CHAPTER

2

THE HUMAN EYE AND THE COLORFUL WORLD

KICK OFF

"Small is the number of people who see with their eyes and think with their minds." - ***Albert Einstein***

Human Eye

Human eye is the most delicate and intricate natural optical instrument that helps us to see the beautiful world around us. It is like a camera having a lens system and forming an inverted, real image on a light sensitive screen inside the eye. The structure and working of the eye is as follows:

Find it

Q. Why do we have two eyes for vision and not just one?

Structure of human eye

Diagram shows the section of a human eye by a horizontal plane. It is a spherical ball of diameter about 2.5 cm. Its essential parts are described below :

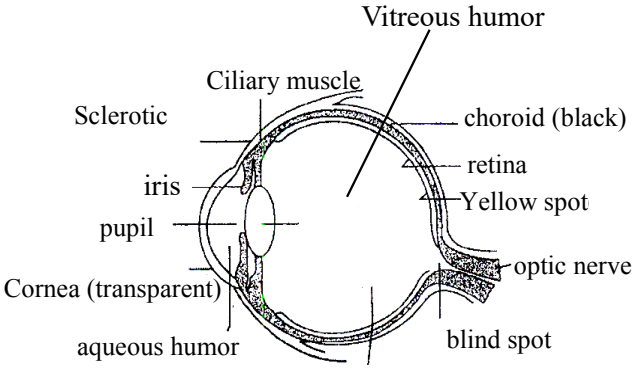


Fig. 1

- **Cornea:** Cornea is the transparent spherical membrane that covers the front of the eye.
- **Iris:** Iris is the coloured region between the cornea and lens.
- **Pupil:** The pupil of the eye is the black circle in the center of the iris. It is 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:** It is a double convex lens immediately behind iris. This is made of transparent concentric layers whose optical density increases towards the centre of the lens.
- **Ciliary muscles:** The lens is connected of the sclerotic by the ciliary muscles. These muscles change thickness of the lens by relaxing and exerting pressure.

- **Aqueous humour:** Anterior chamber is filled with a transparent liquid of refractive index 1.335. The liquid is called the aqueous humour.
- **Vitreous humour:** Posterior chamber is filled with a transparent watery liquid with little common salt having some refractive index. The liquid is called the vitreous humour.
- **Retina:** Retina is the back surface of the eye. It's a thin layer of tissue that covers approximately 65 percent of the back of the eye. It consists of a thin membrane which is rich in nerve fibres, containing two kinds of vision cells called 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.
- **Blind spot:** The blind spot B. It is the spot where the optic nerves enter the eye. It is also slightly raised and insensitive to light, because it is not covered with choroid and retina.

Mind it

In the eye, the image is formed on the retina by successive refractions at the cornea, the aqueous humor, the lens and the vitreous humor. Electrical signals then travel along the optic nerve to the brain to be interpreted. In good light, the yellow spot is most sensitive to detail and the image is automatically formed there.

Power of Accommodation

The ability of the human eye lens to focus the image of the objects on the retina by changing the focal length of the eye-lens is known as the power of accommodation. Eye lens is composed of fibrous jelly-like material and can be modified to some extent by the ciliary muscles.

Near Point and Far Point

In visual perception, the near point is the closest point at which an object can be placed and still form a focused image on the retina, within the eye's accomodation range. For a normal eye, it is about 25 cm and is denoted by the symbol D.

With age, at the eye lens gradually loses its flexibility so the power of accommodation of the eye decreases. For most of the old persons aged nearly 60 years, the near point is about 200 cm and corrective glasses are needed to see the nearby objects clearly.

The farthest point upto which our eye can see objects clearly, without any strain on the eye is called the far point. For a person with normal vision, the far point is at infinity.

Least Distance of Distinct Vision

In optometry the least distance of distinct vision (LDDV) or the reference seeing distance (RSD) is the minimum distance of an object from the eye at which it can be seen most clearly and distinctly without any strain on the eye. For a person with normal vision, it is about 25 cm and is represented by the symbol D.

Persistence of Vision

The impression (or sensation) of the object remains on the retina for about $(1/16)^{th}$ of a second, even after the object is removed from the sight. This prolongation of the sensation of eye is called the persistence of vision.

Let a sequence of still pictures is taken by a camera. If the sequence of these pictures will be projected on a screen at the rate of 24 images or more per second then the successive impression of the images on the screen appear to blend or merge smoothly into one another. This is because an image (or a scene) on the screen appears just before the impression of previous image on the retina is lost. Hence, the sequence of images blend into one another giving the impression of a moving picture. This principle of persistence of vision is used in motion picture projection or in cinematography.

Colour-Blindness

Inability of a person to distinguish between certain colours is called colour blindness.

The retina of our eye has large number of light sensitive cells having shapes of rods and cones. The rod-shaped cells responds to the intensity of light with different level of brightness and the cone shaped cells respond to colours. In dim light rods are sensitive, whereas cones are sensitive only in bright light. The cones are sensitive to green, red and blue colour of light to some different extents.

Due to genetic disorder, some persons do not possess some cone-shaped cells that responds to certain specific colours only. Such persons cannot distinguish between certain colours but can see well otherwise. Such persons are said to have colour-blindness. Government do not issue driving licenses to persons having colour-blindness.

Perception of Colours in Animals

Different animals have different colour perception due to different structure of rod and cone shaped cells. For example, bees have some cone-shaped cells that are sensitive to ultraviolet rays. Therefore, bees can see objects in ultraviolet light which we cannot do.

The retina of chicks have mostly cone shaped cells and only a few rod shaped cells. As rod shaped cells are sensitive to bright light only, therefore, chicks wake up with sunrise and sleep in their resting place by the sunset.

Cataract and its Treatment

A cataract is a dense, cloudy area that is formed in the eye lens.

Sometimes due to the formation of a membrane over the crystalline lens of some people in the old age, the eye lens becomes hazy or even opaque. It results in decrease or loss in vision of the eye. Cataract can be corrected by surgery leading to normal vision. During cataract surgery the clouded lens is removed, and a clear artificial lens is usually implanted.

Defects of Vision

Mind it

- People with normal vision has their far point at infinity. They can focus clearly on very distant objects.

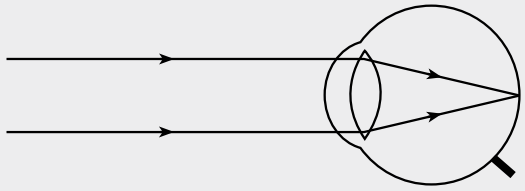


Fig. 2

❒ People with normal vision has their near point at a distance 25 cm from the eye. They can focus clearly on near objects upto a distance of 25 cm.

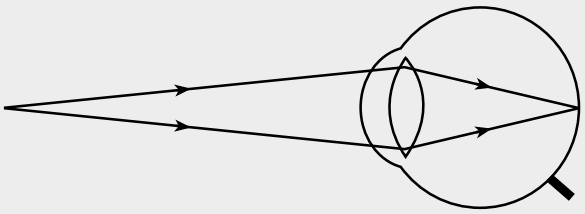


Fig. 3

Due to some irregularities in the normal behaviour of the eye some defect arises.

The major defects of vision are as follow:

(i) Myopia or short sightedness.

(ii) Hypermetropia or long sightedness.

(iii) Presbyopia

(iv) Astigmatism

(i) Myopia or short sightedness

❒ **Symptoms:** The far point of the defective eye has shifted from infinity to a finite distance ahead or we can say eye cannot see clearly beyond a certain distance.

❒ **Reasons:** Myopia happens due to irregularition in eye lens because the image of distant objects is formed in front of the retina. It is shown in fig.

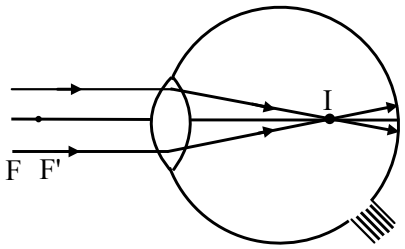


Fig. 4: Myopic eye vision

❒ **Causes :**

(i) This may happen due to **elongated,** eye ball

(ii) The lens may be thicker (more converging) than the normal eye lens.

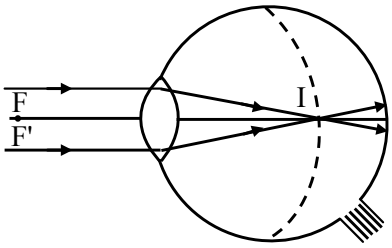


Fig. 5: Elongated eye

❒ **Correction:** Eye glasses and contact lenses are the best treatment options. The extra converging power of eye lens is compensated by using a concave (diverging) lens of proper power (focal length) as shown in the diagram.

