REFRACTION OF LIGHT

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◈ **Definition :**

When light rays travelling in one medium are incident on a transparent surface (medium), they are bent as they travel in second medium.

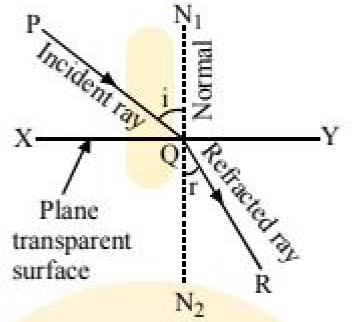


Fig. Refraction of light from a plane transparent denser surface.

◈ **Definitions of some associated terms**

- **Transparent surface :** The plane surface which refracts light, is called transparent surface. In diagram, XY is the section of a plane transparent surface.
- **Point of incidence :** The point on transparent surface, where the ray of light meets it, is called point of incidence. In diagram, Q is the point of incidence.
- **Normal :** Perpendicular drawn on the transparent surface at the point of incidence, is called normal. In diagram, N_1QN_2 is the normal on surface XY.
- **Incident ray :** The ray of light which strikes the transparent surface at the point of incidence, is called incident ray in diagram PQ is the incident ray.
- **Refracted ray :** The ray of light which travels from the point of incidence into the other medium, is called refracted ray. In diagram, QR is the refracted ray.
- **Angle of incidence :** The angle between the incident ray and the normal on the transparent surface at the point of incidence, is called the angle of incidence. It is represented by the symbol i. In diagram, angle PQN_1 is the angle of incidence.
- **Angle of refraction :** The angle between the refracted ray and the normal on the transparent surface at the point of incidence, is called angle of refraction. It is represented by symbol r. In diagram angle RQN_2 is the angle of refraction.

Law of refraction of light

- **First Law :** The incident ray, the normal to the transparent surface at the point of incidence and the refracted ray, all lie in one and the same plane.
- **Second Law :** The ratio of sine of angle of incidence to the sine of the angle of refraction is constant and is called refractive index of the second medium with respect to the first medium.

$$\frac{\sin i}{\sin r} = \mu$$

◈ Refractive index in terms of wave nature of light

- **Introduction :** Light has a wave nature. The waves have a definite velocity. In air (strictly vacuum) light has velocity 3×10^8 m/s. It is represented by the symbol c. It is a universal constant.

- **Expression :**

Velocity of light in air = c

Velocity of light in denser medium = v

Then, $\mu = \frac{c}{v}$

is called the refractive index of the denser medium with respect to air.

- **Successive refraction :** For light going from air to water to glass and to air finally.

Then, ${}_a\mu_w \times {}_w\mu_g \times {}_g\mu_a = 1$; ${}_w\mu_g = \frac{1}{{}_a\mu_w \times {}_g\mu_a} = \frac{{}_a\mu_g}{{}_a\mu_w}$

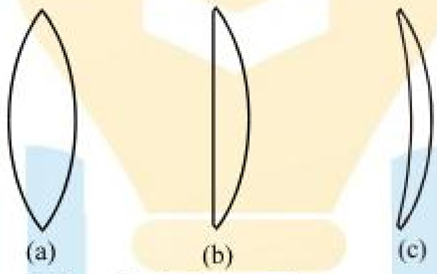
Spherical lens

- **Definition :** A piece of a transparent medium bounded by atleast one spherical surface, is called a spherical lens.
- **Types :** There are two types of spherical lenses:

(i) **Convex or Converging Lenses :** These are thick in the middle and thin at the edges.

(ii) **Concave or Diverging Lenses :** These are thin in the middle and thick at the edges.

There are three types of convex lenses :



(a) **Double Convex Lens :** It has both the surfaces convex.

(b) **Plano–Convex Lens :** It has one surface plane and the other surface convex.

(c) **Concavo–Convex Lens :** It has one surface concave and the other surface convex.

◈ Different types of concave lenses

There are three types of concave lenses :

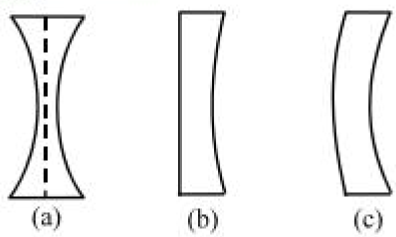


Fig. Three types of concave lenses :

(a) **Double Concave Lens :** It has both the surfaces concave. (Fig.)

