



CHAPTER 11 : HUMAN EYE AND THE COLOURFUL WORLD

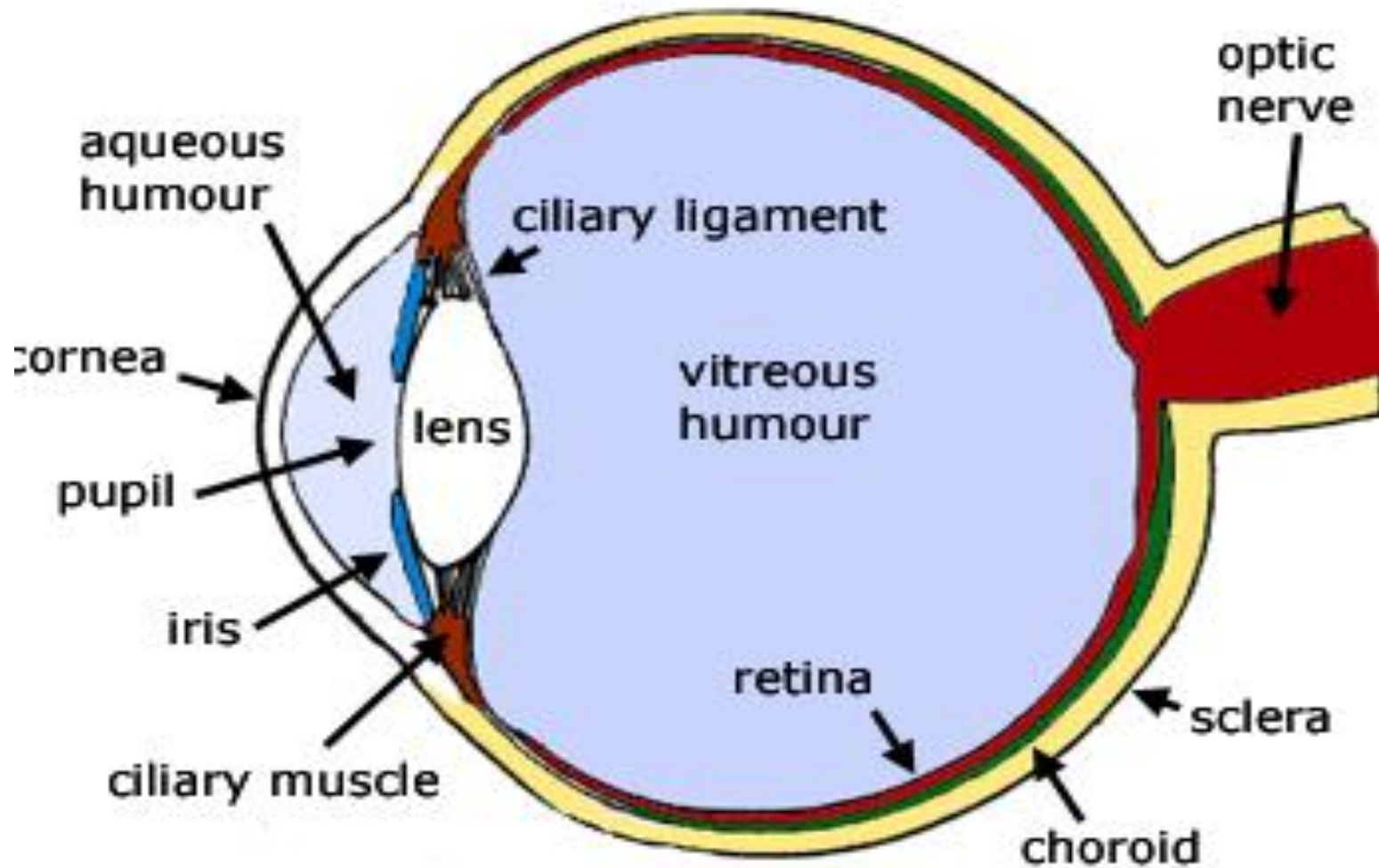
THE HUMAN EYE

Eye is one of the most valuable and sensitive sense organs. As far as physics is concerned the eye consists of a convex lens and a screen. The convex lens form a real image of the object on the screen of eye and we are able to see it.

MAIN PARTS OF HUMAN EYE

Cornea, Iris, Pupil, Ciliary Muscles, Convex Lens(Eye lens), Retina, Optical nerve, Aqueous humour, vitreous humour, choroid and Sclerotic are the main parts of human eye. Eyeball is spherical in shape with a diameter of about 2.3cm.

