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Chapter = 12

GEOMETRICAL OPTICS

LIGHT

Definition:-

Light is a form of energy which enable us to see the objects. OR
It is a form of energy which produce the sensation of vision.

Nature: - It is electromagnetic in nature.

PROPERTIES OF LIGHT

(i) It travels in straight line.
(ii) It does not need a medium for propagation.
(iii) Speed of light in vacuum is 3×10^8 m/s.
(iv) It has dual nature i.e wave as well as particle.
(v) It casts shadow.

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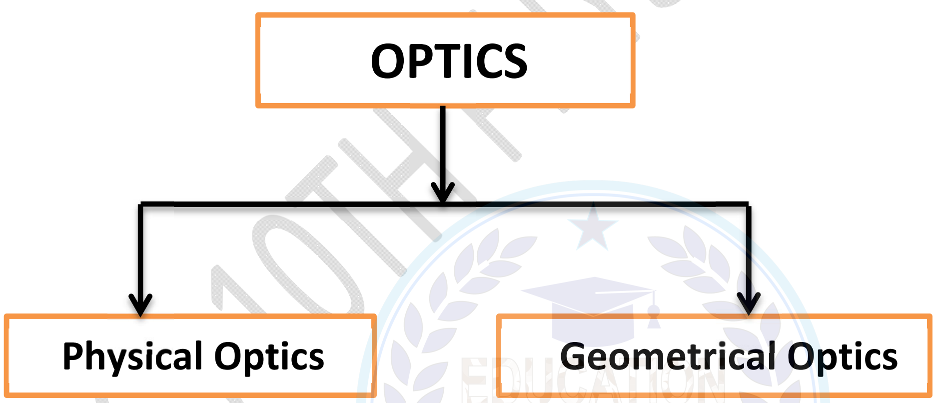
DIFFERENT PHENOMENON EXHIBITED BY LIGHT

(i) Reflection**.**
(ii) Propagation**.**
(iii) Refraction**.**
(iv) Dispersion**.**
(iv) Interference

Ray: - The path on which light energy is travel is known as ray.

Beam of light:- The bundle of light rays is known as beam of light.



OPTICS

Definition:- The study of light is known as optics.

Branches of optics:- There are two branches of optics which are given below.

(1) Physical Optics.
(2) Geometrical Optics.

(1)Physical Optics:-

Definition:- The study of light as a wave is known as Physical optics.

(2)Geometrical Optics:-

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Definition:- The study of light as a ray is known as geometrical optics.
Other Name:- It is also called Ray Optics.

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Medium:- A transparent substance from which light can be passed is known as medium.
Types of medium:- There are two types of medium which are given below .
(i) Rarer Medium.
(ii) Denser Medium

(i) **Rarer Medium:-** A medium from which light can pass easily is known as rarer medium.

Explanation:- In rarer medium the distance between the molecules is greater due to this light can pass through the medium easily.

(ii) **Denser Medium: -** A medium in which light energy cannot pass easily is known as denser medium.

Explanation: - In denser medium the distance the molecules is smaller or closed packed due to this light cannot pass easily.

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LUMINOUS AND NON- LUMINOUS OBJECTS

LUMINOUS OBJECTS:-
Definition:- Those objects which make (Produces) their own light are known as luminous objects.
Examples:- The Sun, electric lamps and candles etc.
NON - LUMINOUS OBJECTS:-
Definition:- Those objects which make (Produces) their own light are known as luminous objects.
Examples:- Moon, Book, teaching board etc.

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SOME INPORTANT DEFINITIONS

(i) **Incident Ray**:- The approaching ray of light is known as incident ray.
(ii) **Reflected Ray**:- The of light reflected from a reflecting surfaces.
(iii) **Point of incidence**:- The point at which the incident ray strikes the reflecting surface.

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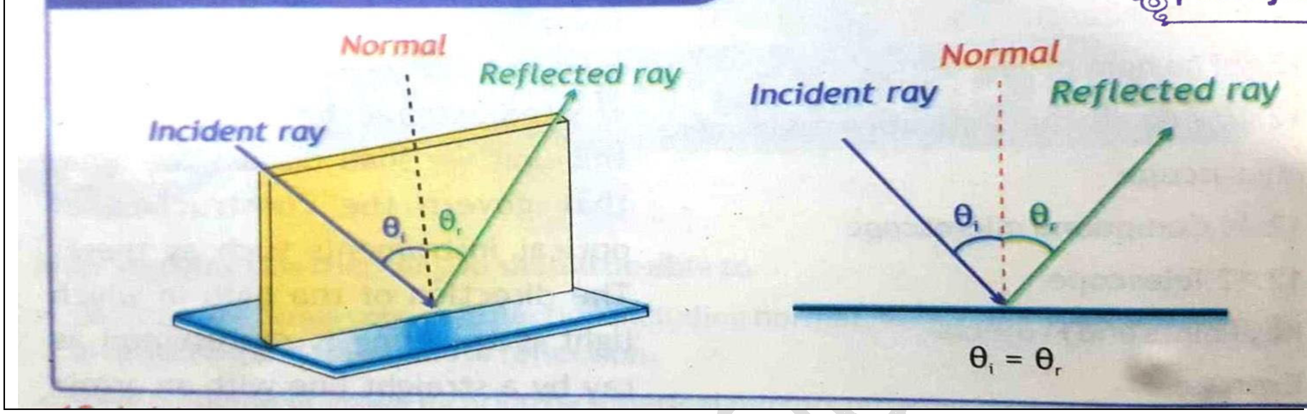
(iv) **Normal**:- The line drawn at right angle to the reflecting surface at the point of incidence.

(v) **Angle of incidence (θ_i):-** The angle between the incident ray and the normal.

(vi) **Angle of reflection (θ_r):-** The angle between the reflected ray and the normal.

FIGURE 12.1 - Laws of reflection



REFLECTION OF LIGHT

Definition: - When light travelling in a certain medium falls on the surface of another medium a part of it turns back in the same medium. This is called reflection of light. OR The bouncing back of light ray when it strikes on a polished surface like mirror is known as reflection of light. OR

The bouncing back of light ray after striking from the other hard medium is known as reflection of light.

Explanation:- When a ray of light ray AO falls on the plane mirror MM', it is reflected along the path OB as shown in figure.

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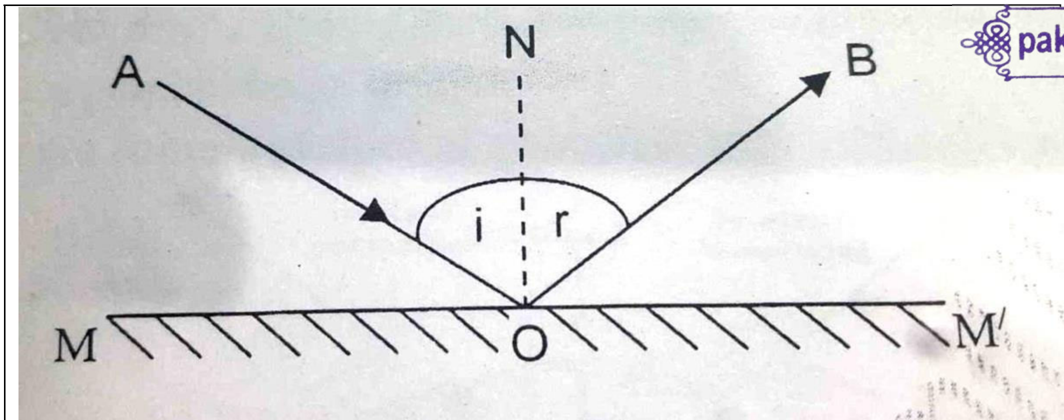

Figure (R)

From figure(R) :-

(i) The ray AO is called incident ray.
(ii) The ray OB is called reflected ray.
(iii) The angle between incident ray AO and the normal N i-e <AON is called angle of incidence which is denoted by <i.
(iv) The angle between the normal N and reflected ray OB i-e < NOB is called angle of reflection which is denoted by <r.

Laws of reflection :- There are two laws of reflection of light which are first of all introduced by a Muslim Scientist **Ibn-ul–Haitham**. These laws are stated as:

(i) First law of reflection: - The incident ray, reflected ray and normal at the same point all lies in the same plane.
(ii) Second law of reflection:- The angle of incidence is always equal to the angle of reflection.

Mathematically: $m < \theta_i = m < \theta_r$

IMAGE

Definition:- If light ray coming from an object meets or appear to meet at a point after reflection or refraction then this point is known as image of the object. OR
It is a point where at least two light rays actually meet or appear to meet.
Types Of images:- There two types images which are given below.
(1) Real Image.
(2) Virtual Image.

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IMAGE CHARACTERISTICS

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We can completely describe any image by defining four characteristics.

(1)THE MAGNIFICATION:- It is the ratio of the size of image to the size of object.

Symbol:- It is denoted by "M".

(i) If the M > 1, the image is larger than the object size.

(ii)If the M = 1, the object and image are the same in size.

(iii) If the M < 1,the image size is smaller than the object.

(2)THE ATTITUDE OF AN OBJECT:- It shows whether the image is oriented the same way as the object (up-right) or upside down (inverted) with respect to the object.

(3)THE IMAGE LOCATION (OR POSITION):- It shows the distance between the image and the optical device – mirror or lens.

(4)THE TYPE OF IMAGE:- It indicates whether the image is real or virtual.

(i) An image is real if light rays are actually converging at a point.

(ii) An image is virtual if light rays are not actually converging at a point.

DIFFERENCE BETWEEN REAL IMAGE AND VIRTUAL IMAGE

REAL IMAGE	VIRTUAL IMAGE
It is formed when light rays actually meet.	It is formed when light rays appear meet.
It can be obtained on screen.	It cannot be obtained on screen.
It is always inverted.	It is always errect.
E.g:- Image formed by concave mirror or Convex lens.	E.g:- Image formed by convex mirror or Concave lens.

MIRROR

Definition: - The smooth and polished surfaces of a medium from where most of light is reflected are called mirrors.

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Types of mirror:- There are two types of mirrors which are given below.

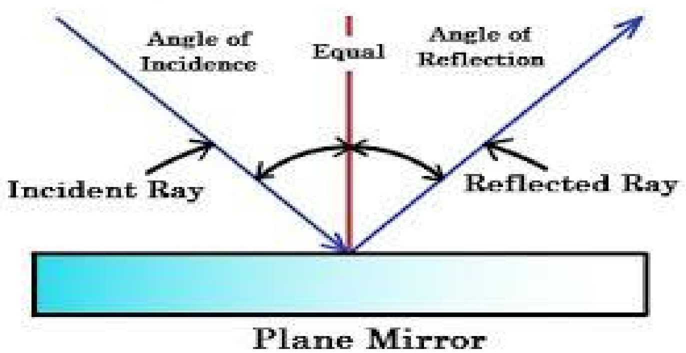
(i) Plane Mirror

(ii) Spherical Mirror

PLANE MIRROR

Definition: - A mirror with a flat reflective surface is known as plane mirror. OR

A flat smooth reflecting surface which shows regular reflection is known as plane mirror.



Characteristics of image formed by plane mirror :-

- Image is laterally inverted.
- The size of image is the same as that of the object.
- The image is erect and virtual.
- The image is as far behind the mirror as the object is in front of the mirror.

SPHERICAL MIRROR

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Definition: -The part of the spherical shell having its outer or inner surface is shining and reflecting is known as spherical mirror. OR

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

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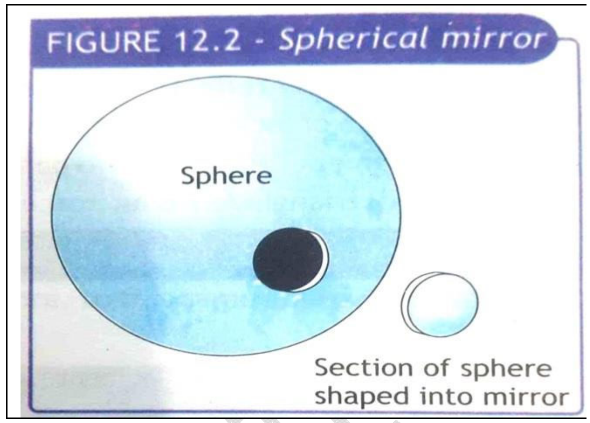


FIGURE 12.2 - Spherical mirror

Types of spherical mirrors:-

There are two types of spherical mirror which are given below.

(1) Concave Mirror

(2) Convex Mirror

Concave Mirror :-

Definition:- A spherical mirror whose inner surface is shining and reflecting is called concave mirror. OR

A spherical mirror whose inner curved surface is reflecting is known as concave mirror. OR

A spherical in which the reflection of light take place at the concave surface is known as concave mirror.

Other Name: This mirror is also called converging mirror because it has ability to converge a parallel beam of light.

Example: - The inner shining surface of a spoon is an example of concave mirror.

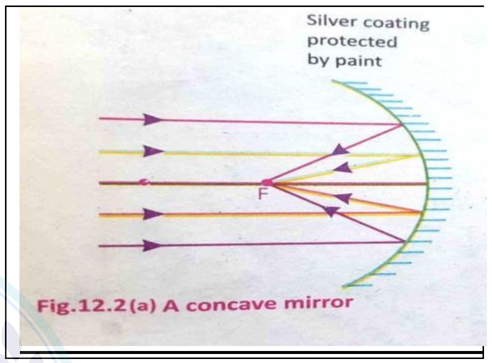


Fig.12.2(a) A concave mirror

Convex mirror:-

Definition: - A spherical mirror whose outer surface is shining and reflecting is known as convex mirror. OR

A spherical in which the reflection of light take place at the convex surface is known as convex mirror. OR

A spherical mirror whose inner curved surface is reflecting is known as convex mirror.

