Geometric Optics

[اكتب العنوان الفرعي للمستند]

Lecturer. Dr. Thill Akeel Kadhum Almusawi

2023-2024

Optics V

Defects of Version and Their Correction

The focal point can be defined as the point where light rays or waves meet after they have been reflected or refracted at the iris.

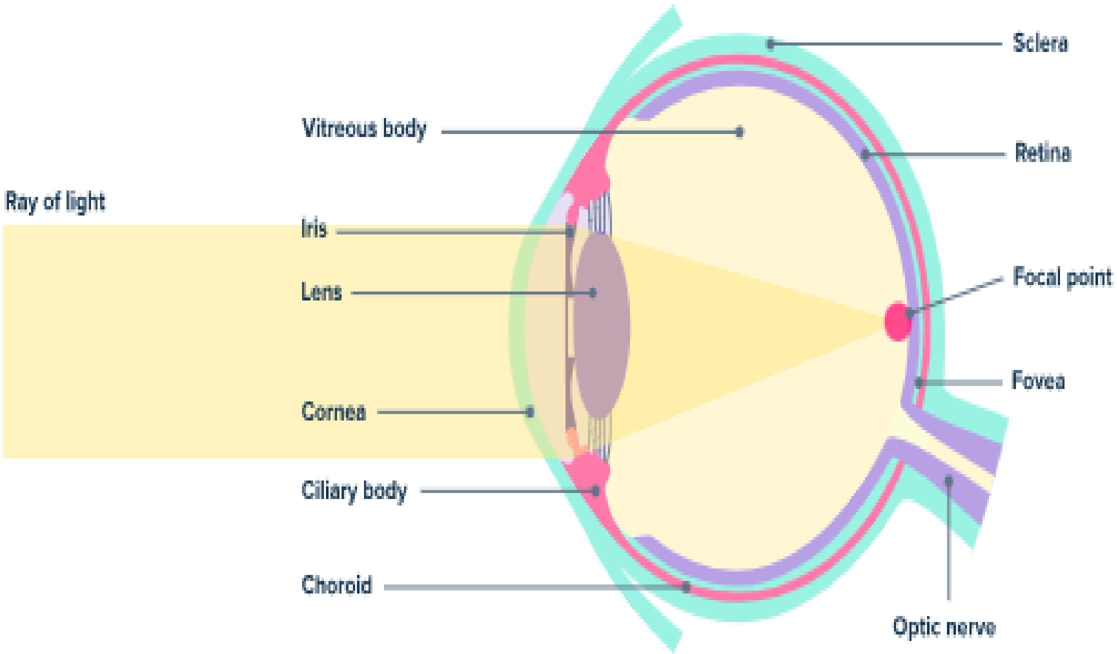


Fig. (40): Diagram of vision without any defects.

There are mainly four common refractive defects of vision. These are
i) Nearsightedness (Myopia).
ii) Farsightedness (Hypermetropia).
iii) Presbyopia.
iv) Astigmatism.

i) Nearsightedness is a defect of vision that affects a person's ability to see distant objects clearly and a person with myopia can see nearby objects clearly but cannot see distant objects distinctly, aperson with this defect has the far point nearer than infinity. Such a person may see clearly up to a distance of a few meters . In a myopic eye, the image of a distant object is formed in front of the retina and not at the retina itself.

