Light

Light

Light is a form of electromagnetic energy that causes the sensation of vision.

(a) Nature of Light:

Theories about nature of light:

❖ **Particle Nature of Light (Newton's corpuscular Theory):**

According to Newton, light travels in space with a great speed as a stream of very small particles called corpuscles.

This theory was failed to explain interference of light and diffraction of light. So wave theory of light was discovered.

❖ **Wave Nature of Light:**

Light waves are electromagnetic waves so there is no need of medium for the propagation of these waves. They can travel in vacuum also. The speed of these waves in air or in vacuum is maximum i.e., 3×10^8 m/s,

Photoelectric effect was not explained with the help of wave theory, so Planck gave a new theory which was known as quantum theory of light.

❖ **Quantum Theory of Light:**

When light falls on the surface of metals like caesium, potassium etc., electrons are given out. These electrons are called 'photo-electrons' and phenomenon is called 'photo-electric effect'.

This wad explained by Einstein. According to planck light consisted of packets or quanta of energy called photons. The rest mass of photon is zero. Each quanta carries energy E = hv.

h $\rightarrow$ Planck's constant + 6.6×10^{-34} J-s.

v $\rightarrow$ frequency of light

Einstein's photo-electric equation $h(v - v_0)$

$$= \frac{1}{2} mv^2{}_{\max}$$

hv_0 = amount of energy spent in ejecting an electron out of metal surface.

$V_{\max}$ = maximum velocity of the ejected electrons diffraction of light are explained with the help of wave theory but wave theory was failed to explain the photo electric effect of light. It was explained with the help of quantum theory. So, light has dual nature:

(i) Wave nature (ii) Particle nature

(b) Sources of Light

Those body which emit light in all directions are called sources of light. The sources can be point one or extended one. The sources of light are of two types:

(i) Luminous Sources:

Those objects which by itself emit light are called luminous sources.

Eg. : Sun and stars (natural luminous sources). Electric lamps, candles and lanterns (artificial luminous sources).

(ii) Non-luminous Sources:

Those objects which do not emit light but become visible only when light from luminous objects falls on them. They are called non-luminous sources.

Eg. : Moon, planets (natural non-luminous sources). Wood, table (artificial non-luminous sources) etc.

(c) 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 them i.e. transmit light through them, are called transparent bodies.

Eg.: Glass, water, etc.

(ii) Translucent Object: Bodies that do not allow light to pass through them at all, are said to be opaque objects.

Eg. : chair, desk etc.

(d) Rectilinear Propagation of Light:

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

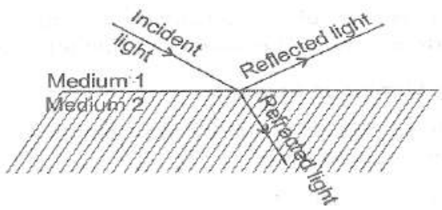
(e) Behaviour of Light at the Interface of two Media:

When light traveling in one medium falls on the surface of a second mefium, 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.



Shadows

The opaque objects do not allow light to pass through them, therefore they give rise to the formation of shadow of the opaque object on the opposite side of the source of light. The size of the shadow depends on the position of the object and its distance from the source of light.

The shape, size and other characteristics of a shadow depend upon :

(i) Position and distance of the source of light with respect to the object.

(ii) The distance between the object and the surface on which the shadow falls.

(iii) The size of the source of light.

❖ **A Shadow has two Regions**

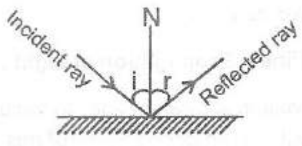
(i) Umbra : The inner region of total darkness is called umbra.

(ii) Penumbra: The outer region of partial darkness is called penumbra.

Umbra and penumbra are clearly formed only when the source of light is big and opaque body is small.

Reflection of Light

When a beam of light falls on any surface, a part of it is sent back into the same medium from which it is doming. This phenomenon is known as the reflection of light.



(i) the ray of light which falls on the mirror surface is called the incident ray. The angle of incidence is the angle made by the incident ray with the normal at the point of incidence.

(ii) the ray of light which is sent back by the mirror is called the reflected ray. The angle of reflection is the angle made by the reflected ray with the normal at the point of incidence.

(a) Laws of Reflection :

(i) Incident ray, normal ray and the reflected ray, all lie in the same plane.

(ii) The angle of reflection is always equal to the angle of incidence.

$$\angle i = \angle r$$

IIlustrations

1. What happens when a ray of light falls normally (or perpendicularly) on the surface of a mirror

Sol. A ray of light which is incident normally on a mirror is reflected back along the same path because the angle of incidence as well as angle of reflection for such a ray of light are zero.

(b) Types of Reflection:

(i) Regular reflection:

When a parallel beam of light is incident on a plane highly polished surface, the reflected beam will also be parallel and hence the whole light falling on the surface is reflected in a definite direction. Such a reflection is called regular reflection.

Such a surface is called a reflector, like a plane mirror, a polished metal surface.

(ii) Irregular reflection:

When a parallel beam of light is incident on rough surface or irregular surface, the rays get reflected in all directions and the reflected light spreads over a wide area. This reflection is known as irregular or diffused reflection.

Mirror

It is a highly polished surface, which is quite smooth and capable of reflecting a good fraction of light from its surface.

(a) Object:

Anything which gives out light rays (either its own or reflected) is called an object.

(b) Image:

The reproduction of object formed by mirror or lens is called an image.

Plane Mirror

(a) Characteristics of Image formed by a Plane Mirror:

(i) It is of the same size as that of the object.

(ii) it is at same distance behind the mirror as the object is in front of it.

(iii) It is laterally inverted. Laterally inverted means that right hand appear to be left hand and vice versa.

(iv) It is virtual and erect.

NOTE:

(i) Minimum size of the mirror required to see full image of a person is atleast half of his own height.

(ii) If object moves with a velocity V towards mirror then image moves with a velocity ZV towards mirror.

(iii) If mirror moves with a velocity V towards stationary object then image moves with a velocity ZV towards mirror.

(iv) Focal length of a plane mirror is infinity.

(v) Power of a plane mirror is zero.

