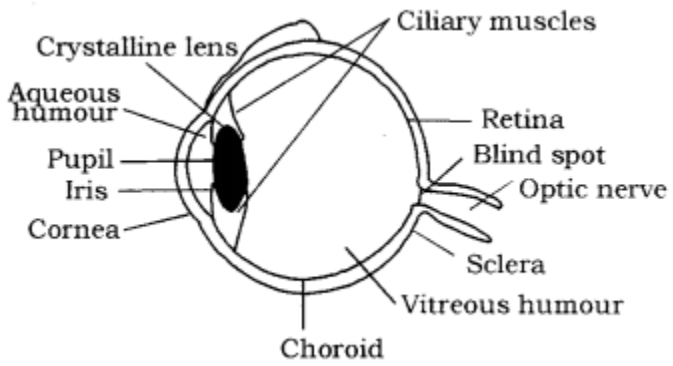
Chapter- 11

HUMAN EYE AND COLOURFUL WORLD

The Human Eye: It is a natural optical instrument which is used to see the objects by human beings. It is like a camera which has a lens and screen system.

Structure of the Human Eye



The various parts of eye and their functions:

- Retina: It is a light sensitive screen inside the eye on which image is formed. It contains rods and cones. Functions: Captures the light rays focussed by the lens and sends
- Cornea: It is a thin membrane which covers the eye trail. It acts like a lens which refracts the light entering the eye.
- Aqueous humour: It is fluid which fills the space between cornea and eye lens.
- Eye lens: It is a convex lens made of transparent and flexible jelly like material. Its curvature can be adjusted with the help of ciliary muscles.
- Pupil: It is a hole in the middle of iris through which light enters the eye. It appears black because light falling on it goes into the eye and does not come back. Functions: Opens and closes in order to regulate and control the amount of light.
- Ciliary muscles: These are the muscles which are attached to eye lens and can modify the shape of eye lens which leads to the variation in focal lengths.
- Iris: It controls the amount of light entering the eye by changing the size of the pupil. Functions: Controls light level similar to the aperture of a camera.
- Optical nerve: These are the nerves which take the image to the brain in the form of electrical signals.

How Pupil Works?

For Example, you would have observed that when you come out of the cinema hall after watching the movie in the bright sunlight, your eyes get closed. And when you entered the hall from the bright light, you won't be able to see and after some time you would be able to see. Here, the pupil of an eye provides a variable aperture, whose size is controlled by iris.

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

(b) When the light is dim: Iris expands the pupil, so that more light enters the eye.

Pupil opens completely when iris is relaxed.

Colour Blindness: A person having defective cone cells is not able to distinguish between the different colours. This defect is known as Colour Blindness.

Defects of Vision:
Myopia (Short-sightedness): It is a kind of defect in the human eye due to which a person can see near objects clearly but he cannot see the distant objects clearly. **Myopia** is due to
(i) excessive curvature of the cornea.
(ii) Elongation of eyeball.
Hypermetropia (Long-sightedness): It is a kind of defect in the human eye due to which, a person can see distant objects properly but cannot see the nearby objects clearly. It happens due to (i) decrease in the power of eye lens i.e., increase in focal length of eye lens.
(ii) Shortening of eyeball.
Presbyopia: It is a kind of defect in human eye which occurs due to ageing. It happens due to the following reasons
(i) decrease in flexibility of eye lens.
(ii) Gradual weakening of ciliary muscles.
In this, a person may suffer from both myopia and hypermetropia.

Astigmatism: It is a kind of defect in human eye due to which a person cannot see (focus) simultaneously horizontal and vertical lines both.

