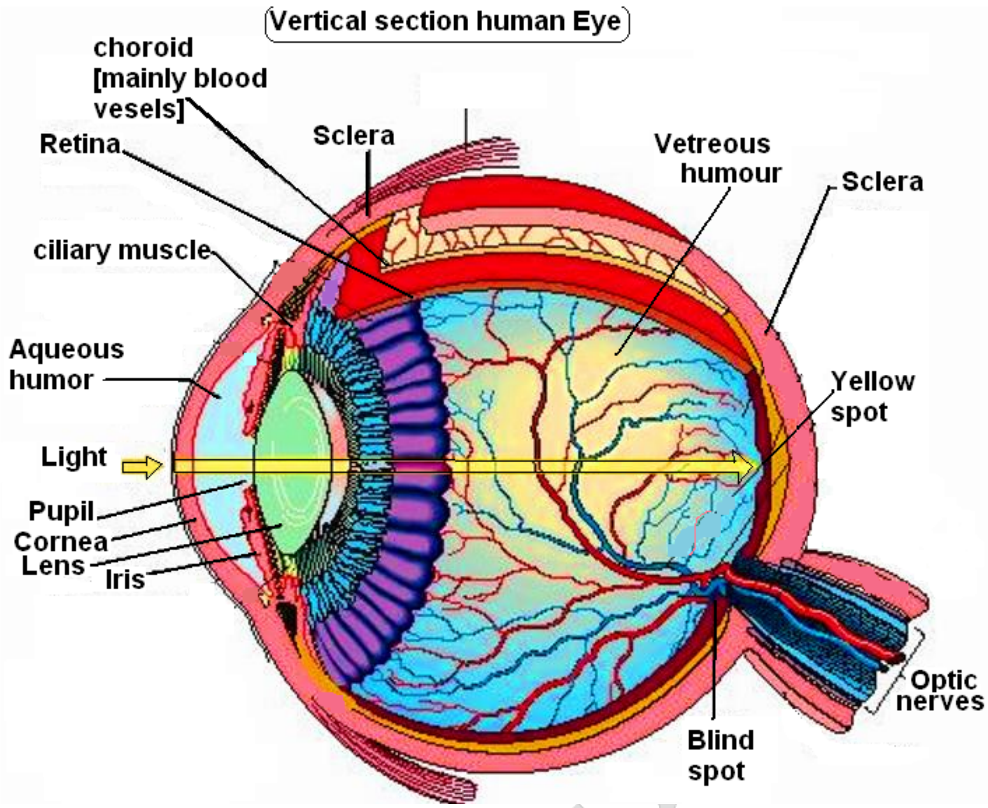
The Human eye



The eyes of insects are simple and light-sensitive structures. The eyes of predatory birds like hawks and eagles are designed to see very small objects at long distances, and are in some ways more complex than the human eye. Each animal eye is eminently suitable for the task it performs, and the task is basically to transform light energy into information relevant to the organism.

The eye, the sense organ of vision, is a compact optical apparatus that is stimulated by light to give a sensation of vision

Parts of human eye:

1. **Cornea**: The transparent dome at the front is the cornea. It is continuous with the sclera. It is also called aperture of eye. The rays of light enter from cornea.
2. **Sclera**: The white portion of the eye is the sclera. It is opaque. It is outermost covering of eyeball.
3. **Choroid**: it is second layer of eyeball, situated below the sclera and contains many blood vessels. It is dark in colour. It absorbs light to prevent **internal reflections**.
4. **Retina**: it is inner most opaque covering of the eye. There is a circular area in retina called **yellow spot** on which ray of light coming from an object focused to form image. Inside the retina **rods and cones** are present which are sensitive to light. The small region of the retina where the optic nerve enters the eye-ball is insensitive to light and is called **blind spot**.
5. **Iris**: the colored portion of the eye is the iris. Iris is a circular muscle with pigments that acts like the **shutter of a camera**. The colour of an eye depends upon the colour of the pigments present in it. Iris **regulates** the amount of light that enters the eye. When the surroundings are very bright the iris has a tiny opening in the center. When the surroundings are dim the iris has

a very large opening. This opening in the iris is the **pupil**.

6. **Lens**: the eye lens is a crystalline double **convex lens** made of transparent and flexible tissue. It is situated directly behind the pupil and held by the ciliary muscles. It focuses the image on retina.
7. **Ciliary muscles**: these muscles hold the eye lens in position. Ciliary muscles control the focal length of the eye lens. When these muscles contracts, the focal length of the lens increase. When they expand, the focal length of the lens decreases.
8. **Optic nerves**: optic nerve is formed by the nerve fiber coming from the retina. It carries the nerve impulses to the brain.

   *The space in the eyeball in front of the lens (between lens and cornea) is filled with a watery fluid called **aqueous humor**. . The space behind the lens (between lens and retina) is filled with a gelatinous substance vitreous **humor.***

Rods and cons: *Rods and cons are **receptors** and have different functions. The rods function especially in dim light, and they do not seem to produce sensations of color. White, black, and intermediate shades of grey can be seen by a person who has only rod vision. The cones function best in bright light. They give us sensations of color, as well as of saturation (degree of color). Damage to the retina, which is fairly common among victims of **diabetes mellitus**, can result in different visual sensations. Damage to the fovea can interfere with color*

Working of eyes: The light rays coming from the object enter the pupil of the eye and fall on the lens. Lens converge the light rays and produces a **real and inverted image** of object on retina. The outer surface of the cornea also acts as a convex lens due to which it converges most of the light ray. Final convergence is done by lens. When the image is formed on retina's **yellow spot** then the light sensitive cells (**rods and cones**) stimulated and generate impulses. These impulses are carried by **optic nerve** to the brain. Brain interprets the image as that of an **erect image**.

Power of accommodation:

A normal eye can see the near and far off objects clearly if the sharp image of these objects are formed on the retina. Since the distance between the eye-lens and retina is fixed(i.e. *v = constat*) , so to see the objects at different position from the eye lens, the focal length of the lens has to be changed accordingly to form the sharp images of these objects.

- If the object to be seen is **far off** (at infinity) then the sharp image of this object can be form on the retina by increasing the **focal length** of the eye-lens.

  The focal length of the lens increases if its **thickness decreases**. Thus, to decrease the thickness of eye lens and hence to increase its focal length, ciliary muscles are completely **relaxed**. Now, the parallel beam of light coming from the distant object is focused on the retina and object is seen clearly.
- If the object to be seen is nearby to the eye, then the sharp image of this object can be form on the retina by decreasing the focal length of the eye-lens.

The focal length of the lens decreases if its thickness increases. Thus, to increase the thickness of eye lens and hence to decrease its focal length, ciliary muscles are contract. Now, the beam of light coming from the nearer object is focused on the retina and object is seen clearly.

The ability of an eye to change the focal length of its lens in such a way that the sharp image of an object at different position from the eye is formed on the retina know as accommodation of the eye.

Near point: The nearest point, up to which the eye can see an object clearly without any strain, is called the near point of the eye.

