LIGHT

CONTENTS

LIGHT

- Light is a form of energy, (optical energy) which helps us in seeing objects by its presence.
- Light travels in a straight line with 3×10^8 m/s in vaccum..
- The velocity of light changes when it travels from one medium to another.
- Light gets reflected back from polished surfaces, such as mirrors, polished metal surfaces, etc.
- Light undergoes refraction (bending) when it travels from one transparent medium to another.

SOURCES OF LIGHT

- The objects which emit (give) light are called **luminous objects**. It may be natural or man-made. Sun is a natural source of light and electric lamp, and oil lamp, etc. are man-made source of light.
- The **Non-luminous objects** do not emit light. However, such objects become visible due to the reflection of the light falling on them. Moon does not emit light. It becomes visible due to the reflection of the sunlight falling on it.

MEDIUM OF LIGHT

Substance through which light propagates or tends to propagate is called a medium of light.

According to the medium of light objects are divided into three parts.

(i) Transparent object :

Bodies that allow light to pass through then i.e. transmit light through them, are called transparent bodies.

Ex. Glass, water, air etc

(ii) Translucent object :

Bodies that can transmit only a part of light through them are called translucent objects.

Ex. Froasted or ground glass, greased paper , paraffin wax etc.

(iii) Opaque object :

Bodies that do not allow light to pass through them at all are said to be opaque objects

Ex. Chair, desk etc.

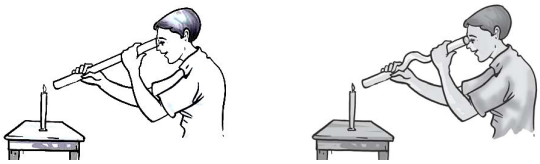
LINEAR PROPAGATION OF LIGHT

Light travels in a straight line. In vaccum or air, light travels with the velocity of 3×10^8 m/s.

Activity : If we see at a lighted candle through a straight pipe as shown in figure(a), we are able to see the candle but if we see the candle through a

bent pipe we are not able to see the candle flame as shown in figure (b).

This activity showed that light travels along straight lines.



(a) b)

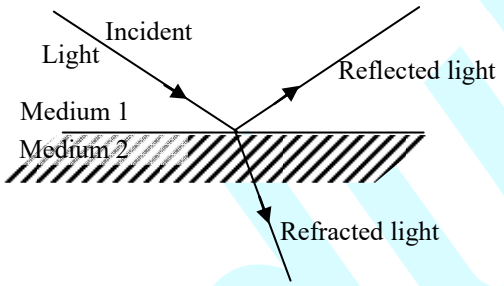
BEHAVIOUR OF LIGHT

When light travelling in one medium falls on the surface of a second medium, the following three effects may occur.

(i) A part of the incident light is turned back into the first medium. This phenomenon is called **reflection of light.**

(ii) A part of the incident light is transmitted into the second medium along a changed direction. This phenomenon is called **refraction of light.**

(iii) The remaining third part of light energy is absorbed by the second medium. This phenomenon is called **absorption of light.**

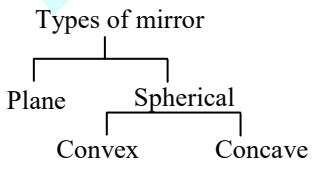


REFLECTION OF LIGHT

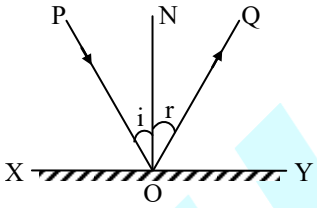
When light rays are incident on an opaque polished surface (medium), these are returned back in the same medium.

This phenomenon of returning of ray of light in the same medium, is called reflection of light.

