

# CS 498 VR

Lecture 10 - 2/19/18

[go.illinois.edu/VRlect10](http://go.illinois.edu/VRlect10)

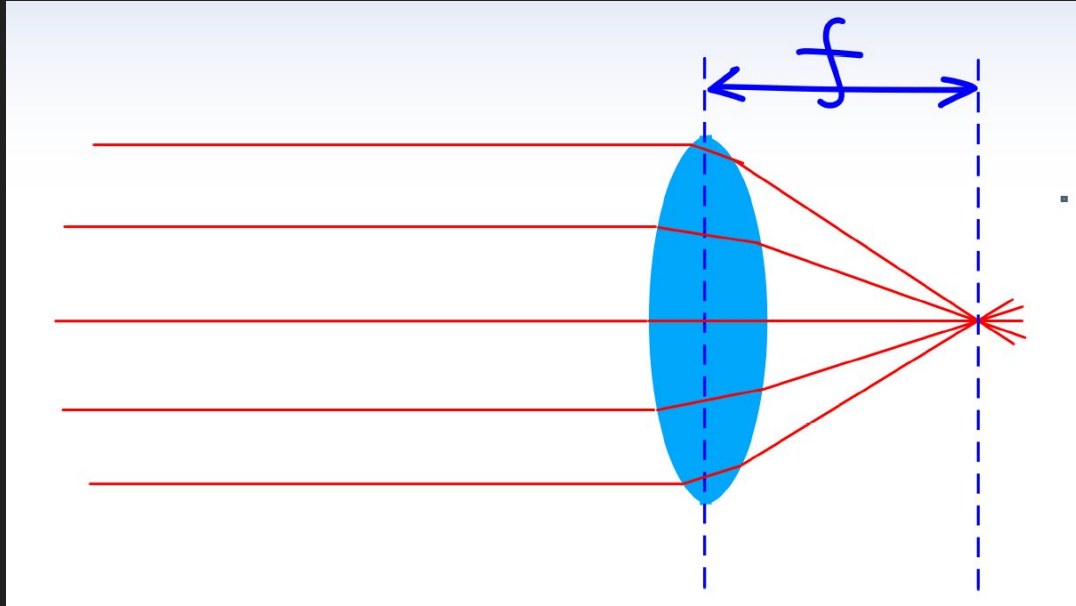
# Reviews from last lecture

- List all possible light models
  - Do rays converge or diverge?
- Why do we use Snell's Law?