Other Name:- This mirror is also called diverging mirror because it has the ability to diverge parallel beam of light.

Example: - The back side of spoon is an example of convex mirror.

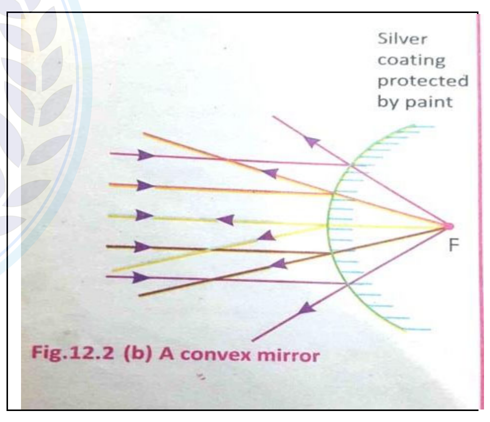
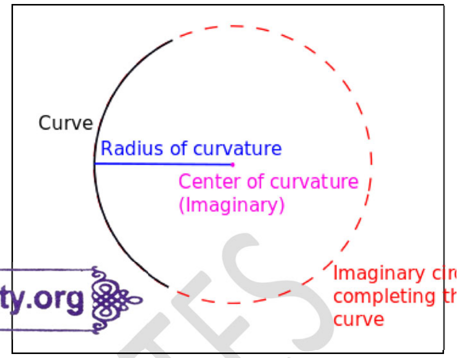


Fig.12.2 (b) A convex mirror

THE TERMS RELATED WITH SPHERICAL MIRRORS



(1) Center of curvature:-The center of the spherical shell of which mirror is a part is called center of curvature.

Symbol:-It is denoted by **"C".** As shown below.

(2)Radius of curvature: - The radius of the spherical shell of which mirror is a part is called radius of curvature.

Symbol:-It is denoted by "R". As shown in figure A.

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3. Pole: - The geometrical center of the spherical mirror is called pole.

Symbol:-It is denoted by "P". As shown in figure A.

4. Principal axis: - The imaginary straight line passing from the pole "P" and center of curvature "C" of the spherical mirror is called principal axis. As shown in figure .

5. Aperture : - The diameter of the circular boundary of the spherical mirror is called aperture. OR

The area of the spherical mirror exposed to the incident light is called aperture. As shown in figure .

6. Principal focus OR Focus point : - In case of concave mirror

The point at which all the reflected rays converging is known as principal focus or focus point. OR

In case of convex mirror

The point from which all the reflected light rays are seem to be diverging is called principal focus or focus point.

Symbol:-It is denoted by "F". As shown in figure .

7. Focal length:-The distance between the pole and focus point of the spherical mirror is called focal length. It is denoted by " f ".

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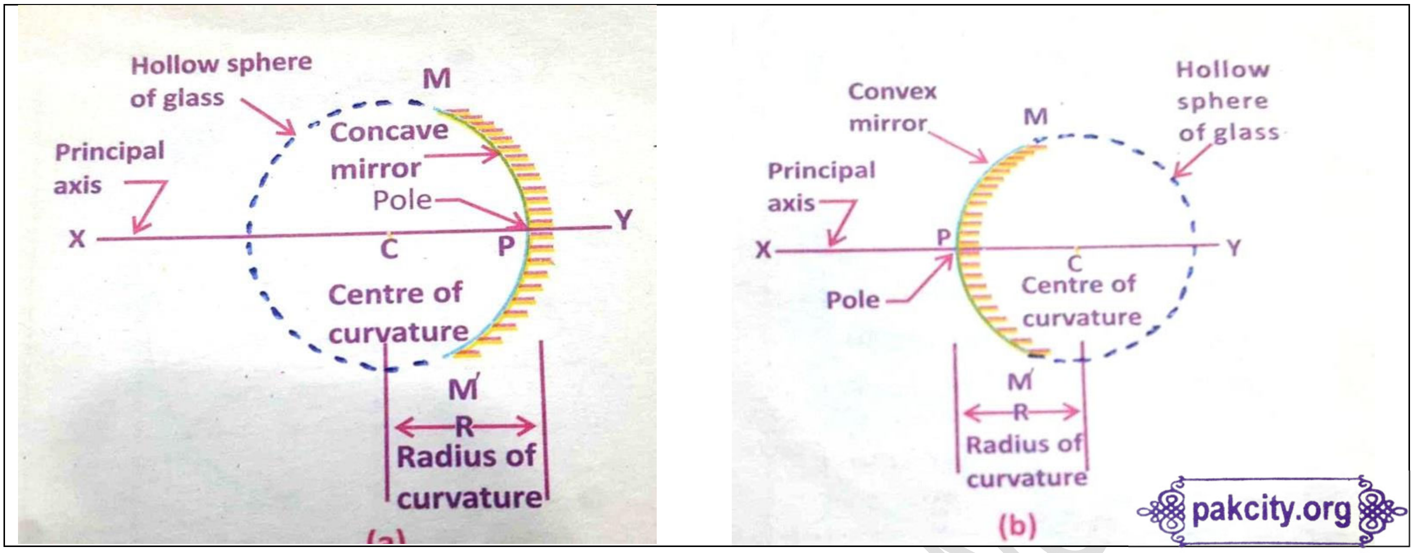
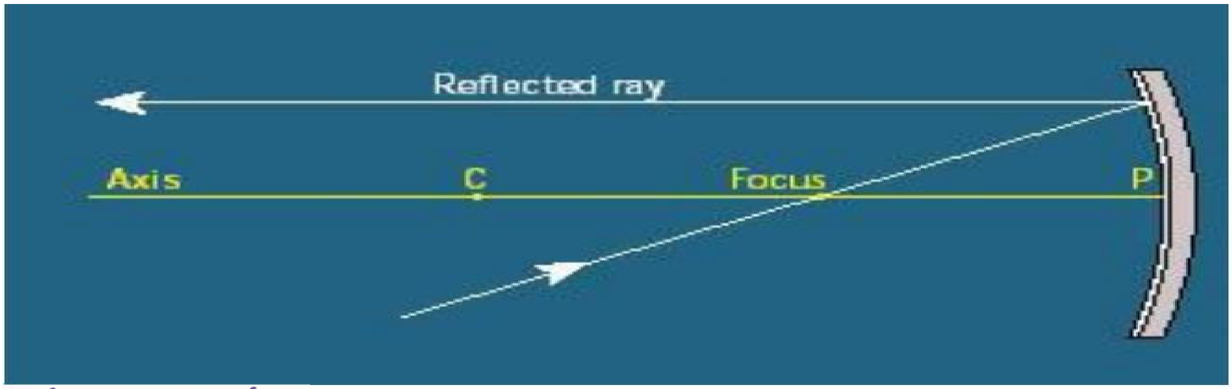


Note:- (i)Focal length of the concave mirror is taken positive while the focal length of the co mirror is taken negative. (ii) f= $\frac{1}{2}$ R

IMAGE FORMATION AND RAY TRACING FOR SPHERICAL

i. When a ray of light is parallel to the principal axis will passes through the focus point of the concave mirror after reflection.

ii. When a ray of light passing through the focus point will becomes parallel to the principal axis after reflection from the concave mirror.



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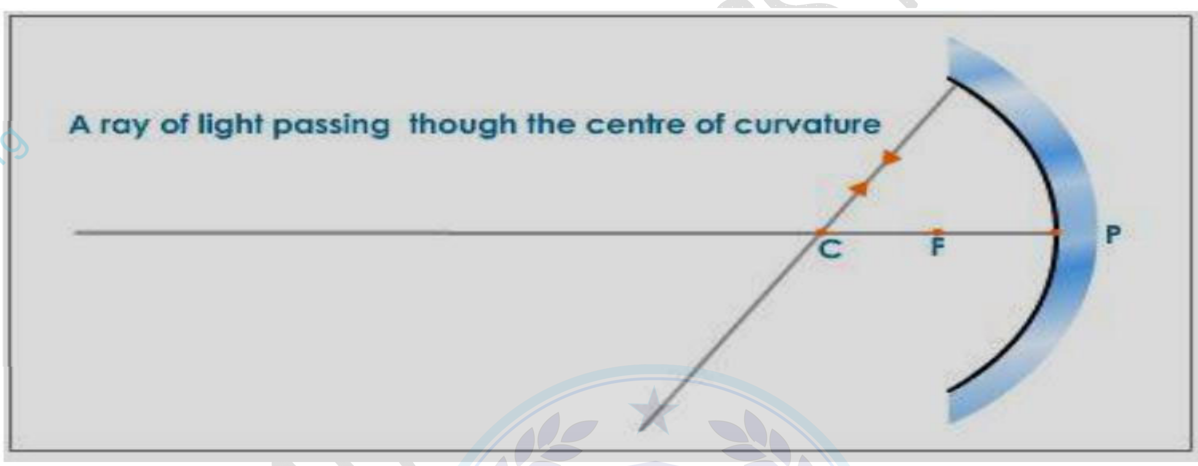
i. When a ray of light passes through the center of curvature of the concave mirror will reflected back along the same path.



ii. When a ray of light falls at the pole of the concave mirror then after reflection

$$< \theta_i = < \theta_r$$

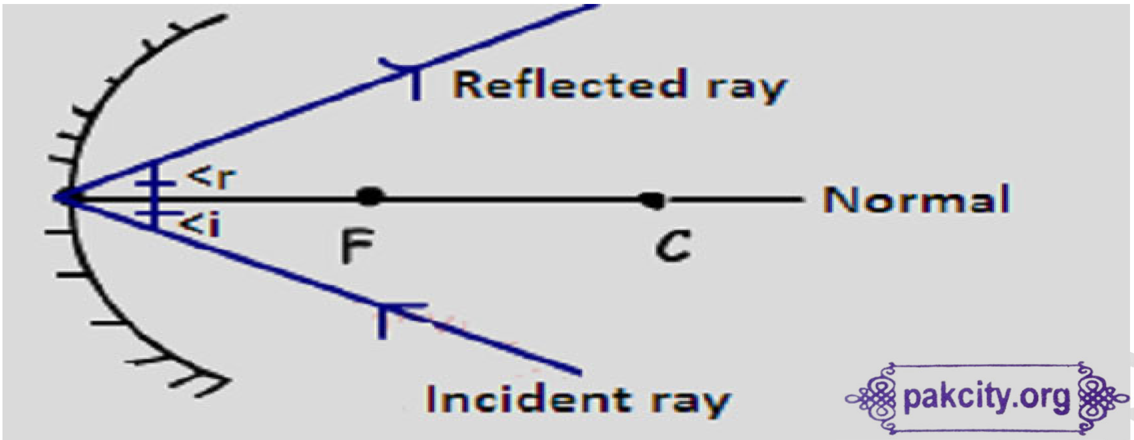


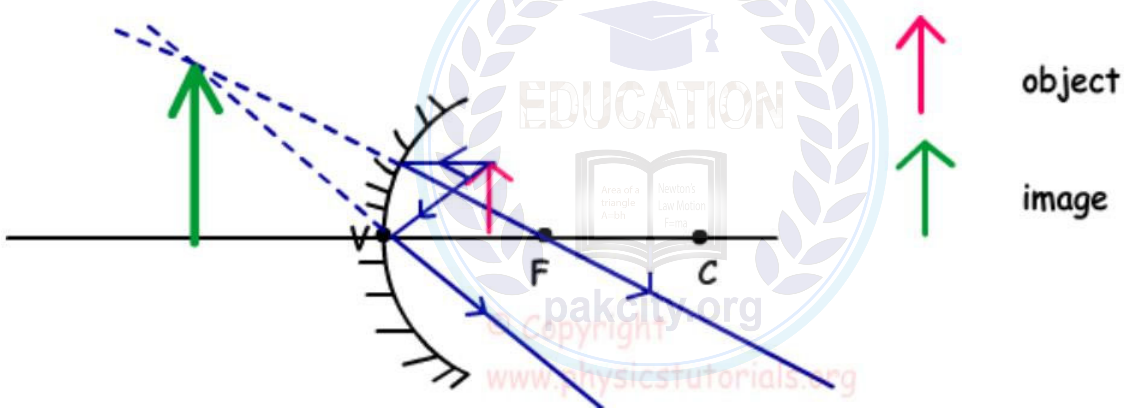
Image formation by convex mirror :-

When an object is placed in the front of a convex mirror then the image is formed by the convex mirror is behind the mirror.

The image formed is

- Erect
- Virtual
- Dimensioned (very small in size)

Diagrammatically:-



SOME GOLDEN POINTS

- **(i)** f= the focal length of the mirror.
- **(ii)** h_0 = the height of object.
- **(iii)** h_i = the height of image.
- **(iv)** d_0 = the distance of object from the mirror.
- **(v)** d_i = the distance of the image from the mirror.
- **(vi)** M= the magnification of the image.

