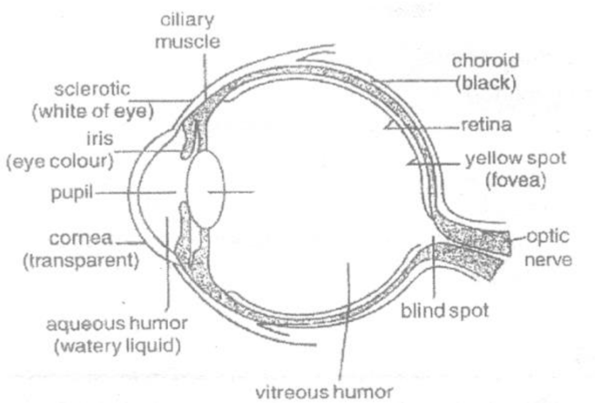
HUMAN EYE

The human eye is one of the most sensitive sense organs of sight which enables us to see the wonderful world of light and colour around us. It is like a camera having la 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 :

5.1 (a) Structure and Working of Human Eye :

The human eye has the following parts :



(jelly)

(i) Cornea : It is the transparent spherical membrane covering the front of the eye.

(ii) Iris : It is the coloured diaphragm between the cornea and lens.

(iii) Pupil : It is the small hole is the iris.

(iv) Eye lens : it is a transparent lens made of jelly like material.

(v) Ciliary muscles : These muscles hold the lens in positions.

(vi) Retina : it is the back surface of the eye.

(vii) Blind spot : it is the point at which the optic nerve leaves the eye. An image formed at this point is not sent to the brain.

(viii) Aqueous humor : It is clear liquid region between the cornea and the lens.

(ix) Vitreous humor : The space between eye lens and retina is filled with another liquid called vitreous humor.

In the eye, the image is formed on the retina by successive refractions at the cornera, 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.

5.1 (b) Power of Accommodation :

The image of the objects at different distances from the eye are brought to focus on the retina by changing the focal length of the eye-lens, which is composed of fibrous jelly-like material, can be modified to some extent by the ciliary muscles.

5.1 (c) Near Point and Far Point :

The nearest point at which a small object can be seen distinctly by the eye is called the near point. For a normal eye, it is about 25 cm and is denoted by the symbol D.
With advancing age, the power of accommodation of the eye decreases at the eye lens gradually loses its flexibility. 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 seen 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.

5.1 (d) Least Distance of Distinct Vision :

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, is called the least distance of distance of distinct vision. For a person with normal vision, it is about 25 cm and is represented by the symbol D, i.e.
least distance of distinct vision = D = 25 cm.

5.1 (e) Persistence of Vision :

The image formed on the retina of the eye does not fade away Instantaneously, when the object is removed from the sight. 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 continuance of the sensation of eye is called the persistence of vision.
Let a sequence of still pictures is taken by a move camera. If the sequence of these still pictures is projected on a screen at a 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 is used in motion picture projection or in cinematography.

5.1 (f) 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 of brightness and darkness were as the cone shaped cells respond to colour. In dim light rods are sensitive, but cones are sensitive only bright. The cones are sensitive to red, green and blue colour of light to 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 colour but can seen well otherwise. Such persons are said to have colour-blindness. Driving licenses are generally not issued to persons having colour-blindness.

5.1 (g) Colour Perception of Animals :

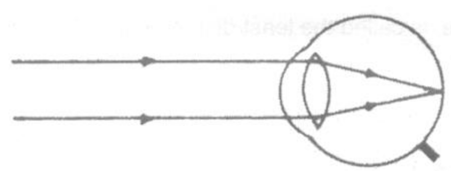
Different animals have different colour perception due to different structure of rod shaped cells and core shaped cells. For example, bees have some cone-shaped cells that are sensitive to ultraviolet. Therefore bees can seen objects in ultraviolet light and can perceive colours which we cannot do. Human beings cannot seen in ultraviolet light as their retina do not have cone-shaped cells that are sensitive to ultraviolet light.
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.

5.1 (h) Cataract :

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. This is called cataract. It results in decrease or loss in vision of the eye. Cataract can be corrected by surgery leading to normal vision.

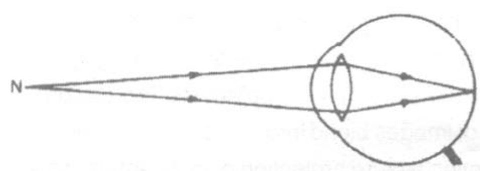
5.2 DEFECTS OF VISION AND THEIR CORRECTION :

People with normal vision can focus clearly on very distant objects. We say their far point is at infinity.