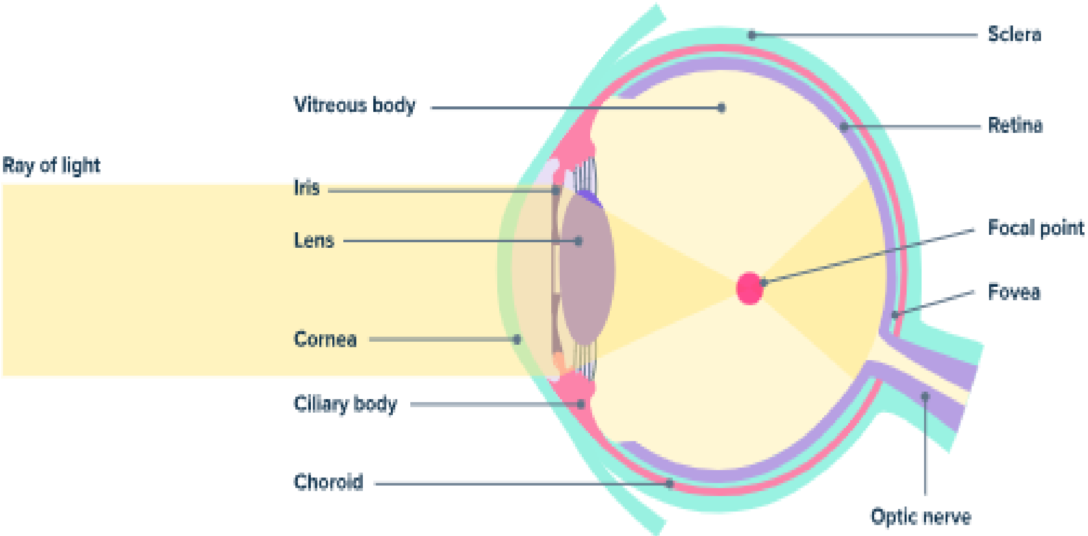


Fig. (41): Human eye with nearsightedness.

Cause of defect

This defect may arise due to:

(i) Excessive curvature of the eye lens.
(ii) Elongation of the eyeball.

Correction of nearsightedness

This defect can be corrected by using a concave lens of suitable power. A concave lens of suitable power will bring the image back on to the retina and thus the defect is corrected.

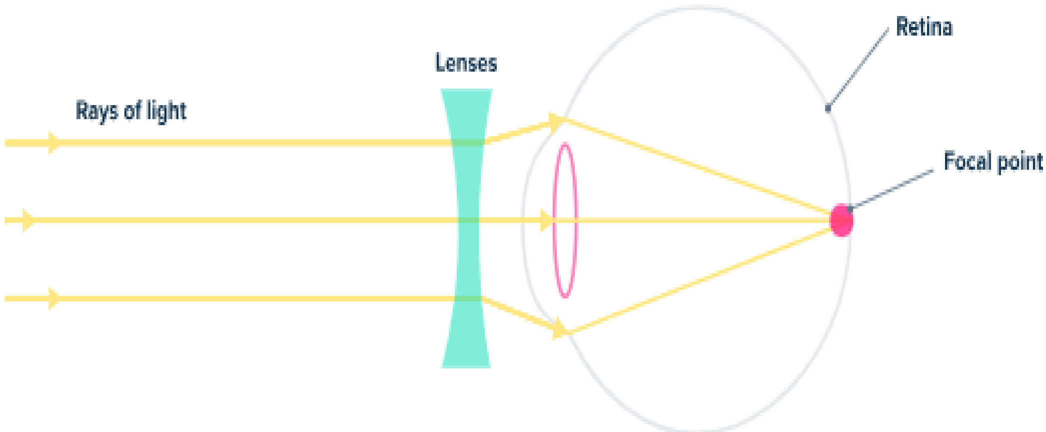


Fig. (42): Correction of human eye with nearsightedness.

ii) <u>Farsightedness</u> is a defect that affects the ability to see nearby objects while still being able to see distant objects clearly. The distant objects that can be seen are usually positioned more than (25 cm) away from the eye.

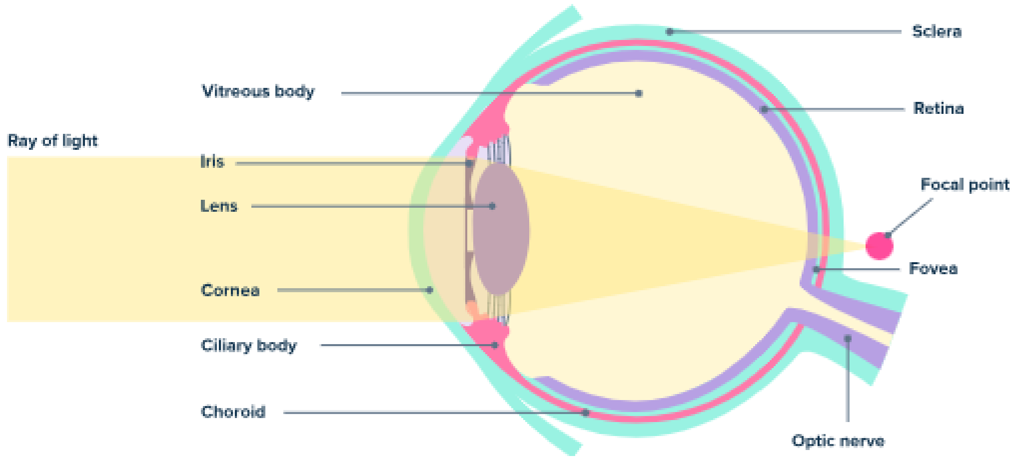


fig. (43): Human eye with farsightedness.

