CHAPTER – 11

The Hyman Eye and the Colourful World

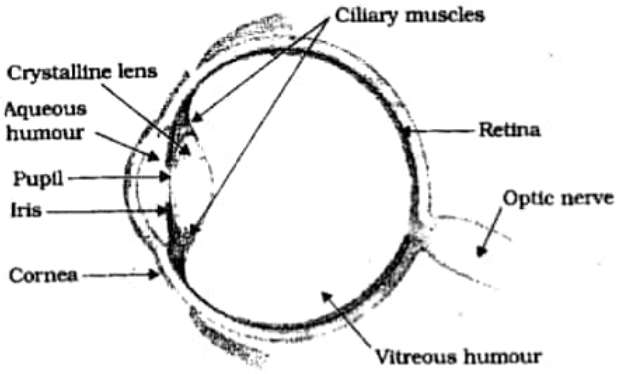
In this chapter we will study Human eye that uses the light and enable us to see the objects.

We will also use the idea of refraction of light in some optical phenomena in nature i.e. Rainbow formation, twinkling of star, blue and red colour of sky etc.

Human Eye : A Sensitive sense organ

It acts like a camera, enable us to capture the colourful picture of the surroundings.

It forms an inverted, real image on light sensitive surface Retina



The Various parts of eye and their functions

1. **Cornea :** It is a thin membrane through which light enters. It forms the transparent bulge on the front of eyeball. Most of the refraction occurs at the outer surface of the cornea.
2. **Eyeball :** it is approximately spherical in shape, with a diameter of about 2.3cm.
3. **Iris :** It is a dark muscular diaphragm that controls the size of pupil. It is behind the cornea.
4. **Pupil :** It regulates and control the amount of light entering the eye. It is the black opening between aqueous humour & lens.
5. **Crystalline eye lens :** Provide the focussed real & inverted image of the object on the retina. It is composed of a fibrous, jelly like material. This is convex lens that converges light at retina.

6. **Ciliary muscles :** It helps to change the curvature of eyelens and hence changes its focal length so that we can see the object clearly placed at different positon.
7. **Retina :** Thin membrane with large no. of sensitive cells.
8. When image formed at retina, light sensitive cells gets activated and generate electrical signal. These signals are sent to brain via optic nerue. Brain analyse these signals after which we perceive object as they are.

How pupil works ?

Example : You would have observed that when you come out of the cinema hall after watching movie in the bright sun light, your eyes get closed . And when you entered the hall from the bright light, you won't be able to see and after some time you would be able to see.

Here the pupil of an eye provide a variable aperture, whose size is controlled by iris

a) When the light is bright : Iris contracts the pupil, so that less light enters the eye.

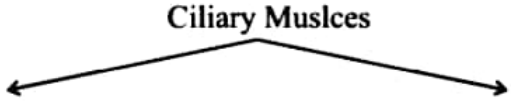
b) When the light is din : Iris expand the pupil, so that more light enters the eye.

Pupil open completely, when iris is relaxed.

Persistence of Vision : It is the time for which the sensation of an object continue in the eye. It is about $1/16^{th}$ of a second.

Power of Accommodation :

The ability of eye lens to adjust it focal length is called accommodation with the help of ciliary muscles.



Relaxed	**Contract**
1. Eye lens become thin	1. Eye lens become thick
2. Increases the focal length	2. Decreases the focal length
3. Enable us to see distant object clearly	3. Enable us to see nearby object clearly

Near point of the Eye	**For point of the Eye**
It is 25cm for normal eye. The minimum distance at which object can be seen most distinctly without strain.	It is infinity for normal eye. It is the farthest point upto which the eye can see object clearly.