Types of mirror



SOME ASSOCIATED TERMS



- **Reflecting surface :** The surface from which the light is reflected, is called the reflecting surface. In diagram, XY is the reflecting surface. (**Actually** XY is the section of a reflecting surface, made by the plane of the book page which is perpendicular to it.)
- **Point of incidence :** The point on the reflecting surface at which a ray of light strikes, is called the point of incidence. In diagram, O is the point of incidence.
- **Normal :** A perpendicular drawn on the reflecting surface at the point of incidence, is called the normal. In diagram, NO is the normal.
- **Incident ray :** The ray of light which strikes the reflecting surface at the point of incidence is called the incident ray. In diagram, PO is the incident ray.
- **Reflected ray :** The ray of light reflected from the reflecting surface from the point of incidence, is called the reflected ray. In diagram, OQ is the reflected ray.
- **Angle of incidence :** The angle that the incident ray makes with the normal, is called the angle of incidence. It is represented by the symbol i. In diagram, angle PON is the angle of incidence.
- **Angle of reflection :** The angle that the reflected ray makes with the normal, is called the angle of reflection. It is represented by the symbol r. In diagram, $\angle$QON is the angle of reflection.

LAWS OF REFLECTION

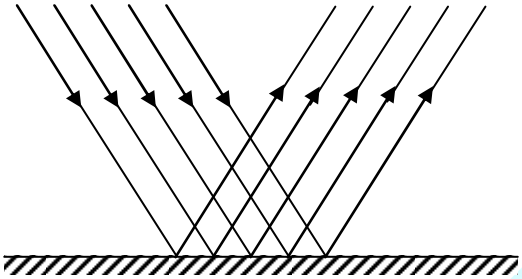
- **First law :** The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

Second law : The angle of reflection ($\angle r$) is always equal to the angle of incidence ($\angle i$).
i.e., $\angle r = \angle i$

(For normal incidence, i = 0, r = 0. The ray is reflected back along normal).

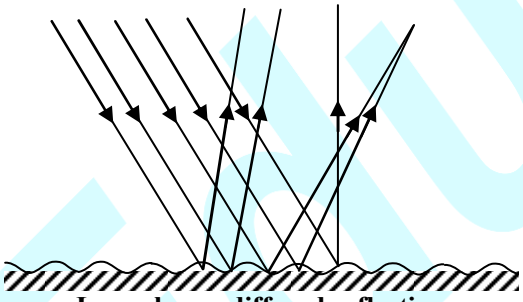
REGULAR & DIFFUSED REFLECTION

◈ **Regular Reflection :**
In this reflection, parallel beam of light goes parallel after reflection from plane surface.
This reflection follows the laws reflection.



Regular reflection

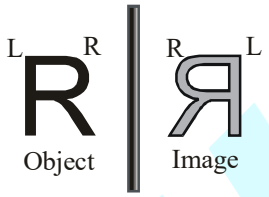
◈ **IRREGULAR REFLECTION OR DIFFUSED REFLECTION :**
In this reflection, parallel beam of light goes random after reflection from a rough surface.
This reflection also follows the laws of reflection.



Irregular or diffused reflection

REFLECTION FROM PLANE MIRROR

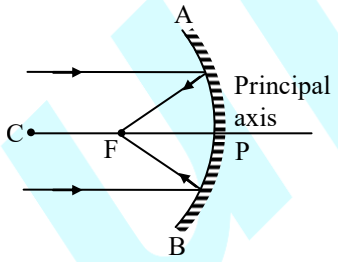
- **Size :** size of the image is same as that of object.
- **Upright or Erect :** Image formed erect with respect to object.
- **Image distance :** It will be same as that of object distance.
- **Lateral inversion :** If you move your right hand, it will appear as if the left hand of your image is moving. If you keep a printed page in front of a plane mirror, the image of the letters appear erect but inverted laterally, or sideways. Such an inversion is called lateral inversion.



REFLECTION FROM SPHERICAL MIRROR

◈ There are two types of spherical mirrors:

(i) Concave mirror :



(ii) Convex mirror :

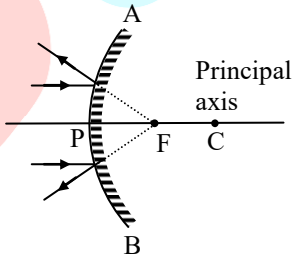
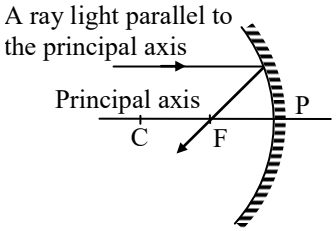