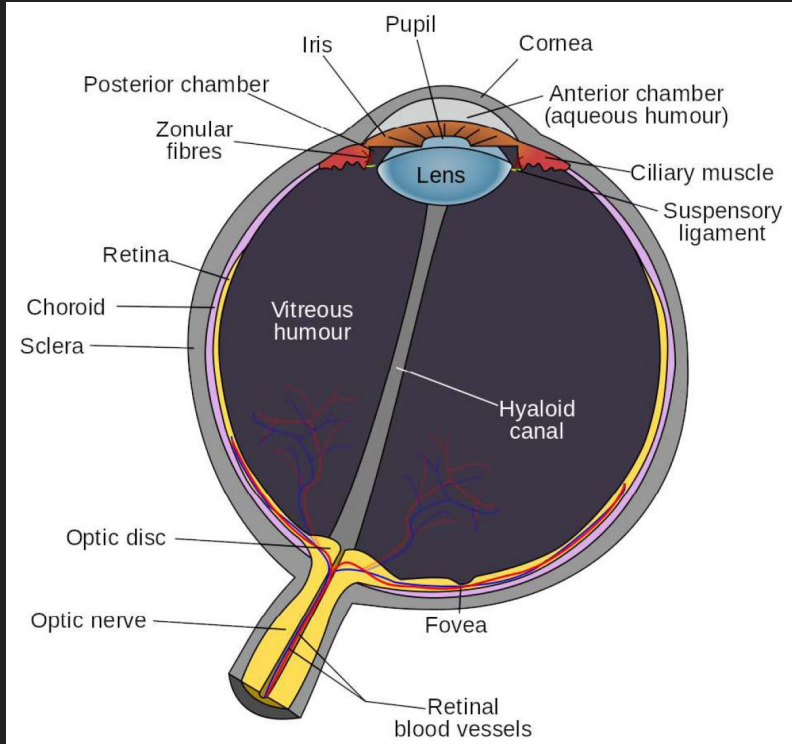
# Imaging Properties of a Lens

$f$  depends on: shape, material property

$$D = 1 / f$$

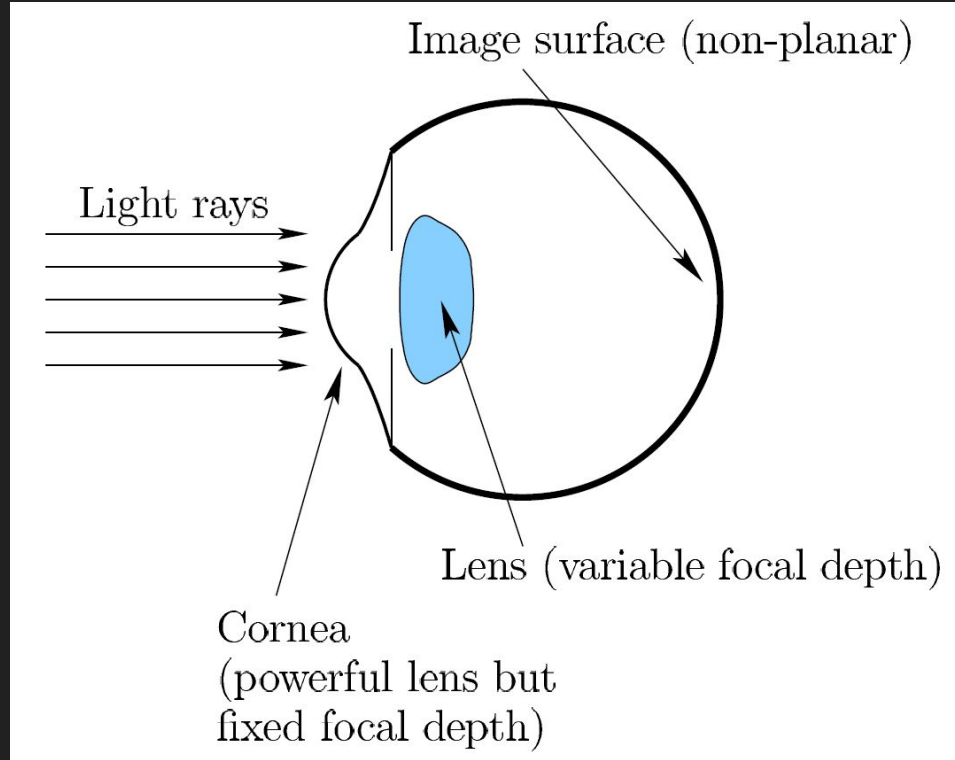


# Structure of the Human Eye

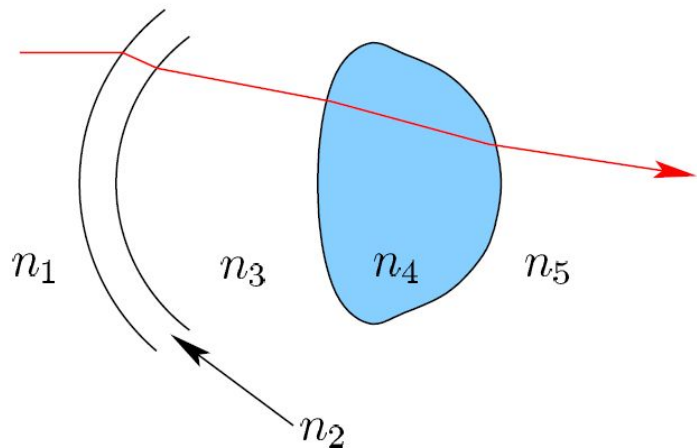


What is the diopter of the human eye?

# Structure of the Human Eye



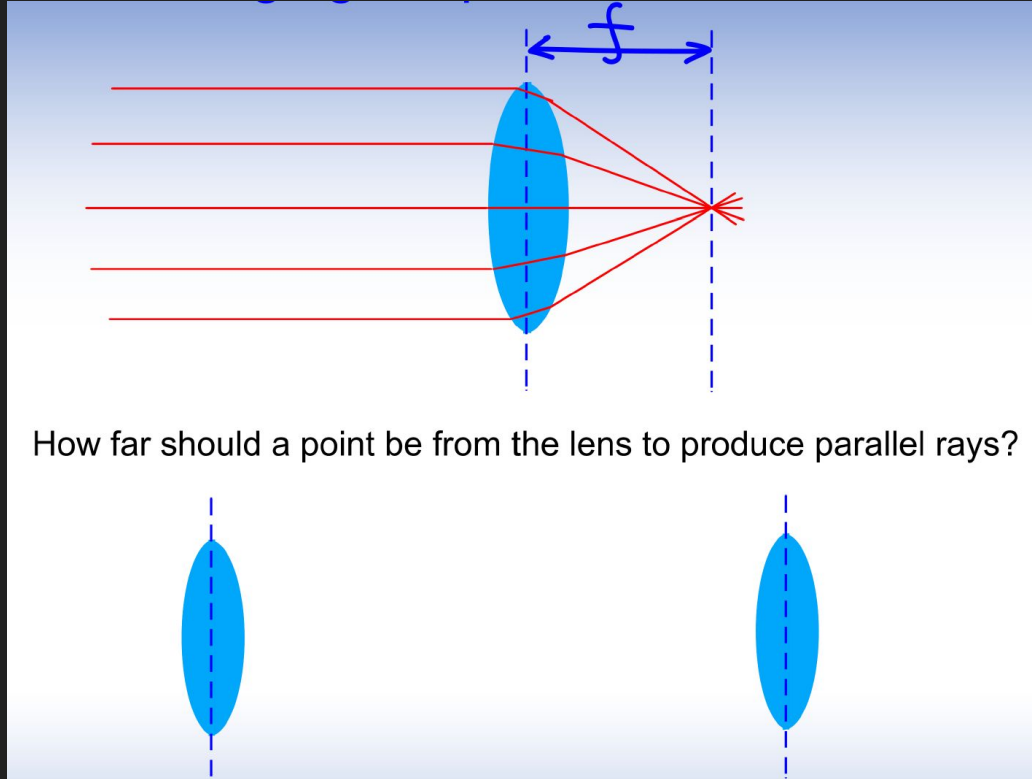
# Optical Power of the Human Eye



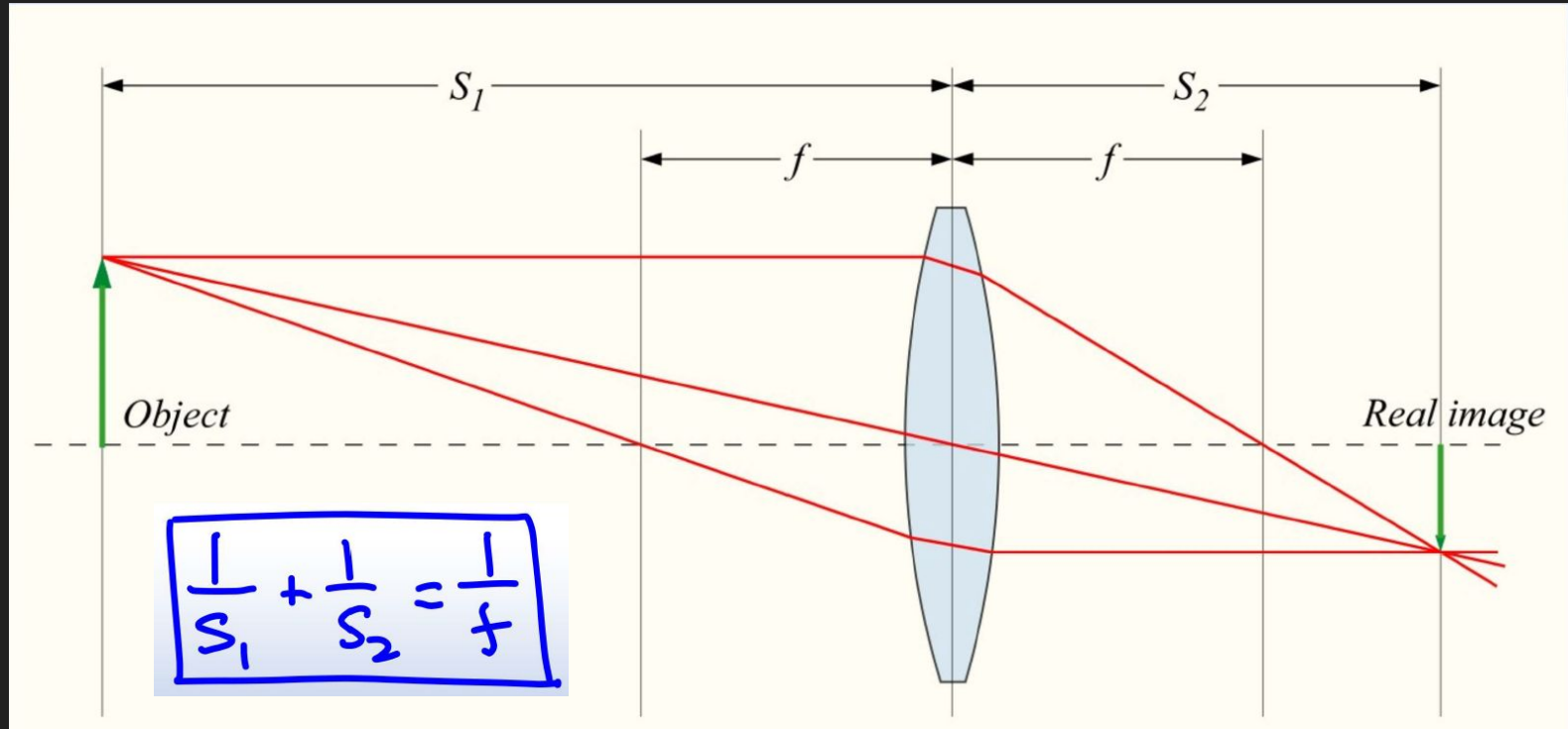
1.  $n_1 = 1.009$  (air)
2.  $n_2 = 1.376$  (cornea)
3.  $n_3 = 1.336$  (aqueous fluid)
4.  $n_4 = 1.413$  (lens)
5.  $n_5 = 1.337$  (vitreous fluid)