DEFECTS OF VISION AND THEIR CORRECTION

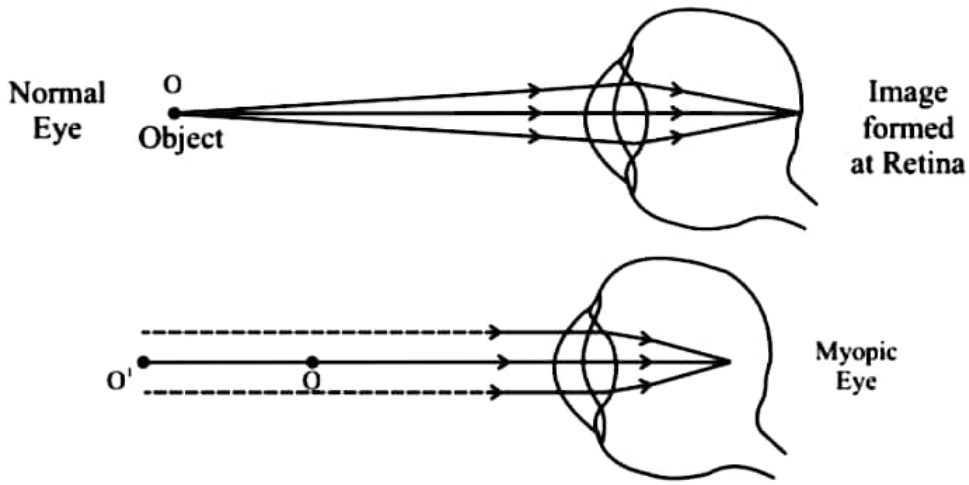
1. CATARACT : The image can not be seen distinctly because eye lens become milky and cloudy. This condition is known as cataract, it can cause complete or partial loss of vision.

   This can be corrected by surgical removal of extra growth (cataract surgery)

2. **Myopia :** (Near Sightedness)

   A person can see nearby object clearly, but cannot see distant object distinctly.

   Image formed in front of the retina.

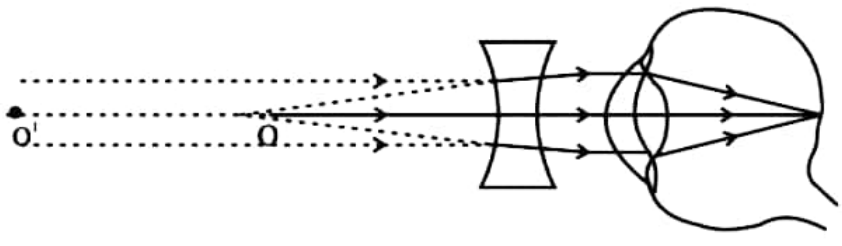


The Reason of defect

1. Excessive curvature of eye lens (thick, decrease focal length)
2. Elongation of the eye ball.

CORRECTION

Corrected by using a Concave Lens of appropriate power.

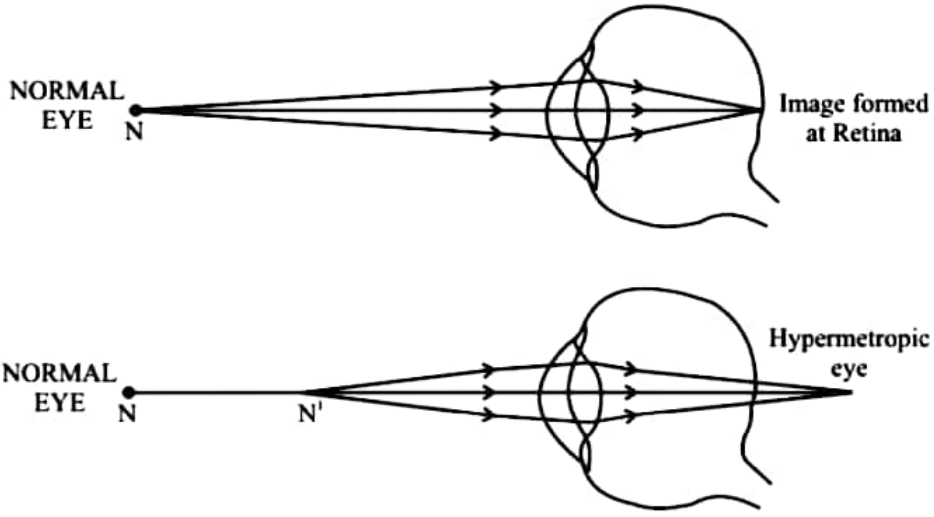


Correction of Myopita

(3) Hypermetropia (Far - Sightedness) –

A person cannot see nearby object clearly, but can see distant object distinctly.

