L23 Defective Vision And Its Correction

Hypermetropia or long-sight

Occurs when an eye cannot focus on nearby objects. The uncorrected near point of the defective eye is further away than 25 cm.

This is because the eye muscles cannot make the eye lens thick enough to focus an image on the retina of an object 25 cm away. The eye can focus distant objects hence the defect is referred to as 'long-sight'.

The cause of hypermetropia is that light, after passing through the eye lens, does not converge enough to form an image on the retina, as shown in Figure . This happens 1. the eye lens cannot become thick enough to focus light onto the retina or 2. if the eyeball is too short.

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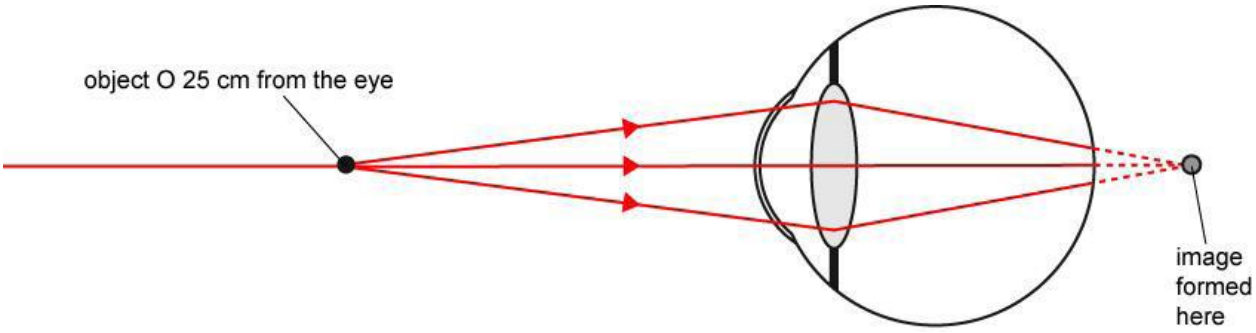
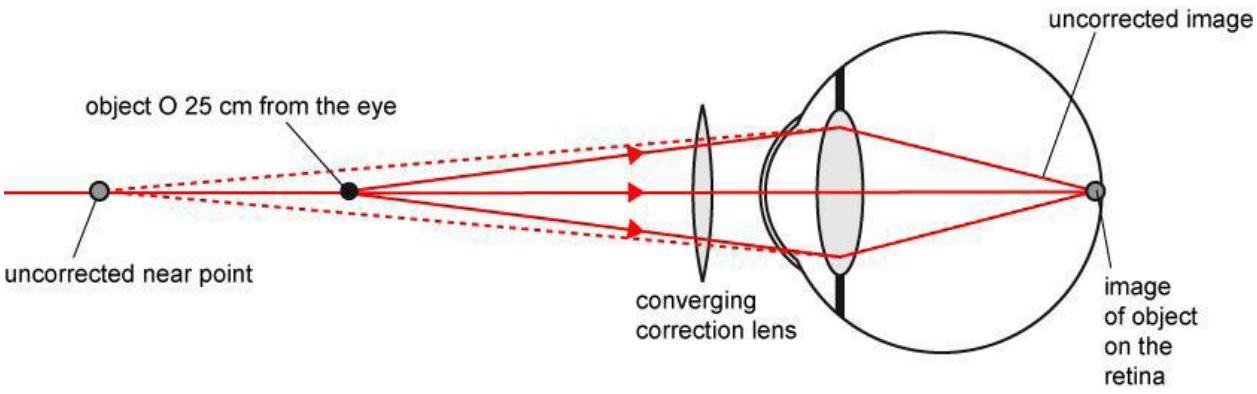


Correct hypermetropia

To correct hypermetropia using a lens, a converging lens of a suitable focal length must be placed in front of the eye. The correcting lens makes the rays from an object 25 cm away diverge less so they appear to come from the uncorrected near point.
Therefore, the correcting lens for hypermetropia must:

- **Converging lens have a focal length which makes an object placed 25 cm from the eye appear as if it is at the uncorrected near point.**
- **The correcting lens forms a virtual image of the point object at the uncorrected near point**
- **The cornea and eye lens see the object as if it was at the uncorrected near point and form a real image of the object on the retina.**