(b) **Plano–Concave Lens :** It has one surface plane and the other surface concave. (fig.)

(c) **Convexo–Concave Lens :** It has one surface convex and the other surface concave. (fig.)

Image formation

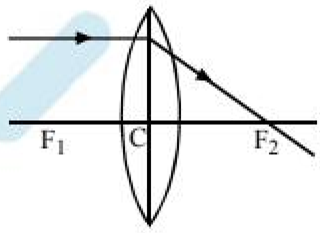
◈ Rules

- **Incident on the lens parallel to principal axis :** After refraction from the lens, it actually passes through second principal focus F_2 (in case of a convex lens) or appears to come from the second principal focus F_2 (in case of a concave lens).
- **Incident on the lens through first principal focus** : F_1 (in case of a convex lens) **in direction of first principal focus F_1** (in case of a concave lens)

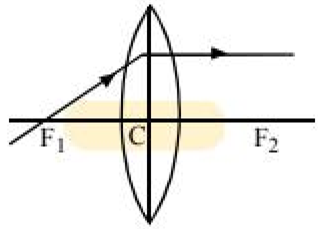
  After reflection from the lens it goes parallel to the principal axis.
- **Incident on the lens in direction of optical centre :** It passes undeviated through the lens.

◈ Three Special rays for convex lens

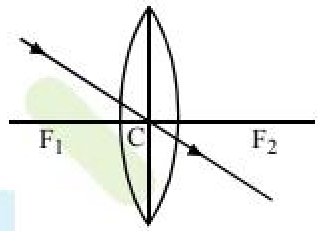
- When light ray incident parallel to principal axis.



- When light ray incident from focus.

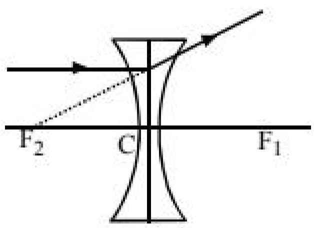


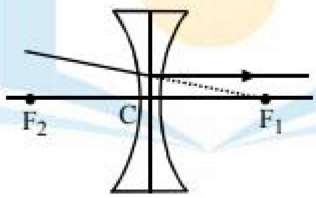
- When light ray incident on the pole.

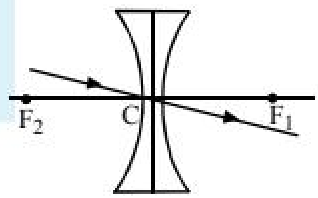


◈ Three Special rays for concave lens

- When light ray incident parallel to principal axis.







Lens formula

- **Definition :** The equation relating the object distance, the image distance and the focal length of the lens is called the lens formula.
- **Assumptions made :**

1. The lens is **thin.**
2. The lens has a **small aperture.**
3. The object lies **close** to principal axis.

4. The incident rays make **small angles** with the lens surface or the principal axis.

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

This is the required lens formula.

Linear magnification

- **Definition :** The ratio of the size of the image formed by refraction from the lens to the size of the object, is called linear magnification produced by the lens. It is represented by the symbol m.

Then, $m = \frac{h_2}{h_1} = \frac{v}{u}$

Image formation

- **Introduction :** From lens formula, we find that for a lens of a fixed focal length as object distance u changes, image distance v also changes. Moreover, as u decreases, increases. This changes the position, the nature and the size of the image.

  Different cases, are as given below with their ray diagrams.

Power of a lens

- **Definition :** It is the capacity or the ability of a lens to deviate (converge or diverge) the path of rays passing through it. A lens producing more converging or more diverging, is said to have more power
- **Relation with focal length :** A lens of less focal length, focuses a parallel beam of light at near point. It produces more converging or more diverging.

  It is said to have more power.

  Hence, power $\propto \frac{1}{\text{focal length}}$ i.e., $P \propto \frac{1}{f}$

We have, $P = \frac{1}{f}$

- **Unit** : Units of power is dioptre (D). One dioptre is the power of a lens of focal length 1 m.

  In general, $P\ (\text{dioptre}) = \frac{1}{f(\text{metres})} = \frac{100}{f(\text{cms})}$

Total internal reflection

- **Definition :** 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).

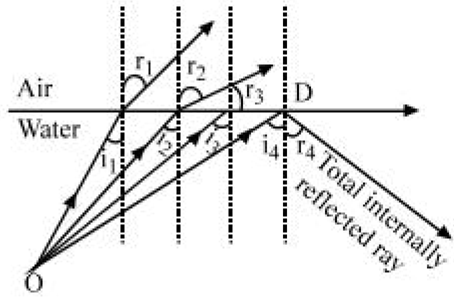


Fig. Total internal reflection.

