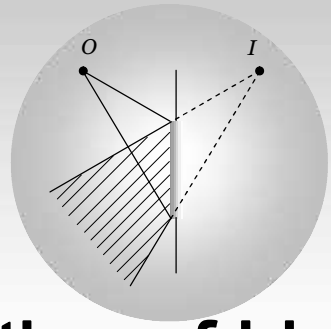
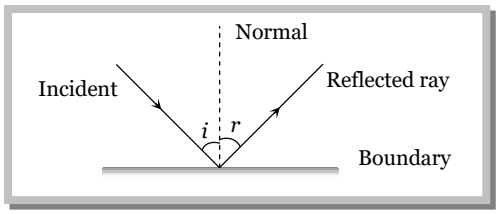


Reflection of Light

When a ray of light after incidenting on a boundary separating two media comes back into the same media, then this phenomenon, is called reflection of light.



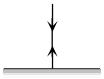
$\Rightarrow \quad \angle i = \angle r$

$\Rightarrow$ After reflection, velocity, wave length and frequency of light remains same but intensity decreases

$\Rightarrow$ There is a phase change of π if reflection takes place from denser medium

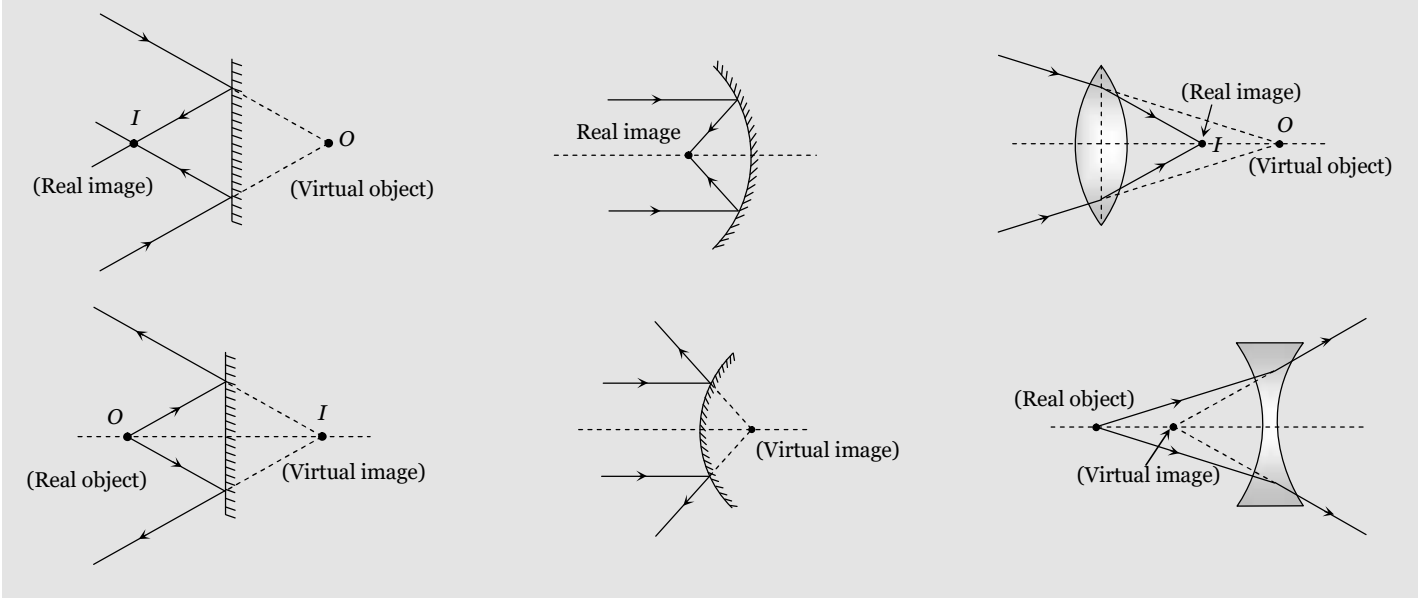
Note : ❑ After reflection velocity, wavelength and frequency of light remains same but intensity decreases.

❑ If light ray incident normally on a surface, after reflection it retraces the path.



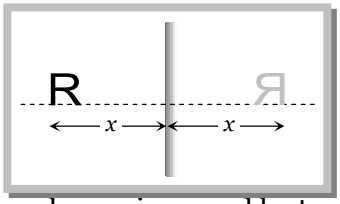
Real and virtual images

If light rays, after reflection or refraction, actually meets at a point then real image is formed and if they appears to meet virtual image is formed.

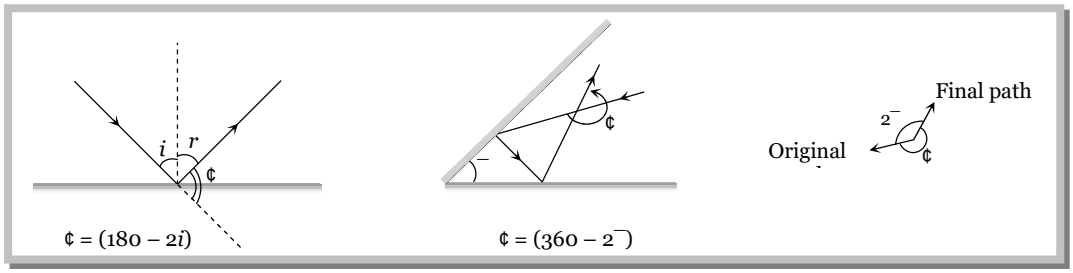


Plane Mirror

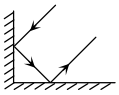
The image formed by a plane mirror is virtual, erect, laterally inverted, equal in size that of the object and at a distance equal to the distance of the object in front of the mirror.



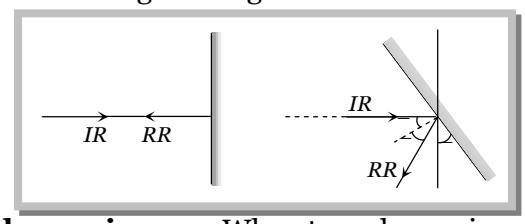
(1) **Deviation :** Deviation produced by a plane mirror and by two inclined plane mirrors.



Note : ❑ If two plane mirrors are inclined to each other at 90°, the emergent ray is anti-parallel to incident ray, if it suffers one reflection from each. Whatever be the angle to incidence.



(2) **Rotation :** If a plane mirror is rotated in the plane of incidence through angle ¯, by keeping the incident ray fixed, the reflected ray turned through an angle 2¯.