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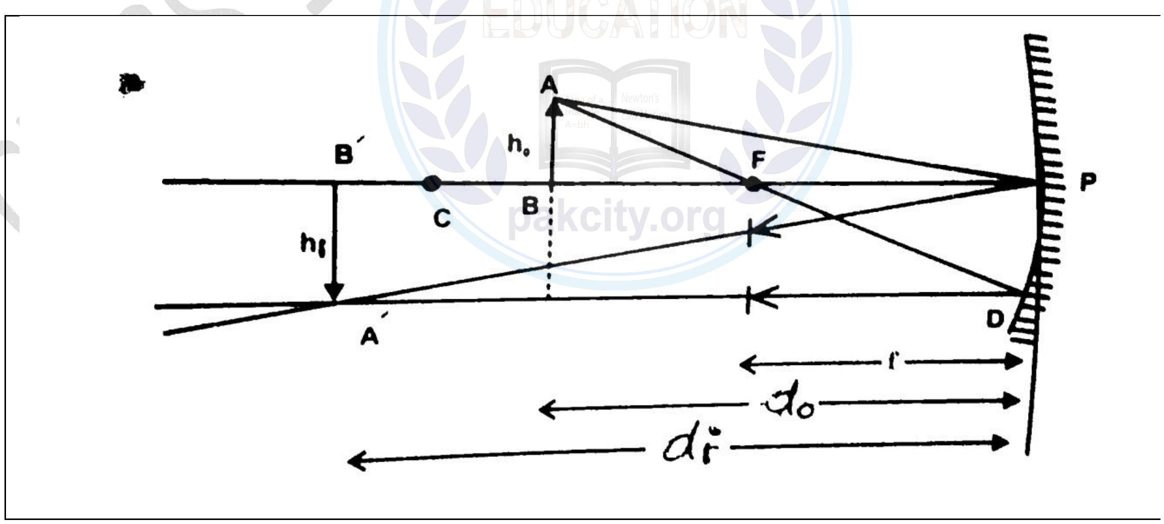
THE MIRROR EQUATION

Definition: - A formula which gives the relationship between image distance (d_o), object distance (d_o) and focal length (f) of a mirror is called mirror formula.

Mathematical form:- $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

Proof: - Consider an object **"AB"** of height h_o is placed at a distance d_0 from the pole (P) of the mirror. One ray of light from the object "AB" strikes the mirror at the pole "P" and is reflected with the same angle as shown in figure. The other ray passing through the principle focus "F" is reflected parallel to principle axis to meet the first ray and produce an image " A'B' ".

Diagrammatically:-



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It is clear from figure that ΔABP and ΔA'B'P are similar. Then

$$\frac{AB}{A'B'} = \frac{PB}{PB'} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

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Similarly ΔABF and ΔFPD are similar, therefore

$$\frac{AB}{DP} = \frac{BF}{FP} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

AS DP = $A'B'$ so equation (2) becomes

$$\frac{AB}{A'B'} = \frac{BF}{FP} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Now by comparing equation (1) and (3) we get

$$\frac{PB}{PB'} = \frac{BF}{FP} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

As BF = BP-FP Then equation (4) becomes

$$\frac{PB}{PB'} = \frac{BP-FP}{FP} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

From figure:

i. FP = f

ii. PB = d_0

iii. PB' = d_i Then equation (5) becomes

$$\frac{d_0}{d_i} = \frac{d_i - f}{f}$$

By cross multiplication we get

$$d_0 \text{ f} = d_i\,(d_0 - \text{f}) \quad \text{OR} \quad d_0 \text{ f} = d_i\, d_0 - d_i \text{ f} \quad \ldots\ldots\ldots (6)$$

Dividing both sides by $d_0 d_i$f of equation (6) we get

$$\frac{d_0 f}{d_0 d_i\, f} = \frac{d_0 d_i - d_i f}{d_0 d_i\, f}$$

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OR $$\frac{d_0 f}{d_0 d_i f} = \frac{d_0 d_i}{d_0 d_i f} - \frac{d_i f}{d_0 d_i f}$$

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_0}$$

OR $$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i} \quad \text{.............} (7)$$

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Equation (6) represents spherical mirror formula.

MAGNIFICATION

Definition: - The ratio of the height of the image to the height of the object is called linear magnification. OR

The ratio of the image distance from the mirror to the object distance is called linear magnification.

Symbol: - It is denoted by "M".

Mathematically :- $M = \frac{Height\ of\ image}{Height\ of\ object}$ =

$$M = \frac{h_i}{h_o} = \frac{q}{p}$$

Explanation:- The size of image formed by a spherical mirror depends on the position of the object from the mirror. The image formed by a spherical mirror can be bigger than the object, equal to the object or smaller than the object.

Unit: - It has no unit because it is the ratio between two similar quantities.

CONVENSION FOR MIRROR EQUATION AND MAGNIFICATION

To include all of the possible properties of both images and objects, the following sign of convection has been established for both concave and convex spherical mirrors.

(a)Object Distance:- d_o is positive for objects in front of mirror (real objects).

(b) Image Distance:-

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(i) d_i is positive for objects in the front of mirror (real images).
(ii) d_i is negative for objects behind the mirror (virtual images).

(c) **Image attitude**:-

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(i) h_i is positive for images that are up-right, compared to the objects.
(ii) h_i is negative for images that are inverted, compared to the object.

(d) **Focal length**: -
(i) "f " is positive for concave mirrors.
(ii) "f " is negative for convex mirrors.

USES OF MIRRORS

(i) As shaving mirror:- Concave mirror of large focal length is used as shaving mirror. When a person looks his face through this mirror, an enlarge erect and virtual image is seen in the mirror.

(ii) By doctors and dentists:- Dentists use a small concave mirror to have a look of backside of tooth and cavity in it. Doctors also use it to examine ear, nose, throat etc.

(iii) As objective of reflecting telescope :- A concave mirror of large aperture is used as objective in telescope. Greater amount of light is incident from the object, so a clear image can be seen by such telescope.

(iv) In microscope :- Concave mirror is used in microscope to concentrate light on the slide.

(v)In automobile headlights and search lights: - Concave mirrors are used behind the bulb such that a bulb lies at their principal focus. The rays of light become parallel after reflection. Thus powerful beam of light is obtained in a particular direction by headlights and search lights. pakcity.org

(vii)In vehicles :- Convex mirrors are used in vehicles to observe rear view. It makes small, erect and virtual images of the objects behind the vehicle and provides a wide field of view.

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SINGLE MIRROR SYSTEN PROPERTIES				
Mirror Type	f	d_0	d_i	M
Plane	NA	$d_0 > 0$	$d_i = d_i$ (negative)	Same size
Concave	+	$d_0 > r$	r> $d_i > f$	Reduced, inverted
		$d_0 = r$	d_i = r	Same size
		r> $d_0 > f$	d_i > r	Enlarged, inverted
		$d_0 = f$	$d_i = \infty$	No image
		f> $d_0 > 0$	$d_i > d_0$ (negative)	Enlarged
Convex	-	$d_0 > 0$	f> $d_i > 0$ (negative)	Reduced

REFRACTION OF LIGHT

Definition: - When a light ray enters from one transparent medium into another obliquely, it slightly bends from its original path. This behavior of light is called refraction of light. OR The deviation of light ray from its original path after entering from one medium to another is known as refraction of light. OR When light enter from one medium to another medium its speed and direction changed such phenomena is called reflection of light. OR

The bending of light when it enters from one medium to another is known as refraction of light.

Explanation: - Whenever light ray enters from a rare medium into a denser medium, the ray of light will slightly bends towards the normal.

In this case: – $\theta_i > \theta_R$.

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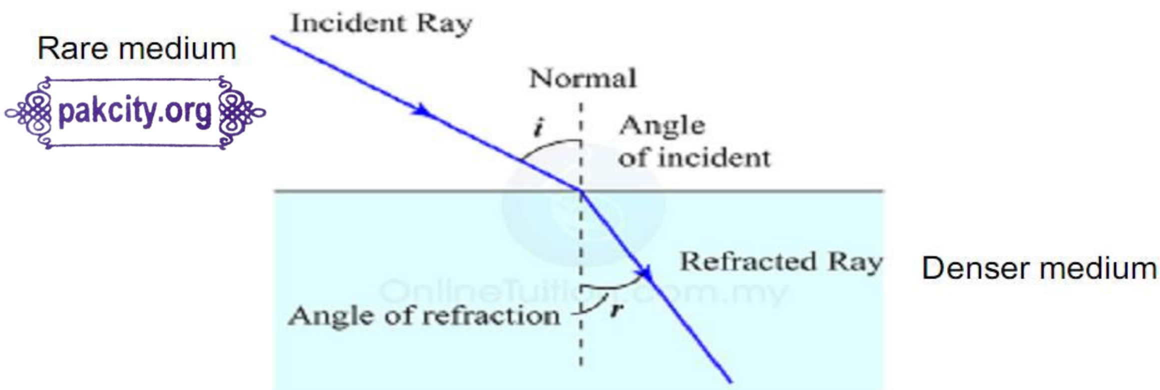


Whenever light ray enters from a denser medium into a rare medium, the ray of light will slightly bends away from the normal.

In this case:- $\theta_i < \theta_R$.

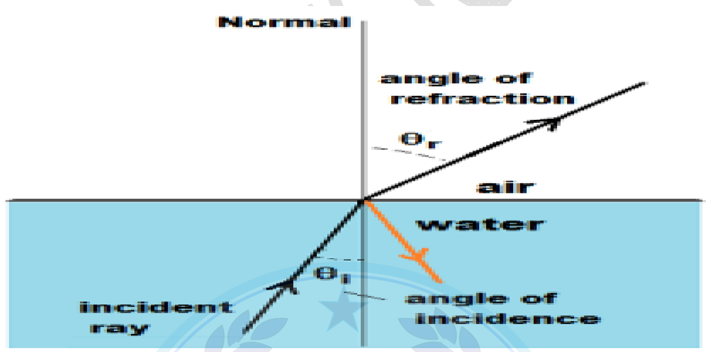
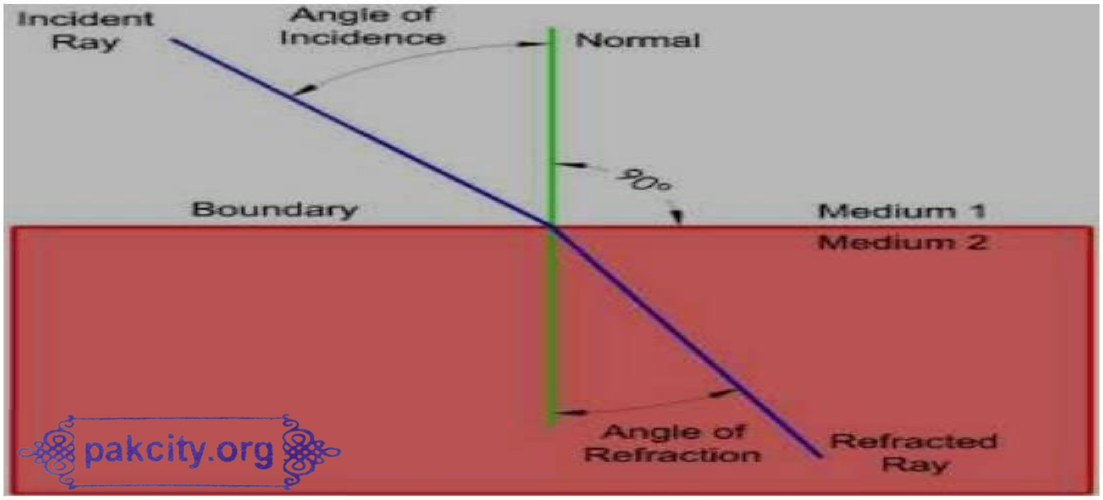


Fig. 3

LAWS OF REFRACTION

There are two laws of refraction that are as under.

(1) <u>First law of refraction</u> :-This law state that "the incident ray, refracted ray and normal to the point of incident all lies in the same plane."



(2) Second law of refraction:- This law state that "the ratio of the sine of angle of incidence to the sine of angle of refraction is constant for a given pair of media.

Mathematically: - $n_1 \sin\theta_1 = n_2 \sin\theta_2$

REFRACTIVE INDEX

Definition: - It can be defined as "the ratio of the speed of light in air or vacuum to the speed of light in the media."

Symbol: - It is denoted by "n".

Mathematically:- $n = \frac{Velocity\ of\ light\ in\ air}{Velocity\ of\ light\ in\ glass}$

$$n = \frac{C}{V} \quad .... (1)$$

Where "C" is the speed of light and its value is 3 x 10^8.

Independence:- The refractive index of a substance does not depends on the angle incidence.

Dependence:-

- Nature of medium

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- Wavelength (colour) of light.

