Optical Devices, The eye and defect of visions

Optical Devices

- ✓ Magnifier and compound microscope are most popular optical devices that extend human vision.

Angular Magnification (magnifying power) M_a

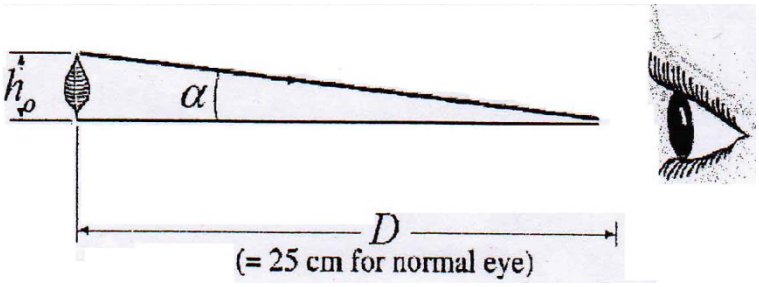
- ✓ The angular magnification of an optical device is defined as the ratio of the angle subtended at the eye by the image, β to the angle subtended at the eye by the object (without lens), α.

$$M_a = \frac{\beta}{\alpha}$$

- ✓ In order to determine the angle α it is necessary to specify the position of the object.
- ✓ Near point is defined as the nearest point to the eye is 25 cm and is known as distance of distinct vision (D).

Magnifier

- ✓ It is known as **magnifying glass** or **simple microscope**.
- ✓ It is an optical device used for viewing object.
- ✓ It is consists of single converging (biconvex) lens.
- ✓ Suppose a leaf is viewed at near point of the human eye as shown in figure below.

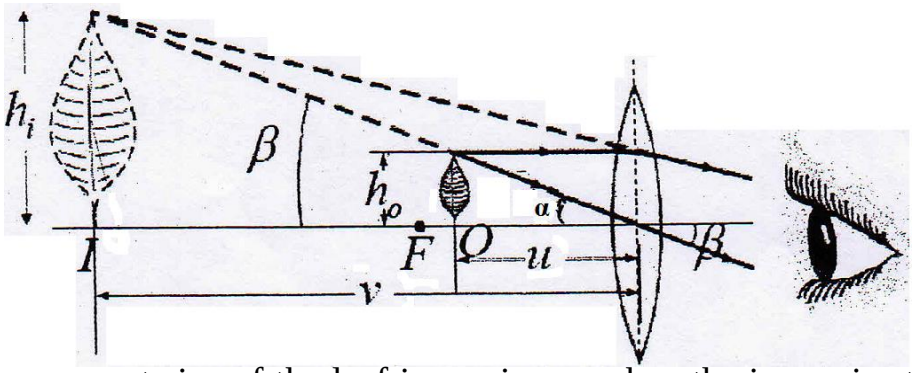


From this figure, $\tan\alpha = \frac{h_o}{D}$

By making small angle approximation, we get

$$\tan\alpha \approx \alpha = \frac{h_o}{D}$$

✓ To increase the apparent size of the leaf, a converging lens can be placed in front of the eye as shown in figure below,



The apparent size of the leaf is maximum when the image is at the near point where

$$v = -D = -25\ cm$$

From the figure above,

$$\tan\beta = \frac{h_i}{D} = \frac{h_o}{u}$$

By making small angle approximation, we get

$$\tan\beta \approx \beta = \frac{h_i}{D} = \frac{h_o}{u}$$

The properties of the image are:

Virtual, **upright** and **magnified** ⟷ $u < f$

➢ The angular magnification in terms of D and f can be evaluated by derivation below

By applying the thin lens formula,

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{Where } v = -D$$

$$u = \frac{Df}{D+f} \text{ ------- (1)}$$

From the definition of angular magnification,

$$M_a = \frac{\beta}{\alpha} = \frac{\left(\frac{h_o}{u}\right)}{\left(\frac{h_o}{D}\right)}$$

$$M_a = \frac{D}{u} \text{ ------- (2)}$$

By substituting eq. (1) into eq. (2), thus

$$\boxed{M_a = \frac{D}{f} + 1}$$

Where:

f: focal length.

D: distance of distinct vision = 25 cm.