For a normal eye the distance of the near point is **25 cm** from the eye. This distance is known as **least distance of distinct vision**. If an object is placed at a distance less than the distance of near point, its image on the retina will be **blurred**. Hence human eye can not see such object clearly.

Far point: The farthest point from the eye at which an object can be seen clearly without any strain, is called the far point of the eye. For a normal eye, **far point is at infinity**.

Range of vision: the distance between the near point and far point of an eye is known as range of vision.

Power of accommodation: it is defined as the maximum variation in the power (*P=1/f*) of the eye lens.

For a normal eye the near point is 25 cm from the eye lens i.e., $u = -25\ cm$.

The distance of the retina form the eye lens is about2.5 cm i.e., $v = 2.5\ cm$, now using

$$\frac{1}{f} = -\frac{1}{u} + \frac{1}{v}, \text{ we get}$$

$$\frac{1}{f} = -\frac{1}{-25} + \frac{1}{2.5} = \frac{1}{25} + \frac{1}{2.5} = \frac{11}{25}cm^{-1}$$

$$\therefore \textbf{Power} \text{ of lens, } P = \frac{100}{f(\text{in cm})} = 100 \times \frac{11}{25} = 44\ D$$

The far point is at the infinity i.e., $u = -\infty$,

Since image is formed at the retina, so $v = 2.5\ cm$

$$\frac{1}{f} = -\frac{1}{u} + \frac{1}{v} = \frac{10}{25}cm^{-1}$$

Hence Power of lens,

$$P = \frac{100}{f} = 100 \times \frac{11}{25} = 40\ D$$

Thus, the maximum variation in the power of eye lens = 44 D – 40 D= 4 D.

Therefore, for a normal eye, the power of accommodation is about 4 D.

The rays of light coming from a distant object (placed at Infinity) are **parallel** when they reach the eye. They ray of light coming from a nearby object are **diverging** when they reach the eye

Vision: *The ability to see is called vision or eye sight.*

Defective eye: Some time eye is unable to see the object clearly or the eye is unable to form a sharp image of objects on its retina. Such eye is known as **defective eye**.

Reason for defect in eye: Due to advancing age, biological changes in human body ciliary muscles become **inactive**. As a result of this, ciliary - muscles do not expend or contract according to the needs of eye. The eye can not accommodate for clear vision either from the near point or from the far off point or both.

Common defects of eye:

1. Long sightedness [Far sightedness or Hypermetropia]:
2. Short sightedness [near sightedness or myopia]:
3. Presbyopia
4. Astigmatism

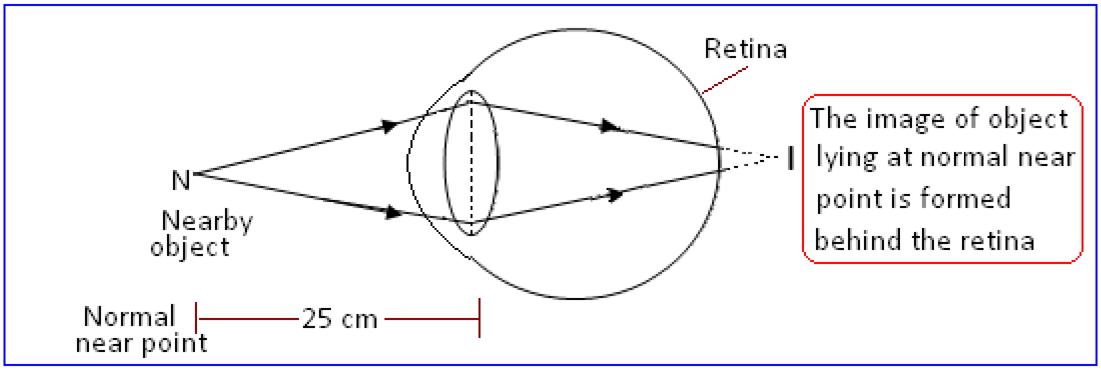
Long sightedness [Far sightedness or Hypermetropia]:

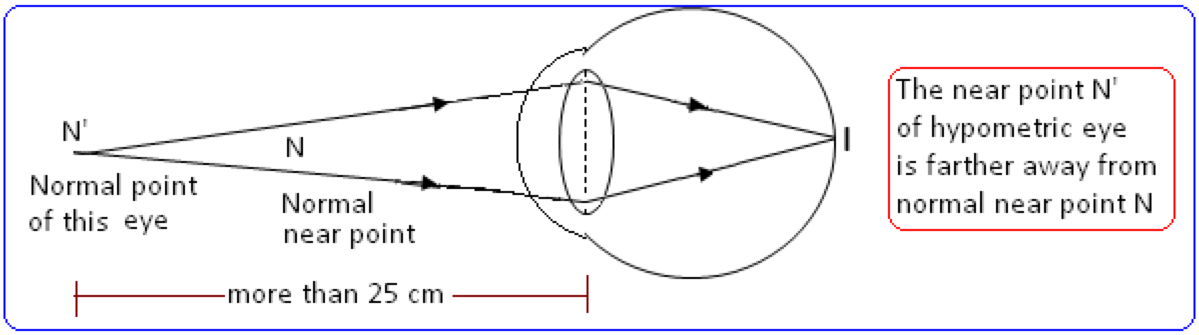
A Human which can see far off objects or distant object clearly but can not see the near objects clearly is said to be suffered with a defect known as **Long sightedness** [Far sightedness or Hypermetropia]

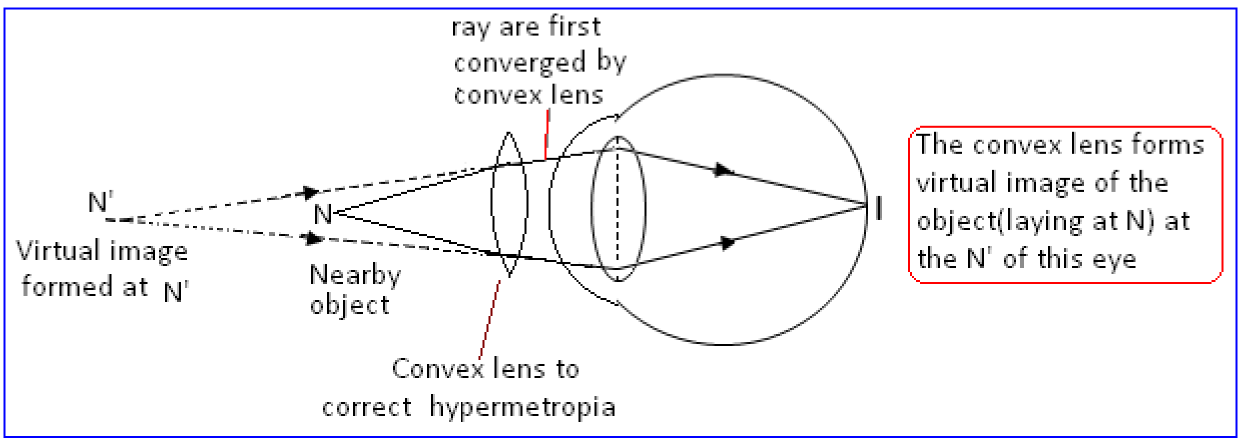
The **near point** of a hypermetropic eye is more than **25 cm** away. Because of this the image of object at normal near point (25 cm) is formed **behind the retina** of eye. In this case the image is formed on the retina is **blurred**.