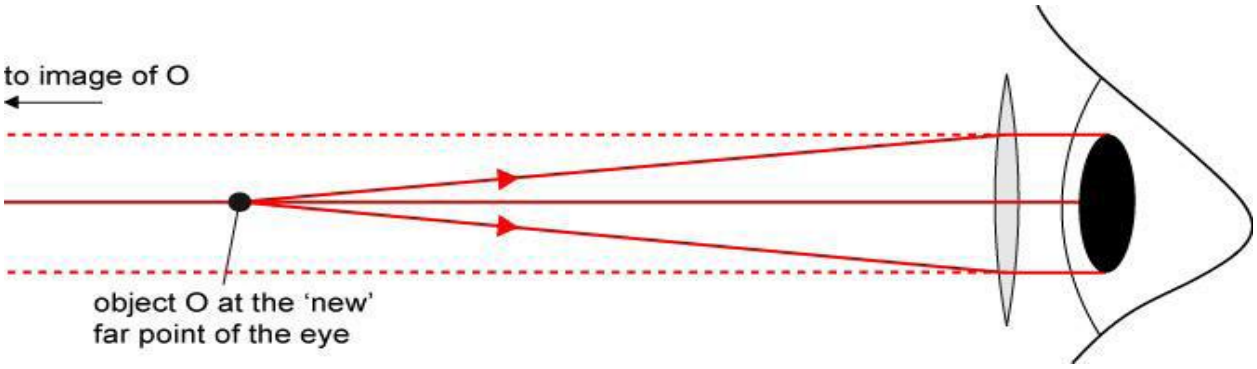


Note

The correcting lens effectively moves the near point of the uncorrected eye nearer the lens to 25 cm away (the near point of a normal eye). It also 'moves' the far point from infinity nearer to the eye. The correcting lens makes the image of an object at the 'new' far point appear to be at infinity.

Effect on the far point

The object must be at the focal point of the converging lens for the rays to become parallel after the lens to make the image appear to be at infinity. Therefore, the new far point is at distance *f* from the lens, where *f* is the focal length of the lens.



Correction to near point

$$\left(\frac{1}{F_{n.p}}\right)_{defect\ eye} = \left(\frac{1}{F_{n.p}}\right)_{normal\ eye} - \left(\frac{1}{F_{n.p}}\right)_{correct\ eye}$$

$$\left(\frac{1}{F_{n.p}}\right)_{defect\ eye} = \left(\frac{1}{u} + \frac{1}{v}\right)_{normal\ eye} - \left(\frac{1}{u} + \frac{1}{v}\right)_{correct\ eye}$$

$$\left(\frac{1}{F_{n.p}}\right)_{defect\ eye} = \left(\frac{1}{0.25} + \cancel{\frac{1}{0.02}}\right) - \left(\frac{1}{n.p} + \cancel{\frac{1}{0.02}}\right)$$

$$\left(\frac{1}{F_{n.p}}\right)_{defect\ eye} = 4 - \frac{1}{n.p(correct\ eye)}$$

Example

A long-sighted eye has the far point at infinity and a near point which is 40 cm from the eye.

a. **State the type of lens needed to correct this defect and calculate the power of the correcting lens.**
b. **Calculate the distance from the lens to the far point of the eye with the correcting lens in front of the eye.**

Solution

a -A converging lens is needed.

For an object at 25 cm from the eye, the object distance

***u* = +25 cm = +0.25 m**

The lens must form a virtual image of the object at the uncorrected near point of the eye.

