Dispersion of Light and Natural Optical Phenomena

Question 1:

Select the proper choice from the given multipule choices :

Question 1.1:

By which optical phenomenon, the splitting of white fight into seven constituent colours occur ?

Solution :

C. Dispersion
The phenomenon of splitting of white light into its constituent colours is called dispersion of light.

Question 1.2:

Which colour of fight deviates maximum in the dispersion of white light by prism ?

Solution :

A. Violet
In dispersion of white light by prism, violet colour deviates the most because in a given medium velocity of violet light is minimum.

Question 1.3:

Which of the following are the primary colours ?

Solution :

D. Red, Green, Blue
Red, green and blue colours are said to be primary colour of white light as on appropriate mixing of these colours, all other colours can be obtained.

Question 1.4:

Which of the following are primary pigments ?

Solution :

B. Magenta, Yellow and Cyan
The cyan, magenta and yellow are the primary pigments.

Question 1.5:

In human eye, the image of an object is formed at————————

Solution :

C. Retina
Retina acts as the screen on which the image of different objects is formed. It has light sensitive cells.

Question 1.6:

Which is the complementary colours of blue colour ?

Solution :

B. Yellow
Any two colours, which on mixing produce a light of white colour are called complementary colours. Yellow and blue are complimentary colours because on mixing the light of these colours, white light is formed.

Question 1.7:

Which colour is obtained by mixing the blue and red colours ?

Solution :

B. Magenta

Question 1.8:

The focal length of an eye lens is changed due to the action of ———————— .

Solution :

C. Ciliary muscles
Ciliary muscles hold the eye-lens in its position and change its focal length by changing its thickness. Thus, when the ciliary muscles contract, the focal length decreases and when the ciliary muscles expand the focal length increases.

Question 1.9:

Which colours are reflected when white light is incident upon blue pigment ?

Solution :

B. Violet, Green, Blue
When white light is incident on blue pigment, blue, violet and green colours are reflected and the remaining colours are absorbed.

Question 1.10:

———— lens is used to correct the defect of vision termed as presbyopia.

Solution :

C. Bifocal
The upper part of bifocal lens is made up of concave lens and the lower part of a small circular section is made up of convex lens. Thus, spectacles made of such a lens help to see nearby as well as distant objects clearly.

Question 1.11:

Which phenomenon does not play a role in the formation of rainbow ?

Solution :

D. Absorption
Absorption does not play any role in the formation of rainbow.
When light enters the water drop from atmosphere, refraction takes place.
When light after refraction enters the drop at an angle greater than critical angle, total internal reflection takes place.
The water droplets act like tiny prisms and disperse light into its constituent seven colours.

Question 1.12:

For which of the following cases, the total internal reflection of light will be possible ?

Solution :

C. Angle of incidence is more than critical angle
For total internal reflection to take place, the angle of incidence in the denser medium should be greater than the critical angle for that given pair of media.

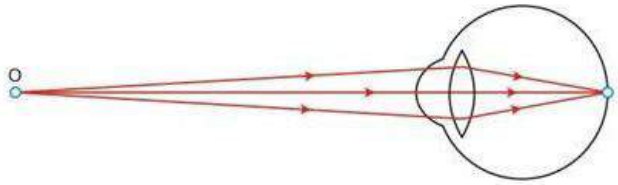
Question 1.13:

Where is the image in eye formed for a person suffering from defect of near sightedness ?

Solution :

C. On a region ahead of retina
In near sightedness, the inability of the eye-lens to become thin causes light rays from

distinct object to focus or form an image at a distance shorter than the retina, after being refracted from eye-lens.



Question 1.14:

Which phenomenon is responsible for the twinkling of stars ?

Solution :

B. Atmospheric refraction
Twinkling of stars happen due to atmospheric refraction. When star light passes through the layers of atmosphere with increasing refractive index, it bends continuously towards the normal till it enters our eye. Due to continuous refraction by the layers of atmosphere (atmospheric refraction), the apparent position is higher than its actual position. In addition, this position is not steady and hence the stars appear to twinkle.