Image formed at a point behind the retina

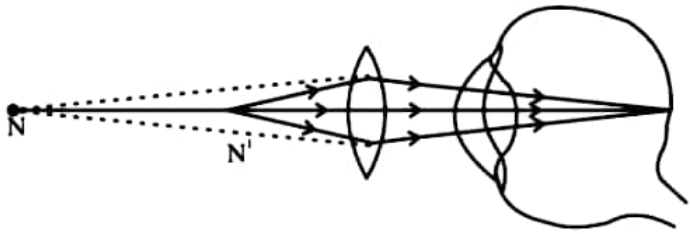


The Reason of defect

1. Increase in focal length of the eye lens (Thin eye lens)
2. Eye ball has become too small.

CORRECTION

Corrected by using a Convex Lens of appropriate power.



Correction of Hypermetropic eye

4. Presbyopia

As we become old, the power of accommodation of the eye usually decreases, the near point gradually recedes away.

This defect is called Presbyopia. Person may suffer from both myopia and hypermetropia.

Reason of defect- Gradual weakening of ciliary muscles and decreasing the flexibility of the eye lens.

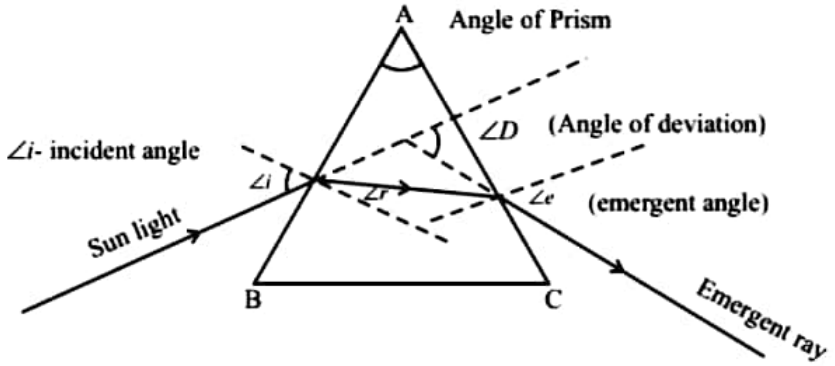
Correction- Using of ***Bifocal lens*** with appropriate power.

Bifocal lenses consist of both concave and convex lens, upper position consist of concave lens and lower portion consist of convex lens.

Refraction of light through a Prism

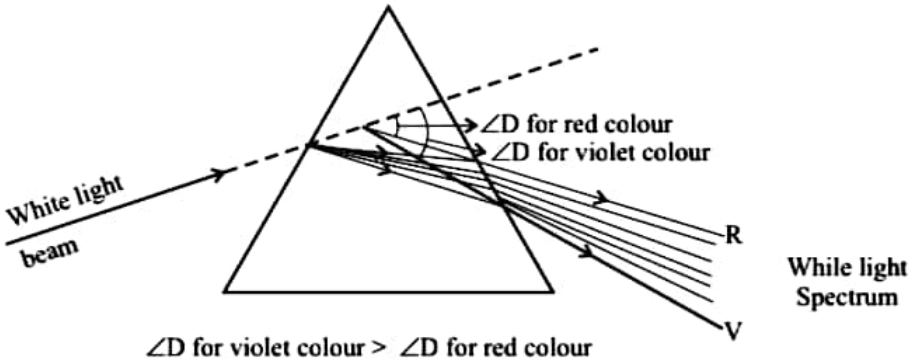
Prism- It has two triangular bases and three rectangular lateral surfaces.

These surfaces are inclines to each other. The angle between its two lateral faces is called **Angle of Prism.**



Angle of Deviation (D) → The angle between the incident ray and emergent ray.

Dispersion fo white light by a Glass Prism



∠D for violet colour > ∠D for red colour

Inclined refracting surfaces of glass prism show exciting phenomenon.

Splitting of White light into band of colours

The band of the coloured components of light beam as called **Spectrum** i.e. VIBGYOR

The splitting of light into its component colours is called **Dispersion.**

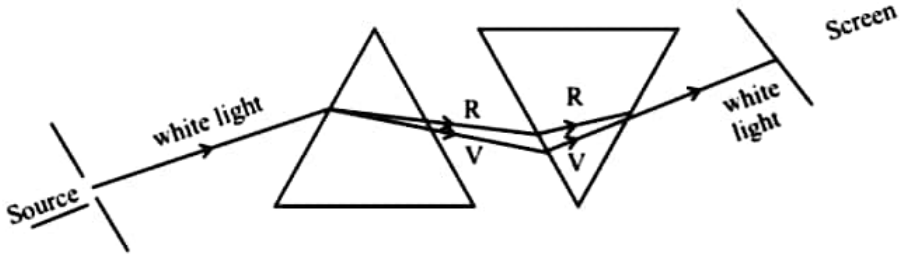
The different component colour of light bends at different angle with respect to incident angle the red light bends the least while the violet bends most.