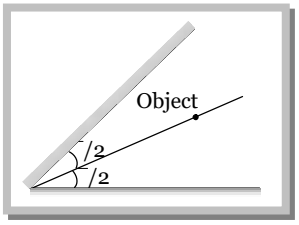


(3) **Images by two inclined plane mirrors :** When two plane mirrors are inclined to each other at an angle ¯, then number of images (n) formed of an object which is kept between them.

(i) $n = \left(\frac{360}{\bar{}} - 1\right)$; If $\frac{360}{\bar{}}$ = even integer

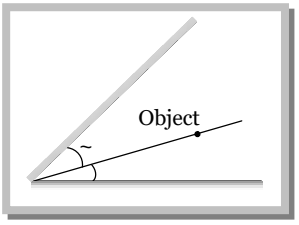
(ii) If $\frac{360}{\bar{}}$ = odd integer then there are two possibilities

(a) Object is placed symmetrically



$n = \left(\frac{360}{\bar{}} - 1\right)$

(b) Object is placed asymmetrically



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

Note : ❑ If $\theta = 0^\circ$ *i.e.* mirrors are parallel to each other so $n = \infty$ *i.e.* infinite images will be formed.

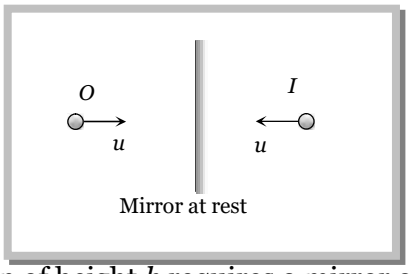
❑ If $\theta = 90^\circ$, $n = \frac{360}{90} - 1 = 3$

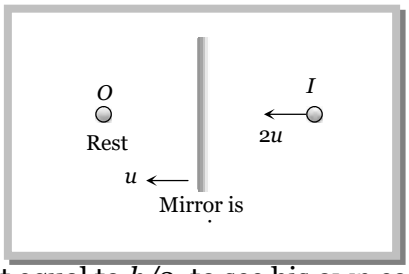
❑ If $\theta = 72^o$, $n = \dfrac{360}{72} - 1 = 4$ (If nothing is said object is supposed to be symmetrically placed).

(4) **Other important informations**

(i) When the object moves with speed u towards (or away) from the plane mirror then image also moves toward (or away) with speed u. But relative speed of image *w.r.t.* object is $2u$.

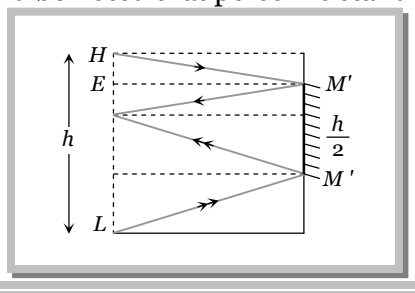
(ii) When mirror moves towards the stationary object with speed u, the image will move with speed $2u$.

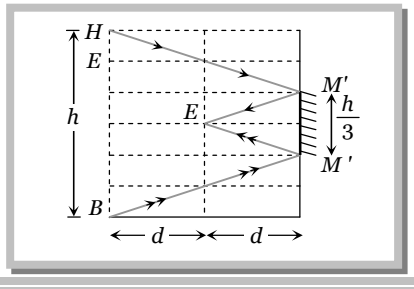




(iii) A man of height h requires a mirror of length at least equal to $h/2$, to see his own complete image.

(iv) To see complete wall behind himself a person requires a plane mirror of at least one third the height of wall. It should be noted that person is standing in the middle of the room.

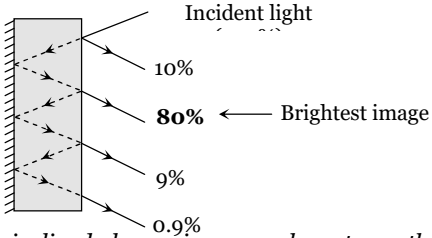




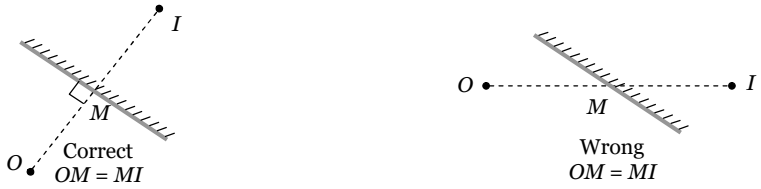
Concepts

☞ *The reflection from a denser medium causes an additional phase change of ® or path change of ª/2 while reflection from rarer medium doesn't cause any phase change.*

☞ *We observe number of images in a thick plane mirror, out of them only second is brightest.*



☞ *To find the location of an object from an inclined plane mirror, you have to see the perpendicular distance of the object from the mirror.*

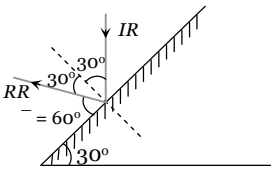


Example

***Example*: 1** A plane mirror makes an angle of 30° with horizontal. If a vertical ray strikes the mirror, find the angle between mirror and reflected ray

(a) 30^o (b) 45^o (c) 60^o (d) 90^o

Solution : (c) Since angle between mirror and normal is 90^o and reflected ray (RR) makes an angle of 30^o with the normal so required angle will be $\theta = 60^o$.



***Example*: 2** Two vertical plane mirrors are inclined at an angle of 60^o with each other. A ray of light travelling horizontally is reflected first from one mirror and then from the other. The resultant deviation is

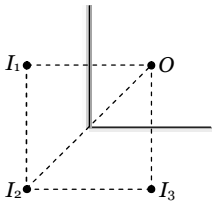
(a) 60^o (b) 120^o (c) 180^o (d) 240^o

Solution : (d) By using $\delta = (360 - 2\theta)$ $\Rightarrow$ $\delta = 360 - 2 \times 60 = 240^o$

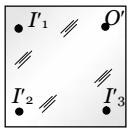
***Example*: 3** A person is in a room whose ceiling and two adjacent walls are mirrors. How many images are formed

(a) 5 (b) 6 (c) 7 (d) 8

Solution : (c) The walls will act as two mirrors inclined to each other at 90^o and so sill form $\frac{360}{90} - 1 = 3$ images of the person. Now these images with object (Person) will act as objects for the ceiling mirror and so ceiling will form 4 images as shown. Therefore total number of images formed = 3 + 4 = 7