Causes of Hypermatropia:

1. **Due to low converging power of eye lens (large focal length)** : In some cases , the ciliary muscles become weak and can not make eye lens fatter to increase its converging power . So, due to the low converging power, the image of nearby object is formed behind the retina and hence the eye can not see it clearly.
2. **Due to eye-ball being to short**: In some cases of hypermatropia the eye-ball is too short due to which the retina is at a smaller distance from the eye lens. This condition results in the formation of the image of nearby object behind the retina [*even though the eye lens may have correct converging power*].







<u>Correction of Long sightedness</u> [Far sightedness or Hypermetropia]:

Long sightedness is corrected by using spectacles containing **convex lenses**.

When a convex lens of suitable power is placed in front of the hypermatropic eye ,then the diverging ray of light coming from the nearby object[at 25 cm] are first converged by this convex lens. Due to this, the convex lens forms **virtual image** of the nearby object [placed at 25 cm] at the near point of the hypermatropic eye. Since the ray of light now appear to be coming from this eye's near point, they can be easily focused by the eye lens to form an image on retina.

The convex lens used for correcting hypermatropia should be of such a focal length [power] that it forms a virtual image of the object [placed at the near point of normal eye] at the near point of the hypermatropic aye.

Calculation of the power of convex lens:

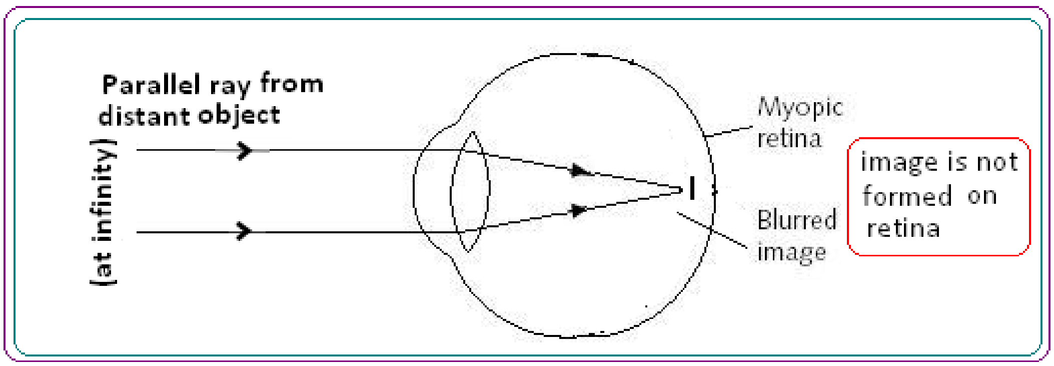
$$P = \frac{1}{f}$$

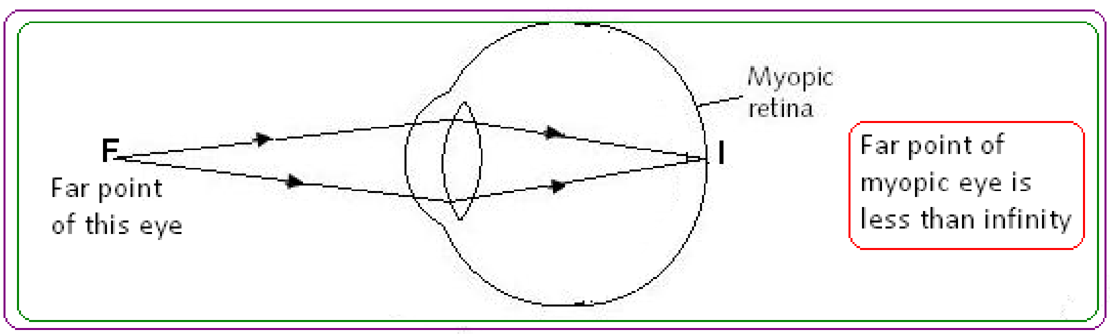
$$f = -\frac{1}{u} + \frac{1}{v}$$

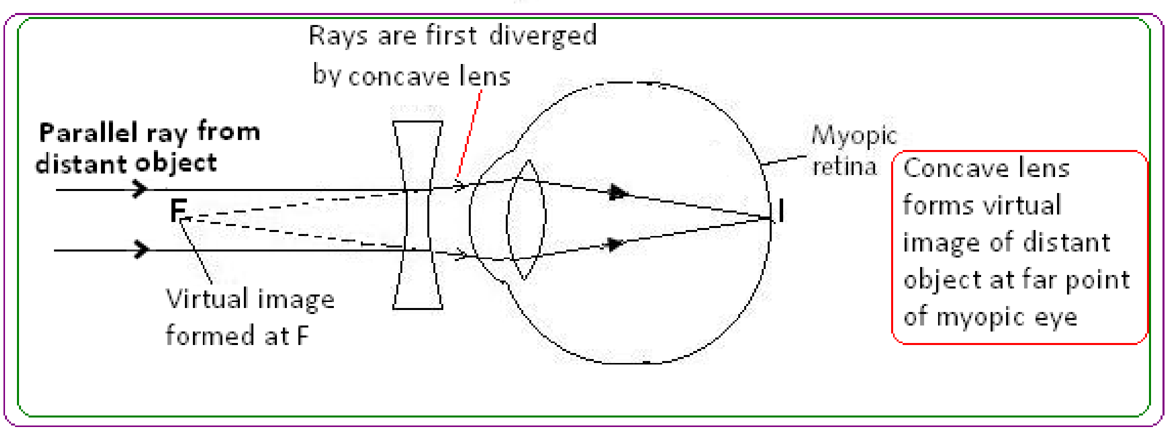
u=object distance (to be taken as normal near point) =25 cm

v=image distance that the distance of the near point of the hypermetropic eye

Short-sightedness [myopia]:







A Human eye which can see near objects clearly but can not see the far off objects clearly is said to be suffered with a defect known as **short sightedness** [nearsightedness or myopia.

The far point of a myopic eye is less than infinity. The image of object placed at infinity is formed in front of the retina of eye. As the image is not formed on retina of the eye so, it can not be seen clearly.

Causes of myopia:

1. **Due to high converging power of eye lens (short focal length)**: In some cases, the ciliary muscles do not relax sufficiently to make the lens thinner to reduce its converging power. So, due to the high converging power, the image of distant object is formed in front the retina and hence the eye can not see it clearly.

2. **Due to eye-ball being too long**: in some cases of myopia the eye-ball is too long due to which the retina is at a greater distance from the eye lens. This condition results in the formation of the image of distant object in front of the retina [*even though the eye lens may have correct converging power*].