ISSAC NEWTON → He was the first, who obtained spectrum of sunlight by using glass prism.

He tried to split the spectrum of white light more by using another similar prism, but he could not get any more colours.

He repeated the experiment using second prism in on inverted position with respect to the first prism.

Allowed all the colours of spectrum to pass through second prism. He found white light emerges on the other side of second prism.



He concluded that sun is made up of seven visible colour 'VIBGYOR'

RAINBOW → It is the spectrum of sunlight in nature It is formed due to the dispersion of sunlight by the tiny water droplet, present in atmosphere.

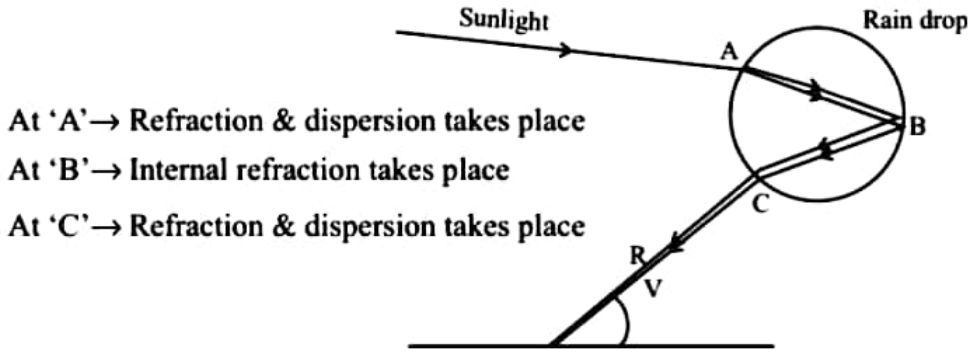
Water droplet act like prism.

It refract and disperse the incident sunlight, then reflect it internally (internal reflection) and finally refract it again, when it emerges out of the water droplet.

A rainbow is always form in a direction opposite to that of sun.

Due dispersion and internal reflection of light different colour reaches to observer's eye.

Red colour appear on top & violet at the bottom of rainbow



Atmospheric Refraction –

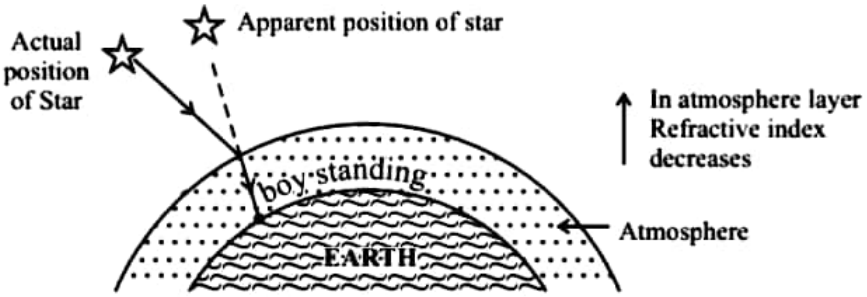
1. **Apparent Star Position**– It is due to atmospheric refraction of star light.

   The temperature and density of different layer of atmosphere keeps varying. Hence we have different medium.

   Distant star act as point source of light. When the starlight enter the earth's atmosphere it undergoes refraction continuously, due to changing refractive index i.e. from Rarer to denser. It bends towards the normal.

   Due to this the apparent position of the star is different from actual position.

   The star appear higher than its actual position.



2. **Twinkling of Star**– It is also due to atmospheric refraction

   Distant star act like a point source of light. As the beam of starlight keeps deviating from its path, the apparent position of star keeps on changing because physical condition of earth's atmosphere is not stationary

   Hence the amount of light enters our eyes fluctuate some time bright and some time faint.