Three images by walls



Four images by

Note : ❑ The person will see only six images of himself (I_1, I_2, I_3, I'_1, I'_2, I'_3)

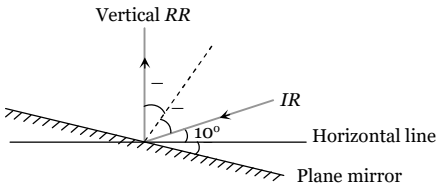
***Example*: 4** A ray of light makes an angle of 10^o with the horizontal above it and strikes a plane mirror which is inclined at an angle θ to the horizontal. The angle θ for which the reflected ray becomes vertical is

(a) 40^o (b) 50^o (c) 80^o (d) 100^o

Solution : (a) From figure

$\theta + \theta + 10 = 90$

$\Rightarrow \theta = 40^o$



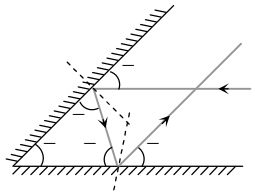
***Example*: 5** A ray of light incident on the first mirror parallel to the second and is reflected from the second mirror parallel to first mirror. The angle between two mirrors is

(a) 30^o (b) 60^o (c) 75^o (d) 90^o

Solution : (b) From geometry of figure

$\theta + \theta + \theta = 180^o$

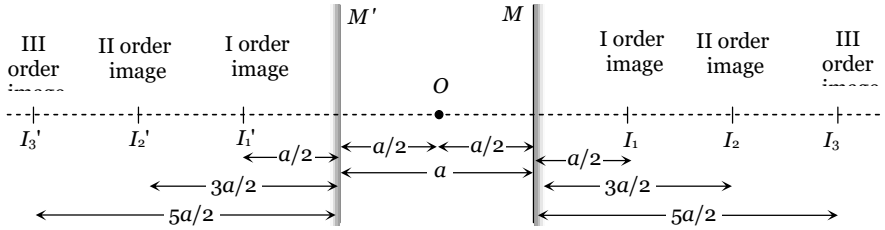
$\Rightarrow \theta = 60^o$



***Example*: 6** A point object is placed mid-way between two plane mirrors distance 'a' apart. The plane mirror forms an infinite number of images due to multiple reflection. The distance between the nth order image formed in the two mirrors is

(a) na (b) $2na$ (c) $na/2$ (d) $n^2 a$

Solution : (b)



From above figure it can be proved that seperation between nth order image formed in the two mirrors = $2na$

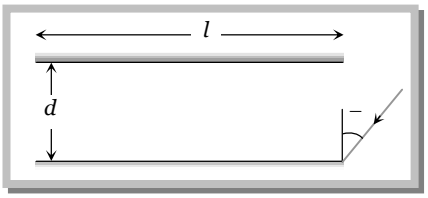
***Example*: 7** Two plane mirrors P and Q are aligned parallel to each other, as shown in the figure. A light ray is incident at an angle of $^{-}$ at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is

(a) $\dfrac{l}{d\tan^{-}}$

(b) $\dfrac{d}{l\tan^{-}}$

(c) $ld\tan^{-}$

(d) None of these

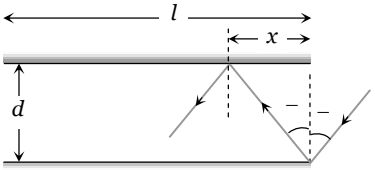


Solution : (a) Suppose n = Total number of reflection light ray undergoes before exist out.

x = Horizontal distance travelled by light ray in one reflection.

So $nx = l$ also $\tan^{-} = \dfrac{x}{d}$

$\Rightarrow \quad n = \dfrac{l}{d\tan^{-}}$



***Example*: 8** A plane mirror and a person are moving towards each other with same velocity v. Then the velocity of the image is

(a) v (b) $2v$ (c) $3v$ (d) $4v$

Solution : (c) If mirror would be at rest, then velocity of image should be $2v$. but due to the motion of mirror, velocity of image will be $2v + v = 3v$.

***Example*: 9** A ray reflected successively from two plane mirrors inclined at a certain angle undergoes a deviation of 300^{o}. The number of images observable are

(a) 10 (b) 11 (c) 12 (d) 13

Solution : (b) By using $¢ = (360 - 2^{-})$ $\Rightarrow$ $300 = 360 - 2^{-}$

$\Rightarrow$ $^{-} = 30^{o}$. Hence number of images $= \dfrac{360}{30} - 1 = 11$

Tricky example: 1

A small plane mirror placed at the centre of a spherical screen of radius R. A beam of light is falling on the mirror. If the mirror makes n revolution. per second, the speed of light on the screen after

reflection from the mirror will be

(a) $4®nR$ (b) $2®nR$ (c) $\frac{nR}{2®}$ (d) $\frac{nR}{4®}$

Solution : (a) When plane mirror rotates through an angle $¯$, the reflected ray rotates through an angle $2¯$. So spot on the screen will make $2n$ revolution per second

y Speed of light on screen $v = \mu R = 2®(2n)R = 4®nR$

Tricky example: 2

A watch shows time as 3 : 25 when seen through a mirror, time appeared will be

(a) 8 : 35 (b) 9 : 35 (c) 7 : 35 (d) 8 : 25

Solution : (a) For solving this type of problems remember

Actual time = 11 : 60 – given time

So here Actual time = 11 : 60 – 3 : 25 = 8 : 35

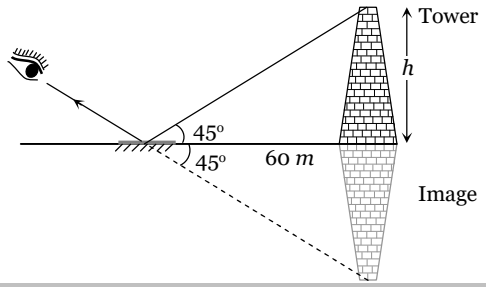
Tricky example: 3

When a plane mirror is placed horizontally on a level ground at a distance of 60 m from the foot of a tower, the top of the tower and its image in the mirror subtend an angle of 90^o at the eye. The height of the tower will be

(a) 30 m (b) 60 m (c) 90 m (d) 120 m

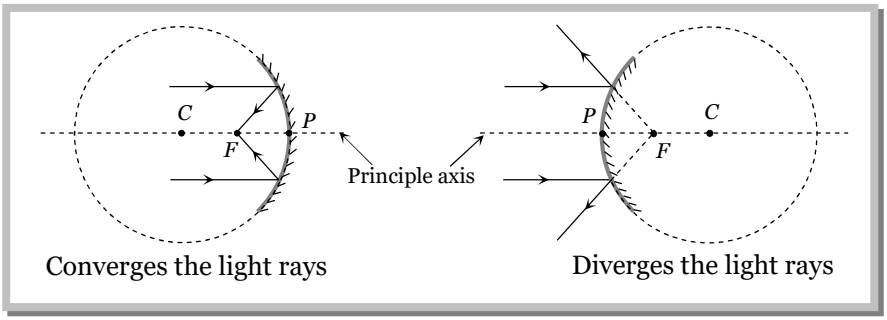
Solution : (b) Form the figure it is clear that $\frac{h}{60} = \tan 45^o$

$\Rightarrow h = 60\ m$



Curved Mirror

It is a part of a transparent hollow sphere whose one surface is polished.