IMAGE FORMATION BY SPHERICAL MIRROR

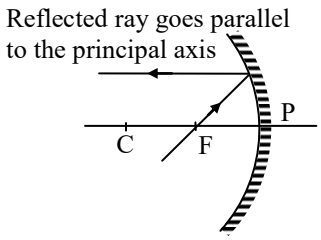
RAY DIAGRAM FOR IMAGE FORMATION FROM CONCAVE MIRROR

(a) *When the light ray incident parallel to the principal axis.*

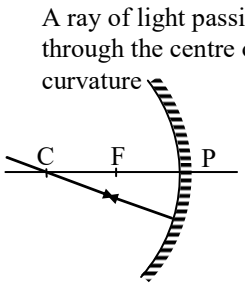


OR

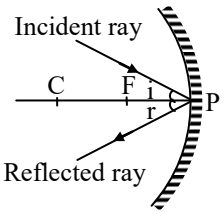
When the light ray incident towards focus.



(b) *When the light ray incident towards centre of curvature.*

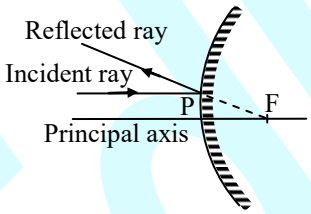


(c) *When the light ray incident on the pole of the mirror.*



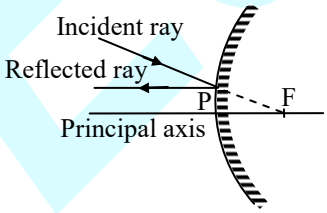
◈ RULES FOR IMAGE FORMATION FROM CONVEX MIRROR

(a) *When the light ray incident parallel to the principal axis.*

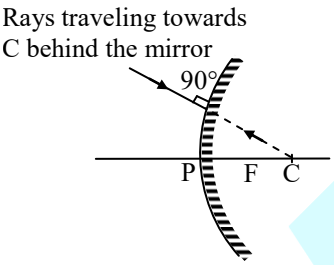


OR

When the light ray incident parallel to the principal axis.



(b) *When the light ray incident on the mirror directing towards centre of curvature.*



➢ REFRACTION OF LIGHT

When light rays travelling in a medium are incident on a transparent surface of another medium they are bent as they travel in second medium.

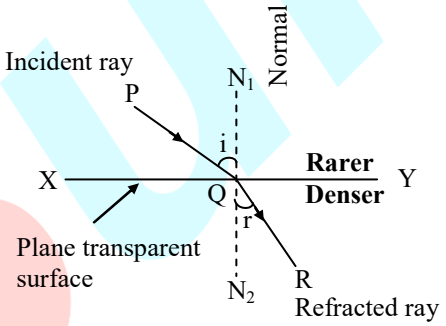


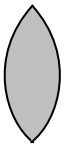
Fig. Refraction of light from a plane transparent denser surface.

➢ SPHERICAL LENS

A piece of a transparent medium bounded by at least one spherical surface, is called a spherical lens.

◆ **Types :** There are two types of spherical lenses:

(i) Convex or Converging Lens : They are thick in the middle and thin at the edges.



(ii) Concave or diverging Lens :
They are thinner in the middle and thin at the edges.

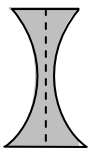
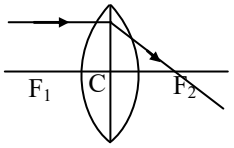


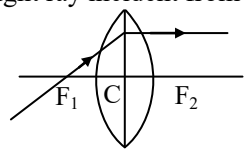
IMAGE FORMATION BY SPHERICAL LENS

RAY DIAGRAM FOR IMAGE FORMATION FROM CONVEX LENS

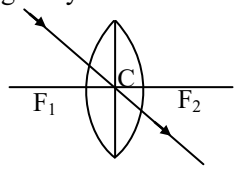
- When light ray incident parallel to principal axis.



- When light ray incident from focus.