Correction of short sightedness [nearsightedness or myopia]:

Short sightedness is corrected by using spectacles containing **concave lenses**.

When a concave lens of suitable power is placed in front of the myopic eye ,then the parallel ray of light coming from the distant object [placed at infinity] are first diverged by this concave lens. Due to this, the concave lens forms virtual image of the distant object [placed at infinity] at the far point of the myopic eye. Since the ray of light now appear to be coming from this eye's far point, they can be easily focused by the eye lens to form an image on retina.

The concave lens used for correcting myopia should be of such a focal length [power] that it forms a virtual image of the object [placed at the infinity] at the far point of the myopic eye.

Calculation of the power of convex lens:

$$P = \frac{1}{f}$$

$$f = -\frac{1}{u} + \frac{1}{v}$$

u = object distance (to be taken as normal near point) =25 cm

v = image distance that is the distance of the far point from eye lens of the myopic eye.

Presbyopia:

*A human eye which can not see the near objects as well as far object [distant] objects clearly is said to be suffered from a defect known as **presbyopia**.*

Cause: This defect arises due to the ageing of a person. The ciliary muscles are weakened and the flexibility of the crystalline lens of the human eye decreases with age of the person. As a result, human eye is unable to see the near as well as distant objects clearly.

Correction: Presbyopia can be corrected by using **bi-focal lenses**. A bi-focal lens consist a concave lens which forms the upper surface of bi-focal lens and a convex lens which forms the lower surface of the bi-focal lens. The upper surface of bi-focal lens [concave lens] enables the person to see distant objects clearly and the lower surface [convex] enables the person to the near objects.

Cataract:

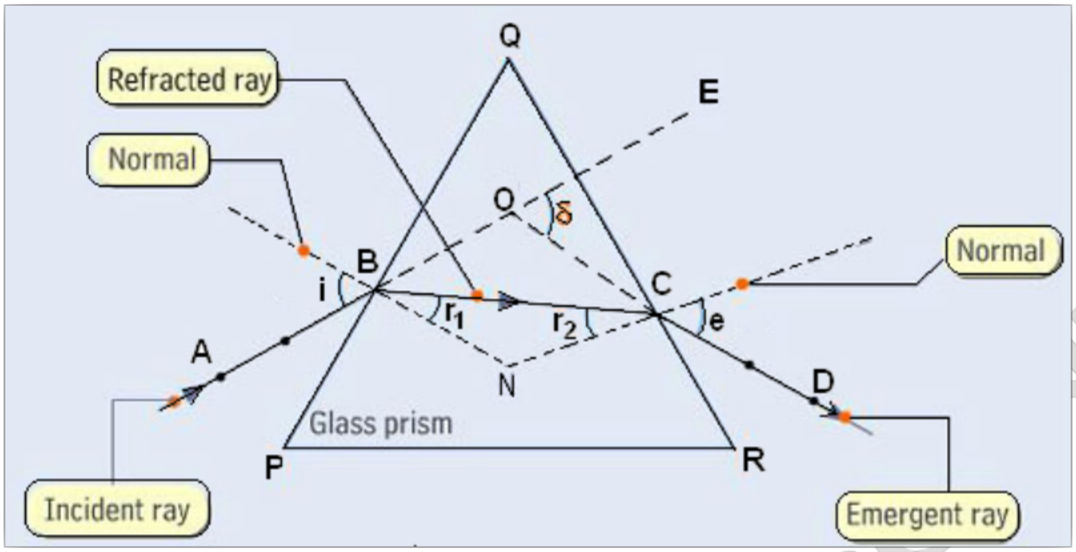
The medical conditions in which the lens of the eye of a person becomes progressively **cloudy** resulting in blurred vision is called cataract. It develops when the eye lens of a person becomes cloudy [or even opaque] due to the formation of a **membrane** over it. Cataract decreases the vision of eye gradually. It can even lead to total loss of the vision of eye. The vision of the person can be restored after getting **surgery** done on the eye having cataract. This defect can not be corrected by any type of spectacle lens.

Refraction of light through a Prism:

Prism: prism is homogenous transparent refracting medium bounded by at least two non-parallel surfaces inclined at some angle. A triangular glass-prism has two tri-angular bases and three rectangular lateral surfaces. These surfaces are inclined to each other.

Angle of prism: the angle between two non-parallel refracting surfaces is called angle of prism or refracting angle. It is denoted by A.

Refracting surface: the two non-parallel plane surfaces participating in the refraction of light are called refracting surfaces.



Refraction through prism: When a ray of light passes through a glass prism, refraction occur both, when it enters the prism as well as when it leaves the prism. Since the refracting surfaces are not parallel, therefore, the emergent ray and incident ray are not parallel to one another. In this case the ray of light is deviated on passing through the prism.

A ray of light AB is incident on the face PQ of the prism PQR. It bends towards the normal due to change in medium [air (rarer medium) to glass (denser medium)]. BC is refracted ray of light.

When the ray of light BC comes out into air, refraction takes place again. Since the ray BC is going from glass to air, so it bends away from the normal and goes along the direction CD. CD is emergent ray.

The emergent ray CD is not parallel to the incident ray AB. There has been a deviation in the path of light in passing through the prism.

When AB is produced upward towards the point E, AE represents the original direction of the incident ray of light. When emergent ray CD produced backwards, it cuts AE at point O. The angle between incident ray and emergent ray is called angle of deviation. EOD is angle of deviation.

It is the triangular shape of the glass prism which makes the emergent ray bends with respect to the incident ray.

Dispersion of white light by a glass prism:

In 1665, ***Newton*** discovered that white light [like sunlight] consists of a mixture of seven colours.

- When white light passes through a glass prism, it splits to form a band of seven colours on a white screen.

- *The bends of seven colours formed on a white screen, when a beam of whilte light is passed thoroiugh a glass prism, is called **spectrum** of white light.* The seven colours of the spectrum are Red, orange, yellow, Green, Blue, Indigo and Violet. The seven colours of the spectrum can be denoted by the word VIBGYOR.

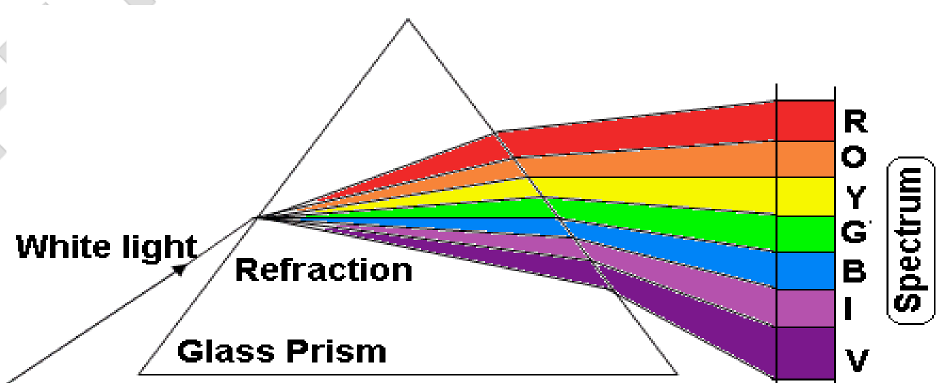
V= Violet, I=indigo, B= Blue, G=Green, Y=Yellow, O=Orange and R= Red.