◈ Critical angle

The angle of incidence in denser medium for which angle of refraction is 90º, is called the critical angle. It is represented by the symbol C.

In diagram, $i_3 = C$ because $r_3 = 90^\circ$.

Angle $C \propto \frac{1}{{}_a\mu_w}$

[Note. More is the value of μ, lesser will be angle C, more are the changes of total internal reflection.]

◆ **Condition**

(i) Light must travel from denser to rarer medium.

(ii) Light must be incident at an angle more than the critical angle for the denser medium.

Merit : In total internal reflection 100% light is reflected, hence images formed are more bright. In ordinary reflection from mirrors, only 85% light is reflected, rest 15% is either absorbed by mirror glass or transmitted due to poor polish. Images formed by ordinary reflection are less bright.

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).

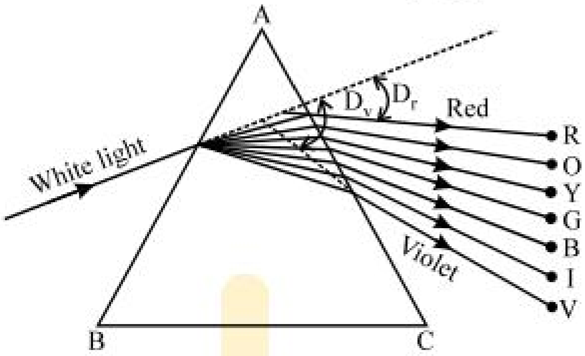
But in a denser medium, their velocities become less and different. Red light waves, being longest in length, travel fastest and have maximum velocity. Violet light waves, being shortest in length, travel slowest and have minimum velocity in the denser medium.

The refractive index (μ)of a medium for a wave is given by the relation.

$$\mu = \frac{\text{Velocity of wave in air (or vacuum)}}{\text{Velocity of wave in the medium}} = \frac{c}{v} \qquad \text{(Wave nature of light)}$$

Since v is maximum for red light waves and minimum for violet light waves. μ is minimum for red light and maximum for violet light.

The prism produces deviation (change in direction) in a light wave. The angle of deviation 'D' produced by a prism of angle 'A' is given by D = (μ – 1) A. Red light waves suffer least deviation, whereas violet light waves suffer maximum deviation. [Fig.]



Dispersion of white light
by a glass prism

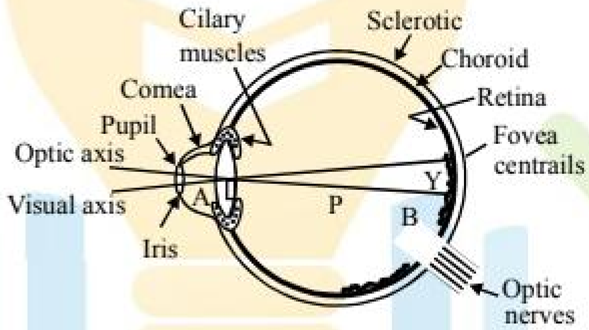
Due to difference in deviation, waves of different colours emerge out from the prism indifferent directions and are said to have been dispersed (separated).

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

◈ **Introduction :** It is the most delicate and complicated natural optical instrument.

◈ **Diagram**



◈ **Construction**

Diagram shows the section of a human eye by a horizontal plane. It is a spherical ball of diameter about 2.5 cm. Its essential parts are described below :

- **Sclerotic :** It is the outermost coating of the eye ball. It is tough, white and opaque and forms **white** of the eye. It keeps eye ball in spherical shape and protects it from shocks and injury. It becomes transparent at the front projected part of eye ball, called **cornea.**
- **Choroid :** It is the second coat under the sclerotic. It is a black membrane and forms black of the eye. Its function is to keep interior of the eye dark by absorbing diffused light falling on it. It forms coloured portion, called **iris**, behind the cornea.
- **Retina :** It forms innermost coat in the interior of the eye. It consists of a thin membrane which is rich in nerve fibres, containing two kinds of vision cells called **rods** and **cones** and blood vessels. It is sensitive to light, for it is a continuation of the optic nerves. It serves the purpose of a sensitive screen for the reception of the image formed by the lens system of the eye.