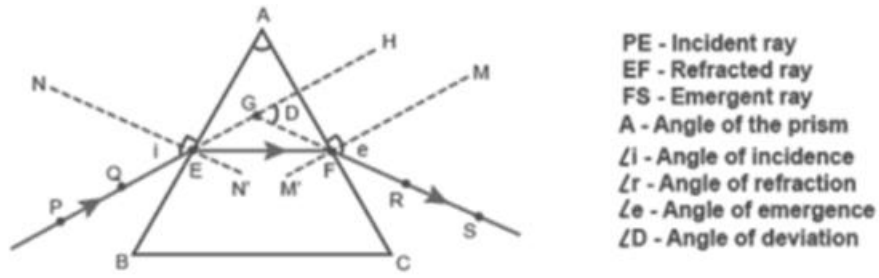
Cataract: Due to the membrane growth over eye lens, the eye lens becomes hazy or even opaque. This leads to a decrease or loss of vision. This problem is called a cataract. It can be corrected only by surgery.

2. Refraction of light through a prism: When a ray of light is incident on a rectangular glass slab, after refracting through the slab, it gets displaced laterally. As a result, the emergent ray comes out parallel to the incident ray. Unlike a rectangular slab, the side of a glass prism are inclined at an angle called the angle of prism.

Prism: A prism is a transparent refracting medium bounded by two plane surfaces, inclined to each other at a certain angle. It has one triangular base and three rectangular lateral surfaces.

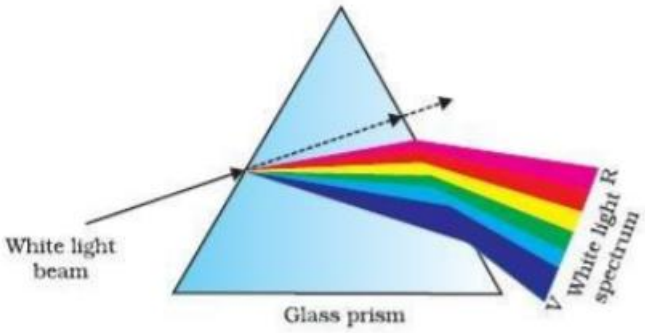
Angle of Prism: Angle between two lateral faces is called angle of prism.

Angle of Deviation: The angle between the incident deviations.



Reflection if light through a triangular glass prism

3. Dispersion of white light by a glass prism: The phenomenon of splitting of white light into its seven constituent colours when it passes through a glass prism is called dispersion of white light. The various colours seen are Violet, Indigo, Blue, Green, Yellow, Orange and Red. The sequence of colours remembers as VIBGYOR. The band of seven colours is called the spectrum. The different component colour of light bends at a different angle with respect to the incident angle. The violet light bends the least while the red bends most.



Dispersion of white light by a prism

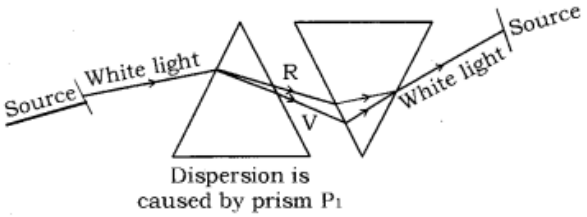
For violet colour, wavelength is minimum and for red colour wavelength is maximum, i.e. frequency for violet colour is maximum and for red colour frequency is minimum.

Composition of white light: White light consists of seven colours i.e., violet, indigo, blue, green, yellow, orange and red.

Monochromatic light: Light consisting of single colour or wavelength is called monochromatic light, example; sodium light.

Polychromatic light: Light consisting of more than two colours or wavelengths is called polychromatic light, example; white light.

Recombination of white light: Newton found that when an inverted prism is placed in the path of dispersed light then after passing through the prism, they recombine to form white light.



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

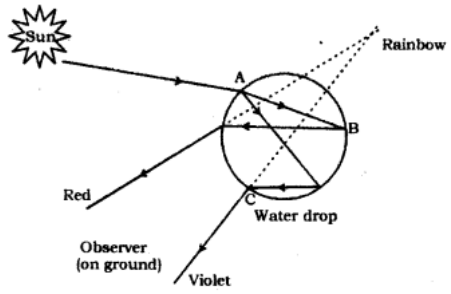
Formation of the rainbow: The water droplets act like small prism. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reach the observer's eye.