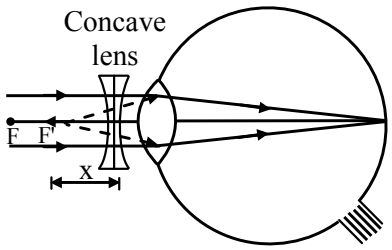


Fig. 6: Correction of myopic eyes

Test Prep

❒ Let distance of far point from eye be x. Then for lens to be used, u = ∞, v = –x, f = ?

From lens formula,

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

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

$$\Rightarrow \frac{-1}{x}-0=\frac{1}{f}$$

$$\Rightarrow f = -x$$

The lens used must have focal length equal to the distance of the far point from the eye (–ve sign means concave lens).

❒ Let distance of near point from the eye be z. For lens to be used

u = –D, v = –z, f = ?

From lens formula,

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

$$\frac{1}{-z}-\frac{1}{-D}=\frac{1}{f}$$

$$f = \frac{zD}{z-D}$$

This is required expression for the focal length of the convex lens to be used.

(ii) Long sightedness or hypermetropia

❒ **Symptoms:** With this defect eye cannot see clearly within a certain distance. It means that the near point of the defective eye has shifted from 25 cm to some farther distance away.

❒ **Reason:** It is so because the image of near objects is formed behind the retina. It is shown in fig.

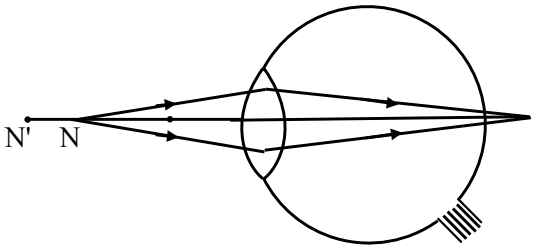


Fig. 7: Hypermetropic eye vision

❒ **Causes :**

(i) The eye lens may be **thinner** (less converging) than the normal eye lens.

(ii) The eye lens becomes thinner than that for normal eye.

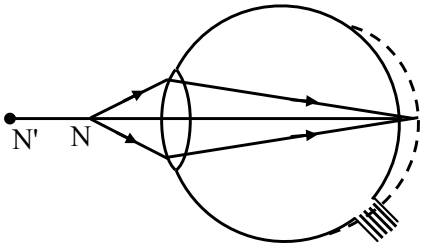


Fig. 8: Oval eye

- **Correction:** The deficiency in converging power of eye lens is compensated by using a convex (Converging) lens of proper power (focal length) as shown in the fig.

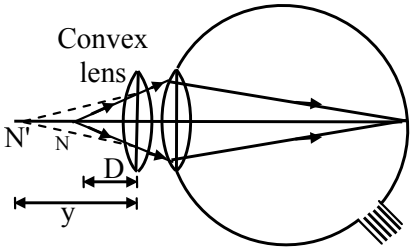


Fig. 9: Correction of hypermetropic eyes

(iii) Presbyopia:

- **Symptoms:** Blurred vision at normal reading distance eyestrain or headaches after reading or doing close-up work.
- **Reason:** It is caused by a hardening of the lens of your eye, which occurs with aging.
- **Causes:** It arises due to the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens. Sometimes, a person may suffer from both myopia and hypermetropia.
- **Correction:** Such people often require bi-focal lenses. A common type of bi-focal lenses consists of both concave and convex lenses. The upper portion consists of a concave lens. It facilitates distant vision. The lower part is a convex lens. It facilitates near vision.

(iv) Astigmation:

Astigmatism is a condition in which the eyes are not completely round. A person suffering from this defect cannot simultaneously focus on both horizontal and vertical lines of a wire gauze.

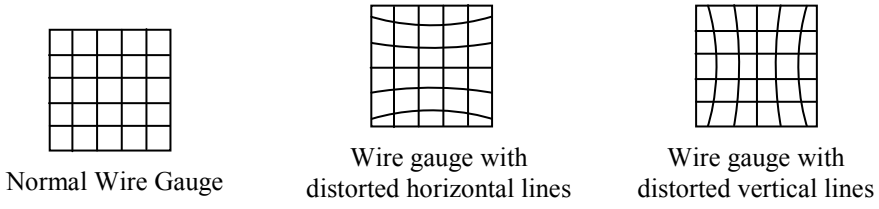


Fig. 10

- **Reason:** This defect arises due to the fact that the cornea is not perfectly spherical.
- **Correction:** This defect can be corrected by using a cylindrical lens.

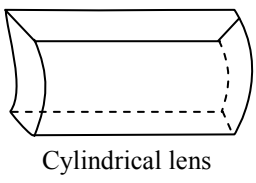


Fig. 11

NCERT Corner

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

Ans. Power of accommodation is the ability of the lens of the eye to adjust its focal length to clearly focus rays coming from distant as well from a near objects on the retina.

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

Ans. Concave lens are used to restore proper vision, for an individual with a myopic eye.

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

Ans. Near point of the human eye is the minimum distance of the object from the eye, where it can be seen distinctly without strain in our eyes. For a person with normal vision this distance is 25 cm.

The far point of the human eye is the maximum distance to which the eye can see objects clearly.

The far point of a person with normal vision is infinity.

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

Ans. The student is suffering from short-sightedness or myopia. Myopia can be corrected by the appropriate use of concave or diverging lens.

Monochromatic Refraction Through A Prism

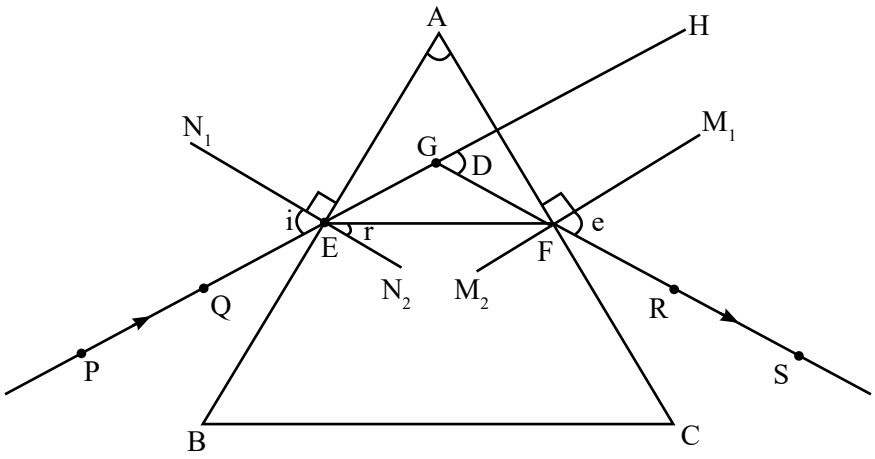


Fig. 12

In the above diagram PE is the incident ray on the prism, EF is the refracted ray and FS is the emergent ray from the prism. Incident ray of light PQ is entering from air to glass at the first surface AB. As the speed of light in glass is less than that in air, so the refracted ray EF bends towards the normal. At the second surface AC, the light ray EF is incident from glass to air. As the speed of light in air is more than the speed of light in glass, hence the emergent ray FS bends away from the normal. The peculiar shape of the prism makes the emergent ray FS bend at an angle to the direction of the incident ray PE . This angle between the incident ray and the emergent ray is called the angle of deviation. In this case $\angle D$ is the angle of deviation. This is an example of monochromatic refraction through a prism.

Test Prep

Spectrum and Colours

Dispersion of Light through a Prism:

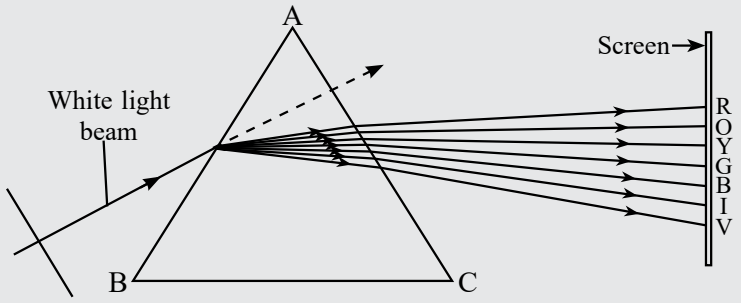


Fig. 13: Dispersion of white light by a prism

The phenomenon of splitting of white light into its constituent colors is called dispersion. Dispersion of light is caused by the change in speed of different colours of light ray by a different amount.

