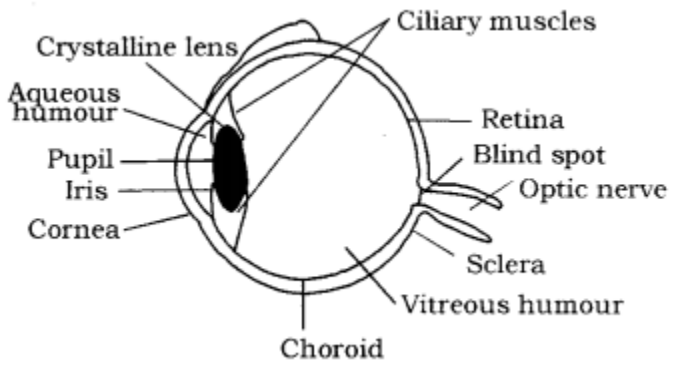
Chapter- 11
HUMAN EYE AND COLOURFUL WORLD

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.

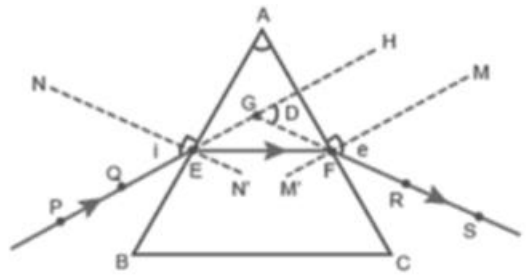
Cataract: Due to the membrane growth over eye lens, the eye lens becomes hazy or even opaque. This leads to a decrease or loss of vision. This problem is called a cataract. It can be corrected only by surgery.

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.

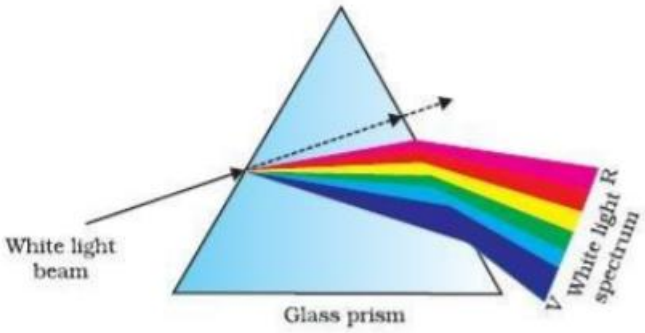
Angle of Deviation: The angle between the incident deviations.



PE - Incident ray
EF - Refracted ray
FS - Emergent ray
A - Angle of the prism
∠i - Angle of incidence
∠r - Angle of refraction
∠e - Angle of emergence
∠D - Angle of deviation

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

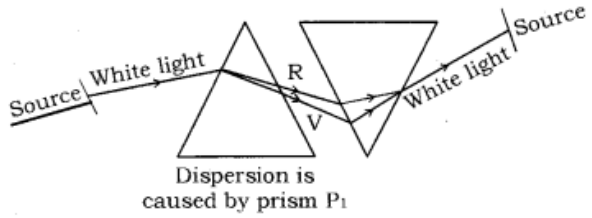
For violet colour, wavelength is minimum and for red colour wavelength is maximum, i.e. frequency for violet colour is maximum and for red colour frequency is minimum.

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.

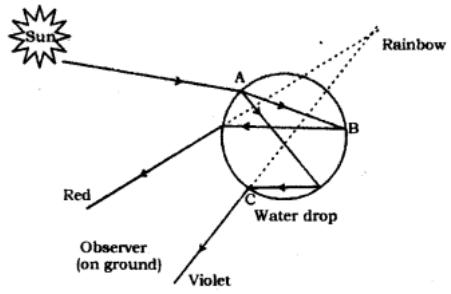
Formation of the rainbow: The water droplets act like small prism. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reach the observer's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

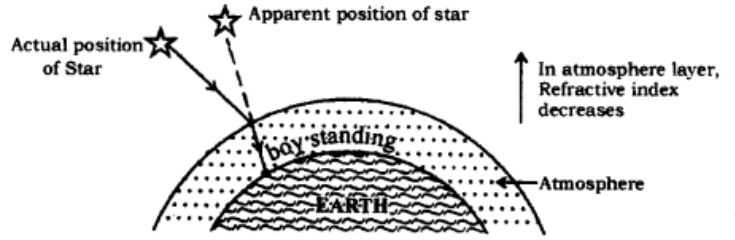
Red colour appears on top and violet at the bottom of rainbow.
A rainbow is always formed in a direction opposite to that of Sun.
At 'A' – Refraction and dispersion take place.
At 'B' – Internal reflection takes place.
At 'C' – Refraction and dispersion take place.



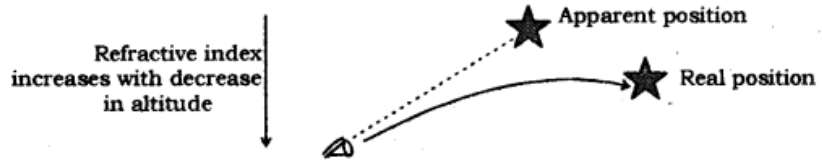
Rainbow formation

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.