Conditions for the formation of rainbow are:

(i) The formation of rainbow involves a series of physical phenomena refraction, dispersion and internal reflection

(ii) Rainbow is always formed in a direction opposite to that of the sun, i.e. sun is always behind the observer.

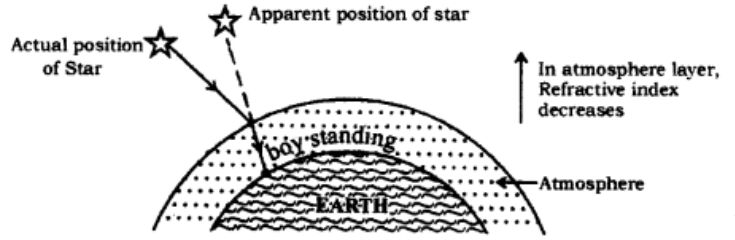
Red colour appears on top and violet at the bottom of rainbow.
A rainbow is always formed in a direction opposite to that of Sun.
At 'A' – Refraction and dispersion take place.
At 'B' – Internal reflection takes place.
At 'C' – Refraction and dispersion take place.



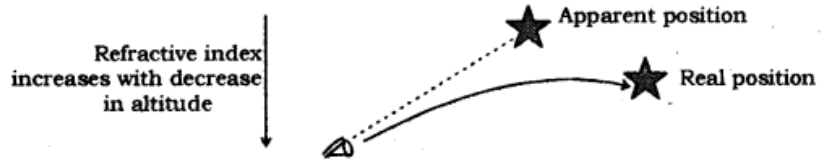
Rainbow formation

4. Atmospheric Refraction: The refraction of light caused by the Earth's atmosphere (having air layers of varying optical densities) is called Atmospheric Refraction.

Appearance of Star Position: It is due to atmospheric refraction of star light.
The temperature and density of different layer of atmosphere keeps varying. Hence, we have different medium. Distant star act as point source of light. When the starlight enters the Earth's atmosphere, it undergoes refraction continuously, due to changing refractive index i.e., from Rarer to denser. It bends towards the normal.
Due to this, the apparent position of the star is different from actual position. The star appears higher than its actual position.



Twinkling of Star: It is also due to atmospheric refraction. Distant star act like a point source of light. As the beam of starlight keeps deviating from its path, the apparent position of star keeps on changing because physical condition of earth's atmosphere is not stationary.
Hence, the amount of light enters our eyes fluctuate sometimes bright and sometime dim. This is the "Twinkling effect of star".



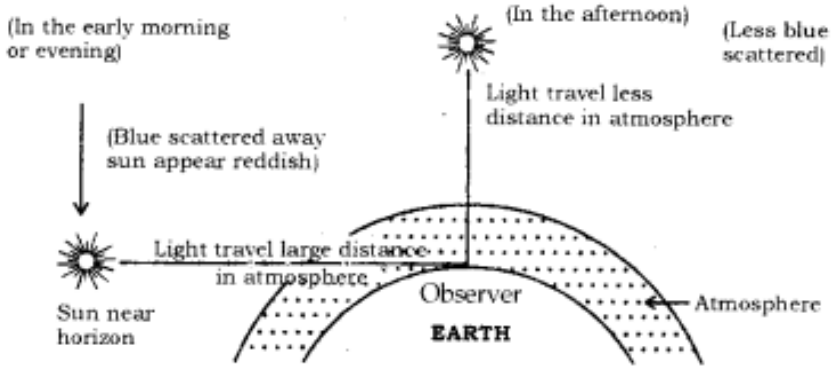
5. Scattering of light: According to Rayleigh' Law of Scattering, the amount of scattered light $\propto 1/\lambda^4$ (λ = wavelength). Scattering of light decreases with increase in wavelength.

Colour of the sky: The sunlight that reaches the earth's atmosphere is scattered in all directions by the gases and dust particles present in the atmosphere.
Sky appears blue; this is because the size of the particles in the atmosphere is smaller than the wavelength of visible light, so they scatter the light of shorter wavelength (blue end of spectrum). The blue colour is scattered more and hence the sky appears blue.

