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## CHAPTER




Human Eye and Colourful World

## The Human Eye

Human eye is the most delicate and complicated natural optical instrument. It is used to see the beautiful nature and the natural phenomena.


It is a spherical ball of diameter about 2.3 cm . Its essential parts are described below :

- Sclerotic : It is the outermost coating of the eye ball. It is tough, white and opaque and forms white of the eye. It keeps eye ball in spherical shape and protects it from shocks and injury.
- Cornea : The transparent front projected part of eye ball is called cornea. It is a thin, transparent and white bulging portion of sclerotic in the front. It refracts most of the light rays into the eye.
- Choroid : It starts below the sclerotic. It is grey-black layer of tissues and its function is to keep the eye dark by absorbing diffused light falling on it and to avoid internal reflections within the eye.
- Iris : It is a dark muscular diaphragm that controls light level inside the eye.
- Pupil : It is the central circular aperture in the iris. Its normal diameter is 1 mm but it can contract in excess light and expand in dim light, by means of two sets of involuntary muscular fibres.
- Crystalline lens : The crystalline lens merely provides the finer adjustment of focal length required to focus objects at different distance on the retina.
- Ciliary muscles : Ciliary muscles controls the focal length of the eye lens. When these muscles contracts, the focal length of the lens increases. On the other hand, when they expand, they exert inward pressure on the eye lens and decrease the focal length of the lens.
- Optic nerve : It is a bundle of nerves originating from the brain and entering the eye ball from the posterior side. It attaches itself to the choroids. Its function is to carry electrical signals to the brain.
- Retina : It forms innermost coat in the interior of the eye. It consists of a thin membrane which is rich in nerve fibres, containing two kinds of vision cells (rods and cones) and blood vessels. It is sensitive to light, for it is a continuation of the optic nerves. It serves the purpose of a sensitive screen for the reception of the image formed by the lens system of the eye.
The retina possesses following two important spots :
- Yellow spot : It is situated at the centre of the retina. It is a slightly raised spot with a minute depression in its peak. It is yellow in colour and most sensitive to light. The central region of the yellow spot is called the fovea centalis.
- Blind spot : The point where optic nerve enters the eye ball is called blind spot. It has no nerve endings. It is the area on the retina which does not have light sensitive cells (rods and cones). So if the image is formed on this part, then no signal is sent to the brain. As a result object is not visible to the eye.

1. The chick wakes up late in the morning and goes to sleep early the evening why?
Ans.: The retina of chick's eye consists of very few rod shaped cells. Due to this it can see only in bright light.

2 Bees are able to see ultra-violet light but human beings cannot. Explain.

Ans.: The retina of bees contains cone cells which are sensitive bee ultra-violet light. Human beings do not have those cone cells and therefore, we are ultra-violet blind.

## $\left.\begin{array}{c}\text { Do You } \\ \text { Know }\end{array}\right]$

There are 100 million rod cells and 10 million cone cells on the retina. Some animals have their two eyes on the opposite sides of head, i.e., one in the front and other at the back of head. This gives a much wider field of view.

## Accommodation of an Eye

A normal eye can see the near and far off objects clearly if the sharp images of these objects are formed on the retina. Since the distance between the eye lens and retina is fixed (i.e., $v=$ constant), so to see the objects at different positions from the eye lens, the focal length of the lens has to be changed accordingly to form the sharp images of these objects $\left(\because-\frac{1}{u}+\frac{1}{v}=\frac{1}{f}\right)$.
If the object to be seen is far off (i.e., at infinity), then the sharp image of this object can be formed on the retina of the eye by increasing the focal length of the eye lens.
The focal length of a lens increases if its thickness decreases. Thus, to decrease the thickness of the eye lens and hence to increase its focal length, ciliary muscles are completely relaxed. Now the parallel beam of light coming from the far off object is focused on the retina and hence the object is seen clearly.


If the object to be seen is close to the eye i.e., near to the eye, then the sharp image of this object can be formed on the retina of the eye by decreasing the focal length of the eye lens. The focal length of a lens decreases if its thickness increases. Thus, to increase the thickness of the eye lens and hence to decrease its focal length,
 ciliary muscles contract.
Now the beam of light coming from the near object is focused by the lens on the retina. Hence the object is seen clearly.

## Conclusion

Thus, we observe that the focal length of the eye lens is adjusted automatically by the action of ciliary muscles such that a sharp images of the objects at different positions from the eye are formed on the retina. This process is known as accommodation of an eye. 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 positions from the eye is formed on the retina is known as accommodation of an eye.


An electron microscope uses an electron beam in place of light to see images of very small objects. It has a magnifying power of more than 5,00,000. It is used to see images of atoms and molecules.

## Near Point

The nearest point up to which the eye can see clearly is called the near point of the eye. For a young adult with normal vision, the near point is about 25 cm . This distance is known as least distance of distinct vision.

## Far Point

The most distant object, the eye can see is called the far point of the eye. For a normal eye it is at infinity. A normal eye can focus the objects situated anywhere from 25 cm to infinite distances.

## Range of Vision

The distance between the near point and the far point is called range of vision of the eye. Within the range of vision, there is one point where object placed are most distinctly visible. The distance of this point, from the eye, is called least distance of distinct vision. For normal eye this least distance is 25 cm .

## Power of Accommodation

The maximum variation in power of the lens to see nearby objects and distant objects clearly is called power of accommodation.
Power of accommodation of eye is the ability of the eye to observe distinctly the objects situated at widely different distances from the eye, on account of change in focal length of eye lens by the action of ciliary muscles holding the lens. The maximum power of accommodation of the eye for a person having normal vision $(d=25 \mathrm{~cm})$ is $P=\frac{100}{f}=\frac{100}{d}=\frac{100}{25}=4$ dioptre.

## Do You Know J]

Focal length of an eye lens cannot be decreased below a certain limit.

## Persistence of Vision

It is one of the important characteristics of human eye. The image of an object formed on the retina of the eye is neither permanent nor it fades away instantly. In fact, the image of any object seen persists on the retina for $1 / 16$ second, even after the removal of the object. This continuance of sensation of eye for some time is called persistence of vision. If another object is seen before the impression of the first object fades away completely, the eye is not able to separate the two impressions, and a sense of continuity developes.

## To study the 3D effect.

This simple demonstration shows exactly how the eyes are used
Activity GORNER during parallel-viewing. For this pick a specific object at a certain distance. Aim your eyes at that target. While looking at that distant target, bring your index fingers, tips touching, up in front of your eyes and in to your line of sight. While still aiming your eyes at the distant target, calmly notice that a mini-frank has appeared between the tips of your fingers. Do not allow the beauty of the mini-frank to distract you at it.


Continue to aim your eyes into the distance at your target. Pull the tips of your finger apart slightly and observe the frank furter floating in the air. Wiggle your fingers and watch the mini-frank dance. Remember how your eyes feel while performing this feat and you can apply the same skills to 3D viewing.

## Defects of Vision and their Correction

Sometimes, the eye may gradually lose its power of accommodation. In such conditions, the person cannot see the objects distinctly and comfortably. The vision becomes blurred due to the refractive defects of the eye. There are mainly three common refractive defects of vision. These are :

- Myopia (near-sightedness or short sightedness)
- Hypermetropia (far-sightedness or long sightedness)
- Presbyopia


## Myopia (Near-sightedness or Short sightedness)

Myopia is that defect of human eye by virtue of which it can see clearly the objects lying at short distance from it. But the far off objects cannot be seen clearly by the myopic eye.

Causes of Myopia : The two possible causes of this defect are :

- Increase in the length of the eye ball, as if distance of retina from the eye lens has increased
- Decrease in focal length of the eye lens when the eye is fully relaxed. This is as if the ciliary muscles holding the eye lens do not relax fully and have some tension.
Correction : The image of a distant object (i.e., at infinity) is formed in front of the retina of eye suffering
from myopia as shown in figure. (a)


As the image of the object lying at infinity is not formed on the retina of the eye, so such object can not be seen clearly by the myopic eye. The far point of such an eye is near to the eye as shown in figure (b).