Refractive index of some common substances

Substances (media)	Refractive index	Substances (media)	Refractive index
Air	1.0003	Benzene	1.50
Ice	1.31	Crown glass	1.52
Water	1.33	Carbon disulphide	1.63
Alcohol	1.36	Dense flint glass	1.65
Sulphuric acid	1.43	Ruby glass	1.71
Kerosene oil	1.44	sapphire	1.77
Turpentine oil	1.47	diamond	2.42

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TOTAL INTERNAL REFLECTION OF LIGHT

Definition: -The reflection of light totally from the boundary of interface is known as total reflection of light. OR

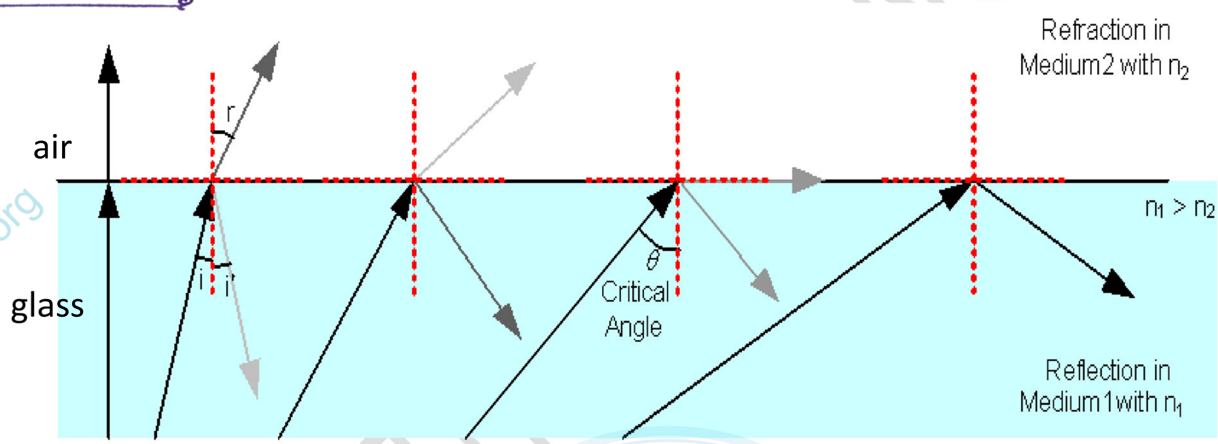
The reflection of light in same denser medium from the surface of rare medium is known as total internal reflection of light.

Condition of total internal reflection: - There are two conditions for total internal reflection of light.

(i) The light ray must go from a denser medium to a rare medium.

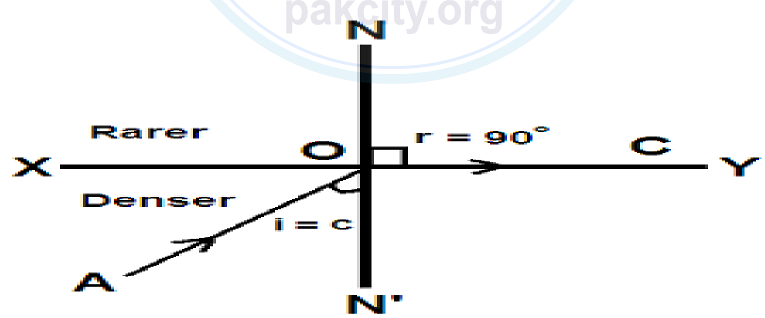
(ii) The angle of incidence in denser medium must be greater than the critical angle of the medium.

Explanation: - When a ray of light enters from an optically denser medium to a rare medium it bends away from the normal. In such a case the angle of refraction <r is greater than angle of incidence. If we increases the angle of incidence gradually, then the corresponding angle of refraction will also increases. At a certain angle of incidence the refracted angle becomes **90°,** this angle of incidence is called critical angle represented by **"θ_c".** Now if the incident angle is increased from critical angle the light ray bounce back to the same medium. This behavior of light is called total internal reflection of light.



RELATIONSHIP BETWEEN REFRACTIVE INDEX AND CRITICAL ANGLE FOR A GIVEN PAIR OF MEDIUM

Consider a light ray enter from a denser medium to a rare medium, so that the incident angle is critical angle and the refracted angle is 90° as shown in figure.



From figure

Angle of incidence =< i = θ_c
ii. Angle of refraction =< r = 90°
Snell's law for "n" when a ray of light move from denser medium to rarer medium then

$$n_1 \sin\angle i = n_2 \sin \angle 90^0$$

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By putting values in equation (i) we get.

$n_1 \sin\theta_c = n_2 \, sin \, (1)$ As sin90=1

$$n_1 \sin\theta_c = n_2$$

$$\sin\theta_c = \frac{n_1}{n_2}$$

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PRACTICAL APPLICATIONS OF TOTAL INTERNAL REFLECTION

PERISCOPE

Definition:- A device used to see objects which are above or below the eye level. OR
It is an optical instrument which can be used to see things that are not direct in sight.
Principle: - It works on the total internal reflection of light.
Construction:- A periscope consists of a long tube which is bent at 90° at both ends. At each end a totally reflecting prism is fixed.
Working : - An object "AB" is placed in front of a periscope, its image is seen through the periscope. Because each of the prism turns the incident ray of light though 90° which is shown in figure.

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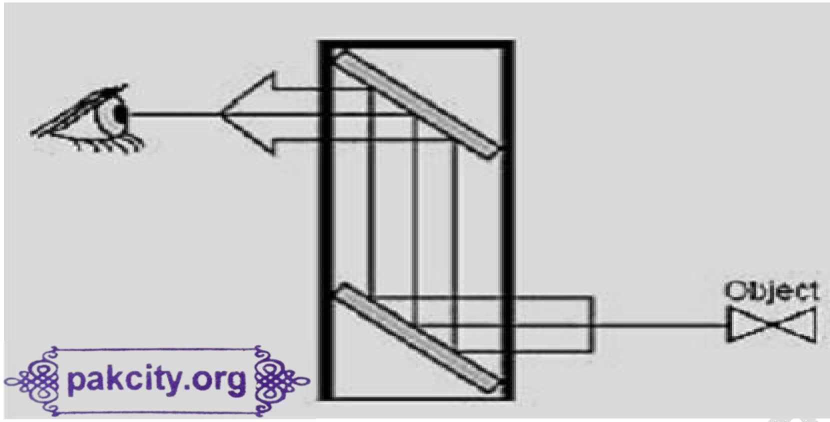

Figure (A) :-

Uses:- They are used in

(i) Submarine

(ii)Tanks.

(2) **The binoculars: -** It consists of prisms that reduce the length of the device and produce erect image. The light rays in a pair of binoculars are bent through 180° by each prism in contrast to the periscope where light rays are only bent through 90° by each prism as shown in figure.

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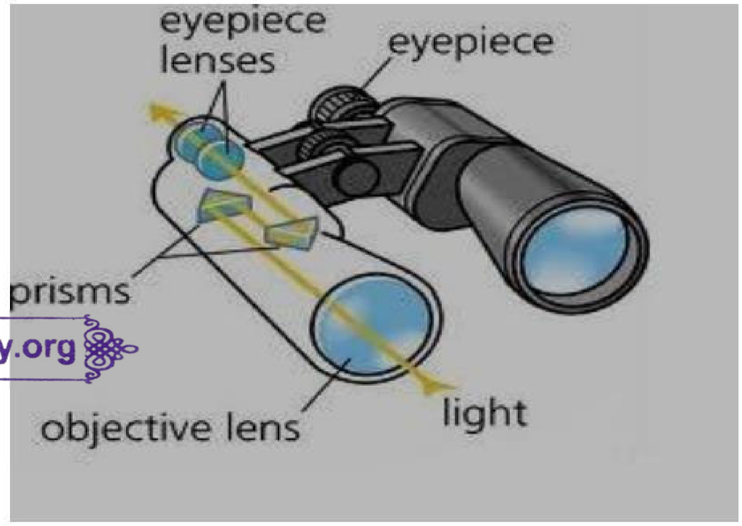

Figure

OPTICAL FIBRES

History:- Optical fibers was first was first of all made by **NARINDER SINGH KAPANY in 1952**.

Definition: - An optical is a very thin flexible glass or plastic rod which is coated with another type of glass whose refractive index is less than the inner tube. OR

Light can be trapped by total internal

Principle:- Its basic principle is total internal reflection.

Structure:- It has a cylindrical shape and consists of three concentric sections which are given below.

(1) The core (Higher refractive index).

(2)The cladding (Lower refractive index) .

(3) The jacket (Mechanical Protection).

WORKING:- When a ray of light enters from one end of the core strikes the core cladding boundary at the angle of incidence greater than the critical angle and reflected back to the core as shown in figure. In this way light travels many kilometers with small loss of energy. An optical fiber is made of a core of high refractive index i.e. glass or plastic. It is normally coated with glass of lower refractive index. A light ray introduce into the optical fiber will

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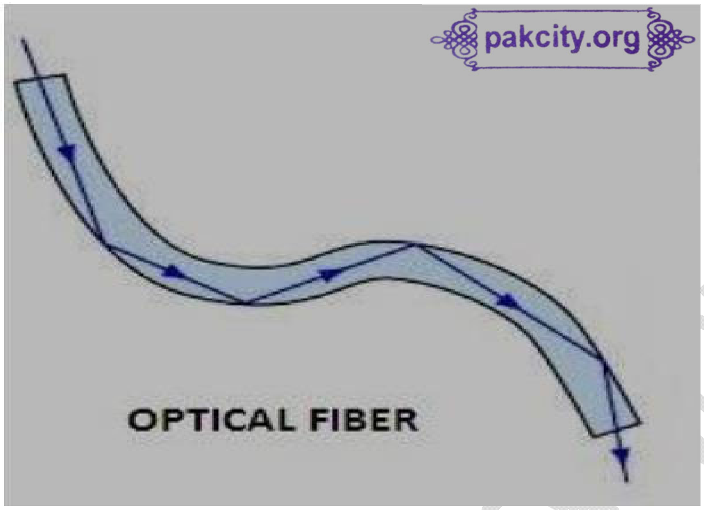
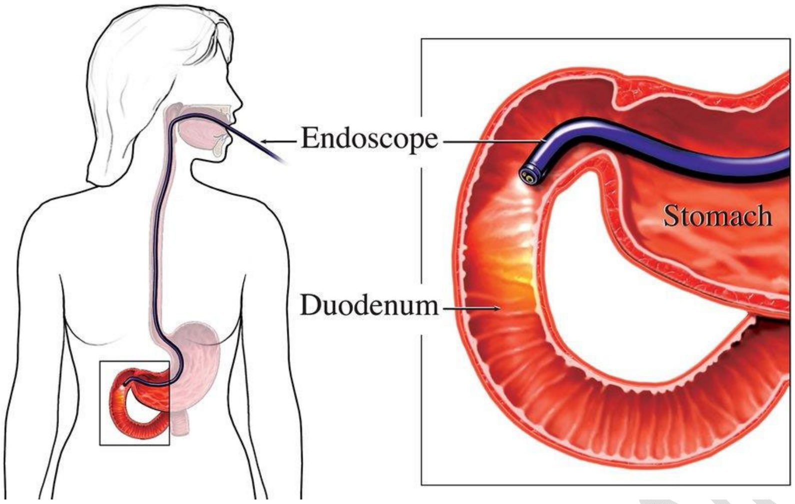
be internally reflected at the surface. The thickness of the fiber is equal to the thickness of the human hair that is 1/ 100 of mm.



Uses- A bundle of several thousands of such fibers are bound together in a flexible tube called light pipe. This light pipe is used by the surgeons to examine the interior parts of the body. Optical fibers are also used in telecommunication as it carries information faster than other wires like iron, copper, etc.

(2) Endoscope :-It is an optical instrument used to view and photograph a hollow organ inside the body such as the bladder, womb, etc. it works on the principle of total internal reflection of light. A video camera is fitted outside the bundle of fibers which can visible the interior organs of the patient which is to be operated.



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REFRACTION OF LIGHT THROUGH PRISM

PRISM

Definition: - It is a transparent body having three rectangular and two triangular surfaces. OR

It is a transparent optical element with at least two polished surface plane faces inclined towards each other from which light is refracted. OR
It is a pyramidal piece of glass with two triangular base and three rectangular lateral surfaces.

Explanation: -The three rectangular surfaces inclined to each other making a triangular boundary, while the two triangular surfaces are parallel to each other. The angle between the two refracting rectangular surfaces opposite to the base is called angle of the prism. Angle of the prism is denoted by" A".

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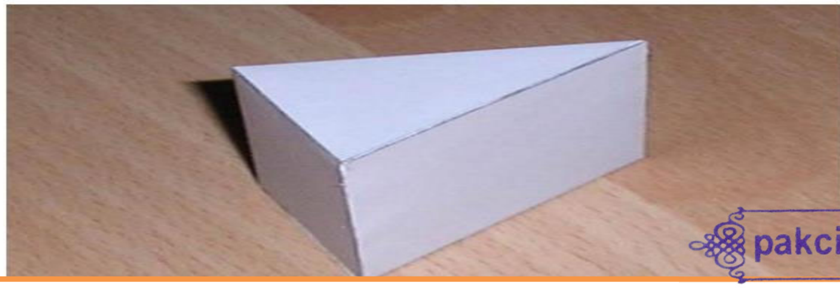
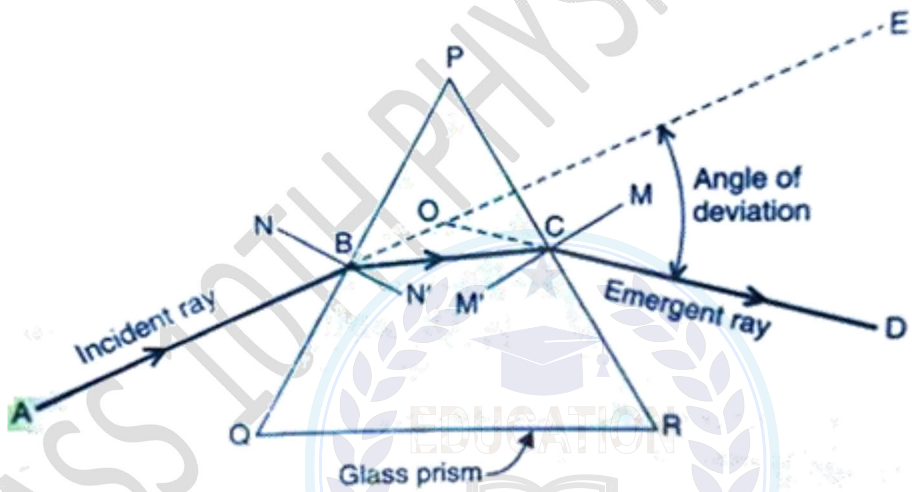


DEVIATION OF LIGHT THROUGH PRISM

Consider the ray of light **"AB"** strikes the face QP of the prism. The entering ray bends towards the normal as glass is denser than air and proceeded along **"BC"** and incident on the face **"PR"** of the prism. The ray **"CD"** bends away from the normal towards the base as air is rare medium and glass is denser. Extend **"AB"** as a **"AE"** and **"CD"** as **"OD",** they meet at point O. Thus the prism deviate the light ray AE through an angle **" EOD"** in the form of **"CD".** This angle "EOD" is called angle of deviation.