Figure 4.25: A ray of light travels through five media before hitting the retina. The indices of refraction are indicated. Considering Snell's law, the greatest bending occurs due to the transition from air to the cornea. Note that once the ray enters the eye, it passes through only liquid or solid materials.

# Imaging Properties of a Lens

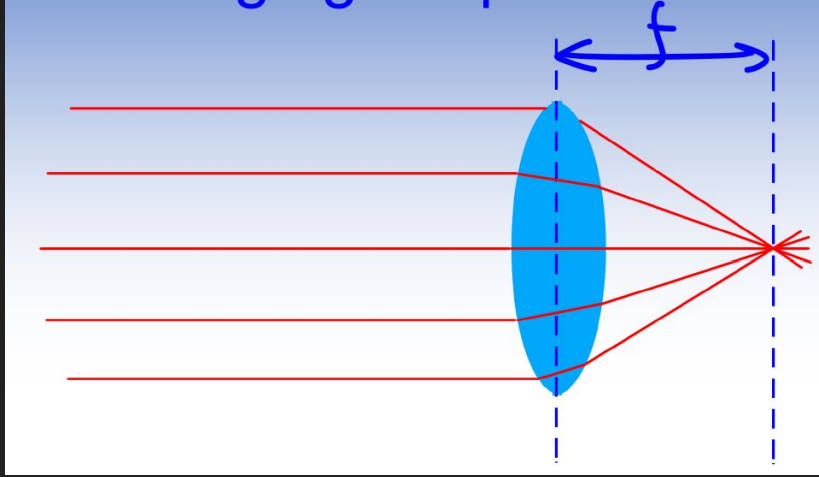


$$S_1, S_2, f > 0$$

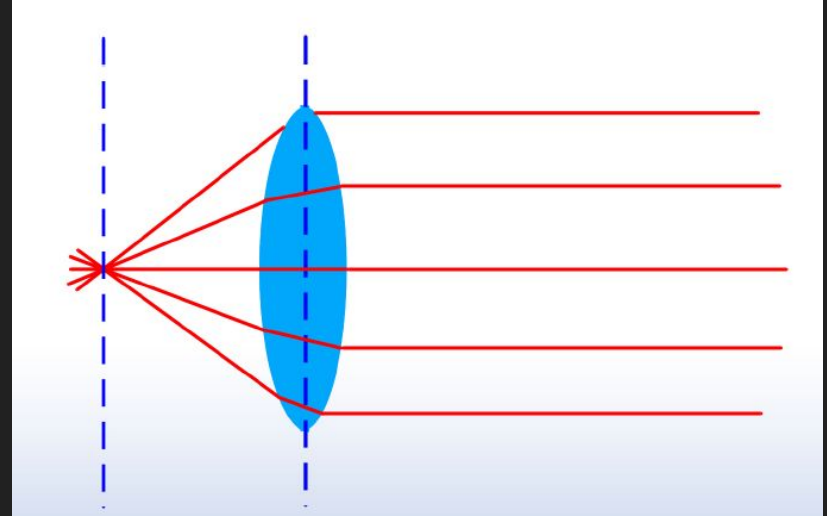




# Imaging Properties of a Lens

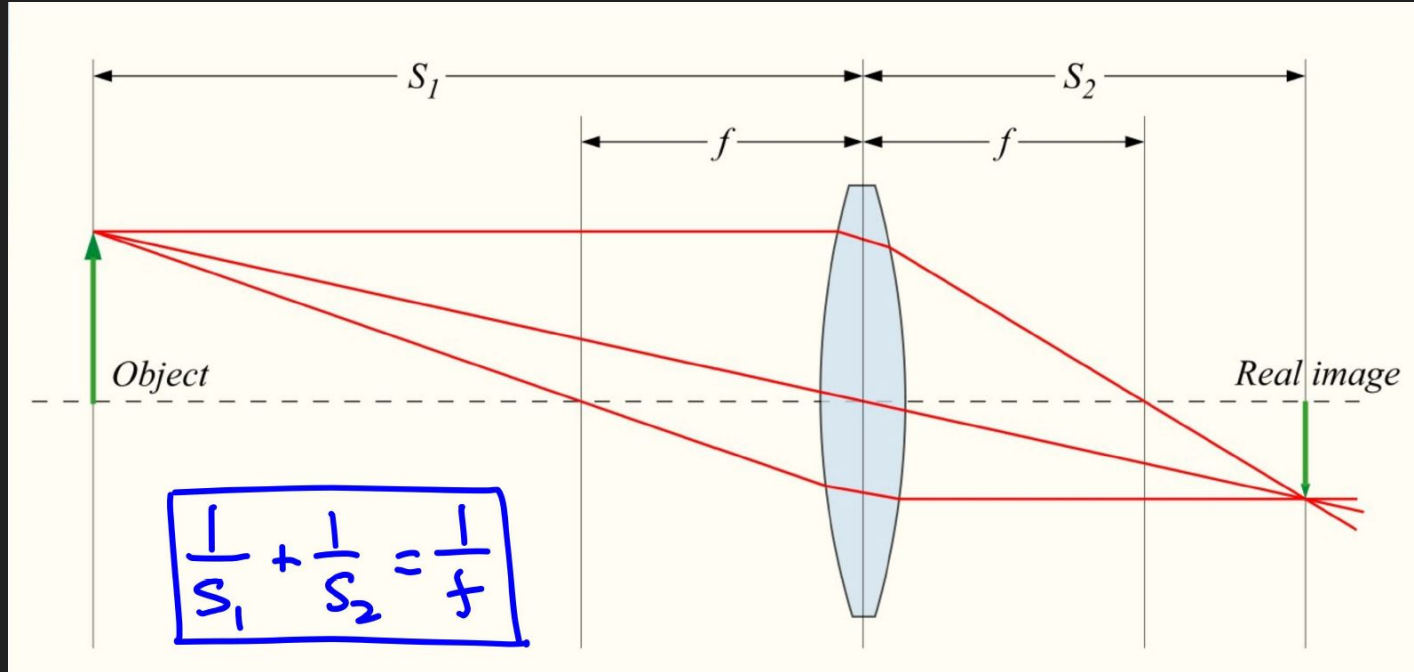


$$\frac{1}{s_1} + \frac{1}{s_2} = \frac{1}{f}$$



Do the formula still work for parallel rays?