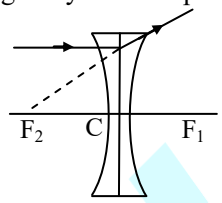


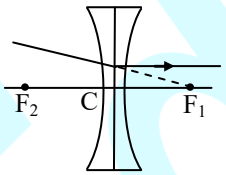
- When light ray incident on the pole.

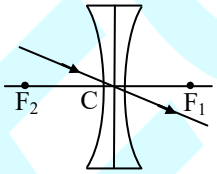


RAY DIAGRAM FOR IMAGE FORMATION FROM CONCAVE LENS

- When light ray incident parallel to principal axis.







TOTAL INTERNAL REFLECTION

When light travels from a denser medium to a rarer medium and is incident at an angle more than the critical angle for that medium, it is completely returned inwardly in the denser medium. This complete inward return of light is called **total** (complete) **internal** (inward) **reflection** (return).

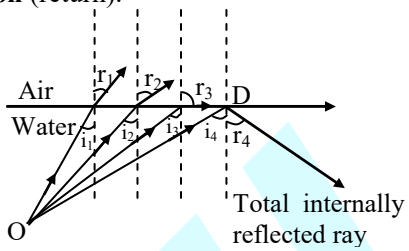
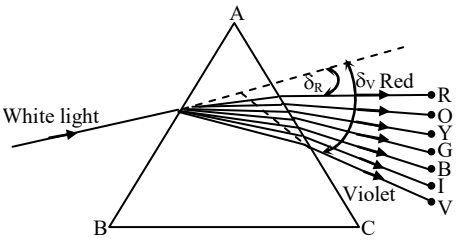


Fig. Total internal reflection.

DISPERSION OF WHITE LIGHT BY A GLASS PRISM

- **Definition :** When a ray of white light (sunlight) enters a glass prism (denser medium). It emerges out from it broken into seven colours.
  This phenomenon, due to which different components of a white light are separated by a denser medium, is called **dispersion (separation).**

- **Explanation :** It is due to different velocities of different components of white light in the denser medium.
  White light has seven colours, namely, violet indigo, blue, green, yellow, orange and red (remembered by the word **VIBGYOR**). In air (strictly in vacuum) light waves of all colours have same velocity (3×10^8 m/s). But in a denser medium, their velocities become less and different. Red light waves, travel fastest and have maximum velocity. Violet light waves, travel slowest and have minimum velocity in the denser medium.



Dispersion of white light by a glass prism

Due to difference in deviation, waves of different colours emerge out from the prism indifferent directions and are said to have been dispersed (separated). When the dispersed white light is made to fall on a white screen, we get a seven coloured band or light. This coloured band is called spectrum

HUMAN EYE

It is the most delicate and complicated natural optical instrument.

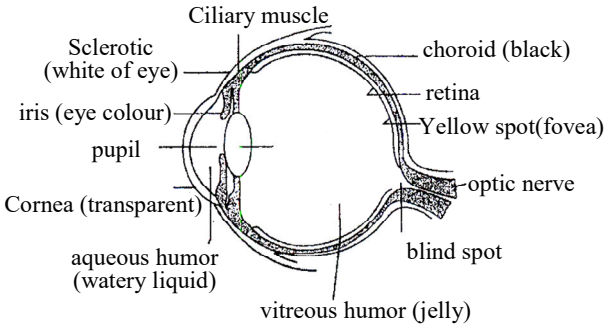


Diagram shows the section of a human eye by a horizontal plane. It is a spherical ball of diameter about 2.5 cm.

DEFECTS OF VISION

DEFECTS OF VISION

The major defects of vision are :

1. Short sightedness or myopia.
2. Long sightedness or hypermetropia.

1. Short sightedness or myopia

- **Symptoms :** Eye cannot see clearly beyond a certain distance. It means that the far point of the defective eye has shifted from infinity to a finite distance ahead.

- **Correction :** The extra converging power of eye lens in compensated by using a concave (diverging) lens of proper power (focal length) as shown in fig.