(b) Number of images formed when the object is placed between two plane mirrors:

When two plane mirrors are placed facing each other at an ang'eθ and an object is placed between them, multiple images are formed as a result of multiple reflections.

If $\frac{360}{\theta}$ is even, then the number of images formed.

$$n = \frac{360}{\theta} - 1$$

If $\frac{360}{\theta}$ is odd then :

Case I : If the object lies symmetrically then,

$$n = \frac{360}{\theta} - 1$$

Case II : If the object lies asymmetrically then,

$$n = \frac{360}{\theta}$$

Spherical Mirror

A mirror whose reflecting surface is a part of a hollow sphere of glass is known as spherical mirror.

Eg.: A dentist uses a curved mirror to examine the teeth closely, large curved mirrors are used in telescopes at observatories. These are of two types: convex and concave.

(a) some terms related to Spherical Mirrors :

(i) Pole: The central point of a mirror is called its pole.

(ii) Centre of curvature: The centre of the sphere of which the mirror is a part, is called centre of curvature.

(iii) Radius of curvature : The radius of the sphere of which the mirror is a part, is called radius of curvature.

(iv) Principal axis : The straight line joining the pole and the centre of curvature is called the principal axis.

(v) Focus point:

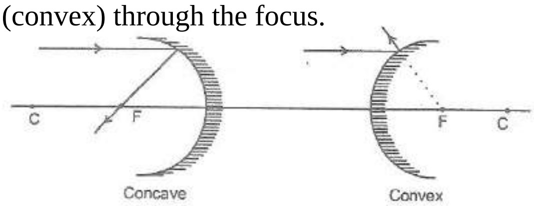
Focus of concave mirror	Focus of convex mirror
A parallel beam of light after reflection from a concave mirror converges at a point in front of the mirror. This point (F) is the focus of a concave mirror and it is real.	A parallel beam of light after reflection from a convex surface diverges and the rays do not meet. However on producing backward, the rays appear to meet at a point behind the mirror. This point is focus of the convex mirror and it is virtual.

(vi) Aperture: The size of the mirror is called its aperture.

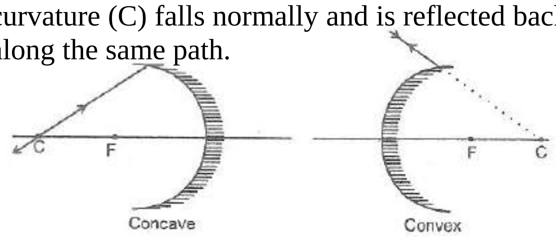
(vii) Focal length: The distance between the pole and the focus is called the focal length. The focal length is half of the radius of curvature.

(b) Rules for the formation of images by Concave and Convex Mirrors:

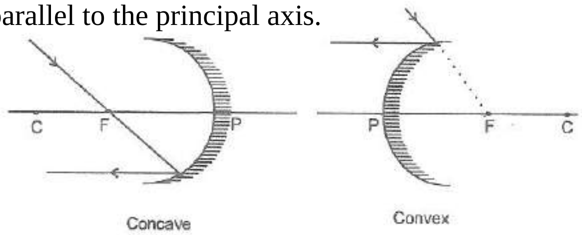
(i) A ray incident parallel to the principal axis actually passes (concave) or appears to pass (convex) through the focus.



(ii) A ray incident through the centre of curvature (C) falls normally and is reflected back along the same path.



(iii) A ray incident through the focus is reflected parallel to the principal axis.



(c) Formation of image by concave Mirror:

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F	Highly diminished	Real and inverted
Beyond D	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between F and C	Beyond C	Magnified	Real and inverted
At F	At infinity	Highly magnified	Real and inverted
Between optical center and F	Behind the mirror	Magnified	Virtual and erect

Uses of Concave Mirror:

(i) They are used as shaving mirrors.

(ii) They are used as reflectors in car head-lights, search lights, torches and table lamps.

(iii) They are used by doctors to concentrate light on body parts like ears and eyes which are to be examined.

(iv) Large concave mirrors are used in the field of solar energy to focus sun-rays on the objects to be heated.

(d) Formation of Image by Convex Mirror:

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At F	Highly diminished	Virtual and erect
Between O and ∞	Between O and F	Diminished	Virtual and erect

Uses of convex mirror:

It is used as a rear view mirror in vechicles to see the traffic coming from behind;

2. How to distinguish between a plane mirror, a concave mirror and a convex mirror without touching them?

Sol. We can distinguish between them by bringing our face close to each of them. All of them will produce a magnified image and our face will look much bigger. A convex mirror will produce a diminished image and our face will look small.

(a) Formulae Related to Spherical Mirror:
Mirror Formula:

The mirror formula is a relation relating the object distance (u), the image distance (v) and the focal length (f) of a mirror.

$$The\ mirror\ \ formula\ is: \frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

Power of mirror:

Optical power of a mirror (in Dioptre) =- $\frac{1}{f\,(in\ metre)}$

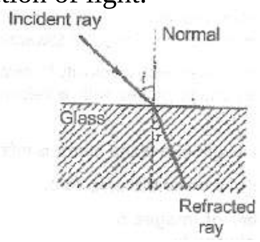
Relation between Focal Length (f) and Radius of Curvature (R) :

$$\mathbf{R}=2f\ \ or\ \ f=\frac{R}{2}$$

A curved or spherical mirror is a reflecting surface, which is formed by a part of a hollow sphere.

Refraction of Light

When light travels in the same homogeneous medium, it travels along a straight path. However, when it passes from one transparent medium to another, the direction of its path changes at the interface of the two media. This is called refraction of light.



❖ **It is observed that:**

(i) When a ray of light passes from an optically rarer medium to a denser medium, it bends towards the normal $(\angle r > \angle i)$.

(ii) when a ray of light passes from an optically denser to a rarer medium. It bends away from the normal $(\angle r > \angle i)$.

(iii) A ray of light traveling along the normal passes undeflected. Here $\angle i = \angle r = 0^0$.

(a) Cause of Refraction:

Refraction occurs because the speed of light is different in different media. Light travels with a greater velocity in a rarer medium like air and with lower velocity in a denser medium like glass or water. The lower the velocity of light in the medium then that in air, the greater the bending because the greater would be the need to take a shorter path.