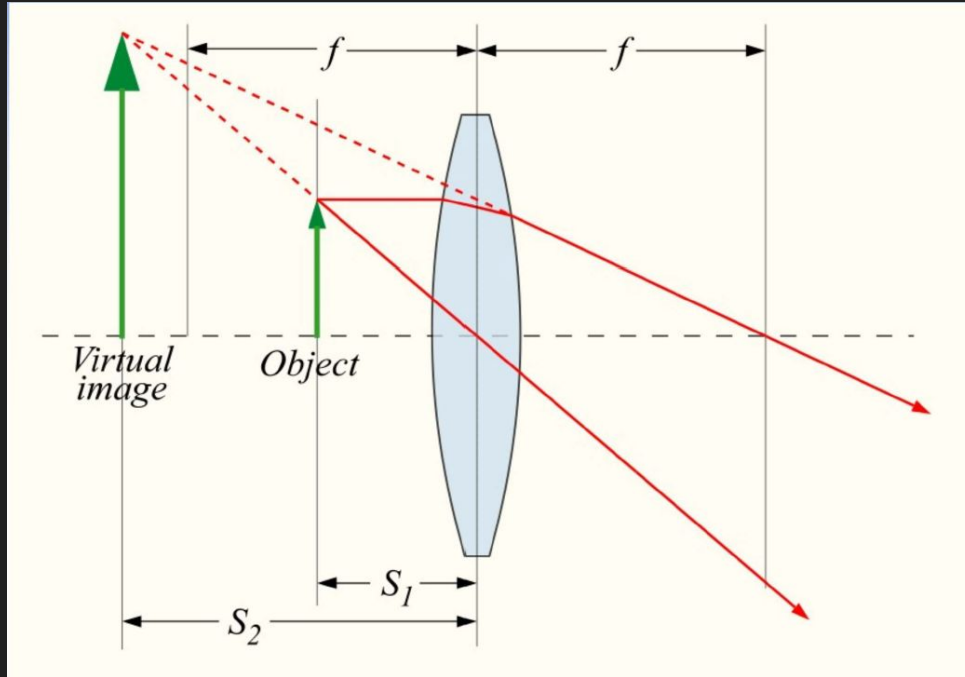
# Imaging Properties of a Lens



Object is at distance \_\_\_\_  $f$ , its “real image” is in focus at distance \_\_\_\_  $f$ .

# Imaging Properties of a Lens

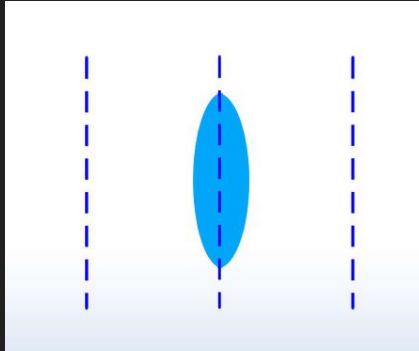
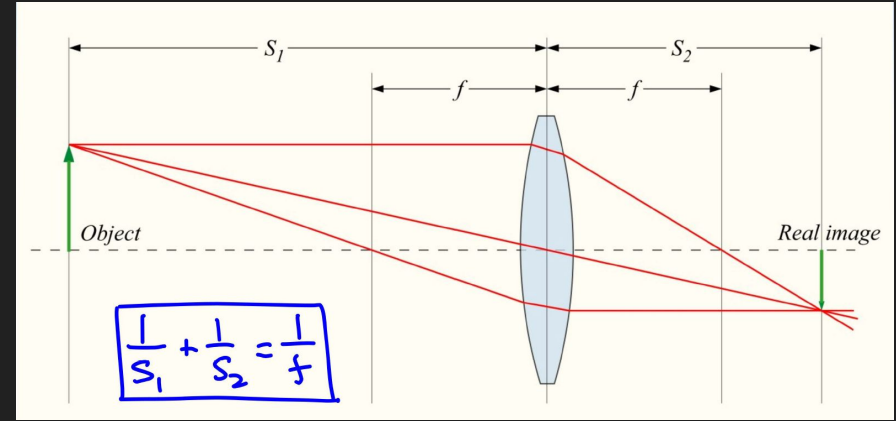
$$\frac{1}{s_1} + \frac{1}{s_2} = \frac{1}{f}$$



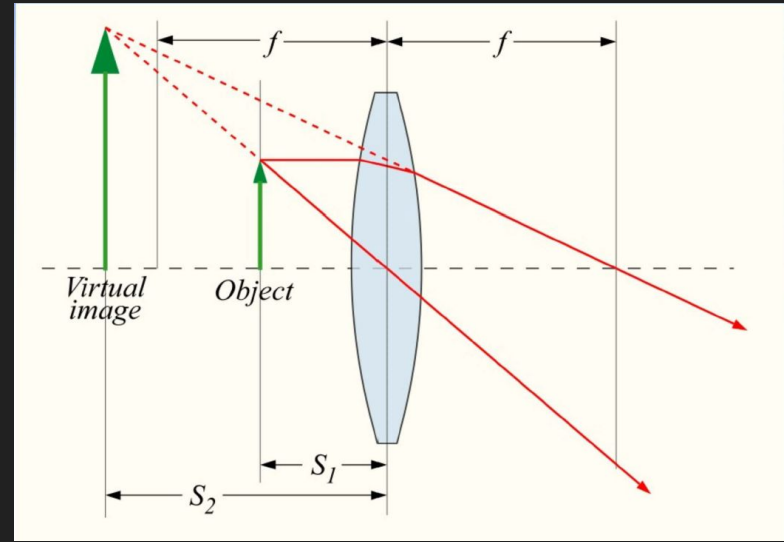
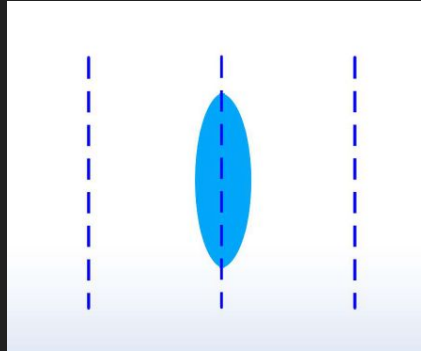
Object is at distance \_\_\_\_\_  $f$ , its  
“real image” is \_\_\_\_\_ focus.