(1) **Some definitions :**

(i) **Pole (P)** : Mid point of the mirror

(ii) Centre of curvature (C) : Centre of the sphere of which the mirror is a part.

(iii) Radius of curvature (R) : Distance between pole and centre of curvature.

($R_{concave} = -ve$, $R_{convex} = +ve$, $R_{plane} = \infty$)

(iv) Principle axis : A line passing through *P* and *C*.

(v) Focus (F) : An image point on principle axis for which object is at ∞

(vi) Focal length (f) : Distance between *P* and *F*.

(vii) Relation between *f* and *R* : $f = \frac{R}{2}$ ($f_{concare} = -ve$, $f_{convex} = +ve$, $f_{plane} = \infty$)

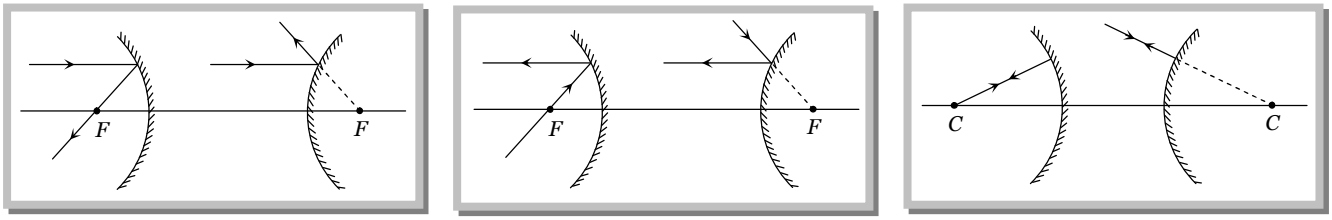
(viii) Power : The converging or diverging ability of mirror

(ix) Aperture : Effective diameter of light reflecting area. Intensity of image $\propto$ Area $\propto$ (Aperture)^2

(x) Focal plane : A plane passing from focus and perpendicular to principle axis.

(2) **Rules of image formation and sign convention** :

Rule (i) Rule (ii) Rule (iii)

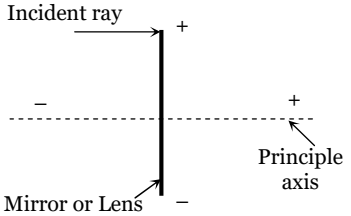


(3) **Sign conventions :**

(i) All distances are measured from the pole.

(ii) Distances measured in the direction of incident rays are taken as positive while in the direction opposite of incident rays are taken negative.

(iii) Distances above the principle axis are taken positive and below the principle axis are taken negative.

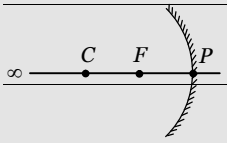
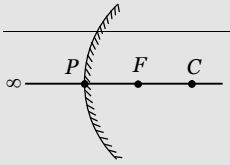


Note : ❑ Same sign convention are also valid for lenses.

Use following sign while solving the problem :

	Concave mirror		Convex mirror
	Real image (u ≥ f)	Virtual image (u< f)	
Distance of object	$u \rightarrow -$	$u \rightarrow -$	$u \rightarrow -$
Distance of image	$v \rightarrow -$	$v \rightarrow +$	$v \rightarrow +$
Focal length	$f \rightarrow -$	$f \rightarrow -$	$f \rightarrow +$
Height of object	$O \rightarrow +$	$O \rightarrow +$	$O \rightarrow +$
Height of image	$I \rightarrow -$	$I \rightarrow +$	$I \rightarrow +$
Radius of curvature	$R \rightarrow -$	$R \rightarrow -$	$R \rightarrow +$
Magnification	$m \rightarrow -$	$m \rightarrow +$	$m \rightarrow +$

(4) Position, size and nature of image formed by the spherical mirror

Mirror	Location of the object	Location of the image	Magnification, Size of the image	Nature	
				Real / virtual	Erect / Inverted
(a) Concave	At infinity *i.e.* $u = \infty$	At focus *i.e.* $v = f$	$m << 1$, diminished	Real	Inverted
	Away from centre of curvature ($u > 2f$)	Between f and $2f$ *i.e.* $f < v < 2f$	$m < 1$, diminished	Real	Inverted
	At centre of curvature $u = 2f$	At centre of curvature *i.e.* $v = 2f$	$m = 1$, same size as that of the object	Real	Inverted
	Between centre of curvature and focus : $F < u < 2f$	Away from the centre of curvature $v > 2f$	$m > 1$, magnified	Real	Inverted
	At focus *i.e.* $u = f$	At infinity *i.e.* $v = \infty$	$m = \infty$, magnified	Real	Inverted
	Between pole and focus $u < f$	$v > u$	$m > 1$ magnified	Virtual	Erect
(b) Convex	At infinity *i.e.* $u = \infty$	At focus *i.e.*, $v = f$	$m < 1$, diminished	Virtual	Erect
	Anywhere between infinity and pole	Between pole and focus	$m < 1$, diminished	Virtual	Erect

Note : ❑ In case of convex mirrors, as the object moves away from the mirror, the image becomes smaller and moves closer to the focus.

❑ Images formed by mirrors do not show chromatic aberration.

❑ For convex mirror maximum image distance is it's focal length.

❑ In concave mirror, minimum distance between a real object and it's real image is zero. (*i.e.* when $u = v = 2f$)

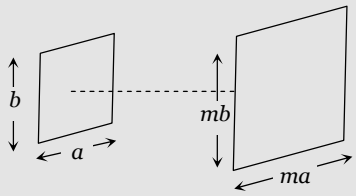
Mirror formula and magnification

For a spherical mirror if u = Distance of object from pole, v = distance of image from pole, f = Focal length, R = Radius of curvature, O = Size of object, I = size of image, m = magnification (or linear magnification), m_s = Areal magnification, A_o = Area of object, A_i = Area of image

(1) **Mirror formula :** $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$; (use sign convention while solving the problems).