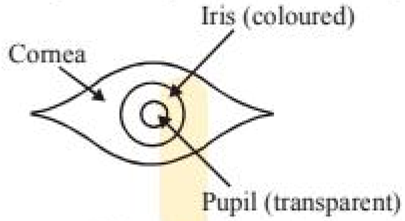
  [The **rods** are responsible for vision in dim light (**Scotopic vision)**. The **cones** are responsible for vision under ordinary day light (**Photopic vision)**.

The retina possesses following two important spots :

(a) **Yellow spot :** The yellow spot Y. It is situated at the centre of the retina. It is a slightly raised spot with a minute depression in its peak. It is yellow in colour and most sensitive to light. The central region of the yellow spot is called the **fovea centralis.**

(b) **Blind spot :** The blind spot B. It is the spot where the optic nerves enter the eye. It is also slightly raised and insensitive to light, because it is not covered with choroid and retina.

- **Cornea :** It is the front bulged out part of eye ball covered by transparent sclerotic.



Cornea of the eye-front view.

- **Iris :** It is the coloured region under cornea formed by choroid. Its colour differs from person to person and country to country. It is this colour which is given to the eye of a person.
- **Pupil :** It is central circular aperture in the iris. Its normal diameter is **1 mm** but it can contract in excess light and expand in dim light, by means of two sets of involuntary muscular fibres.

- **Crystalline lens :** It is a double convex lens L immediately behind iris. Its back (inner) surface is more convex (R_2 = 6mm) than front (outer) surface (R_1 = 10 mm). This is made of transparent concentric layers whose optical density increases towards the centre of the lens. The average refractive index of crystalline lens is 1.437.

  The crystalline lens divides the interior of the eye ball into two spaces called **chambers.** The front chamber (towards cornea), is called the **anterior chamber** (A). The back chamber (towards retina) is called the **posterior chamber (P).**
- **Ciliary muscles :** The lens is connected of the sclerotic by the **ciliary muscles.** These muscles change thickness of the lens by relaxing and exerting pressure. The lens thickness is minimum (3.6 mm) when muscles are relaxed. The thickness becomes maximum (4 mm), when muscles exert maximum pressure (within elastic limit).
- **Aqueous humour :** Anterior chamber is filled with a transparent liquid of refractive index. The liquid is called the aqueous humour.
- **Vitreous humour :** Posterior chamber is filled with a transparent watery liquid with little common salt having some refractive index. The liquid is called the vitreous humour.
- **Optic axis :** The straight line passing through the centre of the cornea and the lens, is called optic axis of the eye.
- **Visual axis :** The line passing through centre of the lens and fovea centralise is called visual axis of the eye. When an object is to be seen more minutely, it is brought on the visual axis to get its image on yellow spot which is most sensitive part of the retina.

◈ Working (Action of the eye)

The cornea and the aqueous humour both having same refractive index, form a single homogeneous medium. Rays of light entering the eye suffer **first** refraction in this region.

The crystalline lens of mean refractive index. produces **second** refraction. The vitreous humour of refractive index produces third refraction.

After these three refractions, light rays fall on retina forming a real and inverted image of object seen. The sensation produced on the eye is communicated to the brain by the optic nerves. The brain interprets this inverted image as erect.

◈ Focussing by eye lens

When seeing objects at infinity, ciliary muscles are perfectly relaxed and lens has least thickness of 3.6 mm. The image is formed at retina. The eye has its **far point (F)** at infinity.

The distance between the near point and the far point is called **range of vision** of the eye. Within the range of vision, there is one point where object placed are most distinctly visible. The distance of this point, from the eye, is called **least distance of distinct vision.** For normal eye this least distance is **25 cm.**

The power (ability) of the eye to change the focal length of the eye lens with the change in the distance of the object, is called power of **accommodation** of the eye.

◈ Power of accommodation

(Range of variation of power) the power of accommodation is 4 dioptres. $\mathbf{P_A = 4D}$.

Defects of vision, symptoms and remedy (correction)

◈ Defects of Vision

The major **defects** of vision are :

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

The minor defects of vision are : (a) Presbyopia. (b) Astigmatism.

1. Short sightedness or myopia

- **Symptoms :** This defect is a born defect. With this defect, the eye can see near very clearly and distinctly, but distance objects are not clearly visible. The defective 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.
- **Reasons :** It is so because the image of distant objects is formed in front of the retina. It is shown in fig.

(a) seeing objects at its far point (b) seeing objects at normal eye far point F

Fig. Myopic eye vision.