(b) Far point of a myopic eye

This defect can be corrected by using a concave lens of suitable focal length. So, a man suffering from this defect wears spectacles having concave lens of suitable focal length. The concave lens diverges the rays of light entering the eye from infinity. Hence this lens makes the rays of light appear come from the far point $\left(O^{\prime}\right)$ of the defective eye as shown in figure (c).

(c) Correction for myopia

Let $x=$ distance of far point of myopic eye, $f=$ focal length of concave lens to be used.
As the object to be seen is at infinity and its image is to be formed at the far point, therefore, $u=\infty$ and $v=-x$. Distance of far point $O^{\prime}$ from eye lens is taken same as the distance of far point $O^{\prime}$ from concave lens.
From, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$ or $f=-x$
Hence, focal length of concave lens used for correcting the myopic eye is equal to distance of far point of the myopic eye.
3. The far point of a myopic person is 80 cm . What is the focal length of the lens required to enable him to see very distant objects clearly?
Ans.: Far point of normal human eye is infinity. i.e.,
and $\quad v=-80 \mathrm{~cm}$
Use lens formula:

$$
\begin{gathered}
\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \\
f=-80^{\frac{1}{-80}-\frac{1}{-\infty}=\frac{1}{f}}
\end{gathered}
$$

negative focal length means concave lens.

## Hypermetropia (Far-sightedness or Long sightedness)

A human eye which can see far off objects or distant objects clearly but can not see the near objects clearly is said to be suffered with a defect known as long sightedness or far sightedness or Hypermetropia.
Causes : The two possible causes of this defect are :

- Decrease in length of the eye ball, as if distance of retina from the eye lens has decreased.
- Increase in focal length of the eye lens, when the eye is fully relaxed.

Correction : The image of a normal near point (which is 25 cm from the eye lens) is formed behind the retina of eye having long-sight defect as shown in figure (a).

(a) Hypermetropic eye

The image of the normal near point formed on the retina is blurred. The near point of such eye is little far from the near point of normal eye as shown in figure (b).

(b) Near Point of a Hypermetropic eye

This defect can be corrected by using a convex lens of suitable focal length. So, a man suffering from this defect wears spectacles having convex lens of suitable focal length. The convex lens of spectacles reduces the divergence of rays of light entering the eye. Hence this lens makes the rays of light appear to come from the near point of the defective eye as shown in figure (c).
Let $x=$ distance of near point $O^{\prime}$ of defective eye,
$d=$ distance of near point $O$ of normal eye
$=$ least distance of distinct vision of normal eye.
$f=$ focal length of convex lens to be used.
For the correcting lens, object is at $O$, i.e., $u=-d$
Image is at $O^{\prime}$,i.e., $v=-x$

(c) Correction for Hypermetropic eye

As $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}, \therefore \frac{1}{f}=\frac{1}{-x}+\frac{1}{d}=\frac{-d+x}{x d} \Rightarrow f=\frac{x d}{x-d}$
As $x>d, f$ is positive. Therefore, correcting lens must be convex.

5 A person cannot see distinctly any object placed beyond 40 cm from his eye. Calculate the power of the lens which will enable him to see distant stars clearly.
Ans.: As the person cannot see objects clearly beyond 0.4 m , his far point is 0.4 m . He wants to see distant stars clearly, i.e., distance of object

## 彩 ILLUSTRATION

is infinity. So he should use lens which forms image of distant object $(u=-\infty)$ at a distance of 40 cm is in front of it.

$$
-\frac{1}{0.40}-\frac{1}{-\infty}=\frac{1}{f}=P \text { i.e., } P=\frac{10}{-4}=-2.5 \mathrm{D}
$$

## Presbyopia

A human eye which cannot see the near objects clearly is said to suffer from a defect known as presbyopia. Eye suffering from presbyopia cannot read and write comfortably. This is a kind of hypermetropia which is experienced in old age and therefore, also called old age hypermetropia.

Cause of Presbyopia: 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 focus on close objects.

## Correction of presbyopia :

(i) This is corrected by using a convex lens of suitable power, which is added to glasses, if any for the distant vision.
(ii) Sometimes a person may suffer from both the defects of vision, i.e., myopia and hypermetropia. Such type of defects can be corrected by using bifocal lenses which consist of both concave and convex lenses.


The upper portion of the spectacles consists of concave lens for the person to see distant objects and the lower portion consists of convex lens which help him to see nearby objects.
To correct presbyopia, an old person has to use spectacles with a convex lens of suitable focal length, or power.

The cause of hypermetropia is decrease in length of eye ball or increase in focal length of eye lens. But the cause of presbyopia is only increase in focal length of eye lens. The eye ball, in presbyopia, has normal length.

## Do You Know J <br> - Presbyopia is a natural part of ageing process. It is not a disease and cannot be prevented. <br> - An eye can suffer from myopia, hypermetropia as well as astigmatism simultaneously.

## Prism

Prism is a homogenous transparent refracting medium bounded by at least two non-parallel surfaces inclined at some angle. The two plane surfaces $P Q B D$ and $P R C D$ are called as refracting faces.


The line along which the two refracting faces meet is called refracting edge of the prism. The angle between the two refracting faces is called the angle of prism and is denoted by $A$. The section $D B C$ of the prism is known as principal section.

## Refraction of Light through a Prism

Figure shows the principal section of a prism $D B C$ with angle $A$. Consider a ray of light $P Q$ incident on refracting face $D B$ at point $Q . N_{1} N$ is the normal at point $Q$. The incident ray $P Q$ is refracted along $Q L$ and bends towards normal. The refracted ray $Q L$ again suffers refraction at $L$ and emerges out along $L M$ away from normal $N_{2} N$ at point $L$. The ray $P Q, Q L$ and $L M$ are known as incident ray, refracted ray and emergent ray respectively.


Further, the angles $P Q N_{1}=\angle i_{1}, M L N_{2}=\angle i_{2}, L Q N=\angle r_{1}$ and $Q L N=\angle r_{2}$ are known as angle of incidence, angle of emergence, angle of refraction at surface $D B$ and angle of incidence at surface $D C$ respectively. If the incident ray is produced forward and emergent ray $L M$ is produced backward, then the two rays meet at $O$. The angle $\angle T O L=\delta$ is known as angle of deviation. So, the angle of deviation means the angle between emergent and incident rays, i.e., the angle through which the incident ray has turned in passing through the prism.
From triangle $Q O L, \delta=\left(i_{1}-r_{1}\right)+\left(i_{2}-r_{2}\right)=\left(i_{1}+i_{2}\right)-\left(r_{1}+r_{2}\right)$
From quadrilateral $D Q N L, A+90^{\circ}+\theta+90^{\circ}=360^{\circ}$
or $A+\theta=180^{\circ}$
From triangle $Q N L, r_{1}+r_{2}+\theta=180^{\circ}$
From eqs. (ii) and (iii), $r_{1}+r_{2}+\theta=A+\theta$
$\therefore \quad r_{1}+r_{2}=A$
Substituting the value in eq. (i) we get $\delta=\left(i_{1}+i_{2}\right)-A$
or $i_{1}+i_{2}=\delta+A$
To find angle of deviation of a ray of light passing through the prism.
Procedure : Place a glass prism on a sheet of white paper. Mark its boundary with a pencil. Now fix two pins at points $B$ and $C$ as shown in figure. Look through the refracting face $a c$ and fix two pins at $H$ and $I$ such that the pins $H$ and $I$ and the images of pins $B$ and $C$ line in a straight lie. Now remove the prism and all pins. Join the points $B$ and $C$ and extend this line so that it touches the refracting surface $a b$ at point $E$. Also join the points $H$ and $I$ and extend this line so that it touches the refracting surface ac at point $G$.


