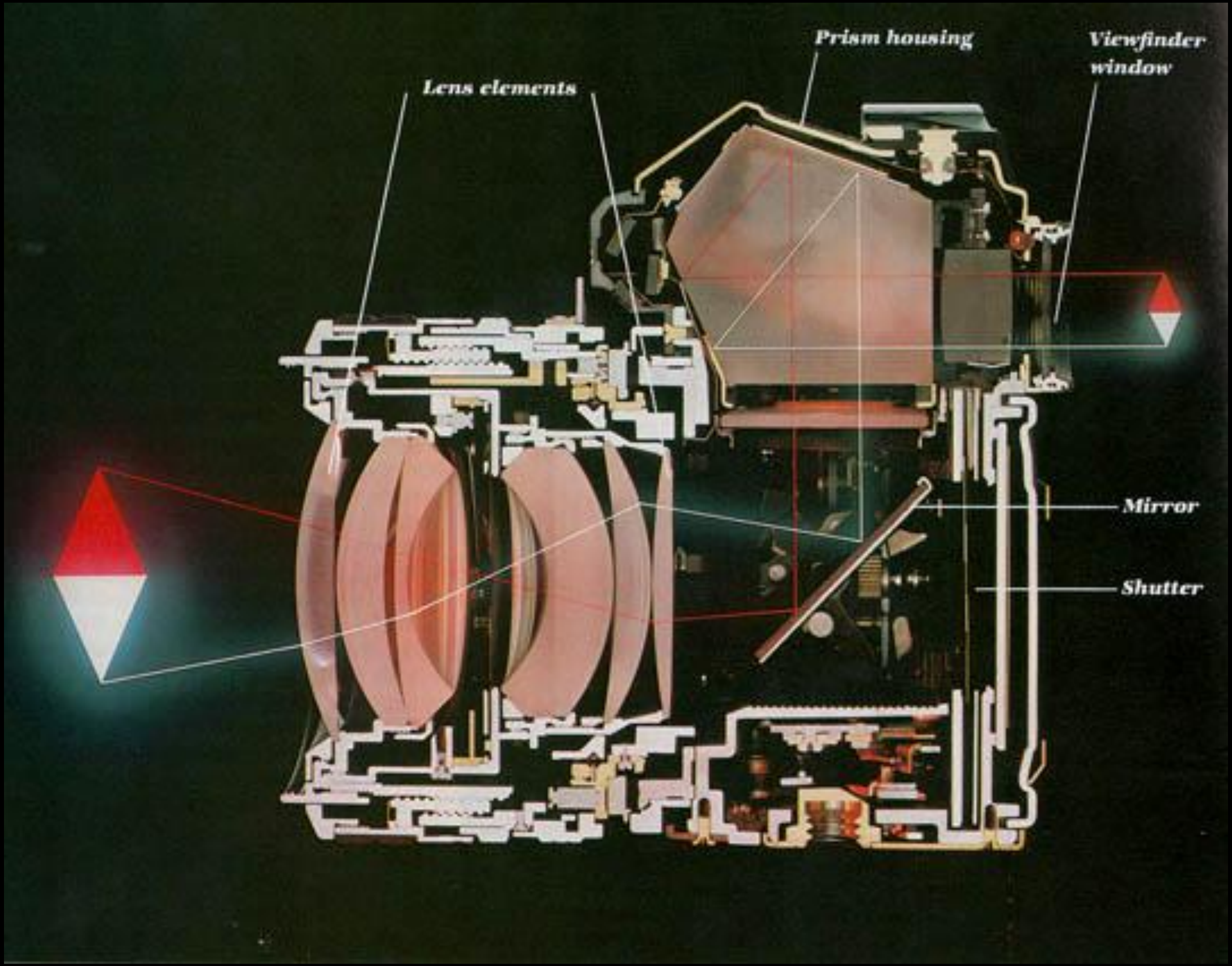
(a)

Compound microscope



(b)