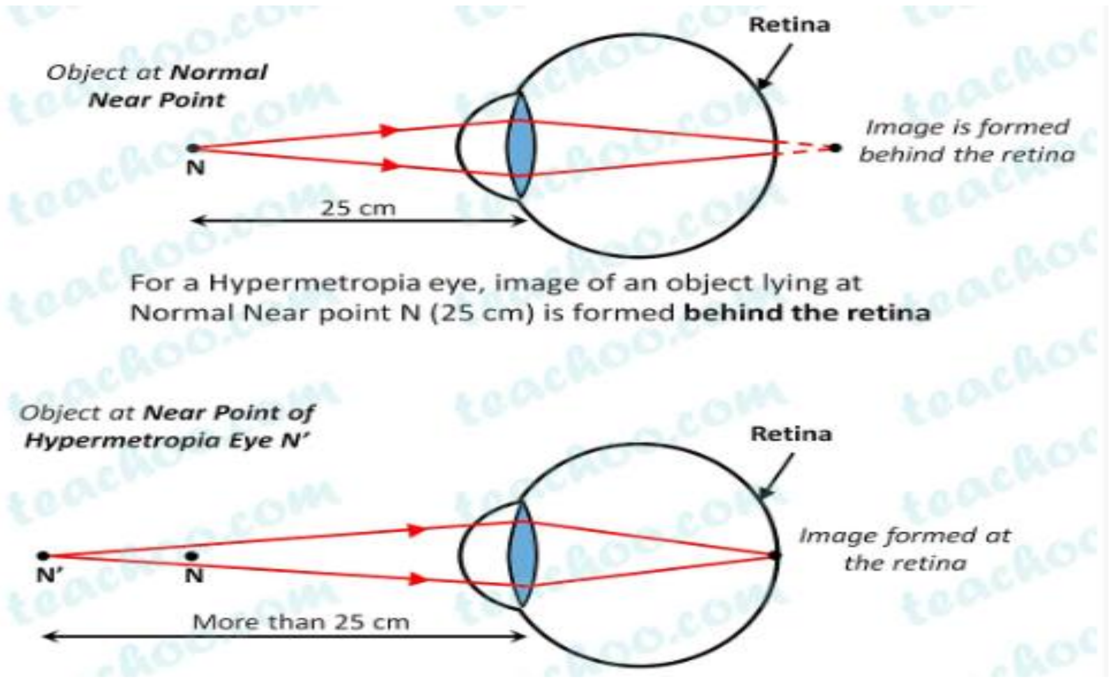
Cause of defect

This defect arises either because

(i) The focal length of the eye lens is too long.
(ii) The eyeball has become too small.

Correction of farsightedness

By using convex lenses, the image is created on the retina instead of behind the retina, as was shown in figure 3. (N) is the normal near point of the eye, which is (25 cm), while (N') is the near point of a farsightedness eye, which is more than (25 cm).



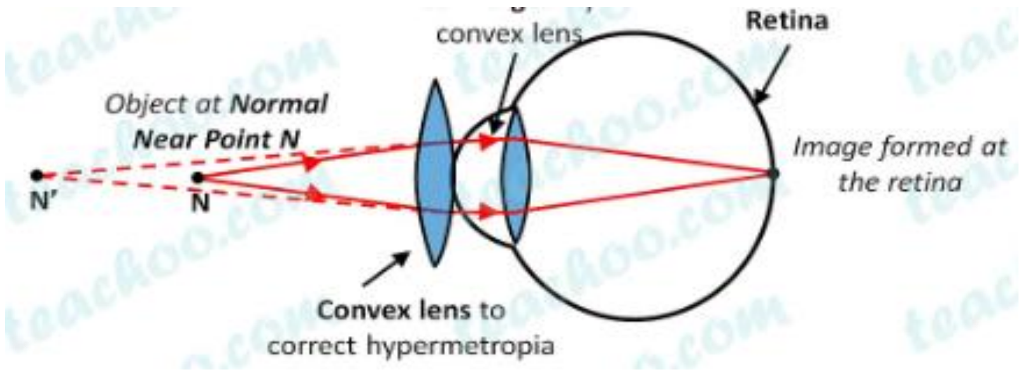


Fig. (44): Correction of human eye with farsightedness.

iii) Presbyopia is the power of accommodation of the eye usually decreases with ageing. For most people, the near point gradually recedes away. They find it difficult to see nearby objects comfortably and distinctly without corrective eye-glasses. This defect is called presbyopia.

