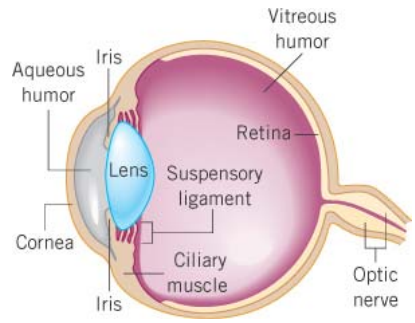
The human eye and the camera

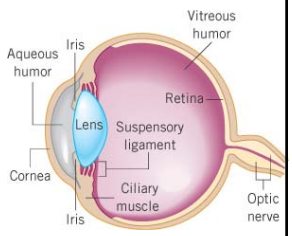
1

Anatomy of the human eye



2

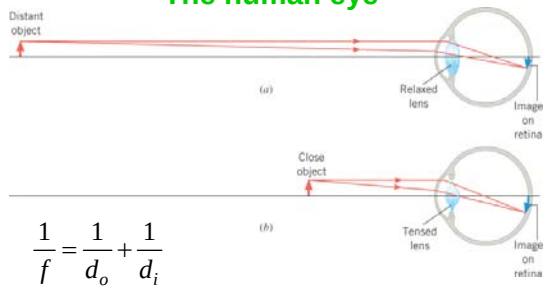
The human eye



Most of the refraction does not occur in the lens, but in the aqueous humor, a liquid on top of the lens. Light is refracted when it comes into the eye through this liquid, refracted a little more by the lens, and then a bit more by the vitreous humor, the jelly-like substance that fills the space between the lens and the retina. The lens is critical in forming a sharp image, however. One of the most amazing features of the human eye is how quickly it adjusts in producing a focused image - this process is known as accommodation.

3

The human eye



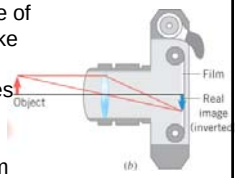
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

The ciliary muscle controls the thickness and hence the focal length of the lens to focus objects at various distances away. By the thin-lens equation, the required focal length decreases as the object distance decreases.

4

The camera

In a camera, the lens forms an image of the object onto the film or CCD. Unlike with human eyes, adjusting the focal length is inconvenient as that requires changing the lens. Instead accommodation is achieved by adjusting the position of the lens from the image, i.e., the image distance (which is not possible with our eyes since the lens-retina distance is fixed). For the same focal length, decreasing d_o would require d_i to increase. This is done by moving the lens towards the object.



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

Simulation

5

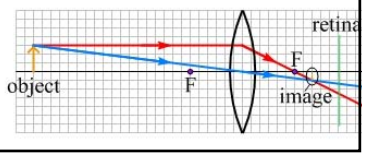
Correcting nearsightedness

A person who is nearsighted can only create sharp images of close objects. It is because the lens of the eye cannot relax to a thin condition and so brings objects that are far away in to focus at a point in front of the retina. So distant objects look fuzzy.

To correct for this, a lens can be placed in front of the eye. What kind of lens is necessary?

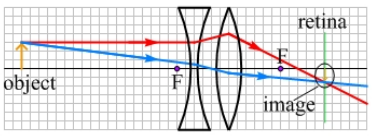
1. A converging lens
2. A diverging lens

Simulation



Correcting nearsightedness

We need a diverging lens to diverge the light rays just enough so that when the rays are converged by the eye they converge on the retina, creating a focused image.



7

Correcting farsightedness

A farsighted person can only create clear images of objects that are far away because their lens cannot tighten to a thick condition. As a result, close objects are brought to a focus behind the retina, which is why they look fuzzy.

To correct for this, a lens can be placed in front of the eye. What kind of lens is necessary?

1. A converging lens
2. A diverging lens

8

Diopters

If you go to an optometrist to get glasses or contact lenses, you will get a prescription specified in units of diopters. This is a measure of the refractive power of the lens, which is the inverse of the focal length.

$$\text{refractive power in diopters} = \frac{1}{f} \quad ,$$

where f is in meters.

A diopter has units of 1 / m . Concave lenses have negative diopters and convex lenses have positive diopters.

9

Visual Acuity

An average person with healthy vision has a 20/20 visual acuity. For reference, a 20/40 vision means that what other people can see clearly from 40 feet away, the individual can only see at 20 feet. A 20/200 vision, after the best correction, is considered legally blind. A crude relation between visual acuity and diopter measure has been reported, as shown below.

Diopter Measure	20/20 Measure
-1.00	20/40
-2.00	20/80*
-3.00	20/150*
-4.00	20/300*
-5.00	20/400*
-6.00	20/500*

http://www.improve-vision-naturally.com/20-20-vision.html

10