Also join points $E$ and $G$. Draw perpendiculars $N_{1} N_{1}^{\prime}$ and $N_{2} N_{2}^{\prime}$ on the refracting surface $a b$ at point $E$ and on the refracting surface $a c$ at point $G$ respectively. $\angle N_{1} E C=\angle i$, angle of incident and the ray $B C E$ is the incident ray. $\angle N_{2} G H=\angle i_{2}$, angle of emergence and the ray $G H I$ is the emergent ray. Produce the emergent ray GHI backward so that it intersects the incident ray produced forward at point $J$. $\angle F J G=\angle D$, angle of deviation of the incident ray of light passing through the prism.
Thus, angle of deviation of a ray of light is defined as the angle between the directions of incident ray of light and the emergent ray of light.

## Dispersion of White Light by a Glass Prism

When a ray of white light (sunlight) enters a glass prism (denser medium), it emerges out from it, broken into seven colours. This phenomenon, due to which different components of a white light are separated by a denser medium, is called dispersion.
The phenomenon of splitting of white light into seven colours when it passes through a glass prism is called dispersion of white light.


When the dispersed white light is made to fall on a white screen, we get a seven coloured band of light. This coloured band is called spectrum.
The order of the colours from the lower end of the spectrum is violet, indigo, blue, green, yellow, orange and red. The colours can be remembered by the word VIBGYOR. In air, light waves of all colours have same velocity $\left(3 \times 10^{8} \mathrm{~m} \mathrm{~s}^{-1}\right)$.

White light is a mixture of seven colours. Every colours has its own characteristic wavelength. Wavelength of different colours are given in the table.

| S. NO. | Colours | Wavelength |
| :---: | :---: | :---: |
| 1 | Violet | $4000 \AA$ |
| 2 | Indigo | $4500 \AA$ |
| 3 | Blue | $4800 \AA$ |
| 4 | Green | $5400 \AA$ |
| 5 | Yellow | $5800 \AA$ |
| 6 | Orange | $6000 \AA$ |
| 7 | Red | $7900 \AA$ |

## Recombination of colours of spectrum to give white light

Isaac Newton was the first to use a glass prism to obtain the spectrum of sunlight. He tried to split the colours of the spectrum of white light further by using another similar prism. However, he could not get any more colours. He then placed a second identical prism in an inverted position with respect to the first prism, as shown in figure.


This allowed all the colours of the spectrum to pass through the second prism. He found a beam of white light emerging from the other side of the second prism. This observation gave Newton the idea that the sunlight is made up of seven colours. Any light that gives a spectrum similar to that of sunlight is often referred to as white light.
The first prism is known as dispersing prism as dispersion takes place at the first face of prism $(A)$ and second prism $(B)$ recombines the dispersed colours therefore it is known as recombination prism. Both the prism $A$ and $B$ together act as a glass slab with parallel sides, and emergent ray is parallel to the incident ray.

## Do You Know 5

In vacuum, dispersion of light does not take place because all colours travel with same speed in vacuum.

6 What will be the colour of the emergent light when white light is incident on a thin walled hollow glass prism.
Ans.: The emergent light is white because the outer faces of the prism behave like hollow plates as shown in figure.


To show that a glass prism splits colours of white light passing through it and does not produce any colour by itself.

## Activity GORNER

After obtaining the spectrum of sunlight; Newton tried a few more experiments. He tried to further split up the colours of the spectrum by using another similar prism. For this he made a small hole in the white screen and obtained the spectrum from the first prism on it. He adjusted the screen in such a way that only a limited portion of spectrum (a single colour say yellow colour) passes through the hole. This is then made to fall on the similar prism $B$ which is placed in an inverted position with respect to the screen.


This shows that prism does not produce any colour by itself. Dispersion takes place at first face of the prism and afterwards at second prism it gets refracted only.

## Dispersion of Light in Nature

When sunlight falls on the water drops suspended in the atmosphere after rainfall, rainbow is formed due to the dispersion of sun light. The water drops suspended in air (or atmosphere) act as prisms.

## Rainbow

It is the example of dispersion of sunlight. When sunlight falls on a water drop suspended in air, then the sunlight is refracted. The refracted sunlight splits (or dispersed) into its constituent colours (i.e., seven colours). Thus, water drop suspended in air behaves as a glass prism. The red colour deviates the least and the violet colour deviated the most. Different colours of refracted sunlight 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 into the air. Thus, we get a spectrum of seven colours, which is known as a rainbow.


Rainbow is observed during a rainfall or after the rainfall or when we look at a water fountain provided the sun is at the back of the observe.

## Atmospheric Refraction

When sunlight enters the earth's atmosphere, then it continuously goes from rarer to the denser medium therefore, refraction of light takes place. The refraction of light taking place in the atmosphere is known as atmospheric refraction.

## Twinkling of Stars

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 close to the surface of the earth are optically denser. As we go higher and higher, the density of layers and refractive index decreases progressively. As the light from a star enters the upper-most layer of the atmosphere, it bends towards the normal as it enters the next layer.


This process continues till the light enters our eyes. So due to refraction of light, the apparent position of the star is different from the actual position of the star. Moreover, 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 change in the apparent position of the star continuously leads to the twinkling of a star.

Planets do not twinkle, because planets are very close to the earth as compared to the stars. So the intensity of light we receive from the planets is very large. Therefore, the variation in the brightness of the planets is not detected.

## Advanced Sunrise and Delayed Sunset

The sun is visible to us about 2 minutes before the actual sunrise, and about 2 minutes after the actual sunset because of atmospheric refraction. By actual sunrise. We mean the actual crossing of the horizon by the sun. In the figure the actual and apparent positions of the sun with respect to the horizon is shown. The time difference between actual sunset and the apparent sunset is about 2 minutes. The apparent flattening of the Sun's disc at sunrise and sunset is also due to the same phenomenon. Thus, we gain about 4 minutes of additional daylight each day.


## The Sun Appears oval (flattened) at Sunset and Sunrise but Appears Circular at Noon

At sunset and sunrise, the sun is near the horizon. The rays of light from the upper and lower edge of the sun bend unequally while traveling through the atmosphere. As a result of this phenomenon, the sun appears oval or flattened.


At noon, the sun is overhead.
The rays of light from 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 re-emit light in all directions. This process is known as scattering of light.
We know that light travels in the form of electromagnetic radiations, when these radiations interact with matter, scattering of light takes place. This phenomenon is exhibited practically by all matter. It can even be observed when a strong beam of light is passed through colloidal solution; the path of beam becomes visible.

Another important factor in scattering of light is relative size of the scatterers (say $x$ ) compared to the wavelength of light $(\lambda)$.
For $x \ll \lambda$, i.e., when size of scatterer is much less than the wavelength of light, Rayleigh scattering is valid.
According to Rayleigh scattering, intensity of light scattered $\propto \frac{1}{\lambda^{4}}$.
However, when $x \gg \lambda$, i.e., size of scatterer is much larger than the wavelength of light, Rayleigh scattering is not valid. In that event, all wavelengths are scattered nearly equal.
These conclusions regarding the scattering of light have been verified experimentally by Tyndall.

## Tyndall Effect

The phenomenon of scattering of light by dust, smoke and tiny water droplets suspended in air is known as Tyndall effect.
Examples of Tyndall effect are
(i) When a beam of sunlight enters a dusty room through a window, then path becomes visible to us.
(ii) A beam of sunlight becomes visible as it passes through dust particles in the air of a room.
(iii) Tyndall effect is seen, when sun light comes down through the clouds.
(iv) When sunlight passes through a canopy of a dense forest, tiny water droplets in the mist scatter light.

## $\underset{\text { Know }}{\text { Do You }}$

Coloured television sets and computer monitors produce the entire range of colours by using red, green and blue phosphors.