Question 1.15:

Due to which phenomenon of light does Tyndall effect result ?

Solution :

C. Scattering
The earth's atmosphere is a mixture of smoke particles, tiny water droplets and air particles. When light falls on such colloidal particles, it is scattered (or deflected) thereby making the path of light beam visible. This phenomenon is called Tyndall effect. The light rays reach us after the deflection (scattering) from all these particles.

Question 1.16:

What is the time difference between actual sunset and apparent sunset ?

Solution :

C. 2 minute
Due to atmospheric refraction, sun is visible two minutes after actual sunset. Thus, the time difference between actual sunset and apparent sunset 2 minutes.

Question 1.17:

Which colour of light scatters maximum due to atmosphere ?

Solution :

A. Blue
The molecules of air and other fine particles in the atmosphere have their size smaller than the wavelength of visible light. Thus, they are more effective in scattering the light of shorter

wavelength, e.g. blue colour light.

Question 1.18:

Which coloured light has minimum velocity in the glass prism ?

Solution :

D. Violet
Violet coloured light has minimum velocity in the glass prism, thus it also is deviated the most.

Question 2:

Answer the following questions in brief :

Question 2.1:

What is the dispersion of light ? “Which are the colours of the spectrum obtained from the dispersion through a glass prism ?

Solution :

The phenomenon of splitting of white light into its constituent colours is called dispersion of light.
Violet, indigo, blue, green, yellow, orange and red colours are obtained from the dispersion of light through glass prism.

Question 2.2:

Write the name of primary colours of light. Write the name of colours obtained from their mixture ?

Solution :

The primary colours of light are red, blue and green.
Magenta, cyan, yellow and white are the colours that can be obtained from their mixture.

Question 2.3:

What are called pigments ? Give the names of primary pigments.

Solution :

The coloured substances which are used as paint are known as pigments.
The colours cyan, magenta and yellow are primary pigments.

Question 2.4:

Write the function of cilliary muscles and retina in human eye.

Solution :

The ciliary muscle to which eye lens is attached helps the eye lens to change its focal length by changing radii of curvature of eye lens.
When the eye is focused on a distant object, the ciliary muscles are relaxed so that the focal length of eye lens has its maximum value, which is equal to its distance from the retina. The parallel rays coming into the eye are then focused on the retina and we see the object clearly.
When the eye is focused on a closer object the ciliary muscles are strained and focal length of eye-lens decreases. The ciliary muscles adjust the focal length in such a way that the image is formed on retina and we see the object clearly.
Retina is the part of the eye where the image of different objects is formed. When the light rays fall on retina, the light sensitive cells (rods and cones) generate electrical signals. The signals are sent to the brain through the optic nerves where the image of an object is interpreted.

Question 2.5:

What is an accommodation power of an eye ? What is the least distance of distinct vision ?

Solution :

The ability of an eye-lens to adjust its focal length to see nearby as well as distant objects is called accommodation power of an eye.
The least distance for distinct vision of normal human eye is 25 cm.

Question 2.6:

What is called atmospheric refraction ? Which phenomenon results from it ?

Solution :

Earth's atmosphere consists of layers of different densities and hence different refractive indices. The lower layers being denser than the upper ones. Thus, the light from objects is refracted at each layer of the atmosphere. In addition, physical situations like temperature are not steady; thus, the apparent position of the object also fluctuates.
This phenomenon of refraction of light due to layers of atmosphere of varying densities is called atmospheric refraction.
Phenomenons like 'twinkling of stars', 'early sunrise' and 'delayed sunset' occur due to atmospheric refraction.