The dispersion of a light ray by a prism is shown in the diagram. When white light is incident on a glass prism, the emergent light appears to be of seven colours (violet, indigo, blue, green, yellow, orange and red). Red light bends the least, while violet light bends the most. Therefore, dispersion is the phenomenon of light splitting into its constituent colors.

Causes of the Dispersion of Light

Dispersion is caused due to the various degrees of refraction suffered by different colors of light. In vacuum, different colors of light travel at the same speed, but in a refracting medium, they travel at different speeds.

Violet color of light travels at a much slower speed than the red color of light. Violet light has the highest refractive index for a given medium, while red light has the lowest refractive index.

Colour	Frequency in 10^{12} Hz	Wavelength in Å
Violet	675 – 750	400 Å to 4460 Å
Indigo	645 – 673	4460 Å to 4640 Å
Blue	600 – 647	4640 Å to 5000 Å
Green	519 – 600	5000 Å to 5780 Å
Yellow	507 – 519	5780 Å to 5920 Å
Orange	484 – 507	5920 Å to 6200 Å
Red	375 – 484	6200 Å to 8000 Å

Refractive index of glass is given as:

$$\mu_{glass} = \frac{\text{speed of light in air}}{\text{speed of light in glass}}$$

The speed of light for different colours is different in glass (medium). The speed of violet light is minimum and the speed of red light is maximum.

$$\therefore \mu_{violet} > \mu_{red}$$

Also, $\mu = \sin i/\sin r$ or $\sin r = \sin i/\mu$

So, the angle of refraction is minimum for violet colored light and maximum for red colored light. Each colour is deviated towards the base of the prism. The violet is deviated the most and the red is deviated the least. As a matter of fact the colours in the spectrum do not have any sharp boundaries.

Recomposition of white light:

Take, two prism P_1 and P_2 of the same material and of the same refracting angle A arrange them a shown in the figure. Sunlight from a narrow slit S falls on the first prism P_1 with its base downwards and gets dispersed into constituent colours (VIBGYOR) and the bending takes place downwards. This dispersed light will falls on the second prism P_2 with its base upwards so that it deviates the light upwards.

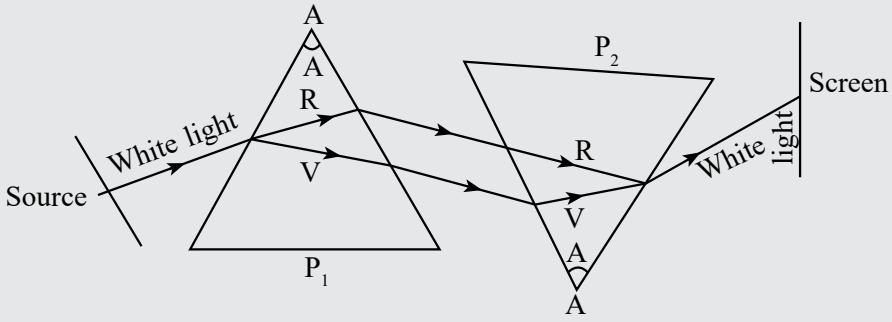


Fig. 14: Recombination of the spectrum of white light

From this experiment it is found that the light coming out of the second prism P_2 is almost white and is in direction parallel to the direction of light incident of the first prism P_1. In fact, the two prisms P_1 and P_2 combined together effectively acts like a parallel sides glass slab. The Prism P_1 simply disperses the white light into its constituent colours and the prism P_2 recombines these colours to form white light. Here prism P_1 is known as **dispersing-prism** and the prism P_2 is known as the **recombination-prism.**

Rainbow

Rainbows are formed when sunlight is scattered from raindrops into the eyes of an observer.

A rainbow is a natural spectrum appearing in the sky after a rain shower. It is caused by dispersion of sunlight by tiny water droplets, present in the atmosphere. A rainbow is always formed in a direction opposite to that of the Sun. The water droplets act like small prisms to scatter the light coming from the sun. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reach the observer's eye.

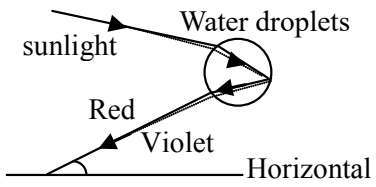


Fig. 15

Scattering of Light

When light from any sources falls on tiny particles that come in their way then diffused reflection takes place and light spreads in all possible direction. This phenomenon of light is known as scattering of light.

Small particles scatter mainly blue light. When size of the particle increases then the light of longer wavelength also scatter. The path of a beam of light passing through a true solution is not visible. However, its path becomes visible through a colloidal solution where the size of the particles is relatively larger.

Rayleigh Scattering Experiment: Rayleigh experiment proved that the intensity of scattered light is inversely proportional to the fourth power of the wavelength, provide the scatters is smaller in size than the wave length of light:

$$\text{scattering} \propto \frac{1}{\lambda^4}$$

Blue colour of the sky

When sunlight enters the atmosphere it gets scattered. The red light has the greatest wavelength and therefore it is least scattered. Violet rays are most scattered followed by blue, green, yellow, orange respectively. As our eye is more sensitive to the blue light, therefore we see the sky as blue.

Red Colour of Sun at Sunrise

Red colour of sun at the time of sunrise and sunset is due to scattering of light. At the time of sunrise and sunset sun rays have to travel a longer distance through the atmosphere therefore, all colours of light get scattered except the red light. Therefore sun appears red in colour at the time of sunrise and sunset.

Tyndall Effect

Tyndall effect is scattering of light by particles in a colloidal or in a very fine suspension.

The earth's atmosphere is a heterogeneous mixture of minute particles. These particles include, tiny water droplets, smoke suspended particles of dust and molecules of air. The path of the beam become visible when a beam of light strikes such fine particles. The light reaches us after being reflected diffusely by these particles. The phenomenon of scattering of light by the colloidal particle gives rise to tyndall effect.

We see Tyndall effect in our surroundings very often, some of the examples of Tyndall effect are:

1. When a beam of sunlight enters dark room through a small hole then its path become visible due to scattering of light by the dust particles present in the room.
2. When a beam of light is projected on a screen from a projector in the cinema hall, it becomes visible, due to the dust particles present in the cinema hall.
3. When sunlight passes through the canopy of a dense forest it get scattered by tiny water droplets, this is due to the Tyndall effect.

Find it

Q. Why sky appears blue?

Atmospheric Refraction

Our earth is covered with the atmosphere having different layers, these layers have different temperatures at different heights, some atmospheric layers are warm and some are cold. The warmer layer of the atmosphere behaves like an optically rarer medium whereas the cooler layer behaves like an optically denser medium.

Advanced sunrise and delayed sunset

Actual sunrise happens much later than what we usually see. When we see sunrise, the light ray coming from the sun undergoes refraction and bends towards us. At that time, the sun is actually below the horizon. The sun, we see, is an image that is formed due to refraction that is actually higher than its actual position. Due to atmospheric refraction the sun is visible 2 minutes before the actual sunrise and for the same reason it remains visible 2 minutes after the actual sunset.

Twinkling of stars

The twinkling of a star is due to atmospheric refraction of star-light. The atmosphere is made of several layers and the refractive indices which keep on changing continuously due to this path of light rap from the star keep on changing their path continuously.

Since the stars are very distant, they approximate point-sized sources of light. As the path of rays of light coming from the star goes on varying slightly, the apparent position of the star fluctuates and the amount of starlight entering the eye flickers – the star sometimes appears brighter, and at some other time, fainter, which is the twinkling effect.

Why don't the planets twinkle?

The planets are much closer to the earth, and are thus seen as extended sources. If we consider a planet as a collection of a large number of point-sized sources of light, the total variation in the amount of light entering our eye from all the individual point-sized sources will average out to zero, thereby nullifying the twinkling effect.

Summary

1. **Cornea:** A transparent spherical membrane which refracts light into the eye is called cornea.
2. **Iris:** A dark muscular diaphragm that controls the size of the pupil is called iris.
3. **Pupil:** A small circular opening in the centre of the iris is called pupil. Pupil appears black because no light if reflected from it.
4. **Eye lens:** A converging lens made of a transparent jelly-like proteinaceous material behind the pupil is called the eye lens.
5. **Retina:** The inside surface of the real (back) part of the eye ball where the light which enters the eye is focussed is called retinat.
6. **Colour blindness:** It is a defect of the eye due to which person is not able to distinguish between certain colours. Colour blindness is a genetic disorder.
7. **Near point:** The nearest point up to which an eye can see clearly is called its near point
8. **Far point:** 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.
9. **Least distance of distinct vision:** The minimum distance up to which an eye can see clearly is called the least distance of distinct vision.