❖ **NOTE:**

(i) Refraction is the deviation of light when it crosses the boundary between two different media (of different optical densities) and there is a change in both wavelength and speed of light.

(ii) the frequency of the refracted ray remains unchanged.

(iii) the intensity of the efracted ray is less than that of the incident ray. It is because there is partial reflection and absorption of light at the interface.

(b) Effects of Refraction:

Refraction produces many effects in our daily life.

(i) The apparent twinkling of a star is due to the bending of light coming from the star as it passes obliquely through the shifting layers of hot and cold air in the earth's atmosphere.

(ii) At sunrise and sunset, we are able to see the sun even when it is just below the horizon. This is due to the refraction of light rays by the earth's atmosphere.

(iii) A swimming pool looks shallower than it really is because of refraction of light.

(iv) A pencil appear bent and short when placed inside the water.

(c) Laws of Refraction:

The refraction of light on going from one medium to another takes place according to two laws of refraction of light:

(i) The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

(ii) The second law is known as the snell's law of refraction. According to snell's law of refraction the ratio of sine of the angle of incidence (i) to the sine of angle of refraction ® is a constant for a given pair of media.

$$\frac{\sin i}{\sin r} = cons\tan t = \mu$$

3. Name the phenomenon due to which a pool of water sppea's less deep than it really is.

Sol. Refraction of light

4. A ray of light traveling in air is incident on the plane surface of a transparent medium. The angle of incidence is 45^0 and that of refraction is 30^0. Find the refractive index of the medium.

Sol. Here, i = 45^0, r = 30^0

$$By\ snell's\ law,\ \mu = \frac{\sin i}{\sin r} = \frac{\sin 450}{\sin 300} = \frac{1}{2}\Big/\frac{1}{2} = \sqrt{2}$$

Refractive Index

(a) Refractive Index in terms of Speed of Light:

The refractive index of a medium may be defined in terms of the speed of light as follows:
The refractive index of a medium for a light of given wavelength may be defined as the ratio of the speed of light in vacuum to its speed in that medium.

$$\text{Re}\ fractive\ index = \frac{Speed\ light\ in\ vacuum}{Speed\ light\ in\ medium}$$

$$or\ \mu = \frac{c}{v}$$

Refractive index of a medium with respect to vacuum is also called absolute refractive index.

(b) Refractive Index in terms of Wavelength:

Since the frequency (v) remains unchanged when light passes from one medium to another, therefore,

$$\mu = \frac{c}{v} = \frac{\lambda_{vac} \times v}{\lambda_{med} \times v} = \frac{\lambda_{vac}}{\lambda_{ned}}$$

The refractive index of a medium may be defined as the ratio of wavelength of light in vacuum to its wavelength in that medium.

(c) Relative Refractive Index:

The relative refractive index of medium 2 with respect to medium 1 is defined as the ratio of speed of light (v_1) in the medium 1 to the speed of light (v_2) in medium 2 and is dinoted by $1\mu2$.

$$Thus, 1\mu2 = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{\mu_2}{\mu_1}$$

As refractive index is the ratio of two similar physical quantities, so it has no unit.

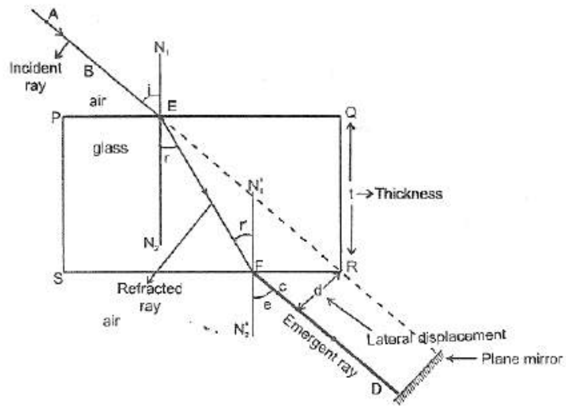
5. Refractive indices of carbon disulphide and ethyl alcohol are 1.63 and 1.36 respectively. Which is optically censer?

Sol. Carbon disulphide is optically denser because its R.I. is greater as compared to that of ethyl alcohol.

Refraction through a Glass Slab

❖ When light is refracted through a glass slab, the ray of light emerging from a glass slab is parallel to the light entering (incident ray) it. Also in glass slab the angle of incidence is equal to angle of emergence.

❖ Lateral shift is the perpendicular distance between the incident and emergent rays when light is incident obliquely on a refracting slab with parallel faces.

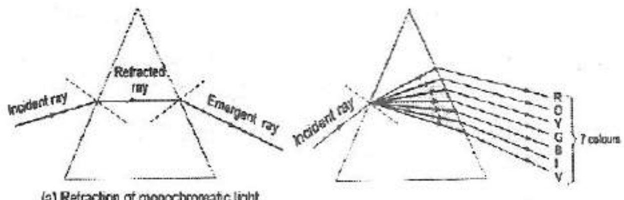


❖ **Factors on which lateral shift depends are:**

(i) Lateral shift is directly proportional to the thickness of glass slab.
(ii) Lateral shift is directly proportional to the incident angle.
(iii) lateral shift is directly proportional to the refractive index of glass slab.
(iv) Lateral shift is inversely proportional to the wavelength of incident light.

Refraction through A Glass Prism

The particular shape of the prism causes the ray of light to bend. It first bends towards the normal at the air glass surface. Wher it leaves the prism, it bends away from the normal. When sunlight (white light) is slowed to pass through a prism, it splits into seven different colours.



(a) Refraction of monochromatic light through a glass prism

(b) Dispersion of white light by a glass prism

❖ The phenomenon of sunlight splitting up into its constituent colours is called dispersion. A medium like glass shows dispersion, but a medium like air does not. That is why sunlight in air does not appear coloured.

❖ In this case red colour deviates least and the violet colour deviates the most. The other colorus suffer deviation in between the red and the violet colours.

- **NOTE:** In the glass slab too, the glass causes dispersion, but since the emergent rays of all the different colours are parallel to each other, they mix up again to give white light.
(i) In vacuum dispersion of light does not take place because all colours travel in vacuum with same speed.
(ii) In crown glass, velocity of red light is simply 1% more than that of violet light.