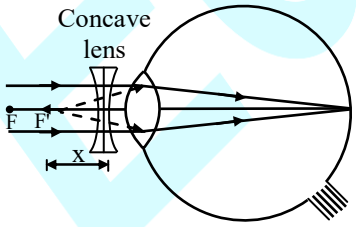


Fig. Myopia corrected by a concave lens

2. Long sightedness or hyper metropia :

- **Symptoms :** With this defect eye cannot see clearly within a certain distance. It means that the near point of the defective eye has shifted from 25 cm to some more distance behind (away).

- **Correction :** The deficiency in converging power of eye lens is compensated by using a convex (Converging) lens of proper power (focal length) as shown in fig.

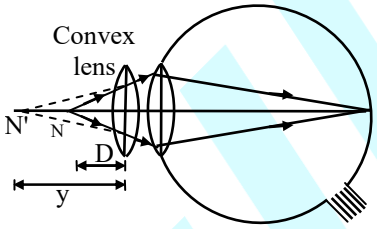
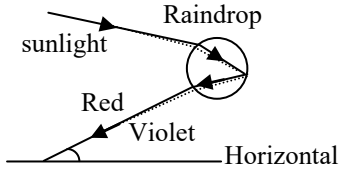


Fig : Hypermetropia corrected by a convex lens.

REFRACTION IN NATURE

(A) FORMATION OF RAINBOW

A rainbow is a natural spectrum appearing in the sky after a rain shower. It is caused by dispersion of sunlight by tiny water droplets, present in the atmosphere. A rainbow is always formed in a direction opposite to that of the Sun. The water droplets act like small 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 reach the observer's eye.



(B) ATMOSPHERIC REFRACTION

We can observe the apparent random wavering or flickering of objects seen through a turbulent stream of hot air rising above a fire or a radiator. The air just above the fire becomes hotter than the air further up. The hotter air is lighter (less dense) than the cooler air above it, and has a refractive index slightly less than that of the cooler air. Since the physical conditions of the refracting medium (air) are not stationary, the apparent position of the object, as seen through the hot air, fluctuates. This wavering is thus an effect of atmospheric refraction (refraction of light by the earth's atmosphere) on a small scale in our local

environment. The twinkling of stars is a similar phenomenon on a much larger scale.

(a) Twinkling of stars :

The twinkling of a star is due to atmospheric refraction of starlight. The starlight, on entering the earth's atmosphere, undergoes refraction continuously before it reaches the earth. The atmospheric refraction occurs in a medium of gradually changing refractive index.

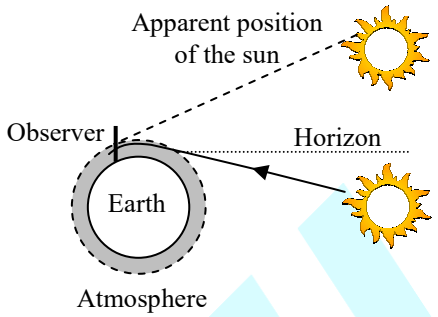
Since the stars are very distant, they approximate point-sized sources of light. As the path of rays of light coming from the star goes on varying slightly, the apparent position of the star fluctuates and the amount of starlight entering the eye flickers – the star sometimes appears brighter, and at some other time, fainter, which is the twinkling effect.

(b) Why don't the planets twinkle?

The planets are much closer to the earth, and are thus seen as extended sources. If we consider a planet as a collection of a large number of point-sized sources of light, the total variation in the amount of light entering our eye from all the individual point-sized sources will average out to zero, thereby nullifying the twinkling effect.

(C) ADVANCE SUNRISE AND DELAYED SUNSET :

Advance sunrise and delayed sunset 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. figure shows the actual and apparent positions of the Sun with respect to the horizon. The time difference between 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.



Atmospheric refraction at sunrise and sunset

SCATTERING OF LIGHT

The interplay of light with objects around us gives rise to several spectacular phenomena in nature. The blue colour of the sky, colour of water in deep sea, the reddening of the sun at sunrise and the sunset are some of the wonderful phenomena we are familiar with. The path of a beam of light passing through a true solution is not visible. However, its path becomes visible through a colloidal solution where the size of the particles is relatively larger.