CONSTRUCTION OF EYE



CORNEA

The cornea is the transparent part of the eye that covers the front portion of the eye. It covers the pupil, iris , and anterior chamber (the fluid-filled inside of the eye). The cornea's main function is to refract, or bend, light. The cornea is responsible for focusing most of the light that enters the eye.

IRIS

The iris is a flat and ring-shaped membrane behind the cornea of the eye with an adjustable circular opening in the center called a pupil. This is the structure that provides an individual with eye color.

PUPIL

The pupil is the opening in the center of the iris . The function of the pupil is to allow light to enter the eye so it can be focused on the retina to begin the process of sight.

Typically, the pupils appear perfectly round, equal in size and black in color. The black color is because light that passes through the pupil is absorbed by the retina and is not reflected back .

EYE LENS

It is a transparent biconvex structure in the eye that, along with the cornea, helps to refract light to be focused on the retina. It is made of a transparent and flexible material like jelly made of proteins.

CILIARY MUSCLES

The muscles which hold the position of eye lens are called ciliary muscles. The focal length of eye lens can be changed by action of ciliary muscles.

RETINA

The screen on which the image is formed in the eye is called retina. The retina is behind the eye lens and at the back part of the eye. The retina is delicate membrane having a large number of light sensitive cells called 'rods' and 'cones'. These cells respond to the intensity of light and colours of objects respectively, by generating electrical signals.

EYE-LID

Eyelid is present in front of the eye and acts as a shutter of eye. When eyelid is open light can enter the eye but when eyelid is closed no light can enter in the eye.

AQUEOUS HUMOUR

It is a viscous liquid which is filled between the cornea and eye lens. It acts as a convex lens and helps in the refraction of light rays entering the eye.

VITREOUS HUMOUR

A viscous liquid which is filled between eye-lens and retina is called vitreous humour .

OPTIC NERVE

Optic nerves are the paths via which electrical signals produced by rods and cons are transmitted to brain.

CHOROID

Choroid is a membrane inside eye ball behind retina.

SCLEROTIC

The outer hard membrane of the eye ball is called sclerotic.

BLIND SPOT

It is the region on the retina where the optic nerve enters the eye. It has no nerve endings. An image formed at this point is not sent to brain.

SOME IMPORTANT TERMS

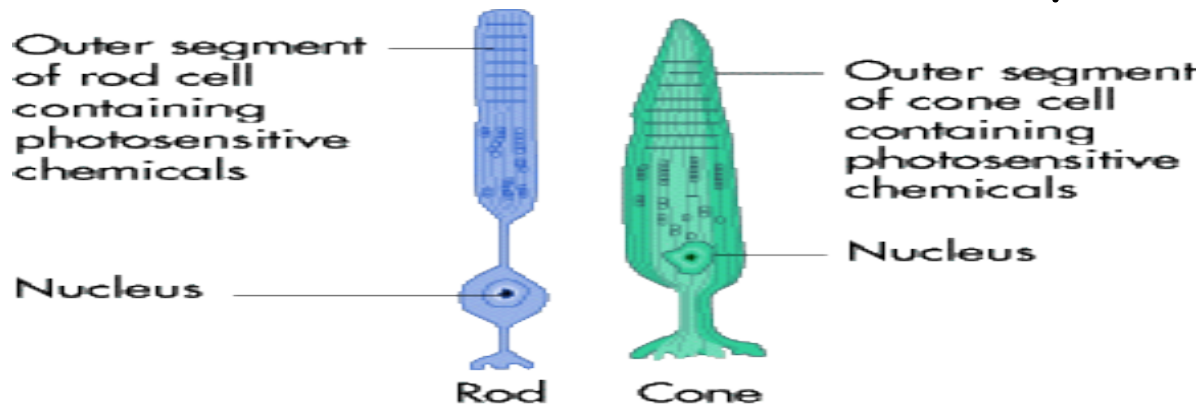
PERSISTENCE OF VISION

In human eye the impression of the formed image remains on the retina for about $1/16^{\text{th}}$ of a second, even after the removal of the object. This continuance of the sensation of the image in eye is called persistence of vision.

HOW DO WE SEE COLOURS?

Our retina has a large number of light sensitive cells having shapes of rods and cones.

The rod shaped cells respond to the intensity of light, with different degree of brightness and darkness. The cone shaped cells of retina responds to various colours and make colour perception possible.