Real and Apparent Depth

It is on account of refraction of light that the apparent depth of an object placed in denser medium is less than the real depth when viewed from rarer medium.

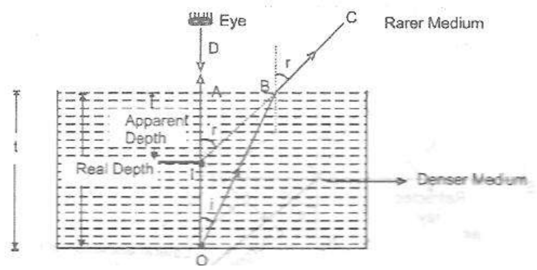


Figure shows a point object O placed at the bottom of a beaker filled with water. The rays OA and OB starting from O are refracted along AD and BC, respectively. These rays appear to diverge from point I.

- So, I is the virtual image of O. Clearly, the apparent depth AI is smaller than the real depth AO. That is why a water tank appears shallower or an object plced at the bottom appears to be raised.

$$\text{Re}\,fractive\ index\ (R\mu O) = \frac{\text{Re}\,al\ depth}{Apparent\ depth}$$

$$Apparent\ depth = \frac{\text{Re}\,al\ depth}{\text{Re}\,fractive\ index}$$

The refractive index of any medium (other than vacuum) is greater than unity. Apparent depth is lesser than real depth.

- **Normal shift:**
The height through which an object appears to be raised in a denser medium is called normal shift. Clearly, Normal shift = Real – Apparent depth.
The normal shift in the position of an object when seen through a denser medium depends on two factors.
(i) The real depth of the object or the thickness (t) of the refracting medium.
(ii) The refractive index of the denser medium. The higher the value of μ greater is the normal shift d.

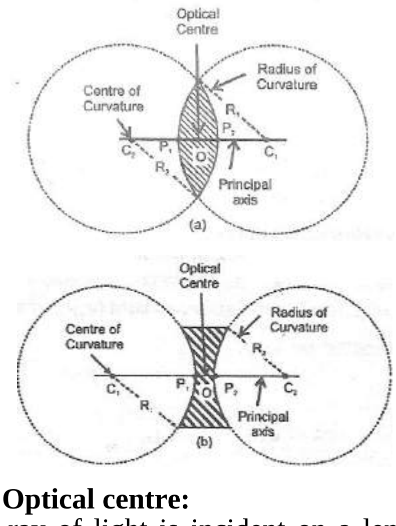
Spherical Lenses

A lens is a piece of transparent refracting material bounded by two spherical surfaces or one spherical and other plane surface.
A lens is the most important optical component used in microscopes, telescopes, cameras, projectors etc. Basically lenses are of two types:
(i) Convex lens or converging lens
(ii) Concave lens or diverging lens

(a) Convex Lens:
A lens which is thick at the centre and thin at the edges is called a convex lens. The most common form of a convex lens has both the surfaces bulging but at the middle.

(b) Concave Lens:
A lens which is thin at the middle and thick at the edges is called a concave lens. The most common form of a concave lens has both the surfaces depressed Inward at the middle.

(c) Definitions in connection with Spherical Lens:
(i) Centre of curvature (C):
The centre of curvature of the surface of a lens is the centre of the sphere of which it forms a part, because a lens has two surfaces, so It has two centres of curvature. In figure (a) and (b) points C_1 and C_2 are the centres of curvature.
(ii) Radius of curvature (R):
The radius of curvature of the surface of a lens is the radius of the sphere of which the surface forms a part. R_1 and R_2 in the figure (a) and (b) represents radius of curvature.
(iii)Principal axis (C_1 C_2):
It is the line passing through the two centres of curvature (C_1 and C_2) of the lens.



(iv) Optical centre:
If a ray of light is incident on a lens such that after refraction through the lens the emergent ray is parallel to the incident ray, then the point at which the refracted ray intersects on the principal axis is called the optical centre of the

lens. In the figure O is the optical centre of the lens. It divides the thickness of the lens in the ratio of the radius of curvature of its two surfaces. Thus:

$$\frac{OP_1}{OP_2} = \frac{P_1C_1}{P_2C_2} = \frac{R_1}{R_2}$$

If the radius of curvature of the two surfaces are equal, then the optical centre coincides with the geometric centre of the lens.

For a ray passing through the optical centre, the incident and emergent rays are parallel. However, the emergent ray suffers some lateral displacement relative to the incident ray. The lateral displacement decreases with the decrease in thickness of the lens. Hence a ray passing through the optical centre of a thin lens does not suffer any lateral deviation.

(v) Principal foci and focal length:

(A) First principal focus:

It is a fixed point on the principal axis such that rays starting from this point (in convex lens) or appearing to go towards this point (concave lens), after refraction through the lens, become parallel to the principal axis. It is represented by F_1. the distance between first principal focus and the optical centre is called the first focal length. It is denoted by f_1.

(B) Second principal focus:

It is a fixed point on the principal axis such that the light rays incident parallel to the principal axis, after refraction through the lens, either converge to this point (in convex lens) or appear to diverge from this point (in concave lens). The distance between the second principal focus and the optical centre is called the second focal length. It is denoted by f_2.

Generally, the focal length of a lens refers to its second focal length. It is obvious from the above figures that the foci of a convex lens are real and those of a concave lens are virtual. Thus the focal length of a convex lens is taken poditive and the focal length of a concave lens is taken negative.

If the medium on both sides of a lens is same, then the numerical values of the first and second focal lengths are equal. Thus

$f_1 = f_2$

(vi) Aperture:

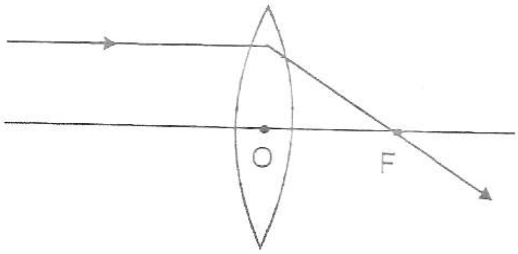
It is the diameter of the circular boundary of the lens.

