Chapter- 10
HUMAN EYE AND COLOURFUL WORLD

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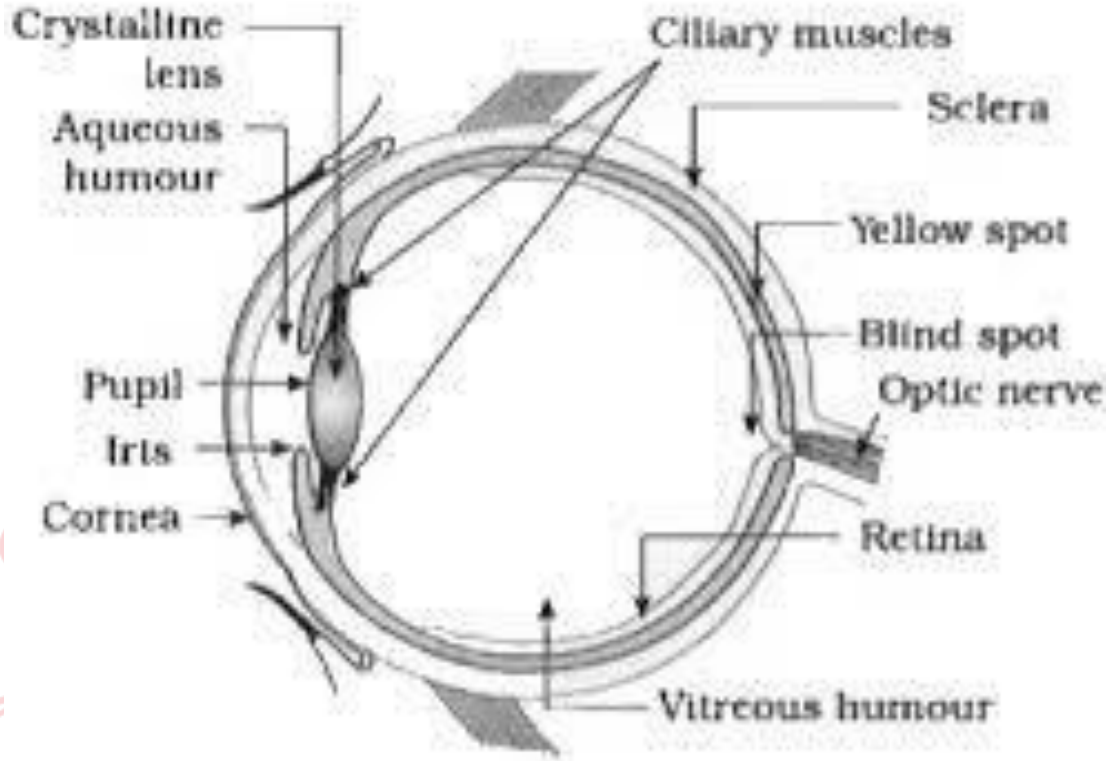
Structure of the Human Eye

A human eye is roughly 2.3 cm in diameter and is almost a spherical ball filled with some fluid. It consists of the following parts:



- **Sclera:** It is the outer covering; a protective tough white layer called the sclera (white part of the eye).
- **Cornea:** The front transparent part of the sclera is called the cornea. Light enters the eye through the cornea.
- **Iris:** A dark muscular tissue and ring-like structure behind the cornea is known as the iris. The colour of the iris indicates the colour of the eye. The iris also helps regulate or adjust exposure by adjusting the iris.
- **Pupil:** A small opening in the iris is known as a pupil. Its size is controlled by the help of the iris. It controls the amount of light that enters the eye.

- **Lens:** Behind the pupil, there is a transparent structure called a lens. By the action of ciliary muscles, it changes its shape to focus light on the retina. It becomes thinner to focus on distant objects and becomes thicker to focus on nearby objects.
- **Retina:** It is a light-sensitive layer that consists of numerous nerve cells. It converts images formed by the lens into electrical impulses. These electrical impulses are then transmitted to the brain through optic nerves.
- **Optic nerves:** Optic nerves are of two types. These include cones and rods.

1. **Cones:** Cones are the nerve cells that are more sensitive to bright light. They help in detailed central and colour vision.
2. **Rods:** Rods are the optic nerve cells that are more sensitive to dim lights. They help in peripheral vision.

At the junction of the optic nerve and retina, there are no sensory nerve cells. So, no vision is possible at that point and is known as a **blind spot.**

An eye also consists of six muscles. It includes the medial rectus, lateral rectus, superior rectus, inferior rectus, inferior oblique, and superior oblique. The basic function of these muscles is to provide different tensions and torques that further control the movement of the eye.

DEFECTS OF HUMAN EYES

Myopia

Near-sightedness, or myopia, is the defect of vision due to which a person can see nearby objects clearly, but find it difficult to see far-off objects distinctly.

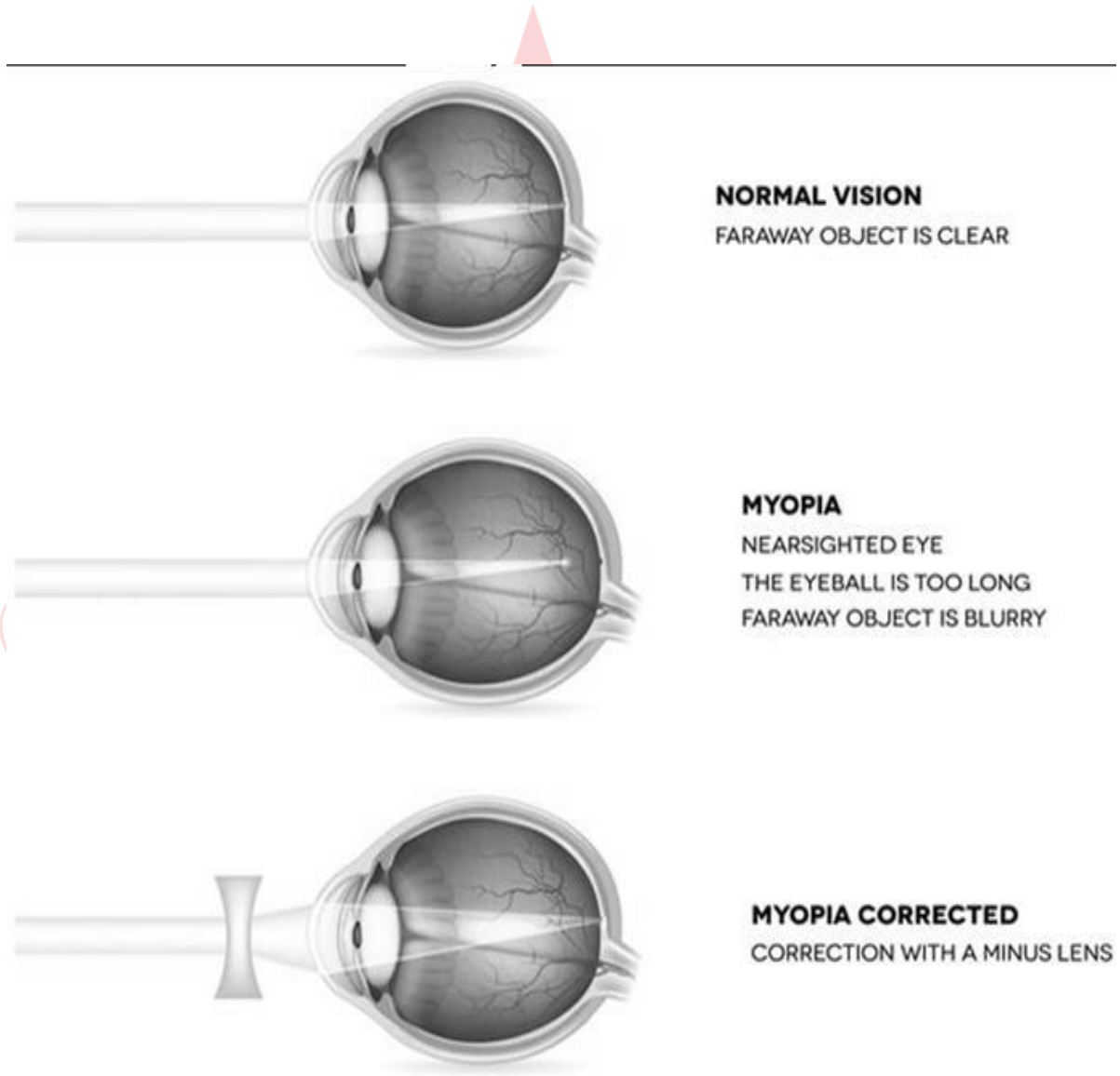
In a myopic person's eye, there is a bulge around the cornea, causing a reduction in the radius of the curvature of the whole eye, and hence, the fo cal length of the eye is decreased. The eye becomes unable to focus the image of distant objects at the retina as the eyeball is longer (from front to back) than normal. This causes images to be focused in front of the retina instead of on the retina. Thus , the image is formed near the eye lens; that is why this eye defect is called near - sightedness or myopia. As a result of this defect of vision, the distant objects look blurred. The maximum distance at which a myopic eye could see an object is known as its far point; beyond this far point, an image is formed near the eye lens instead of at the retina.