   For a normal eye of an adult, the least distance of distinct vision is 25 cm.
10. **Accommodation power of the eye:** The property due to which the eye lens is able to change its focal length is called accommodation of the eye. When the eye is focussed on any distant object, the ciliary muscle is most tense (strained).
11. **Myopia (shortsightedness):** The defect on eye due to which eye is not able to see the distant objects clearly though it can see the nearby objects clearly is called myopia or shortsightedness.

    Myopia is caused by a decrease in the focal length of the eye lens. It can be corrected by using spectacles made from concave lenses of suitable focal length.
12. **Hypermetropia (Longsightedness):** The defect of the eye due to which eyes is not able to see clearly the nearby objects through it can see the distant objects clearly is called hypermetropia or longsightedness. Hypermetropia (long-sightedness) is caused by an increase in the focal length of the eye lens. It can be corrected by using spectacles made from convex lenses of suitable focal lengths.
13. **Dispersion of white light:** The process of splitting white light into its seven constituent colours is called dispersion of white light. The band of seven colours is called spectrum of visible light.
14. **Rainbow :** Rainbow is a band of seven colours across the sky produced due to the dispersion of white light by small raindrops hanging in the air after the rain.
15. **Scattering of light:** The earth's atmosphere consists of gases, and many different kinds of particulate matter. When light falls on such particles, it get scattered in all direction. Smaller particles scatter blue light to a larger extent than the red light.

Quick Recall

Fill in the blanks

1. _____ is used for signals as it is less scattered.
2. _____ is used to correct presbyopic refractive error.
3. Hypermetropic eye can be corrected by using _____ lens.
4. When light is travelling from denser to rarer medium and falls at critical angle on the surface of a rarer medium the refractive index will be _____ .
5. The dispersion of white light occurs because _____ of lights of different colors is different when passing through the glass prism.
6. The ability of the eye to focus both near and distant objects, by adjusting its focal length, is called the _____ of the eye.
7. _____ of light is the reason behind the blue colour of sky.
8. Most of the refraction of rays of light entering the eye occurs at the outer surface of the _____.
9. Due to the greater converging power of the eye lens in a _____, the image of distant object is formed in front of the retina.
10. A person suffering from both myopia and hypermetropia uses _____ lenses.

True and False Statements

1. 32 frames per second are projected in motion picture.
2. Excessive curvature in cornea is one of the reason for myopia.
3. A lens of lower focal length has less power.
4. Near point for a normal eye is 5 dioptre.
5. Rod cells are highly sensitive to light and function in night vision.

Match The Followings

1. Match the following with correct response.

(1)	Near points	(A)	Farthest point to which the eye can see clearly
(2)	Power of accommodation	(B)	Nearest point which the eye can see clearly
(3)	Far point	(C)	Minimum distance at which eye can see the objects clearly without strain
(4)	Least distance of distinct vision	(D)	The ability of eye lens to focus near and far objects

2. Match the following with correct response

(1)	Cataract	(A)	Old age person unable to see near objects clearly due to weakening of cilliary muscles
(2)	Myopia	(B)	A person can see near object but not able to see for objects clearly
(3)	Hyper metropia	(C)	Opacity of the lens
(4)	Presbyopia	(D)	A person can see far objects but not able to see near objects clearly

3. Match the following with correct response.

(1)	Retina	(A)	Region without any sensory cells
(2)	Blind spot	(B)	Change the focal length of eye lens
(3)	Iris	(C)	Give colours to the eye
(4)	Ciliary Muscles	(D)	Light sensitive layer

4. Match the following with correct response.

(1)	Hypermetropia	(A)	Cylindrical lens
(2)	Myopia	(B)	Concave lens
(3)	Presbyopia	(C)	Convex lens
(4)	Astigmatism	(D)	Bifocal lens

Answers

Fill in the Blanks

1. Red light
2. Bi focal lens
3. convex
4. 90°
5. speed
6. accommodation
7. Scattering
8. cornea
9. Myopic eye
10. bifocal

True and False

1. False
2. True
3. False
4. False
5. True

Match the Followings

1. 1-B, 2-D, 3-A, 4-C
2. 1-C, 2-B, 3-D, 4-A
3. 1-D, 2-A, 3-C, 4-B
4. 1-C, 2-B, 3-D, 4-A

NCERT Exercise

1. 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**

Exp. (b) The human eye can focus objects at different distances by adjusting the focal length of the eye lens due to accommodation.

2. The human eye forms an image of an object at its

a. Cornea **b. Iris**

c Pupil **d. Retina**

Exp. (d) Human eye forms the image of an object at its retina. The retina is the layer of nerve cells lining the back wall inside the eye. This layer senses the light and sends signals to the brain.

3. 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**

Exp. (c) The least distance of distinct vision for a young adult with normal vision is 25 cm.

4. The change in focal length of an eye lens is caused by the action of the

a. Pupil **b. Retina**

c. Ciliary muscles **d. Iris**

Exp. (c) Changes in the focal length of an eye lens is caused by the action of the ciliary muscles.

5. 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?

Exp. The power (P) of a lens and it's focal length f is related as

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

(i) Power of the lenses = –5.5 D

$$\text{Focal length (f)} = \frac{1}{P}$$

$$f = \frac{1}{-5.5}$$

$$f = -0.181 \text{ m}$$

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

$$\text{Focal length (f)} = \frac{1}{P}$$

$$f = \frac{1}{1.5}$$

$$= +0.667 \text{ m}$$

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

6. 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?

Exp. If a person is suffering from myopia then the image of a distant object is formed in front of the retina. So, a concave lens is used to correct this defect of vision.

Here,

Object distance (u) = ∞

Image distance (v) = –80 cm

Focal length = f

From the lens formula,

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

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

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

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

Also,

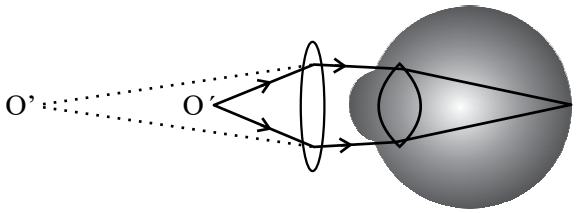
$$\text{Power, } P = \frac{1}{f(\text{in metres})}$$

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

Therefore, a concave lens of power –1.25 D is required by the individual to correct his defect.

7. 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.

Exp. Hypermetropia is corrected by using a convex lens. A convex lens of a suitable power is used to converges the incoming light in such a way that the image is formed on the retina, as shown in the following diagram.



Correction for Hypermetropic Eye

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

The 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 cm

Focal length, f

From the lens formula, we have

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

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

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

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

Also,

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

$$P = \frac{1}{0.33} = +3.0\,D$$

Therefore, a convex lens of power + 3.0 D is required to correct the defect.

8. Why is a normal eye not able to see clearly the objects placed closer than 25 cm?

Exp. The ciliary muscles of the human eye are unable to contract beyond a certain limit. So a normal eye is not able to see the objects placed closer than 25 cm clearly.

9. What happens to the image distance in the eye when we increase the distance of an object from the eye?

Exp. The image distance always remains same for our eyes. The image is formed on the retina even on increasing the distance of an object from the eye. For this eye lens becomes thinner and its focal length increases as the object is moved away from the eye.

10. Why do stars twinkle?

Exp. The stars twinkle due to atmospheric refraction of starlight. The starlight, on entering the earth's atmosphere, undergoes refraction continuously before it reaches the earth. The atmospheric refraction occurs in a medium of gradually changing refractive index.

11. Explain why the planets do not twinkle?

Exp. Planets don't twinkle like the stars because they are closer to the earth than the distant stars. There is not much atmospheric refraction of light. Hence, refraction of light is not enough for the planets to twinkle.

12. Why does the Sun appear reddish early in the morning?

Exp. The white light coming from the sun travels through larger distance in the atmosphere before reaching the observer. During this, the scattering of all colored lights except the light corresponding to red color takes place and so only the red colored light reaches to the observer. That's why sun appears reddish at sunrise and sunset.

13. Why does the sky appear dark instead of blue to an astronaut?

Exp. The sky appears dark instead of blue to an astronaut, because the scattering of light does not take place outside the earth's atmosphere.