COLOUR BLINDNESS

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

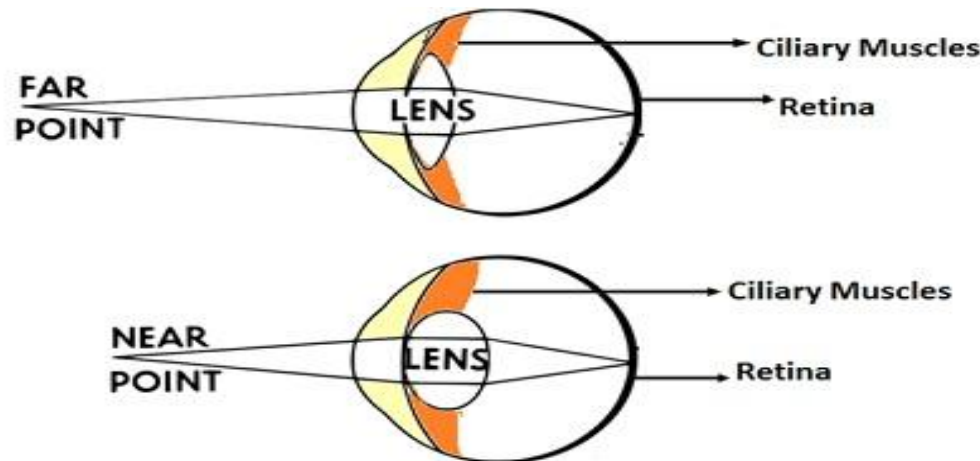
It is a genetic disorder which has not been cured so far.

ACCOMMODATION

The ability of the eye lens to adjust its focal length accordingly as the distances is called power of accommodation.

The maximum accommodation of a normal eye is reached when the object is at a distance of about 25 cm from the eye. After this the ciliary muscles cannot make eye lens bulge more.

Power of accommodation of the eye for a person having normal vision is about 4 dioptres i.e. 4D.



RANGE OF VISION OF A NORMAL HUMAN EYE

The range of vision of a normal human eye is from infinity to about 25 cm.

FAR POINT

The farthest point from the eye which can be seen clearly and distinctly is known as far point of the eye. The far point of a normal human eye is at infinity.

NEAR POINT

The nearest point upto which an eye can see objects clearly and distinctly is called near point of the eye. The near point of a human eye is at 25 cm from the eye.

LEAST DISTANCE OF DISTINCT VISION

The minimum distance at which an object must be placed so that a normal eye may see it clearly is called least distance of distinct vision or clear vision. The least distance of distinct vision of a normal eye is about 25 cm.

DEFECTS OF VISION

There are four defects of vision which can often be corrected with the eye glasses, contact lenses or surgery. These are :-

1. Hypermetropia (Long Sightedness)
2. Myopia (Short Sightedness)
3. Presbyopia
4. Astigmatism

1. HYPERMETROPIA (Long Sightedness)

Hypermetropia is that defect of eye due to which an eye cannot see the nearby objects clearly, though it can see the distant objects clearly.