To study the scattering of light in colloidal solution.
Place a strong source $(S)$ of white light at the focus of a converging lens $\left(L_{1}\right)$. This lens provides a parallel beam of light.
Allow the light beam to pass through a transparent glass tank ( $T$ ) containing clear water. Allow the beam of light to pass through a circular hole (C) made in a cardboard. Obtain a sharp image of the circular hole on a screen (MN) using a second converging lens ( $L_{2}$ ), as shown in Figure.


Dissolve about 200 g of sodium thiosulphate (hypo) in about 2 L of clean water taken in the tank. Add about 1 to 2 mL of concentrated sulphuric acid to the water. What do you observe?
You will find fine microscopic sulphur particles precipitating in about 2 to 3 minutes. As the sulphur particles begin to form, you can observe the blue light from the three sides of the glass tank. This is due to scattering of short wavelengths by minute colloidal sulphur particles. Observe the colour of the transmitted light from the fourth side of the glass tank facing the circular hole. It is interesting to observe at first the orange red colour and then bright crimson red colour on the screen.

## Applications of Scattering of Light

## The blue colour of the clear sky

In white light, the blue colour has smallest wavelength and in the atmosphere the molecules of air and other fine particles have sizes smaller than the wavelength of visible light. Therefore blue light is scattered more than any other colour. That is why sky appears blue. If earth had no atmosphere there would not have been any scattering and the sky would have looked dark. That is why it appears dark to the passengers flying at very high altitudes, as scattering is not prominent at such heights.

## Colour of the sun at sunrise and sunset

At the time of sunrise and sunset, 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 red light. As a result of this, more red light reaches our eyes than any other colour. Therefore at sunset and sunrise sun appears red.

When the sun is overhead in the noon, the light waves of shorter wavelengths of light-blue and violet get scattered by the particles near the horizon but the longer wavelengths (colours orange and red) are scattered least, i.e., they travel relatively undisturbed
 and reach the earth.

## White colour of clouds

We know that if the size of the scattering particles is large enough, than the scattered light may even appear white. Clouds are generally at lower heights of the atmosphere and lower atmosphere contains large dust particles and water droplets which scatter all colours or wavelength and clouds generally appear white.

## Danger signals are of red colour

When light falls on the signal, all colours are scattered much more than that of red colour. So the red colour suffering least scattering remains confined around the signal, which in turn illuminates the signal significantly. Thus, the danger signals can be seen from very far off distances. Moreover, among all colours, red colour or red light is scattered least by smoke or fog. Hence red signals are visible even through the smoke or fog.

## Yellow colour headlights in foggy weather

In a foggy weather scattering of light is large because of more particles (scatters) are present in air. Yellow colour light is used in the headlights of the vehicles because wavelength of yellow colour of the light is large and it does not undergo large scattering. It is observable from a large distance and is easy to produce.


Sky appears greyish over cities having industrial units. The smoke and dust particles in the atmosphere over such cities scatter red, orange and yellow colours more than other colours of small wavelength. Hence, the sky appears greyish.

## CONCEPT MAP




Refraction through a prism
Minimum deviation

$$
n=\frac{\sin \left(\frac{A+D_{m}}{2}\right)}{\sin \left(\frac{A}{2}\right)}
$$

## Atmospheric refraction

- Twinkling of stars.
- Advanced sunrise and delayed sunset.
- Sun appear oval at sunset and sunrise but circular at noon.


Occurs in old age. It can be corrected by using bifocal lens.

Cannot focus on both horizontal and vertical lines simultaneously. It can be corrected by using cylindrical lens.

Scattering of light : It is the bouncing off of light by atoms/molecules of the medium through which they are travelling.

Human Eye and Colourful World



Tyndall effect : It deals with the phenomenon of scattering of light by colloidal particles.

## ESSENTIAL POINTS for COMPETITIVE EXAMS

- Human Eye : It is a light sensitive organ which enable us to see.
- Parts of human eye are cornea, iris, lens, ciliary muscles, retina and optic nerve.
- Cornea is the aperture or window of an eye. It allows light to enter in the eye.
- Iris controls the amount of light entering the eye through pupil.
- Ciliary muscles : It increases or decreases the focal length of the eye lens.
- Retina : It acts as the screen or film to obtain the image of an object.
- Optic nerve : It carries signal to the brain for interpretation.
- Accommodation of an eye : It is the ability of eye lens to change its focal length to form sharp images of objects at different positions from the eye on the retina of the eye.
- Near point : It is the nearest position of an object from human eye so that its sharp image is formed on the retina.
- Near point of a normal human eye is 25 cm .
- Far point is the farthest position of an object from a human eye so that the sharp image of the object is formed on the retina.
- Range of vision : It is the distance between the near point and the far point of an eye.
- For normal human eye, the range of vision is 25 cm to infinity
- Power of accommodation of a normal human eye is about 4 dioptre.
- Myopia or near-sightedness : A person with myopia can see nearby objects clearly but cannot see distant objects distinctly. It is caused by (i) excessive curvature of the eye ball (ii) elongation or increase in the size of the eye lens. It can be corrected by using spectacles with a concave lens of suitable focal length.
- Hypermetropia or far-sightedness: A person with hypermetropia can see distant objects clearly but cannot see nearby objects distinctly. It is caused by (i) increase in the focal length of the eye lens (ii) shortening or decrease in the size of the eye lens. It is corrected by using spectacles made from convex lens of suitable focal length.
- Presbyopia : In this defect, the power of accommodation of the eye decreases with ageing. It can be corrected by using a bifocal lens consisting of a concave and convex lens.
- Astigmatism: A human eye which cannot focus on both horizontal and vertical line simultaneously suffers from astigmatism.
- Cataract: An eye in which an opaque membrane is formed over the eye lens suffers form cataract. Cataract can be corrected by performing surgery.
- Prism : It is a homogeneous transparent refracting medium bounded by at least two non-parallel surfaces inclined at some angle.
- Dispersion of white light: The phenomenon of splitting of white light in to seven colours when it passes through a glass prism is called dispersion of white light.
- Red colour deviates the least while passing through a glass prism.
- Violet colour deviates the most while passing through a glass prism
- Spectrum: The band of colour components of a light beam obtained on a white screen when white light passes through a prism is called the spectrum.
- Rainbow: A rainbow is a natural spectrum of sunlight in the form of bows appearing in the sky when the sun shines on raindrops after the rain. The raindrops act like small prisms.
- Atmospheric refraction: When the light rays pass through the atmosphere having layers of different densities and refractive indices, then refraction of light takes place. This refraction of light by the earth's atmosphere is called atmospheric refraction.
- Scattering of light: It is a phenomenon of change in the direction of light on striking a particle like an atom, a molecule, dust particles, water droplets, etc. It explains the phenomenon like blue colour of the sky, the reddening of the sun at sunrise and the sunset, etc.
- Intensity of scattered light, $I \propto \frac{1}{\lambda^{4}}$, if size of scatterer is small as compared to the wavelength $(\lambda)$ of light.
- In a clear atmosphere of the earth, colours of small wavelengths like violet, and blue are scattered more than red colour.
- In a polluted atmosphere of the earth, the scattering of colours of higher wavelengths is more than the scattering of colours of smaller wavelengths.
- Blue colour of sky, greenish-blue colour of sea water, red colour of sunset and sunrise and white colour of clouds are due to scattering of light.