Myopia can be corrected with concave lenses. The lenses focus images farther back in the eye, so they fall on the retina instead of in front of it.

Causes of Myopia

It is caused due to:

1. High converging power of the eye lens (because of its short focal length): Due to the high converging of the eye lens, the image is formed in front of the retina, and a person cannot see distant objects.
2. Eyeball being too long or cornea bulged: If the eyeball is too long, then the retina is at a larger distance from the eye lens. In this case, the image is also formed in front of the retina even though the eye-eye lens corrects converging power.
3. Hereditary or due to uncontrolled diabetes or unattended cataract growths.



(NORMAL VISION & MYOPIA)

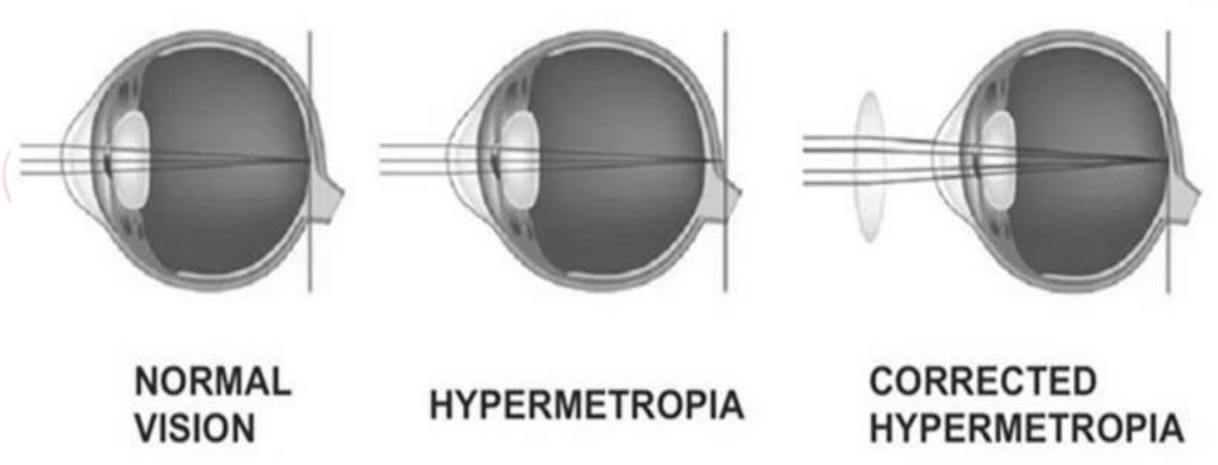
Correction

Myopic eyes do not diverge light rays from far-off objects; hence, a focused image cannot be formed on the retina. Instead, the rays converge much before they reach the retina. *Myopia or short-sightedness can be corrected by wearing spectacles containing a concave lens.* When a concave lens of suitable power is used for the myopic eye, the concave lens first diverges the parallel rays of light from a distant object. Therefore, first, a virtual image is formed at the far point of the myopic eye. Then, since the rays of light appear to be coming from the eye's far point, they are easily focussed by the eye lens, and the image is formed on the retina. Thus, a concave lens is used for a myopic eye to decrease the converging power of the eye lens.

Causes of Hypermetropia

It is caused due to:

1. Low converging or focusing power of crystalline eye lens (because of its large focal length)
2. Eyeball being too short.
3. Hypermetropia can be present in babies at the time of their birth, but as they grow older, the eyeball lengthens to normal, and the defect is cured naturally.



Correction

The near-point of an eye having hypermetropia is more than 25cm.
25cm. *Therefore, this defect can be corrected by putting a convex lens in front of the eye*. When a convex lens of suitable power is placed in front of the hypermetropic eyes, the convex lens first converges the diverging rays of light coming from a nearby object near the eye, which is the virtual image of the nearby object formed. Since the light rays now appear to be coming from the eye's near point, the eye lens easily focuses and forms the image on the retina.

Thus, a convex lens is used for hypermetropia to increase the converging power of the eye lens.
The hypermetropic eye has positive power. This indicates that the corrective lens required is convex. Such lenses are mainly used during reading or using laptops.

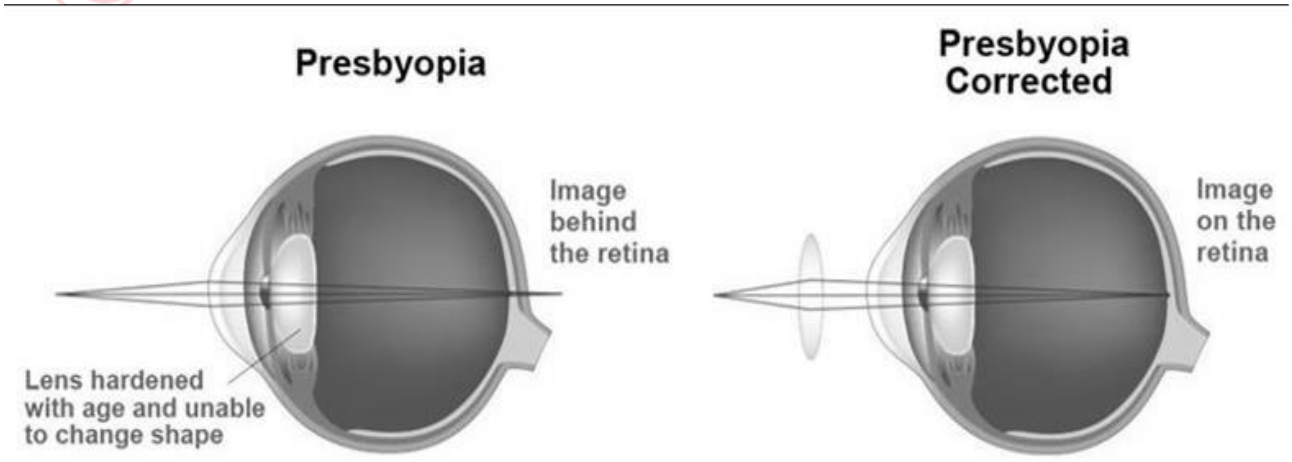
Presbyopia

The eyes lose their power of accommodation with ageing. As people grow old, the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens results in the hardening of the eye lens, making it more difficult for the eye to focus on close objects. This causes the near point to recede away in older people gradually. As a result, these people may find it difficult to see nearby objects distinctly without corrective eyeglasses. This defect of farsightedness caused by the loss of elasticity of the eye lens is called presbyopia. Sometimes, a person may have both farsightedness and short-sightedness. People suffering from presbyopia often require bi-focal lenses. Bi-focal lenses, in general, contain both concave and convex lenses. The upper portion consists of a concave lens to assist distant vision. The lower part is a convex lens to assist near vision.