Measurement of angle deviation:- We can determine the angle of deviation for any shape of prism by applying Snell's law at each air-glass interface.

Factors of angle of deviation:- The value of angle of deviation depends upon the following factors:-

(i) Angle "A" of the prism.

(ii) The refractive index of the material of the prism.

(iii) The angle of prism.

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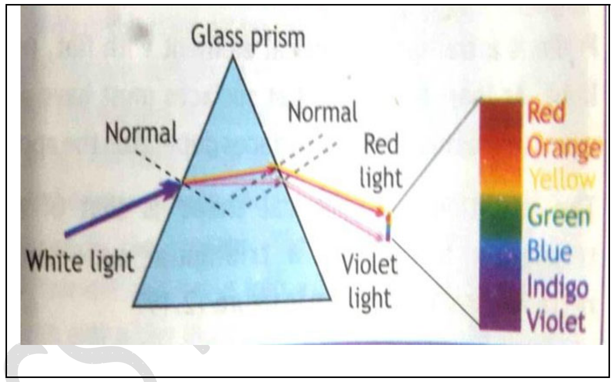
DISPERSION OF LIGHT THROUGH PRISM



Definition:- The phenomenon of splitting of white light into its seven constituent is known as dispersion of light.

Spectrum:- The band of seven colours formed due dispersion of white light is known as spectrum.

Explanation:- When sunlight (white light) falls on a triangular glass prism as shown in figure.A band of colours called spectrum is obtained. The effect is termed dispersion.

Reason:- It arises because white light is a mixture of many colours, the prism separates the colours because the refractive index of glass is different for each colour (it is greatest for violet light).

LENSES

Definition: - A lens is a transparent material usually made of glass which is bounded by a spherical surface at least from one side. OR

A transparent object having two faces at least one is curved is called as lens.

Basic principle: - Its basic principle is refraction of light.

Uses of lenses: - They are used in

(i) Cameras

(ii) Projectors

(iii) Telescopes

(iv) Spectacles etc.

Note: - Basically lenses are used to converge or diverge the incident beam of light.

TYPE OF LENSES

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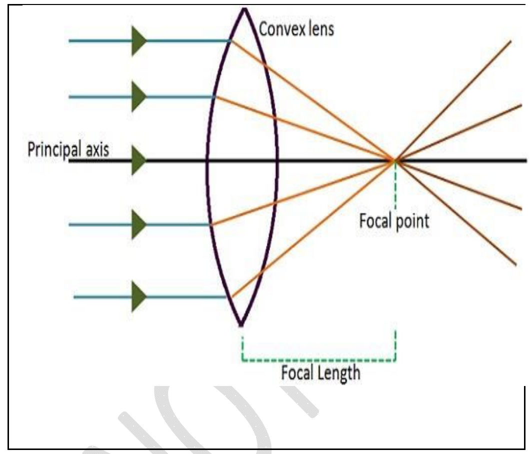
There are two main types of lenses which are given below.

(1) Convex lens

(2) Concave lens



(1) <u>Convex lens</u>:-

<u>Definition:</u> - A type of lens which is thicker at the center and thinner at the edges is called convex lens.

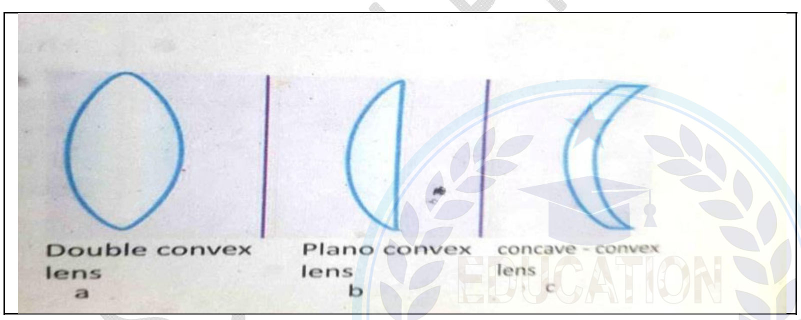
<u>Other Name</u>: - It is also called as converging lens, because it focus a parallel beam of light at a point known as focus point of the lens.

<u>Types of convex lens</u>: - There are three sub types of a convex lens which are given below.

(**<u>i) Double convex lens</u>** :- A convex lens whose both bounded surfaces are convex is known as double convex lens.

(ii) <u>Plano convex lens</u> :-A convex lens whose one bounded surface is plane and the other is convex is known as Plano convex lens.

(iii)<u>Concave convex lens</u>:- A convex lens whose one bounded surface is concave and the other is convex is known as concave convex lens.



(2) CONCAVE LENS

Definition: - A type of lens which is thinner at the center and thicker at the edges is called convex lens.

Other Name: - It is also called as diverging lens, because it scattered the parallel beam of light falls on it.

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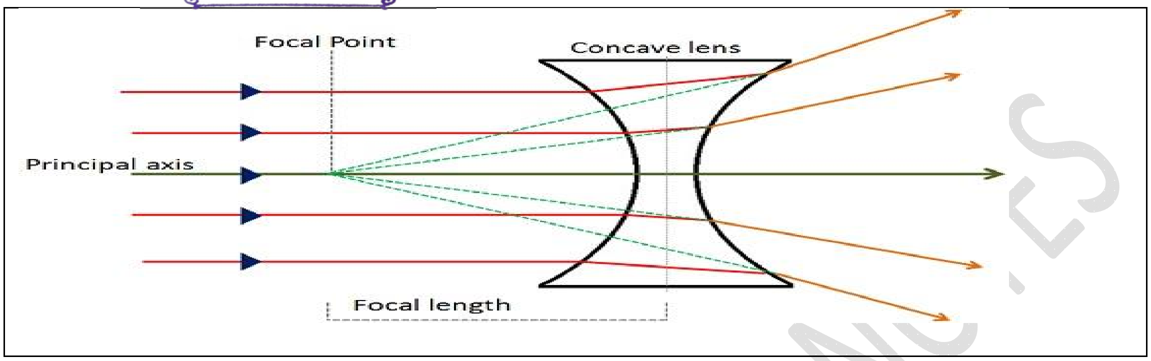
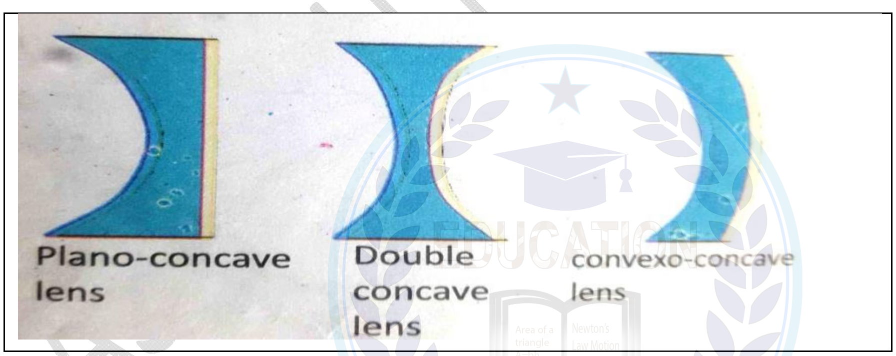


(2) Types of concave lens: There are three sub types of concave lens which given below.

(i) **Double concave lens:-** A concave lens whose both bounded surfaces are concave is known as double concave lens.

(ii) Plano concave lens :- A concave lens whose one bounded surface is plane and the other is concave is known as Plano concave lens.

(iii)Convex concave lens:- A concave lens whose one bounded surface is convex and the other is concave is known as convex concave lens.



THE MAIN TERMINOLOGIES IS USED IN LENSES

(1) Optical Centre:- The center point of a lens is called optical center.

Symbol:-It is denoted by "O".

(2) Principal axis :-The imaginary straight line passing from the optical center "O" and are perpendicular to both the faces of the lens is called principal axis.

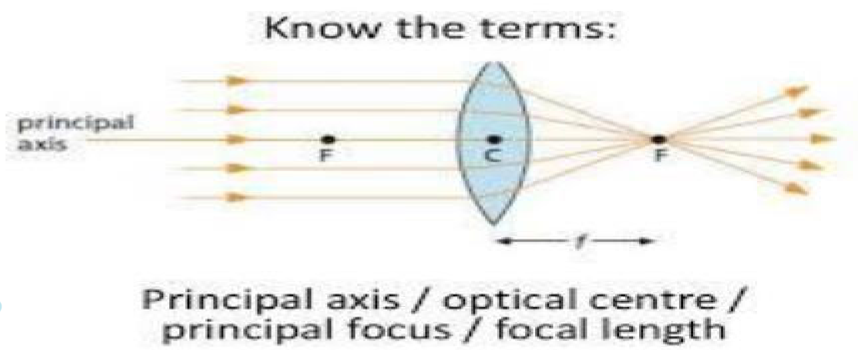
(3) Principal focus :-The point of a convex lens at which all the refracted rays are seem to converging is called principal focus or focus point. OR

The point of a concave lens from which all the refracted light rays are seem to be diverging is called principal focus or focus point. pakcity.org

Symbol:-It is denoted by "F". Lenses have two foci and are at equal distance from the optical centre at either side.

(4) Focal length:- The distance between the optical centre and focus point of the lense is called focal length.

Symbol:-It is denoted by **" f ".**



Focal length of the convex lens is taken positive while the focal length of the concave lens is taken negative.

SPECIAL RAYS DIAGRAM :-

(i) The ray of light through optical centre passes without refraction.

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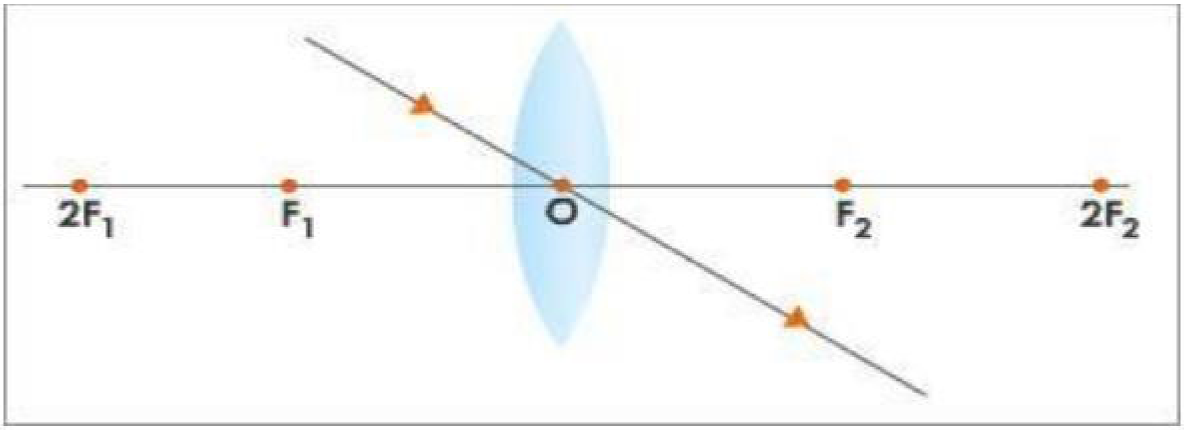
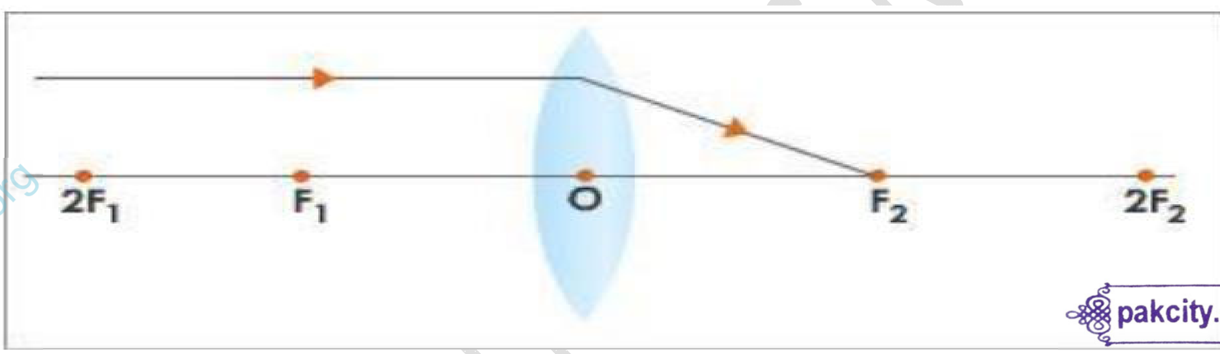
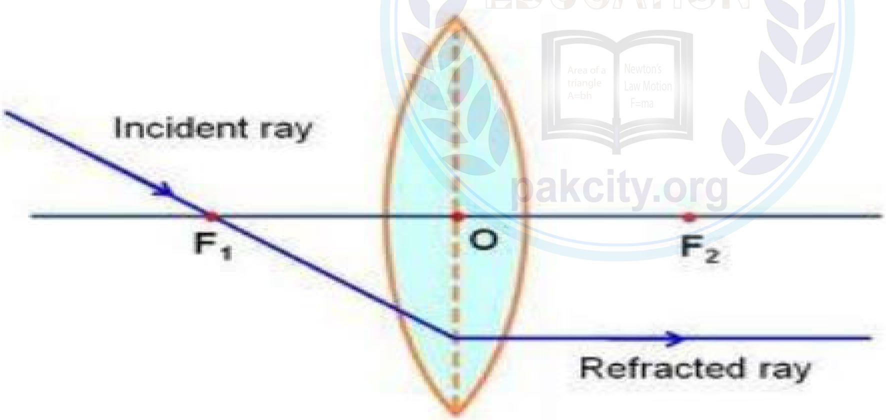


The ray of light parallel to the principal axis passes through focus point after refraction.