## SOLVED EXAMPLES

1. Calculate the power of the eye lens of the normal eye when it is focused at its (a) far point, infinity and (b) near point, 25 cm from the eye. Assume the distance of the retina from the eye lens to be 2.5 cm .
Ans.: (a) When the object is at infinity, the image forms at the focus of the lens $(v=f)$. Hence, the focal length in this case is 2.5 cm . Thus the power is

$$
P_{1}=\frac{1}{f}=\frac{1}{2.5 \times 10^{-2} \mathrm{~m}}=40 \mathrm{D}
$$

(b) In this case, the object is at 25 cm from the eye lens, and the image is formed at 2.5 cm from the eye lens.
So, $u=-25 \mathrm{~cm}, v=2.5 \mathrm{~cm}$. Then,

$$
\begin{aligned}
& \frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{2.5 \mathrm{~cm}}-\frac{1}{25 \mathrm{~cm}} \\
\therefore \quad & P_{2}=\frac{100}{2.5 \mathrm{~m}}+\frac{100}{25 \mathrm{~m}}=44 \mathrm{~m}^{-1}=44 \mathrm{D}
\end{aligned}
$$

The maximum variation in the power is, $44 \mathrm{D}-40 \mathrm{D}=4 \mathrm{D}$
2. A person is able to see object clearly only when these are lying at distance between 50 cm and 300 cm from his eye.
(i) What kind of defect of vision he is suffering from?
(ii) What kind of lenses will be required to increase his range of vision from 25 cm to infinity? Explain briefly.
Ans.: (i) For a normal eye, the near point is at 25 cm and the far point is at infinity from the eye. The given person cannot see object clearly either closer to the eye or far away from the eye. So, he is suffering from both myopia and hypermetropia.
(ii) A bi-focal lens consisting of a concave lens and convex lens of suitable focal lengths will be required to correct the
defects and to increase his range or vision from 25 cm to infinity. In a bi-focal lens, upper portion is concave which corrects distant vision and lower portion is convex which corrects near vision.
3. When white light passes through a glass prism, seven colours namely red, orange, yellow, green, blue, indigo and violet are seen on the white screen. All these colours have different angles of deviation. Explain why?
Ans.: Speed of colour in a medium depends upon its wavelength. All the colours have different wavelength. The red colour has the longest wavelength and violet colour has the least wavelength. Therefore, red colour has the highest speed in the glass prism and the violet colour has the lowest speed in the glass prism. Hence, all colours of white light are refracted by different amount while passing through the glass prism. Therefore, all the colours have different angles of deviations.
4. The near point of an elderly person in 50 cm from the eye. Find the focal length and power of the corrective lens that will correct his vision.
Ans.: The near point of an elderly person $=50 \mathrm{~cm}$ from the eye.
Hence, $v=-50 \mathrm{~cm}, u=-25 \mathrm{~cm}$
$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{-1}{50}+\frac{1}{25}=\frac{-1+2}{50}=\frac{1}{50 \mathrm{~cm}}$
$\therefore \quad f=50 \mathrm{~cm}$ or 0.5 m
Power of the lens $=\frac{1}{f}=\frac{1}{0.50 \mathrm{~m}}=+2$ dioptres
5. A person cannot see distinctly any object placed beyond 40 cm from his eye. Calculate the power of the lens which will enable him to see distant stars clearly.

Ans.: As the person cannot see objects clearly beyond 0.4 m , his far point is 0.4 m . He wants to see distant stars clearly, i.e., distance of object is infinity. So he should use lens which forms image of distant object ( $u=-\infty$ ) at a distance of 40 cm in front of it.
Using lens formula, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$
\frac{1}{-0.40}-\frac{1}{-\infty}=\frac{1}{f}=P
$$

i.e., $\quad P=-\frac{10}{4}=-2.5 \mathrm{D}$
6. (a) What is the power of the eye glasses worn by a person whose far point is 5 m ?
(b) Locate the virtual image of an object 2 m in front of the eye glasses.
Ans.: (a) As here far point is 5 m while for normal eye it is $\infty$, $u=-\infty$ and $v=-5 \mathrm{~m}$
So, $\frac{1}{-5}-\frac{1}{-\infty}=\frac{1}{f}=P$ i.e., $P=-0.2 \mathrm{D}$
(b) If the object is at a distance of 2 m
$\frac{1}{v} \times \frac{1}{2}=\frac{1}{-5} \quad$ i.e., $\frac{1}{v}=\frac{1}{-5}-\frac{1}{2}$
i.e., $\frac{1}{v}=-\frac{7}{10} \quad$ or $v=\frac{10}{7}=1.43 \mathrm{~m}$
i.e., the virtual image of object which is at 2 m will be formed at a distance of 1.43 m from the lens on the same side.
7. A person needs a lens of power -6.5 dioptres for correcting his distant vision. For correcting his near vision he needs a lens of power +2.5 dioptre. What is the focal length of the lens required for correcting (i) distant vision, and (ii) near vision?
Ans.: (i) Focal length of distance vision

$$
=\frac{1}{\text { Power }}=\frac{-100}{6.5} \mathrm{~cm}=-15.38 \mathrm{~cm}
$$

(ii) Focal length in near vision

$$
=\frac{100}{2.5} \mathrm{~cm}=40 \mathrm{~cm}
$$

8. Why the sun appears oval at sunrise and sunset, and circular at noon?
Ans.: This can be explained in terms of atmospheric refraction. At sunrise and sunset, the sun is near the horizon. The rays of light from the upper part and lower part of the periphery of the sun bend unequally on travelling through earth's atmosphere. That is why the sun appears oval or flattened at the time of sunrise and sunset.
At noon, the sun is overhead. The rays of light from the sun enter earth's atmosphere normally. Therefore, they suffer no refraction or bending on passing through earth's atmosphere. Hence the sun appears circular at noon.
9. What is meant by accommodation of human eye? How is it achieved?
Ans.: Accommodation or power of accommodation of human eye is the ability of the eye to observe distinctly the objects situated at widely different distances from the eye. This property is due to the action of ciliary muscles holding the eye lens. For observing distant objects, eye is in relaxed state, i.e., unaccommodated. The eye lens is thin and image of distant object is formed on the retina.
For observing nearby objects, the ciliary muscles contract, the eye is in a state of tension. It is said to be accommodated.
10. What is meant by range of vision? What is its value for a person with normal vision?
Ans.: The range of vision of a person is the distance between near point $(N)$ and far point $(F)$ of his eyes. The point at closest distance, at which an object can be seen clearly by the eye is called near point ( $N$ ) of the eye.
The most distant point at which an object can be seen clearly is called far point $(F)$ of the eye. For a normal eye, far point lies at infinity. Therefore, for a person with normal vision, the range of vision is infinite.
11. What is meant by power of accommodation of the eye?
Ans.: Power of accommodation of eye is the ability of the eye to observe distinctly the objects situated at widely different distances from the eye, on account of change in focal length of eye lens by the action of ciliary muscles holding the lens.
12. 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 corrective lens should form the image of the far off object at the far point of the myopic person. So, by using the lens formula, we can write

$$
\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-1.2 \mathrm{~m}}-\frac{1}{\infty}=-\frac{1}{1.2 \mathrm{~m}}
$$

or, $f=-1.2 \mathrm{~m}$
So, power of the lens, $P=-\frac{1}{1.2} \mathrm{D}=-0.83 \mathrm{D}$
3. What is the far point and near point of the human eye with normal vision?
Ans.: The nearest point up to which an eye can see clearly is called its near point. For a normal eye, the near point is at a distance of 25 cm .
The farthest point up to which an eye can see clearly is called its far point. For a normal eye, the far point is at infinity.
4. A student has difficulty in 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.: The student is suffering from myopia. Myopia can be corrected by using glasses made from concave lens of suitable focal length.
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) near-sightedness
(c) accommodation
(d) far-sightedness

Ans.: (c) The property of the eye to adjust the focal length of eye lens is called accommodation. Choice (c) is correct.
6. The human eye forms the image of an object at its
(a) cornea
(b) pupil
(c) iris
(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 for a young adult with normal vision is 25 cm .
8. The change in focal length of an eye lens is caused by the action of
(a) pupil
(b) retina
(c) iris
(d) ciliary muscles