Causes of Presbyopia

It is caused due to:
1. Gradual weakening of the ciliary muscles.
2. Decreasing flexibility or stiffness of the eye lens.

Both these occur with the eye's natural ageing between 4040 to 6060 years of age, although they may have had normal vision throughout their lives.



Correction

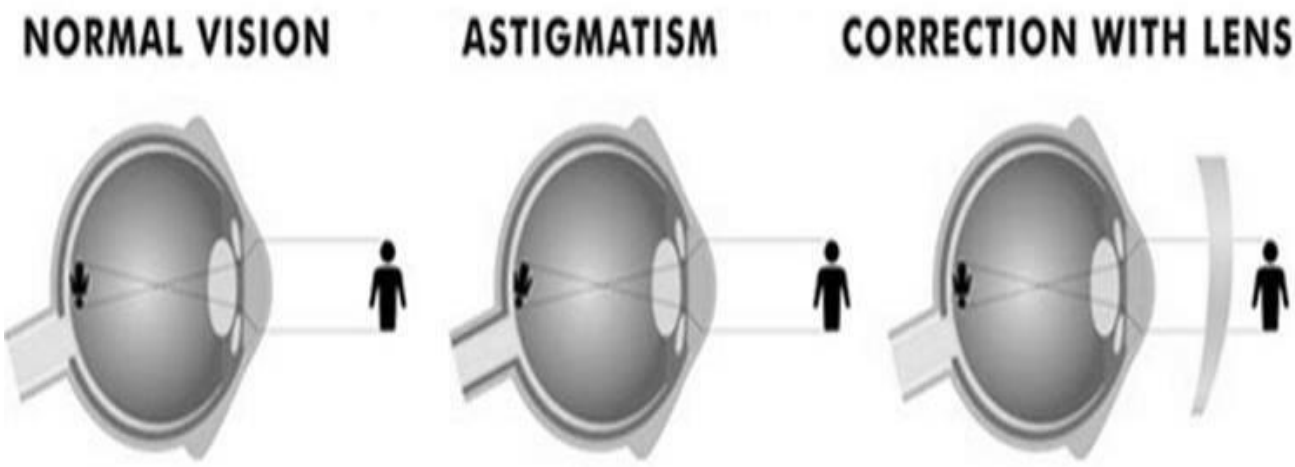
Presbyopia defect is corrected by using bi-focal lenses, which consist of both concave and convex lenses. The upper portion consists of a concave lens. It

facilitates distant vision. The lower part is a convex lens. It facilitates near vision. Such difference is not visible in progressive lenses, which also function similarly but do not have a line distinguishing the two lenses. Since the transition is smoother, it is more comfortable.
Presbyopia may also be corrected with eyeglasses or contact lenses having a convex lens if both myopia and hypermetropia are not present simultaneously.

Contact lenses used have each lens correcting one defect. People having both defects also use monovision. However, the practical perceptive may not be very good. Modified monovision contact lenses solve the problem of depth perception.

Astigmatism

Astigmatism is a condition caused by a refractive error in which the eye does not focus light evenly on the retina. This results in distorted or blurred vision at any distance. Astigmatism is a common vision problem caused by a fault in the shape of the cornea, resulting in an irregular curve. This can change the way light passes through the cornea and refracts onto the retina. As a result, people with this condition have blurry, fuzzy, or distorted vision.



With developing technologies, it is possible to correct these refractive defects with contact lenses or surgical interventions.

Causes of Astigmatism

1. Irregularly shaped cornea
2. Distorted lens

Types of Astigmatism

1. Corneal Astigmatism: This is due to the irregular shape of the cornea.
2. Lenticular Astigmatism: This is due to the distorted shape of the lens.

Correction

This defect can be corrected by using eyeglasses with cylindrical lenses oriented to compensate for the irregularities in the cornea. Usually, the cornea is spherically shaped, like a baseball. However, in astigmatism, the cornea is elliptically shaped, more like a football. Therefore, the lenses are shaped to counteract the shape of the sections of the cornea that cause the difficulty. Hence, only cylindrical lenses are used to correct astigmatism.

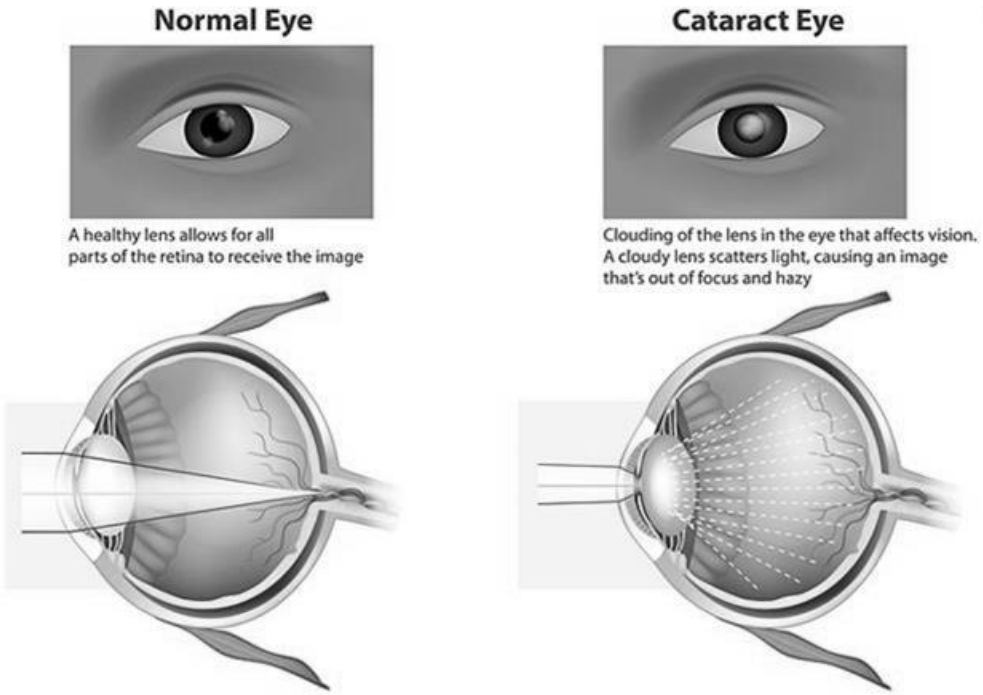
Other Common eye-related Problems

Colour – Blindness

The retina of our eye has a large number of light-sensitive cells having shapes of rods and cones. The rod-shaped cells respond to the light intensity with different brightness and darkness as the cone-shaped cells respond to colour. In dim light, rods are sensitive, but cones are sensitive only in bright. The cones are sensitive to red, green and blue colours of light to different extents.

Due to genetic disorders, some persons do not possess cone-shaped cells that only respond to certain specific colours. Such persons cannot distinguish between particular colours but can be seen well otherwise. Such persons are said to have colour blindness. Driving licenses are generally not issued to persons having colour blindness.

Cataract



Yet another defect of the eye that usually comes old is the *cataract*. The medical condition in which the lens of a person's eyesight becomes progressively cloudy results in blurred vision. It develops when the eye-lens of a person become clouded due to the formation of a membrane over it. It decreases the eye's vision gradually and can lead to a total loss of eye vision. It can be restored after getting surgery. The opaque lens is removed, and an artificial lens is inserted in its place via operation. Any spectacle lenses cannot correct this defect.

Glaucoma

The eyes generate a clear fluid (aqueous humour), filling the space between the cornea and the iris. This causes fluid to filter out through a complex drainage system. This is the balance between the production and drainage of this liquid that determines the eye's intraocular pressure (IOP). Glaucoma is a disease that is caused by increased IOP, usually resulting from a malfunction in the eye's drainage system. High IOP can also cause irreversible damage to the optic nerves and retinal fibres and, if left untreated, can result in a permanent loss of vision.