- **Causes :** It may be due to any one or both of the following two factors.

(i) The lens may be **thicker** (more converging) that the normal eye lens.

(ii) The eye ball may be **elongated,** as shown in fig. Due to elongation, distance between lens and retina becomes more than that for normal eye.

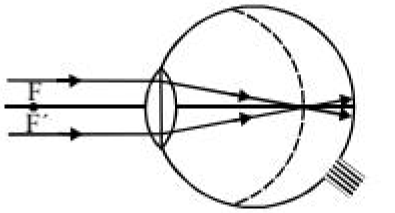


Fig. Elongated eye.

◆ **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.

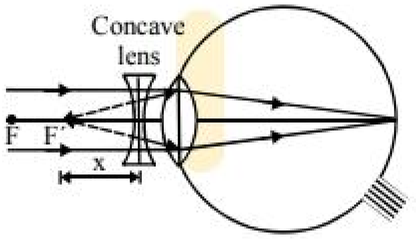


Fig. Myopia corrected by a concave lens

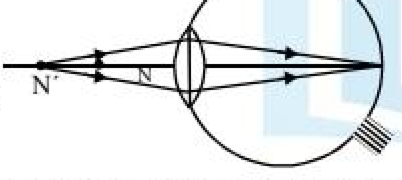
◆ **Explanation :** The concave lens kept just in front of the eye, receives distant parallel rays and diverges them. On eye lens the rays fall as if coming from far point F' of the defective eye. The eye lens focuses them at retina. In a way, the concave lens used makes a virtual image of distant (out of range) object within range of vision.

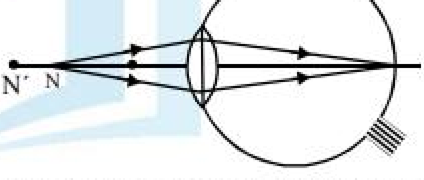
The lens used must have focal length equal to the distance of the far point from the eye (–ve sign means concave lens).

Long sightedness or hypermetropia

◆ **Symptoms :** This defect is a born defect. With this defect, the eye can see distant objects very clearly and distinctly, but near objects are not clearly visible. The defective 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).

◆ **Reason :** It is so because the image of near objects is formed behind the retina. It is shown in fig.





(a) seeing objects at its near point N' (b) seeing objects at normal eye near point N

Fig : Hypermetropic eye vision.

◆ **Causes :** It may be due to any one or both of the following two factors :

(i) The eye lens may be **thinner** (less converging) than the normal eye lens.

(ii) The eye ball may be **oval** as shown in fig. Due to oval shape, distance between lens and retina becomes less than that for normal eye.

◆ **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.

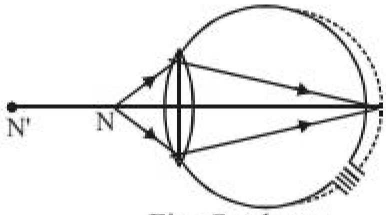


Fig. Oval eye.

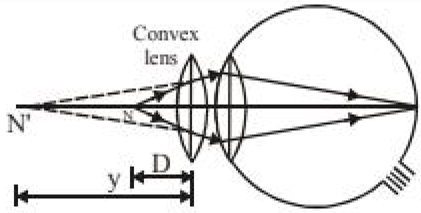


Fig : Hypermetropia corrected by a convex lens.

Solved Examples

Ex.1 Speed of light in water is 2.25×10^8 m/s. Calculate the refractive index of water.

Sol. Refractive index is given by

$$n = \frac{\text{speed of light in vaccum(c)}}{\text{speed of light in water}(v)} = \frac{3\times10^8\,\text{m/s}}{2.25\times10^8\,\text{m/s}} = 1.33$$

Ex.2 Refractive index of diamond is 2.42. Calculate the speed of light in diamond.

Sol. We know that refractive index,

$$n = \frac{c}{v} = \frac{\text{speed of light in vaccum}}{\text{speed of light in diamond}}$$

or $$2.42 = \frac{3\times10^8}{v}$$

or $$v = \frac{3\times10^8}{2.42} = 1.24 \times 10^8 \text{ m/s.}$$

Ex.3 If the refractive index of water is 4/3 and that of glass is 3/2. Calculate the refractive index of glass with respect to water.