(i) The ray of light passing through focus point moves parallel to the principal axis after refraction.



Sign convention for lenses:-

(i)All the distance are measured from the optical centre "O" of the lense.

(ii)The distance of the real image from the lens is taken positive.

(iii)The distance of the virtual image from the lens is taken negative.

(iv)The focal length of a convex lens is taken positive and for a concave lens it is negative.

Lens formula:-

Definition: - A formula which gives the relation between image distance, object distance and focal length of a length is known as lens formula.

Mathematical form:- $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

Proof: - Consider an object "AB" is placed in front of a convex lens, its image " A'B' " is formed behind the lens. The distance of the object from the lens is "d_0" and distance of the image from the lens is "d_i".

Diagrammatically :-

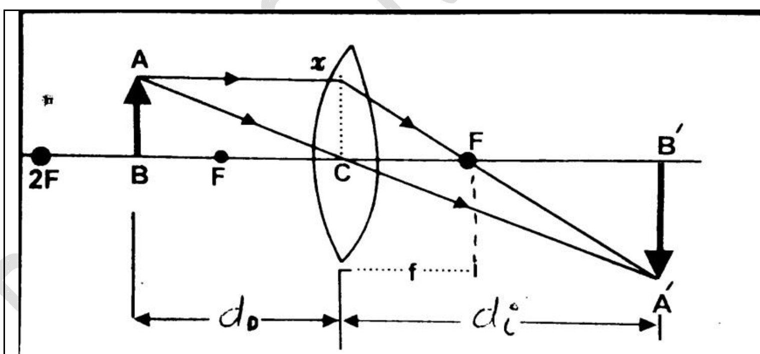


Fig.(14B.20). Thin lens formula diagram

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From figure Δ ABC and Δ A′ B′C are similar. Then

$$\frac{AB}{A'B'} = \frac{CB}{CB'} \quad \text{-------------------------(1)}$$

Similarly ΔFXC and ΔFA′B′ are similar, therefore

$$\frac{CX}{A'B'} = \frac{CF}{B'F} \quad \text{---------------------------(2)}$$

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AS CX= AB and CB′=OB′ – CF so eq (2) becomes

$$\frac{AB}{A'B'} = \frac{CF}{FB'} \quad \text{----------------------------- (3)}$$

Now comparing eq (1) and eq (3) we have

$$\frac{CB}{CB'} = \frac{CF}{FB'} \quad \text{------------------------- (4)}$$

As BC= d_o , CF= f and B'C= d_i and then eq (4) become

$$\frac{d_o}{d_i} = \frac{f}{d_i - f}$$

By cross multiplication we get

$$d_o \ (d_i - f) = d_i f$$

$$d_o d_i - d_o f = d_i f$$

Dividing both sides by $d_i d_o f$ we have

$$\frac{d_o d_i}{d_i d_o f} - \frac{d_o f}{d_i d_o f} = \frac{d_i f}{d_i d_o f}$$

$$\frac{1}{f} - \frac{1}{d_i} = \frac{1}{d_o}$$

$$OR$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

Equation (5) represent the required lens formula.

Liner magnification :-

Definition:-The ratio of the size of the image to the size of the object is called liner

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magnification.

Other Name: - It is also called magnifying power.

Representation:- It is represented by "M"

Mathematical Form: -

$$M = \frac{Size\ of\ the\ image}{size\ of\ the\ object} = \frac{OC}{O'C}$$

$$M = \frac{h_i}{h_0} \text{ -----------------------} \qquad (1)$$

Since $\frac{OC}{O'C} = \frac{q}{p}$ so we can also write M as

$$M = \frac{q}{p} \text{ --------------------------} \qquad (2)$$

Comparing eq (1) and (2) we have

$$M = \frac{h_i}{h_0} = \frac{q}{p}$$

Note:-The liner magnification is a unit less quantity because it is the ratio between two similar quantities.

Resolving Power:-

Definition: - The ability of an instrument to resolve two points which are close together is known as resolving power.

Explanation: -The term resolution is used to describe the precision with which any instrument measures and records any variables in the sample under study.

Power of a lens :-

Definition: - It can be defined as" the reciprocal of the focal length of a lens in meter is called power of a lens." OR The degree of convergence or divergence of light rays falling on lens is known as power of lens.

Representation: - It is represented by "D".

Mathematically: - $D = \frac{1}{f\ (m)}$

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CLASS 10TH PHYSICS NOTES

Unit: - Its SI unit is dioptre.

Dioptre:- One diopter is the power of lens whose focal length is one meter.

Factor: - The power of a lens depends on its focal length. The smaller the focal length the greater will be its converging or diverging power of the lens.

Measurement:- The power of a lens can be measured with the help of diopter meter.

Uses:- It is used by opticians to test the power of spectacle lenses.

Note: - The power of a convex lens is taken positive, while for a concave lens it is negative.

HUMAN EYE

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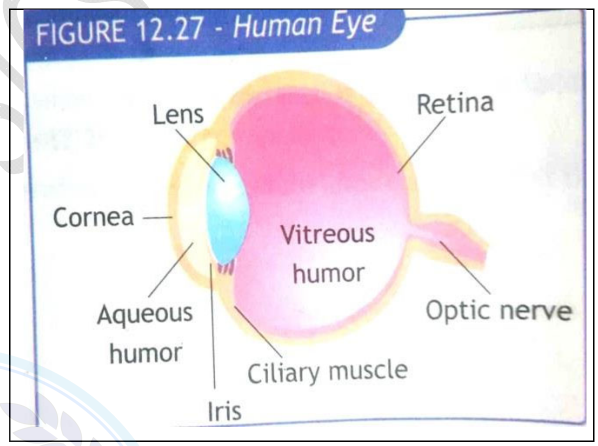
Definition:- It is the sense organ that helps us to see.

Location:- It is located in eye socket in skull.

Parts of eye:-



(i)**Sclera:-** It is the outer covering, a protective tough white layer called the sclera (white part of the eye).

(ii)**Cornea:-** The front transparent part of the sclera is called cornea. Light enters the eye through the cornea.

(iii)**Iris:-** A dark muscular tissue and ring like structure behind the cornea are known as the iris. The color of iris actually indicates the color of the eye. The iris also helps regulate or adjust exposure by adjusting the iris.

(iv)**Pupil:-** A small opening in the iris is known as a pupil. Its size is controlled by the help of iris. It controls the amount of light that enters the eye.

(v)**Lens:** Behind the pupil, there is a transparent structure called a lens. By the action of ciliary muscles, it changes its shape to focus light on the retina. It becomes thinner to focus distant objects and becomes thicker to focus nearby objects.

(vi)**Retina:** It is a light sensitive layer that consists of numerous nerve cells. It converts images formed by the lens into electrical impulses. These electrical impulses are then transmitted to the brain through optic nerves.

(vii)**Optic nerves:** Optic nerves are of two types. These include cones and rods.

DEFECTS OF VISION

Definition:- The inability of the eye to see the image of the objects clearly is known as defects of vision.

Cause: - The defects of vision arise when the eye lens is unable to accommodate effectively. The image formed is therefore blurred. OR

The defects of vision arise due to the inability of the eye lens to produce sharp image on retina.

Types of defects of vision:-There are two types of defects of vision which are given below.

(1) Short sightedness

(2) Long-sightedness

(1) Short sightedness: -

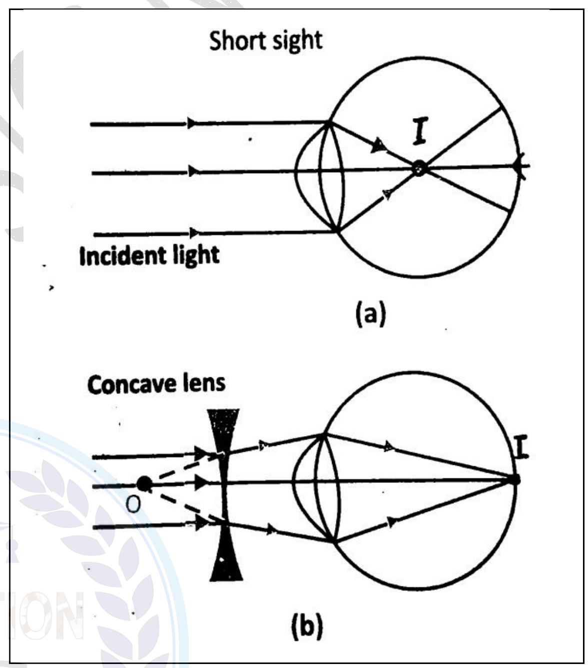
Definition:-The defect in which an eye can see near objects clearly but distance objects are not clearly seen is known as short sightedness.

Other Name: - This defect is also called myopia.

Cause: - This defect of eye is caused due to the high converging power of the eye lens or the eye ball being too long.

Location of image: - The rays from a distant object are focused in the front of the retina and the a blurred image is produced.

Correction (treatment): - This defect can be corrected by using a concave lens of suitable focal length in the spectacles.

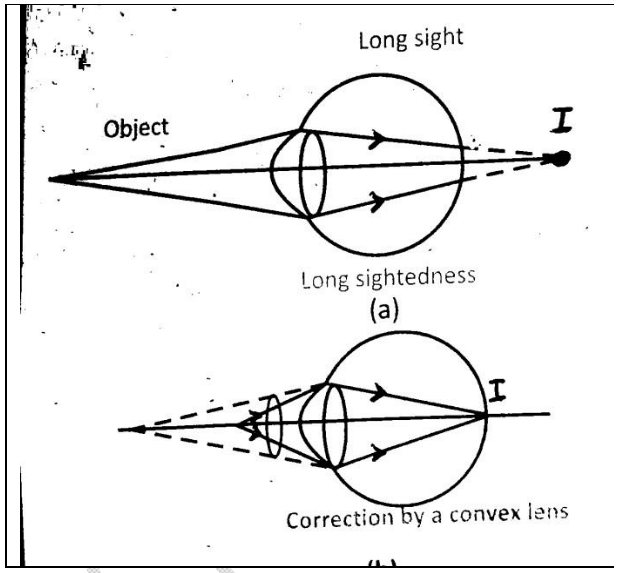


2. Long sightedness: -

Definition: - The defect in which an eye can see far objects clearly but near objects are not clearly seen is known as long sightedness.

Other Name: - This defect is also called Hypermetropia.

Cause: - This defect of eye is caused due to the low converging power of the eye or the eye ball being too short.



- **Location of image:** - The rays of the near objects focus behind the retina and the images formed behind of retina.
- **Correction (treatment):** - This defect can be corrected by using a convex lens of suitable focal length in the spectacles.

ANGULAR MAGNIFICATION

Definition:- It is the angular size " θ'" of the final image produced by instruments divided by a reference angular size " θ".

Other Name:- It is also called "Magnifying Power ".

Symbol:- It is denoted by " m_θ".

Mathematical Form:-

$$\text{Angular Magnification} = \frac{\text{Angular size of final image produced by by optical instrument}}{\text{Refrence angular size of objects seen without optical instrument}}$$

$$m_\theta = \frac{\theta'}{\theta}$$

SIMPLE MICROSCOPE

Definition: -It is an optical device with the help of which we can see the magnified image of very small objects is known as simple microscope.

Other Name: - It is also called magnifying glass.

Construction: - It is a convex lens of short focal length.

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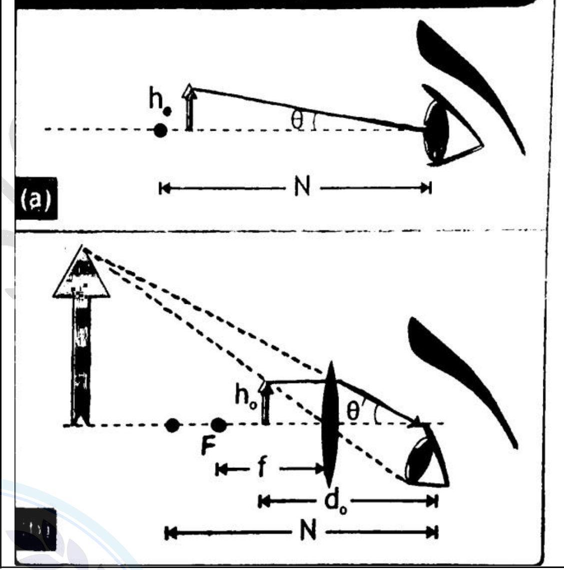
Principle: - It works on the principle that when an object is placed within its focal length, a magnified, virtual and erect image is formed. The image formed through a microscope is larger than the object, it becomes easy to study small objects.