Note : ❑ **Newton's formula :** If object distance (x_1) and image distance (x_2) are measured from focus instead of pole then $f^2 = x_1\, x_2$

(2) **Magnification :** m = $\frac{\text{Size of object}}{\text{Size of image}}$

Linear magnification		**Areal magnification**
Transverse	**Longitudinal**	
When a object is placed perpendicular to the principle axis, then linear magnification is called lateral or transverse magnification. It is given by $m=\frac{I}{O}=-\frac{v}{u}=\frac{f}{f-u}=\frac{f-v}{f}$ (* Always use sign convention while solving the problems)	When object lies along the principle axis then its longitudinal magnification $m=\frac{I}{O}=\frac{-(v_2-v_1)}{(u_2-u_1)}$ If object is small; $m=-\frac{dv}{du}=\left(\frac{v}{u}\right)^2$ Also Length of image = $\left(\frac{v}{u}\right)^2\times$ Length of object (L_0) $(L_i)=\left(\frac{f}{u-f}\right)^2.L_o$	 If a 2D-object is placed with it's plane perpendicular to principle axis It's Areal magnification $M_s=\frac{\text{Area of image }(A_i)}{\text{Area of object }(A_o)}=\frac{ma\times mb}{ab}=m^2$ $\Rightarrow\ m_s=m^2=\frac{A_i}{A_o}$

Note : ❑ Don't put the sign of quantity which is to be determined.

❑ If a spherical mirror produces an image 'm' times the size of the object (m = magnification) then u, v and f are given by the followings

$$u=\left(\frac{m-1}{m}\right)f,\quad v=-(m-1)f \quad \text{and} \quad f=\left(\frac{m}{m-1)}\right)u \quad \text{(use sign convention)}$$

(3) **Uses of mirrors**

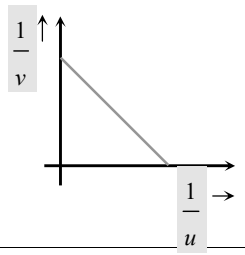
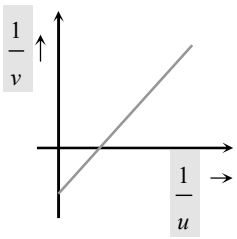
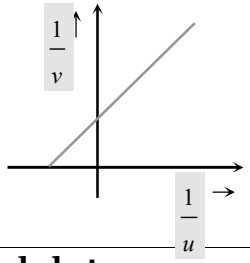
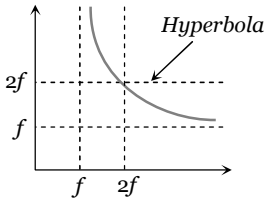
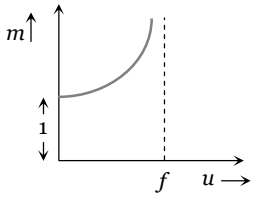
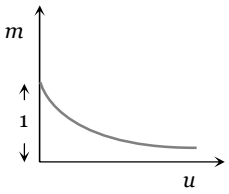
(i) **Concave mirror:** Used as a shaving mirror, In search light, in cinema projector, in telescope, by E.N.T. specialists etc.

(ii) **Convex mirror:** In road lamps, side mirror in vehicles *etc*.

Note : ❑ Field of view of convex mirror is more than that of concave mirror.

Different graphs

Graph between $\frac{1}{v}$ and $\frac{1}{u}$

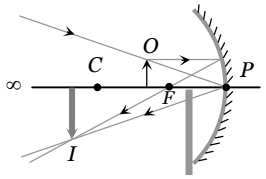
(a) Real image formed by concave mirror	(b) Virtual image formed by concave mirror	(c) Virtual image formed by convex mirror
		
Graph between *u* and *v* for real image of concave mirror	**Graph between *u* and *m* for virtual image by concave mirror**	**Graph between *u* and *m* for virtual image by convex mirror.**
		

Concepts

- *Focal length of a mirror is independent of material of mirror, medium in which it is placed, wavelength of incident light*
- *Divergence or Convergence power of a mirror does not change with the change in medium.*
- *If an object is moving at a speed v_o towards a spherical mirror along it's axis then speed of image away from mirror is*

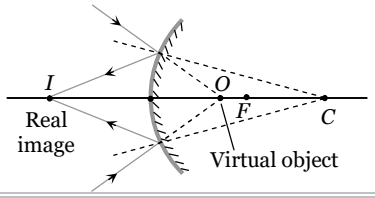
  $v_i = -\left(\frac{f}{u-f}\right)^2 . v_o$ *(use sign convention)*

- *When object is moved from focus to infinity at constant speed, the image will move faster in the beginning and slower later on, towards the mirror.*
- *As every part of mirror forms a complete image, if a part of the mirror is obstructed, full image will be formed but intensity will be reduced.*



- *Can a convex mirror form real images?*

  yes if (distance of virtual object) u < f (focal length)



Example

***Example*: 10** A convex mirror of focal length f forms an image which is $1/n$ times the object. The distance of the object from the mirror is

(a) $(n-1)f$ (b) $\left(\frac{n-1}{n}\right)f$ (c) $\left(\frac{n+1}{n}\right)f$ (d) $(n+1)f$

Solution : (a) By using $m = \frac{f}{f-u}$

Here $m = +\frac{1}{n}$, $f \to +f$ So, $+\frac{1}{n} = \frac{+f}{+f-u} \Rightarrow u = -(n-1)f$

***Example*: 11** An object 5 cm tall is placed 1 m from a concave spherical mirror which has a radius of curvature of 20 cm. The size of the image is

(a) 0.11 cm (b) 0.50 cm (c) 0.55 cm (d) 0.60 cm

Solution : (c) By using $\frac{I}{O} = \frac{f}{f-u}$

Here $O + 5\ cm$, $f = -\frac{R}{2} = -10\ cm$, $u = -1\ m = -100\ cm$

So, $\frac{I}{+5} = \frac{-10}{-10-(-100)} \Rightarrow I = -0.55\ cm.$

***Example*: 12** An object of length 2.5 cm is placed at a distance of 1.5 f from a concave mirror where f is the magnitude of the focal length of the mirror. The length of the object is perpendicular to the principle axis. The length of the image is

(a) 5 cm, erect (b) 10 cm, erect (c) 15 cm, erect (d) 5 cm, inverted

Solution : (d) By using $\frac{I}{O} = \frac{f}{f-u}$; where $I = ?$, $O = +2.5\ cm.$ $f \to -f, u = -1.5f$

$\therefore \quad \frac{I}{+2.5} = \frac{-f}{-f-(-1.5f)} \Rightarrow I = -5\ cm.$ (Negative sign indicates that image is inverted.)