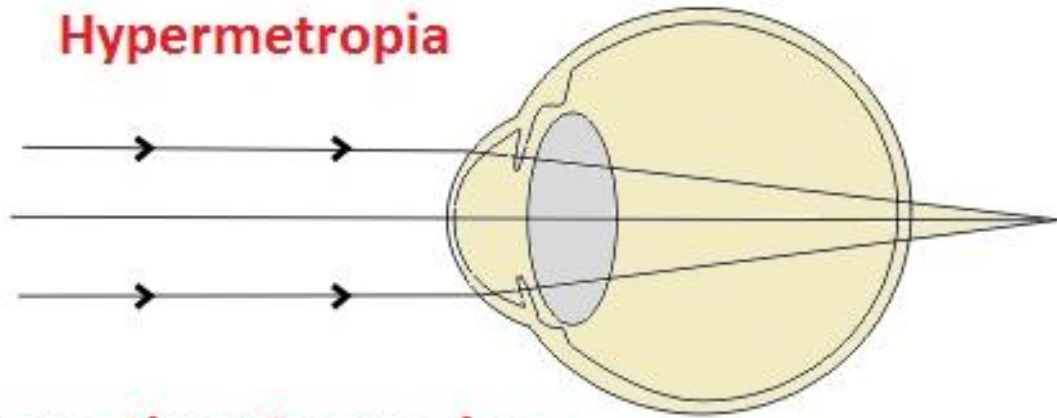
CAUSE

1. Due to low converging power of the eye lens.
2. Due to eye ball being too short.

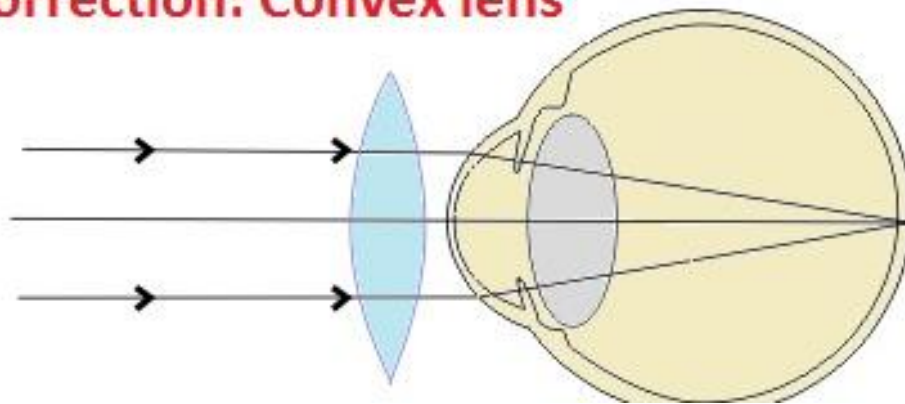
CORRECTION

It is corrected by using spectacles containing convex lenses. Due to combined converging action of the convex lens used and the eye lens the image is formed at retina and hence the eye can see it clearly.

Hypermetropia



Correction: Convex lens



2. MYOPIA (Short Sightedness)

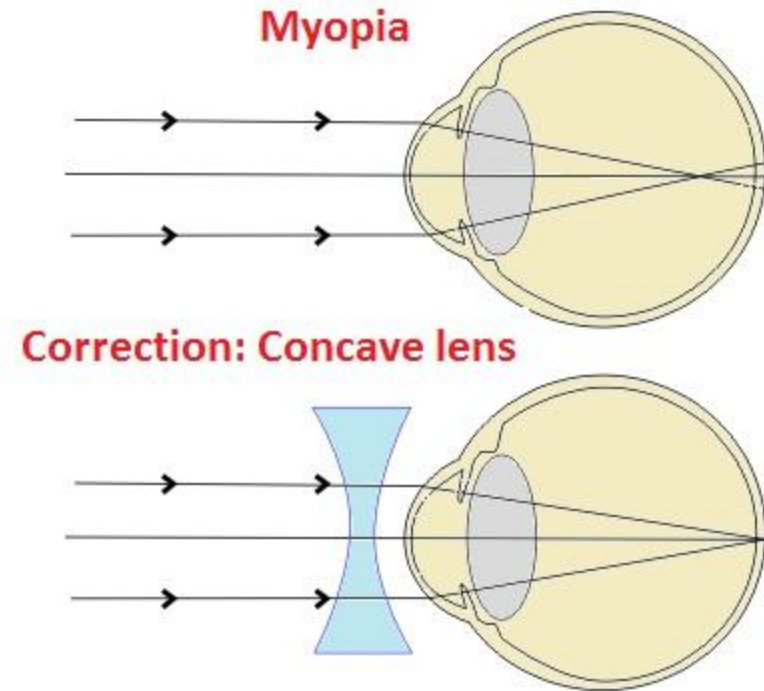
Myopia is that defect of eye due to which an eye cannot see the distant objects clearly though it can see nearby objects clearly.

CAUSES

1. Due to the high converging power of the lens.
2. Due to the eye ball being too long.

CORRECTION

It is corrected by using spectacles containing concave lenses. Due to the combined diverging action of the concave lens used and the eye lens, the image is formed at retina and hence the eye can see it clearly.



3. PRESBYOPIA (Old Age Hypermetropia)

Presbyopia is the defect of eye due to which an old person cannot read comfortably and clearly without spectacles.

CAUSE

Due to gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens.

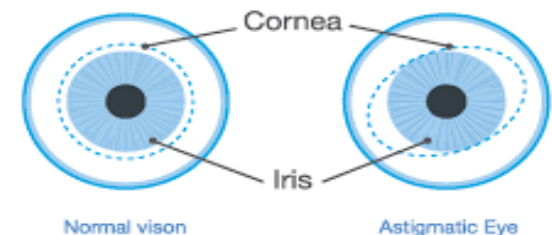
CORRECTION

Presbyopia is corrected by using spectacles having convex lenses. In case of both myopia and hypermetropia, bifocals are used.

4. ASTIGMATISM

Astigmatism is that defect of the eye due to which a person cannot focus on both horizontal and vertical lines simultaneously.

Impaired vision with astigmatism.



CAUSE

Due to irregularities in the surface of cornea.

CORRECTION

Astigmatism can be corrected by superimposing cylindrical lenses upon the spherical shape of spectacle lenses. The cylindrical lenses make up for the irregularities in the cornea surface and correct astigmatism.