Convex Lenses

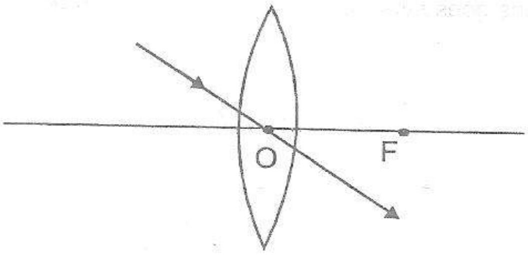
(a) Rules for the formation of images by Convex Lens :

The position of the image formed by a convex lens can be found by considering two of the following rays (as explained below) :

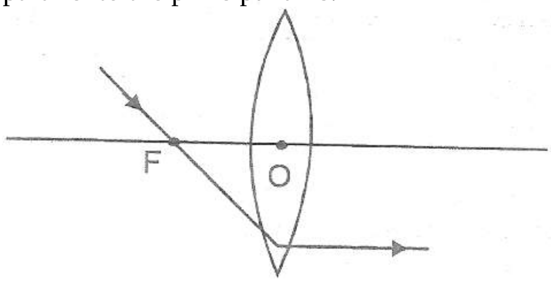
(i) A ray of light coming parallel to principal axis, after refraction through the lens, passes through the principal focus (F).



(ii) A ray of light passing through the optical centre O of the lens goes straight without suffering any deviation.



(iii) A ray of light coming from the object and passing through the principal focus of the lens after refraction through the lens, becomes parallel to the principal axis.



(b) Image formed by convex Lens:

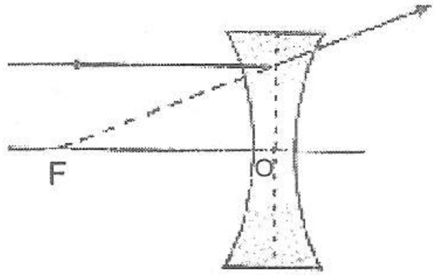
Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F	Highly diminished	Real and inverted
Beyond 2F	Between F and 2F	Diminished	Real and inverted
At 2F	At 2F	Same size	Real and inverted
Between F and 2F	Beyond 2F	Magnified	Real and inverted
At F	At infinity	Highly magnified	Real and inverted
Between O and F	On the side of the object	Magnified	Virtual and erect

Concave Lens

(a) Rules for image formation by concave Lens:

The position of the image formed by a concave lens can be found by considering following two

rays coming from a point object (as explained below).
(i) A ray of light coming parallel to the principal axis, after refraction, appears to pass through the principal focus F of the lens, when produced backward.



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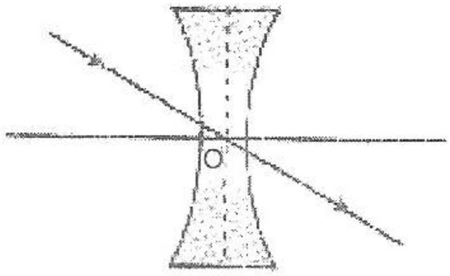


(b) Image formed by Concave Lens:

Position of the object	Position of the image	Size of the image	Nature the image
At infinity	At F	Highly diminished	Virtual and erect
Between O and ∞	Between O and F	Diminished	Virtual and erect

6. An object is place at a distance of 100 cm from a converging lens of focal length 40 cm. What is the nature and position of the image?

Sol. As object is placed at a distance greater than twice of focal length (2F) from a convex lens, therefore a real image will form between F and 2F.

Some Terms and Formula Related to Spherical Lenses

(a) Power of a lens:
It is the measure of deviation produce by a lens. It is defined as the rediprocal of its focal length in meters. It's unit is Dioptre (D) (f should always bi in metre).

$$Power\ (P) = \frac{1}{focal\ length\,(f\ in\ m)}$$

❖ Power of a convex lens is +ve (As it has a real focus and its focal length measured is +ve.)

❖ Power of a concave lens is-ve (As it has a virtual focus and its focal length measured is –ve.)

❖ **NOTE:**
(i) If two thin lenses are placed in contact, the combination has a power equal to the algebraic sum of the powers of two lenses,

$$P = P_1 + P_2 \Rightarrow \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

(ii) If two thin lenses are placed at d distance. Then the combination has a power equal to :

$$P = P_1 + P_2 - d\ P_1P_2 \Rightarrow \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

Here, f_1 and f_2 and the focal length of lenses and f is focal length of combination of lenses.

(b) Lens formula:
Linear magnification (m) is defined as the ratio of the size of the image to the size of the object.

$$m = \frac{A'B}{AB} = \frac{h2}{h1} = \frac{height\ of\ image}{hieght\ of\ object}\ ,$$

also,

$$m = \frac{v}{u} \quad \left\{ \begin{array}{l} if\ m\ is + ve\ (image\ is\ virual\ and\ erect.) \\ uf\ n\ us - ve\ (\ image\ is\ real\ and\ inverted\ ) \end{array} \right\}$$

7. A lens has a power of +0.5d. What type of lens is this ?

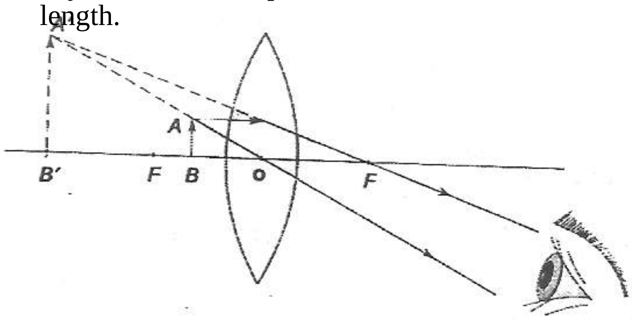
Sol. Since its power is positive, therefore it is a convex lens.

$$Focal\ lehgth = \frac{1}{Power} = \frac{1}{0.5} = 2\ m$$

Applications of Lens

(a) Magnifying Glass:
(i) Principle:
When as object is place in between the optical centre O and the principal focus F of a convex lens, then a virtual, erect and magnified image of the object is formed on the same side as that of the object.

