11 HUMAN EYE AND COLOURFUL WORLD

BASIC CONCEPTS – A FLOW CHART

HUMAN EYE AND COLOURFUL WORLD

Human Eye

Main Parts of the Eye

Cornea
Transparent spherical membrane covering front of the eye through which light enters.

Iris
Coloured diaphragm between the cornea and the lens that controls size of pupil.

Pupil
A hole in the middle of the iris that regulates the amount of light entering the eye.

Retina
Screen on which the image is formed by the lens system of human eye.

Types of light sensitive cells

- **Rods**: Respond to the intensity of light and enable vision in dim light.
- **Cones**: Respond to colour so that we perceive objects as they are.

Eye Lens
Transparent crystalline convex lens converges the light rays and produces a real and inverted image of object on retina.

Power of Accommodation
- Ability of the eye lens to adjust its focal length.
- Relaxation of ciliary muscles → lens becomes thin → increase in focal length.
- Contraction of ciliary muscles → lens becomes thick → focal length decreases.

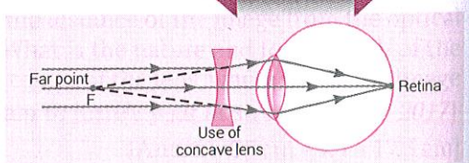
Optic Nerve
Transfers signals from retina to the brain.

Defects of Eye

Myopia or Near-sightedness
- Eye cannot see distant objects clearly.
- Image of distant object forms in front of retina.

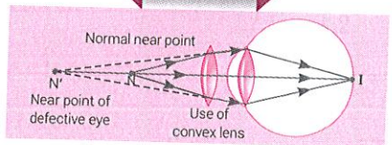
Reasons:
(i) Focal length of eye lens is too short
(ii) Elongation of eyeball.

Correction → **Concave Lens**



Hypermetropia or Far-Sightedness
- Eye cannot see nearby objects clearly.
- Image of close by object forms behind retina.
- Reasons:
  (i) Focal length of eye lens is too long.
  (ii) Eyeball becomes small.

Correction → **Convex Lens**



Presbyopia
- Eye suffers from myopia as well as from hypermetropia.
- Due to gradual weakening of ciliary muscles and diminishing flexibility of eye lens.

Correction → **Bi-focal Lens (concave + convex lenses)**

Phenomena Occurring in Nature

Dispersion of Light
- Splitting of light into its component colours.
- White light disperses into its seven-colour components in the order VIBGYOR (Violet, Indigo, Blue, Green, Yellow, Orange, Red).
- Red light bends least, violet the most.
- Rainbow appears due to dispersion of sunlight by tiny rain droplets.

Atmospheric Refraction
- Refraction of light by the earth's atmosphere.
- The twinkling of stars is due to continuously atmospheric refraction of starlight before it reaches earth.

Scattering of Light

Tyndall Effect
- When a beam of light strikes fine particles in air, path of the beam becomes visible.
- Very fine particles scatter mainly blue light while particles of larger size scatter light of longer wavelengths.

Calculation of focal length for correcting lenses:

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

(i) For Myopia: $u = \infty$
v = far point of myopic person

(ii) For Hypermetropia: u = normal near point of eye (25 cm)
v = near point of hypermetropic eye.

MORE POINTS TO REMEMBER

❒ **Working of eye:**

- Light reflects off from the object and enters the eyeball through the cornea.
- The cornea bends the light rays through the pupil.
- The adjusted light passes through the eye's lens.
- The eye lens is convex in nature. The image formed on the retina is real, small and inverted.
- The retina converts the light rays into electrical signals which are sent to the brain via optic nerve.

❒ **Near Point:** The closest distance at which the eye can focus clearly is called the near point or least distance of distinct vision. For young adults with normal vision, it is about 25 cm.

❒ **Far Point:** The farthest distance at which an object can be seen clearly is called far point. It is infinity for a normal eye.

❒ **Persistence of Vision:** The impression or sensation of the image remains on the retina for about 1/16th of a second. It is called persistence of vision. In cinematography the principle of persistence of vision is used. The sequence of still pictures taken by a movie camera is projected on the screen at a rate of 24 images or more per second. The images on the screen appear to blend or merge smoothly into one another.

❒ **How do We See Colours:** The retina of our eye has a larger number of light sensitive cells. The cells on the retina are of two shapes—rod-shaped and cone-shaped. The rod-shaped cells respond to the intensity of light. The cone-shaped cells of our retina respond to colours. Thus, cones make colour perception possible.

❒ **Colour Blindness:** The defect of the eye due to which a person is unable to distinguish between certain colours, is known as colour blindness. The colour blind persons do not possess cone cells that respond to certain colours. Colour blindness is a genetic disorder which occurs by inheritance. It has not been cured so far.

❒ **Calculation of Focal Length and Power of Concave Lens to Correct Myopia:** The focal length of concave lens required to correct myopia is calculated by the lens formula:

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

In this case, $u = \infty$, (infinity)

v = far point of myopic person

Knowing the focal length, power is calculated by

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

❒ **Calculation of Focal Length and Power of Convex Lens to Correct Hypermetropia:**

Formula used: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

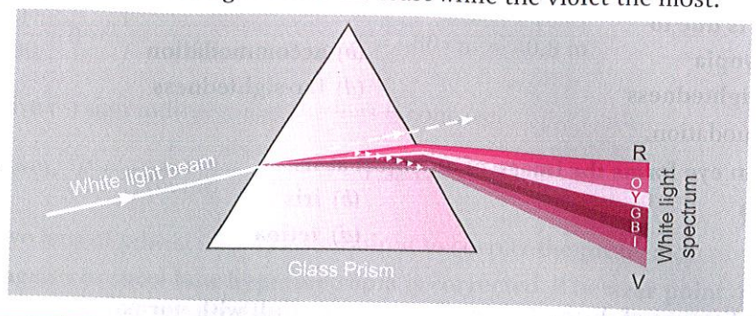
Take, u = normal near point of the eye (25 cm)

v = near point of the hypermetropic eye.

Knowing f, power is calculated by

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

❒ **Dispersion through glass prism:** The prism splits the incident white light into a band of colours. Different colours of light bend through different angles with respect to the incident ray, as they pass through a prism. The red light bends the least while the violet the most.



NCERT Intext Questions

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

Ans. The ability of the eye to focus on the distant objects as well as the nearby objects on the retina by changing the focal length or converging power of its lens is called accommodation.

The normal eye has a power of accommodation which enables the objects as close as 25 cm and as far as infinity to be focused on its retina.

