Chapter 34: Geometrical Optics (Part 2)

Brief review

Optical instruments

- Camera
- Human eye
- Magnifying glass
- Telescope
- Microscope
- Optical Aberrations





The Lens Equation





Sign convention:

- 1) f is positive for converging lens, negative for diverging lens.
- 2) d_o is positive if it is on the same side of incident light, negative otherwise.
- 3) d_i is positive if it is on the opposite side of incident light, negative otherwise
- h_i (or m) is positive if the image is upright and negative if inverted, relative to the object. (h_o is always taken as positive)





ConcepTest 34.3

 An object is placed within the focal length of a converging lens. What is the image?

Lenses

- (1) Real, upright, enlarged
- (2) Virtual, upright, enlarged
- (3) Real, inverted, enlarged
- (4) Virtual, inverted, enlarged
- (5) Virtual, upright, reduced



Optical Instruments





Phys 22: Chap. 33, Pg 5

The Human Eye: Physiology

cornea

Most (³/₄) of the refraction takes place at the air-cornea interface



lens

Completes the focusing. Focal length adjusted by muscles

retina

The image is produced here. Rod and cone cells are sensitive to light and generate signal for optic nerve

fovea

Cone cells concentrated here for high resolution viewing

blind spot

There are no rod or cone cells where the optic nerve attaches to the retina, and so it is a blind spot. The brain fills in the picture, though.

The Eye: Optics

Near point:closest distance at which the eye can focus clearlyFar point:furthest distance at which the eye can focus clearly

"Normal" eye: near point = 25 cm far point = ∞

Common Defects

- Nearsightedness Eye cannot focus on distant objects. Far point < ∞
- Farsightedness Eye cannot focus on nearby objects. Near point > 25 cm

Astigmatism

Lens of eye is not spherical











The eye: correcting nearsightedness



The eye: correcting farsightedness



The eye: correcting astigmatism



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



(b) A cylindrical lens corrects for astigmatism

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Example: Far-sighted eye

A particular farsighted person has a near point of 100 cm. Reading glasses must have what lens power so that this person can read a newspaper at a distance of 25 cm? Assume the lens is very close to the eye.



1/f = 1/25 + 1/(-100). So f=33 cm, or Power=1/f=3.0D

Example: near-sighted eye

- A near-sighted eye has near and far points of 12 cm and 17 cm, respectively.
 - What lens power is needed for this person to see distant objects clearly?
 - What then will be the near point?

(Assume that the lens is 2 cm from the eye)



 $1/f = 1/[-(17-2)] + 1/\infty$. So f=-15 cm, or Power=1/f=-6.7D



 $1/(-15) = 1/(12-2)+ 1/d_o$. So d_o = 30 cm

Magnifying Glass

The same object subtends a larger angle at a closer distance:

For eye focused at ∞ (relaxed eye), angular magnifying power

$$M = \frac{N}{f}$$



(b)



For eye focused at near point, angular magnifying power

$$M = 1 + \frac{N}{f}$$

The near point for normal eye is N=25 cm.

For example: a 8-cm-focal-length converging lens (jeweler's loupe) has $M=25/8\approx3$ if the eye is relaxed, $M\approx4$ if the eye is focused at the near point.

Refracting Telescopes

Two converging lens at the two ends: objective lens and eyepiece lens.

Magnifying power

$$M = -\frac{f_0}{f_e}$$

For example: the largest one is located in Wisconsin, a 40-in telescope. Its $f_o=19$ m, $f_e=10$ cm. So the magnifying power is M = -19/0.1 = -190



Reflecting Telescopes

Advantages:

Only one surface has to be ground, unlike a lens. Can be made large and supported over the entire surface.

Parabolic surface can reduce aberration

The largest optical telescopes are of this kind.





Microscope

Magnifying power

$$M \approx \left(\frac{N}{f_e}\right) \left(\frac{l}{f_o}\right)$$

Slightly different from Eq.(34.23) of the book.

For example: for I=17.5 cm, $f_e=1.6$ cm, $f_o=0.65$ cm, N=25 cm, the magnifying power is about M=420.

Click here for compound microscope



ConcepTest 34.4

Cameras

 For a given shutter speed, which of the following fstop settings gives the brighter picture?

(A) f/11(B) f/5.6(C) the same

ConcepTest 34.5 Lenses

- A person's eyeglass prescription calls for lens powers of +2.1 D for the left eye and +2.5 D for the right eye. This person is
- (A) far-sighted(B) near-sighted(C) cannot tell frominformation given

Optical Aberrations



Optical Aberrations

spherical aberration



chromatics aberration



aberration correction by compound lenses