Subjective Questions

Very Short Answer Type Questions

1. The persistence of vision for human eye is?
2. What is the range of vision for normal eye?
3. Name the structure formed in human eye that controls the size of the pupil.
4. What is the other name of old age eye defect?
5. What is the angle of the prism for an equilateral glass prism.
6. What is the nature of the eye lens of human eye and that of the image formed at the retina of the eye by it?
7. Which part of our eyes helps us to focus near and distant objects in quick succession?
8. What is the role of optic nerve in the human eye.
9. Name a thin membrane through which light enters the human eye.
10. Name the following part of human eye : A dark muscular diaphragm that controls the size of the pupil.
11. In which direction, the near point of hypermetropic eye is shifted from the normal near point?
12. Name the ability of eye lens to adjust its focal length.
13. Which part of human eye acts as a screen to obtain the image of an object?
14. In a human eye, name the a thin membrane which allows light to enter the eye.
15. What is the value of near point for normal eye.
16. What is the function of pupil in human eye?
17. What is the value of far point for normal eye.
18. A person suffering from an eye defect uses lenses of power 1 dioptre. Name the defect he is suffering from and the nature of lens used.

Short Answer Type Questions

1. What is short-sightedness ? How can this defect be corrected?
2. The ciliary muscles of a normal eye are in their (i) most relaxed (ii) most contracted state. In which of the two cases is the focal length of the eye-lens more?
3. The far point of a person suffering from myopia is 2 m from the eye. Calculate the focal length and the power of the corrective lens.
4. A human eye lens is a convex lens that can form sharp images on the retina of eye for different positions of the objects but a convex lens made of glass forms a sharp image on the screen for a particular position of an object with respect to the lens. Explain, why?
5. The near point of an elderly person lies at 50 cm from the eye. Calculate the focal length and power of the corrective lens.
6. How is a normal eye able to see clearly, distant as well as nearer objects ? What is the distance of distinct vision?
7. A person cannot see objects closer than 75 cm from the eye. What will be the power of the corrected lens he should use.
8. When we enter a dim-lit room from a bright light, we are unable to see the object in the room for some time. Give the reason
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 enable him to see very distant objects distinctly?
10. Why do we have two eyes instead of one eye?

Long Answer Type Questions

1. What is long-sightedness? List two causes for development of long-sightedness. Describe with a ray diagram, how this defect may be corrected using spectacles.

Or

What is hypermetropia? State the two causes of hypermetropia. With the help of a ray diagram, show (i) the eye defect hypermetropia, (ii) correction of hypermetropia by using a lens.

2. Write different parts of eye and explain their functions. Also explain, how an image of an object is formed on the retina of eye.

3. What is short-sightedness? List two causes for development of short-sightedness. Describe with a ray diagram, how this defect may be corrected using spectacles.

Or

What is myopia? State the two causes of myopia with a labelled ray diagram show

(i) the eye defect myopia,

(ii) correction of myopia using lens.

4. At a distances between 50 cm and 300 cm from his eye, a person is able to see objects clearly.

a. Mention the kind of defect of vision he is suffering from.

b. What kind of lenses will be required to increase his range of vision from 25 cm to infinity?

Explain briefly.

Integer/ Numeric Type Questions

1. 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.

2. Power of a lens (in diopter) used for the correction of a hypermetropic eye whose near point is 40 cm should be _____.

3. 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.

4. The power of the lens used for the correction of a myopic eye whose far point is 75.5 cm should be _____.

Multiple Choice Questions

Level-I

1. The deflection of light by minute particles and molecules of the atmosphere in all direction is known as.

a. Interference b. Scattering

c. Dispersion d. Refraction

2. Having two eyes facilitates in

A : Bringing three-dimensional view

B : Increasing the field of view

C : Observing the concept of height and distance

Then the correct option is/are

a. A only b. B only

c. A and B only d. A, B and C

3. The defective eye of a person has near point 0.5 m and far point 3 m. The power of corrective lens required for

(i) seeing distant objects

(ii) reading purpose and

a. 0.2 D and +3D respectively

b. +2D and $-\frac{1}{3}$D respectively

c. – 2D and + $\frac{1}{3}$D respectively

d. 0.2 D and –3.0 D respectively

4. The clear sky appears to be blue because

a. Blue light gets reflected in the atmosphere.

b. Ultraviolet radiations are absorbed in the atmosphere.

c. Violet and blue lights get scattered more than lights of all other colours by the atmosphere.

d. Light of all other colours is scattered more than the violet and blue colour lights by the atmosphere.

5. Refraction of light by the earth's atmosphere due to variation in air density is called

a. Atmospheric refraction

b. Dispersion

c. Scattering

d. Atmospheric reflection

6. Far and near points of a young person normal eye respectively are

a. Infinity and 0 b. Infinity and 25 cm

c. 0 and 25 cm d. 150 cm and 25 cm.

7. The size of the pupil is controlled by the muscular diaphragm called.

a. Iris b. Ciliary muscles

c. Cornea d. Rod and cons

8. One cannot see through the fog, because

a. It is an opaque object

b. Light suffers total reflection at droplets

c. Light is scattered by the droplets

d. Fog absorbs light

9. Hypermetropia and myopia can be corrected respectively by

a. Plano-convex and Concave lens

b. Convex and concave lens

c. Concave and convex lens

d. Plano-concave and plano-convex lens

10. Bi-focal lens are required to correct

a. Myopia b. Presbyopia

c. Astigmatism d. Coma

11. The nature of image formed on the retina of the human eye is

a. Virtual and inverted b. Real and inverted

c. Real and erect d. Virtual and erect

12. A person is able to see distant object distinctly but cannot see nearby objects clearly this defect of vision is called

a. Hypermetropia b. Far-sightedness

c. Long-sightedness d. All of the above

13. When white light enters a prism, it gets split into its constituent colours after entering a prism. This is due to

a. Each colours has same velocity in the prism.

b. Different refractive index for different wavelength of each colour

c. Prism material have high density.

d. Scattering of light

14. At noon the sun appears white as

a. Light is least scattered

b. Different colours of the white light are scattered away

c. Blue colour is scattered the most

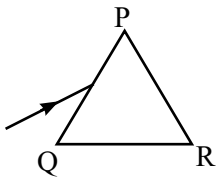
d. Red colour is scattered the most

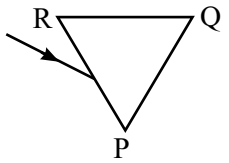
15. A person cannot see distinctly objects kept beyond 2 m. This defect can be corrected by using a lens of power

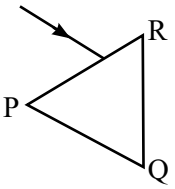
a. +0.9 D b. –0.2 D

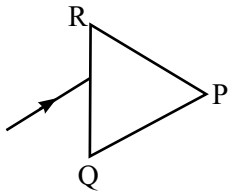
c. +0.2 D d. –0.5 D

16. A prism PQR (with QR as base) is placed in different orientations. A narrow beam of white light is incident on the prism as shown in figure. In which of the following cases, after dispersion, the third colour from the top corresponds to the colour of the sky?

a. 

b. 

c. 

d. 

17. The ability of eye lens to adjust its focal length to form a sharp image of the object at varying distances on the retina is called

a. Converging power of the eye

b. Power of accommodation of the eye

c. Power of adjustment of the eye

d. Diverging power of the eye

18. Twinkling of stars is caused due to the atmospheric

a. Dispersion of light by water droplets

b. Refraction of light by different layers of varying refractive indices

c. Reflection of light by dust particles

d. Internal reflection of light by clouds.