Hence the image distance *v* = −40 cm

Using 1/f= 1/u + 1/v

with *u*= + 0.25 m and *v* = −0.40 m gives

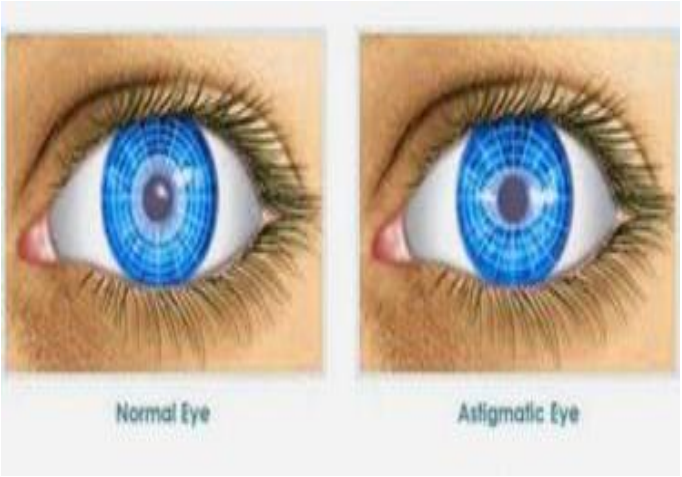
1/f= 1/(0.25) +1/(-0.4) = 4 -2.5 = +1.5 D

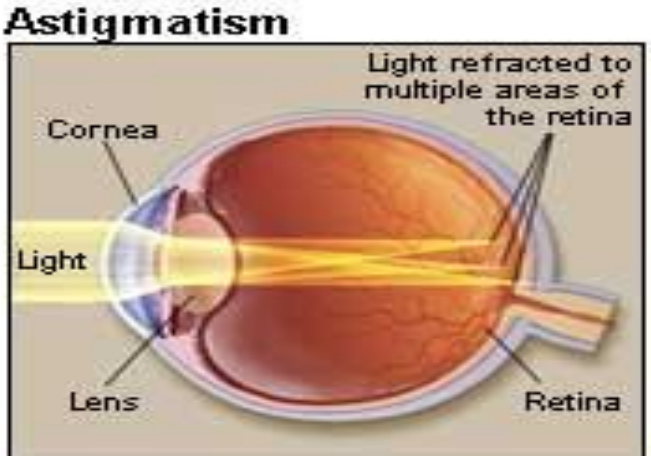
b .The distance from the lens to the 'new' far point = *f* = *1/1.5*.= 0.67 m.

The new far point is at distance *f* from the lens, where *f* is the focal length of the lens.

Astigmatism and its correction

Astigmatism : is a condition where the parallel beam of light rays incident on the cornea after refraction are not focused to form a point image near or on the retina. Astigmatism, occurs when the cornea does not have a spherical shape. In most cases, the curvature in one direction is different from the curvature in another.

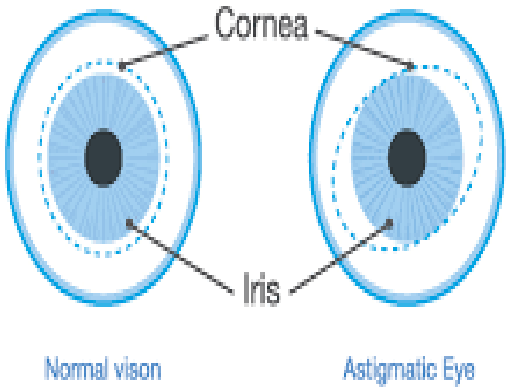




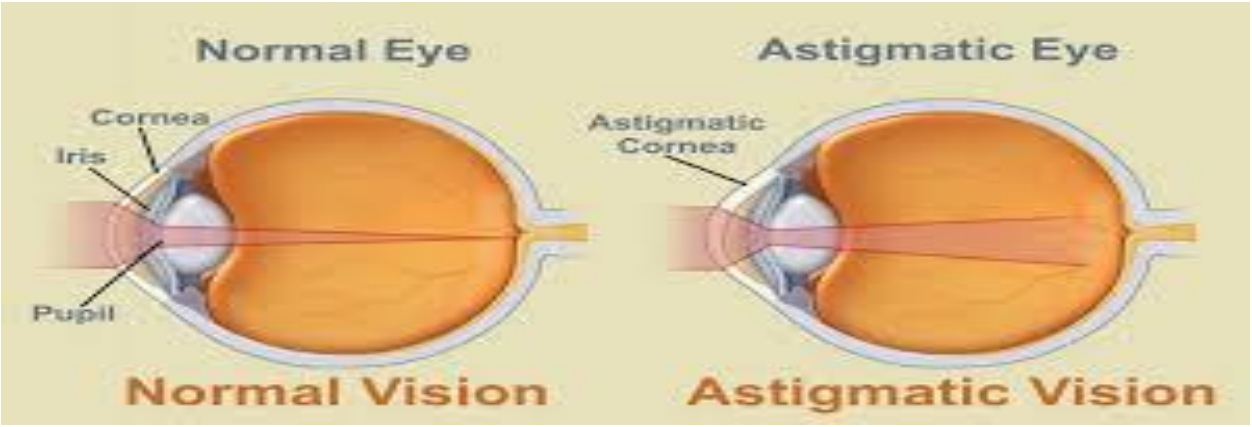
What causes astigmatism?