(a) Tyndall effect

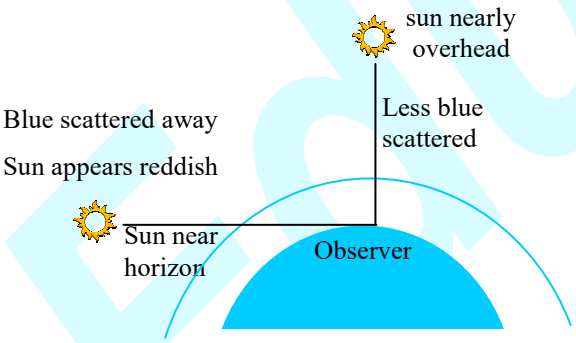
The earth's atmosphere is a heterogeneous mixture of minute particles. These particles include smoke, tiny water droplets, suspended particles of dust and molecules of air. When a beam of light strikes such fine particles, the path of the beam becomes visible. The light reaches us, after being reflected diffusely by these particles. The phenomenon of scattering of light by the colloidal particles gives rise to **Tyndall effect**. This phenomenon is seen when a fine beam of sunlight enters a smoke-filled room through a small hole. Thus, scattering of light makes the particles visible. Tyndall effect can also be observed when sunlight passes through a canopy of a dense forest. Here, tiny water droplets in the mist scatter light. The colour of the scattered light depends on 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 even appear white.

(b) Why is the colour of the clear sky blue :

The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. These are more effective in scattering light of shorter wavelengths at the blue end than light of longer wavelengths at the red end. The red light has a wavelength about 1.8 times greater than blue light. Thus, when sunlight passes through the atmosphere, the fine particles in air scatter the blue colour (shorter wavelengths) more strongly than red. The scattered blue light enters our eyes. If the earth had no atmosphere, there would not have been any scattering. Then, the sky would have looked dark. The sky appears dark to passengers flying at very high altitudes, as scattering is not prominent at such heights. You might have observed that 'danger' signal lights are red in colour. Do you know why? The red is least scattered by fog or smoke. Therefore, it can be seen in the same colour at a distance.

(c) Colour of the sun at sunrise and sunset

The sky and the Sun at sunset or sunrise appears red. 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.



◈ MIRAGE OR INFERIOR MIRAGE

It is an optical illusion, seen in deserts at summer noon, due to which an inverted image of a distant tree is seen formed in hot sand below it, as if formed in water. Actually there is no water anywhere.

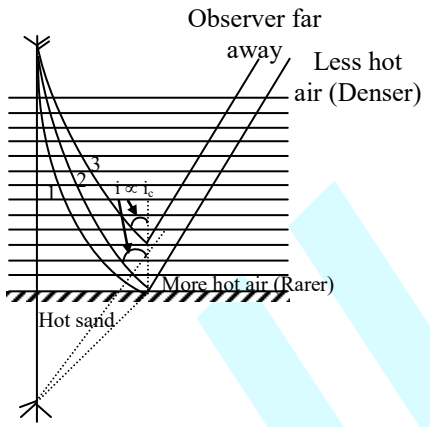


Fig. Mirage in hot desert–Inverted image of tree in hot sand

◆ **Explanation :** It is due to total internal reflection. At summer noon, in desert, sand becomes hot. The air in its contact becomes very hot and hence rarer. As we move up, air becomes less and less hot, hence less and less rarer. The air can be divided into layers of different optical density (fig.).

For rays (like number 1 ray), incident at small angle at upper most layer, the angle of incidence on lowest layer may not be more than critical angle. These rays are all absorbed by sand.

The ray no. 2 starting from tree top and making a bigger angle since beginning, reaches the lowest layer at bigger angle. The angle of incidence may become just more than the critical angle. The ray is totally reflected upward and outward. All rays on the right of ray no. 2 will start with still bigger angle and will have angle of incidence becoming more than critical angle from upper and upper layers. They are also totally reflected.

◈ LOOMING OR SUPERIOR MIRAGE

It is an optical illusion seen at sea–shore in winter evening, due to which an image of a ship is seen formed in air in sea–sky. The actual ship is nowhere visible.