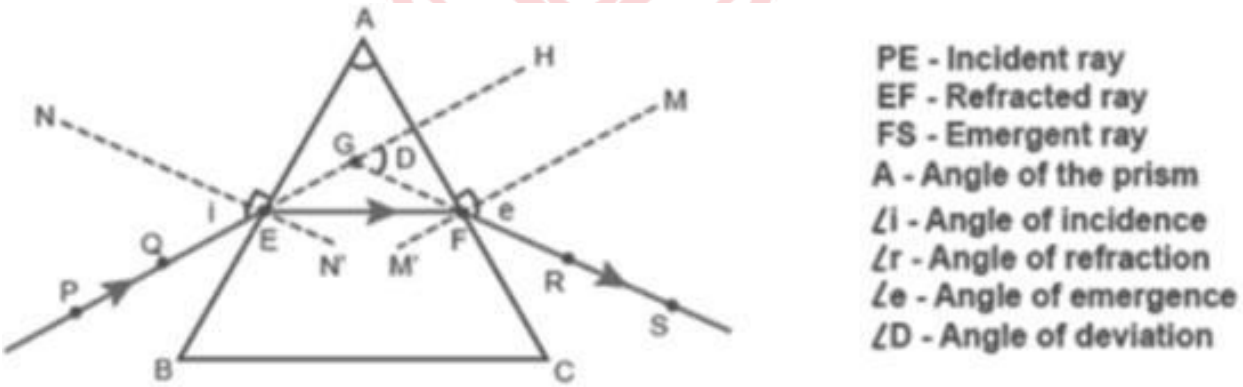
Age-Related Macular Degeneration (ARMD)

It is a degenerative condition of the macula (the central retina). The reason for its cause is the hardening of the arteries that nourish the retina. This deprives the retinal tissue of the nutrients and oxygen needed to function and causes a deterioration in central vision.

Refraction of light through a prism:

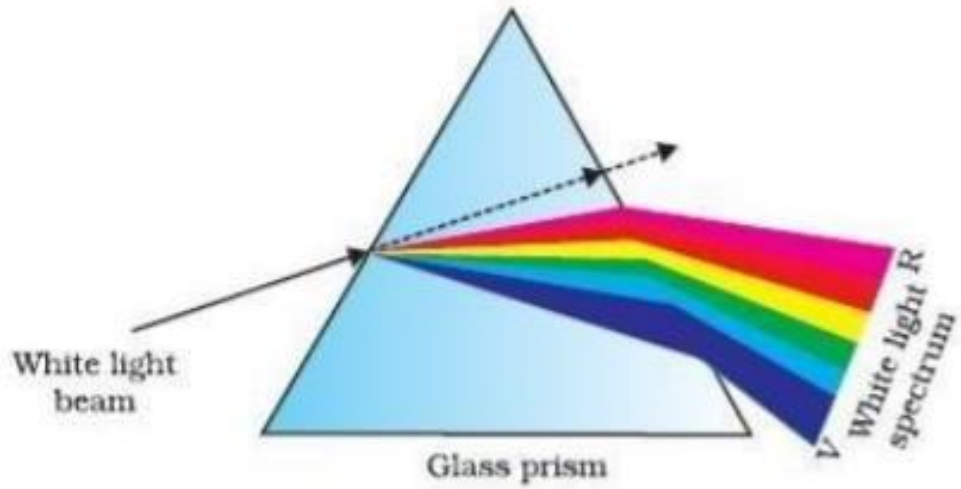
When a ray of light is incident on a rectangular glass slab, after refracting through the slab, it gets displaced laterally. As a result, the emergent ray comes out parallel to the incident ray. Unlike a rectangular slab, the side of a glass prism is inclined at an angle called the angle of the prism.

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.
The angle of Prism: The angle between two lateral faces is called the angle of the prism.
The angle of Deviation: The angle between the incident deviations.



Reflection of light through a triangular glass prism

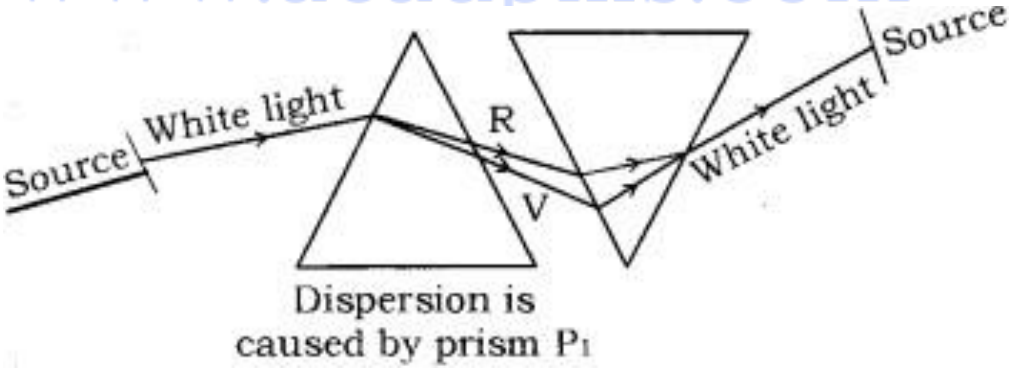
3. Dispersion of white light by a glass prism: The phenomenon of splitting of white light into its seven constituent colours when it passes through a glass prism is called dispersion of white light. The various colours seen are Violet, Indigo, Blue, Green, Yellow, Orange and Red. The sequence of colours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



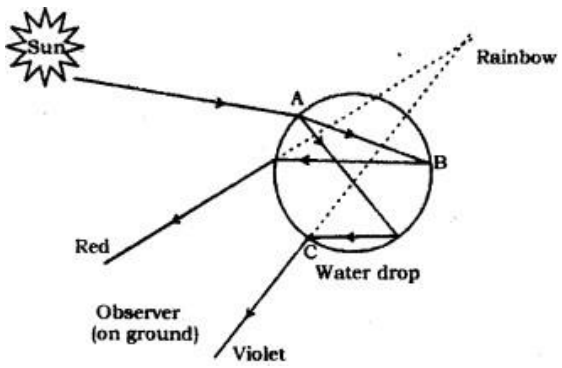
Dispersion of white light by a prism

For violet colour, the 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, for 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.



Dispersion is caused by prism P_1



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 a 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 a 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. the sun is always behind the observeThe red

The red colour appears on top and violet at the bottom of the rainbow.

A rainbow is always formed in a direction opposite to that of Sun.

At 'A' – Refraction and dispersion take place.

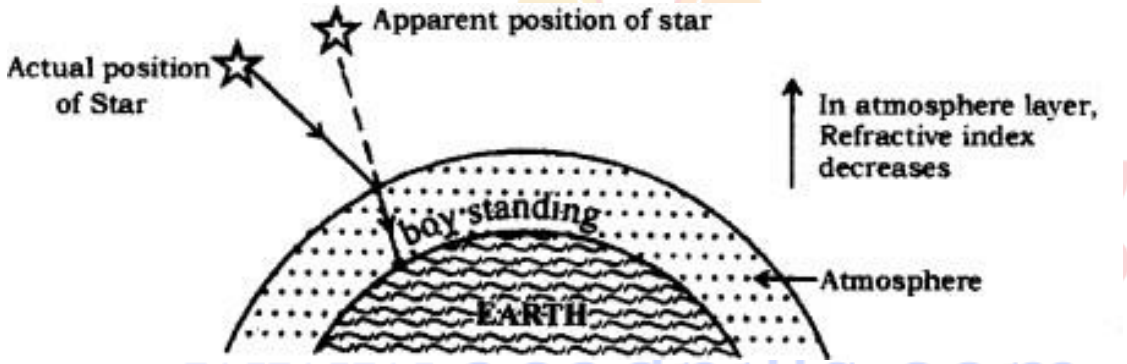
At 'B' – Internal reflection takes place.

At 'C' – Refraction and dispersion take place.