Sol. We known that

$$^{w}\mu_g = \frac{\mu_g}{\mu_w}$$

where $^{w}\mu_g$ = refractive index of glass with respect to water

μ_g = refractive index of glass = 3/2

μ_w = refractive index of water = 4/3

$$\therefore \quad ^{g}\mu_w = \frac{3/2}{4/3} = \frac{9}{8} = 1.1$$

Ex.4 The refractive index of diamond is 2.42 and that of carbon disulphide is 1.63. Calculate the refractive index of diamond with respect to carbon disulphide.

Sol. Refractive index of carbon disulphide, $n_1 = 1.63$

Refractive index of diamond, $n_2 = 2.42$

$\therefore$ Refractive index of diamond with respect for carbon disulphide,

$$^1n_2 = \frac{n_2}{n_1} = \frac{2.42}{1.63} = 1.48$$

Ex.5 A coin is placed in a tumbler, water is then filled in the tumbler to a height of 20 cm. If the refractive index of water is 4/3, calculate the apparent depth of the coin.

Sol. Here,

Real depth, $h = 20$ cm

Refractive index, $n = 4/3$

Now, $$n = \frac{\text{real depth}}{\text{apparent depth}} \quad \text{or} \quad \frac{4}{3} = \frac{20}{\text{apparent depth}}$$

or Apparent depth $= \frac{20 \times 3}{4} = 15$ cm

Ex.6 There is a black spot on a table. A glass slab of thickness 6 cm is placed on the table over the spot. Refractive index of glass is 3/2. At what depth from the upper surface will the spot appear when viewed from above?

Sol. Real depth of the spot = 6 cm

Refractive index of glass, $n = \frac{3}{2}$

Now, $$n = \frac{\text{real depth}}{\text{apparent depth}} \Rightarrow \frac{3}{2} = \frac{6}{\text{apparent depth}}$$

$\therefore$ Apparent depth $= \frac{6 \times 2}{3} = 4$ cm

Ex.7 Refractive index of diamond is 2.42 and that of glass is 1.5. Calculate the critical angle for diamond-glass surface.

Sol. Refractive index of diamond, $n_1 = 2.42$

Refractive index of glass, $n_2 = 1.5$

Now, $$\sin i_c = \frac{n_2}{n_1} = \frac{1.5}{2.42} = 0.6198$$

$\therefore$ $i_c = 38.3°$

Ex.8 Refractive index of glass is 3/2. A ray of light travelling in glass is incident on glass-water surface at an angle 30° with normal. Will it be able to come out into the water Refractive index of water = 4/3.

Sol. Refractive index of glass, $n_1 = 3/2$

Refractive index of water, $n_2 = 4/3$

Now, $\sin i_c = \frac{n_2}{n_1} = \frac{4/3}{3/2} = \frac{8}{9} = 0.88$

$\therefore$ $i_c = 62°$

Since, the angle of incidence (30°) is less than the critical angle, the ray will be refracted into the water.

Ex.9 The refractive index of dense flint glass is 1.65 and that of alcohol is 1.36, both with respect to air. What is the refractive index of flint glass with respect to alcohol?

Sol. Refractive index of flint glass, $n_2 = 1.65$

Refractive index of alcohol, $n_1 = 1.36$

$\therefore$ Refractive index of flint glass with respect to alcohol is given by

$$^{1}n_2 = \frac{n_2}{n_1} = \frac{1.65}{1.36} = 1.21$$

Ex.10 An object is placed 36 cm from a convex lens. A real image is formed 24 cm from the lens. Calculate the focal length of the lens.

Sol. According to the sign convention the object is placed on the left-hand side of the lens. So object distance (u) is negative. Real image is formed on the other side of the lens. So the image distance (v) is positive. Thus, u = –36 cm, v = +24 cm, f = ?

Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we get

$$\frac{1}{+24} - \frac{1}{-36} = \frac{1}{f}$$

or $$\frac{1}{f} = \frac{1}{24} + \frac{1}{36} = \frac{5}{72}$$

$\therefore$ $$f = \frac{72}{5} = 14.4 \text{ cm}$$

Ex.11 A point object is placed at a distance of 18 cm from a convex lens on its principal axis. Its image is formed on the other side of the lens at 27 cm. Calculate the focal length of the lens.