Clear Image

People with normal vision can focus clearly on near objects upto a distance of 25 cm. We say their near point is at a distance 25 cm from the eye.



Clear Image

But there are some defected due to eye irregularities which are as follows :

5.2 (a) Short Sightedness (or Myopia):

A person who can seen the near objects clearly but cannot focus on distant objects in short sightedness. The far point of a short-sighted person may be only a few metres rather than at infinity. This defect occurs if a person's eyeball is larger that the usual diameter. In such a case, the image of a distant object is formed in front of the retina as shown in the figure. It is because the eye lens remain too converging, forming the image of the object in front of the retina.

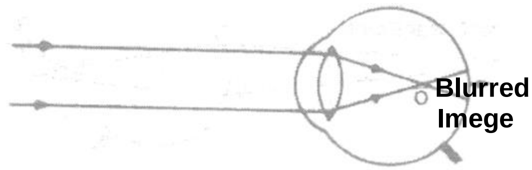
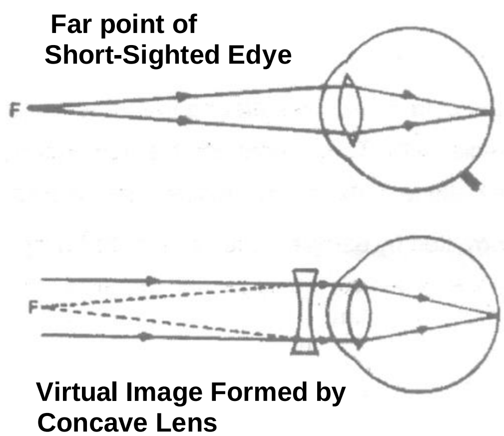


Figure : Ray diagram in casse of short sightedness

To correct short-sighted vision, a diverging lens (concave lens) of suitable focal length is place din front of the eyes as whose in figure. The rays of light from distant object are diverged by the concave lens so that final image is formed at the retina. If the object is very far off (i.e. $u \cong \infty$), then focal length of the concave lens is so chosen that virtual image of the distant object is formed at the far point F of the short-sighted eye. Therefore rays of light appear to come the image at the far point F of the short-sighted eye and not from the more distant object.



Note that focal length of the lens for a short-sighted person is equal to the negative value of the person's far point.

5.2 (b) Far Sightedness (or Hyperopia or Hypermetropia) :

A person who can seen distant objects clearly but cannot focus on near objects is farsighted, whereas the normal eye has a near point of about 25 cm. A farsighted person may have a near point several metres from the eyes. This defect may occur if the diameter of person's eyeball is smaller than the usual or if the lens of the eye is unable to curve when ciliary muscle contract. In such a case, for an object placed at the normal near point (i.e. 25 cm from eye), the image of the object is formed behind the retina as shown in the figure (i). It is because the lens of the eye is to sufficiently converging to focus the object located at the normal nearer point.

A farsighted person has the normal far point but needs a converging lens in order to focus objects which are as close as 25 cm. The converging lens of correct focal length will cause the virtual image to be formed at the actual near point of the farsighted person's eye as shown in figure (iii).