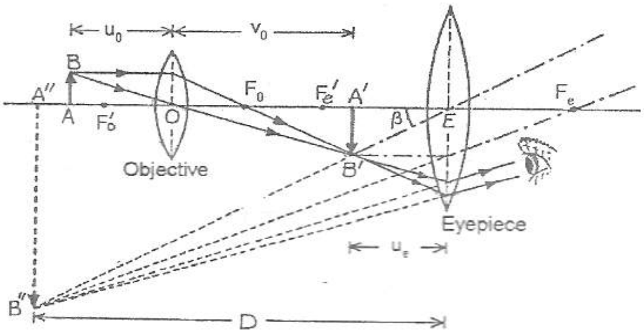
A convex lens often used as magnifying glass for reading small, fine print, etc. To form a virtual, erect and magnified image of an object, the object should be kept at a distance less than focal length.



(ii) Uses:
(A) It is used by jewelers and watch-makers to obtain magnified view of the fine jewellery and small parts of watch.

(B) It is used in laboratory to read the vernier scale of traveling microscope and spectrometers.
(C) It is used for magnifying the printed letters in a book/newspaper, texture of fibres or thread of cloth, details of a stamp, size of particles of different soils, etc.

(b) Compound Microscope:
A simple magnifier provides only limited assistance with inspection of the minute details of an object. Greater magnification can be achieved by combining two lenses in a device called a compound microscope.



- It uses two convex lenses, one objective and other eyepiece. The focal length and aperture of objective is less as compared to that of eyepiece.
- Total magnification = $M_O \times M_0$
- Here, M_O is magnification produced by objective and M_o is magnification produced by eyepiece.

(c) Telescope:
A telescope is and optical device which enables us to see distant objects clearly. It provides angular magnification of the distant objects.

Different types of telescope:
Broadly, the telescopes can be divided into two categories:

(i) Refracting telescopes:
These make use of lenses to view distant objects. These are of two types:

(A) Astronomical telescope:

- It is used to see heavenly objects like the sun, stars, planets, etc. The final image formed is inverted one which is immaterial in the case of heavenly bodies because of their round shape. An astronomical telescope is used for seeing heavenly bodies such as sun and stars.
- The astronomical refracting telescopes consists of an objective of long focal length (f_o) and an eyepiece of short focal length (f_o). Both lenses are converging. Here f_O is larger than f_o.
- The objective produces a real image of the object being viewed. This (intermediate) image acts as an object for the eyepiece which behaving as a magnifying glass, produces a virtual image of it.

(b) Terrestrial telescope:

- It is used to see distant objects on the surface of the earth. The final image formed is erect one. This is an essential condition for viewing the objects on earth's surface correctly.

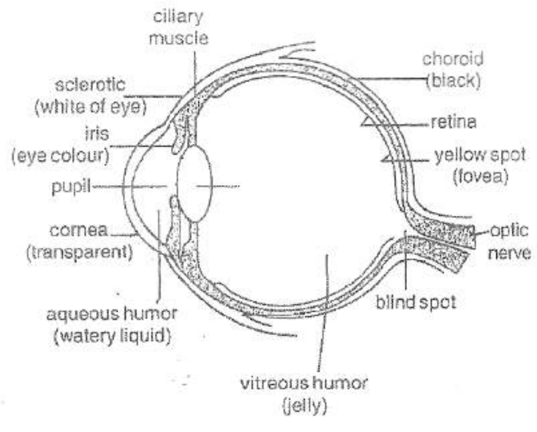
- A terrestrial telescope provides an erect image of the distant object. The astronomical telescope can be converted into terrestrial by introducing one more convex les (called erecting lens) between the objective and the eyepiece.

(ii) Reflecting telescopes:
These make use of converging mirrors to view the distant objects. For example. Newtonian telescope.

(d) Photographic camera:

- The principle behind the camera is that if an object is placed beyond 2F of a convex lens, if forms a real, inverted and diminished image of the object between F and 2F on the other side of the lens.
- A camera has a viewfinder with which we can focus on the object we want to take a photograph of. A convex lens with a very short focal length is fitted at the front end of the camera case.
- The film is loaded at the back end. A shutter is built in just after the lens with the help of which one can control the amount of light falling on the film, depending upon external condition, i.e. whether it is sunny or cloudy, cark or well-lit.

Human Eye



(a) Structure and working of Human Eye:
The human eye has the following parts:
(i) Cornea: It is the transparent spherical membrane covering the front of the eye.
(ii) Iris : It is the coloured diaphragm between the cornea and lens.
(iii) Pupil : It is the small bole in the iris.
(iv) Eye lens : It is a transparent lens made of jelly like material.
(v) Ciliary muscles : these muscles hold the lens in position.
(vi) Retina : It is the back surface of the eye.

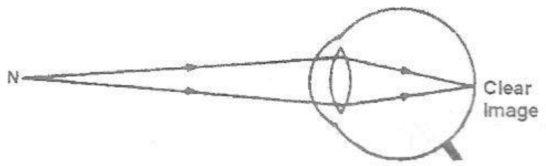
(vii) Blind spot : It is the point at which the optic nerve leaves the eye. An image formed at this point is not sent to the brain.
(viii) Aqueous humor : It is a clear liquid region between the cornea and the lens.
(ix) Vitreous humor ; The space between eye lens and retina is filled with another liquid called vitreous humor.

In the eye, the image is formed on the retina by successive refractions at the cornea, the equeous humor, the lens and the vitreous humor. Electrical signals then travel along the optic nerve to the brain to be interpreted. In good light, the yellow spot is most sensitive to detail and the image is automatically formed there.

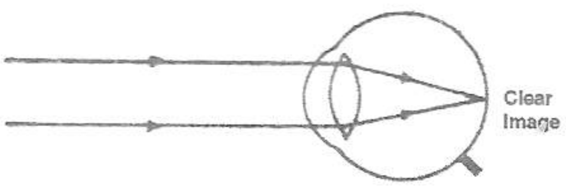
(b) Power of Accommodation:
The images of the objects at different distances from the eye are brought to focus on the retina by changing the focal length of the eye-lens, which is composed of fibrous jelly-like material, can be modified to some extent by the ciliary muscles.

(c) Near Point and Far Point:

❖ The nearest point at which a small object can be seen distinctly by the eye is called the near point. For a normal eye, it is about 25 cm and is denoted by the symbol D. With advancing age, the power of accommodation of the eye decreases as the eye lens gradually loses its flexibility.



