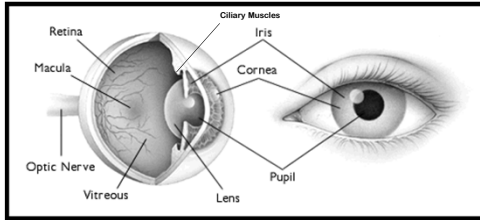
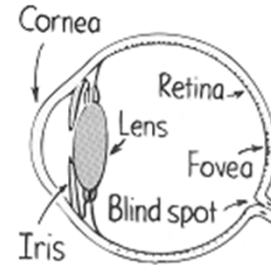


Physics 1161: Lecture 19 Lenses and your EYE

- Textbook sections 27-1 – 27-3

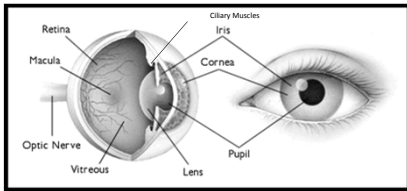


Parts of the Eye



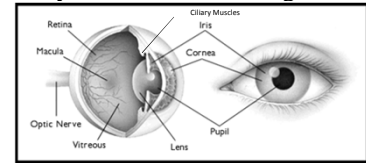
Amazing Eye

- One of first organs to develop.
- 100 million Receptors
 - 200,000 /mm²
- $10\text{ million } 6,500\text{ /mm}^2$ } Digital Camera
 - Sensitive to single photons!
- <http://hyperphysics.phy-astr.gsu.edu/hbase/vision/retina.html#c2>



Which part of the eye does most of the light bending?

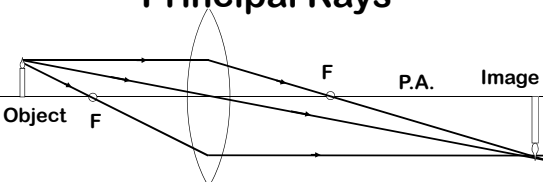
Cornea $n = 1.38$
 Lens $n = 1.4$
 Vitreous $n = 1.33$



1. Lens
2. Cornea
3. Retina
4. Cones



Review: Converging Lens Principal Rays



- 1) Rays parallel to principal axis pass through focal point.
- 2) Rays through center of lens are not refracted.
- 3) Rays through F emerge parallel to principal axis.

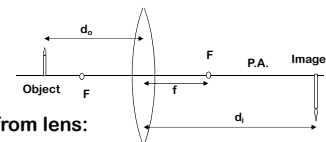
Image is real, inverted and enlarged

Assumptions:

- monochromatic light incident on a **thin** lens.
- rays are all "near" the principal axis.

Lens Equation

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



- d_o = distance object is from lens:
 - Positive: object in front of lens
 - Negative: object behind lens
- d_i = distance image is from lens:
 - Positive: real image (behind lens)
 - Negative: virtual image (in front of lens)
- f = focal length lens:
 - Positive: converging lens
 - Negative: diverging lens

Example

Example **Eye (Relaxed)**

Determine the focal length of your eye when looking at an object far away.

Object is far away: $d_o =$

Want image at retina: $d_i =$ $f_{relaxed} =$

Example **Eye (Tensed)**

Determine the focal length of your eye when looking at an object up close (25 cm).

Object is up close: $d_o =$

Want image at retina: $d_i =$ $f_{tense} =$

Looking in the Mirror
Checkpoint

A person with normal vision (near point at 26 cm) is standing in front of a plane mirror.

What is the closest distance to the mirror where the person can stand and still see himself in focus?

- 1) 13 cm
- 2) 26 cm
- 3) 52 cm

Looking in the Mirror
Checkpoint

A person with normal vision (near point at 26 cm) is standing in front of a plane mirror.

What is the closest distance to the mirror where the person can stand and still see himself in focus?

- 1) 13 cm
- 2) 26 cm
- 3) 52 cm

Image from mirror becomes object for eye!