FIGURE 12.32 - Simple microscope



Ray diagram of simple microscope: -

Angular magnification:- As we know that

$$m_\theta = \frac{\theta'}{\theta} \text{ .... (1)}$$

For calculation of θ: - From figure (a) the angle subtended by the object without the magnifier is given by

$$\tan\theta = \frac{Perpendicular}{Base} = \frac{h_0}{N} \text{ .... (2)}$$

For calculation of θ': - From figure (b)

$$\tan\theta' = \frac{Perpendicular}{Base} = \frac{h_0}{d_0} \text{ .... (3)}$$

For small angles:-

(i) $\tan\theta = \theta$

(ii) $\tan\theta' = \theta'$

So equation(2) and (3) becomes.

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$$\theta = \frac{Perpendicular}{Base} = \frac{h_0}{N} \text{ .... (4)}$$

$$\theta^/ = \frac{Perpendicular}{Base} = \frac{h_0}{d_0} \text{ .... (5)}$$

Now by putting equation (4) and (5) in equation (1) we get

$$m_\theta = \frac{\theta^/}{\theta} = \frac{\frac{h_0}{d_0}}{\frac{h_0}{N}} = \frac{h_0 \times N}{d_0 \times h_0} = \frac{h_0 \times N}{d_0 \times h_0} = \frac{N}{d_0} \text{ .... (6)}$$

$$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i} \quad \text{OR} \quad \frac{1}{d_0} = \frac{1}{f} - \frac{1}{d_i} \text{ .... (7)}$$

Now by putting equation (7) in equation (6) we get.

$$m_\theta = \frac{N}{d_0} = \left(\frac{1}{f} - \frac{1}{d_i}\right) N \text{ .... (8)}$$

Special cases:-

(1) For nearer image:- d_i **= - N then**

$$m_\theta = \left(\frac{1}{f} - \frac{1}{-N}\right) N = N\left(\frac{1}{f} + \frac{1}{N}\right) = \frac{N}{f} + \frac{N}{N} = \frac{N}{f} + 1$$

$$m_\theta = \frac{N}{f} + 1 \text{ .... (9)}$$

Eq (9) represents the magnifying power simple microscope for nearer image.

(2) For farthest image:- $d_i = \infty$ **then from equation (8)**

$$m_\theta = \left(\frac{1}{f} - \frac{1}{\infty}\right) N = N\left(\frac{1}{f} - 0\right) = N\left(\frac{1}{f}\right) = \frac{N}{f} \qquad \frac{1}{\infty} = 0$$

$$m_\theta = \frac{N}{f} \text{ .... (10)}$$

Eq (10) represents the magnifying power simple microscope for **farthest** image.

Uses: -

i. Watch maker used simple microscope to see the small parts of a watch clearly.

ii. Jewelers used it to observe fine parts of jewelry etc.

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COMPOUND MICROSCOPE

Definition: - An optical instrument which is used for observing small objects clearly.

Construction:- It consist of two convex lenses of

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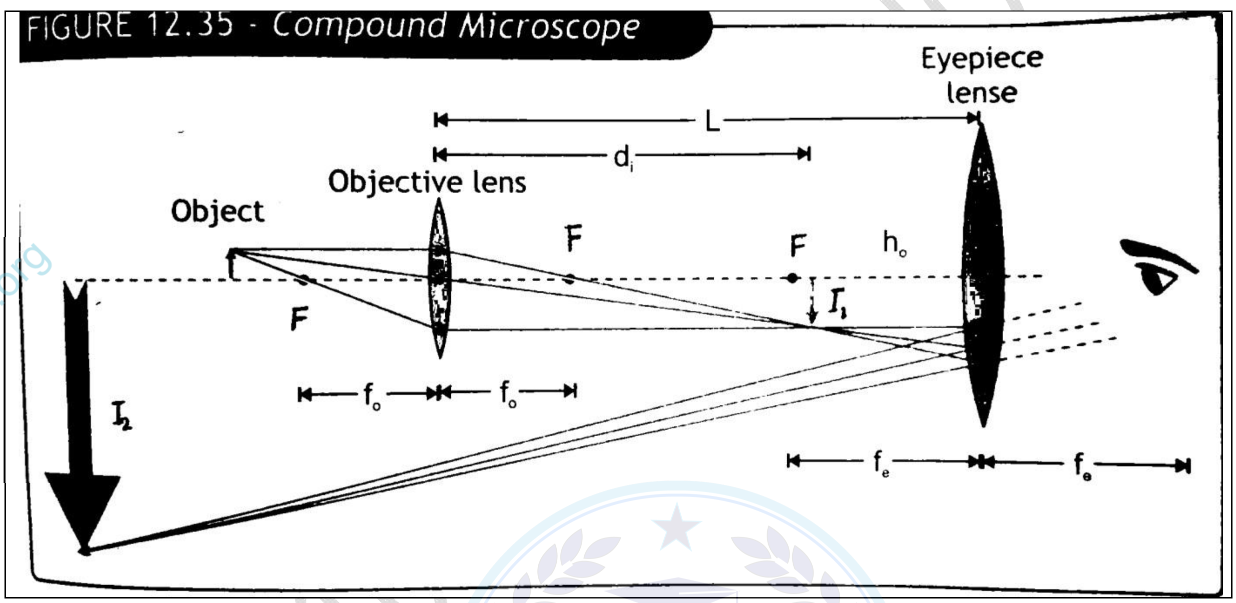
i. Objective lens of short focal length.

ii. Eyepiece of large focal length.

Ray Diagram :-



Working of compound microscope: - The object is placed beyond the principle focus of the objective lens. This produces a real, magnified image of the object at a place situated within the focal eye-piece. This image now act as an object for eye-piece lens. It is then further magnified by the eye-piece, so that the final magnified image is produced by the compound microscope.

Magnifying Power of compound microscope (M): As we know that

$$M = Mo \times Me \text{ .... } (1)$$

In equation (1)

(i) M_o represents the magnifying power of objective.

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(ii) M_e represents the magnifying power of eye-piece.

Magnification produced by the objective lens (M_0):-

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$$M_0 = -\frac{h_i}{h_0} = -\frac{d_i}{d_0} = \frac{d_i}{f_0} \text{ .... (2)}$$

In equation (2)

i. p = focal length of objective = f_o

ii. q = length of tube of microscope = L

thus equation (2) becomes $\quad Mo = \frac{L}{f_o}$ .... (3)

For Me:- As the eye-piece behave like a simple microscope so its magnifying power will be $\quad m_e = \frac{N}{fe}$ .... (3) Now

by putting the eq (2) and (4) in eq (3) we get

$$m = -\frac{d_i}{f_o} \times \frac{N}{f_e} \text{ .... (4)}$$

The equation (4) represent the magnifying power of compound microscope. The minus sign indicates that the image is inverted. This equation shows magnifying power of compound microscope will be greater by using shorter focal length.

Uses: - It is used

(i) To study bacteria and other micro objects.

(ii) For research in several field of sciences like microbiology, botany, genetics etc.

REFRACTING TELESCOPE

Definition:- A device used to view heavenly bodies and distant objects like sun, stars, moon etc. are known as astronomical telescope. OR

An optical instrument which is used to observe distant objects uses lenses or mirrors is know is astronomical telescope.

Other Name:- It is also called **"Astronomical Telescope".**

Construction: - It consist of two convex lenses:-

(1) Objective lens of large focal length which forms a real image.

(2) Eyepiece of short focal length (also called ocular) which is used to view this real image.

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Working: - When parallel rays from a point on a distant object pass through the objective lens, a real image (I_1) is formed at the focus (F_0) of the objective lens. This image acts as an object for the eyepiece. A large virtual image I2 of I1 is formed by eyepiece at a large distance from the objective lens. pakcity.org

Rey diagram of telescope: -

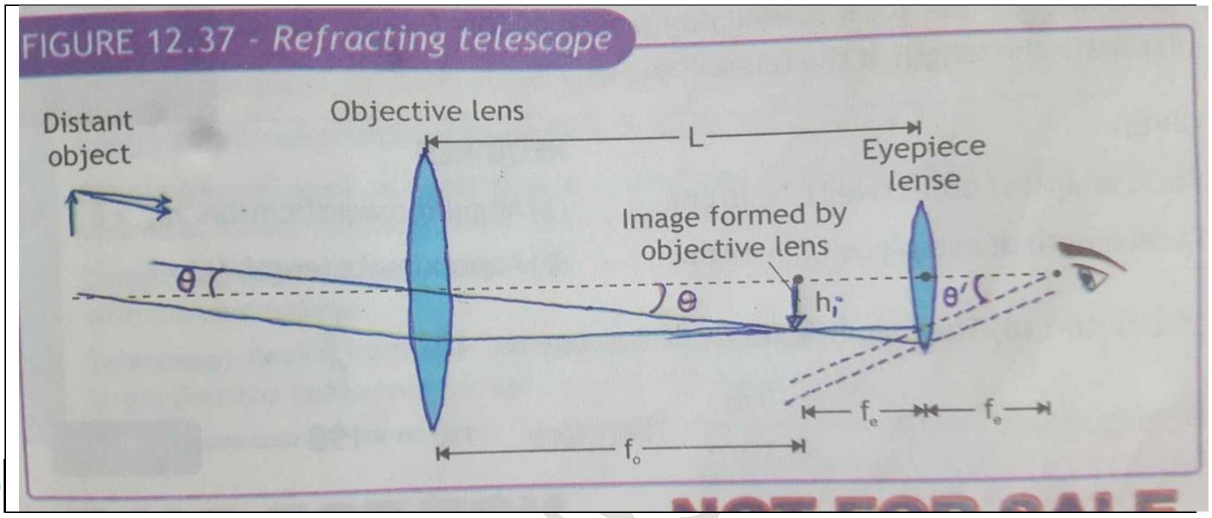

FIGURE 12.37 - Refracting telescope

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Angular Magnification of telescope: -

$$m_\theta = \frac{\theta^/}{\theta} \text{ .... (1)}$$

For θ :- $\theta = -\frac{h_i}{f_0}$ .... (2)

For$\theta^/$:- $\theta^/ = \frac{h_i}{f_e}$ .... (3)

By putting values in equation (2) and (3) in equation (1) we get.

$$m_\theta = \frac{\theta^/}{\theta} = \frac{\frac{h_i}{fe}}{\frac{h_i}{fe}} = \frac{h_i}{f_e} \times \frac{f_0}{h_i} = \frac{f_o}{f_e}$$

$$m_\theta = \frac{f_o}{f_e} \text{ .... (1)}$$

In equation (1):-

i.f_0 = focal length of objective of the telescope.

Ii. f_e = focal length of eyepiece of the telescope.

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Note: - From equation (1) it is cleared that for high magnifying power of telescope the focal length of its objective (f_0) should be large.

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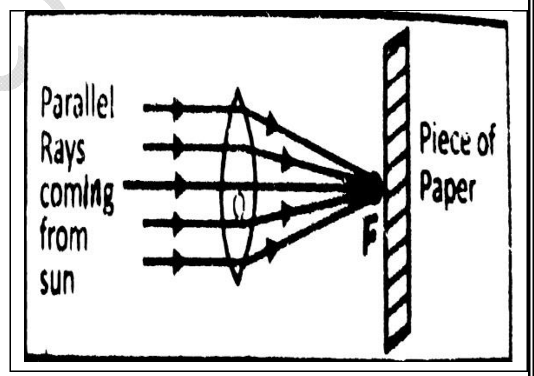
CONCEPTUAL QUESTIONS

Q # 01: Which type of lens would you use to start fire from sun concave or convex , would work does best ? At what distance from the lens should the paper be held for best result?

Ans:- Statement:- We will use convex lens to start fire from the sun and for best result the paper will be held at focus point of the convex lens.



Reason:- It is because that the convex lens is converging in nature.

Explanation:- As we know that a convex lens has the ability to converge a parallel beam of light. Therefore it is also called converging lens. When rays of sun of light, parallel to the principle axis, fall on a convex lens, they converge at a point on the principle axis after refraction from the lens. When sunlight is concentrated on a paper placed at the principal focus of a convex lens, then the paper starts to burn because the sunlight gets focused on a small region. The paper starts burning after reaching its ignition temperature.

Conclusion:- As conclusion we find that We use convex lens to start fire from the sun and the paper will be held at focus point of the convex lens.

Q # 02:- If a concave mirror produces a real image, is the image necessarily inverted? Explain.

Ans: - Statement:- Yes, the image will be necessarily inverted if a concave mirror produces a real image.

Reason:- It is because of converging nature.

Explanation:- As we know that concave mirror is also called converging mirror because it has ability to converse a parallel beam of light and normally it produce a real image. A real image is an image which is formed when light rays actually passes through the point where the image is formed. Real image will be always inverted because it is, its nature.

Conclusion:- As conclusion we find that the image will be necessarily inverted if a concave mirror produces a real image.

Q # 03:- Are rearview mirrors used in cars concave or convex?