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

Ans. In normal eye, the far point is infinity. The lens used should be such that an object at infinity forms virtual image at 1.2 m.

Now, $v = -1.2$ m, $u = -\infty, f = ?$

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

$$\frac{1}{f}=\frac{1}{-1.2}-\frac{1}{(-\infty)}=-\frac{1}{1.2}$$

or $f = -1.2$ m

Power, $P=\frac{1}{f}=\frac{1}{-1.2}$

$$=\frac{-5}{6}=-0.83\ D$$

A concave (or divergent) lens of focal length 1.2 m and power – 0.83 D should be used to restore proper vision.

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

Ans. For normal vision, the near point is about 25 cm and far point is infinity. Thus, a normal eye can see objects clearly that are between 25 cm and infinity.

Q. 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 child is suffering from myopia. It can be corrected by using spectacles containing concave lenses.

NCERT Exercises

Q. 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**

Ans. (b) accommodation.

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

(a) cornea **(b) iris**

(c) pupil **(d) retina**

Ans. (d) retina.

Q. 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**

Ans. (c) 25 cm.

Q. 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**

Ans. (c) ciliary muscles.

Q. 5. A person needs a lens of power –5·5 diopters for correcting his distant vision. For correcting his near vision he needs a lens of power + 1·5 diopter. What is the focal length of the lens required for correcting (*i*) distant vision, and (*ii*) near vision?

Ans. (*i*) Power, $P = -5.5$ D, Focal length, f = ?

$$\because \quad P = \frac{1}{f(\text{in m})}$$

$$\text{or} \quad -5.5 = \frac{1}{f}$$

$$\text{or} \quad f = \frac{1}{-5.5} = -0.18 \text{ m}$$

The negative (–) sign indicates that the lens is concave.

(*ii*) Power, $P = +1.5$ D

Focal length, f = ?

$$\because \quad P = \frac{1}{f(\text{in m})}$$

$$\text{or} \quad +1.5 = \frac{1}{f}$$

$$\text{or} \quad f = \frac{1}{+1.5}$$

$$\text{or} \quad f = +0.67 \text{ m}$$

The positive sign indicates that the lens is convex.

Q. 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?

Ans. The far point of this myopic person is 80 cm. This means that this person can see the distant object (which is kept at infinity) clearly if the image of this object is formed at his far point (80 cm). Therefore, in this case,

$u = \infty, v = -80$ cm, f = ?

Using lens formula

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \text{or} \quad \frac{1}{-80} - \frac{1}{\infty} = \frac{1}{f}$$

$$\text{or} \quad -\frac{1}{80} - 0 = \frac{1}{f} \quad \text{or} \quad f = -80 \text{ cm} = -0.8 \text{ m}$$

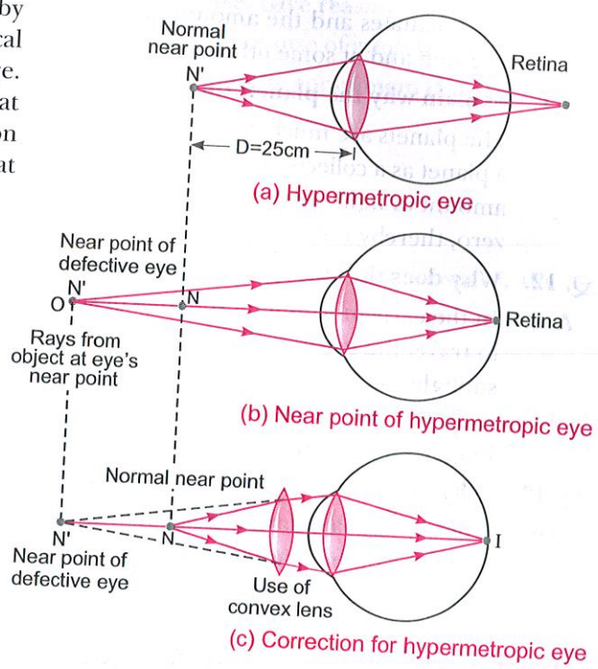
The negative (–) sign indicates that the lens is concave.

Now, Power, $P = \frac{1}{f(\text{in m})} = \frac{1}{-0.8} = -1.25$ D

The concave lens of power – 1.25 D is required to correct the problem.

Q. 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.

Ans. The hypermetropic eye is corrected by using a convex lens of appropriate focal length as spectacles in front of the eye. This convex lens makes a virtual image at the position of near point of the person so that the person is now able to see that image clearly.



Here, $u = -25$ cm (Normal near point)

$v = -1$ m $= -100$ cm

(Near point of defective eye)

f = ?

Using lens formula,

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

$$\text{or} \quad \frac{1}{-100} - \frac{1}{-25} = \frac{1}{f}$$

$$\text{or} \quad \frac{1}{-100} + \frac{1}{25} = \frac{1}{f}$$

$$\text{or} \quad \frac{-1+4}{100} = \frac{1}{f}$$

$$\text{or} \quad f = \frac{100}{3} = 33.3 \text{ cm}$$

Thus, the convex lens of focal length + 33.3 cm is required to correct this defect.

Here, $f = 33.3$ cm $= 0.33$ m

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

$$= \frac{1}{+0.33} + 3.0 \text{ D}$$

Thus, the convex lens of power + 3.0 D is required.

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

Ans. The maximum accommodation of a normal eye is reached when the object is at a distance of 25 cm from the eye. The focal length of the eye lens cannot be decreased below this minimum limit. Thus, an object placed closer than 25 cm (or very close to eye) cannot be seen clearly by a normal eye.

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

Ans. The distance between eye lens and retina is the image distance inside the eye. The image distance is fixed. It cannot be changed at all. Therefore, when we increase the distance of an object from the eye, there is no change in the image distance, inside the eye.

Q. 10. Why do stars twinkle? *[CBSE (F) 2015]*

Ans. The twinkling of a star is due to the atmospheric refraction of starlight. The atmospheric refraction occurs in a medium of gradually changing refractive index.

Since the atmosphere bends starlight towards the normal, the apparent position of the star is slightly different from its actual position. This apparent position of the star is not stationary, but keeps on changing slightly, as the physical conditions of the earth's atmosphere are not stationary. 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 appear brighter, and at some other time, fainter, which is the twinkling effect.

Q. 11. Explain why the planets do not twinkle. *[CBSE (F) 2015]*

Ans. 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.