- The relationship between linear magnification, M with angular magnification, M_a

  From the definition of angular magnification,

$$M_a = \frac{\beta}{\alpha} = \frac{\left(\frac{h_i}{D}\right)}{\left(\frac{h_o}{D}\right)}$$

  then

$$M_a = \frac{h_i}{h_o} = M$$

- **Note:**

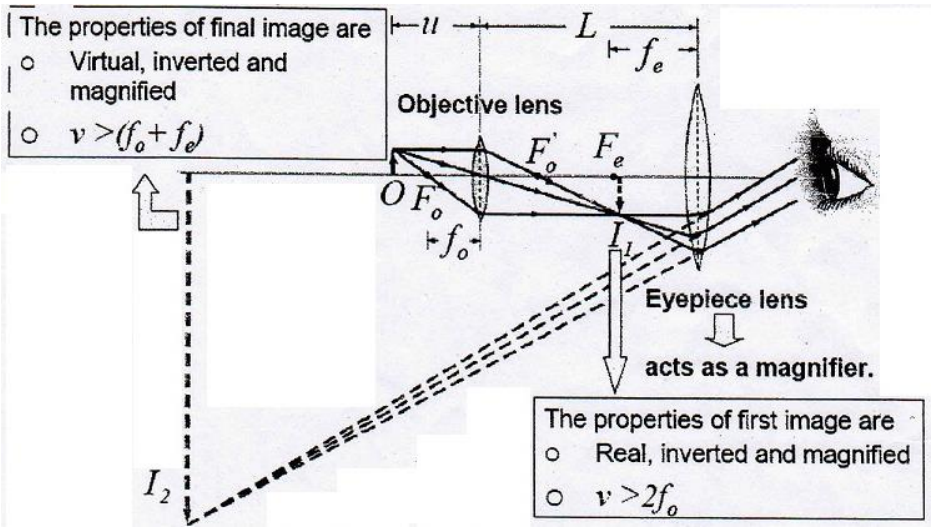
  If the object placed at the focal point of the converging lens, the image formed at infinity. Thus

$$\beta = \frac{h_o}{f}$$

Therefore, since $M_a = \frac{\beta}{\alpha}$ then $M_a = \frac{\left(\frac{h_o}{f}\right)}{\left(\frac{h_o}{D}\right)} \Longrightarrow \boxed{M_a = \frac{D}{f}}$

Compound Microscope

- ✓ Because it makes use of two lenses, the magnifying power of the compound microscope is much greater than that of the magnifier.
- ✓ The tow lenses are converging lens and is known as objective lens (close to object) and eyepiece (close to the eye).
- ✓ The figure below shows the diagram of the compound microscope.



- The angular magnification formula is given by

$$M_a = -\frac{L}{f_o}\left[\frac{D}{f_e}\right]$$

Where:

f_e: focal length of the eyepiece lens.

f_o: focal length of the objective lens.

D: distance of distinct vision = 25 cm.

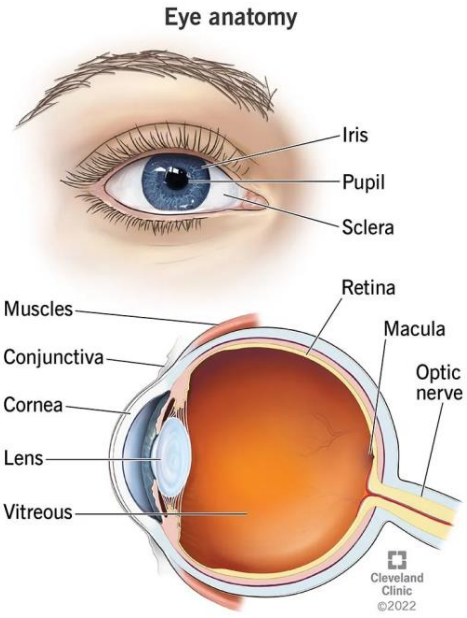
- The negative sign indicates that the image is inverted.
- It is used for viewing small objects that are very close to the objective lens.

Human Eyes

Eyes are organs of the visual system. They provide living organisms with vision, the ability to receive and process visual detail, as well as enabling several photo response functions that are independent of vision. Eyes detect light and convert it into electro-chemical impulses in neurons (neurones).

What are the parts of the eye?