***Example*: 13** A convex mirror has a focal length f. A real object is placed at a distance f in front of it from the pole produces an image at

(a) Infinity (b) f (c) $f/2$ (d) $2f$

Solution : (c) By using $\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \quad \frac{1}{+f} = \frac{1}{v} + \frac{1}{(-f)} \Rightarrow v = \frac{f}{2}$

***Example*: 14** Two objects A and B when placed one after another infront of a concave mirror of focal length 10 cm from images of same size. Size of object A is four times that of B. If object A is placed at a distance of 50 cm from the mirror, what should be the distance of B from the mirror

(a) 10 cm (b) 20 cm (c) 30 cm (d) 40 cm

Solution : (b) By using $\frac{I}{O} = \frac{f}{f-u} \Rightarrow \frac{I_A}{I_B} \times \frac{O_B}{O_A} = \frac{f-u_B}{f-u_A} \Rightarrow \frac{1}{1} \times \frac{1}{4} = \frac{-10-u_B}{-10-(-50)} \Rightarrow u_B = -20\,cm$.

***Example*: 15** A square of side 3 *cm* is placed at a distance of 25 *cm* from a concave mirror of focal length 10 *cm*. The centre of the square is at the axis of the mirror and the plane is normal to the axis. The area enclosed by the image of the wire is

(a) 4 cm^2 (b) 6 cm^2 (c) 16 cm^2 (d) 36 cm^2

Solution : (a) By using $m^2 = \frac{A_i}{A_o}$; where $m = \frac{f}{f-u}$

Hence from given values $m = \frac{-10}{-10-(-25)} = \frac{-2}{3}$ and $A_o = 9\,cm^2$ $\therefore$ $A_i = \left(\frac{-2}{3}\right)^2 \times 9 = 4\,cm^2$

***Example*: 16** A convex mirror of focal length 10 *cm* is placed in water. The refractive index of water is 4/3. What will be the focal length of the mirror in water

(a) 10 *cm* (b) 40/3 *cm* (c) 30/4 *cm* (d) None of these

Solution : (a) No change in focal length, because *f* depends only upon radius of curvature *R*.

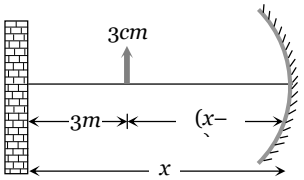
***Example*: 17** A candle flame 3 *cm* is placed at distance of 3 *m* from a wall. How far from wall must a concave mirror be placed in order that it may form an image of flame 9 *cm* high on the wall

(a) 225 *cm* (b) 300 *cm* (c) 450 *cm* (d) 650 *cm*

Solution : (c) Let the mirror be placed at a distance *x* from wall

By using

$\frac{I}{O} = \frac{-v}{u} \Rightarrow \frac{-9}{+3} = \frac{-(-x)}{-(x-3)}$ $\Rightarrow x = -4.5m = -450\,cm.$



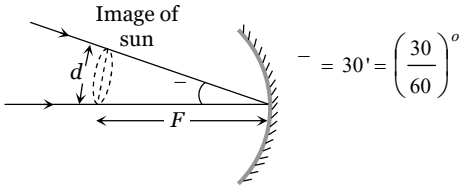
***Example*: 18** A concave mirror of focal length 100 *cm* is used to obtain the image of the sun which subtends an angle of 30'. The diameter of the image of the sun will be

(a) 1.74 *cm* (b) 0.87 *cm* (c) 0.435 *cm* (d) 100 *cm*

Solution : (b) Diameter of image of sun $d = f\theta$

$\Rightarrow d = 100 \times \left(\frac{30}{60}\right) \times \frac{\pi}{180}$

$\Rightarrow$ $d = 0.87\,cm$.



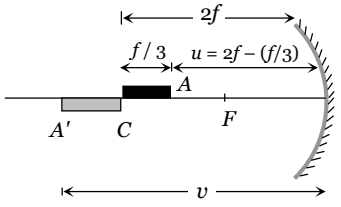
***Example*: 19** A thin rod of length $f/3$ lies along the axis of a concave mirror of focal length *f*. One end of its magnified image touches an end of the rod. The length of the image is

(a) f (b) $\frac{1}{2}f$ (c) $2f$ (d) $\frac{1}{4}f$

Solution : (b) If end *A* of rod acts an object for mirror then it's image will be *A*' and if $u = 2f - \frac{f}{3} = \frac{5f}{3}$

So by using $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ $\Rightarrow \frac{1}{-f} = \frac{1}{v} + \frac{1}{\frac{-5f}{3}}$ $\Rightarrow v = -\frac{5}{2}f$

$\therefore$ Length of image $= \frac{5}{2}f - 2f = \frac{f}{2}$

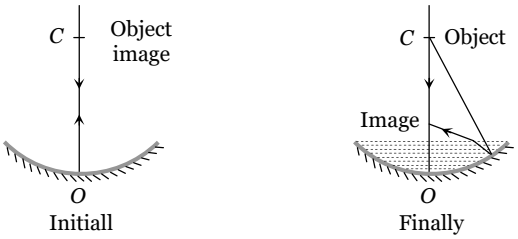


***Example*: 20** A concave mirror is placed on a horizontal table with its axis directed vertically upwards. Let O be the pole of the mirror and C its centre of curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be

(a) Real, and will remain at C (b) Real, and located at a point between C and ∞

(c) Virtual and located at a point between C and O (d) Real, and located at a point between C and O

Solution : (d)



Tricky example: 4

An object is placed infront of a convex mirror at a distance of 50 cm. A plane mirror is introduced covering the lower half of the convex mirror. If the distance between the object and plane mirror is 30 cm, it is found that there is no parallel between the images formed by two mirrors. Radius of curvature of mirror will be

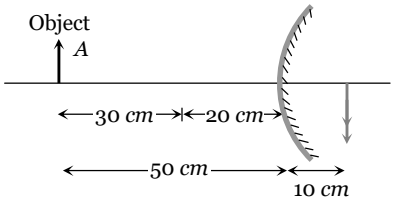
(a) 12.5 cm (b) 25 cm (c) $\frac{50}{3}cm$ (d) 18 cm

Solution : (b) Since there is no parallel, it means that both images (By plane mirror and convex mirror) coinciding each other.