The phenomenon of splitting white light into seven colours when it passes through a transparent medium like glass-prism is called dispersion of light.

Wavelengths of different colour

Red	=	7900 A°
Orange	=	6000 A°
Yellow	=	5800 A°
Green	=	5400 A°
Blue	=	4800 A°
Indigo	=	4500 A°
Violet	=	4000 A°

Causes of dispersion: White colour consists of ***seven colour***. Each colour has its own wave-length. The wavelength of ***red*** colour is **longest** and the wavelength of ***violet*** colour is ***shortest***. The speed of light [color] depends upon the wave length. If wavelength of a colour is large, the speed of the colour is also large. Thus, each colour of white light travels with ***different speed*** in a given medium. The speed of red colour is more than the speed of orange colour and so on. Therefore, the speed of red colour red colour in a medium is the highest and the speed of violet colour is the least. Hence, all colours of white light are refracted by ***different amount*** while passing through the glass prism therefore different constituents colours come out of the prism at ***deferent angles***. This gives rise to the dispersion of white light.



Dispersion of white light

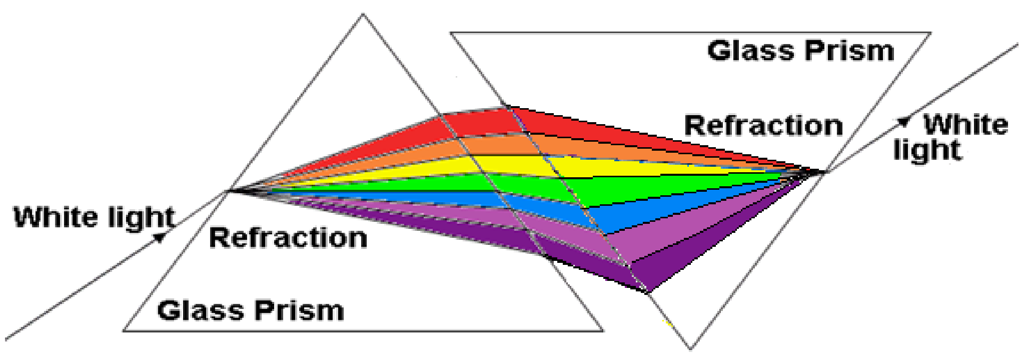
A glass prism splits colours of white light passing through it and does not produce any colour by itself.

Recombination of white light:

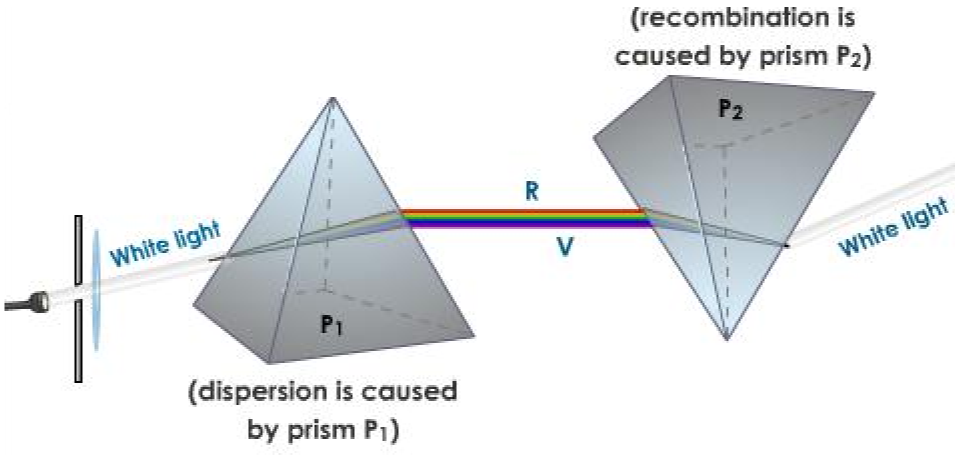
The seven coloured light of the spectrum can be ***re-combined*** to give back white light. This can be done by placing ***two prisms***, one is erect and another is in the ***inverted*** position.

When a beam of light is allowed to fall on first prism, then a patch of ordinary white light is obtained on a white screen placed behind the second prism.

- The first glass prism ***splits*** [disperses] the white light into ***seven coloured rays***.
- The second glass prism ***receives*** all the seven coloured ray from the first prism and ***recombines*** them into original beam of white light which ***fall on the screen***.
- The recombination of seven colours is due to the fact that the second prism has been placed in reversed position due to which the *refraction produced by the second prism is equal to and opposite to that produced by the first prism.*



Recombination of white light

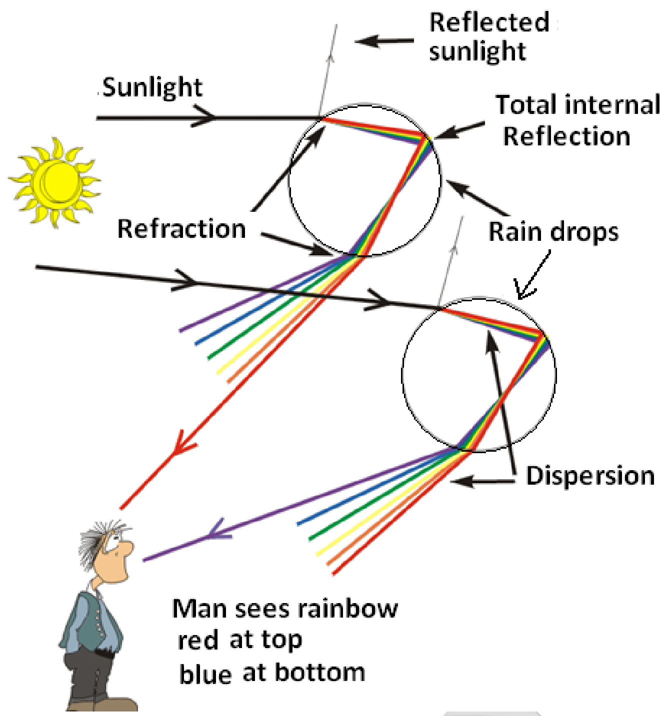


Dispersion of light in nature:

Dispersion of light in nature can be seen in the form of rainbow.

Rainbow: The rainbow is an ***arch*** of seven colour visible in the sky which is produced by the ***dispersion*** of the sun light by ***rain drops*** in the atmosphere. Rainbow is ***natural spectrum*** of sunlight. It is formed when the sun is ***shinning*** and it is ***raining*** at the same time. Each raindrop acts as a tiny ***glass prism***.