Ans:- Statement:- Convex mirrors are used as a rearview in cars.
Reason:- Because it provide a larger field of view than the concave mirrors.
Explanation:- As we know that convex mirrors are used in vehicles to observe rear view. It makes small, erect and virtual images of the objects behind the vehicle. This type of mirror collects together spread-out rays of light and thereby provides a wide field of view. For the same reason large convex mirrors are often placed at dangerous roads bends for safe drive.
Conclusion:- As conclusion we find that Convex mirrors are used as a rearview in cars.

Q#04:- A magician during a show makes a glass lens with n=1.47 disappears in a trough (tub) of liquid. What is the refractive index of the liquid? Could the liquid be water?

Ans:- Statement:- A magician during a show makes a glass lens with n=1.47 disappears in a trough (tub) of liquid. The refractive index of the liquid is n=1.47.
Reason:- It is because of same value of refractive index.

Explanation:- As we know that

Refractive index of glass = n_g=1.47

Refractive index liquid = n_L=1.47

Condition:- If $n_g = n_L$ then f = ∞(at infinity).

Hence the lens in the liquid will act like a plane sheet, when refractive index of the lens and the surrounding medium is the same.
As for water n_w = 1.33, so water cannot be used for disappearance of the lens. It may be glycerin or turpentine because same refractive index which is equal to 1.47.
Conclusion: - As conclusion we find that A magician during a show makes a glass lens with n=1.47 disappears in a trough of liquid. The refractive index of the liquid is n=1.47.

Q#05: Suppose that you were handed a lens and a ruler and told do determine the focal length of the lens. How would you proceed? pakcity.org

Ans: - Statement:- We can determine the focal of the lens by using a ruler.

Explanation:- First focus an image of a distant object. The focusing point should be sharp. Take a ruler and measure the distance of image (d_i) from the mirror, then determine the distance of the object (d_0) from the mirror and at last using formula.

$$\frac{1}{f} = \frac{1}{d_i} - \frac{1}{d_0} \quad \text{............................} (1)$$

By using equation (1) we can find the focal length of the lens.

Q#06:- Can we achieve total internal reflection from optically rare medium to optically dense medium?

Ans:- **Statement:-** No we cannot achieve total internal reflection from optically rare medium to optically dense medium.
Reason:- It is because in this case the condition of total internal reflection is not satisfied.
Explanation:- As we know that from wave theories the two conditions required for total internal reflection to occurs are as follows:-

(1) The light must be travel from an optically more dense medium into optically less dense medium.

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(2) The angle of incidence must exceeds the critical angle, θ_c associated with the material.

Conclusion:- As conclusion we find that we cannot achieve total internal reflection from optically rare medium to optically dense medium.

Q#07:-Will a nearsighted person who wear corrective lenses in her glass be able to see clearly underwater when those glasses?

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Ans:- **Statement**:- No the person will not see clearly underwater who wearing nearsighted corrective lenses .
Reason:- It is because of both the water and air has different refractive index.

Explanation:- As we know that

(i) Refractive index of water = n_w = 1.33
(ii) Refractive index of air = n_{air} = 1.0003.

This high refractive index of water affects the refraction of light rays. Due to this effect in different media, our vision would be different, when our eyes are exposed to air, we have normal vision, which might be good. But when we get underwater, the medium is water, so our vision would be lowered and limited. . So, nearsighted people would have worse vision than those with good vision.

Conclusion:- As conclusion we find that the nearsighted person will not be able see clearly in the water by wearing nearsighted corrective lenses.

Q #8 :- When you use a simple magnifying glass, does it matter whether you hold the object to be examined closer to the lens than its focal length or farther away ? Explain.

Ans:- Statement:- Yes it matters whether we hold the object to be examined closer to the lens than its focal length or further away by using magnifying glass.

Reason:- It is because the basic principle of magnifying glass.
Explanation:- As we know that magnifying glass or simple microscope is an optical device with the help of which we can see the magnified image of very small objects.

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Its basic principle is that When an object is placed with in its focal length a magnified, virtual and erect image is formed.

Conclusion:- As conclusion we find that it matters whether we hold the object to be examined closer to the lens than its focal length or further away by using magnifying glass.

Q # 9:- In blind turns on hilly roads, mirrors are used to help drivers. Are these mirrors plane mirrors, concave mirrors or convex mirrors? Explain.

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Ans:- Statement:- Convex mirrors are used in blind turns on hilly roads to help the drivers.

Reason:- It is because they provides a wider angle of vision and a larger field of view.

Explanation:- :- As we know that convex mirrors are used in blind turns on hilly roads to help the drivers to see vehicle coming from the other side. It makes small, erect and virtual images of the objects behind the vehicle. This type of mirror collects together spread-out rays of light and thereby provides a wide field of view.

Conclusion:- As conclusion we find that Convex mirrors are used in blind turns on hilly roads to help the drivers.

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CLASS 10TH PHYSICS NOTE
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NUMERICAL QUESTIONS

Pb# 01: A 1.50 cm high object is placed 20.0 cm from a concave mirror with radius of curvature 30.0 cm. Determine (a) the position of the image, and (b) its size, also draw the ray diagrams.

GIVEN DATA:-

Height of object = h_o = 1.50 cm

Object distance = d_0 = 20 cm

Radius of curvature = R= 30 cm

Focal length of a concave mirror= f= $\frac{R}{2} = \frac{30}{2}$ = 15 cm

REQUIRED DATA:-

a) Image position = d_i=?

b) Size of image = h_i = ?

SOLUTION:-

a) For Image position = d_i :-

FORMULA:-

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \text{ .... (1)}$$

CALCULATION:- By Putting values in equation (1) we get

$$\frac{1}{d_i} = \frac{1}{15} - \frac{1}{20}$$ take 60 as LCM we have

$$\frac{1}{d_i} = \frac{4-3}{60} = \frac{1}{60}$$

$$d_i = 60\text{cm}$$

b) **For size of image = h_i :-**

FORMULA:-

$$h_i = -\frac{d_i}{d_o} \times h_o \text{ .... (2)}$$

CALCULATION:- By Putting values in equation (2) we get

$$h_i = -\frac{60}{20} \times 1.5 = -4.5 \text{ cm.}$$

The negative sign shows that image will be inverted.

Pb# 02:-A candle of height 8.0 cm is located at a distance of 300 mm from a convex mirror; its virtual image is formed behind the mirror at a distance of 3.0 cm from the pole (or vertex). Find the focal length of the mirror and height of the image formed.

GIVEN DATA:-

Height of object = h_o = 8.0 cm

Object distance = d_0 = 300 mm= 30cm

Image distance = d_i= -3.0 cm

REQUIRED DATA:-

a) Focal length mirror = f=?
b) Size of image = h_i = ?

SOLUTION:-

a) For focal length = f:-

FORMULA:-

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \quad \text{...} \quad (1)$$

CALCULATION:- Putting values in eq 1 we get

$$\frac{1}{f} = \frac{1}{30} + \frac{1}{-3} \quad \text{take 30 as LCM we have}$$

$$\frac{1}{f} = \frac{1-10}{30} = -\frac{9}{30} = -\frac{3}{10}\text{ cm}$$

f = -3.33 cm

FORMULA:-

$$h_i = -\frac{d_i}{d_o} \times h_o \quad \text{...} \quad (2)$$

CALCULATION:- Putting values in eq 2 we get

$$h_i = -\frac{-3}{30} \times 8 = 0.8 \text{ cm}$$

RESULT:- (i) f = -3.33 cm. (ii) h_i = 0.8 cm.

Pb#03:Calculate the speed of light in zircon with index of refraction n = 1.923, a material used in jewelry to replicate diamond.

GIVEN DATA:-
Refractive index= n= 1.923
Speed of light= c= 3×10^8 m/sec

REQUIRED DATA:-
Speed of light in Zircon=v= ?

SOLUTION:- As we know that

FORMULA:- n= $\frac{C}{V}$ OR v= $\frac{C}{n}$ .... (1)

CALCULATION:- By putting values in eq (1) we get

$$v = \frac{C}{n} = \frac{3\times10^8}{1.923} = 1.56 \times 10^8 \text{ m/sec}$$

RESULT:- v= **1.56×10^8 m/sec**

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Pb#04: A light ray strikes an air / water surface at an angle of 46 ^{0} with respect to the normal. The refractive index for water is 1.33. Find the angle of refraction when the direction of the ray is (a) from air to water and (b) from water to air.

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GIVEN DATA:-

Angle of incidence = θ_i= 46^0

Refractive index of water= n_w = $n_{2=}$1.33

Refractive index of air= n_{air} = n_1=1.33

REQUIRED DATA:-

(a) Angle of refraction from air to water= θ_r= ?

(b) Angle of refraction from water to air= θ_r= ?

SOLUTION:- As we know that

For (a) Angle of refraction from air to water= θ_r:-

FORMULA:- From Snell's law

$$n_1 \text{ Sin } \theta_1 = n_2 \text{ Sin } \theta_2 \quad \text{OR} \quad \frac{n_1}{n_2} = \frac{sin\theta_2}{sin\theta_1}$$

……………. (1)

CALCULATION:- By Putting values in eq 1 we get

$sin\theta_r$= $\frac{\sin 46^0}{1.33}$ = $\frac{0.71}{1.33}$ = 0.54

θ_r =sin^{-1} (0.54)= 32.68^0

For (b) Angle of refraction from water to air= θ_r:-

FORMULA:- n= $\frac{sin\theta_r}{sin\theta_i}$ OR

$sin\theta_r$= n sinθ_i …..(2)

By Putting values in eq 2 we get

$sin\theta_r$= n sinθ_i = 1.33 x sin 46^0= 1.33 x 0.71= 0.94

θ_r= sin^{-1}(0.94)= 70^0

RESULT:- (a) θ_r= 32.68^0 (b) θ_r= 70^0

Pb# 05:An optical fiber is made from flint glass with index of refraction 1.66 and is surrounded by a cladding made of crown glass with index of refraction 1.52. What is the critical angle?

GIVEN DATA:-
Refractive index of flint glass=n_1= 1.66
Refractive index of crown glass=n_2= 1.52
REQUIRED DATA:-
Critical angle =θ_c=?
SOLUTION:- As we know that
FORMULA:- $\sin\boldsymbol{\theta_c}=\frac{\boldsymbol{n_2}}{\boldsymbol{n_1}}$ OR $\boldsymbol{\theta_c}=\sin^{-1}(\frac{\boldsymbol{n_2}}{\boldsymbol{n_1}})$ .... (1)

CALCULATION:- By putting values in eq1 we get
$\theta_c=\sin^{-1}(\frac{1.52}{1.66})=\sin^{-1}(0.91)=65.5^0$
RESULT:- $\theta_c=65.5^0$

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Pb#06:Suppose the book page is held 7.50 cm from a concave lens of focal length 10.0 cm and convex lense of focal length -10 cm. What magnification is produced in each case?

GIVEN DATA:-
Distance of book= d_0= 7.50cm
Focal length of concave lens= 10.0 cm
Focal length of convex lens= -10.0 cm
REQUIRED DATA:-
(a) Magnification due to concave lens=M_1=?
(b) Magnification due to convex lens=M_2=?
SOLUTION:- As we know that
FORMULA:-
(a)For Magnification due to concave lens=M_1:-
$M_1=\frac{d_i}{d_o}=\frac{fd_o}{d_o(f-d_o)}=\frac{f}{f-d_o}$ .... (1)

As $d_i=\frac{fd_o}{f-d_o}$

CALCULATION:- By putting values in eq 1 we get
$M_1=\frac{f}{f-d_o}=\frac{10}{10-7.50}=4$
For (b) Magnification due to convex lens=M_2:
$M_2=\frac{d_i}{d_o}=\frac{fd_o}{d_o(f-d_o)}=\frac{f}{f-d_o}$ .... (2)

As $d_i=\frac{\boldsymbol{f}d_o}{f-d_o}$

CALCULATION:- By putting values in eq 2 we get
$M_1=\frac{f}{f-d_o}=\frac{-10}{-10-7.50}=0.57$

Pb#07:Gulalai is viewing a flea using a magnifier with f = 3.0 cm. If her near point is at N = 25 cm then calculate the maximum magnification she can get.

GIVEN DATA:-
Focal length=f= 3.0cm
Her near point =N= 25cm
REQUIRED DATA:- magnification =M=?
SOLUTION:- As we know that
FORMULA:- $M=\frac{N}{f}+1$ .... (1)

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CALCULATION:- By putting values in eq 1 we get
$M=\frac{N}{f}+1=\frac{25}{3}+1=\frac{28}{3}=9.33$
RESULT:- M= 9.33

Pb#08: A telescope has a magnification of 40.0 and a length of 1230 mm. What are the focal lengths of the objective and eyepiece?

GIVEN DATA:-
Magnification= M= 40.0
Approximate length of telescope= f_e=1230mm
REQUIRED DATA:-
(a) Focal length of objective = f_o=?
(b) Focal length of eyepiece = f_e=?
SOLUTION:- As we know that
FORMULA:- For (b) Focal length of eyepiece = f_e :- $f_e=\frac{L}{(1-M)}$ .... (1)
CALCULATION:- By putting Values in eq 1 we get
$f_e=\frac{L}{(1-M)}=\frac{1230}{(1-40)}$ = 31.5 mm
FORMULA:- For (a) Focal length of objective = f_o :- $f_o = L-f_e$ .... (2)
CALCULATION:- By putting Values in eq 2 we get
$f_o = L-f_e$ = 1230-31.5= 1198.5 mm

RESULT:- (a) f_o **=** 1198.5mm
(b) f_e = 31.5 mm

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