Q. 12. Why does the sun appear reddish early in the morning? *[CBSE Delhi 2015]*

Ans. In the early morning (at the time of sunrise), when the sun is near the horizon, the sunlight has to travel the greatest distance through the atmosphere to reach us. During this long journey of sunlight, most of the blue colour and shorter wavelength present in it is scattered out and away from our line of sight. So, the light reaching us directly from the rising sun consists mainly of longer wavelength, red colour due to which the sun appears reddish early in the morning.

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

Ans. The sky appears dark instead of blue to an astronaut because there is no atmosphere containing air in the outer space to scatter sunlight. As there is no scattered light to reach our eyes in outer space, so, the sky appears dark.

VERY SHORT ANSWER QUESTIONS [1 mark]

Q. 1. 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?

Ans. In most relaxed state.

Q. 2. Write in one word or at the most in one sentence about the following

(*i*) Mirrors used by dentists to examine teeth.

(*ii*) The smallest distance, at which the eye can see objects clearly without strain.

Ans. (*i*) Concave mirror (*ii*) Near point or 25 cm.

Q. 3. Which defect of the eye can be corrected by using a cylindrical lens?

Ans. Astigmatism.

Q. 4. A person is advised to wear spectacles with concave lenses. What type of defect of vision is he suffering from?

Ans. Near-sightedness/Short-sightedness/Myopia.

Q. 5. A person is advised to wear spectacles with convex lenses. What type of defect of vision is he suffering from?

Ans. Far-sightedness/Long-sightedness/Hypermetropia.

Q. 6. What is colour blindness?

Ans. Colour blindness is that defect of the eye due to which a person is unable to distinguish certain colours, sometimes even the primary colours.

Q. 7. When a monochromatic light having only one wavelength, passes through a prism, will it show dispersion?

Ans. No, it will not show dispersion. It will only show deviation.

Q. 8. What do you understand by spectrum of white light?

Ans. The band of seven colours formed on white screen when a beam of white light (or sunlight) is passed through a glass prism is called spectrum of white light.

Q. 9. The sun can be seen about two minutes before actual sunrise. Give reason.

Ans. The sun can be seen about two minutes before actual sunrise because of atmospheric refraction.

Q. 10. Name the component of white light that deviates the least and the component that deviates the most while passing through a glass prism.

Ans. Least deviated component: Red

Most deviated component: Violet

Q. 11. Why does the sky appear dark to astronauts?

Ans. For scattering of light, particles are required. Since there are no particles in space, the sky appears dark to astronauts.

SHORT ANSWER QUESTIONS–I [2 marks]

Q. 1. How do we see colours?

Ans. The retina of a human eye has a large number of light sensitive cells. These cells are of two types, *i.e.*, rod cells and cone cells. The rod shaped cells show response towards the intensity of light rays, while the cone shaped cells respond to colours. It is these cone cells, which make it possible for a person to see different colours and distinguish between them.

Q. 2. What is colour-blindness? What kind of retinal cells are lacking in person suffering from this defect?

Ans. The defect of the eye due to which a person is unable to distinguish between certain colours, is known as colour blindness. Cone shaped retinal cells are responsible for making a person differentiate between colours. The colour blind persons do not possess cone cells that respond to certain colours.

Q. 3. Why there is no dispersion of light refracted through a rectangular glass slab?

Ans. After refraction at two parallel faces of a glass slab, a ray of light emerges in a direction parallel to the direction of incidence of white light. As rays of all colours emerge in the same direction, *i.e.*, the direction of the incidence of white light, there is no dispersion. However, there is lateral displacement.

Q. 4. Why are 'danger' signal lights red in colour?

Ans. Danger signal lights are red in colour because the red coloured light having longer wavelength is scattered the least by fog or smoke. Therefore, it can be seen clearly from a distance.

Q. 5. What is meant by dispersion of white light? Name the various colours of spectrum of white light in proper sequence.

Ans. The splitting of white light into its component colours is called dispersion of light. The band of the coloured components formed due to dispersion of white light is called 'spectrum'. Seven colours of spectrum are violet, indigo, blue, green, yellow, orange and red also known as 'VIBGYOR'.

Q. 6. What is the cause of dispersion?

Ans. All colours of light travel at the same speed in a vacuum. When these enter a transparent substance like prism, all slow down by different amounts depending on their wavelength. As these slow down by different amounts, different colours are refracted through different angles which causes dispersion.

Q. 7. Why do different rays deviate differently in the prism?

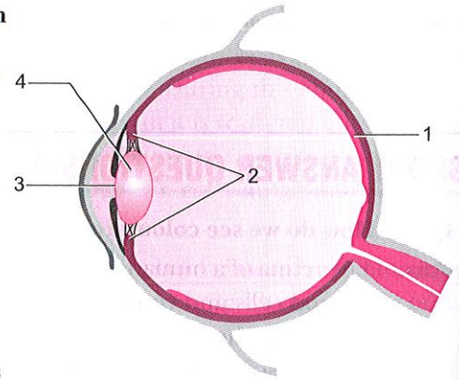
Ans. Different wavelengths deviate differently in the prism because the angle of refraction for different colours having different wavelengths is different while passing through the glass prism.

Q. 8. How will you use two identical prisms so that a narrow beam of white light incident on one prism emerges out of the second prism as white light? *[NCERT Exemplar]*

Ans. By using two identical prisms, one placed inverted with respect to the other we get a narrow beam of white light incident on one prism emerges out of the second prism as white light.

SHORT ANSWER QUESTIONS–II [3 marks]

Q. 1. (a) Name the four parts labelled as 1, 2, 3 and 4 in the given diagram.
(b) At which place is the image of an object formed?



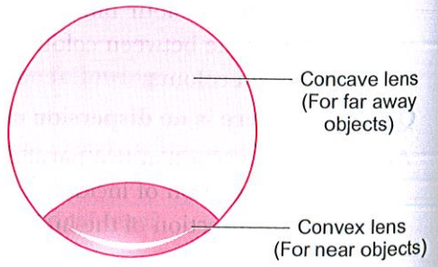
Ans. (a) 1. Retina
2. Ciliary muscles
3. Pupil
4. Crystalline lens

(b) Retina.

Q. 2. What is presbyopia? What causes presbyopia? How is presbyopia corrected?

Ans. The power of accommodation of the eye decreases with ageing. For most people, the near point gradually recedes and the far point comes closer. This defect is called presbyopia.

It arises due to the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens. Such a person may suffer from myopia and hypermetropia. This defect is then corrected by using bi-focal lenses of suitable focal lengths. The upper part of the lens is concave lens which corrects myopia to see the distant objects clearly, while the lower part of the lens has convex lens which corrects the hypermetropia to see the nearby objects clearly.