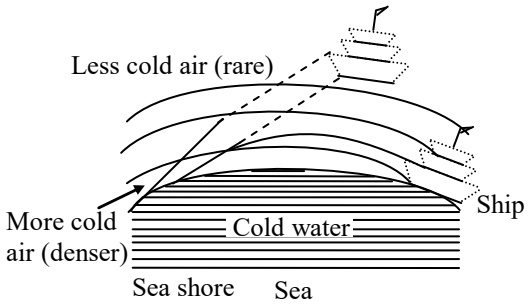


Fig. Looming at cold sea–shore

◆ **Explanation :** It is due to total internal reflection. In cold evening, over sea–bed sea water becomes too cold. Air layer in its contact is cold and denser. As we go up, air layers become less and less colder and hence rarer. (Fig.)

Rays from invisible ship going upward go from denser to rarer air layers. They are totally reflected downwards and received by an observer at sea–shore. The observer sees an image (virtual) of the ship hanging in the sky.

EXERCISE # 1

A Very Short Answer Type Questions

Q.1 What do you understand by the rectilinear propagation of light ?

Q.2 What is the relation between the incident ray, the reflected ray and the surface of a plane mirror ?

Q.3 Write three properties of the image formed by a plane mirror

Q.4 An object is placed beyond the focus of a concave mirror. What is the nature of the image–real or virtual erect or inverted

Q.5 An object is placed beyond the focus of a convex lens. What is the nature of the image–real or virtual, erect or inverted ?

Q.6 You have a concave mirror. Where will you place an object to see an erect and magnified image ?

Q.7 You have a convex lens. Where will you place an object to see an erect and magnified image?

Q.8 Mention two uses of a concave mirror

Q.9 State two uses of a convex lens.

Q.10 What is white light ?

B Short Answer Type Questions

Q.11 Why is the image formed by a pinhole inverted ?

Q.12 What happens when parallel rays of light fall on a curved reflecting surface ?

Q.13 Convex mirrors are used as rear view mirrors. Why ?

Q.14 What do you understand by the spectrum of white light ?

Q.15 How is a rainbow formed ?

Q.16 Why does a Newton's disc appear white when it is rotated ?

C Long Answer Type Questions

Q.17 What are real and virtural images ? What are the differences between them ?

Q.18 What do you understand by the focus of a lens ? How will you find the focus of the convex lens ?

Q.19 What is refraction ? Explain with an example.

D. Fill in the blanks

Q.20 An image formed by a plane mirror..... be seen on a screen.

Q.21 A ..... image can be formed on a screen.

Q.22 A convex mirror is one in which the reflecting surface bulges .....

Q.23 A magnifying glass is a ..... lens.

Q.24 Parallel rays of light after passing through a ..... lens, they seem to come from a point.

EXERCISE # 2

Single Correct Answer type Questions

Q.1 Which of these form virtual images only ?
(A) Concave mirror (B) Convex mirror
(C) Convex lens (D) None of these

Q.2 A drop of water on a leaf forms a magnified image of the veins because of-
(A) refraction
(B) reflection
(C) radiation
(D) rectilinear propagation

Q.3 If we mix lights of the colours of the rainbow, we will get
(A) pink light (B) brown light
(C) colourless light (D) black light

Q.4 If you bring a faraway object towards the focus of convex lens, the size of the image will-
(A) increase (B) decrease
(C) double (D) remain the same

Q.5 Which of these are due to the rectilinear propagation of light ?
(A) rainbow
(B) inverted image in a pinhole camera
(C) shadow
(D) reflection

Q.6 Light causes the sensation of-
(A) Vision
(B) Light
(C) Both (A) and (B)
(D) None

Q.7 Light is-
(A) an electromagnetic radiation
(B) a longitudinal wave
(C) massless
(D) all of the above

Q.8 Which of the following is a natural luminous source of light ?
(A) sun (B) wood
(C) electric lamp (D) torch

Q.9 Light shows -
(A) random propagation
(B) curvilinear propagation
(C) rectilinear propagation
(D) None of these

Q.10 Which of the following is a reflector of light ?
(A) Sun (B) Star
(C) Filament (D) Moon

Q.11 Wood is an example of-
(A) translucent (B) Transparent
(C) Polymer (D) Opaque