- **Astigmatism occurs when the front surface of the eye (the cornea) or the lens inside the eye is more oval or cylindrical than round.**
- **Astigmatism is caused by small differences in the growth and alignment of the components of the eye.**
- **Genetics may play a role in the development of refractive error.**

- **Astigmatism may also result from such factors as pressure of the eyelids on the cornea.**



The result of the different curvatures is that the eye has more than one place where the image focuses. When astigmatism is present, point objects do not form point images on the retina.



Because of the lack of symmetry in the lens or cornea , a person with astigmatism cannot see any objects clearly. This condition is frequently accompanied by one of the other eye conditions.

What are the types of astigmatism?

The two main types of astigmatism are corneal and lenticular.

- **A corneal astigmatism happens when your cornea is misshapen.**
- **A lenticular astigmatism happens when your lens is misshapen.**

This is normally due to the corneas unequal curvature in different directions. If the curvature is greater in a horizontal section than in the vertical section, rays brought to a focus more quickly in the horizontal than in the vertical plane.

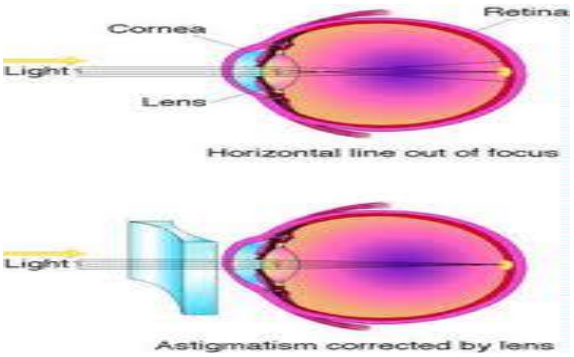
The correction of astigmatism:

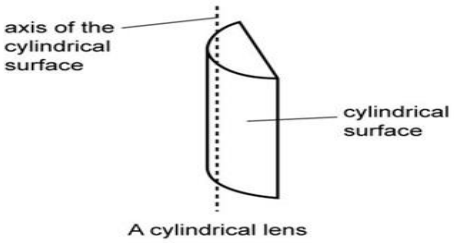
Astigmatism, usually can be corrected with eyeglasses, contact lenses or refractive surgery.

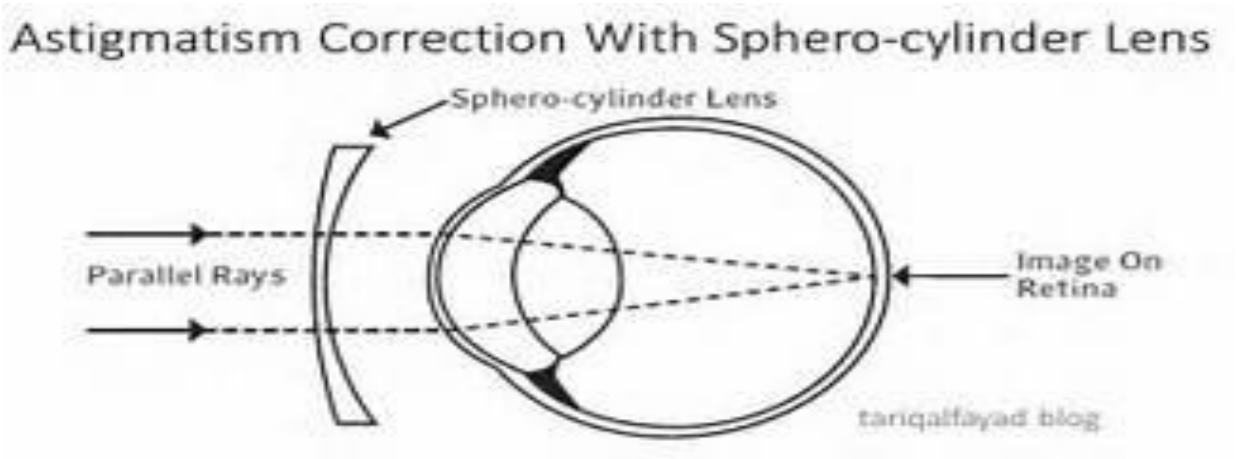
Astigmatism requires a lens with a cylindrical-shaped surface orientated so that it compensates for the uneven curvature of the cornea.