The “virtual image” is formed at  
distance \_\_\_\_\_.

# Examples of Use Cases



# Examples of Use Cases



# Structure of the Human Eye

The diopter of the human eye is about \_\_\_\_\_.

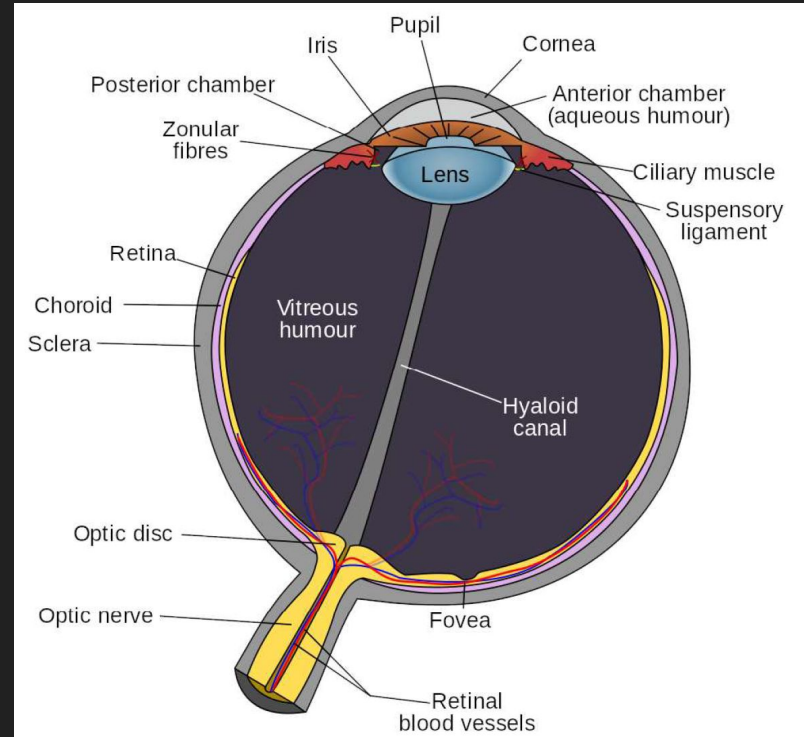
Eye lens is not \_\_\_\_\_.

Retina (and retinal image) is not \_\_\_\_\_.

Ciliary muscle has the ability \_\_\_\_\_  
\_\_\_\_\_ (lose at age  $\approx 40$ ).

Optic nerve forms \_\_\_\_\_.

Assume the person has no vision defect.



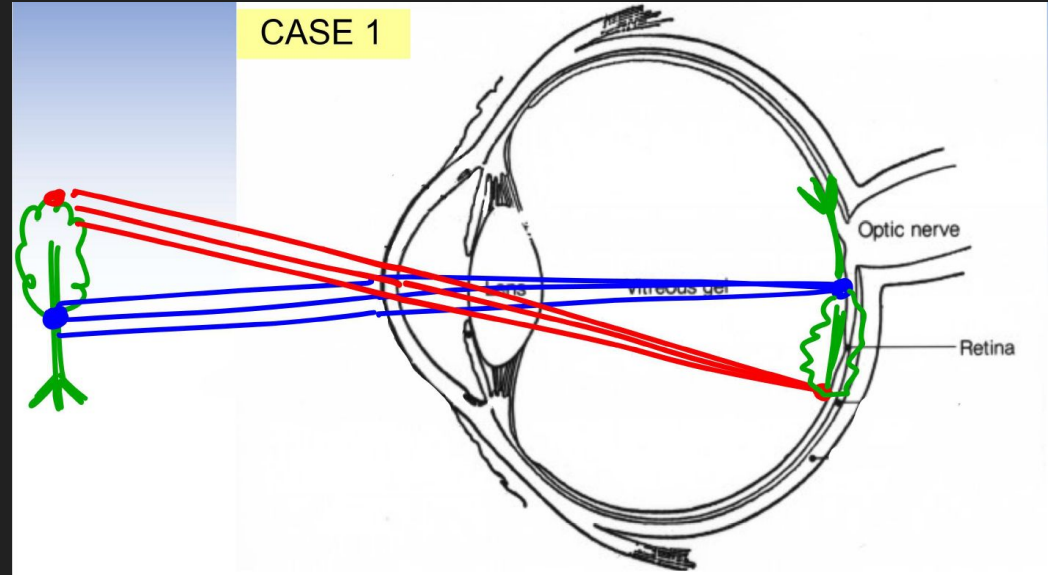
# Imaging System Inside of a Human Eye

The eye muscle is \_\_\_\_\_.

Object is at \_\_\_\_ Rays are \_\_\_\_\_

Rays \_\_\_\_ get converged \_\_\_\_ retina.

The image is \_\_\_\_\_.



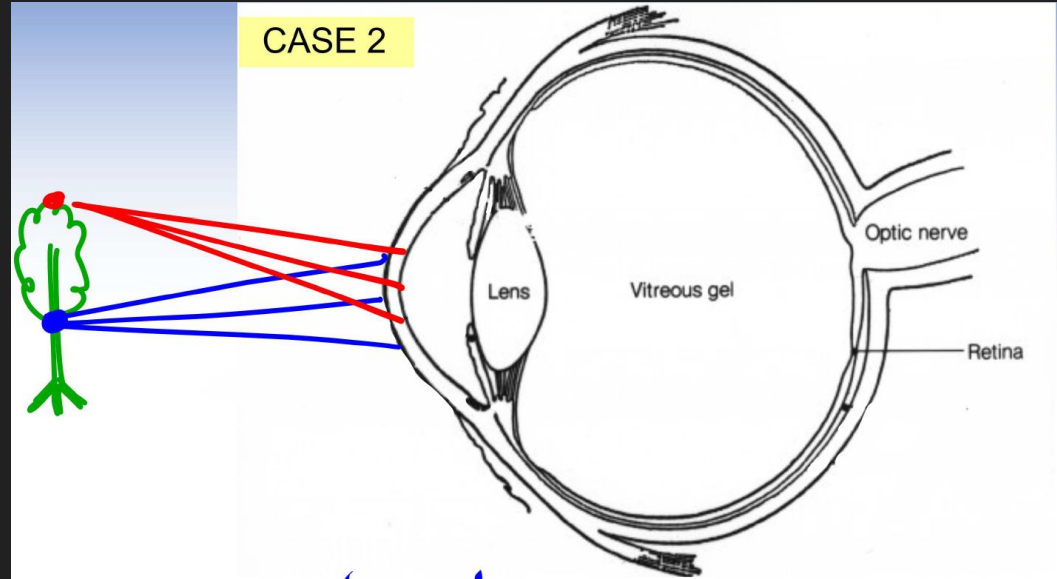
# Imaging System Inside of a Human Eye

The eye muscle is \_\_\_\_\_.