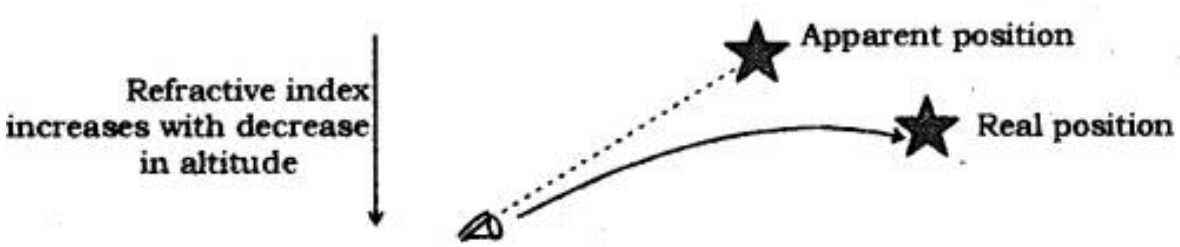
Rainbow formation

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 sometimes dim. This is the "Twinkling effect of the star".



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

Examples of the Tyndall effect: Shining a flashlight beam into a glass of milk, the visible beam of headlights in fog is caused by the Tyndall effect. The water droplets scatter the light, making the headlight beams visible.

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.
The 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 a shorter wavelength (blue end of the spectrum). The blue colour is scattered more and hence the sky appears blue.

Some applications of scattering of light in daily life are:

1. The sun's reddish hue at daybreak and sunset.
2. The bright white of the noonday sky.
3. The sky's blue colour forms due to the molecules nitrogen and oxygen.
4. The absence of an atmosphere is what causes the sky to be so dark.
5. Red light is used as a warning signal because, due to its longer wavelength, it is least scattered by particles.
6. The increase in temperature is what gives clouds their white colour.

QUESTIONS FROM PREVIOUS BOARD EXAMS

Question 1.
State one function of the iris in the human eye. (AI 2012)
Answer:
Irish is a dark muscular diaphragm that controls the size of the pupil.

Question 2.
State one function of the crystalline lens in the human eye. (Foreign 2012)
Answer:
The crystalline lens of the human eye focuses the light that enters the eye and forms the image on the retina.

Question 3.
Define the term power of accommodation. Write the modification in the curvature of the eye lens which enables us to see the nearby objects. (Delhi 2019)
Answer:
The ability of the eye lens to adjust its focal length is called the power of accommodation. The ciliary muscles modify the curvature to some extent. The change in the curvature of the eye lens can thus change its focal length. When the ciliary muscles contract, the lens becomes thick and its focal length decreases, thus enabling us to see nearby objects.

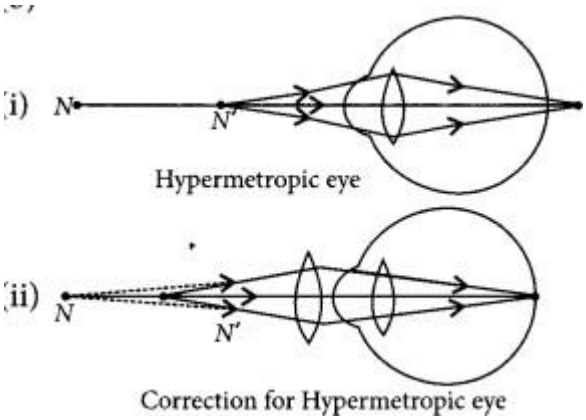
Question 4.
Trace the sequence of events that occur when a bright light is focused on your eyes. (Delhi 2019)
Answer:
When a bright light enters the eye then most of the refraction for the light rays entering the eye occurs at the outer surface of the cornea. Then, the crystalline lens merely provides the finer adjustment of the focal length required to focus an object at different distances on the retina. The pupil regulates and controls the amount of light entering the eye. At the retina, the light-sensitive cells get activated upon illumination and generate electric signals. These signals are sent to the brain via the optic nerves. The brain interprets these signals and finally, processes the information so that we perceive objects as they are.

Question 5.
Write about the power of accommodation of the human eye. Explain why the image distance in the eye does not change when we change the distance of an object from the eye. (Delhi 2017)
Answer:
The ability of the eye lens to adjust its focal length is called the power of accommodation. The ciliary muscles modify the curvature to some extent. The change in the curvature of the eye lens can thus change its focal length. Thus, the focal length of the human lens increases or decreases depending on the distance of the object value to this distance of the image does not change. For example, when the ciliary muscles are relaxed, the lens becomes thin and its focal length increases, thus enabling us to see distant objects.

Question 6.
A person suffering from cataracts has
(a) elongated eyeball
(b) excessive curvature of the eye lens
(c) weakened ciliary muscles
(d) opaque eye lens
Answer:
(d) A person suffering from cataracts has a cloudy opaque eye lens.

Question 7.
(a) List two causes of hypermetropia.
(b) Draw ray diagrams showing (i) a hypermetropic eye and (ii) its correction using a suitable optical device. (2020)
Answer:
(a) Hypermetropia is caused due to following reasons:

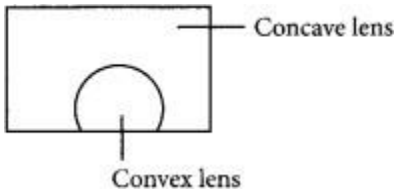
(i) Shortening of the eyeball
(ii) Focal length of the crystalline lens is too long.



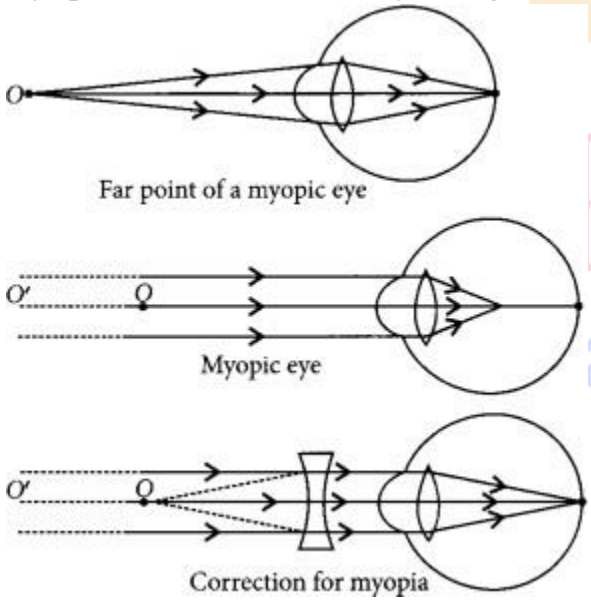
Question 8.
(a) A person is suffering from both myopia and hypermetropia.
(i) What kind of lenses can correct this defect?
(ii) How are these lenses prepared?
(b) A person needs a lens of power +3 D for correcting his near vision and -3 D for correcting his distant vision. Calculate the focal lengths of the lenses required to correct these defects. (2020)
Answer:
(a) (i) The lens which can correct the vision of such a person suffering from both myopia and hypermetropia is a bifocal lens.

(ii) A common type of bifocal lens contains both concave and convex lenses. It is prepared with the upper portion consisting of a concave lens facilitating distant vision and the lower portion consisting of a convex lens facilitating near vision, (b) The power for correcting his near vision,
P_N = +3 D.
As P = 1f(m)
∴ The focal length of the convex lens needed,
f_N = 1PN = 0.33 m = +33.33 cm
Power required to correct distant vision, PD = -3D
∴ The focal length of a concave lens,
f_D = 1PD = -0.33 m = -33.33 cm.
Question 9.
A person may suffer from both myopia and hypermetropia defects.
(a) What is this condition called?
(b) When does it happen?

(c) Name the type of lens often required by the persons suffering from this defect. Draw a labelled diagram of such lenses. (2020)
Answer:
(a) This condition is called presbyopia.
(b) It happens due to the gradual weakening of ciliary muscles and diminishing flexibility of the eye lens due to ageing.
(c) It can be corrected by using bifocal lenses.



Question 10.
What eye defect is myopia? Describe with a neat diagram how this defect of vision can be corrected by using a suitable lens. (AI 2011)
Answer:
Myopia is also known as near-sightedness. A person with myopia can see nearby objects clearly but cannot see distant objects distinctly.
Myopia can be corrected by using a concave lens of appropriate focal length.