Q. 3. What is astigmatism? What causes astigmatism? How is astigmatism corrected?

Ans. In this defect, a person cannot focus on both horizontal as well as vertical lines at the same time. So he can see the objects clearly only in one plane.

This defect is mainly due to the cornea that is not perfectly spherical. As a result, the cornea has different curvatures in different directions of the horizontal and vertical planes.

This defect can be corrected by using cylindrical lenses of suitable focal length and suitable axis in the spectacles.

Q. 4. What is meant by 'persistence of vision'? We are able to see the movie picture in a cinema hall. How does this happen?

Ans. The ability of the human eye to continue to see the image of an object for a very short duration even after the removal of that object is called persistence of vision. Infact the sensation produced by the image of an object lasts for nearly $1/16^{th}$ of a second on retina.

It is due to persistence of vision that we are able to see movie pictures in a cinema hall. The pictures in the form of a long film are projected on the screen at a rate of about 24 pictures per second. Under these conditions, the image of one picture persists on the retina of the eye till the image of the next picture falls on the screen, and so on. Due to this, the slightly different images of the successive pictures present on the film merge smoothly with one another and give us the feeling of continuity and moving images.

Q. 5. What is meant by scattering of light? Use this phenomenon to explain why the clear sky appears blue or the sun appears reddish at sunrise.
[CBSE (F) 2017, CBSE Delhi (C) 2017, CBSE (AI) 2015]

Ans. The phenomenon in which a part of the light incident on a particle is redirected in different directions is called the scattering of light.

The blue colour of the sky is due to the scattering of sunlight by the molecules of atmosphere. The light of shorter wavelength (blue) of the visible spectrum is scattered more than the light of longer wavelength by the atmospheric particles. When we look at the sky, the scattered light enters our eyes which majorly contains blue, colour and hence the sky appears blue.

At the time of sunrise and sunset, when the Sun is near the horizon, sunlight travels a greater distance through the atmosphere to reach us. During this, most of the shorter wavelengths present in it are scattered away from our line of sight by the molecules of air and other fine particles in the atmosphere. So, light reaching us directly from the rising or setting Sun consists mainly of the longer wavelength red colour because of which the Sun appears red.

Q. 6. Using the phenomenon of scattering of light, explain why there is a difference in the colour of the sun as it appears during sunrise and at noon. *[CBSE (F) 2017]*

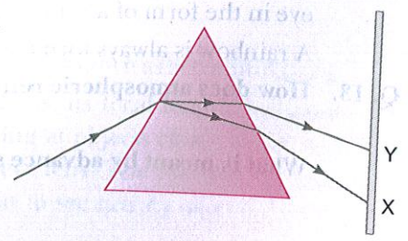
Ans. At sunrise, light from the sun near the horizon passes through thicker layers of air and larger distance in the earth's atmosphere before reaching our eye. Hence shorter waves are scattered away and longer (red) waves reach our eye. Hence sun appears red.

However, at noon sunlight would travel relatively shorter distance only a little blue and violet colours are reflected and it is nearly the white light which reaches our eye.

Q. 7. Why does it take sometime to see objects in a dim room when you enter the room from bright sunlight outside?

Ans. In the bright sunlight, iris causes the pupil to become smaller so that only a small portion of light enters the eye and rods of the retina are also adjusted in the same way. But, when a person enters into a dimly lighted room, each iris takes some time to increase the diameter of the pupil, so that more amount of light can enter the eyes to see the object clearly and rod cells of the retina also take some time to adjust themselves to get the picture of the object in the dim light.

Q. 8. In the given figure, a narrow beam of white light is shown to pass through a triangular glass prism. After passing through the prism it produces a spectrum XY on a screen.



(a) State the colour seen at X and Y.

(b) Why do different colours of white light bend through different angles with respect to the incident beam of light?

Ans. (a) X — Violet

Y — Red

(b) Different colours of white light bend through different angles with respect to the incident beam of light due to difference in speed of light of different wavelengths.

Q. 9. Explain giving reason why the sky appears blue to an observer from the surface of the Earth. What should the appearance of the sky be during the day for an astronaut staying in the international space station orbiting the Earth? State reason to justify your answer.

[CBSE (F) 2015]

Ans. The fine particles in the atmosphere scatter light of shorter wavelength (blue colour) more strongly than the light of longer wavelength (red colour). Therefore, the sky appears blue from the surface of the Earth.

For an astronaut the sky would appear dark because in space there is no atmosphere to scatter light.

Q. 10. Why is the colour of sky blue? *[NCERT Exemplar]*

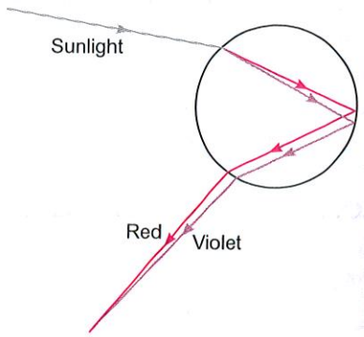
Ans. The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. These are more effective in scattering light of shorter wavelengths at the blue end than light of longer wavelengths at the red end. When sunlight passes through the atmosphere, the fine particles in air scatter the blue colour more strongly than red. The scattered blue light enters our eyes. Since we see the blue light from everywhere overhead, the sky appears blue.

Q. 11. What is Tyndall effect? Explain with an example.

Ans. The scattering of light by particles in its path is called Tyndall effect. When a beam of light enters a smoke-filled dark room through a small hole, then its path becomes visible to us. The tiny dust particles present in the air of room scatter the beam of light all around the room. Thus, scattering of light makes the particles visible. Tyndall effect can also be observed when sunlight passes through a canopy of a dense forest. Here, tiny water droplets in the mist scatter light.

Q. 12. Describe the formation of rainbow in the sky with the help of a diagram.

Ans. A rainbow is a natural spectrum appearing in the sky after a rain. It is produced by dispersion of sunlight by tiny water droplets, present in the atmosphere. The water droplets act like small prisms. When a ray of light falls on water drop (or raindrop) it undergoes refraction and dispersion to form a spectrum. This spectrum undergoes internal reflection (inside the raindrop) and finally refracted again when it comes out of the raindrop. After the dispersion of light and internal reflections, the band of colours reaches observer's eye in the form of a rainbow.



A rainbow is always formed in the direction opposite to that of the sun.