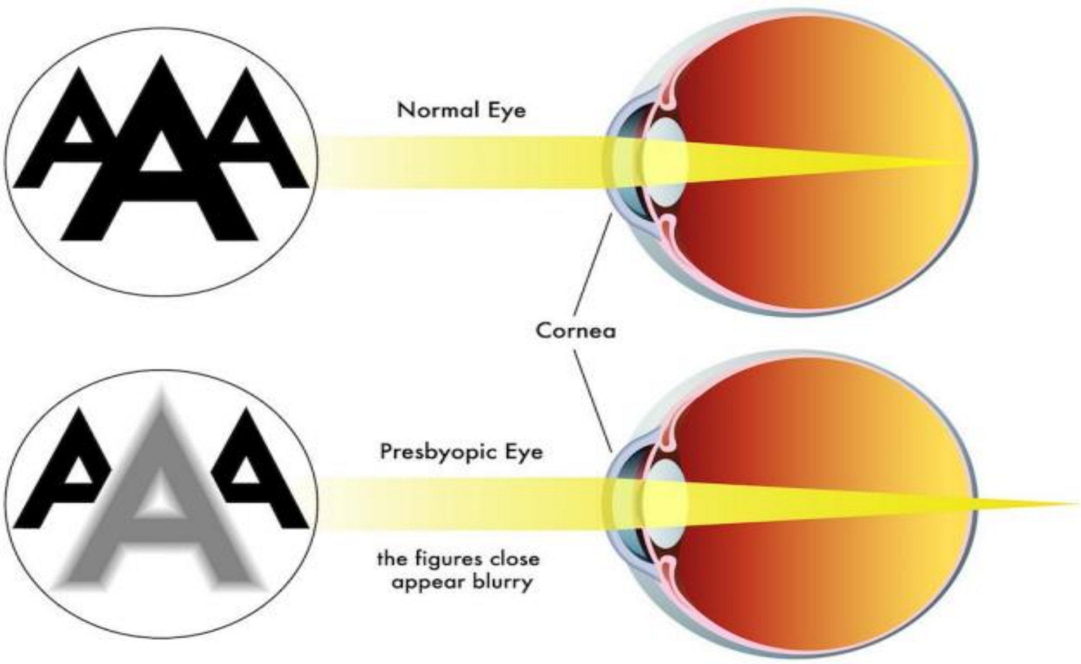


Fig. (45): Human eye with presbyopia.

Cause of defect

It arises due to the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens.

Correction of Presbyopia

Presbyopia defect is corrected in the same way as hypermetropia i.e. by using spectacles having convex lenses.

iv) Astigmatism: The inability of the eye in focusing objects in both horizontal and vertical lines clearly is called astigmatism. Instead of hitting the retina in a focused point, the light is spread over two or more points. The result is a blurry or stretched image.

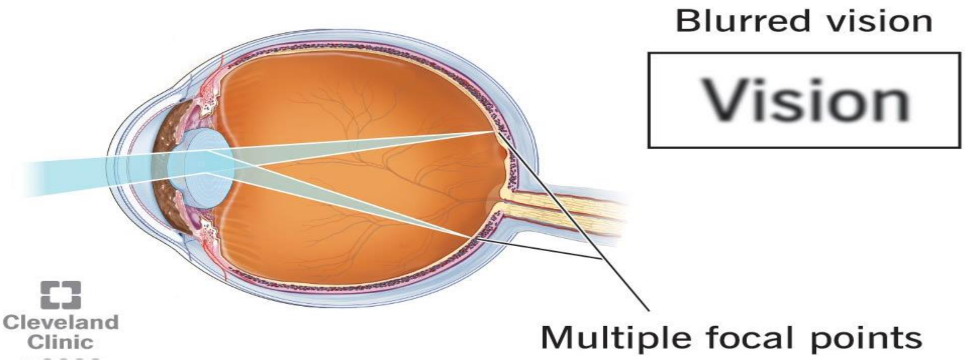


Fig. (46): Human eye with astigmatism.