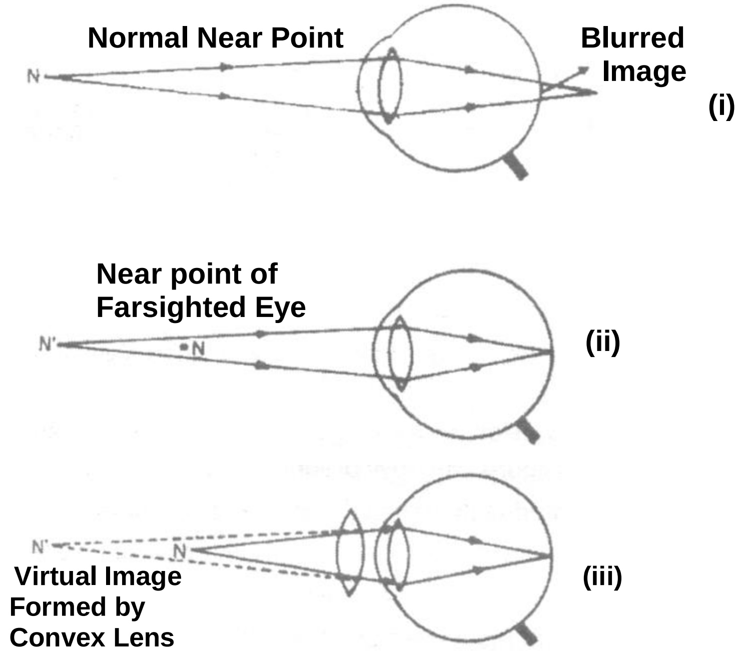


Figure : Correction of far sightedness by convx lens

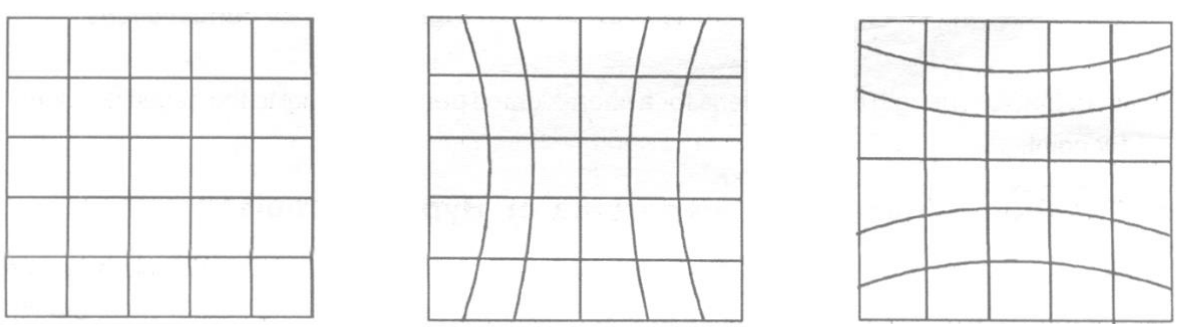
5.2 (c) Prsbyopia :

This defect arises with aging. A person suffering from this defect can see neither nearby objects nor distant objects clearly/distinctly. This is because the power of accommodation of the eye decreases due to the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens.

This defect can be corrected by using bi-focal lenses. Its lower part consists of a convex lens and is used for reading purpose whereas the upper part consists of a concave lens and in used for seeing distant objects.

5.2 (d) Astigmatism :

A person suffering from this defect cannot simultaneously focus on both horizontal and vertical lines of wire gauze.



Normal Wire Gauge **Wire Gauge with** **Wire Gauge**
with
Distorted Vertical Lines **Distorted Hjorizontal**
Lines

This defect arises due to the fact that the cornea is not perfectly spherical and has different curvatures for horizontally and vertically lying objects. Hence, objects in on direction are well focused whereas objects in the perpendicular direction are not well focused. This defect can be corrected by using cylindrical lenses. The cylindrical lenses are designed in such a way so as to compensate for the irregularities in the curvature of cornea.

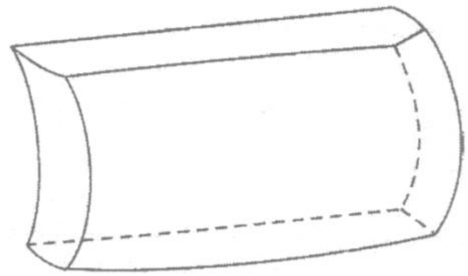
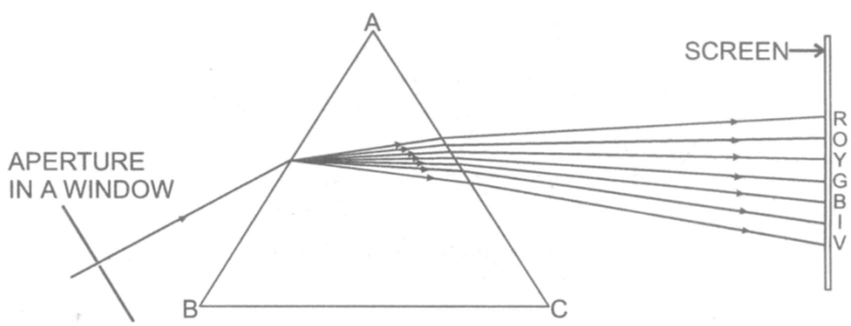


Figure : Cylindrical lens

5.3 SPECTRUM AND COLOURS :

5.3 (a) Dispersion of Light through a Prism :



Dispersion by a prism

The phenomenon of splitting of white light into its constituent colours is known as dispersion of light. It is discovered by Newton.