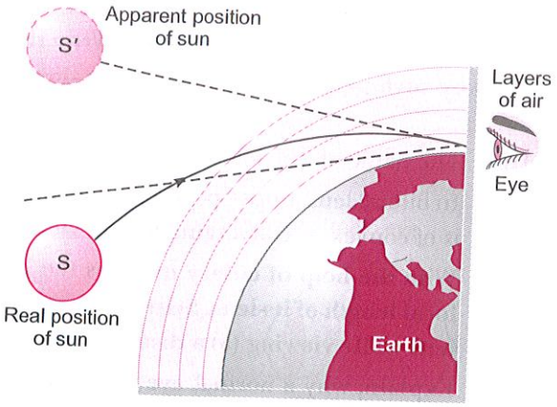
Q. 13. How does atmospheric refraction affect sunrise and sunset?

Or

What is meant by advance sunrise and delayed sunset. Draw a labelled diagram to explain.

[CBSE (F) 2015, 2017]

Ans. The layers of air nearer to earth are denser than those above it. At sunrise and sunset when the sun is below the horizon, the light rays starting from sun are incident on these layers. They pass through successively denser layers and thus get bent more and more towards the normal until they fall upon the eye of the observer O. To the observer O these rays appear to come from S' which is above horizon. It is for this reason that the sun is visible to us a little before it rises above the horizon and so also till a little later it sets below the horizon. The difference of time is about 2 minutes each for early rise and late setting of the Sun.



Q. 14. How does refraction of light take place in the atmosphere ? Explain the reason why stars appear to twinkle and the planets do not twinkle. *[CBSE Delhi (C) 2017]*

Ans. Since the atmosphere consists of varying densities the apparent position of the object, as seen through the hot air fluctuates. This wavering of light is an effect of atmospheric refraction.

The twinkling of a star is due to atmospheric refraction of star light. The atmospheric refraction of light occurs in a medium of gradually changing refractive index.

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

Q. 15. A person needs a lens of power – 4.5 D for correction of her vision.

(a) What kind of defect in vision is she suffering from?

(b) What is the focal length of the corrective lens?

(c) What is the nature of the corrective lens? *[NCERT Exemplar]*

Ans. (a) Myopia

(b) $f = \frac{1}{-4.5} = -\frac{2}{9}\text{m} = -0.22\text{ m}$

(c) Concave lens

Q. 16. Write about power of accommodation of human eye. Explain why the image distance in the eye does not change when we change the distance of an object from the eye?

[CBSE Delhi 2017]

Ans. Ability of the eye lens to focus nearby as well as distant objects on the retina by changing the curvature or focal length of the eye lens is known as power of accommodation.

Image distance in the eye is the distance between the eye lens and the retina and it is fixed. As the object approaches from infinity towards the eye, the focal length of the eye lens decreases (or vice-versa) so as to maintain the same image distance.

Q. 17. How are we able to see nearby and also the distant objects clearly?

Ans. This is due to the ability of the eye lens to adjust its focal length which is known as accommodation.

When the ciliary muscles are relaxed, the lens becomes thin. Thus, its focal length increases. This enables us to see distant objects clearly. When we are looking at objects closer to the eye, the ciliary muscles contract. This increases the curvature of the eye lens. The eye lens becomes thicker. The focal length of the eye lens decreases. This enables us to see nearby objects clearly.

Q. 18. Due to gradual weakening of ciliary muscles and diminishing flexibility of the eye lens a certain defect of vision arises. Write the name of this defect. Name the type of lens required by such persons to improve the vision. Explain the structure and function of such a lens.

[CBSE Delhi 2017]

Ans. The name of the defect is Presbyopia. Bifocal lens is required to improve the vision.

In bifocal lens, upper portion is of concave or diverging lens to view far off objects and lower part is of convex or converging lens to view nearby objects.

Q. 19. With the help of ciliary muscles the human eye can change its curvature and thus alter the focal length of its lens. State the changes that occur in the curvature and focal length of the eye lens while viewing (a) a distance object, (b) nearby objects.

Explain, why a normal eye is not able to see distinctly the objects placed closer than 25 cm, without putting any strain on the eye. *[CBSE Delhi 2017]*

Ans. (a) Lens becomes thin

Curvature decreases.

Focal length increases.

(b) Curvature increases.

Focal length decreases.

This is because focal length of the lens of a normal human eye cannot be decreased below a certain limit *i.e.*, 25 cm.

LONG ANSWER QUESTIONS [5 marks]

Q. 1. State the function of each of the following parts of the human eye:

(*i*) Cornea **(*ii*) Iris**

(*iii*) Pupil **(*iv*) Retina**

Millions of people of the developing countries are suffering from corneal blindness. This disease can be cured by replacing the defective cornea with the cornea of a donated eye. Your school has organised a campaign in the school and its neighbourhood in order to create awareness about this fact and motivate people to donate their eyes after death. How can you along with your classmates contribute in this noble cause? State the objectives of organising such campaigns in schools. *[CBSE (F) 2015]*

Ans. **(*i*) Cornea:** Refraction of the light rays falling on the eye.

(*ii*) Iris: To control the size of the pupil.

(*iii*) Pupil: To regulate and control the amount of light entering the eye.

(*iv*) Retina: To act as a screen to obtain the image of object and generate electrical signals which are sent to the brain via optic nerves.

We can contribute by participating in different ways of motivating people for the noble cause of eye donation such as, street play, banners, poster, door to door campaign, etc.

Objectives of organising such campaigns:

(*i*) To develop the habit of group work,

(*ii*) To work for a common cause,

(*iii*) To understand social issues and problems.

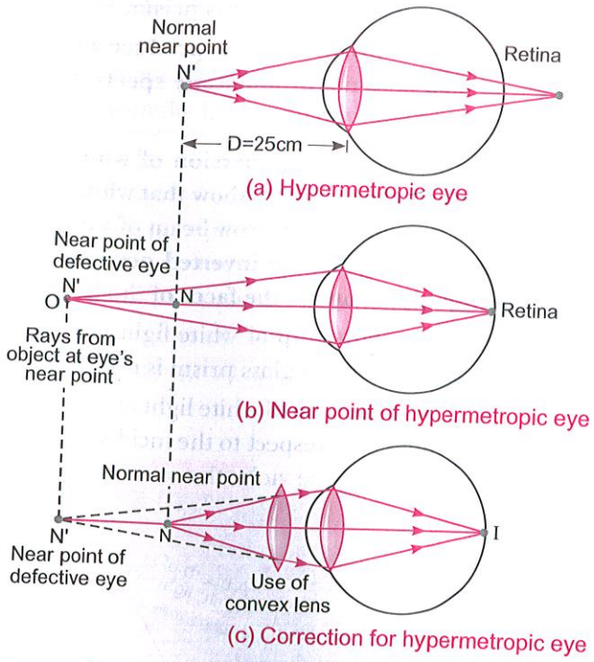
Q. 2. What is hypermetropia? Write two causes for development of this defect. Describe with a ray diagram how this defect of vision can be corrected by using spectacles.