Sol. According to the sign convention, the object is placed on the left-hand side of the lens, therefore object-distance is negative, i.e. u = –18 cm. Since the image is formed on the other side, the image-distance is positive, i.e., v = +27 cm. Using lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}, \text{ we have}$$

$$\frac{1}{+27} - \frac{1}{-18} = \frac{1}{f}$$

or $$\frac{1}{27} + \frac{1}{18} = \frac{5}{54} = \frac{1}{f}$$

or $$f = \frac{54}{5} = 10.8 \text{ cm}$$

Ex.12 A convex lens forms an image of the same size as the object at a distance of 30 cm from the lens. Find the total length of the lens. Also find power of the lens. What is the distance of the object from the lens?

Sol. A convex lens forms the image of the same size as the object only when the object is placed at a distance 2f from the lens. In this case the image is also equal to 2f from the lens.

Hence, $2f = 30$ cm

or $f = 15 \text{ cm} = 0.15 \text{ m}$

Power of the lens, $P = \frac{1}{f} = \frac{1}{0.15} D = 6.6D$

The distance of the object from the lens is also $2f = 30$ cm.

Ex.13 A beam of light travelling parallel to the principal axis of a concave lens appears to diverge from a point 25 cm behind the lens after refraction. Calculate the power of the lens.

Sol. When a parallel beam after refraction through the lens is incident on a concave lens, if appears to diverge from the focus of the lens. Hence, the focal length of the lens is 25 cm. According to sign convention, focal length of a concave lens is negative.

$\therefore$ $f = -25 \text{ cm} = -0.25 \text{ m}$

$\therefore$ Power, $P = \frac{1}{f} = \frac{1}{-0.25} = -4D$

Ex.14 A convex lens of focal length 40 cm and a concave lens of focal length 25 cm are placed in contact in such a way that they have the common principal axis. Find the power of the combination.

Sol. Focal length of the convex lens, $f_1 = 40 \text{ cm} = +0.4 \text{ m}$

$\therefore$ Power of the convex lens, $P_1 = \frac{1}{+0.40} = +2.5D$

Focal length of the concave lens, $f_2 = -25 \text{ cm} = -0.25 \text{ m}$

$\therefore$ Power of the concave lens, $P_2 = \frac{1}{-0.25} = -4D$

Power of the combination, $P = P_1 + P_2 = 2.5 - 4D = -1.5D$

EXERCISE

MULTIPLE CHOICE QUESTIONS

Q.1 Light travels through a glass plate of thickness 't' and refractive index 'n'. If c is the velocity of light in vacuum, then the time taken by light to travel the thickness of the plate will be
(A) nt/c (B) t/nc (C) tc/n (D) c/nt

Q.2 How will the image formed by a convex lens be affected, if the central portion of the lens is wrapped in black paper, as shown in the fig.

(A) No image will be formed
(B) Full image will be formed but it is less bright
(C) Full image will be formed but without the central portion
(D) Two images will be formed, one due to each exposed half.

Q.3 An endoscope is employed by a physician to view the internal parts of a body organ. If is based on the principle of:
(A) refraction
(B) reflection
(C) total internal reflection
(D) dispersion

Q.4 An object is immersed in a fluid. In order that the object becomes invisible, it should
(A) behave as a perfect reflector
(B) absorb all light falling on it
(C) have refractive index one
(D) have refractive index exactly matching with that of the surrounding fluid.

Q.5 A lens forms a virtual, diminished image of an object placed at 2 m from it. The size of image is half of the object. Which one of the following statements is correct regarding the nature and focal length of the lens?
(A) Concave, | f | = 1 m
(B) Convex, | f | = 1
(C) Concave, | f | = 2 m
(D) Convex, | f | = 2 m

Q.6 A lens will be invisible in vacuum when the refractive index of the lens is.
(A) negative (B) one
(C) more than one (D) less than one

Q.7 The sun is visible to us a little before the actual sunrise and a little after the actual sunset. This is because of atmospheric.

(A) reflection (B) refraction

(C) scattering (D) diffraction

Q.8 The refractive index of a certain glass is 1.5 for light whose wavelength in vacuum is 6000Å. The wavelength of this light when it passes through glass is –

(A) 4000 Å (B) 6000 Å

(C) 9000 Å (D) 15000 Å

Q.9 When light travels from one medium to the other of which the refractive index is different, then which of the following will change –

(A) Frequency, wavelength and velocity (B) Frequency and wavelength

(C) Frequency and velocity

(D) Wavelength and velocity

Q.10 How much water should be filled in a container 21 cm in height, so that it appears half filled when viewed from the top of the container (given that ${}_a\mu_w = 4/3$)