Camera


Prism housing
Viewfinder window
Lens elements
Mirror
Shutter

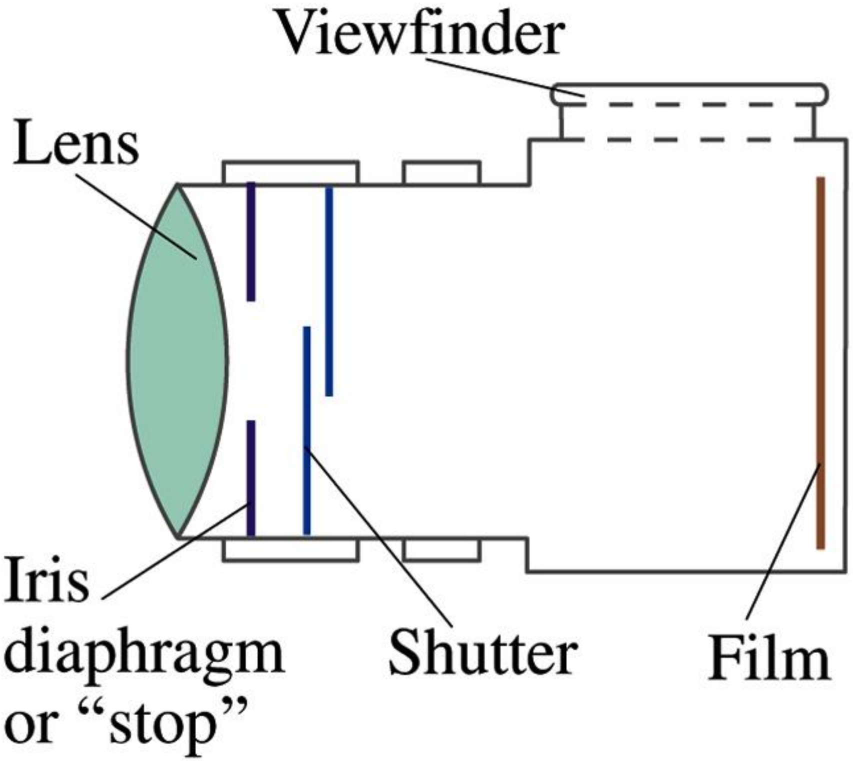
Light vs. depth of field

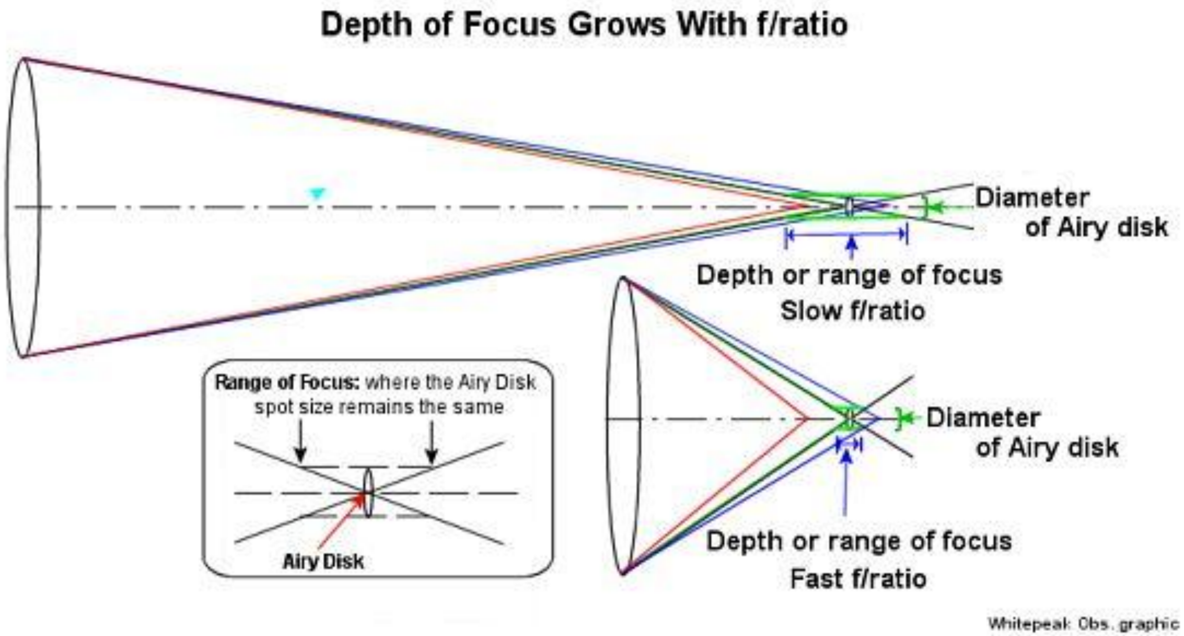
Shutter speed

f-stop=f/D, each f-stop=factor of 2 in light intensity

Faster the object or darker the day, need slower speed and/or larger D

Larger D means narrower depth of field




Depth of Focus Grows With f/ratio
Diameter
of Airy disk
Depth or range of focus
Slow f/ratio
Range of Focus: where the Airy Disk
spot size remains the same
Airy Disk
Diameter
of Airy disk
Depth or range of focus
Fast f/ratio
Whitepeak Obs. graphic

Slow exposure time
(Note hand motion)

Small opening

large depth of field of focus

fast Time

large opening

Narrow field of focus