ATMOSPHERIC REFRACTION

The atmosphere consists of multiple layers of variable density. When the light rays pass from those layers multiple refraction of light takes place due to which various effects are produced.

EFFECTS OF ATMOSPHERIC REFRACTION

1. OBJECTS SEEN THROUGH THE HOT AIR ABOVE THE FIRE APPEAR TO FLUCTUATE

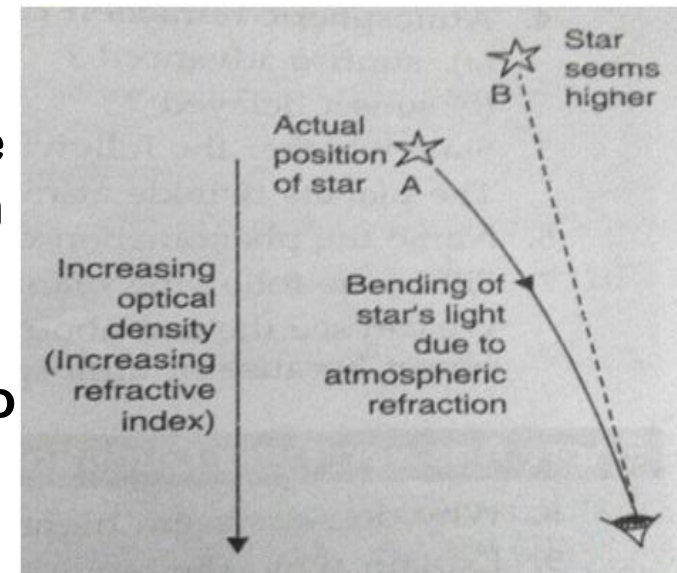
This is because the air just above the fire becomes hotter. This hotter air is optically rarer but the colder air further up is denser. When we see objects by the light coming from them through hot and cold air layers having different optical densities, refraction of light takes place due to which objects appear to fluctuate.

2. STARS TWINKLE BECAUSE OF THE REFRACTION OF LIGHT

Due to the varying optical densities of air from stars at the different altitudes in the atmosphere, the light is refracted by different amounts from one moment to the next. Thus star light reaching our eyes increases and decreases continuously due to atmospheric refraction and the star appears to twinkle.

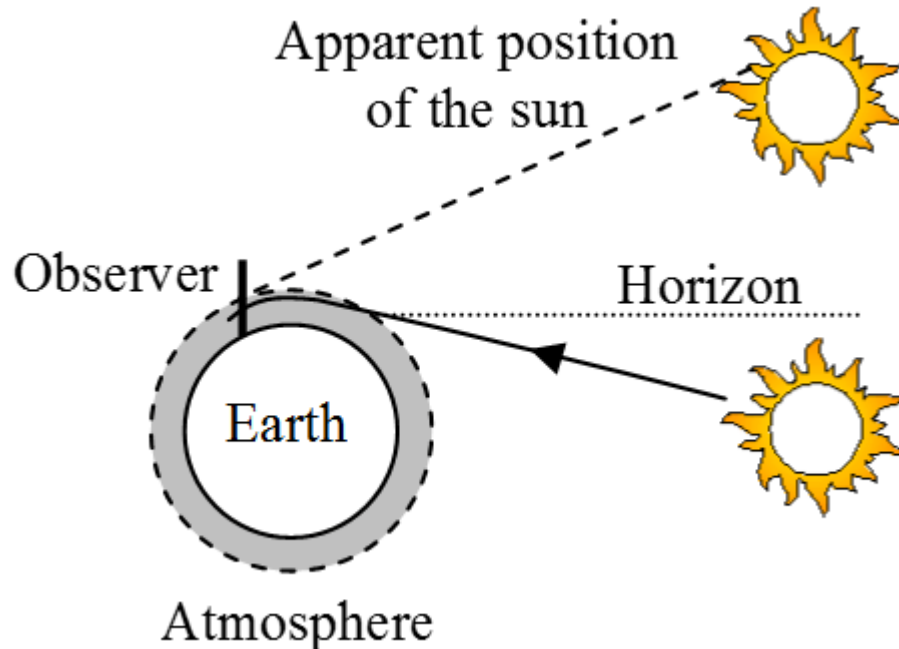
3. THE STARS SEEM HIGHER THAN THEY ACTUALLY ARE

Light from a star is refracted as it leaves space and enters earth's atmosphere. Air higher up in the sky is rarer but nearer the earth surface is denser. So when the light from a star comes down the dense air bends the light more. Due to this the star appears to be higher.