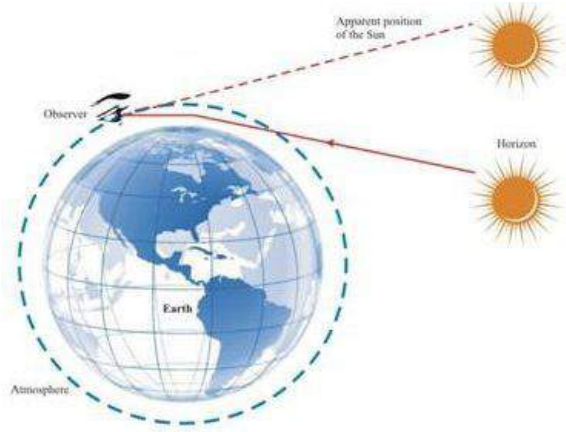
Question 2.7:

Give the reason for two minute early sunrise.

Solution :

When a ray of light passes through the atmosphere having layers of different densities and refractive indices, then refraction of light takes place (atmospheric refraction). The actual sunrise takes place when the sun is just above the horizon. When the Sun is just below the horizon, the light rays coming from it, on entering the Earth's atmosphere suffer atmospheric refraction from a rarer medium to a denser medium. So they move towards the normal after refraction at each layer. Due to continuous refraction of light at each layer of atmosphere, it follows a curved path and reaches the eye of the observer as shown. As a result, we see the

Sun two minutes before it rises above the horizon in the morning.



Question 2.8:

What is the scattering of light ? On what factors does it depend ?

Solution :

The deflection of light by minute particles and molecules of atmosphere in all directions is known as scattering of light.
It depends on the size of the scattering particles. The scattering particles (atoms or molecules) respond to the light wh

Question 2.9:

Why are the danger signal lights red in colours ?

Solution :

The danger signals are red in colour because being of longer wavelength, the red coloured light gets least scattered by fog or smoke and hence it can be seen from a long distance.

Question 2.10:

Why does the sun appear reddish at sunrise and sunset ?

Solution :

At sunrise and sunset, the sunrays (white light) have to travel maximum distance in the atmosphere before reaching the observer. During this, the scattering of blue light takes place so the light corresponding to reddish colour reaches the observer and hence the sun appears reddish.

Question 2.11:

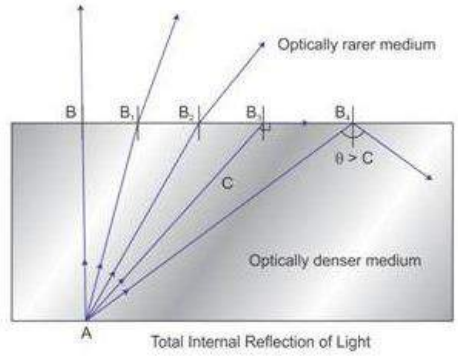
What is the total internal reflection of light ? Give its illustrations.

Solution :

For a ray of light travelling from denser to rarer medium, when the angle of incidence in the denser medium is greater than critical angle, the light ray gets reflected into the denser

medium at the interface i.e., light does not enter the rarer medium. This phenomenon is called total internal reflection.

Illustration: Consider a ray of light AB travelling from denser (glass) to rarer (air) medium as shown below.



Total Internal Reflection of Light

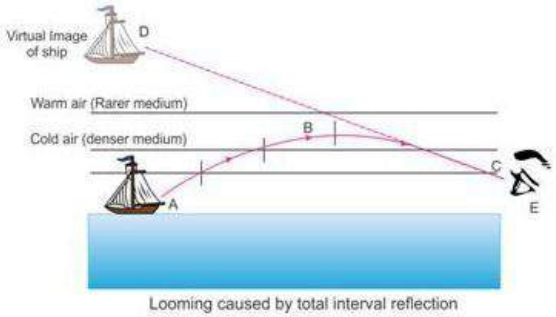
As the angle of incidence increases, the angle of refraction also increases and the ray of light moves away from normal. For a certain angle of incidence, the angle of refraction is 90^{o}; this angle of incidence is called 'critical angle' (C). For angle of incidence greater than the critical angle ($\theta > C$), the light is completely reflected in the denser medium. This phenomenon is known as total internal reflection.