Question 11.
Name the three common defects of vision. What are their causes? Name the type of lens used to correct each of them. (Foreign 2011)
Answer:
Three common defects of vision are

- Myopia
- Hypermetropia
- Presbyopia

Myopia can be caused due to following reasons.

- Elongation of the eyeball.
- Excessive curvature of the eye lens.

Hypermetropia can be caused due to following reasons.

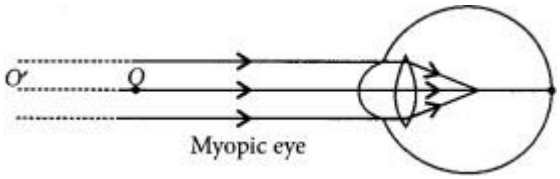
- Shortening of the eyeball.
- Focal length of the eye lens becomes too long.

Presbyopia is caused due to gradual weakening of ciliary muscles and diminishing flexibility of eye lenses due to ageing.

Correction of these defects:

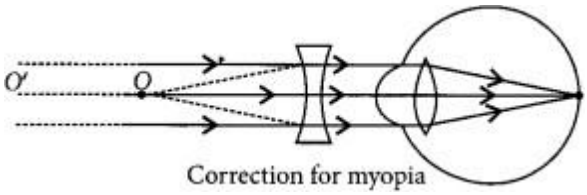
- Myopia can be corrected by using the concave lens of appropriate focal length.
- Hypermetropia can be corrected by using a convex lens of appropriate focal length.
- Presbyopia can be corrected by using the bifocal lens.

Question 12.
A student is unable to see the words written on the blackboard placed at a distance of approximately 3 m from him. Name the defect of vision the boy is suffering from. State the possible causes of this defect and explain the method of correcting it. (3/5, 2018)
Answer:
The student is suffering from myopia.
The two possible reasons due to which the defect of vision arises are excessive curvature of the eye lens and elongation of the eyeball.
A student with myopia has a far point nearer than infinity, thus, the image of a distant object is formed in front of the retina.



Correction of myopia: This defect can be corrected by using a concave lens of suitable

power as it brings the image back onto the retina, thus the defect is corrected.



Correction for myopia

Question 13.
Millions of people in developing countries of the world are suffering from corneal blindness. These persons can be cured by replacing the defective cornea with the cornea of a donated eye. A charitable society in your city has organized a campaign in your neighbourhoods to create awareness about this fact. If you are asked to participate in this mission, how would you contribute to this noble cause?
(a) State the objective of organizing such campaigns.
(b) List two arguments that you would give to motivate people to donate their eyes after death.
(c) List two values that are developed in the persons who actively participate and contribute to such programs. (VBQ, 3/5, Delhi 2016)
Answer:
We can encourage people to participate in the camp and also register ourselves as donator.
(a) The objective of organising such a campaign is to make people aware and realize their duties towards society.
(b) (i) By donating our eyes after we die, we can light the life of a blind person.
(ii) One pair of eyes gives vision to two corneal blind people.
(c) (i) It shows concern for others.
(ii) It also shows responsible behaviour towards society.

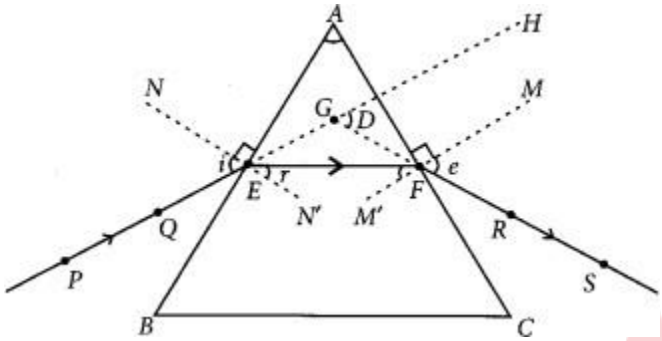
Question 14.
Write the importance of ciliary muscles in the human eye. Name the defect of vision that arises due to the gradual weakening of the ciliary muscles in old age. What type of lenses are required by persons suffering from this defect to see objects?
Akshay, sitting in the last row in his class, could not see the words written on the blackboard. When the teacher noticed it, he announced if any student sitting in the front row could volunteer to exchange his seat with Akshay. Salman immediately agreed to exchange his seat with Akshay. He could now see the words written on the blackboard. The teacher thought it fit to send the message to Akshay s parents advising them to get his eyesight checked.
In the context of the above event, answer the following questions:
(a) Which defect of vision is Akshay suffering from? Which type of lens is used to correct this defect?

(b) State the values displayed by the teacher and Salman.
(c) In your opinion, in what way can Akshay
express his gratitude towards the teacher and Salman? (VBQ, AI 2015)
Answer:
Ciliary muscles modify the curvature of the eye lens and the head just uses its focal length. It enables us to see objects.
The defect of vision that arises due to the weakening of ciliary muscles in old age is presbyopia, a person suffering from this defect should wear bifocal lenses. These lenses consist of both concave and convex lenses.
(a) Akshay is suffering from myopia or near-sightedness. He should use the concave lens to correct this defect.
(b) Teacher and Salman are concerned and caring.
(c) Akshay can show his gratitude by saying thank you.

Question 15.
Do you know that the corneal-impairment can be cured by replacing the defective cornea with the cornea of the donated eye?
How and why should we organise groups to motivate community members to donate their eyes after death? (2/5, AI 2014)
Answer:
Yes, we know that corneal – impairment can be cured by replacing the objective cornea with the cornea of the donated eye. We can provide the importance of eye donation to the community members. Our eyes can live even after our death. By donating our eyes after die, we can light the life of a blind person. The human eye is one of the most valuable and sensitive sense organs. It enables us to see the wonderful world and colours around us. It is, however, impossible to identify colours while closing the eyes. Thus, of all the sense organs, the human eye is the most significant one as it enables us to see the beautiful colourful world around us. Hence, we should donate our eyes after death.

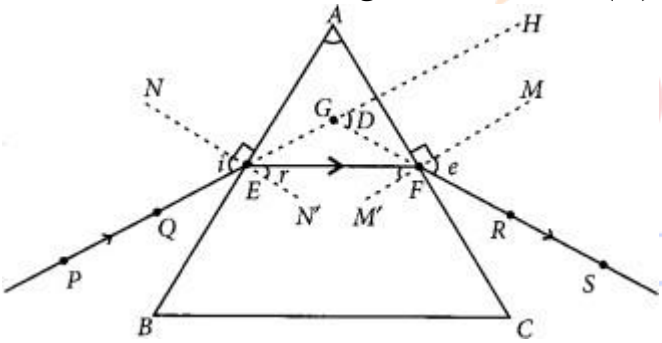
Question 16.
What is myopia? List two causes for the development of this defect. How can this defect be corrected using a lens? Draw ray diagrams to show the image formation in case (i) defective eye and (ii) corrected eye. (Foreign 2014)
Answer:
Myopia is also known as a near-sightedness defect in which a person can see nearby objects clearly but cannot see distant objects distinctly. This defect may arise due to
(a) excessive curvature of the eye.
(b) elongation of the eyeball.
This defect can be corrected by using a concave lens of suitable power.

Question 17.
Draw a ray diagram to show the refraction of light through a glass prism. Mark on it (a) the incident ray, (b) the emergent ray and (c) the angle of deviation. (AI 2011)
Answer:

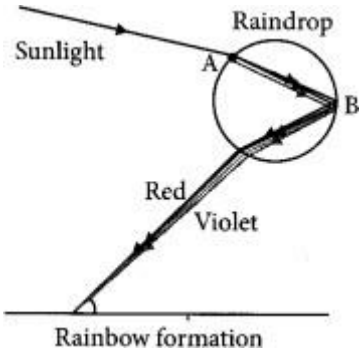


i = angle of incidence
(a) PE = incident ray
(b) FS = emergent ray
(c) ∠D = angle of deviation

Question 18.
Draw a ray diagram to explain the term angle of deviation. (1/5, Delhi 2017)
Answer:
The emergent ray bends at an angle to the direction of the incident, thus the angle between them is known as the angle of deviation (D).