   This is the "Twinkling effect of star"

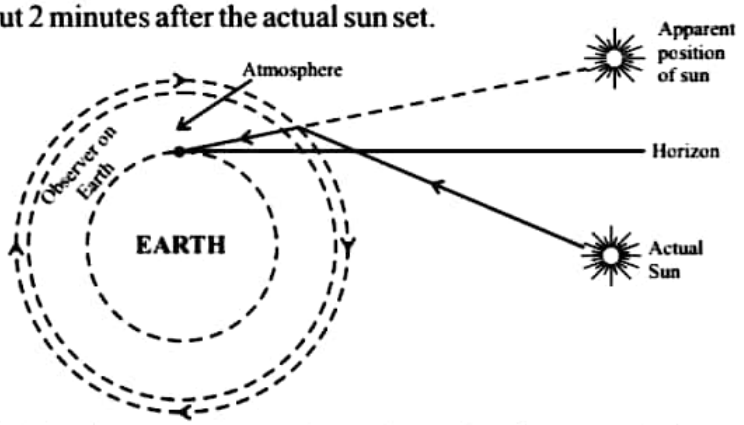
Q. **Why Planet do not twinkle?**

Ans. Planets are closer to earth and are seen as extended source of light i.e. the collection of large no: of point sized sources of light. Therefore the total amount of light entering our eyes from all individual point source will nullify the twinkling effect.

(3) **Advance Sunrise and delayed sunset**

This is also due to atmospheric refraction.

Because of this sun is visible about 2 minutes earlier than actual sunrise and about 2 minutes after the actual sun set.



Apparent flattering of the sun's disc at sun set and sun rise is due to atmospheric refraction.

Scattering of Light

Tyndall Effect– When a beam of light strikes the minute particle of earth's atmosphere suspended particles of dust and molecule of air the path of beam become visible. The phenomenon of scattering of light by the colloidal particle gives rise to Tyndall Effect.

It can be observed when sunlight passes through a canopy of a dense forest.

The colour of the scattered light depends on the size of the scattering particles

Very fine particle (scatter mainly blue colour short wave length)	Large size particle (Scatter light of longer wave length i.e. red)	Very large enough (The sky appear white)

(1) **Why cloud Appear white**– The size of water droplet (scattering particle) is very large, hence scattered all wavelength of light almost equally.

(2) **Why colour of sky is blue**– The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. Since the blue has shorter wavelength than red, hence it will scattered the most.

According to Rayleigh scattering

Scattering of light $\alpha \frac{1}{\lambda 4}$ (λ – Wavelength)

Scattering of light decreases with increase in wavelength

Q. **If there is no earth's atmosphere? What will happen to scattering phenomenon?**

Ans. There will be no scattering and sky will appear dark.

(3) **Colour of the Sun of Sunrise and Sunset**

While sunset and sunrise, the colour of the sun and its surrounding appear red.

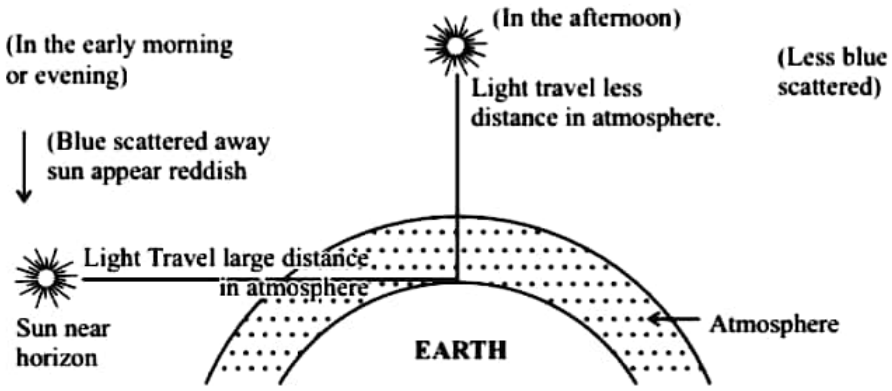
During sunset and sunrise, the sun is near horizon, and therefore the sunlight has to travel larger distance in atmosphere. Due to this most of the blue light (shorter wavelength) are scattered away by the particles. The light of longer wavelength (red colour) will reach our eye. This is why sun appear red in colour.

(4) **Why the danger signal or sign are made of red colour.**

Red colour scattered the least when strikes the small particle of fog and smoke because in has the maximum wavelength (visible spectrum). Hence at large distance also, we can see the red colour clearly.

(4) **At noon sun appear white–**

At noon the, sun is overhead and sunlight would travel shorter distance relatively through the atmosphere. Hence, at noon, the Sun appear while as only little of the blue and violet colours are scattered.