19. The black opening between the aqueous humour and the lens is called

a. Ciliary muscles b. Iris

c. Cornea d. Pupil

20. The layer of air of atmosphere whose temperature is less then the hot layer behave as optically

a. Rarer medium

b. Denser medium

c. Inactive medium

d. Either denser or rarer medium

Level-II

1. Human eye is one of the most valuable and sensitive organ that

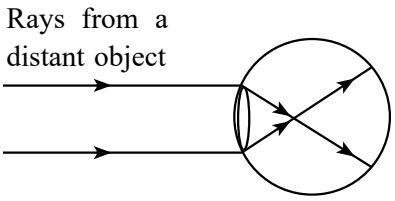
a. Enables us to see the wonderful world and colours around us

b. Can identify the objects

c. Is like a camera

d. All of these

2. A person is suffering from some sight problem. From the given diagram say which defect he suffers from? **[JSTSE 2015]**



a. Myopia b. Hypermetropia

c. Cataract d. Astigmatism

3. Iris contracts the pupil

a. In darkness

b. To allow less light to enter

c. In bright light

d. Only (b) and (c)

4. Hypermetropia is also known as far sightedness as

a. The person is able to see clearly the distant objects, but not near objects

b. The person is not able to see clearly the distant objects, but can see near objects clearly

c. The person is unable to see the distant or near objects clearly

d. The person is able to see the distant or near objects clearly

5. If a person can see an object clearly when it is placed at 25 cm away from him but not distant objects he is suffering from: **[JSTSE 2015]**

a. Myopia b. Hyper meteropia

c. Asitgmatism d. None of these

6. A person is not able to see nearby objects clearly, because
   a. Focal length of the eye lens is too great
   b. Image is formed behind the retina
   c. Use of convex lens has been ignored, though it was advised
   d. All of the above
7. The far point of a myopic person is 40 cm. To see the distant object clearly, the focal length and the power of the lens used should be: **[Punjab 2012]**
   a. –40 cm, –2.5 D b. –25 cm, –4.0 D
   c. +40 cm, +2.5 D d. –40 cm, +2.5 D
8. A normal eye is not able to see objects closer than 25 cm because
   a. The eye lens has the focal length of 25 cm
   b. The distance of the retina from the eye-lens is 25 cm
   c. The eye is not able to decrease the focal length beyond a limit
   d. The eye is not able to decrease the distance between the eye-lens and the retina beyond a limit
9. Presbyopia can be corrected by
   a. Using binoculars b. Using microscopes
   c. Using bifocal lenses d. Using sunglasses
10. The defect of human eye in which far off objects can not be seen clearly can be corrected by using **[JSTSE 2017]**
   a. Concave Mirror b. Concave Lens
   c. Convex Lens d. Convex Mirror

Assertion & Reason Type Questions

Direction: In the following Questions, the Assertion and Reason have been put forward. Read the statements carefully and choose the correct alternative from the following:

(a) Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion.

(b) Both the Assertion and the Reason both are correct but the Reason is not the correct explanation of the Assertion.

(c) Assertion is true but the Reason is false.

(d) Assertion is false but the Reason is true.

1. **Assertion:** Concave mirrors are used as reflectors in, vehicle head-lights, torches and in search lights.

   Reason: When an object is placed beyond the centre of curvature of a concave mirror, the image formed is real and inverted.
2. **Assertion:** When a pencil is partly immersed in water and held obliquely to the surface, the pencil appears to bend at the water surface.

   Reason: The apparent bending of the pencil is due to the refraction of light when it passes from water to air.
3. **Assertion:** Myopia is the defect of vision in which a person cannot see the distant objects clearly.

   Reason: Myopia is due to elongated eye-ball.
4. **Assertion:** Small area of the retina which is insensitive to light where the optic nerve leaves the eye named as blind spot.

   Reason: There are no rods or cones present at the junction of optic nerve and retina in the eye.
5. **Assertion:** The emergent light ray emerges from a parallel-sided glass slab in a direction perpendicular with that in which enters the glass slab.

   Reason: The perpendicular distance between the incident ray and emergent ray coming out of glass slab is called lateral displacement of the emergent ray of light.
6. **Assertion:** The near-point of a myopic eye is more than 25 cm away.

   Reason: Myopia is corrected using spectacles of concave lenses.

Case-Based Type Questions

Case-Based-I: The stars shine in the night sky due to their own light. 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. Planets does not appear to twinkle because
   a. They are very very close to earth
   b. They are far away from earth
   c. They are small in size
   d. None of these
2. When the atmosphere refracts less starlight towards us, then the star appears to be
   a. Dim b. Bright
   c. No change d. None of these

Case-Based-II: Suppose a person is suffering from hypermetropia. The near point of the person is 1.5 m. The near point of the normal eye is 25 cm.

1. The focal length of the lens should be
a. 10 cm b. 30 cm
c. 40 cm d. 50 cm

2. Which type of lens should be used in his spectacles
a. Convex b. Concave
c. Plano concave d. Plano convex

3. The power of the lens is
a. 3.3 D b. 2.8 D
c. 1.1 D d. 4.4 D

Olympiad & NTSE Type Questions

1. Consider the following statements:
(a) Colour blindness can be cured.
(b) Astigmatism is a defect in which on eye cannot view all the directions with equal clarity.
Which of these statement(s) is/are correct?
a. (a) only b. (b) only
c. Both (a) and (b) d. Neither (a) nor (b)

2. The colour of water in deep sea is bluish due to
a. The presence of algae and other plants found in water
b. Total internal reflection of sky in water
c. Absorption of light by the sea
d. Scattering of light

3. Advanced sunrise is due to
a. Scattering of light
b. Total infernal reflection
c. Dispersion of light
d. Atomspheric refraction of hight

4. The focal length of the eye lens increases when eye muscles
a. Contract and lens becomes thicker
b. Are relaxed and lens becomes thinner
c. Are relaxed and lens becomes thicker
d. Contract and lens becomes thinner

5. A person is suffering from both near sightedness and far sightedness. His spectacles would be made of **[NTSE 2015]**
a. Two convex lenses with the upper lens having a larger focal length than the lower lens.
b. Two concave lenses with the upper lens having a smaller focal length than the lower lens.
c. A concave lens as the upper lens and a convex lens as the lower lens.
d. A convex lens as the upper lens and a concave lens as the lower lens.

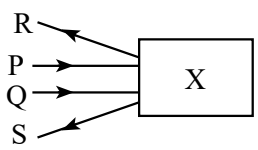
6. The danger signals installed at the top of tall buildings are red in colour. These can be easily seen from a distance because among all other colours, the red light
a. Moves fastest in air
b. Is scattered the least by smoke or fog
c. Is absorbed the most by smoke or fog
d. Is scattered the most by smoke or fog

7. A person can see clearly only the objects situated in the range 50 cm to 300 cm. He went to an optometrist who prescribed him a lens of certain power to increase the maximum distance of his vision to infinity, i.e., it corrected the near-sightedness. However, upon using the prescribed lens the person discovered that the near point of his vision has shifted from 50 cm to a distance 'd'. What is the value of d? **[NTSE 2016]**
a. 60 cm b. 100 cm
c. 40 cm d. 500 cm

8. When light rays enter the eye, most of the refraction occurs at the
a. Retina b. Outer surface of the cornea
c. Iris d. Pupil

9. To read a poster on a wall, a person with defective vision needs to stand at a distance of 0.4 m from the poster. A person with normal vision can read the poster from a distance of 2.0 m. Which one of the following lens may be used to correct the defective vision? **[NTSE 2017]**
a. A concave lens of 0.5 D
b. A concave lens of 1.0 D
c. A concave lens of 2.0 D
d. A convex lens of 2.0 D

10. Two light rays P and Q are incident on an optical device 'X' which finally goes along 'R' and 'S'. Identify optical device 'X'. **[NTSE 2017]**



a. Concave lens b. Concave mirror
c. Convex lens d. Convex mirror

Explanations

Subjective Questions

Very Short Answer Type Questions

1. $\frac{1}{16}$th of a second.

2. The range of vision for normal eye is from its near point to far point or from 25 cm to infinity.

3. Iris controls the size of the pupil.

4. Old age eye defect is also known as the presbyopia.

5. 60°

6. The eye lens in human eye is convex lens and nature of the image formed on the retina by it is real, inverted and smaller than the size of the object.

7. The ciliary muscles of our eyes help in changing the focal length of the eye lens.

8. Optic nerve in human eye transmits the visual information in the form of electrical signal generated at retina to the brain.

9. Cornea.

10. Iris.

11. The near point of hypermetropic eye is shifted farther away from the normal near point.

12. Accommodation.

13. Retina.

14. Cornea

15. 25 cm.

16. Function of pupil is to controls and regulates the light entering the eye.

17. Infinity.

18. Hypermetropia; convex lens has positive focal length.

Short Answer Type Questions

1. Short-sightedness is also known as near-sightedness or Myopia

A human eye is said to be myopic if it can see the near objects clearly but unable to see far off objects or distant objects clearly.

This defect can be corrected using a concave lens

2. The focal length of eye-lens is more when the ciliary muscles of a normal eye are in their most relaxed state whereas the focal length of eye-lens is less when the cillary muscles are in contracted state.

3. Given that the far point lies at 2 m. So the concave lens of focal length 2 m should be used so that the objects lying at infinity can be focused at the far point.