❖ The farthest point upto which eye can see objects clearly, without any str4ain on the eye is called the far point. For a person with normal vision, the far point is at infinity.



(d) Least Distance of Distinct Vision:
The minimum distance of an object from the eye at which it can be seen most clearly and distinctly without any strain on the eye, is called the least distance of distinct vision. For a person with normal vision, it is about 25 cm and is represented by the symbol D.
Least distance of distinct vision, D = 25 cm.
(e) Persistence of Vision:
The image formed on the retina of the eye does not fade away instantaneously, when the object is removed from the sight. The impression (or sensation) of the object remains on the retina for about (1/16)th of a second, even after the object is removed from the sight. This continuance of the sensation of eye is called the persistence of vision.

(f) Colour-Blindness:

❖ The retina of our eye has large number of light sensitive cells having shapes of rods and cones. The rod-shaped cells respond to the intensity of light with different degrees of brightness and darkness whereas the cone shaped cells respond to colors. In dim light rods are sensitive but cones are sensitive to red, green and blue colours of light to different extents.

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

(g) Colour Perception of Animals:

❖ Different animals have different colour perception due to different structure of rod shaped cells and cone shaped cells. For example, bees have some cone-shaped cells that are sensitive to ultraviolet. Therefore bees can see objects in ultraviolet light and can perceive colours which we cannot do.

❖ Human beings cannot see in ultraviolet light as their retina do not have cone-shaped cells that are sensitive to ultraviolet light.

❖ The retina of chicks have mostly cone shaped cells and only a few rod shaped cells. As rod shaped cells are sensitive to bright light only, therefore, chicks wake up with sunrise and sleep in their resting place by the sunset.

(h) Cataract:
Sometimes due to the formation of a membrane over the crystalline lens of some people in the old age, the eye lens becomes hazy or even opaque. This is called cataract. It results in decrease or loss in vision of the eye. Cataract can be corrected by surgery leading to normal vision.

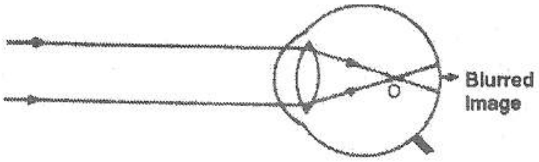
Defects of Vision and Their Correction

(a) short Sightedness (or Myopia) :

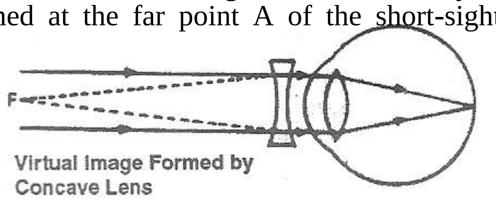
❖ A person who can see the near objects clearly but cannot focus on distant objects in short sightedness.

❖ The far point of a short-sighted person may be only a few matres rather than at infinity.

❖ This defect occurs if a person’s eyeball is larger than the usual diameter. In such a case, the image of a distant object is formed in front of the retina as shown in the figure. It is because the eye lens remains too converging, forming the image of the object in front of the retina.

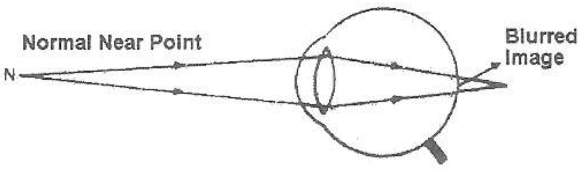


- To correct short sighted vision, a diverging lens (concave lens) of suitable focal length is placed in front of the eye as shown in figure. The rays of light from distant object are diverged by the concave lens so that final image is formed at the retina. If the object is very far off (i.e.$u \approx \infty$), then focal length of the concave lens is so chosen that virtual image of the distant object is formed at the far point A of the short-sighted eye.

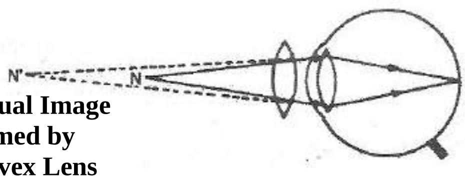


(b) Far sightedness (or Hyperopia or Hypermetropia):

- A person who can see distant objects clearly but cannot focus on ear objects is farsighted, whereas the normal eye has a near point of about 25cm. A farsighted person may have a near point several metres from the eye.
- This defect may occur if the diameter of person's eyeball is smaller than the usual or if the lens of the eye is unable to curve when ciliary muscle contract. In such a case, for an object placed at the normal near point (i.e. 25 cm from eye), the image of the object is formed behind the retina as shown in the figure. It is because the lens of the eye is not sufficiently converging to focus the object located at the normal near point.



- A farsighted person has the normal far point but needs a converging lens in order to focus objects which are as close as 25 cm. The converging lens of correct focal length will cause the virtual image to be formed at the actual near point of the farsighted person's eye as shown in figure.



Virtual Image Formed by Convex Lens

(c) Presbyopia :

- This defects arises with aging. A person suffering from this defect can see neither nearby objects nor distant objects clearly/distinctly. This is because the power of accommodation of the eye decreases due to the gradual weakekning of the ciliary muscles and diminishing flexibility of the eye lens.
- This defect can be corrected by using bi-focal lenses. Its lower part consists of a convex lens and is used for reading purposes whereas the upper part consists of a concave lens and is used for seeing distant objects.

(d) Astigmatism:

- A person suffering from the defect cannot simultaneously focus on both horizontal and vertical lines of a wire gauze.
- This defect arises due to the fact that the cornea is not perfectly spherical and has different curvatures for horizontally and vertically tying objects. Hence, objects in one direction are well focused whereas objects in the perpendicular direction are not well focused.
- This defect can be corrected by using cylindrical lenses. The cylindrical lenses are designed in such a way so as to compensate for the irregularities in the curvature of cornea.