Ans.: (d) The action of ciliary muscles holding the eye lens changes the focal length of eye lens enabling the eye to focus the image of objects at varying distances.
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 (a) distant vision, and (b) near vision?
Ans.: For the near-sighted person, the power of the lens used for distant-viewing is -5.5 D .
So, For distance viewing

$$
\begin{aligned}
& =\frac{1}{\text { Power }}=\frac{1}{-5.5 \mathrm{D}}=\frac{1}{-5.5 \mathrm{~m}^{-1}} \\
& =-0.18 \mathrm{~m}=-18 \mathrm{~cm}
\end{aligned}
$$

Since the near-viewing section of the lens is corrected by + 1.5 D,
$\therefore$ Focal length of near vision correction,

$$
=\frac{1}{\text { Power }}=\frac{1}{1.5}=.67 \mathrm{~m}=67 \mathrm{~cm}
$$

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.: Here, concave lens is required.
The corrective concave lens should form the image of the far off objects i.e. lying at infinity at the far point of the myopic person. So, using the lens formula,

$$
\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-80 \mathrm{~cm}}-\frac{1}{\infty}=-\frac{1}{80 \mathrm{~cm}}
$$

So, $f=-80 \mathrm{~cm}$
So, Power of the lens, $P=\frac{100}{-80} \mathrm{D}=-1.25 \mathrm{D}$
11. 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 .
Ans.: The diagram to show the correction of hypermetropia is given here.


Given: Near point distance for a hypermetropic eye, $D=100 \mathrm{~cm}$
Near point distance for a normal eye, $D=25 \mathrm{~cm}$
So, $v=-100 \mathrm{~cm}, u=-25 \mathrm{~cm}$
Using the lens formula,

$$
\begin{aligned}
\frac{1}{f} & =\frac{1}{v}-\frac{1}{u}=\frac{1}{-100 \mathrm{~cm}}-\frac{1}{-25 \mathrm{~cm}} \\
& =-\frac{-1+4}{100 \mathrm{~cm}}=\frac{3}{100 \mathrm{~cm}}
\end{aligned}
$$

So, $f=\frac{100 \mathrm{~cm}}{3}=33.3 \mathrm{~cm}$ and

$$
P=\frac{100}{33.3} \mathrm{D}=+3.0 \mathrm{D}
$$

12. Why is a normal eye not able to see clearly the objects placed closer than 25 cm ?
Ans.: The least distance of distinct vision for a normal eye is 25 cm . So, a normal eye will
not be able to see clearly any object placed closer than 25 cm .
13. What happens to the image distance in the eye when we increase the distance of an object from the eye?
Ans.: For a normal eye, image distance in the eye is fixed and is equal to the distance of retina from the eye lens. When we increase the distance of the object from the eye, focal length of eye lens is changed on account of accommodating power of the eye so as to keep image distance constant.
14. Why do stars twinkle?

Ans.: Due to wind and convection currents, density of the atmospheric layers keeps on changing. As a result, the position of a star keeps fluctuating from its mean position. This fluctuating image of the stars makes them appear twinkling to the observer.
15. Explain why the planets do not twinkle.

Ans.: Planets do not emit light. However, they become visible due to reflection of light falling on them. The planets are much closer to the earth and thus can be considered as the extended source of light.
The fluctuations in the light coming from various points of the planet due to atmospheric refraction get averaged out. As a result, no twinkling of planets is seen.
16. Why does the sun appear reddish early in the morning?
Ans.: At sunrise and sunset, the sun is closer to the horizon. The sunlight near the horizon passes through denser layers of the air and covers larger distance before reaching our eyes. Most of the blue light gets scattered. The light that reaches our eyes is of longer wavelengths, mainly orange and red. That is why the sun appears red at the sunrise and at the sunset.
17. Why does the sky appear dark instead of blue to an astronaut?
Ans.: This is because at such huge heights of the astronaut, there is nothing to scatter the sunlight. Therefore the sky appears dark.

## EXERCISE

## Multiple Choice Questions

## Level - 1

1. The size of the pupil of the eye is adjusted by
(a) cornea
(b) retina
(c) iris
(d) blind spot
2. When we enter a cinema hall, we cannot see properly for a short time. This is because
(a) pupil does not open
(b) pupil does not close
(c) adjustment of the size of pupil takes some time
(d) none of these
3. When we go out in bright sunlight, the pupil of the eye
(a) contracts
(b) expands
(c) sometimes contracts and sometimes, expands
(d) neither contracts nor expands
4. Which cells respond to colour of light?
(a) Rod shaped cells
(b) Cone shaped cells
(c) Both types of cells
(d) Neither of the two
5. Eye lens is a
(a) double convex lens
(b) double concave lens
(c) plano convex lens
(d) plano concave lens
6. The property of persistence of vision is used in
(a) short sightedness
(b) long sightedness
(c) cinematography
(d) colour vision
7. Focal length of eye lens is
(a) fixed
(b) variable
(c) sometimes fixed and sometimes variable
(d) cannot say
8. Variable focal length of eye lens is responsible for
(a) accommodation of eye
(b) persistence of vision
(c) colour blindness
(d) least distance of distinct vision
9. Far point of normal human eye is
(a) 25 cm
(b) 25 m
(c) 500 m
(d) infinity
10. Near point of normal human eye is
(a) 25 cm
(b) 25 mm
(c) 25 m
(d) not fixed
11. When ciliary muscles are relaxed, focal length of the eye lens is
(a) maximum
(b) minimum
(c) neither maximum nor minimum
(d) cannot say
12. Splitting of white light into seven colours on passing through a glass prism is called
(a) reflection
(b) refraction
(c) scattering
(d) dispersion
13. Which of the colours of visible light has minimum wavelength?
(a) Violet
(b) Red
(c) Yellow
(d) Green
14. Which of the colour of visible light has minimum frequency?
(a) Violet
(b) Red
(c) Yellow
(d) Green
15. Which colour has maximum speed in glass?
(a) Violet
(b) Red
(c) Yellow
(d) Green
16. For which colour, refractive index of glass is maximum?
(a) Red
(b) Violet
(c) Green
(d) Yellow
17. Which colour suffers least deviation on passing through a prism?
(a) Red
(b) Violet
(c) Indigo
(d) Blue
18. Scattering of light involves
(a) reflection
(b) refraction
(c) diffraction
(d) change in direction of light
19. Blue colour of sky is due to
(a) scattering of light
(b) reflection of light
(c) refraction of light
(d) diffraction of light
20. Twinkling of stars is due to
(a) reflection
(b) dispersion
(c) atmospheric refraction
(d) none of these
21. Coloured band of light obtained by dispersion of white light is called
(a) mirage
(b) spectrum
(c) shadow
(d) image
22. Twinkling of stars is visible when the stars are
(a) any where
(b) no definite situation
(c) near the horizon
(d) over head
23. The phenomena of mirage is seen due to
(a) total dispersion
(b) total internal interference
(c) reflection
(d) refraction
24. In an eye the focal length of the eye-lens increases when
(a) ciliary muscles contracts
(b) ciliary muscles expands
(c) iris expands
(d) iris contracts
25. Short sightedness is also called
(a) presbyopia
(b) astigmatism
(c) myopia
(d) hypermetropia
26. Long-sightedness is also called
(a) presbyopia
(b) astigmatism
(c) myopia
(d) hypermetropia
27. Eye defect at old age is called
(a) presbyopia
(b) astigmatism
(c) myopia
(d) hypermetropia
28. Convex lens is used in case of
(a) presbyopia
(b) astigmatism
(c) myopia
(d) hypermetropia
29. Concave lens is used in case of
(a) presbyopia
(b) astigmatism
(c) myopia
(d) hypermetropia
30. Cylindrical lens is used in case of
(a) presbyopia
(b) astigmatism
(c) myopia
(d) hypermetropia