An optician's prescription for astigmatism will state:

- **The curvature of the cylindrical-shaped surface**
- **The orientation of the axis of the cylindrical surface.**







Presbyopia:

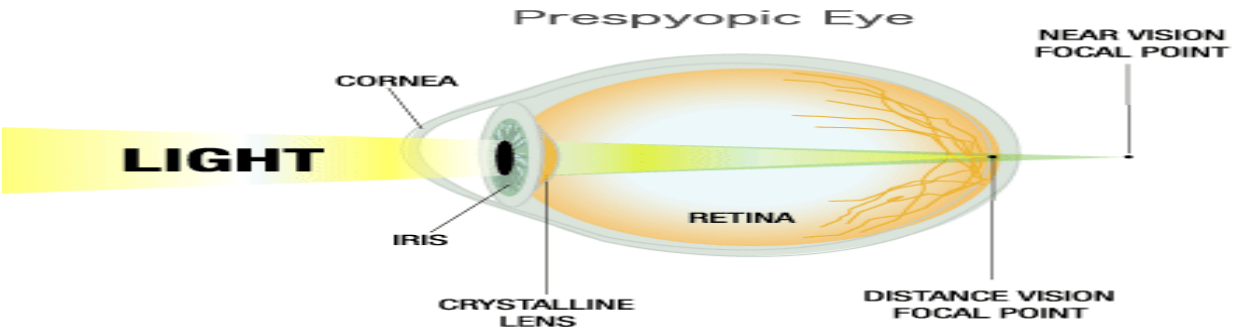
Sometime in your 40s, it gets harder to see close up, but you can see things far away just fine. This is called presbyopia. In spite of the big name, it isn't a disease. It's a natural part of the aging process.

As people get older, gradually losing the ability to read things at near without visual hardware.

This is due to the Lens inside the eye losing its elasticity, thus becoming unable to focus when things are at a close range.

Presbyopia is often confused with farsightedness, but the two are different:

1. **Presbyopia happens when the natural lens in the eye gets less flexible.**
2. **Farsightedness is from a misshaped eyeball that causes light rays to focus incorrectly once they have entered the eye**



The cillary muscles weaken and lens losses some of its elasticity.

The correction of Presbyopia

The power of accommodation diminishes with age.

This defect is corrected by two parts of lenses(bifocal lenses)

- **upper half of each lens is diverging and corrects the myopia when the wears is looking ahead at distance objects,**
- **The lower half corrects the presbyopia with a suitable converging lens, and the wearer looks through this part when reading.**

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Bifocal spectacle is prescribed for patient, the components having focal lengths of 40 cm and -300 cm. What are the near and the far points of the patient's eye?

EX.(تم شرحه في الحاضرة السابقة)

Let us determine the strength of a lens needed to correct a myopic eye (near-sighted eye) with a far point of 1.0 m. We consider the image distance (lens to retina) to be 2cm (Q=0.02 m).

Solution

An eye able to focus at infinity (∞) has a lens strength of

1/ F= 1/P + 1/Q

1/F(normal eye) =(1/∞) + (1/0.02) = 50 D.

A person who is focusing an object at 1.0 m has a lens strength of:

1/F(defect eye)= (1/1.0) + (1/0.02) = 51 D.

Thus a myopic person with a far point at 1.0 m has:

1/F(normal eye) - 1/F(defect eye)= 50 - 51 = -1 D,

and this negative (diverging) lens of -1.0 D will correct his vision.