Question 2.12:

What is looming ? How is it formed ?

Solution :

Looming is a kind of mirage observed in very cold regions in which distant object appears to be hanging mid way in the air.
It is formed by the total internal reflection of light (in downward direction) caused by atmospheric refraction.
Looming produces a virtual and erect image of an object above horizon where the warmer (optically rarer) air remains above the colder (optically denser) air in the atmosphere.



Looming caused by total interval reflection

Question 3:

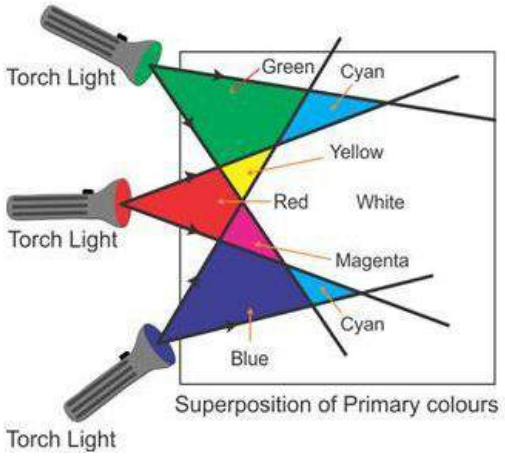
Write answer of the following questions :

Question 3.1:

Explain the superposition of primary colours of light with necessary illustration.

Solution :

Primary colours are mixed or superimposed in right proportions to produce a wide range of colours by the method called additive mixture method. The colours so obtained are called composite colours.
Illustration: Take three torches and transparent glass plates of red, blue and green colours and obtain light of these three colours. Next, place a white paper on a table. Arrange these three torches horizontally on a table in such a way that the patches of all three colours are seen as shown in figure below.

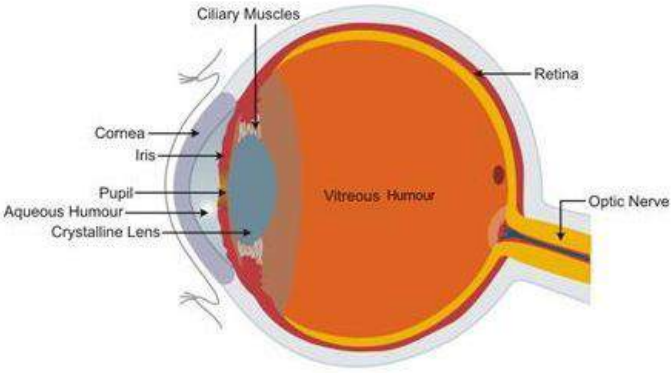


We observe that the portion of white paper where all the three patches superimpose on one another will appear white. The portions of the screen where blue and green light superimpose appear cyan. The portion of the screen where blue and red light superimpose appear magenta and it will be yellow at the superposition of red and green colours.

Question 3.2:

Explain the function of main parts of an eye by drawing a simple sketch of it.

Solution :



Main parts	Functions
Cornea	Light enters the eyes through cornea.
Iris	It controls the amount of light entering the eyes.
Pupil	It dilates and contracts and thus enables us to in bright and dark light.

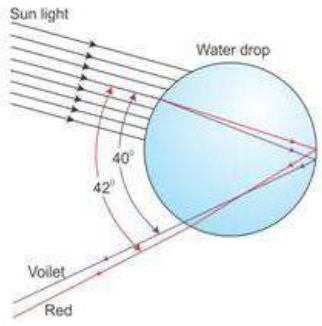
Eye-lens	It is a convex lens and focuses the light entering the eyes.
Ciliary muscles	Holds the eye lens and helps it to change its focal length.
Retina	Part of the eyes where image is formed
Optic nerve	It helps to carry the signals from the retina to the brain.

Question 3.3:

Explain the formation of rainbow with a neat figure.