According to property of plane mirror it will form image at a distance of 30 cm behind it. Hence for convex mirror $u = -50\ cm,\quad v = +10\ cm$

By using $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ $\Rightarrow \frac{1}{f} = \frac{1}{+10} + \frac{1}{-50} = \frac{4}{50}$

$\Rightarrow \quad f = \frac{25}{2}cm$ $\Rightarrow\ R = 2f = 25\,cm.$



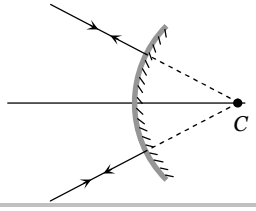
Tricky example: 5

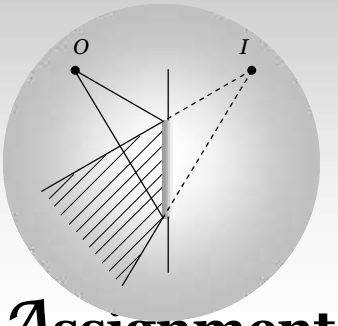
A convergent beam of light is incident on a convex mirror so as to converge to a distance 12 cm from the pole of the mirror. An inverted image of the same size is formed coincident with the virtual object. What is the focal length of the mirror

(a) 24 cm (b) 12 cm (c) 6 cm (d) 3 cm

Solution : (c) Here object and image are at the same position so this position must be centre of curvature

$\therefore\ R = 12\ cm \quad \Rightarrow f = \frac{R}{2}$





Assignment

Reflection of light at plane surface

Basic Level

1. A light bulb is placed between two mirrors (plane) inclined at an angle of 60^o. Number of images formed are

(a) 2 (b) 4 (c) 5 (d) 6

2. Two plane mirrors are inclined at an angle of 72^o. The number of images of a point object placed between them will be

(a) 2 (b) 3 (c) 4 (d) 5

3. To get three images of a single object, one should have two plane mirrors at an angle of

(a) 30^o (b) 60^o (c) 90^o (d) 120^o

4. A man of length h requires a mirror of length at least equal to, to see his own complete image

(a) $\frac{h}{4}$ (b) $\frac{h}{3}$ (c) $\frac{h}{2}$ (d) h

5. Two plane mirrors are at 45^o to each other. If an object is placed between them then the number of images will be

(a) 5 (b) 9 (c) 7 (d) 8

6. An object is at a distance of 0.5 m in front of a plane mirror. Distance between the object and image is

(a) 0.5 m (b) 1 m (c) 0.25 m (d) 1.5 m

7. A man runs towards a mirror at a speed 15 m/s. The speed of the image relative to the man is

(a) 15 ms^{-1} (b) 30 ms^{-1} (c) 35 ms^{-1} (d) 20 ms^{-1}

8. The light reflected by a plane mirror may form a real image

(a) If the rays incident on the mirror are diverging (b) If the rays incident on the mirror are converging

(c) If the object is placed very close to the mirror (d) Under no circumstances

9. A man is 180 cm tall and his eyes are 10 cm below the top of his head. In order to see his entire height right from toe to head, he uses a plane mirror kept at a distance of 1 m from him. The minimum length of the plane mirror required is

(a) 180 cm (b) 90 cm (c) 85 cm (d) 170 cm

10. A small object is placed 10 cm infront of a plane mirror. If you stand behind the object 30 cm from the object and look at its image, the distance focused for your eye will be

(a) 60 cm (b) 20 cm (c) 40 cm (d) 80 cm

11. Two plane mirrors are at right angles to each other. A man stands between them and combs his hair with his right hand. In how many of the images will he be seen using his right hand

(a) None (b) 1 (c) 2 (d) 3

12. A man runs towards mirror at a speed of 15 m/s. What is the speed of his image

(a) 7.5 m/s (b) 15 m/s (c) 30 m/s (d) 45 m/s

13. A ray of light is incidenting normally on a plane mirror. The angle of reflection will be

(a) 0^o (b) 90^o (c) Will not be reflected (d) None of these

14. A plane mirror produces a magnification of

(a) – 1 (b) + 1 (c) Zero (d) Between 0 and + ∞

15. When a plane mirror is rotated through an angle $^-$, then the reflected ray turns through the angle 2^-, then the size of the image

(a) Is doubled (b) Is halved (c) Remains the same (d) Becomes infinite

16. What should be the angle between two plane mirrors so that whatever be the angle of incidence, the incident ray and the reflected ray from the two mirrors be parallel to each other

(a) 60^o (b) 90^o (c) 120^o (d) 175^o

17. Ray optics is valid, when characteristic dimensions are

(a) Of the same order as the wavelength of light (b) Much smaller than the wavelength of light

(c) Of the order of one millimeter (d) Much larger than the wavelength of light

18. It is desired to photograph the image of an object placed at a distance of 3 m from the plane mirror. The camera which is at a distance of 4.5 m from the mirror should be focussed for a distance of

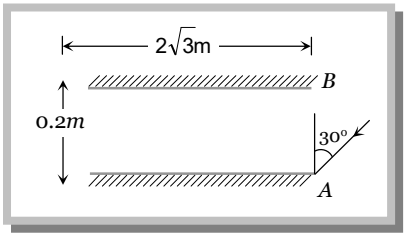
(a) 3 m (b) 4.5 m (c) 6 m (d) 7.5 m

19. Two plane mirrors are parallel to each other an spaced 20 cm apart. An object is kept in between them at 15 cm from A. Out of the following at which point an image is not formed in mirror A (distance measured from mirror A)

(a) 15 cm (b) 25 cm (c) 45 cm (d) 55 cm

Advance Level

20. Two plane mirrors A and B are aligned parallel to each other, as shown in the figure. A light ray is incident at an angle of 30^o at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is



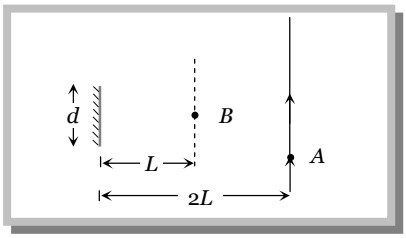
(a) 28

(b) 30

(c) 32

(d) 34

21. A point source of light B is placed at a distance L in front of the centre of a mirror of width d hung vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance $2L$ from it as shown. The greatest distance over which he can see the image of the light source in the mirror is