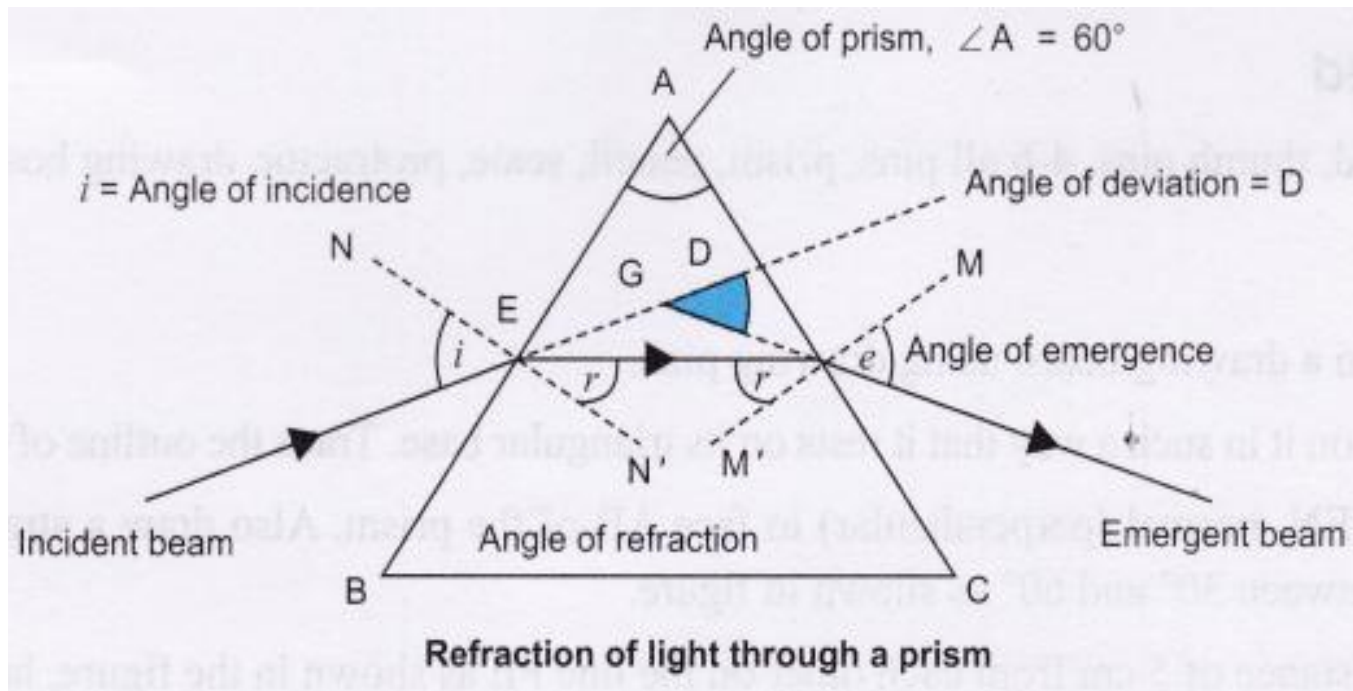
4.ADVANCED SUNRISE AND DELAYED SUNSET

The sun is visible to us about two minutes before the actual sunrise and two minutes after the actual sunset because of atmospheric refraction. When the sun is slightly below the horizontal surface then the sun's light coming from less dense air to more dense air is refracted downwards as it passes through the atmosphere, thus, sun appears to be raised above the horizon when it is slightly below it.