Solution :

A rainbow is a natural spectrum appearing in the sky after a rain shower. It is produced by the dispersion of sunlight by tiny water droplets present in the atmosphere. When a ray of light falls on a water drop, it undergoes refraction and dispersion to form a spectrum. On reaching the opposite side of the drop, this spectrum undergoes total internal reflection (inside the drop). Arriving at the first surface of the drop, each colour is refracted back to air. The angle between the incoming and outgoing rays can be anything between 0^0 and about 42^0. We observe a bright rainbow when the angle between the incoming and outgoing rays is close to the maximum value of 42^0. A rainbow is always formed in the direction opposite to that of the Sun.

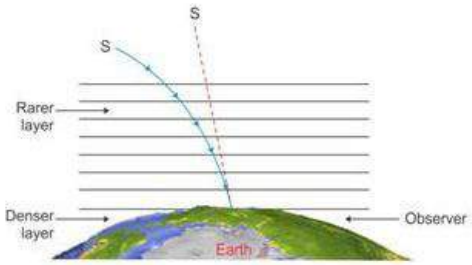


Question 3.4:

Write a note on “twinkling of stars.”

Solution :

The twinkling of stars is due to the atmospheric refraction of the sunlight. The atmospheric refraction occurs in a medium of gradually changing refractive index, i.e. the atmosphere. Light from stars travel from rarer to denser medium.



Thus, at each layer of the atmosphere, the sunlight bends towards the normal and the apparent position of the star is slightly different from the actual position. So, the star appears

to be at S1 instead of S. In addition, this apparent position is not stationary, and it fluctuates. Therefore, the amount of sunlight entering the eyes flickers – the star sometimes appears brighter, and sometimes fainter, which is the twinkling effect.
Previous

Question 3.5:

Describe Tyndall effect.

Solution :

The earth's atmosphere is a mixture of smoke particles, tiny water droplets and air particles. When light falls on such colloidal particles, it is scattered (or deflected) thereby making the path of light beam visible. This phenomenon is called Tyndall effect. The light rays reach us after the deflection (scattering) from all these particles. Tyndall effect is also seen due to scattering of light through tiny droplets in mist or when sunlight enters a canopy of dark forest.

Question 3.6:

Why does the clear sky appear blue in colour ?

Solution :

The molecules of air like N_2 and O_2, and other fine particles in the atmosphere have size comparable to the wavelength of blue light. They are more effective in scattering light of shorter wavelengths at the blue end than light of longer wavelengths at the red end. When sunlight passes through the atmosphere, the fine particles in air scatter the blue colour more strongly than red colour. The scattered blue light enters our eye. Since, we see the blue light from everywhere overhead, the sky appears blue.

Question 4:

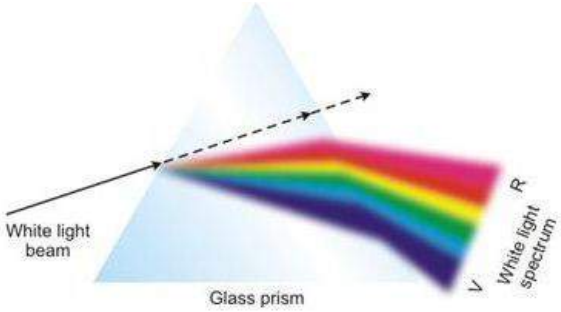
Answer the following questions in detail :

Question 4.1:

Explain the dispersion of white light by a glass prism using necessary figure.

Solution :

The phenomenon of splitting of white light into its constituent colours is called dispersion of light. The band of seven colours obtained from the splitting of white light is called the spectrum.



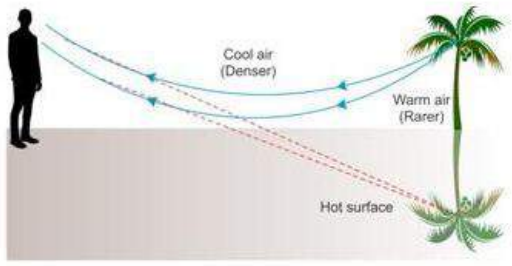
All the constituent colours of a white light have same velocity in vacuum, but when it passes through a transparent medium like glass prism, their velocity changes. At the first face of the prism, different colours are deviated by different angles. Violet having the minimum speed gets deviated by maximum angle and red having the maximum speed gets deviated by minimum angle. On reaching the other face of the prism, these colours are refracted according to the laws of refraction. Thus, the dispersion of white light occurs on entering a prism.