Colour of Sun at Sunrise and Sunset: While sunset and sunrise, the colour of the sun and its surrounding appear red. During sunset and sunrise, the sun is near to horizon, and therefore, the sunlight has to travel larger distance in atmosphere. Due to this, most of the blue light (shorter wavelength) is scattered away by the particles. The light of longer wavelength (red colour) reaches our eye. This give rise to reddish appearance of the sun and the sky.

The danger signal or sign is made of red colour because red colour scatters the most when strikes the small particle of fog and smoke because it has the maximum wavelength (visible spectrum). Hence, from large distance also, we can see the red colour clearly.

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



1. Define the power of accommodation?

Ans: The power of the eye lens to focus on objects near or far from the retina by adjusting its focal length is called the power of accommodation.

2. Which part of the human eye provides most of the refraction for the light rays entering the eye?
Ans: Cornea and Aqueous humor provides most of the refraction for the light rays entering the eye.

3. What happens to the image distance in the eye when we increase the distance of an object from the eye?
Ans: When the distance of an object from the eye is increased, the image distance remains the same and the image is formed on the retina of the eye.

4. What happens to the pupil of the eye when the light is very bright?
Ans: When the light is very bright, the pupil's size becomes smaller and limits the extent of light entering the eye.

5. Which part of the human eye conveys the electrical signals generated by the light sensitive cells of the retina to the brain?
Ans: Optic nerves convey the electrical signals generated by the light sensitive cells of the retina to the brain.

6. What would have been the colour of the sky if there had not been any atmosphere around the earth?
Ans: The colour of the sky would be black if there had not been any atmosphere around the earth.

7. For dispersion of light through a prism which colour has a maximum deviation?

Ans: Violet has the maximum deviation for dispersion of light through a prism.

8. What is the least distance of distinct vision of a normal human eye?
Ans: The least distance of distinct vision of a normal human eye is 2525 cm.

9. Name the muscle responsible for bringing change in the focal length of the eye lens?
Ans: Ciliary muscles are responsible for bringing change in the focal length of the eye lens.

10. Name one defect of vision which cannot be corrected by any type of spectacle lens?
Ans: Cataract, clouding of the lens of the eyes is a vision defect that cannot be corrected by any type of spectacle lens.

11. State one effect produced by the scattering of light by the atmosphere?
Ans: Tyndall effect is produced by the scattering of light by the atmosphere.

12. What is the nature of the image formed on the retina of the eye?
Ans: The image formed on the retina of the eye is real and inverted.

13. What type of lens is used for correcting hypermetropia?
Ans: Convex lens is used to rectify hypermetropia or long-sightedness.

14. Who was the first person to obtain the spectrum of sunlight?
Ans: Sir Isaac Newton was the first person to obtain the spectrum of sunlight.

15. As light rays pass from air into glass prisms, are they refracted towards or away from the normal?
Ans: As light rays pass from air into a glass prism they are refracted towards the normal as glass is denser than air.

16. Which colour has the largest wavelength?
Ans: Red colour of light has the longest wavelength in the visible spectrum of light.

17. Which defect of vision can be rectified using a concave lens?
Ans: Myopia (short-sightedness) can be rectified using a concave lens.

18. What phenomenon causes the twinkling of stars on a clear night?
Ans: Atmospheric refraction is the phenomenon that causes the twinkling of stars on a clear night.

19. What is meant by scattering of light?
Ans: Scattering of light is defined as the change in the direction of light on striking an obstacle such as dust, water vapour, etc.

20. Name the phenomenon responsible for the observed twinkling of stars. Will this twinkling be observed by an observer on the moon?
Ans: The phenomenon responsible for the twinkling of stars is atmospheric refraction.

Since the moon has no atmosphere, the observer on the moon will not be able to observe the twinkling of stars.