When sunlight falls on water drops suspended in air the sun light is ***refracted***. The refracted sun light ***splits*** [or ***dispersed***] into it's constitutes colours. The red colour deviated the least and the violet colour deviated the most. Different colours of refracted sun light fall on the opposite face of the water drop. Now, each colour is ***partly reflected*** back into the drop. The reflected colours on reaching the lower surface of water drop are ***refracted again*** in to the air. Thus rainbow is formed.



Atomosphetic refraction

The refraction of light caused by the earth's atmosphere [having air layers of varying optical densities] is called ***atmospheric refraction***,

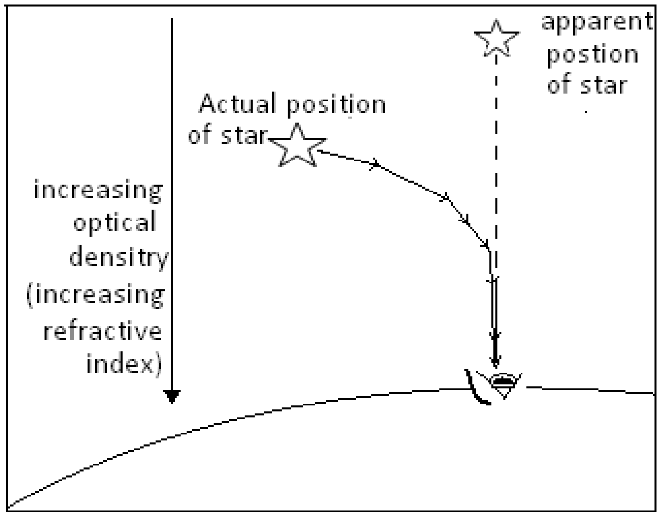
Cause: the air in the atmosphere is in the ***form of layers***. The different layers of air have different densities. As we go, higher and higher, the density of the layer of air goes on increasing. Thus, the layer of air close to the surface of the earth has more density than the density of air layers far away from the surface of the earth. Therefore, the layers of air close to the surface of the earth behave as optically denser medium and the layer of air far away from the surface of the earth behaves as optically rarer medium.

When sunlight enters the earth's atmospheres, it continuously goes from rarer to the denser medium and hence, refraction of light takes place.

Atmospheric refraction gives rise to many optical phenomenons:

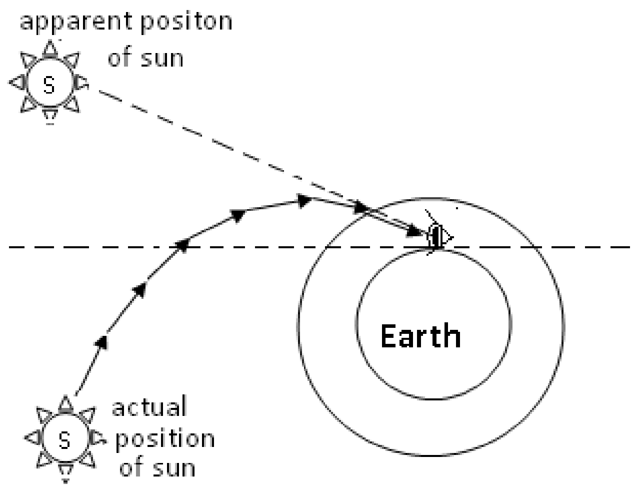
1. **The star seems higher than they actually are:** light emitted by stars passes through the atmosphere of the earth before reaching our eyes. The atmosphere of the earth is not ***uniform*** but consists of many layers of different densities. The layers closed to the surface to the earth are ***optically denser***. As we go higher and higher, the density of layer and refractive index decreases progressively. As the light from stars enters to upper most layer of the atmosphere, it ***bends towards*** the normal as it enters the next layer. This process is continuous till the light enters our eyes. So, ***due to refraction of light***, the apparent position of stars is different from the actual position of the star.

   Twinkling of stars: The different layers of the atmosphere are mobile and the temperature and the density of layers of atmosphere changes continuously. Hence, the apparent position of the star changes continuously. ***The intensity*** of light coming from the star also changes with the change in the apparent position of the star. This leads of twinkling of stars.



2. **<u>Planets do not twinkle</u>:** A planet appears to be ***quit big to us*** (*because they are much near to the earth*). So, a planet can be considered to be a ***collection*** of a very large number of ***point sources of the light***. The ***dimming effect*** produced by some of the point sources of light in one part of the planet is ***nullified*** by the brighter effect produced by the point sources of light in its other part. Thus on the whole, the ***brightness*** of a planet always ***remains the same*** and hence it does not appear to twinkle. The continuously changing atmosphere is ***unable to cause variations*** in the light coming from big sized planet because of which the planet does not twinkle at all.

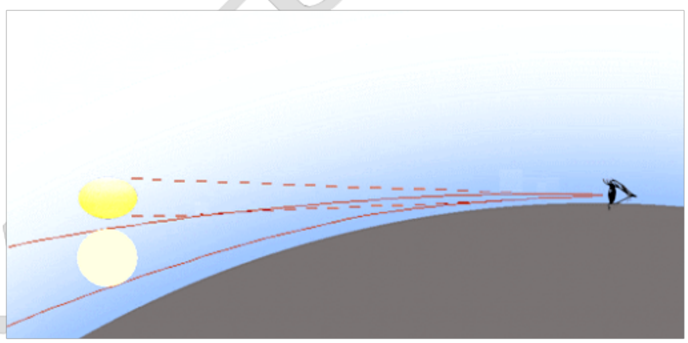
3. **<u>Advanced Sunrise and Delayed sunset</u>:** Actual sun sets when it is ***below the horizon*** in the evening. The rays of light form the sun below the horizon reach our eyes because of ***refraction of light***. These rays appear to come from the apparent position of the sun which is above the horizon. Hence, we can see the sun for few minutes (***about 2 minute***) even after it has actually set. Similarly the sun can be seen about 2 minute before it actually rises. Thus we ***gain about four minutes*** of additional day light each day.



4. **<u>The sun appears oval (or flattened) at sunset and sunrise but appears circular at noon</u>:**

At sunset and sun rise, the sun is near the horizon. The rays of light from the upper and lower edge ***<u>bend unequally</u>*** while traveling through the atmosphere. As a result of this phenomenon, the sun appears ***<u>oval</u>***.

At noon, the sun is ***overhead***. The rays of light form the sun enter the atmosphere ***normally*** and hence they ***do not bend*** at all while passing through the atmosphere. Therefore, the sun appears ***circular at noon***.



Scattering of light:

When sunlight enters the atmosphere of the earth, the atoms and molecules of different gases present in the atmosphere absorb this light. Then these atoms and molecules of the gases ***<u>re-emit light</u>*** in all directions. The process is known as ***scattering of light.***

The atoms or particles scattering light are known as scaterers.

"The intensity of scattered light is inversely proportional to the fourth power of the wavelength of incident length, if the size of the particles (atom and molecules) scattering the light is less than the wavelength of the incident light."

$$I \propto \frac{1}{\lambda^4}$$

Wavelength of red light is greater than the wavelength of blue or violet light. Therefore, the intensity of scattered red light is less than the intensity of the scattered blue or violet light.