So, for the corrective lens, focal length, f = –2 m

$$\therefore \text{ Power, } \quad P = \frac{1}{f} = \frac{1}{-2} = -0.5D$$

4. The focal length of human eye lens can be changed by the action of ciliary muscles whereas a convex lens made of glass has a fixed focal length and hence it forms a sharp image on the screen for a particular position of an object.

5. The near point of the elderly person lies at 50 cm. Therefore, a convex lens should be used for the correction of his vision. The focal length of the corrective lens is

From lens formula

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

$$= \frac{1}{-50} - \frac{1}{-25}$$

$$\therefore f = \frac{1}{50}$$

$\therefore$ Power of the corrective lens,

$$P = \frac{1}{f} = \frac{1}{0.5} = +2D$$

6. The ability of eye to see distant as well as nearer objects clearly is known as accommodation. When objects is placed far away, from the eye the focal length of lens is increased due to the relaxed ciliary muscles. Hence sharp image of object is formed on the retina of eye. When object is nearer to the eye, the focal length of lens is decreased due to the contraction of ciliary muscles and hence sharp image of the object is formed on the retina of eye. The distance of distinct vision is 25 cm.

7. Given that the person cannot see objects lying closer than 75 cm, he suffers from hypermetropia. His near point has shifted from 25 cm to 75 cm. Let the focal length of the corrective lens be f

   Given: u = –25 cm, v = –75 cm

   From lens formula we have, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-75}-\frac{1}{-25}$

   $\Rightarrow \frac{1}{f}=\frac{2}{75}$ or $f=\frac{75}{2}\text{cm}=\frac{0.75}{2}\text{m}$

   $\text{Therefore, Power}(P)=\frac{1}{f}=\frac{2}{0.75}\text{D}=+\frac{8}{3}\text{D}$

8. When we are in a bright light, the iris contracts the pupil of an eye to allow less light to enter into the eye. Thereafter, when, we enter the dim-lit room, iris of our eyes takes time to expand the pupil of an eye to allow more light to enter the eye so that the visible image of the object lying in the room are formed on the retina of the eye.

9. Since the person suffers from myopia, concave lens of focal length 80 cm = –0.80 m should be used.

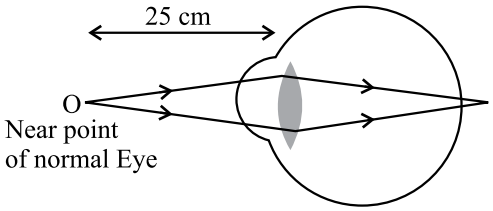
   $\therefore\ P=\frac{1}{-0.80}=-1.25\text{D}$

10. The field of view with two eyes is more than with one eye, that's why two eyes are better than one eye.

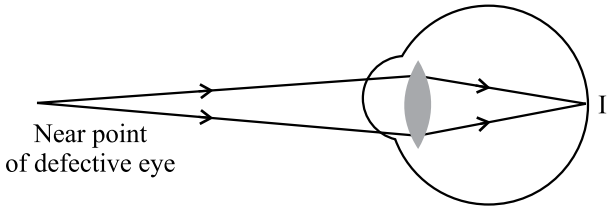
Long Answer Type Questions

1. A human eye which can see distant objects clearly but can not see the nearby objects clearly is said to be suffering with a defect of long sightedness or Hypermetropia.

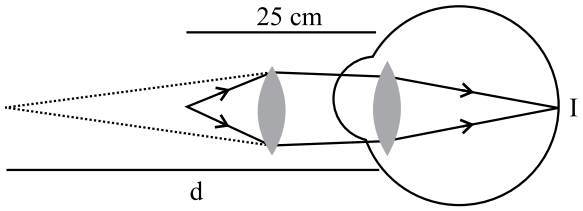
Correction of long-sightedness (or Hypermetropia)



(a) Eye suffering from hypermetropia (or long sightedness)



(b)



(c) Correction of long sightedness

In case of hypermetropia image of an object placed at normal near point is formed behind the retina of eye as shown in the diagram (a) above. Hence, the image on the retina is blurred. The near point of such eye is little far from the near point of normal eye as shown in diagram (b).

Hypermetropia 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 diagram (c).

Causes of Hypermetropia: This defect arises either due to the increase in the focal length of eye lens or due to the thinning of the eye lens so that the light rays from the nearby points or objects are not brought to focus on the retina of the eye.

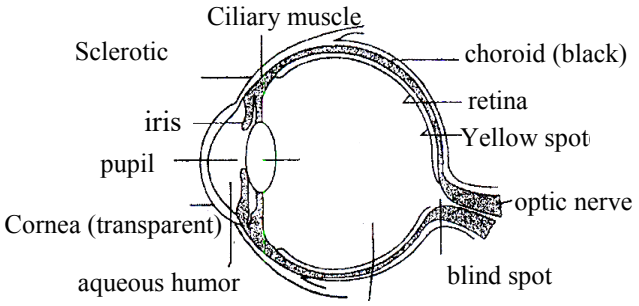
2. Main parts of Eye and their function:

   Cornea: Cornea is the transparent spherical membrane that is in the form of a bulge on the front surface of the eyeball.

It covers the front portion of the eye. Most of the refraction for the light rays occurs at the outer surface of the cornea.

Aqueous humour: Anterior chamber of the eye is filled with a transparent liquid having refractive index 1.335. This liquid is known as the aqueous humour.

Iris: Iris is a dark muscular diaphragm present in the eye. Iris controls the size of the pupil.



Pupil: The pupil regulates and controls the amount of light entering the eye. It contracts in excess of light and expands in dim light allowing us to view in excess light as well as in dim light.

Eye lens: Eye lens provides the adjustment of focal length of the eye so that the images of objects at different distances can be formed at the retina.

Ciliary muscles: Ciliary muscles are connected to the eye lens. These muscles change the thickness of the eye lens by relaxing or by exerting pressure on the lens.

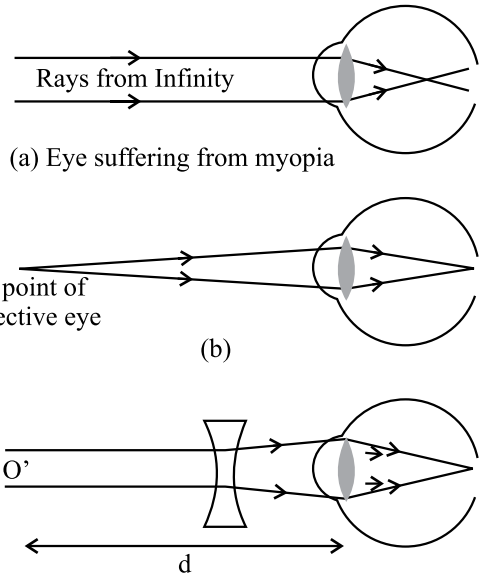
Vitreous humour: Posterior chamber of the eye is filled with a transparent watery liquid. This liquid is called the vitreous humour.

Retina: Retina is the back surface of the eye. It consists of a thin membrane which is rich in nerve fibres, containing two kinds of vision cells called rods and cones. Retina is sensitive to light and serves as the purpose of a sensitive screen where the images are formed.

Blind spot: The blind spot is a part of the eye where the optic nerves enter the eye. This part of the eye is insensitive to light.

3. If a human eye can see the near objects clearly but is unable to see distant objects clearly then it is said to be myopic.

The image of a distant object is formed in front of the retina of eye suffering from myopia as shown in figure. 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.



This defect can be corrected by using a concave lens of suitable focal length (or power). So, a man suffering from this defect wears spectacles having concave lens of suitable focal length. The concave lens used diverges the rays of light entering the eye from infinity. Hence this lens makes the rays of light appear to come from the far point (O') of the defective eye as shown in figure.

Causes of Myopia: This defect arises either due to the elongation of the eye ball or the excessive curvature of the cornea.

4. (a) For the given condition the person is suffering from myopia as well as hypermetropia.

(b) (Case-I) We need to make his near point of vision to 25 cm

Given u = –25 cm

v = –50 cm

From lens formula,

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

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

$$\frac{1}{f}=\frac{1}{-50}-\frac{1}{-25}=\frac{1}{25}-\frac{1}{50}=\frac{1}{50}$$

f = +50 cm

∴ convex lens of focal length 50 cm is required to make his near point to 25 cm.

(Case-II) We need to make his far point of vision to 300 cm.