- **Cornea:** is the clear outer part of the eye's focusing system located at the front of the eye.
- **Iris:** is the colored part of the eye that regulates the amount of light entering the eye.
- **Lens:** is a clear part of the eye behind the iris that helps to focus light, or an image, on the retina.
- **Pupil:** is the black circle which is an opening or window in the middle of your iris. It expands and contracts to control the light gets into your eye.
- **Sclera:** is the white parts of your eye that surround the iris.
- **Conjunctiva:** a clear, thin tissue that covers the sclera and lines the inside of your eyelids.
- **Retina:** a collection of cells that line the inside of the back of your eye. Part of your nervous system, the retinas sense light and convert it into electrical impulses or neural signals.
- **Optic nerve:** which is behind the retina it carries signals from the retina to your brain which then interprets that visual information to tell you what you are seeing.
- **Muscles,** which control your eye's position and movement, how much light gets into your eye and your eyes' ability to focus
- **Vitreous,** a transparent gel that fills your entire eye. It protects and maintains the shape of the eye.



How do your eyes work?

The different parts of your eye work together to help you see images and send visual information to your brain. This process all happens extremely quickly. When you look at an object:

1. Light enters your eye through the cornea and goes to your lens. Your pupil gets bigger and smaller to control the amount of light that gets into your eye.
2. Your cornea and lens refract (bend) the light to bring what you're seeing into focus.
3. Light reaches the retina at the back of your eye, and the retina changes the images into electrical impulses or signals.
4. The optic nerve transfers these signals to the part of your brain that's responsible for vision (visual cortex). The optic nerve carries signals from both eyes at once.
5. Your brain interprets what you've seen. It combines the visual information from both eyes and brings it all together into one clear image.

Defects of vision and their correction

Defects in the eye happen due to many reasons. Due to growing age, the vision also decreases, and when the focal length alters, the vision also alters. We know that cataract is a common defect seen in the eye. Cataracts cause partial or sometimes complete vision loss when not treated properly. When the crystalline lens at old age becomes milky and cloudy, it is known as a cataract. When a person undergoes cataract surgery, the vision can be restored.

When the eye loses its ability to adjust its focal length, problems appear like a person cannot see the image correctly (blurring of vision), unable to view nearby objects or far away objects. When the defect in the refractive index occurs, the person cannot see the objects comfortably and distinctly. If not taken timely care of, the eyes might completely lose the power of accommodation. In this article, let us learn about various vision defects and their correction.

Some of the common defects of vision are:

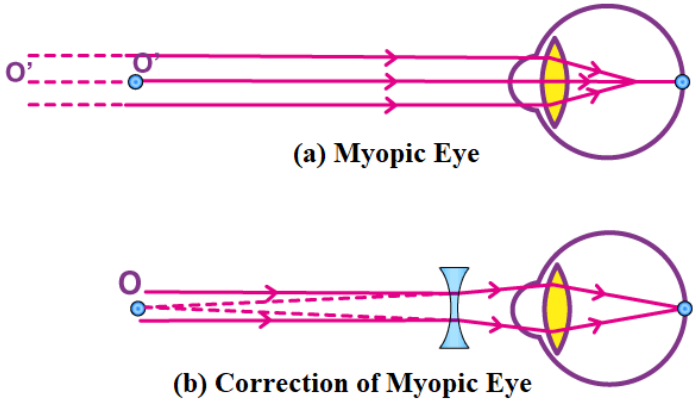
(i) Myopia or near-sightedness

(ii) Hypermetropia or far-sightedness

(iii) Astigmatism

(i) Myopia or Near-Sightedness

Myopia is commonly known as near-sightedness. In this condition, the person can see the objects nearby but cannot see distant objects clearly. Faraway objects appear blurry, and a person will not be comfortable seeing them. Myopia condition takes place when the shape of the eyes leads the light rays to bend in a wrong way, focusing images in front of the retina rather than focusing on the retina. Myopia is explained in the figure below.



(a) Myopic Eye

(b) Correction of Myopic Eye

Symptoms:

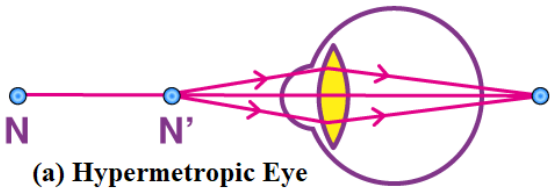
- Blurry vision.
- Difficulty in seeing while driving, particularly during night times.
- Headaches due to eyestrain.

Correction: When a concave lens of suitable power is used, it assists in focusing the image onto the retina.