Colour	Frequency in 10^{14} Hz	Wavelength (nearly)
Violet	6.73 – 7.5	400 Å to 4460 Å
Indigo	6.47 – 6.73	4460 Å to 4640 Å
Blue	6.01 – 6.47	4640 Å to 5000 Å
Green	5.19 – 6.0	5000 Å to 5780 Å
Yellow	5.07 – 5.19	5780 Å to 5920 Å
Orange	4.84 – 5.07	5920 Å to 6200 Å
Red	3.75 – 4.84	6200 Å to 8000 Å

Dispersion takes place because light of different colours have different speed is a medium. Therefore the refractive index of glass is different for different colours of light. When white light is incident on the first surface of a prism and enters it, light of different colours if refracted or deviated through different angles. Thus the dispersion or splitting of white light into its constituent colours takes place.

NOTE : From the definition of refractive index

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

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

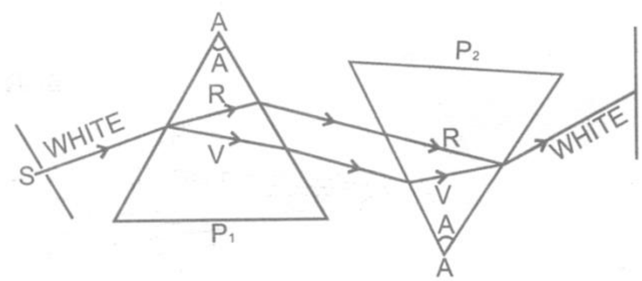
$$\mu_{violet} > \mu_{red}$$

But μ = sin i/sin r or sin r = sin i/ μ

Therefore, the angle of refraction is minimum for light of violet colour and maximum for light of red colour. 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 :

For this experiment, two prism P_1 and P_2 of the same material and of the same refracting angle A are arranged as shown is 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. Now this dispersed light falls on the second prism P_2 with its base upwards so that is deviates the light upwards.



Recomposition of white light

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. This shows that 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. The prism P_1 is called **dispersing-prism** and the prism P_2 is known as **recombination-prism.**

5.4 SCATTERING OF LIGHT :

When light falls on tiny particles then diffused reflection takes place and light spreads in all possible direction. This phenomenon 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 is size of the particles is relatively larger. Rayleigh 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 o light :

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

5.4 (a) Tyndall Effect :

The earth's atmosphere is a heterogeneous mixture of minute particles. These particles include smoke, tiny water droplets, suspended particles of dust and molecules of air. When a beam of light strikes such fine particles, the path of the beam become visible. 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. This phenomenon is seen when a fine beam of sunlight enters a smoke filled room through a small hole. Thus, scattering or 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.

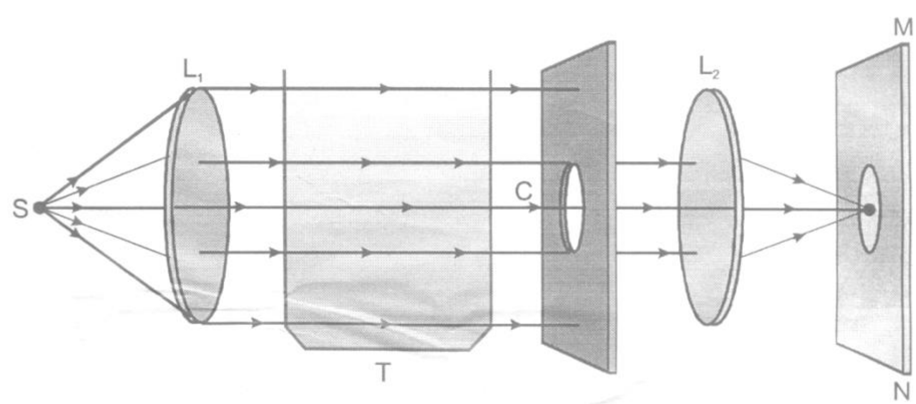
5.4 (d) Phenomena based upon Scattering of Light

(i) Colour of the clear sky is blue :

The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. These are more effective is scattering light of shorted wavelength at the blue end then light of longer wavelength at the red end. The red light has a wavelength about 1.8 times greater then blue light. Thus, 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. If the earth had no atmosphere, there would not have been any scattering. Then, the sky would have looked dark. The sky appears dark to passenger flying at very high attitudes, as scattering is not prominent at such heights.