EXERCISE

1. Which medium has the minimum refractive index with respect to vacuum?
(A) Glass B) Air
(C) Water D) Oil

2. The unit of refractive index is :
(A) cm/s (B) It has in unit
(C) N-m (D) m/s^2

3. The image formed by convex lens in a simple microscope is :
(A) Virtual and erect
(B) real and inverted
(C) equal in size with the object
(D) none of these

4. A man wearing glasses of focal length – 1m cannot clearly see beyond one meter :
(A) If he is far sighted
(B) If he is near sighted
(C) If his vision is normal
(D) In each of these cases

5. At the time of sun set, the sun seems to be :
(A) Lower than its actual position
(B) At its actual position
(C) Higher than its actual position
(D) None of these

6. The phenomenon of light in which light that strikes to smooth surface and thrown back into the same medium is called :
(A) reflection (B) refraction
(C) scattering (D) none of these

7. On entering a glass prism, sum rays are :
(A) Deviated but not dispersed
(B) Deviated and dispersed
(C) Dispersed but not deviated
(D) Neither deviated nor dispersed

8. A cut diamond sparkles because of its :
(A) Hardness
(B) High refractive index
(C) Emission of light by the diamond
(D) Absorption of light by the diamond

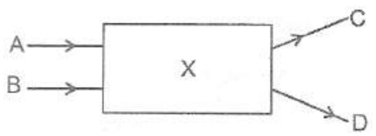
9. If angle of incidence is 60^0, than the angle of reflection will be :
(A) 30^0 (B) 60^0
(C) 120^0 (D) 90^0

10. A person standing in front of a mirror finds his image smaller that himself and erect, This implies the mirror is:
(A) plane (B) concave
(C) conve x (D) None of the above

11. Mark the wrong statement.
(A) Refractive index decreases with increase in temperature.
(B) Refractive index depends on the angle of incidence.
(C) Both (A) & (B)
(D) None of these

12. If the refractive indices for water and diamond relative to air are 1.33 and 2.4 respectively then the refractive index of diamond relative to water is:
(A) 0.55 (B) 1.80
(C) 3.19 (D) None of these

13. Light rays A and B fall on optical component X and come out as C and D.



The optical component is a:
(A) concave lens (B) convex lens
(C) convex mirror (D) none of these

14. The lens used in spectacles for the correction of short sightedness is a:
(A) concave lens (B) convex lens
(C) piano-convex lens (D) none of these

15. A tall man of height 6 feet, want to see his full image. Then required minimum length of the plane mirror will be :
(A) 12 feet (B) 3 feet
(C) 16 feet (D) any length

16. According to law of reflection of light:
(A) Angle of incidence is equal to the angle of reflection
(B) Angle of incidence is less than the angle of reflection
(C) Angle of incidence is greater than the angle of reflection
(D) None of these

17. To get three images of a single object, one should have two plane mirrors at an angle of:
(A) 30^0 (B) 50^0
(C) 60^0 (D) 90^0

18. What should be the minimum height of a plane mirror to get a full image of a man whose height is h?
(A) h (B) 2h
(C) h/2 (D) h/4

19. A point source of light is placed in front of a plane mirror, then :
(A) all the reflected rays meet at a point when produced backward
(B) only the reflected rays close to the normal meet at a point when produced backward
(C) only the reflected drays making a small angle with the mirror, meet at a point when produced backward
(D) light of different colours make different images

20. In convex lens, if the object is at infinity then position of image is at :
(A) Infinity (B) Between F and 2F
(C) At the Focus (D) None of these

21. The R.I. of kerosene is 1.42. Calculate the speed of light in it:
(A) 4,26,000 km/s (B) 300,000 km/s
(C) 211,268 km/s (D) 279,988 km/s

22. When light goes from glass to air, it bends:
(A) Away the normal
(B) Towards the normal
(C) (A) AND (B) both correct
(D) None of these

23. If a convex lens is thin (radius of curvature is large), then its focal large), then its focal length is:
(A) Small (B) large
(C) nothing can be said (D) None of these

24. Visual optical instrument used for seeing near tiny objects magnified, is called a :
(A) Telescope (B) Microscope
(C) spectroscope (D) Thermoscope

25. Hypermetropia is due to the :
(A) low converging power
(B) low diverging power
(C) high converging power
(D) high diverging power

26. The refractive indices of two media are equal. When a ray of light entres from first medium to second medium :
(A) Velocity of ray will change.

(B) The direction of motion of the ray will change.
(C) The ray will move in the same direction.
(D) The ray will reflect from the surface of the medium.

27. The image of an object formed by a concave lens is always :
(A) enlarged, inverted and real
(B) small, inverted and real
(C) enlarged, erect and virtual
(D) small, erect and virtual

28. Light ray AB incidents on a plane mirror XY at an angle of 500. The second plane mirror is placed is such a way that the reflected ray BC from the mirror XY retraces its path. Angle of inclination of two mirrors will be :
(A) 25^0 (B) 50^0
(C) 75^0 (C) 90^0

29. At what angle two plane mirrors should be placed to form 11 of an object ?
(A) 20^0 (B) 30^0
(C) 40^0 (D) 50^0

30. An object is placed at focus of a convex lens the image will be formed at :
(A) At focus
(B) Between focus and infinity
(C) At infinity
(D) No where

31. A ray light falling at an angle passes through a rectangular glass slab, then the :
(A) incident and emergent rays are parallel to each other
(B) emergent rays bend away from the normal
(C) refracted rays bend away from the normal
(D) rays split into their constituents and a spectrum is formed

32. A photographic camera has a convex lens fixed on one face while the film, acting as screen, is kept on opposite face. The lens makes an image of the object to be photographed, which is :
(A) real, inverted and smaller in size
(B) virtual, inverted and smaller in size
(C) virtual, inverted and of the same size
(D) real, erect and of the same size

33. A ray of light is incident on a plane mirror at an angle of incidence i. After reflection the ray will deviate b an angle :
(A) i (B) $\pi - i$
(C) 2i (D) $\pi - 2i$

34. Match the items given in Column I with II

Column-I	**Column-II**
I. A plane mirror	A. Used for shaving
II. A concave mirror	B. Forms an image which is as far behind the mirror as the object is in front of it.
III. A convex lens	C. Used as a magnifier
IV. A concave lens	D. Forms an image which is erect and smaller in size than the object

Which of the following matching is correct?
(A) I.B; II.A; III, C; IV,D
(B) I,B; II,D; III,C; IV, A
(C) I,B; II,A; III,D; IV,C
(D) I,A; II,B; III,C; IV,D

ANSWER – KEY

LIGHT

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