## Level - 2

31. The intensity of scattered light varies inversely as $n^{\text {th }}$ power of wavelength $(\lambda)$ of incident light where
(a) $n=2$
(b) $n=1$
(c) $n=4$
(d) $n=-4$
32. Which of the following statements is correct about rainbow?
(a) In primary rainbow, red colour is on the outside and violet colour is on the inside.
(b) In primary rainbow, violet colour is on the outside and red colour is on the inside.
(c) Secondary rainbow is brighter than primary rainbow.
(d) In secondary rainbow, light wave suffers one total internal reflection before coming out.
33. A fish looking up through the water sees the outside world contained in a circular horizon. If the refractive index of water is $\frac{4}{3}$ and the fish is 12 cm below the surface, the radius of this circle in cm is
(a) $36 \sqrt{5}$
(b) $4 \sqrt{5}$
(c) $36 \sqrt{7}$
(d) $\frac{36}{\sqrt{7}}$
34. Prism angle of a prism is $10^{\circ}$. Their refractive index for red and violet colour is 1.51 and 1.52 respectively. Then dispersive power will be
(a) 0.5
(b) 0.15
(c) 0.019
(d) 0.032
35. The far point of a myopic person is 80 cm in front of the eye. What is the power of the lens required to enable him to see the distant objects clearly?
(a) 1.25 D
(b) 1.50 D
(c) 1 D
(d) 1.75 D
36. Velocity of light in glass is $2 \times 10^{8} \mathrm{~m} \mathrm{~s}^{-1}$ and in air is $3 \times 10^{8} \mathrm{~m} \mathrm{~s}^{-1}$. If the ray passes through glass to air, calculate the value of critical angle.
(a) $40^{\circ}$
(b) $42^{\circ}$
(c) $45^{\circ}$
(d) $50^{\circ}$
37. Which of the following phenomena of light are involved in the formation of a rainbow?
(a) Reflection, refraction and dispersion
(b) Refraction, dispersion and total internal reflection
(c) Refraction, dispersion and internal reflection
(d) Dispersion, scattering and total internal reflection
38. A concave lens of suitable focal length is used for correcting a
(a) myopic eye
(b) hypermetropic eye
(c) both (a) and (b)
(d) neither (a) nor (b)
39. The broad wavelength range of visible spectrum is
(a) $4000-8000 \AA$
(b) $2000 \AA-4000 \AA$
(c) $10000-2000 \AA$
(d) none of these
40. The amplitude of scattered lightly varies with wavelength $\lambda$ as
(a) $\propto \frac{1}{\lambda^{4}}$
(b) $\propto \frac{1}{\lambda}$
(c) $\propto \frac{1}{\lambda^{2}}$
(d) $\propto \lambda^{2}$
41. The intensity of scattered light varies with amplitude (a) of scattered light as
(a) $\propto a^{2}$
(b) $\propto \frac{1}{a^{2}}$
(c) $\propto a$
(d) $\propto \frac{1}{a}$
42. For Rayleigh elastic scattering size of scatterer $(x)$ should be
(a) $x \approx \lambda$
(b) $x>\lambda$
(c) $x \gg \lambda$
(d) $x \ll \lambda$
43. Red colour of sun at the time of sunrise and sunset is because
(a) Red colour is least scattered
(b) Blue colour is least scattered
(c) Red colour is scattered the most
(d) All colours are equally scattered
44. If the refractive index of a material of equilateral prism is $\sqrt{3}$, then angle of minimum deviation of the prism is
(a) $30^{\circ}$
(b) $45^{\circ}$
(c) $60^{\circ}$
(d) $75^{\circ}$
45. Prism angle and refractive index for a prism for a $60^{\circ}$ and 1.414. Angle of minimum deviation will be
(a) $15^{\circ}$
(b) $30^{\circ}$
(c) $45^{\circ}$
(d) $60^{\circ}$
46. A piece of cloth looks red in sun light. It is held in the blue portion of a solar spectrum, it will appear
(a) red
(b) black
(c) blue
(d) white
47. A student sitting on the last bench can read the letters written on the blackboard but is not able to read the letters written in his textbook. Which of the following statements is correct?
(a) The near point of his eyes has receded away.
(b) The near point of his eyes has come closer to him.
(c) The far point of his eyes has come closer to him.
(d) The far point of his eyes has receded away.
48. Which of the following statements is correct regarding the propagation of light of different colours of white light in air?
(a) Red light moves fastest.
(b) Blue light moves faster than green light.
(c) All the colours of the white light move with the same speed.
(d) Yellow light moves with the mean speed as that of the red and the violet light.
49. The refractive index of glass is $3 / 2$. Velocity of light in glass would be
(a) $3 \times 10^{8} \mathrm{~m} \mathrm{~s}^{-1}$
(b) $2 \times 10^{8} \mathrm{~m} \mathrm{~s}^{-1}$
(c) $10^{8} \mathrm{~m} \mathrm{~s}^{-1}$
(d) $1.33 \times 10^{8} \mathrm{~m} \mathrm{~s}^{-1}$
50. A ray of light falls on one face of an equilateral glass prism at $40^{\circ}$ and emerges from the other face at the same angle. The deviation suffered by the ray is
(a) $60^{\circ}$
(b) $40^{\circ}$
(c) $80^{\circ}$
(d) $20^{\circ}$

## Fill in the Blanks

1. For an object at infinity, the focal length of a normal eye lens is about $\qquad$
2. Light enters through the eye through a thin membrane called $\qquad$
3. The image formed on the retina is retained by it for about $\qquad$ of a second.
4. Bees have cones that are sensitive to $\qquad$ light.
5. Astigmatism can be corrected by using lenses.
6. The eye lens is held in position by $\qquad$
7. The diameter of a mature person's eye is about
$\qquad$
8. The pupil appears black because no light is
$\qquad$ from it.
9. A single eye gives a horizontal field of view of about $\qquad$
10. The $\qquad$ cells respond to the intensity of light.

## True or False

1. Persistence of vision means the continuation of impression of image on the retina for about $(1 / 16)^{\text {th }}$ of a second even after the object is removed.
2. The ciliary muscles adjust for changing the intensity of light entering the eye.
3. The distance between near point and far point of the eye is called the range of vision.
4. Our eyes can live even after our death if we donate our eyes to a corneal blind person.
5. Cornea is a dime-shaped tissue and forms the window for the eye.
6. Myopic eye can be corrected by bi-focal lenses
7. Rod cells are for sensing intensity whereas cone cells are for sensing colours.
8. The function of iris is to regulate the amount of light entering the eyes.
9. There are approximately 100 million rod cells and 10 million cone cells on the retina.
10. The near point of a hypermetropic person is 50 cm . The focal length of a convex lens used in his spectacles should be 50 cm .

## Match the Following

In this section, each question has two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (a), (b), (c) and (d) out of which one is correct.

## 1. List-I

(P) Rods
(Q) Hypermetropia
(R) Cones
(S) Myopia

Code :

|  | $\mathbf{P}$ | $\mathbf{Q}$ | $\mathbf{R}$ | $\mathbf{S}$ |
| :--- | :--- | :--- | :--- | :--- |
| (a) | 1 | 2 | 3 | 4 |
| (b) | 3 | 1 | 4 | 2 |
| (c) | 2 | 1 | 4 | 3 |
| (d) | 4 | 2 | 1 | 3 |

2. List-I
(P) Presbyopia
(Q) Retina
(R) Astigmatism
(S) Accommodation

Code :

|  | $\mathbf{P}$ | $\mathbf{Q}$ | $\mathbf{R}$ | $\mathbf{S}$ |
| :--- | :--- | :--- | :--- | :--- |
| (a) | 1 | 2 | 3 | 4 |
| (b) | 3 | 1 | 4 | 2 |
| (c) | 2 | 3 | 4 | 1 |
| (d) 2 | 1 | 4 | 3 |  |

3. List-I
(P) Inverted crown flint glass prism
(Q) Achromatism
(R) Hollow prism
(S) Tyndall effect

## Code :

|  | $\mathbf{P}$ | $\mathbf{Q}$ | $\mathbf{R}$ | $\mathbf{S}$ |
| :--- | :--- | :--- | :--- | :--- |
| (a) | 4 | 3 | 2 | 1 |
| (b) | 3 | 1 | 4 | 2 |
| (c) | 2 | 3 | 4 | 1 |
| (d) | 4 | 2 | 1 | 3 |

## Assertion \& Reason Type

Directions: In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If assertion is false but reason is true.