Object is at \_\_\_\_\_ Rays are \_\_\_\_\_.

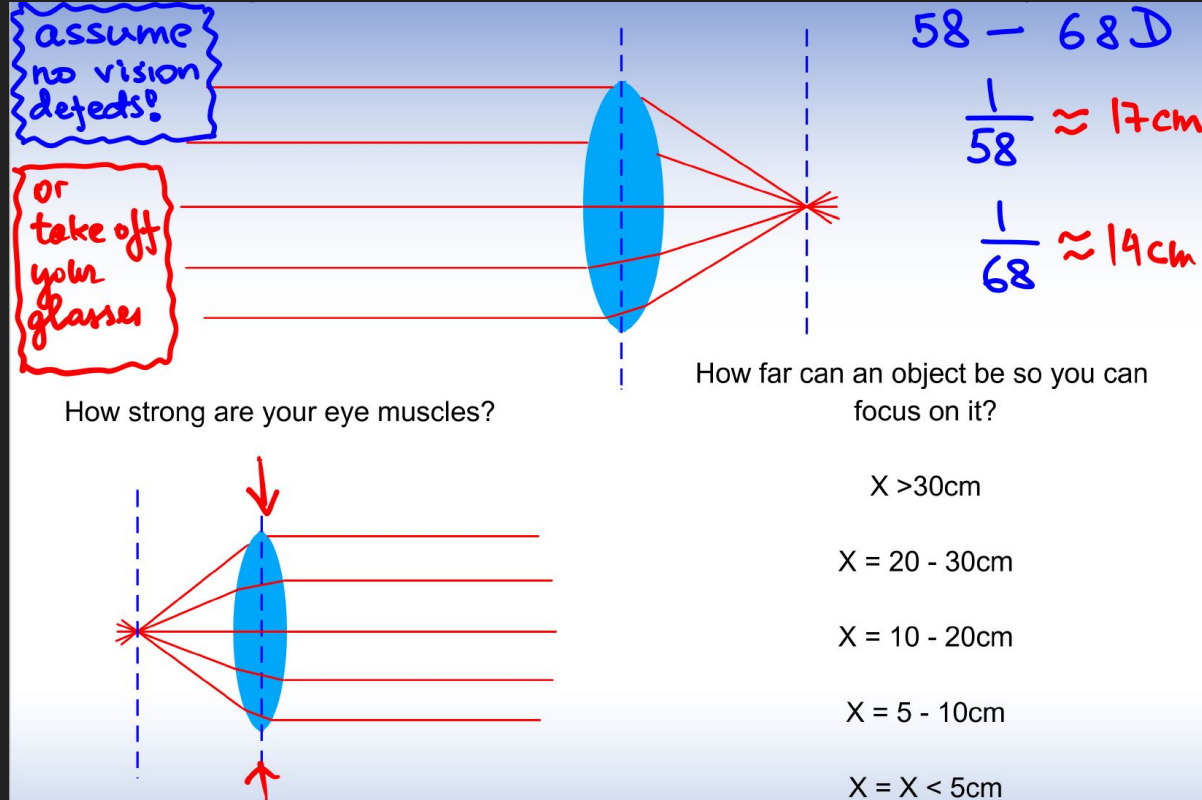
The rays \_\_\_\_\_ get converged on retina.

The image is \_\_\_\_\_.





# Imagine Properties of the Human Eye



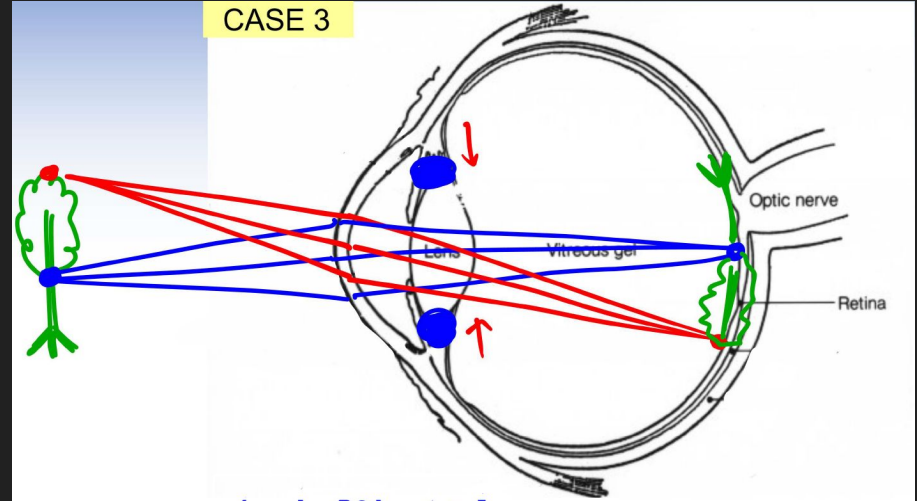
# Imaging System Inside of a Human Eye

The eye muscle is \_\_\_\_\_.

Object is at \_\_\_\_\_ Rays are \_\_\_\_\_.