Ans. A person can see distant objects distinctly but cannot see nearby objects so clearly in this case, the image is formed behind the retina. This defect of the eye is hypermetropia.

Causes of hypermetropia: This defect arises because either

(*i*) the focal length of the eye lens is too long, or

(*ii*) the eyeball becomes too short, so that light rays from the nearby object, say at point N, cannot be brought to focus on the retina to give a distinct image.



Hypermetropia can be corrected by using convex lens of suitable focal length in spectacles.

Q. 3. (*a*) What is myopia? State the two causes of myopia. With the help of labelled ray diagrams show

(*i*) the eye defect myopia

(*ii*) correction of myopia using a lens.

(*b*) Why is the normal eye unable to focus on an object placed within 10 cm from the eye?

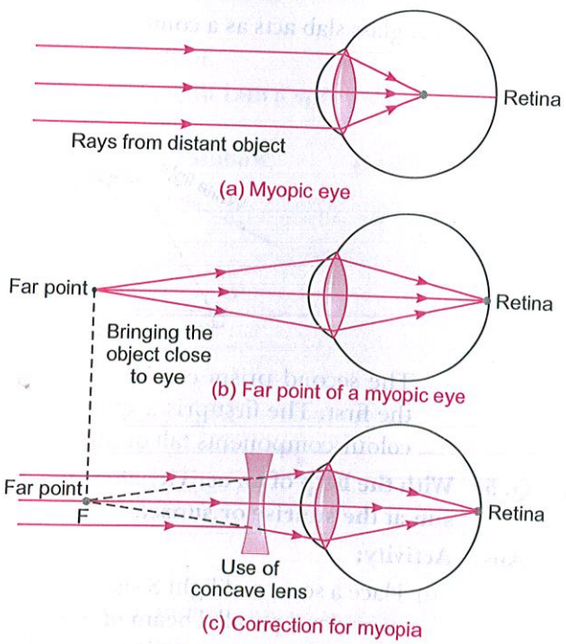
Ans. (*a*) Myopia is the defect of the eye vision due to which a person can see the nearly objects clearly but cannot see the far objects so distinctly.

Causes of myopia: Myopia is caused:

—due to the elongation of the eyeball.

—due to decrease in the focal length of the eye lens.

Myopia can be corrected by using a concave lens of suitable focal length in the spectacles of such a person.



(*b*) The ability of the eye lens to adjust its focal length is called automatic accommodation. However, the focal length of the eye lens cannot be decreased below a certain limit. The maximum accommodation of a normal eye is reached when the object is at a distance of 25 cm from the eyes. Thus, the normal eye is unable to focus an object placed within 10 cm from the eye because it is beyond its power of accommodation.

Q. 4. **(*a*) What is dispersion of white light? State its cause. Draw a ray diagram to show the dispersion of white light by a glass prism.** *[CBSE (AI) 2017]*

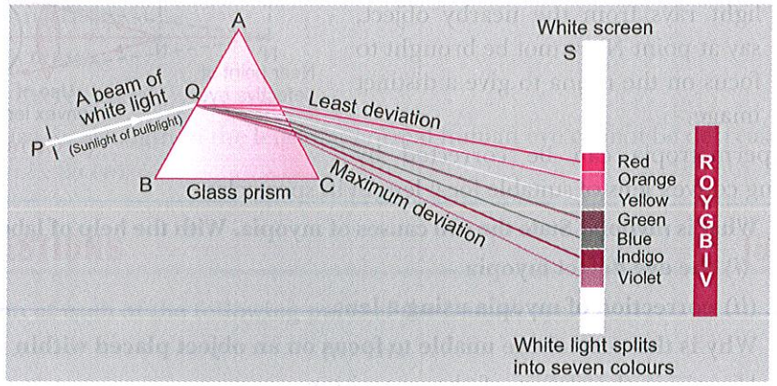
(*b*) A glass prism is able to produce a spectrum when white light passes through it but a glass slab does not produce any spectrum. Explain why it is so.

OR

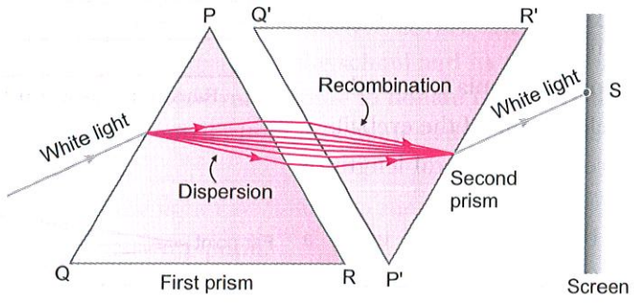
State the cause of dispersion of white light by a glass prism. How did Newton, using two identical glass prisms, show that white light is made of seven colours ? Draw a ray diagram to show the path of a narrow beam of white light, through a combination of two identical prisms arranged together in inverted position with respect to each other, when it is allowed to fall obliquely on one of the faces of the first prism of the combination. *[CBSE (AI) 2017]*

Ans. (*a*) The splitting up of white light into its constituent colours on passing through a refracting medium like a glass prism is called dispersion of light.

The dispersion of white light occurs because different colours of light bend through different angles with respect to the incident ray, as they pass through a prism. The red light bends the least while the violet the most as shown below.



(*b*) A glass slab acts as a combination of two identical glass prisms.



The second prism can be considered to be placed in an inverted position with respect to the first. The first prism splits the white light into its seven colour components. When these colour components fall on the second prism, it recombines them to form white light.

Q. 5. **With the help of an activity show the blue colour of the sky and the reddish appearance of the sun at the sunrise or sunset.**

Ans. **Activity:**

(*i*) Place a source of light S such as an electric bulb at the focus of a converging lens L_1. This lens provides a parallel beam of light.