(A) 8.0 cm

(B) 10.5 cm

(C) 12.0 cm

(D) None of the above

Q.11 Light of different colours propagates through air–

(A) With the velocity of air

(B) With different velocities

(C) With the velocity of sound

(D) Having the equal velocities

Q.12 A monochromatic beam of light passes from a denser medium into a rarer medium. As a result–

(A) Its velocity increases

(B) Its velocity decreases

(C) Its frequency decreases

(D) Its wavelength decreases

Q.13 Refractive index for a material for infrared light is

(A) Equal to that of ultraviolet light (B) Less than for ultraviolet light

(C) Equal to that for red colour of light

(D) Greater than that for ultraviolet light

Q.14 A rectangular tank of depth 8 meter is full of water ($\mu = 4/3$), the bottom is seen at the depth

(A) 6 m (B) 8/3 m
(C) 8 cm (D) 10 cm

Q.15 When light passes from water to olive oil. The ray –
(A) Bends away from the normal
(B) Bends towards the normal
(C) Emerges undeviated
(D) Bends either away or toward the normal depending one whether, the surface separating the two media is plane or spherical.

Q.16 When light passes from glass (ordinary) to benzene, the ray –
(A) Bends away from the normal
(B) Bends towards the normal
(C) Emerges undeviated
(D) Bends either away or toward the normal depending one whether, the surface separating the two media is plane or spherical.

Q.17 The speed of light in methyl alcohol, as compared to that in water is –
(A) same
(B) more
(C) less
(D) either of (A), (B) or (C), depending on the wavelength

Q.18 The wavelength of yellow line of sodium (D) in diamond, as compared to that is sugar is –
(A) Same (B) More
(C) Less
(D) Either of (A), (B) or (C)

Q.19 The time taken by light to cover a distance of 9 mm in water is –
(A) 0.04 ns (B) 0.4 ns
(C) 4 ns (D) 400 ns

Q.20 The bending of light ray when passing from two optically different mediums is called
(A) Reflection (B) Refraction
(C) Polarization (D) Effervescence

Q.21 The image of an object placed at the focus of a convex lens is formed at
(A) F
(B) 2F
(C) Between F and 2F
(D) Infinity

Q.22 The twinkling of stars at night is caused by
(A) Reflection of light
(B) Refraction of light
(C) Dispersion of light
(D) Polarization of light

Q.23 The rainbow that appears in sky after the rains is caused by the .... of light by water droplets present in upper atmosphere.
(A) Reflection of light
(B) Refraction of light
(C) Dispersion of light
(D) Polarization of light

Q.24 A convex lens acts as a magnifying lens when the object is placed at
(A) Focus
(B) Centre of curvature
(C) Beyond centre of curvature
(D) Between focus and optical centre

Q.25 When an object is at infinity, the image by convex lens is formed at
(A) Focus
(B) Centre of curvature
(C) Beyond the centre of curvature
(D) Optical centre

Q.26 In visible spectrum, the ray of light with maximum wavelength is
(A) Violet rays (B) Green ray
(C) Blue ray (D) Red ray

Q.27 When a ray of light passes from a rare into a denser medium, its velocity
(A) Increases
(B) Decreases
(C) Remains the same
(D) None of these

Q.28 If a convex lens is cut horizontally into two equal halves, its focal length will
(A) Remain the same
(B) Reduced to half
(C) Be doubled
(D) Be quadrupled

Q.29 If a convex lens is cut vertically into two equal halves, its focal length will –
(A) Remain the same
(B) Reduced to half
(C) Be doubled
(D) Be quadrupled

Q.30 If the apparent depth and real depth of a stone lying at the bottom of a pond is 26 cm and 13 cm, respectively, the refractive index of pond water is

(A) 2.6 (B) 1.3
(C) 2 (D) 2.3

Q.31 Dispersion is

(A) splitting of light into its constituent colours
(B) formation of many images
(C) formation of only two images
(D) a rainbow

Q.32 The difference in the colour of the eye is due to difference in

(A) retina (B) pupil
(C) iris (D) sclera

Q.33 The image of the object is always formed at the

(A) iris (B) retina
(C) pupil (D) lens

Q.34 Cataract is the condition that affects the

(A) lens (B) pupil
(C) retina (D) macula

EXERCISE

ANSWER KEY

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	A	B	C	D	C	B	B	A	D	C	D	A	B	C	B
Ques.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	C	A	C	A	B	D	B	B	D	A	D	B	A	C	C
Ques.	31	32	33	34											
Ans.	A	C	B	A											