Ch-10 Light – Reflection and Refraction

Reflection of Light

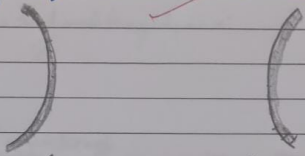
The laws of reflection are:-

(i) Angle of ~~reflection~~ incidence ($\angle i$) = Angle of reflection ($\angle r$)

(ii) Incident ray, reflected ray, and normal, all lie on the same plane.

Spherical Mirrors

A spherical mirror whose reflecting surface is curved inward is called a concave mirror. A spherical mirror whose reflecting surface is curved outwards is called convex mirror.



Concave mirror

Convex mirror

[shaded side non-reflecting]

Terms commonly used in spherical mirror

- Pole: Center point of the reflecting surface. Represented by 'P'.
- Center of Curvature: The radius of the sphere of which the reflecting surface of a spherical region forms a part is called the radius of curvature, represented by 'R'. (Radius)

> Center of Curvature: The reflecting surface of a spherical mirror forms a part of a sphere which has a center called radius of curvature. It is represented by 'C'.

> Principal Axis: Imaginary straight line passing through the pole and center of curvature of a spherical mirror. Principal axis is normal to the mirror at the pole.

> Focus: The reflected rays from a spherical mirror meet at a point or appears to come from a point on the principal axis. This point is called focus, represented by 'F'.

> Aperture: The diameter of the reflecting surface of a spherical mirror is called aperture.

For a spherical mirror, the radius of curvature is found to be twice the focal length, i.e:

$2f = R$

Questions:

> Radius of curvature of spherical mirror is 20cm. Find its focal length.

> Given $R = 20cm$

$2f = 20cm$

$f = 10cm$

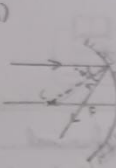
> Find focal length of convex mirror whose radius of curvature is 32cm

> Given $R = 32cm$

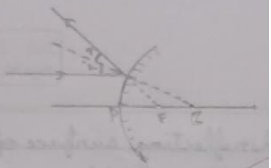
$2f = R = 32cm$

$f = 16cm$

(i)

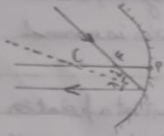


(a)

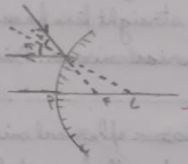


(b)

(ii)

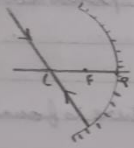


(a)

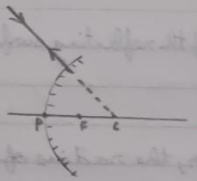


(b)

(iii)

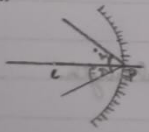


(a)

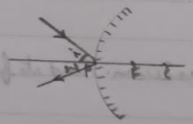


(b)

(iv)



(a)



(b)

(a) concave

(b) convex

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Rules for drawing ray diagram

(i) A ray parallel to the principal axis, after reflection will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.

(ii) A ray passing through the principal focus of a concave mirror or a ray directed towards the principal focus of a convex mirror, will emerge parallel to the principal axis.

(iii) A ray passing through the center of curvature of a concave mirror or directed towards the center of curvature of a convex mirror is reflected back along the same path. The light rays come back along the same path because the incident rays fall on the mirror along the normal to the reflecting surface.

(iv) A ray incident obliquely to the principal axis towards the pole is reflected obliquely. The incident and reflected rays follow the laws of reflection at the point of incidence making equal angles with the principal axis.

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Exercise Questions

14. An object of length 5.0cm is placed at a ~~length~~ distance of 20cm in front of a convex mirror of radius of curvature of 30cm. Find the position of the image, its nature and size.