The colour of the scattered light depends on the size of the scattering particles in the atmosphere.

a. *The larger particle so f dust and water droplets present in the atmosphere scatter the light as such due to which the scattered light also appears white.*

b. *The extremely minute particles such as air molecules present in the atmosphere scatter mainly the blue light present tin the white light.*

Sky would appear black in day time if earth had no atmosphere:

If earth had ***no atmosphere***, then there will be no gas present in the atmosphere. Since there is ***no scatterer*** in the atmosphere of the earth, so there will be ***no scattering of light***. Hence the sky would ***appear dark*** as there is no scattering of light.

When the earth had no atmosphere, sun light would be visible only if we look directly at the sun.

Danger signal lights are red:

The '***danger***' signal lights are ***red*** in colour. This is because the red coloured light having ***longer wavelength*** is the ***least scattered*** by fog or smoke particles. Due to this the red light can be seen in same colour even from a ***distance***.

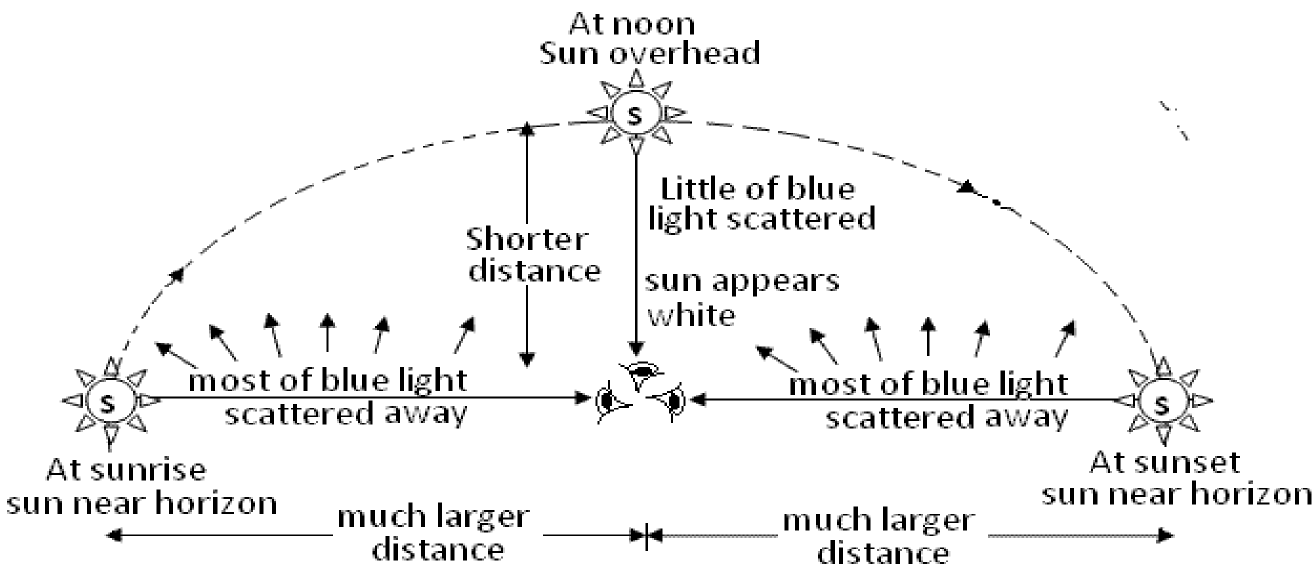
Clouds are white:

The clouds are made of different sized ***water-droplets***. These different sized droplets ***scatter different colours***. For example, the ***tiniest*** droplets scatter ***more blue*** light than other colours. Droplets of size ***greater than the tiniest*** droplets scatter ***green light*** more and the ***largest*** droplets scatter ***red*** light more. As, all the colours are scattered by the droplets in the clouds, so the resultant light is white. Hence, clouds ***appear white***.

At Sun rise and sun set sun appears red:

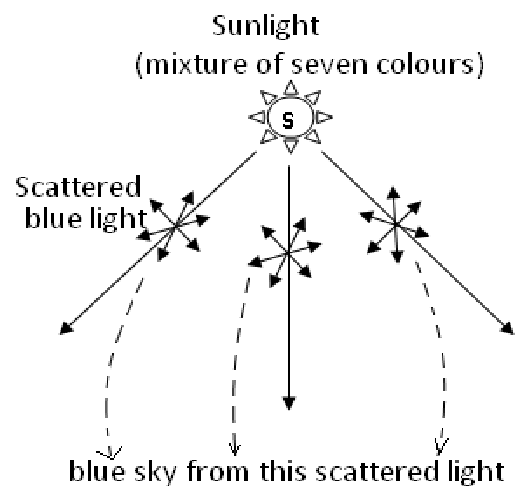
At Sun rise and sun set, the position of the sun is very ***far away from us***. The sunlight travels ***longer distance*** through the atmosphere of the earth before reaching our eyes. Scattering of blue light is more than the scattering of the red light. As a result of this, ***more red lights reaches*** our eyes than any other colour. Hence sun and sun set ***appear red***.

During noon, the sun is ***overhead*** and sunlight travels ***less distance*** through the earth's atmosphere to reach our eyes. In this case, the scattering of almost ***all colours*** is very small. Hence the ***sun appears white***.



Sun appears red at sunrise ans sunset but white at noon

Sky is blue: When sun light enters earth's atmosphere, the atom or molecules of the gases present in it scatter this light. Since the Wavelength of red light is greater than the wavelength of other colours in sunlight. Therefore, the intensity of scattered red light is less than the intensity of the scattered other light. Violet colour is scattered the most followed by blue, green, yellow, orange and red colour respectively. Our eye is more sensitive to the blue light than the violet light. Therefore, scattered light in the sky contains blue clour in plenty and hence the clear sky appears blue.



Tyndall effect:

The phenomenon of scattering of light by dust, smoke and water droplets suspended in air is known as ***Tyndall-effect***.

It can be seen (1) from dust particles in air when sun-light comes through a window or a slit in a window (2) when sun-light comes down through the clouds and (3) when head-light of vehicles come through fog.

COLOR BLINDNESS

The human eye, basically, discriminates on three dimensions:
a) light-dark,
b) blue-yellow, and
c) red-green.