REFRACTION OF LIGHT THROUGH A GLASS PRISM

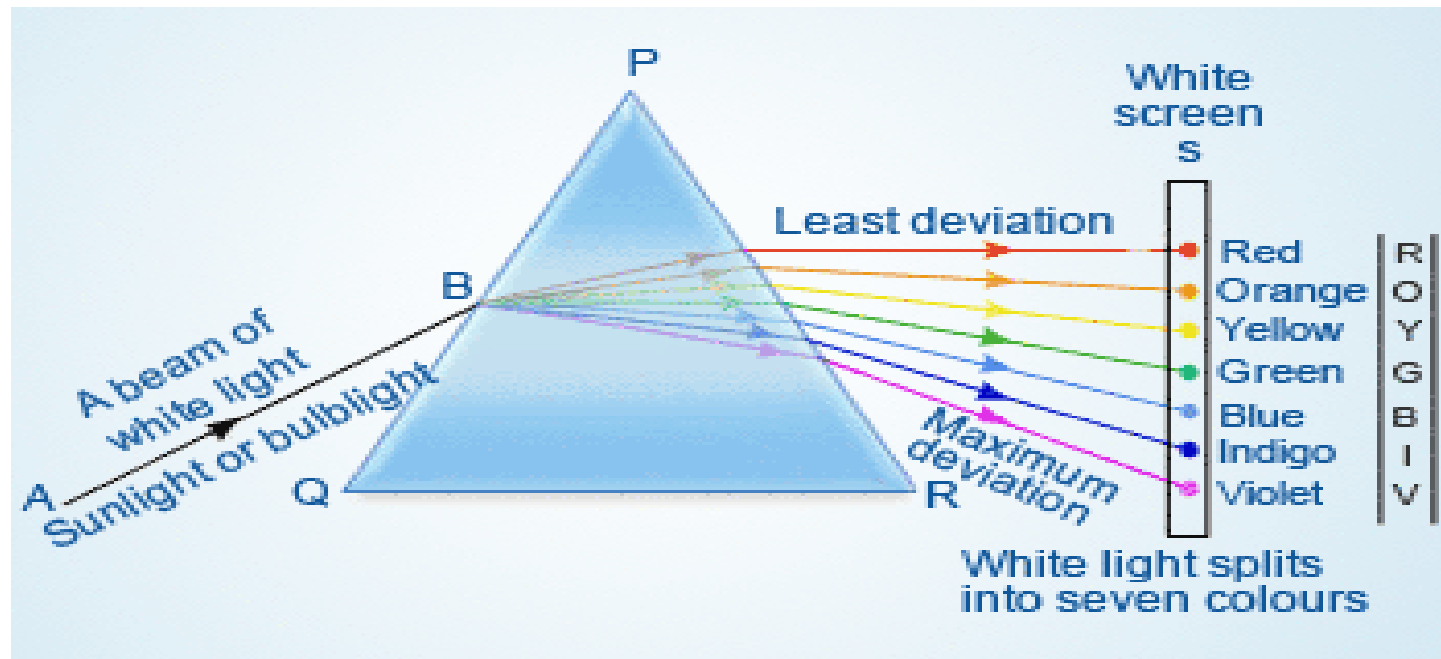
When a ray of light passes through a glass prism, it is refracted using laws of refraction.



DISPERSION OF LIGHT

The splitting of white light into seven colours on passing through a transparent medium like a glass prism is called dispersion of light. The band of seven colours formed on a white screen when a beam of white light is passed through a glass prism is called spectrum of white light.

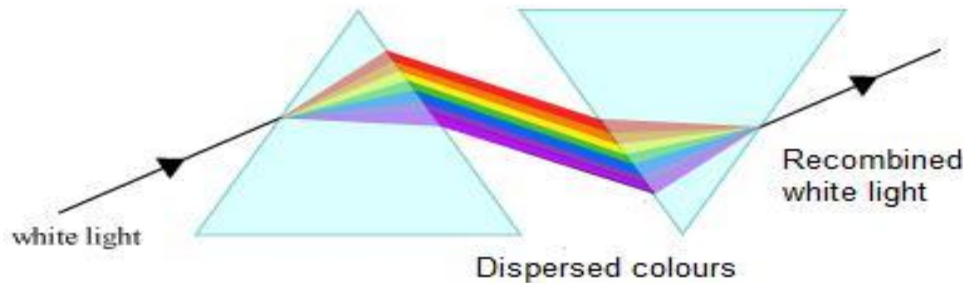
Seven colours of spectrum are Red, Orange, Yellow, Green, Blue, Indigo, Violet.



CAUSE OF DISPERSION OF WHITE LIGHT

The dispersion of white light occurs because the angle of refraction of different colours is different when passing through the glass prism. Each colour is refracted by a different angle. The red colour is deviated least so it forms the upper part of the spectrum. Violet colour is deviated the maximum, so violet appears at the bottom of the spectrum.

RECOMBINATION OF SPECTRUM OF WHITE LIGHT



EXPLANATION

The first glass prism disperses the white light into seven coloured rays. The second glass prism receives all the seven coloured rays from the first prism and recombines them into original white beam of light.