Q.12 If the angle of incidence is 50°, then calculate the angle between the incident ray and the reflected ray-
(A) 50° (B) 80°
(C) 130° (D) 100°

Q.13 Which of the following statement is true ?
(A) The angle of incidence is twice the angle of reflection

(B) The incident ray, the reflected ray and the normal drawn at the same point of incidence lie in the same plane
(C) Some types of virtual images can be caught on the screen.
(D) A plane mirror forms a real image

Q.14 Two plane mirrors are inclined at a angle 60°, the number of images of an object which is placed between mirror will be-
(A) 4 (B) 3
(C) 5 (D) 6

Q.15 Plane mirror are arranged parallel to each other to get-
(A) A single image
(B) Two images
(C) A large number of reflected images
(D) No image

Q.16 When an object is moved towards the plane mirror-
(A) Image moves away from the object
(B) Size of the image increases
(C) Image moves closer to the object
(D) Size of the image decrease

Q.17 David is observing his image in a plane mirror. The distance between the mirror and his image is 5m. If he moves 1m towards the mirror, then the distance between David and his image will be-
(A) 3 m (B) 5 m
(C) 6 m (D) 8 m

Q.18 The rear view mirror of a car is a plane mirror. A driver is reversing his car at a speed of
2 m/s. The driver sees in his rear view mirror the image of truck parked behind his car. The speed at which the image of the truck appears to approach the driver will be-
(A) 1 m/s (B) 2 m/s
(C) 4 m/s (D) 8 m/s

Q.19 For a concave mirror when the object is placed between the pole and the focus then the image formed will be-
(A) Virtual (B) Real
(C) Inverted (D) Diminished

Q.20 Mirror used to form magnified image is
(A) Concave mirror (B) Convex mirror
(C) Plane mirror (D) None of these

Q.21 A convex mirror always produces-
(A) an erect, real image of diminished size
(B) an erect, real image of enlarged size
(C) a virtual, erect image of enlarged size
(D) an erect, virtual image of diminished size

Q.22 A reflecting surface is curved inwards. Now the mirror formed is-
(A) concave (B) plane
(C) convex (D) none of these

Q.23 The phenomenon of the change in the path of the light as it passes from one optical medium to another is called-
(A) Reflection of the light
(B) Refraction of light
(C) Dispersion of light
(D) Both (A) and (B)

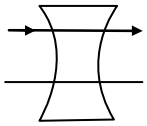
Q.24 Arrange the optical mediums in ascending order according to optically denser.
(A) Air, water glass (B) Water, glass, air
(C) Glass, water, air (D) Glass, air, water

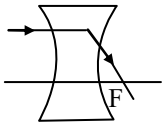
Q.25 We put glass piece on a printed page image of prints on the page has same size. The piece is-
(A) Convex lens (B) Glass slab
(C) Concave lens (D) Prism

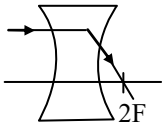
Q.26 What happens, when a ray incident at the optical centre ?
(A) It passes with deviation of 30° angle through the lens
(B) It passes undeviated through the lens
(C) It passes with deviation of 45° angle through the lens
(D) None of these

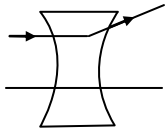
Q.27 If the lower part of a convex lens is blackened then the image formed will be
(A) incomplete
(B) complete
(C) of lower intensity
(D) both (B) and (C)

Q.28 Which of the following diagrams correctly represent the passage of a ray of light through a concave lens ?

(A) 

(B) 

(C) 

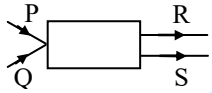
(D) 

Q.29 White light spectrum contains-

(A) 5 colours (B) 7 colours

(C) 6 colours (D) No colour

Q.30 The diagram below shows two incident rays P and Q which emerge as parallel rays R and S. The appropriate device used in the box A is-



(A) convex lens (B) concave lens

(C) prism (D) concave mirror

ANSWER KEY

EXERCISE-2

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	B	A	C	A	C	A	A	A	C	D	D	D	B	C	C
Ques.	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Ans.	C	D	B	A	A	D	A	B	A	B	B	D	D	B	B