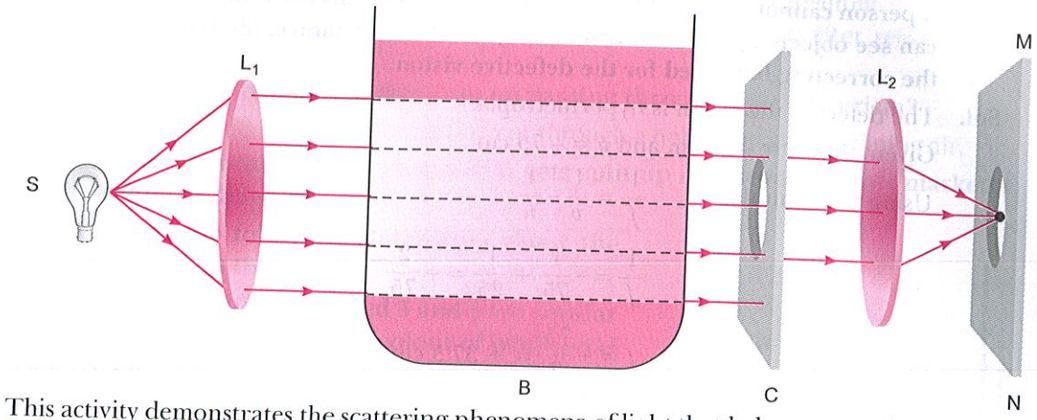
(*ii*) Allow the light beam to pass through a transparent glass beaker B of capacity 500 mL filled with water.

(*iii*) After passing through the beaker containing about 400 mL of water allow the light beam to pass through a circular hole made in cardboard C. Obtain a sharp image of the hole on a screen MN using another convex lens L_2.

(*iv*) Dissolve about 200 g of sodium thiosulphate (hypo) in water taken in the beaker B. Add about 1 to 2 mL of concentrated sulphuric acid with the help of an injection syringe dropwise in the beaker containing hypo solution.

(*v*) What do you observe?

You will notice fine microscopic sulphur particles precipitating in about 2 to 3 seconds. As the sulphur particles begin to form, you can observe the blue light from the sides of the beaker. This is due to scattering of short wavelengths by minute colloidal sulphur particles. Observe the colour of the light patch on the screen. It is interesting to observe the change in colour of the patch–from orange red colour in the beginning to bright crimson red colour later on the screen.



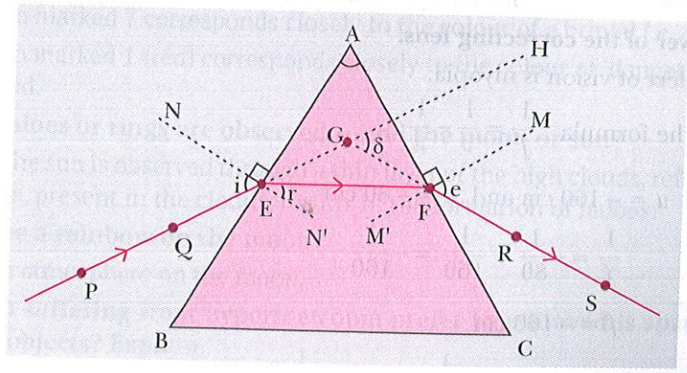
This activity demonstrates the scattering phenomena of light that helps us to understand the bluish colour of the sky in general and the reddish appearance of the sun at the sunrise or the sunset.

Q. 6. **(*a*) Draw a ray diagram to explain the term angle of deviation.**

(*b*) Why do the component colours of incident white light split into a spectrum while passing through a glass prism, explain.

(*c*) Draw a labelled ray diagram to show the formation of a rainbow. *[CBSE Delhi 2017]*

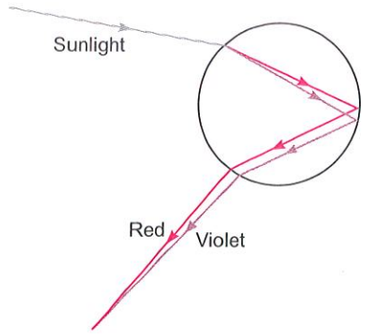
Ans. (*a*)



$\angle\delta$ is the angle of deviation.

(*b*) Different colour of white light bend through different angles with respect to the incident light, as they pass through the glass prism. Thus, each colour emerges along a different path, forming a spectrum.

(*c*)



Some Important Numericals

Q. 1. A person cannot see objects nearer than 75 cm from his eyes while a person with normal vision can see objects upto 25 cm from his eyes. Find the nature, the focal length and the power of the correcting lens used for the defective vision.

Sol. The defect of the vision is hypermetropia.

Given, that $u = -25$ cm and $v = -75$ cm.

Using the formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\therefore \quad \frac{1}{f} = -\frac{1}{75} + \frac{1}{25} = +\frac{2}{75}$

or $\quad f = +\frac{75}{2} = +37.5 \text{ cm}$

$$\text{Power of the lens} = \frac{1}{f(\text{in metres})}$$

$$= \frac{100}{75/2} = +\frac{8}{3} = +2.67 \text{ D}$$

The + sign with f or the power indicates a convergent lens.

Q. 2. A person cannot see objects beyond 80 cm from his eye while a person with normal eyesight can see object easily placed upto 160 cm from the eye. Find the nature, the focal length and the power of the correcting lens.

Sol. The defect of vision is myopia.

Using the formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

Given, $u = -160$ cm and $v = -80$ cm

$\therefore \quad \frac{1}{f} = -\frac{1}{80} + \frac{1}{160} = -\frac{1}{160}$

or $\quad f = -160$ cm

$$\text{Power} = \frac{1}{f(\text{in metres})} = -\frac{1}{1.60}$$

$$= -0.625 \text{ D}$$

The –ve sign with f indicates the concave lens.

Q. 3. A person can see clearly only up to 3 metres. Prescribe a lens for spectacles so that he can see clearly up to 12 metres.

Sol. Here, $v = -3$ m, $u = -12$ m, $f = ?$

Using $\quad \frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad$ or $\quad -\frac{1}{3} + \frac{1}{12} = \frac{1}{f}$

$f = -4$ m

A concave lens of focal length 4 m should be used.

HOTS (Higher Order Thinking Skills)

Q. 1. Is the position of a star as seen by us in its true position? Justify your answer.

[NCERT Exemplar]

Ans. No, light from stars undergoes atmospheric refraction which occurs in medium of gradually changing refractive index. So, we see the apparent position of the star after refraction by atmosphere.

Q. 2. Does a beam of white light give a spectrum on passing through a hollow prism?

Ans. No, this is because dispersion of light cannot occur through a hollow prism containing air.