Given u = –∞; v = –300 cm

From lens formula,

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

$$\frac{1}{f}=\frac{1}{-300}-\frac{1}{\infty}=\frac{-1}{300}$$

$\Rightarrow$ f = –300 cm

Concave lens of focal length 300 cm is required.

Integer/ Numeric Type Questions

1. **(b)** From lens formula,

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=-\frac{1}{50}-\frac{1}{-25}$$

$$\therefore \frac{1}{f}=\frac{1}{25}-\frac{1}{50}=\frac{1}{50}$$

f = 50 cm,

$$P=\frac{100}{f}=\frac{100}{50}=2\ D$$

2. A hypermetopic eye is corrected by using a convex lens.

Focal length of lens used, f = + (defected near point)

f = + d $\Rightarrow$ + 40 cm

$$\therefore \text{Power of lens}=\frac{100}{f(cm)}=\frac{100}{+40}=+2.5D$$

Hence, the correct answer is 2.5.

3. **(c)** $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$

$$\frac{1}{f}=\frac{1}{-40}-\frac{1}{-25}$$

$$\frac{1}{f}=\frac{3}{2}$$

P = 1.5 D

4. Distance of far point x = 75.5 cm

As f = –x = –0.755 m

$$P=\frac{-1}{0.755}=-1.32\ D$$

Hence, the correct answer is 1.32 D.

Multiple Choice Questions

Level-I

1. **(b)** This phenomenon of deflection of light by minute particles and molecules of the atmosphere in all direction is called scattering of light.

2. **(d)** Two eyes increases the field view, enables three-dimensional view and let us observe the height and distance.

3. **(b)** For distant objects

u = ∞, v = –3m, f = ? P = ?

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-3}-\frac{1}{\infty}=-\frac{1}{3}$$

$$\therefore P=\frac{1}{f(m)}=-\frac{1}{3}D$$

For reading purpose

u = –25 cm, v = 0.5 m = –50 cm, f = ? P = ?

From lens formula, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-50}-\frac{1}{-25}=\frac{1}{50}$

$$\therefore P=\frac{100}{f(cm)}=100\times\frac{1}{50}=+2D$$

4. **(c)** Violet and blue colour have shorter wavelength. So, they are scattered more than lights of other colour by the molecules present in the atmosphere.

5. **(a)** This phenomena is called atmospheric refraction.

6. **(b)** Far point = infinity and near point = 25 cm.

7. **(a)** Iris is the muscular diaphragm that control the size of pupil.

8. **(c)** Objects are not visible through the fog because droplets scatter the light rays.

9. **(b)** Myopia is corrected by using concave lens whereas hypermetropia is corrected by using convex lens.

10. **(b)** Upper point of bifocal lens consists of concave lens used for distant vision while lower point consists of convex lens facilitate near vision. Together

they are called bifocal lens and used to correct presbyopia.

11. **(b)** So, image formed by eye lens on the retina is real and inverted as eye lens is convex in nature.

12. **(d)** Hypermetropia is also called long-sightedness or far-sightedness.

13. **(b)** Dispersion takes place because refractive index of the material of prism is different for different wavelength.

14. **(a)** At noon, the sun is at the top and the light rays coming from the sun have to travel less distance therefore, all colours get scattered very less.

15. **(d)** Person cannot see distant objects clearly. So he is suffering from myopia. The defect is corrected by using concave lens of power

$$P = \frac{1}{f} = \frac{-1}{2} = -0.5 \text{ D}$$

16. **(b)** In figure (a) base BC of the prism is at the bottom, then violet colour lies at the bottom but in figure (b), the base BC is at the top, then violet would be at the top after dispersion, and third colour would be blue.

17. **(b)** The ability of the eye lens to adjust its focal length is called power of accommodation of the eye.

18. **(b)** Twinkling of star is due to atmospheric refraction of starlight caused due to the gradual change in refractive index of different air layers at different height, the apparent position of star keeps on changing.

19. **(d)** The black opening between the aqueous humour and the eye lens is called pupil.

20. **(b)** The cold air layer of the atmosphere acts as a optically denser medium than hot air as the molecules are closely packed together in cold air.

Level-II

1. **(d)** Working of the human eye as a camera makes it one of the most valuable and sensitive organ of the body. It is only because of the eye that we are able to see the wonderful world and colours around us.

2. **(a)** In mypoia the, image formation will take place before the retina. This is what is happening in the diagram

3. **(d)** Iris contracts the pupil in bright light so as to allow less light to enter.

4. **(a)** Hypermetropia is also known as far sightedness because the person is able to see clearly the distant objects, but not nearby objects.

5. **(a)** Myopia or short shightedness is the defect of eye where person is not able to see far off objects and see near by objects clearly.

6. **(d)** A person is not able to see near by object as the focal length of the eye lens is too large or the eye ball has shrunk. The image is formed behind the retina and the person faces difficulty in seeing the near objects clearly.

7. **(a)** Given far point of myopic person is 40 cm. Focal length of lens to be used must be equal to distance of far point.

So, f = –40 cm

(As myopic person needs concave lens so f negative)

Power of lens, $P = \frac{1}{f(\text{in metre})} = -\frac{1}{0.40} = -2.5\text{D}$

8. **(c)** A normal eye is not able to see objects closer than 25 cm because the focal length of eye lens can not decrease beyond a certain limit.

9. **(c)** Presbyopia is a condition in which a person is suffering from both myopia and hypermetropia. It can be corrected by using bifocal lenses in which upper portion is a concave lens and the lower portion is a convex lens.

10. **(b)** Myopia is corrected by concave lens.

Assertion & Reason Type Questions

1. **(b)** The Assertion and the Reason are correct but the Reason is not the correct explanation of the Assertion.

2. **(a)** Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion.

3. **(a)** Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion.
4. **(a)** Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion.
5. **(d)** The statement of the Assertion is false but the Reason is true.
6. **(d)** Assertion is false but the Reason is true.

Case-Based Type Questions

Case-Based-I

1. **(a)** The planets are much closer to the earth and thus can be considered as the extended source of light. So, fluctuation in the light coming from various points of the planet gets averaged out due to atmospheric refraction.
2. **(a)** When the atmosphere refracts less starlight, then the star appears to be dim and when the atmosphere refracts more star light towards us, the star appears to be bright.

Case-Based-II

1. **(b)** Given, near point (d) = 150 cm

   D = 25 cm

   v = –150 cm

   u = –25 cm

   From lens formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

   $\Rightarrow \frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-150\text{ cm}}-\frac{1}{-25\text{ cm}}$

   $=\frac{-1+6}{150\text{ cm}}=\frac{5}{150\text{ cm}}$ or $f=30\text{ cm}$
2. **(a)** Convex lens is used for hypermetropia
3. **(a)** $P=\frac{1}{f(\text{in metre})}=\frac{1}{0.3}=3.3\text{D}$

Olympiad & NTSE Type Questions

1. **(b)** Colour blindness can't be cured at present. There are coloured lenses that can be used to help distinguish certain colours, but they are impractical for daily use.
2. **(d)** The fine water molecules mainly scatter blue light due to its shorter wavelength.
3. **(d)**
4. **(b)** Ciliary muscles modify the curvature of eye lens. When eye muscles are relaxed, eye lens becomes thinner and therefore the focal length of the eye lens will increase.
5. **(c)** Concave lens (upper part) for viewing distant object and convex lens (lower part) for viewing near objects.
6. **(b)** Red light colour has longer wavelength so least scattered by smoke or fog.
7. **(a)** To make far point to infinity,

   image distance v = –300 cm

   When u = –∞ (max. distance of vision to infinity)

   f = ?

   $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}\Rightarrow\frac{1}{f}=-\frac{1}{300}\Rightarrow f=-300\text{ cm}$

   For near point

   $\text{Now, }\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\Rightarrow\frac{-1}{50}-\frac{1}{d}=\frac{-1}{300}$

   $\Rightarrow\frac{1}{d}=\frac{-1}{50}+\frac{1}{300}\Rightarrow d=-60\text{ cm}$
8. **(b)** Most of the refraction for light entering the eye occurs at the outer surface of cornea.
9. **(c)** Object distance u = 2 meter, image distance v = 0.4 meter, f = ?

   $\frac{1}{f}=\frac{1}{v}-\frac{1}{4}=\frac{-5+1}{2}=\frac{-4}{2}=-2$

   $P=\frac{1}{f}=-2\text{D (concave lens)}$

   So a concave lens of 2D will be used.
10. **(d)** A convex mirror diverges a parallel beam of ray falling on it on the same side of the mirror.