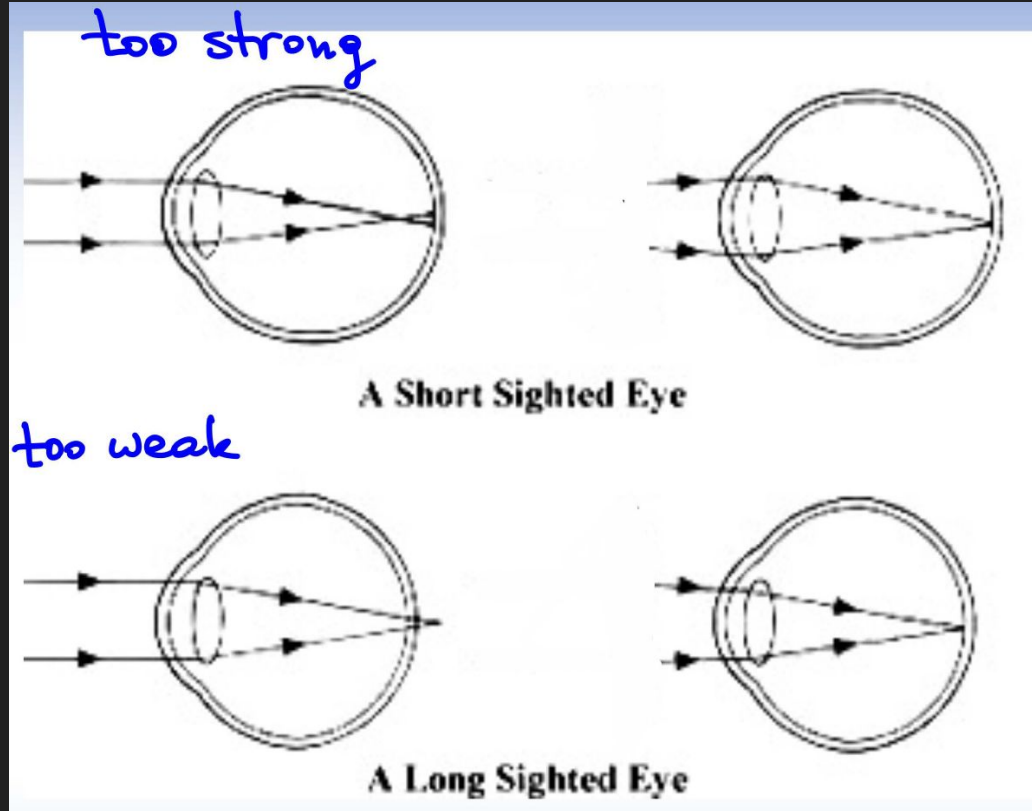
The rays \_\_\_\_\_ get converged \_\_\_\_\_ retina.

The image is \_\_\_\_\_.



# Vision Defects of a Human Eye

- Relaxed muscles
- Objects at infinity



Hard to diagnose

# Imaging System Inside of a Human Eye

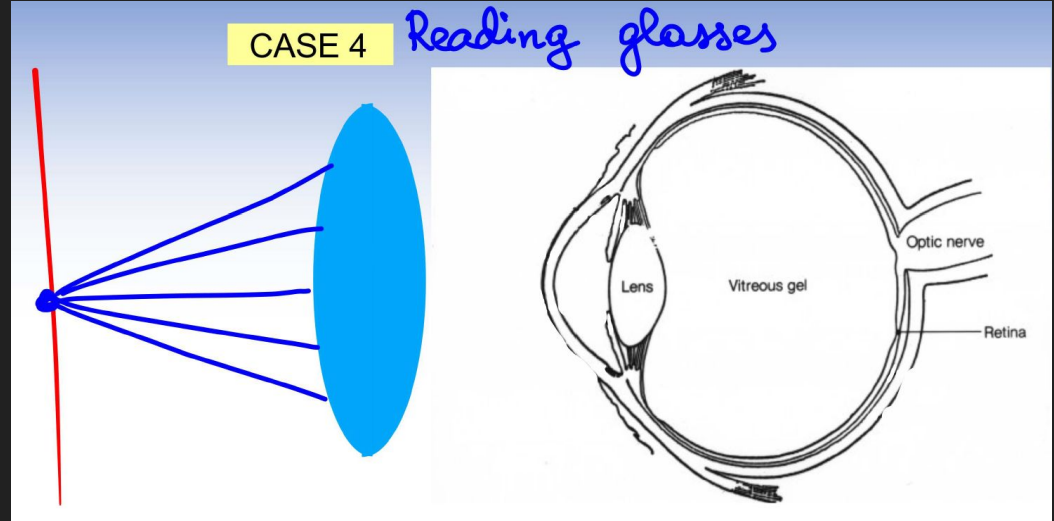
The eye muscle is \_\_\_\_\_.

Object is at \_\_\_\_\_.

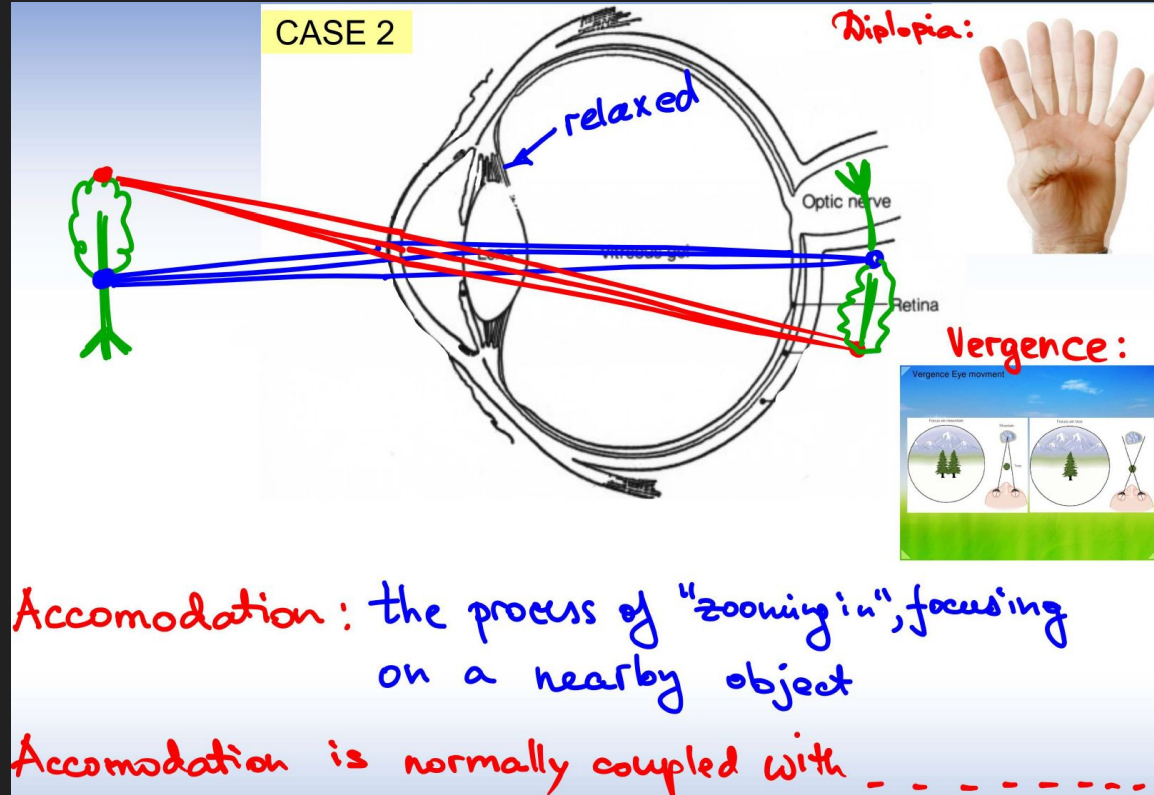
Rays are \_\_\_\_\_.