EXERCISE

(Question Bank)

Very Short Answers (1 Mark)

1. What is the phenomenon responsible for the blue colour of sky?
2. What is the near and far point of a normal eye?
3. Name the component of eye that is responsible for the adjustment of eyelens?
4. To an astronaut why does the sky appear dark instead of blue?
5. How can your remove the defect of vision 'Presbyopia'.
6. Name three primary colour? (Ans. RED, BLUE, GREEN)
7. Write the nature of image formed by our eye?
8. What do you understand by Dispersion of light?
9. What is Tyndall Effect?
10. A student has difficulty reading the black board while sitting in the last row. What is the defect of vision and how it can be corrected?

Short Answers (2 Marks)

1. Name the phenomenon responsible for formation of rainbow? Explain it with the help of diagram?
2. What is power of accommodation. How ciliary muscles helps in accommodation?
3. Why the sun appear red while sunset and sunrise. Explain?
4. Why the star twinkle but not earth?
5. Explain the function of

   (i) Iris (ii) Pupil (iii) Retina
6. Explain the refraction of light through glass prism with the help of diagram. Show angle of emergence and angle of deviation?

Long Answer Type Questions (5 Marks)

1. What is myopia. State the two causes of myopia? With the help of labelled ray diagram show
   (1) Eye defect
   (2) Correction of myopia
2. What is hypermetropia. State the two causes? With the help of labelled ray diagram show
   (1) Eye defect
   (2) Correction of hypermetropia.
3. Draw the labelled diagram of human eye and explain the image formation?

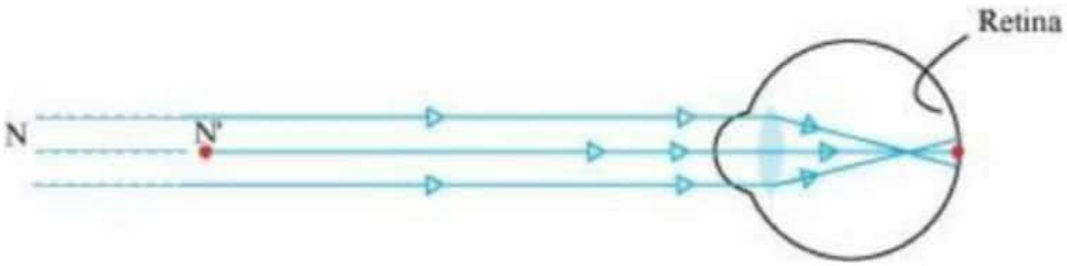
Human Eye and Colourful World

Question 1: What is meant by power of accommodation of the eye?

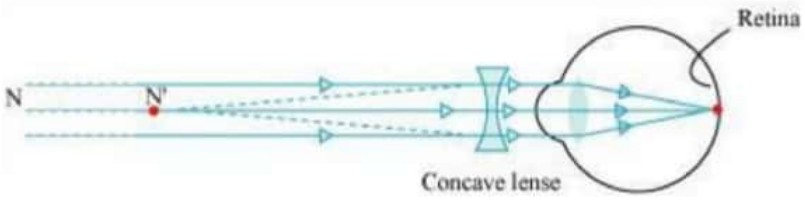
Answer: When the ciliary muscles are relaxed, the eye lens becomes thin, the focal length increases, and the distant objects are clearly visible to the eyes. To see the nearby objects clearly, the ciliary muscles contract making the eye lens thicker. Thus, the focal length of the eye lens decreases and 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.

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?

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.



Question 2: What is the far point and near point of the human eye with normal vision?

Answer: 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.

Question 3: 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?

Answer: 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.

Question 4: 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

Answer: (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.

Question 5: The human eye forms the image of an object at its

(a) cornea (b) iris (c) pupil (d) retina

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

Question 6: 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

Answer: (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.

Question 7: 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?

Answer: 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, $f = \frac{1}{P}$

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

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

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

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

Question 8: 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?

Answer: 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,

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

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

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

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

We know,

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

$$P = \frac{1}{-0.8} = -1.25 \text{ D}$$

A concave lens of power −1.25 D is required by the person to correct his defect.

Question 9: 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?