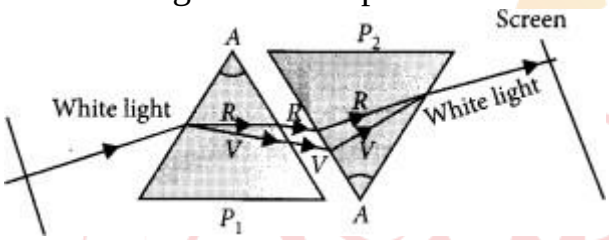


Question 19.
Draw a labelled diagram to explain the formation of a rainbow in the sky. (Foreign 2015)
Answer:
A rainbow is a natural spectrum caused by the dispersion of sunlight by tiny water droplets, present in the atmosphere.



Point A denotes dispersion and point B denotes internal reflection.

Question 20.
How will you use two identical glass prisms so that a narrow beam of white light incident on one prism emerges out of the second prism as white light? Draw and label the ray diagram. (2020)
Answer:
Newton was the first to use a glass prism to obtain the spectrum of white light. He then placed a second identical prism in an inverted position concerning the first prism. This allowed all the colours of the white light to pass through the second prism combining to form a white light emerging from the other side of the second prism. This made him believe that white light was composed of different colours.



Question 21.
Differentiate between a glass slab and a glass prism. What happens when a narrow beam of (i) a monochromatic light and (ii) white light passes through (a) glass slab and (b) glass prism. (2020)
Answer:
Glass slab:

- It is a substance made of glass having three dimensions and has cuboidal structure.
- It does not deviate from the path of light falling on it but produces a lateral displacement of the light ray after refraction. The incident and emergent ray are parallel to each other.

Glass prism:

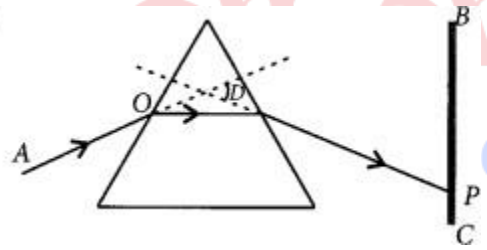
- A prism is a structure made of glass with two triangle bases and three rectangular lateral surfaces. These surfaces are inclined to each other.
- A prism deviates the path of light rays falling on it. Here the incident ray and emergent ray are not parallel to each other.

(i) When a narrow beam of monochromatic light falls on a
(a) glass slab, it gets refracted at its surface and the emergent ray is laterally displaced from the incident ray.
(b) prism, it gets refracted at the surface and the light gets deviated from its initial path. The angle between the incident ray and emergent ray is known as the angle of deviation.

(ii) When white light passes through a
(a) glass slab, the light does not undergo dispersion as its two refracting surfaces are parallel to each other. The white light is laterally displaced from its initial path.
(b) prism, the white light undergoes dispersion and splits into its constituent colours along with deviation from its initial path.

Question 22.
(a) With the help of a labelled ray diagram show the path followed by a narrow beam of monochromatic light when it passes through a glass prism.
(b) What would happen if this beam is replaced by a narrow beam of white light? (2020)
Answer:

(a)

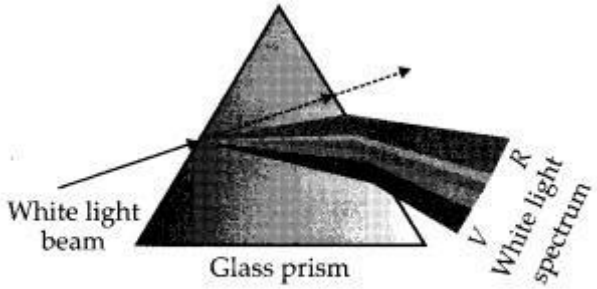


Here, in the figure, ∠D is the angle of deviation of the given monochromatic light by the glass prism.
(b) If AO were a ray of white light, then on screen BC, a spectrum will be observed, consisting of seven colours arranged from bottom to top as follows. Violet, Indigo, Blue, Green, Yellow, Orange, Red (VIBGYOR)

Question 23.
What is a rainbow? Draw a labelled diagram to show the formation of a rainbow. (Delhi 2019)

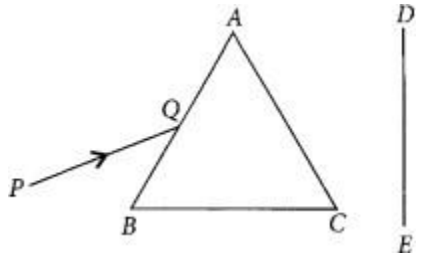
Answer:
After a rain shower, the sunlight gets dispersed by tiny droplets, present in the atmosphere. The water droplets act like small glass prisms. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reaches the observer's eye, which is called a rainbow.

Question 24.
What is 'dispersion of white light'? State its cause. Draw a ray diagram to show the dispersion of white light by a glass prism. (AI 2017)
Answer:
The splitting of white light into its seven constituent colours due to refraction is known as the dispersion of white light.
Cause of dispersion: When a beam of white light enters a prism, it gets refracted and splits into seven constituent colours. The splitting of the light ray occurs due to the different bending angles for each colour. Thus, each colour ray when passing through the prism bends at different angles concerning the incident beam, thus giving rise to a spectrum.



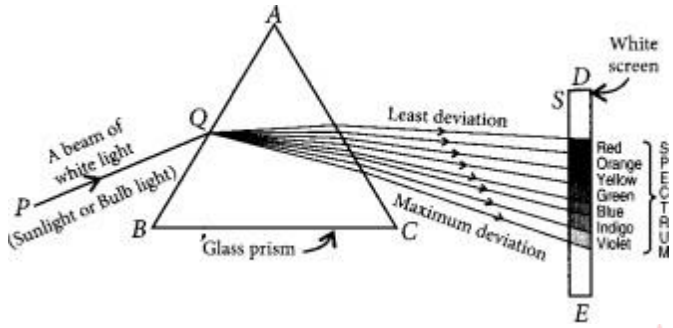
Dispersion of white light by the glass prism

Question 25.
A narrow PQ of white light is passing through a glass prism ABC as shown in the diagram. Trace it on your answer sheet and show the path of the emergent beam as observed on the screen DE.



(i) Write the name and cause of the phenomenon observed.
(ii) Where else in nature is this phenomenon observed?

(iii) Based on this observation, state the conclusion which can be drawn about the constituents of white light. (AI 2014)
Answer:



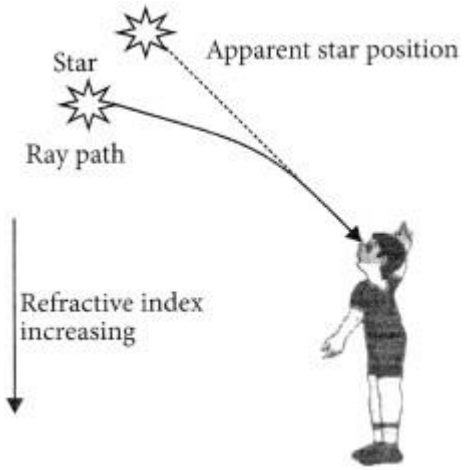
(i) The phenomenon of the splitting up of the white light into its constituent's colours is called dispersion of light. Dispersion of light is caused due to, different constituents and colours of light after different refractive indices to the material of the prism.
(ii) The formation of a rainbow is caused by the dispersion of the white sunlight into its constituent colours.
(iii) Based on the dispersion of white light into its constituent's colours, we can conclude that
(a) The white light consists of seven colours.
(b) The violet light suffers maximum deviations and the red light suffers minimum deviation.

Question 26.
Give reasons:
(i) The extent of deviation of a ray of light on passing through a prism depends on the colour.
(ii) Lights of red colour are used for danger signals. (Foreign 2011)
Answer:
(i) The extent of deviation of a ray of light on passing through a prism depends on the colour because the refractive index of glass for different colours is different. It depends on the wavelength of a particular light.