(ii) Colours of the sun at sunrise and sunset :

Let us do an activity to understand the colour of sun at sunrise and sunset. Place a strong source (s) of white light at the focus of converging lens (L_1). This lens provides a parallel beam of light. Allow the light beam to pass through a transparent glass tank (T) containing clear water. Allow the beam of light to pass through a circular hole (C) made in a cardboard. Obtain a sharp image of the circular hole of a screen (MN) using a second converging lens (L_2). Dissolve 200 g of sodium thiosulphate in 2 L of clear water taken in the tank. Add 1 to 2 mL of concentrated sulphuric acid to the water.
We observe the microscopic sulphur particles precipitate in 2 to 3 minutes. As sulphur particles being to form we can observe the blue light from the three sided of the glass tank.
It is due to scattering of short wavelengths by minute colloidal sulphur particles. We observe that the colour of the transmitted light from the fourth side of glass tank facing the circular tank at first is orange red colour and then bright crimson red colour of the screen. Light from the sun travel relatively short distance. At moon, the sun appears white as a little of blue and violet colours are scattered. Near the horizon, most of the blue light shorter wavelength are scattered away by the particles. Therefore, the light that reaches our eye is of longer wavelength. This gives rise to the reddish appearance of the sun.



DAILY PRACTIVE PROBLEMS # 5

OBJECTIVE DPP - 5.1

1. The focal length of eye lens controlled by-
(A) Iris (B) Cornea (C) Ciliary muscles (D) Optic nerve

2. A white lights falls on a glass prism, the least deviated colour is -
(A) Violet (B) Orange (C) Red (D) Yellow

3. Blue colour of sky is due to -
(A) dispersion of light (B) scattering of light (C) refraction of light (D) reflection of light

4. Rainbow is formed due to -
(A) reflection and dispersion of light through a water droplet
(B) Total internal reflection, refraction and dispersion of light through a water droplet
(C) only dispersion of light
(D) only refraction of light

5. Power of accommodation (max. variation in power of eye lens) of a normal eye is about -
(A) 1D (B) 2D (C) 3D (D) 4D

6. Dispersion of light by a prism is due to the change in -
(A) frequency of light (B) speed of light (C) scattering (D) none of these

7. Least distance of distinct vision of a long-sighted man is 40 cm. He wish to reduce it to 25 cm by using a lens, the focal length of the lens is -
(A) $+\frac{200}{3}$ cm (B) $-\frac{200}{3}$ cm (C) + 200 cm (D) – 200 cm

8. Which of the following colour has the least wave length ?
(A) red (B) orange (C) violet (D) Blue

9. Convex lens of suitable focal length can correct -
(A) short sightedness (B) long sightedness (C) presbyopia (D) astigmatism

10. The focal length of human eye lens is -
(A) 2.5 cm (C) 25 cm (C) 25m (D) ∞

SUBJECTIVE DPP - 5.2

1. What are the causes of near sightedness ?

2. How is the amount of light entering our eye is controlled

3. Which colour bends the maximum from its path when a beam of white light is incident on it ?

ANSWERS

(Objective DPP 1.1)

Q.	1	2	3	4	5	6	7	8
A.	B	A	D	A	D	C	B	C

(Subjective DPP 2.1)

1. $\theta = 130^0$ **2.** 60^0

Q.	1	2	3	4	5	6	7	8
A.	B	B	B	D	D	A	C	C

(Subjective DPP 2.1)

1. (a) v = - 30 cm, m = -3 (b) V = 15 cm, m = 3 3. - 30 cm

(Objective DPP 3.1)

Q.	1	2	3	4	5	6	7	8
A.	B	C	D	B	D	D	A	A

(Subjective DPP 3.2)

3. 2×10^8 ms^{-1} **4.** (a) 2×10^8 ms^{-1} (b) 6×10^{14} Hz (C) $\frac{10^{-6}}{3}$ m

(Objective DPP 4.1)

Q.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A.	B	B	B	C	B	B	B	A	A	C	A	A	A	D	D

(Subjective DPP 4.2)

1. u = 50 cm, P = 4D/ **2.** Yes **3.** -2D

4. Power = 1D, Focal length = 1m

(Objective DPP 5.1)

Q.	1	2	3	4	5	6	7	8	9	10
A.	C	C	B	B	D	B	A	C	B	A