A person who is totally blind discriminates none of these. A person who has normal vision discriminates all of them; he is, therefore, a trichromat (three color discriminator). On rare occasions, a person is totally color-blind; he sees only shades of grey. Such a person monochromat. The partially color- blind person is a dichromat. There are two types of dichromats: those who cannot discriminate between red and green, and those who cannot discriminate between blue and yellow. By far the most common type of color blindness is the red-green type, and there seem to be several variations of this. In most cases, color blindness is hereditary. It was discussed in Unit Two, Human Development, as a sex-linked genetic defect

Key Learning

1. Human eye is a valuable sense organ. Its various parts and the respective functions include:

Eye part	Eye function
Cornea	Protective layer of eye
Eye lens	Refracts the light so as to form the image on retina

Retina Behaves as the screen on which the image is formed
Pupil Controls the intensity of light entering the eye
Ciliary's muscles Adjust the thickness of the lens

2. The farthest point up to which the eye can see clearly is called the far point of the eye.
3. The distance of the closest point from the eye that can be seen clearly without accommodation is known as least distance of distinct vision.
4. The ability of the eye to observe distinctly the objects situated at widely different distances from the eye is called power of accommodation.
5. The smallest distance, at which the eye can see objects clearly without strain, is called the near point of the eye or the least distance of distinct vision. For a young adult with normal vision, it is about 25 cm.
6. In myopia distant objects are not clearly visible. It is corrected by using concave lens.
7. In hypermetropia nearby objects are not clearly visible. It is corrected by using convex lens.
8. Presbyopia arises due to weakening of ciliary muscles in old age. It can be corrected by using bi-focal lenses.
9. The phenomenon of splitting of white light into its constituent seven colors on passing through a glass prism is called dispersion of light.
10. Different colors undergo different deviations on passing through prism.
11. If a second identical prism is placed in an inverted position with respect to the first prism, all the seven colors recombine to form white light.
12. Atmospheric refraction is the phenomenon of bending of light on passing through earth's atmosphere.
13. As we move above the surface of earth, density of air goes on decreasing.
14. Light traveling from rarer to denser layers always bends towards the normal.
15. Stars twinkle on account of atmospheric refraction.
16. Sun appears to rise 2 minutes earlier and set 2 minutes later due to atmospheric refraction.
17. The phenomenon in which a part of the light incident on a particle is redirected in different directions is called scattering of light.
18. Very small particles scatter lights of shorter wavelengths better than longer wavelengths.
19. The scattering of longer wavelengths of light increases as the size of the particles increases.
20. Larger particles scatter lights of all wavelengths equally well.

NCERT Solutions

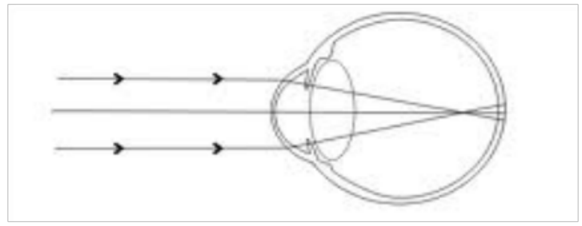
1. What is meant by power of accommodation of the eye?

ANS: When the ciliary muscles are relaxed, the eye lens becomes thin, the focal length increases, and the distant objects are clearly visible to the eyes. To see the nearby objects clearly, the ciliary muscles contract making the eye lens thicker.
Thus, the focal length of the eye lens decreases and the nearby objects become visible to the eyes. Hence, the human eye lens is able to adjust its focal length to view both distant and nearby objects on the retina. This ability is called the power of accommodation of the eyes.

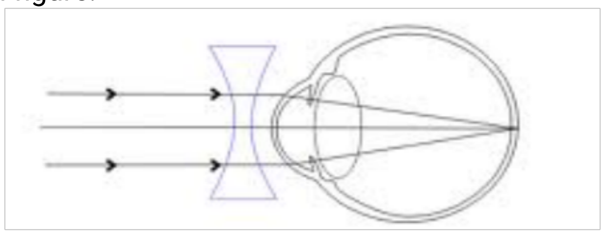
2. A person with a myopic eye cannot see objects beyond 1.2 m distinctly. What should be the type of the corrective lens used to restore proper vision?

ANS: The person is able to see nearby objects clearly, but he is unable to see objects beyond 1.2 m. This happens
because the image of an object beyond 1.2 m is formed in front of the retina and not at the retina,

as shown in the given figure.



To correct this defect of vision, he must use a concave lens. The concave lens will bring the image back to the retina as shown in the given figure.



3. What is the far point and near point of the human eye with normal vision?

ANS: The near point of the eye is the minimum distance of the object from the eye, which can be seen distinctly without strain. For a normal human eye, this distance is 25 cm.
The far point of the eye is the maximum distance to which the eye can see the objects clearly. The far point of the normal human eye is infinity.

4. A student has difficulty reading the blackboard while sitting in the last row. What could be the defect the child is suffering from? How can it be corrected?

ANS: A student has difficulty in reading the blackboard while sitting in the last row. It shows that he is unable to see distant objects clearly. He is suffering from myopia.
This defect can be corrected by using a concave lens.

5. The human eye can focus objects at different distances by adjusting the focal length of the eye lens. This is due to
(a) presbyopia (b) accommodation (c) near-sightedness (d) far-sightedness

ANS: (b) Human eye can change the focal length of the eye lens to see the objects situated at various distances from the eye. This is possible due to the power of accommodation of the eye lens.

6. The human eye forms the image of an object at its
(a) cornea (b) iris (c) pupil (d) retina

ANS: (d) The human eye forms the image of an object at its retina.

7. The least distance of distinct vision for a young adult with normal vision is about
(a) 25 m (b) 2.5 cm (c) 25 cm (d) 2.5 m

ANS: (c) The least distance of distinct vision is the minimum distance of an object to see clear and distinct image. It is 25 cm for a young adult with normal visions.

8. The change in focal length of an eye lens is caused by the action of the
(a) pupil (b) retina (c) ciliary muscles (d) iris

ANS: (c) The relaxation or contraction of ciliary muscles changes the curvature of the eye lens. The change in curvature of the eye lens changes the focal length of the eyes.
Hence, the change in focal length of an eye lens is caused by the action of ciliary muscles.

9. A person needs a lens of power -5.5 dioptres for correcting his distant vision. For correcting his near vision he needs a lens of power +1.5 dioptre. What is the focal length of the lens required for correcting (i) distant vision, and (ii) near vision?

ANS: For distant vision = -0.181 m, for near vision = 0.667 m

The power P of a lens of focal length f is given by the relation

$$P = \frac{1}{f\,(\text{in metres})}$$

(i) Power of the lens used for correcting distant vision = -5.5 D

Focal length of the required lens, f = 1/P

$$f = \frac{1}{-5.5} = -0.181 \text{ m}$$

The focal length of the lens for correcting distant vision is -0.181 m.

(ii) Power of the lens used for correcting near vision = +1.5 D

Focal length of the required lens, f = 1/P

$$f = \frac{1}{1.5} = +0.667 \text{ m}$$

The focal length of the lens for correcting near vision is 0.667 m.

10. The far point of a myopic person is 80 cm in front of the eye. What is the nature and power of the lens required to correct the problem?

ANS: The person is suffering from an eye defect called myopia. In this defect, the image is formed in front of the retina. Hence, a concave lens is used to correct this defect of vision.

Object distance, u = infinity = ∞
Image distance, v = -80 cm
Focal length = f
According to the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$-\frac{1}{80} - \frac{1}{\infty} = \frac{1}{f}$$

$$\frac{1}{f} = -\frac{1}{80}$$

$$f = -80 \text{ cm} = -0.8 \text{ m}$$