(ii) Since the wavelength of light is maximum in the spectrum, its penetration power in the air is maximum and so we can see red colour from farther distances. Thus, the danger signal uses red colour.

Question 27.
Why do stars appear to twinkle? Explain. (Foreign 2015)

Answer:

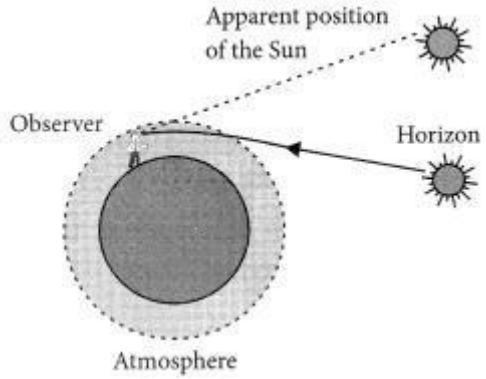


Due to atmospheric refraction, the position of a star visible from the sun is slightly different from its actual position. This apparent position of the star is not stationary but keeps on changing with the change in the physical condition of the earth's atmosphere. Since the stars are very distant, they are approximately 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 appears brighter, and at some other time, fainter, which is the twinkling effect.

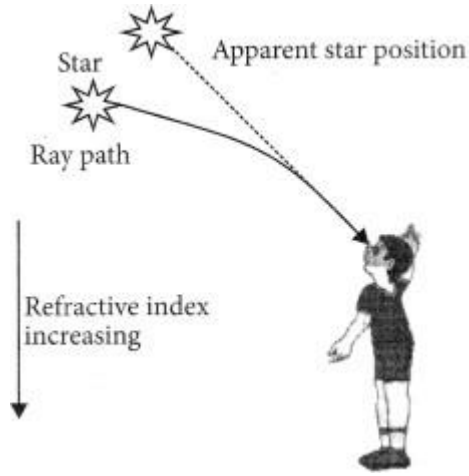
Question 28.
Explain why the planets do not twinkle. (Foreign 2015)
Answer:
Planets do not emit light. However, they become visible due to the reflection of light falling on them. The planets are much closer to the earth and thus can be considered as the extended source of light. The fluctuations in the light coming from various points of the planet due to atmospheric refraction get averaged out. As a result, no twinkling of planets is seen.

Question 29.
Explain in brief the reason for each of the following:
(a) Advanced sun-rise
(b) Delayed sun-set
(c) Twinkling of Stars (Foreign 2016)
Answer:
(a, b): The Sun is visible to us about 2 minutes before the actual sunrise, and about 2 minutes after the actual sunset because of atmospheric refraction. By actual sunrise, we mean the actual crossing of the horizon by the Sun. The figure shows the actual and apparent positions of the Sun concerning the horizon. The time difference between the actual sunset and the apparent sunset is about 2 minutes. The apparent flattening of the Sun's disc at sunrise and

sunset is also due to the same phenomenon.



Question 30.
A star appears slightly higher (above) than its actual position in the sky. Illustrate it with the help of a labelled diagram. (AI2012)
Answer:
A star appears slightly above its actual position in the sky. Starlight, on entering the earth's atmosphere undergoes refraction continuously in a medium of gradually changing refractive index, before it reaches the earth. Since the atmosphere bends starlight towards the normal, the star appears slightly above its actual position.



Question 31.
The sky appears dark to passengers flying at very high altitudes mainly because
(a) Scattering of light is not enough at such heights.
(b) There is no atmosphere at great heights.
(c) The size of molecules is smaller than the wavelength of visible light.
(d) The light gets scattered towards the earth. (2020)
Answer:
(b) There is no atmosphere at great heights.

Question 32.
Consider the following reasons for the reddish appearance of the sun at sunrise or sunset:
(A) Light from the sun near the horizon passes through thinner layers of air.
(B) Light from the sun covers a larger distance of the earth's atmosphere before reaching our eyes.
(C) Near the horizon, most of the blue light and shorter wavelengths are scattered away by the particles.
(D) Light from the sun near the horizon passes through thicker layers of air.
The correct reasons are
(a) A and C only
(b) B, C and D
(c) A and B only
(d) C and D only (2020)
Answer:
(b) Near the horizon, the light rays from the sun have to travel a larger distance through the Earth's atmosphere as compared to when it is away from the horizon. Thus, when this light travels through the atmosphere, most short wavelength lights are scattered away causing the reddish appearance of the sun.

Question 33.
What will be the colour of the sky when it is observed from a place in the absence of any atmosphere? (Delhi 2012)
Answer:
If the earth had no atmosphere, there would not have been any scattering. Then, the sky would look dark.

Question 34.
Give an example of a phenomenon where the Tyndall effect can be observed. (AI 2011)
Answer:
The phenomenon of scattering of light by the colloidal particle gives rise to the Tyndall effect.
This phenomenon is seen when a fine beam of sunlight enters a smoke-filled room through a small hole. This can also be observed when sunlight passes through a canopy of a dense forest.

Question 35.
Why is the colour of the clear sky blue? (Foreign 2011)
Answer:
When sunlight passes the atmosphere, the fine particles in the air scatter blue colour more

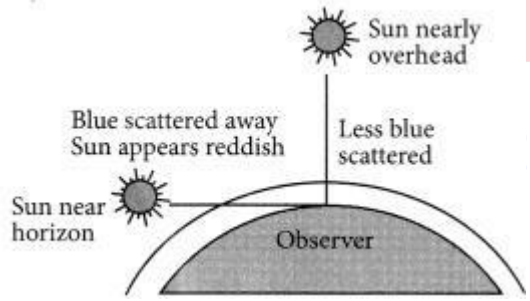
strongly than red. This scattered blue light enters our eye and the colour of the clear sky appears blue.

Question 36.
Why is the Tyndall effect shown by colloidal particles? State four instances of observing the Tyndall effect. (2020)
Answer:
The phenomenon of scattering of light by the colloidal particles gives rise to the Tyndall effect. When a beam of light strikes colloidal particles, the path of the beam becomes visible. This is known as the Tyndall effect.

This phenomenon can be observed when

- sunlight passes through a canopy of dense forest when tiny water droplets in the mist scatter light.
- torch light is switched on in a foggy environment, light rays are visible after being scattered by the fog particles in the surrounding air.
- a fine beam of sunlight enters a smoke-filled room through a small hole.
- shining a flashlight beam into a glass of dilated milk produces a Tyndall effect.

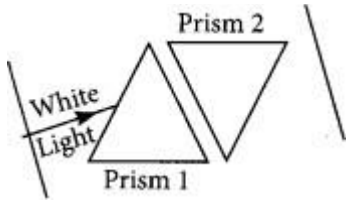
Question 37.
Draw a labelled diagram to show (i) the reddish appearance of the sun at sunrise or sunset and (ii) white appearance of the sun at noon when it is overhead. (2020)
Answer:
(i)



At sunrise and sunset, light from the sun passes through thicker layers of air and a larger distance in the earth's atmosphere. As the red colour has the longest wavelength hence, it is least scattered by the air and dust particles. So, the sun appears reddish.

(ii) At noon, when the sun is overhead, the distance to be travelled is the least. All wavelengths are scattered equally and hence sun appears white.

Question 38.
(a) State the relation between the colour of scattered light and the size of the scattering particle.
(b) The apparent position of an object, when seen through the hot air, fluctuates or waves. State the basic cause of this observation.



Answer:
(a) The colour of scattered light depends on the size of the scattering particle. Very fine particles scatter short wavelengths such as blue and violet, lights. Large-size particles scatter light of longer wavelengths.

(b) The basic cause of this observation is atmospheric refraction. As hot air is less dense than the colder air surrounding it, it has a slightly lower refractive index. Since the physical condition of the refracting medium, in the air is not stationary, the apparent position of an object, when seen through hot air fluctuates.

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