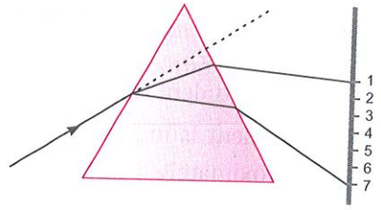
Q. 3. A beam of white light falling on a glass prism gets split up into seven colours marked 1 to 7 as shown in the diagram.

A student makes the following statements about the spectrum observed on the screen.

(*a*) The colours at positions marked 3 and 5 are similar to the colour of the sky and the colour of gold metal respectively.

Is the above statement made by the student correct or incorrect? Justify.

(*b*) Which two positions correspond closely to the colour of (*i*) brinjal, (*ii*) 'danger' or stop signal lights?



Ans. (*a*) The statement made by the student is incorrect.

Positions marked 3 (yellow) and 5 (blue) are similar to the colour of gold metal and the colour of the sky respectively. The student is stating the nature of colours in reverse order.

(*b*) (*i*) The position marked 7 corresponds closely to the colour of a brinjal *i.e.*, violet.

(*ii*) The position marked 1 (red) corresponds closely to the colour of 'danger' or stop signal lights *i.e.*, red.

Q. 4. Why sometimes haloes or rings are observed round the moon or sun?

Ans. When the moon or the sun is observed through a thin layer of the high clouds, reflection of light from fine icy crystals, present in the clouds, results in the formation of haloes.

Q. 5. Can an observer see a rainbow on the moon?

Ans. No, since there is no atmosphere on the moon.

Q. 6. Why does a person suffering from hypermetropia prefer to remove his spectacles while looking at distant objects? Explain.

Ans. A hypermetropic eye can have normal far point. If he uses spectacles of converging lens, he will have more converging power than needed for parallel rays so the distant object may get focused in front of the retina and so distant objects will appear blurred.

Proficiency Exercise

Very Short Answer Questions [1 mark]

1. A person suffering from an eye defect uses lenses of power -1D. Name the defect he is suffering from and the nature of lens used.
2. Name the
   (*a*) Component of white light that deviates the least.
   (*b*) Component of white light that deviates the most, while passing through a glass prism.
3. State the function of pupil of an eye.
4. Name the two phenomenon involved in the formation of rainbow.
5. List the factors on which scattering of light depends.

Short Answer Questions–I [2 marks]

6. Four students A, B, C and D were asked by their teacher to find the corresponding image distance for the given object distance keeping the object at various distance in case of a given convex lens of focal length 15 cm. The following observation were recorded by them.

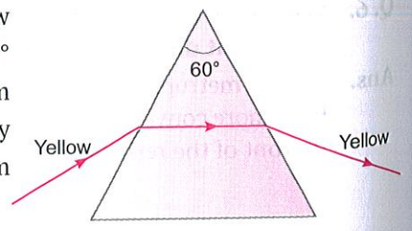
Student	Object distance (cm)	Image distance (cm)
A	22.5	45
B	25	39.5
C	37.5	25
D	45	22.5

Which student recorded the incorrect observation?

7. A student is unable to see clearly the words written on the blackboard placed at a distance of approximately 4 m from him. Name the defect of vision the boy is suffering from. Explain the method of correcting this defect. Draw ray diagram for the:
   (*i*) defect of vision and also
   (*ii*) for its correction. *[CBSE (AI) 2015]*
8. A person is unable to see objects nearer than 50 cm. He wants to read a book placed at a distance of 25 cm. Find the nature, focal length and power of the lens, he requires for his spectacles.
   [**Ans.** Convex lens, $f = 50$ cm, $P = 2$D]
9. A person with a myopic eye cannot see objects beyond a distance of 1.5 m from it. What would be the nature and power of the corrective lens used to restore proper vision? [**Ans.** $P = -0.67$D]

Short Answer Questions–II [3 marks]

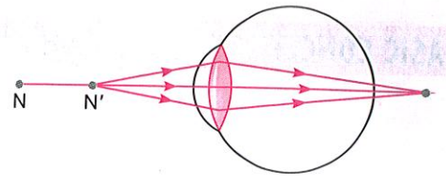
10. (*a*) What is the least distance of distinct vision for a normal eye?
    (*b*) Does the above distance increase or decrease for a long-sighted eye? Give reason for your answer with diagram.
11. The adjoining diagram shows the path taken by a narrow beam of yellow monochromatic light passing through a 60° glass prism. Now the yellow light is replaced by a narrow beam of white light incident at the same angle. Draw another ray diagram to show the passage of the beam through the prism and label it, to show the effect of the prism on the light.



12. Explain with the help of diagram why the sun is visible to us two minutes before the actual sunrise and two minutes after the sunset.
13. What is "dispersion of white light" ? Draw a labelled diagram to illustrate the recombination of the spectrum of white light. Why is it essential that the two prisms used for the purpose should be identical and placed in an inverted position with respect to each other? *[CBSE (AI) 2017]*

Long Answer Questions [5 marks]

14. Study the given diagram and answer the questions that follows:



   (*i*) Which defect of vision is represented in this case? Give reason for your answer.
   (*ii*) What could be the two causes of this defect?
   (*iii*) With the help of a diagram show how this defect can be corrected by the use of a suitable lens.
15. Explain structure and function of a human eye. How are we able to see nearby as well as distant objects. *[NCERT Exemplar]*
16. A person needs a lens of power – 5.5 diopters for correcting his distant vision. For correcting his near vision he needs a lens of power + 1.5 diopter. What is the focal length of the lens required for correcting (*i*) distant vision, and (*ii*) near vision?
17. Give reasons for each of the following:
   (*i*) The sky appears dark instead of blue to an astronaut in space.
   (*ii*) The sky near the horizon appears to have a reddish hue at the time of sunset and sunrise.
   (*iii*) The stars appear to twinkle.
18. (*a*) Write the functions of each of the following parts of the human eye:
   (*i*) Cornea
   (*ii*) Iris
   (*iii*) Crystalline (Eye) lens
   (*iv*) Ciliary muscles
   (*v*) Retina
   (*b*) A person is unable to see distinctly the objects closer than 1 m. Name the defect of vision he is suffering from. Draw ray diagrams to illustrate the cause of the defect and its correction by suitable lens. *[CBSE (F) 2017]*
19. A person is unable to see distinctly the words printed on a newspaper. Name the defect of vision he is suffering from. Draw ray diagram to illustrate this defect. List its two possible causes. Draw a ray diagram to show how this defect may be corrected using a lens of appropriate focal length. *[CBSE Delhi (C) 2017]*