21. Name the part of the eye that
    a. determines the color of a person's eye

Ans: Iris

b. Controls the amount of light entering the eye

Ans: Iris

22. What is the role of the ciliary muscles?

Ans: The main role of the ciliary muscles is to hold the eye lens in its position. The ciliary muscles contract and relax to focus on near or far away objects by changing the shape of the eye lens which in turn increases or decreases the focal length of the eye lens.

23. Why is a convex lens called a converging lens?

Ans: A convex lens focuses all the parallel light rays at its focus after refraction. Hence, it is called a converging lens.

24. State the role of the eye lenses in the human eye?

Ans: The eye lens focuses the light rays entering the eye on the retina forming a real and an inverted image of the object on the retina.

25. A person with a myopic eye cannot see objects beyond 1.21.2 m distinctly. What should be the corrective lens used to restore proper vision?

Ans: Since the person is myopic and cannot see objects clearly beyond 1.21.2 m, he should use a concave lens having a focal length 1.21.2 m to restore his normal vision.

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

Ans: For a human eye with proper vision, the near point is 2525 cm from the eye and the far point is at infinity.

27. 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: Since, the student has difficulty reading the blackboard, sitting in the last row, he is suffering from myopia or short-sightedness. A concave lens of suitable power should be used to correct his vision defect.

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

Ans: The normal eye is unable to see the objects clearly placed closer than 2525 cm because at a distance of 2525 cm power of accommodation gets exhausted. Hence, the eye is unable to focus the light rays on the retina, when the object is placed closer than 2525 cm.

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

Ans: During sunrise, the sun is at the farthest distance from the earth's surface. The light rays travel a large distance in the Earth's atmosphere before reaching our eyes.

While passing through the atmosphere, the light rays with shorter wavelengths get scattered by the Earth's atmosphere and the red-colored light with the longest wavelength is able to reach our eyes. Hence, the Sun appears reddish early in the morning.

30. Why do we observe random wavering or flicking of the objects near a fire or on a very hot day?
Ans: We observe random wavering or flicking of the objects near a fire or on a very hot day because of atmospheric refraction. The area above the fire is hot and is lighter than the cool air above it due to which its refractive index is low and density also does not remain the same. Therefore, the apparent position of the object flickers.

31. Why are we not able to see things clearly when we come out of a dark room?
Ans: In a dark room, the iris expands the pupil which allows more light to enter the eye. As we come out of the darkroom, a large amount of light enters our eyes and because of the glare, we are not able to see things clearly.

32. What is the function of the optic nerve in the human eye?
Ans: Optic nerve carries the visual information from the retina to the brain in the form of electrical signals.

33. Why do different colours deviate through different angles on passing through a prism?
Ans: Different colours deviate through different angles on passing through a prism because different colours with different wavelengths travel through glass at different speeds and the glass has a different refractive index for different colours.
34. Name the defect of vision in the person
a. Whose near point is more than 2525 cm away?
Ans: Hypermetropia

b. Whose far point is less than infinity.
Ans: Myopia

35. What is a spectrum?
Ans: A continuum of colour obtained by dispersion of white light by passing through a prism is called a spectrum.

36. Why does the clear sky look blue?
Ans: As white light passes through the atmosphere, the tiny particles held in the atmosphere scatter the light of a shorter wavelength. Therefore, blue light having the shortest wavelength is scattered the most and the clear sky appears blue.

37. Can visible light be scattered by atoms/molecules in the earth's atmosphere?
Ans: Yes, visible light is scattered by atoms/molecules in the earth's atmosphere as the size of molecules/atoms is much less than the wavelength of visible light.

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

Ans: Outer space does not have an atmosphere. As a result, the light does not scatter into its constituent colors in outer space and hence the sky appears dark instead of blue to an astronaut.

39. What is the basic cause of atmospheric refraction?
Ans: Atmospheric refraction is caused by the bending of light when it passes through the layers of the Earth's atmosphere with different optical densities.

40. What is the range of vision?
Ans: The range of vision of a normal human eye is the distance between the near point and far point of the human eye. Hence, for a normal human eye, it ranges from 25cm to infinity.