The rays \_\_\_\_\_ get converged  
\_\_\_\_\_ retina.

The image is \_\_\_\_\_.



# Imaging System Inside of a Human Eye



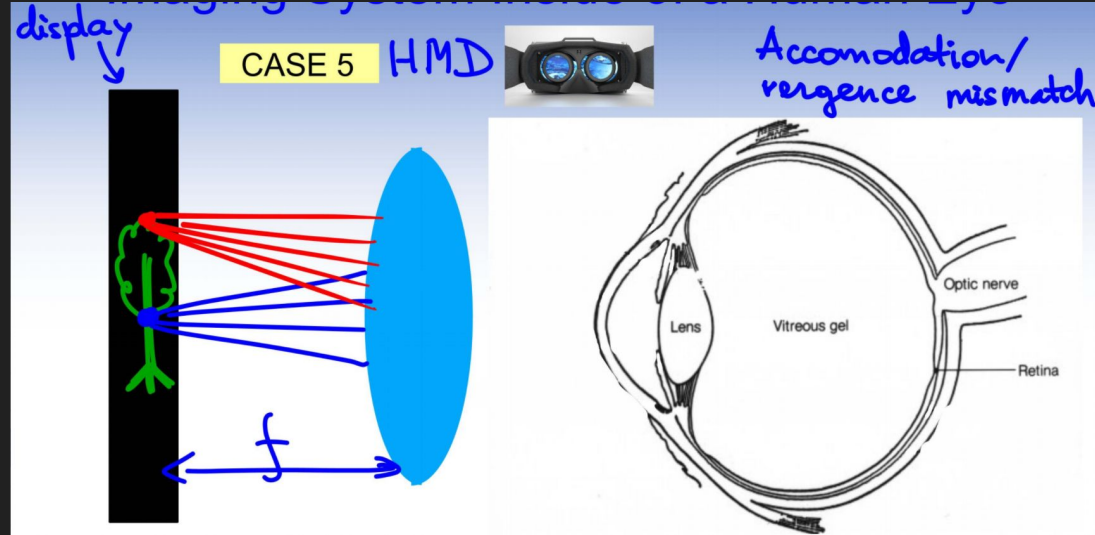
# Imaging System Inside of a Human Eye

The eye muscle is \_\_\_\_\_.

Object is at \_\_\_\_\_ Rays  
are \_\_\_\_\_.

Rays \_\_\_\_\_ get converged

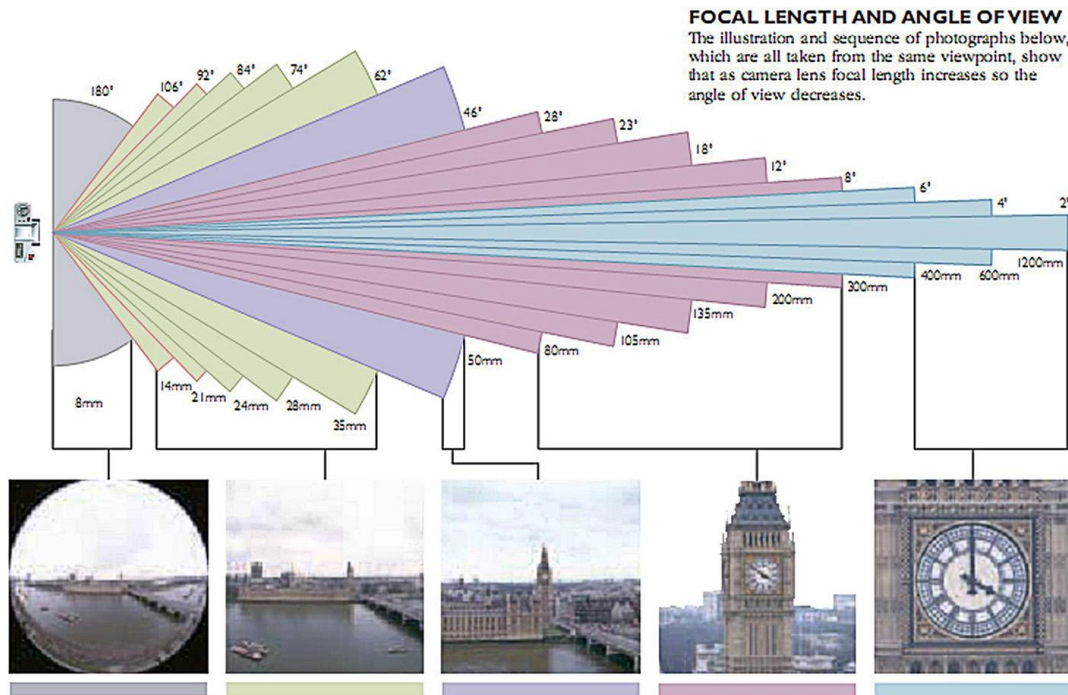
\_\_\_\_\_ retina.



# Lens Aberrations

Trade off:

- Size
- Weight
- Focus length
- Field of view
- Distortion
- Cost
- Ease of manufacturing



## **Fisheye lens**

Extreme wide-angle lenses of 6–8mm are known as fisheyes. They record a circular image of at least 180°, with some lenses even looking behind the camera with a 220° angle of view. The resulting image is very distorted, with vertical and horizontal lines bowed.

## **Wide-angle lens**

Wide-angle lenses of 18–35mm have more general applications than fisheye lenses. Angles of view are generous and depth of field at all apertures is extensive. Poor-quality wide-angle lenses may sometimes show some distortion toward the edges of the image.

## **Standard lens**

A standard 50mm lens is fitted on most 35mm SLRs. Useful for most types of subject, it often has a wide maximum aperture, making it good in low light. It does not show the same distortion as a wide or long lens, and its angle of view is similar to that of the human eye.

## **Long-focus lens**

Angles of view of long-focus lenses of 80–400mm start to diminish rapidly. With so little of the scene filling the frame, the subject is shown very large, making a long lens ideal for distant subjects or detailed close-ups. Depth of field decreases as the lens gets longer.

## **Extreme long-focus lens**

Focal lengths above 400mm are specialized and are not usually found on standard zooms. The use of a tripod to support the lens is essential because of its relatively heavy weight. A long lens has a shallow depth of field and a small maximum aperture.

# Recap from today lecture

- How does an image appear on the retina?
  - Is it a real image or virtual image?
- Is the human eye a concave or convex lens?
  - After light rays pass through a convex lens, what does the focus distance depend on?



# Announcements

- MP 2.2-2.4 was due before this lecture!
- MP 3 & 4 are posted!
- Teams for final projects are posted!
- Details for the 4th credit hour assignment are posted!

- Read Ch. 4 & 5.1