Near Point, Far Point

- Eye's lens changes shape (changes f)
 - Object at any d_o can have image be at retina ($d_i =$ approx. 25 mm)
- Can only change shape so much
- “Near Point”
 - Closest d_o where image can be at retina
 - Normally, ~25 cm (if far-sighted then further)
- “Far Point”
 - Furthest d_o where image can be at retina
 - Normally, infinity (if near-sighted then closer)

If you are nearsighted...
(far point is too close)

Example

Too far for near-sighted eye to focus

Near-sighted eye can focus on this!

Contacts form virtual image at far point – becomes object for eye.

Want to have (virtual) image of distant object, $d_o = \infty$, at the far point, $d_i = -d_{far}$

$f_{lens} =$

Refractive Power of Lens

$$\text{Diopter} = 1/f$$

where f is focal length of lens in meters.

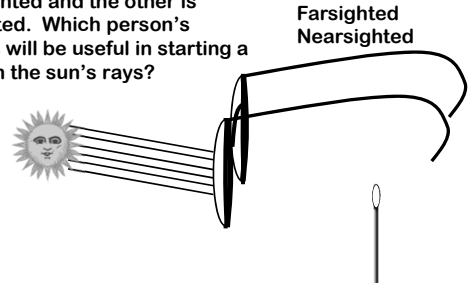
Person with far point of 5 meters, would need contacts with focal length -5 meters.

Doctor's prescription reads:

$$1/(-5\text{m}) = -0.20 \text{ Diopters}$$

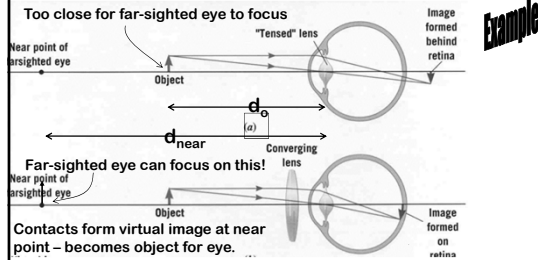
Nearsighted Farsighted Checkpoint

Two people who wear glasses are camping. One of them is nearsighted and the other is farsighted. Which person's glasses will be useful in starting a fire with the sun's rays?



If you are farsighted...

(near point is too far)



When object is at d_o , lens must create an (virtual) image at $-d_{near}$ $f_{lens} =$

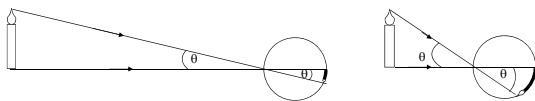
Candles Checkpoint

Which candle's image takes up more space on the retina of the person in the picture?



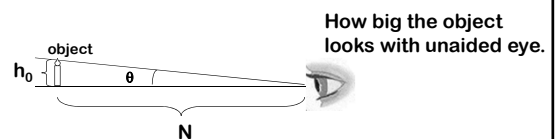
Angular Size

Both are same size, but nearer one looks bigger.



- Angular size tells you how large the image is on your retina, and how big it appears to be.

Unaided Eye

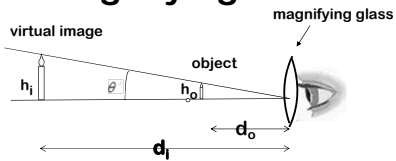


Bring object as close as possible (to near point N)

$$\tan(\theta) = \frac{h_o}{N} \implies \theta \approx \frac{h_o}{N}$$

**If θ is small and expressed in radians.

Magnifying Glass



Magnifying glass produces virtual image behind object, allowing you to bring object to a closer d_o : and larger θ'

Compare to unaided eye:

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

$$\theta' = \frac{h_i}{d_i} = \frac{h_o}{d_o}$$

Ratio of the two angles is the angular magnification M :

$$M = \frac{\theta'}{\theta} = \frac{h_o/d_o}{h_o/N} = \frac{N}{d_o}$$

The focal length of the lens of a simple camera is 40 mm. In what direction must the lens be moved to “change the focus of the camera” from a person 25 m away to a person 4.0 m away? i.e. does the image distance increase or decrease?

1. Away from the film
2. Towards the film