Ans: $h = 5cm$

$u = -20cm$

$R = 30cm$

$f = \frac{R}{2} = 15cm$

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

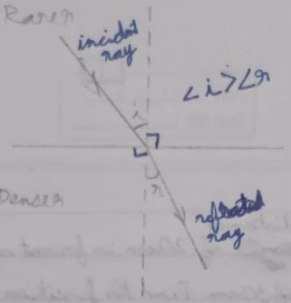
$\Rightarrow \frac{1}{v} = \frac{1}{15} - \frac{1}{(-20)}$

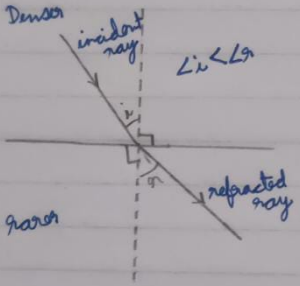
$\Rightarrow \frac{1}{v} = \frac{1}{15} + \frac{1}{20}$

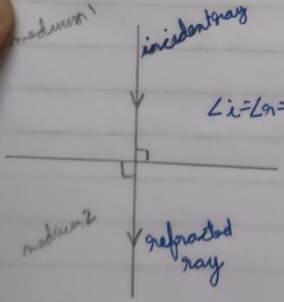
$\Rightarrow \frac{1}{v} = \frac{35}{300} \Rightarrow v = \frac{300}{35} = 8.5cm$

$m = \frac{-v}{u} = \frac{-8.5}{-20} = \frac{17}{40} = 0.425cm$

Image is erect and virtual


Rarer
incident ray
$\angle i > \angle r$
i
r
Denser
refracted ray


Denser
incident ray
$\angle i < \angle r$
i
r
refracted ray
Rarer


medium 1
incident ray
$\angle i = \angle r = 0°$
medium 2
refracted ray

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Refraction of light

Refraction is the process of changing the direction of the path of light when it moves from one medium to another. When light moves from rarer medium to denser medium, refracted ray bends towards normal, i.e. $\angle i > \angle r$. Where i is the incident angle and r is refracted angle. When light moves from denser medium to rarer medium, refracted ray bends away from the normal, i.e. $\angle i < \angle r$. When light falls on same direction of normal, it does not get refracted.

Refraction through rectangular glass slab

When the light falls through rectangular glass slab, it will undergo 2 refraction processes:

(i) Light (which) is coming from air to glass slab. (incident ray)

(ii) Light going out of glass slab. (emergent ray)

Emergent ray will be $\parallel$ to the incident ray.

Laws of refraction.

(i) Incident ray, refracted ray and normal to the interface of two transparent media all lie in the same plane.

(ii) The ratio of sin of $\angle i$ and sin of $\angle r$ is constant for the light of a given colour and pair of media. This law is also known as Snell's law of refraction. (True if $0° \leq i < 90°$)

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

This constant value is the refractive index.

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Refractive index

When light moves from one medium to another, the extent of the change in direction which takes place in a given pair of media can be expressed in terms of refractive index. The refractive index for a given pair of media depends on the speed of light in the two media. Eg: When light moves from medium 1 to medium 2, let v_1 be speed of light in medium 1 and v_2 be speed of light in medium 2. Then, refractive index of medium 2 to medium 1 $= n_{21} =$ Speed of light in medium 1 / Speed of light in medium 2

$$= \frac{v_1}{v_2}$$

Then, refractive index of medium 1 to medium 2 $= n_{12}$

$$= \frac{\text{Speed of light in medium 2}}{\text{Speed of light in medium 1}} = \frac{v_2}{v_1}$$

If medium 1 is vacuum or air, refractive index of medium 2 is considered with respective to vacuum. It is called absolute refractive index represented by n.

$$n = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}} = \frac{c}{v}$$

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1. A ray of light travelling in air enters obliquely into water. Does light ray bend towards or away from normal? Why?

Ans: Light ray bends towards normal because the density of water is more than air.

2. Light enters from air to glass having refractive index 1.5. What is the speed of light in glass? Speed of light in vacuum is 3×10^8 m/s.

Ans: $c = 3 \times 10^8$ m/s [given]

$n = 1.5$ [given]

$n = \frac{c}{v}$

$\Rightarrow 1.5 = \frac{3 \times 10^8 \text{ m/s}}{v}$

$\Rightarrow 1.5v = 3 \times 10^8$ m/s

$\Rightarrow v = \frac{3 \times 10^8 \text{ m/s}}{1.5} = 2 \times 10^8$ m/s

3. Find out from table 10.3 medium with highest and lowest optical density.

Ans: Highest: diamond Lowest: air