RAINBOW

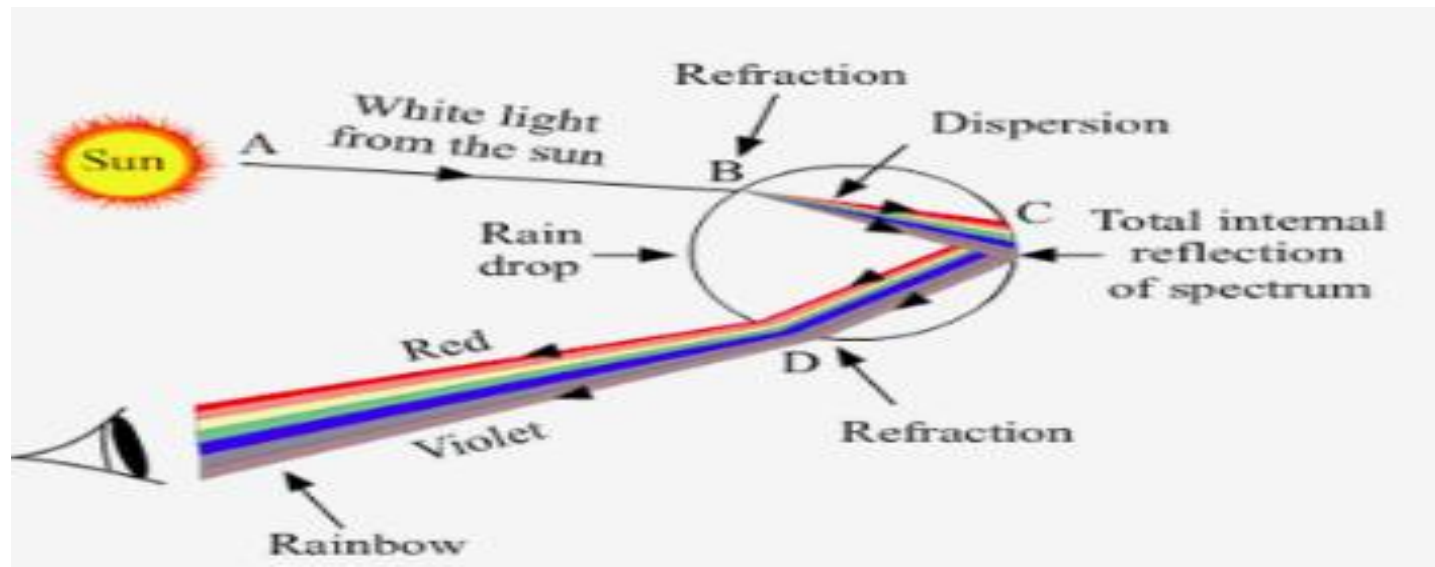
It is the spectrum of sunlight in nature. It is formed due to the dispersion of sunlight by the tiny water droplets, present in the atmosphere.

FORMATION OF 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.

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.



SCATTERING OF LIGHT

Scattering of light is defined as the change in the direction of light on striking an obstacle like an atom, a molecule, a dust particle , water droplets etc. Due to the scattering of light in the atmosphere following effects are produced:-

1. Blue colour of the sky

When the 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 and the sky appears to be blue.

2. Red hues of sunrise and sunset

When the sun is overhead the light travel relatively shorter distance and the sun appears white as only a little of violet and blue colours are scattered. Near the horizon most of the blue light and shorter wavelengths are scattered away by the particles. Therefore the light that reaches our eyes is of longer wavelengths . This gives rise to the reddish appearance of the sun.

COLOUR OF THE SCATTERED LIGHT

The colour of scattered light depends upon the size of the scattering particles. Very fine particles scatter mainly blue light while particles of larger size scatter light of longer wavelengths. If the size of the scattering particles is large enough, then , the scattered light may appear white.

The Tyndall Effect

The scattering of visible light by colloidal particles is called the **Tyndall effect**.



EXAMPLE

1. When a fine beam of sunlight enters a smoke filled or dust filled room, the particles become visible due to the scattering of light by these particles. In this way the path of light becomes visible.



2. When light passes through a canopy of dense forest , tiny water droplets in the mist scatter the light.



KEY POINTS AND CONCEPTS

- The ability or the property of the eye lens to adjust its focal length in order to be able to focus both near and distant objects is known as the power of accommodation.
- The minimum distance at which objects can be seen most distinctly without strain is called the least distance of distinct vision.
- Retina contains light sensitive cells known as rod and cones. These cells get activated upon illumination and generate electrical signals or pulses.
- The electrical signals are sent to the brain through optic nerves.
- In the brain, the signals are processed, interpreted and the objects in front of the eye are perceived.
- The process of splitting up of white light into its constituent colour as it passes through a refracting medium is known as dispersion of light
- The phenomenon of scattering of white light by colloidal particles is known as Tyndall Effect.

➤ The sky appears blue due to atmospheric refraction and scattering of light.

➤ Rainbow is formed due to dispersion and refraction

➤ In the morning, the sunlight covers a larger distance and thick layers of atmosphere, so except the red colour light, most of the other colours are scattered into the atmosphere. As only red colour light reaches our eye, the morning sun appears to be red.



Thank
you!!