Cause of defect

This defect is caused due to varying curvature in the eye lens in horizontal and vertical lines.

Correction of Astigmatism

This defect is corrected by using cylindrical lenses.

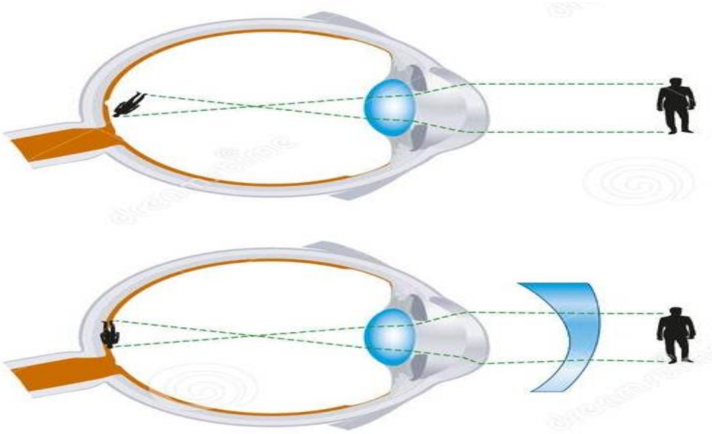


Fig. (57): Correction of human eye with astigmatism.

Examples:

1) Suppose the focal length of a person's eye is (3 cm) when fully relaxed (looking at a distant object). If the person's retina is (3.3 cm) behind the eye lens (a nearsighted eye compared to the normal distance of 3.0 cm), what must be the focal length of the corrective lenses so that this person can see objects at infinity?

Solution:

Using the thin lens equation with (u=∞, v=3.3 cm), we find an effective focal length of (3.3 cm) needed. Because the effective focal length of such a two-lens system (the lens of the eye and the corrective lenses) is:

$$\frac{1}{f_{\text{effective}}} = \frac{1}{f_{\text{lens}}} + \frac{1}{f_{\text{eye}}}$$

$$\frac{1}{f_{\text{lens}}} = \frac{1}{f_{\text{effective}}} + \frac{1}{f_{\text{eye}}} \quad \Longrightarrow f_{\text{lens}} = -33\ cm$$

$$P = \frac{1}{f_{\text{lens}}(m)} = \frac{1}{-0.33(m)} = -3\ D$$

Exercises:

1) What power of spectacle lens is needed to allow a farsighted person, whose near point is (1 m), to see an object, clearly that is (25 cm) away? Assume the spectacle (corrective) lens is held 1.50 cm away from the eye by eyeglass frames.

2) A person needs a lens to correct his distant vision. The lens has a focal length of +18 cm. What is the power of the lens in dioptres?
a. (5.5 D) b. (-5.5 D) c. (1.5 D) d. (-1.5D)

3) People who do very detailed work close up, such as jewelers, often can see objects clearly at much closer distance than the normal (25 cm).
a. What is the power of the eyes of a woman who can see an object clearly at a distance of only (8 cm)?
b. What is the size of an image of a (1 mm) object, such as lettering inside a ring, held at this distance?
c. What would the size of the image be if the object were held at the normal (25 cm) distance?

4) What is the far point of a person whose eyes have a relaxed power of (50.5 D)?

5) A student's eyes, while reading the blackboard, have a power of (51 D). How far is the board from his eyes?

6) What is the angular magnification of a telescope that has a (100 cm) focal length objective and a (2.5 cm) focal length eyepiece?

7) Find the distance between the objective and eyepiece lenses in the telescope in the above problem needed to produce a final image very far from the observer, where vision is most relaxed. Note that a telescope is normally used to view very distant objects.

8) A large reflecting telescope has an objective mirror with a (10 m) radius of curvature. What angular magnification does it produce when a (3 cm) focal length eyepiece is used?

9) A small telescope has a concave mirror with a (2 m) radius of curvature for its objective. Its eyepiece is a (4 cm) focal length lens.
a. What is the telescope's angular magnification?
b. What angle is subtended by a (25,000 km) diameter sunspot?
c. What is the angle of its telescopic image?

10) A 7.5×7.5× binocular produces an angular magnification of −7.50−7.50, acting like a telescope. (Mirrors are used to make the image upright.) If the binoculars have objective lenses with a (75 cm) focal length, what is the focal length of the eyepiece lenses?