Answer: 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,

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

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

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

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

We know,

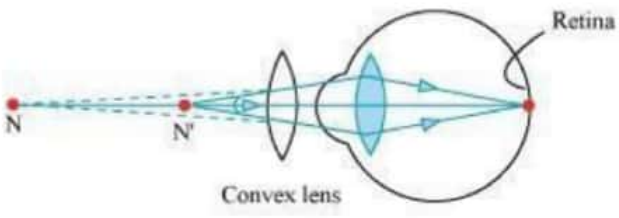
$$\text{Power, } P=\frac{1}{f\,(\text{in metres})}$$

$$P=\frac{1}{-0.8}=-1.25\text{ D}$$

A concave lens of power −1.25 D is required by the person to correct his defect.

Question 10: Make a diagram to show how hypermetropia is corrected. The near point of a hypermetropic eye is 1 m. What is the power of the lens required to correct this defect? Assume that the near point of the normal eye is 25 cm.

Answer: A person suffering from hypermetropia can see distinct objects clearly but faces difficulty in seeing nearby objects clearly. It happens because the eye lens focuses the incoming divergent rays beyond the retina. This defect of vision is corrected by using a convex lens. A convex lens of suitable power converges the incoming light in such a way that the image is formed on the retina, as shown in the following figure.



Correction for hypermetropic eye

The convex lens actually creates a virtual image of a nearby object (N' in the figure) at the near point of vision (N) of the person suffering from hypermetropia.

The given person will be able to clearly see the object kept at 25 cm (near point of the normal eye), if the image of the object is formed at his near point, which is given as 1 m.

Object distance, u = −25 cm

Image distance, v = −1 m = −100 m

Focal length, f

Using the lens formula,

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

$$\frac{1}{-100}-\frac{1}{-25}=\frac{1}{f}$$

$$\frac{1}{f}=\frac{1}{25}-\frac{1}{100}$$

$$\frac{1}{f}=\frac{4-1}{100}$$

$$f=\frac{100}{3}=33.3\text{ cm}\ =0.33\ \text{m}$$

$$\text{Power, } P=\frac{1}{f\,(\text{in metres})}=\frac{1}{0.33\text{ m}}=+3.0\text{ D}$$

A convex lens of power +3.0 D is required to correct the defect.

Question 11: Why is a normal eye not able to see clearly the objects placed closer than 25 cm?

Answer: A normal eye is unable to clearly see the objects placed closer than 25 cm because the ciliary muscles of eyes are unable to contract beyond a certain limit.

If the object is placed at a distance less than 25 cm from the eye, then the object appears blurred and produces strain in the eyes.

Question 12: What happens to the image distance in the eye when we increase the distance of an object from the eye?

Answer: Since the size of eyes cannot increase or decrease, the image distance remains constant. When we increase the distance of an object from the eye, the image distance in the eye does not change. The increase in the object distance is compensated by the change in the focal length of the eye lens. The focal length of the eyes changes in such a way that the image is always formed at the retina of the eye.

Question 13: Why do stars twinkle?

Answer: Stars emit their own light and they twinkle due to the atmospheric refraction of light. Stars are very far away from the earth. Hence, they are considered as point sources of light. When the light coming from stars enters the earth's atmosphere, it gets refracted at different levels because of the variation in the air density at different levels of the atmosphere. When the star light refracted by the atmosphere comes more towards us, it appears brighter than when it comes less towards us. Therefore, it appears as if the stars are twinkling at night.

Question 14: Explain why the planets do not twinkle?

Answer: Planets do not twinkle because they appear larger in size than the stars as they are relatively closer to earth. Planets can be considered as a collection of a large number of point-size sources of light. The different parts of these planets produce either brighter or dimmer effect in such a way that the average of brighter and dimmer effect is zero. Hence, the twinkling effects of the planets are nullified and they do not twinkle.

Question 15: Why does the Sun appear reddish early in the morning?

Answer: During sunrise, the light rays coming from the Sun have to travel a greater distance in the earth's atmosphere before reaching our eyes. In this journey, the shorter wavelengths of lights are scattered out and only longer wavelengths are able to reach our eyes. Since blue colour has a shorter wavelength and red colour has a longer wavelength, the red colour is able to reach our eyes after the atmospheric scattering of light. Therefore, the Sun appears reddish early in the morning.

Question 16: Why does the sky appear dark instead of blue to an astronaut?

Answer: The sky appears dark instead of blue to an astronaut because there is no atmosphere in the outer space that can scatter the sunlight. As the sunlight is not scattered, no scattered light reach the eyes of the astronauts and the sky appears black to them.