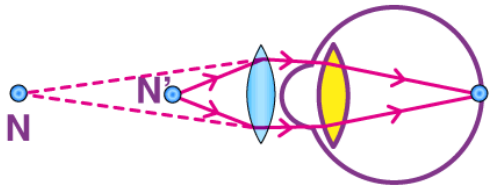
(ii) Hypermetropia or Far-Sightedness

Hypermetropia is commonly known as far-sightedness. In this condition, the person can see objects at a distance but cannot see nearby objects clearly. Usually, the person with this disorder squints to see nearby objects. Hypermetropia is caused when the light rays from a close by object are focused

at a point behind the retina. The condition of hypermetropia is clearly explained in the figure below.



(a) Hypermetropic Eye



(b) Correction of Hypermetropic Eye

Symptoms:

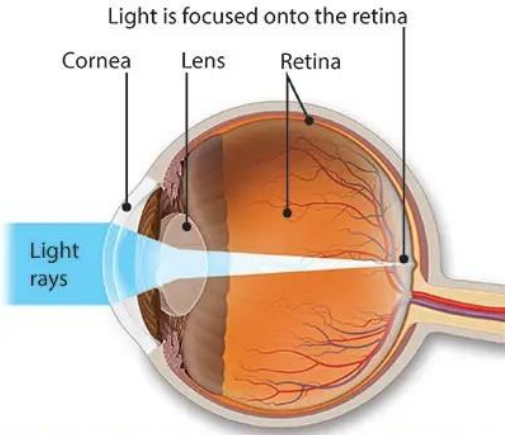
- Blurry vision.
- Headaches due to eyestrain.
- Squinting.

Correction: Using spectacles with a converging lens imparts additional focusing power and thus helps form the image on the retina.

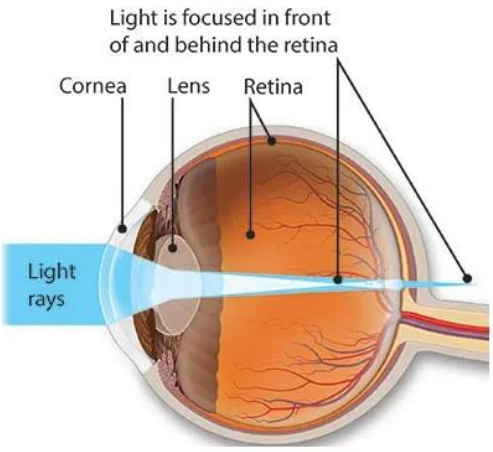
(iii) Astigmatism

Is a common eye problem that can make your vision blurry or distorted. It happens when your cornea or lens has a different shape than normal. To understand astigmatism, it is helpful to think of the normal eye as evenly rounded, like a basketball. With astigmatism, the eye is egg- or oval-shaped like an American football. There are two basic types of astigmatism: horizontal astigmatism (when the eye is wider than it is tall), and vertical astigmatism (when the eye is taller than it is wide). With either type of astigmatism, near and far vision is blurry because of the eye's irregular shape.

One of the primary differences between myopia and astigmatism is the vision problems they can cause. Myopia by itself typically only affects a person's distance vision. In contrast, astigmatism may affect near and distant vision, depending on its shape. People can also get astigmatism from eye disease, eye injury or after surgery.



In a normal eye, the cornea and lens focus light rays on the retina.



In astigmatism, images focus infront of and beyond the retina

How is Astigmatism corrected?

- Eyeglasses or contact lenses: They work by refocusing light on the retina in the back of your eye so that you can see more clearly.
- Refractive surgery: With Lasik and other procedures, a laser reshapes the cornea to adjust how light travels through it.

➢ **Home works about lecture 7:**

Q1: It happens when your cornea or lens has a different shape than normal.
(a) Myopia, (b) Hypermetropia, (c) Astigmatism, (d) none of them
Q2: The person can see objects at a distance but cannot see nearby objects clearly.
(a) Hypermetropia, (b) Astigmatism, (c) Myopia, (d) none of them
Q3: The person can see the objects nearby but cannot see distant objects clearly.
(a) Astigmatism, (b) Myopia, (c) Hypermetropia, (d) none of them
Q4: The colored part of the eye that regulates the amount of light entering the eye.
(a) Lens, (b) Cornea (c) Pupil, (d) Iris
Q5: A clear part of the eye behind the iris that helps to focus light.
(a) Cornea (b) Lens (c) Iris (d) Pupil