Question 4.2:

Describe the fomation of mirage through an appropriate figure.

Solution :

Mirage is an optical illusion caused by the total internal reflection of light at layers of air of different densities.



In a desert, sand is very hot during day time; as a result, the successive upper layers are denser than those below them.
A ray of light coming from a distant object, like the top a tree, is refracted from a denser to a rarer medium. Consequently the refracted ray bends away from the normal until at a particular layer, the light is incident at an angle greater than the critical angle. At this stage, the incident ray suffers total internal reflection and is reflected upwards. When this reflected beam of light enters the eyes of the observer, it appears as if an inverted image of the tree is seen and the sand looks like a pool of water.

Question 5:

Answer the following questions pointwise :

Question 5.1:

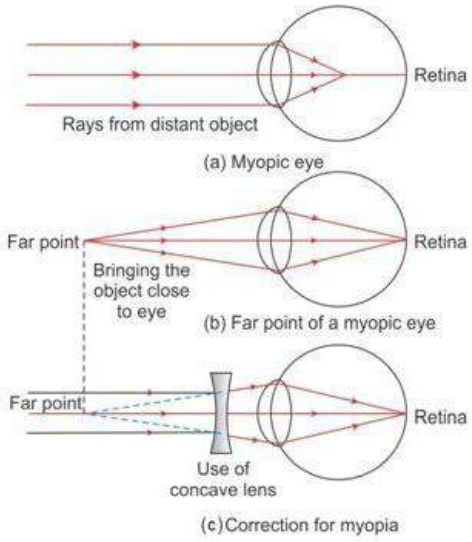
What is the defect of vision in the human eye ? State its types and explain in detail.

Solution :

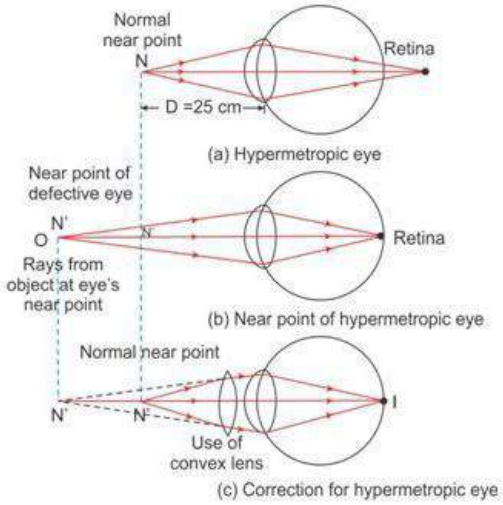
The inability of ciliary muscles to change the thickness of eye-lens as per requirement and to form the image of an object on retina leads to the defect of vision.
The three main common defects of vision are:

i. Myopia or near-sightedness: It is the inability of eyes to see distant objects clearly. It arises when the eye-lens does not become thin as per requirement and as such the image of the object is formed at a distance shorter than retina.
Myopia can be corrected by using a concave lens of suitable focal length in the spectacles of

such a person.



ii. Hypermetropia or far-sightedness: It is the inability of eyes to see nearby objects clearly. It arises when the eye-lens does not become thick as per requirement and as such the image of the object is formed at a distance beyond than retina.
Hypermetropia can be corrected by using a convex lens of suitable focal length in the spectacles of such a person.



iii. Presbyopia: This defect of eye arises with ageing due to the weakening of ciliary muscles and loss of elasticity of eye-lens. Due to this defect, a person finds it difficult to view nearby as well as distant objects clearly. This defect is corrected by using a bifocal in the spectacles of the person of such a person.