1. Assertion : Myopia is due to the increased converging power of the eye lens.
Reason : Myopia can be corrected by using spectacles made from concave lenses.
2. Assertion : Reddening of the sun at the sunrise and the sunset is due to the reflections of sun light.
Reason : Scattering of light results in the reddening of sun at sunrise and sunset.
3. Assertion : In astigmatism, the rays of light coming from the horizontal and vertical planes of an object do not come to focus at the same point.
Reason : Astigmatism occurs when the cornea or the eye lens or both are perfectly spherical.
4. Assertion : Higher the refractive index of the prism material, lower is the angle of deviation.
Reason : The angle of deviation is directly proportional to the angle of prism.
5. Assertion : The light of violet colour deviates the most and the light of red colour the least, while passing through a prism.
Reason : For a prism material, refractive index is highest for red light and lowest for the violet light.
6. Assertion : The rainbow is seen when the sun is behind the observer.

Reason : Rainbow is produced due to dispersion of white light by small rain drops hanging in the air after the rain.
7. Assertion : The phenomenon of persistence of vision is made use of in cinematography.
Reason : The ability of the eye to retain the image for about $1 / 10^{\text {th }}$ of a second even after we have stopped seeing the object is called persistence of vision.
8. Assertion : Bending of light at the interface of the two media is called refraction.
Reason : Whenever light traces from a denser medium to a rarer medium, it bends away from the normal.
9. Assertion : Critical angle is maximum for red colour in water-air system for visible light.
Reason : Because $\sin \theta_{c}=\frac{1}{n_{r}}$ and $n_{r}$ (refractive index of red colour) is minimum for visible light.
10. Assertion : Bird flying high up in air does not cast shadow on the earth ground.
Reason : The size of bird is smaller than sun.

## Comprehension Type

PASSAGE-I : A person is suffering from hyper- metropia (long sightedness). The near point of the person is 1.5 m . Assume that the near point of the normal eye is 25 cm .

1. The type of lens to be used in his spectacles is
(a) concave
(b) convex
(c) plano concave
(d) cylindrical
2. The focal length of the lens he should use is
(a) 20 cm
(b) 30 cm
(c) 40 cm
(d) 50 cm
3. The power of the lens is
(a) 1.1
(b) 2.2
(c) 3.3
(d) 4.4

PASSAGE-II : A near sighted person wears eye glass with power of 5.5 D for distant vision. His doctor prescribes a correction of +1.5 D in near vision section of his bi-focals, which is measured relative to main part of the lens.

1. The focal length of his distant viewing part of lens is
(a) -16.16 cm
(b) -17.17 cm
(c) -18.18 cm
(d) -19.19 cm
2. Focal length of near vision section of the lens is
(a) -20 cm
(b) -25 cm
(c) -26 cm
(d) -27 cm

PASSAGE-III : Stars emit their own light called star-light. Due to this light, the stars shine in the night sky. When we look at a star in the sky on a clear night, we observe that the intensity of light coming from it changes continuously.

1. When the atmosphere refracts less star - light towards us, then the star appears to be $\qquad$
(a) bright
(b) $\operatorname{dim}$
(c) no charge
(d) can't say
2. Planet does not appear to twinkle because
(a) they are small in size
(b) they are far away from earth
(c) they are very very to close to earth
(d) none of these

## Subjective Problems

## Very Short Answer Type

1. When is the thickness of the eye lens minimum?
2. A person has normal vision, but he cannot distinguish between red-green colours. Why?
3. We can see a rainbow on a sunny day by looking at the sky through a water fountain. Why?
4. Why do stars appear higher than they actually are?
5. What enables the eye to focus objects at different distances?
6. How near is the near point of a normal eye?
7. Why does a person become colour blind?
8. How does the iris regulate the amount of light entering the eye?
9. Why do chickens can see only in bright light?
10. What is the cause of astigmatism?
11. Write the formula used for calculating the focal length of the lens to be used by a person to correct his myopic eye.
12. Why does the clear sky appear blue?
13. How are we able to see nearby and also the distant objects clearly?
14. Why do we see a rainbow in the sky only after rainfall?
15. Why has nature given us two eyes instead of one?

## Short Answer Type

1. For a person, the distance between the retina and the eye lens is fixed. To get the images of various objects at different distances from the eye, the focal length of the lens should be different.
(a) How does the human eye manage this?
(b) Name the part/parts of the eye involved in it.
(c) Name this property of the eye.
2. A person needs a lens of power - 3.5 dioptres for distant viewing. His doctor prescribes a correction of +0.5 dioptre in the near vision section of his bifocals. This is measured relative to the main part of the lens.
(a) What is the focal length of his distant viewing part of the lens?
(b) What is the focal length of the near vision section of the lens?
3. Why does it take some time to see objects in a dim room when you enter the room from bright sunlight outside?
4. A person with a defective eye-vision is unable to see the objects nearer than 1.5 m . He wants to read books at a distance of 30 cm . Find the nature, focal length and power of the lens he needs in his spectacles.
5. What is meant by accommodation of human eye ? How is it achieved?
6. The near point of a hypermetropic eye is 50 cm . Calculate the power of the lens to enable him to read a book at 40 cm ?
7. A person cannot see the objects distinctly, when placed at a distance less than 100 cm . What is the power of the spectacles that should be used to see clearly the objects placed at 25 cm ?
8. A ray of light is travelling in water medium falls on the water-air interface at an angle of $45^{\circ}$ with the vertical. Will it be possible by the ray of light to come out of the water surface?
9. 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?
10. The refracting angle of the prism is $60^{\circ}$. What is the angle of incidence for minimum deviation? The refractive index of material of prism is $\sqrt{2}$.

## Long Answer Type

1. (i) During its passage from one medium to another, when does a light ray change its path?
(ii) Define the term absolute refractive index of a medium.
(iii) With the help of a ray diagram, explain the term critical angle.
(iv) What is the value of refractive index of the medium if the critical angle of incidence in a denser-rarer interface is equal to $45^{\circ}$ ?
2. A person is able to see objects clearly only when they lie at distances between 50 cm and 300 cm from his eye.
(a) What kind of defect of vision is he suffering from?
(b) What kind of lenses will be required to increase his range of vision from 25 cm infinity?
Explain briefly.
3. Give briefly the structure and working of human eye.
4. State two main causes of a person developing near sightedness. With the help of a ray diagram, suggest how he can be helped to overcome this disability?
5. Explain
(a) Why stars seem higher than they actually are.
(b) Sun appears to rise 2 minutes before and set 2 minutes later.
(c) Sun appears oval or flattened at sunrise and sunset.

## Integer Answer Type

In this section, each question, when worked out will result in one integer from 0 to 9 (both inclusive).

1. 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 .
2. The far point of a myopic eye is 80 cm in front of the eye. What is the power of the lens required to enable him to see far off objects?
3. A thin glass prism of refractive index 1.5 produces a deviation of $4^{\circ}$ for a ray incident at a small angle. What will be the deviation of the same incident ray by the same prism if it is immersed in water of refractive index $4 / 3$ ?
4. A thin prism $P$ with angle $5^{\circ}$ and made from glass of refractive index 1.54 is combined with another prism $P_{2}$ made from glass of refractive index 1.92 to produce dispersion without deviation. Find the angle of prism $P_{2}$.
5. A person can read a newspaper from a distance of 50 cm . Find the power of the lens required by him to read it from 25 cm .