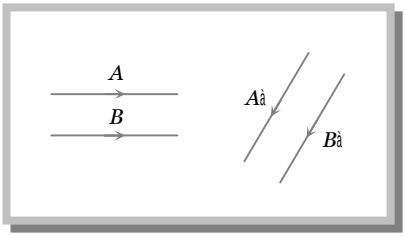
(a) $d/2$

(b) d

(c) $2d$

(d) $3d$

22. The figure shows two rays A and B being reflected by a mirror and going as A' and B'. The mirror is



(a) Plane

(b) Concave

(c) Convex

(d) May be any spherical mirror

23. An object is initially at a distance of 100 cm from a plane mirror. If the mirror approaches the object at a speed of 5 cm/s, then after 6 s the distance between the object and its image will be

(a) 60 cm (b) 140 cm (c) 170 cm (d) 150 cm

24. An object placed in front of a plane mirror is displaced by 0.4 m along a straight line at an angle of 30^o to mirror plane. The change in the distance between the object and its image is

(a) 0.20 m (b) 0.40 m (c) 0.25 m (d) 0.80 m

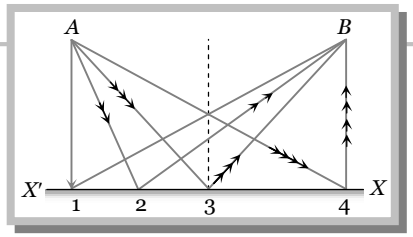
25. A ray of light travels from A to B with uniform speed. On its way it is reflected by the surface XX'. The path followed by the ray to take least time is

(a) 1

(b) 2

(c) 3

(d) 4



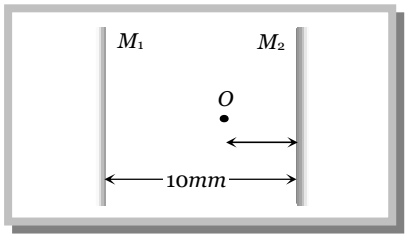
26. A point object O is placed between two plan mirrors as shown is fig. The distance of the first three images formed by mirror M_2 from it are

(a) 2 *mm*, 8 *mm*, 18 *mm*

(b) 2 *mm*, 18 *mm*, 28 *mm*

(c) 2 *mm*, 18 *mm*, 22 *mm*

(d) 2 *mm*, 18 *mm*, 58 *mm*



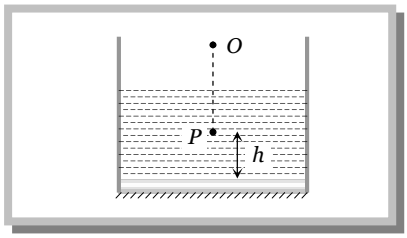
27. A plane mirror is placed at the bottom of the tank containing a liquid of refractive index « . P is a small object at a height h above the mirror. An observer O-vertically above P outside the liquid see P and its image in the mirror. The apparent distance between these two will be

(a) $2«h$

(b) $\frac{2h}{«}$

(c) $\frac{2h}{« - 1}$

(d) $h\left(1+\frac{1}{«}\right)$



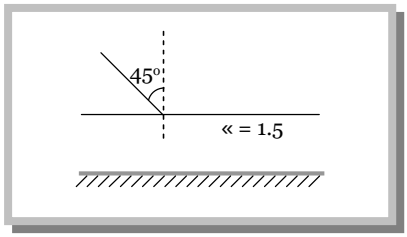
28. One side of a glass slab is silvered as shown. A ray of light is incident on the other side at angle of incidence $i = 45^o$. Refractive index of glass is given as 1.5. The deviation of the ray of light from its initial path when it comes out of the slab is

(a) 90°

(b) 180°

(c) 120°

(d) 45°



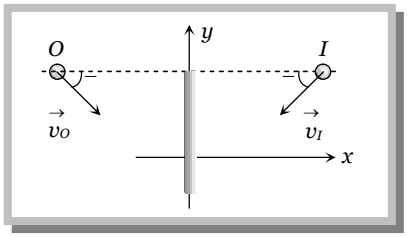
29. If an object moves towards a plane mirror with a speed v at an angle $^{-}$ to the perpendicular to the plane of the mirror, find the relative velocity between the object and the image

(a) v

(b) $2v$

(c) $2v\cos^{-}$

(d) $2v\sin^{-}$



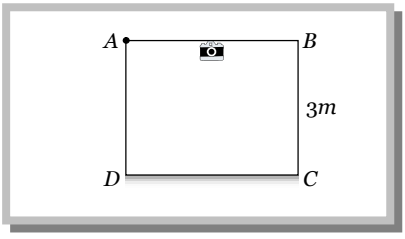
30. Figure shows a cubical room $ABCD$ will the wall CD as a plane mirror. Each side of the room is $3m$. We place a camera at the midpoint of the wall AB. At what distance should the camera be focussed to photograph an object placed at A

(a) 1.5 m

(b) 3 m

(c) 6 m

(d) More than 6 m



Reflection of light at spherical surface

Basic Level

31. A man having height 6 *m*, want to see full height in mirror. They observe image of 2*m* height erect, then used mirror is

(a) Concave (b) Convex (c) Plane (d) None of these

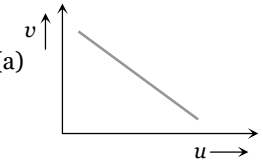
32. An object of length 6*cm* is placed on the principal axis of a concave mirror of focal length *f* at a distance of 4 *f*. The length of the image will be

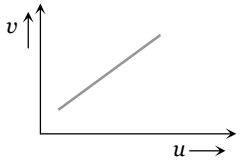
(a) 2 *cm* (b) 12 *cm* (c) 4 *cm* (d) 1.2 *cm*

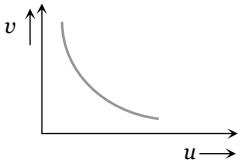
33. Convergence of concave mirror can be decreased by dipping in

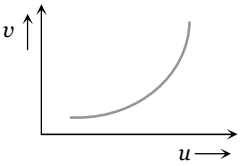
(a) Water (b) Oil (c) Both (d) None of these

34. In an experiment of find the focal length of a concave mirror a graph is drawn between the magnitudes of u and v. The graph looks like

(a) 

(b) 

(c) 

(d) 

35. An object 2.5 *cm* high is placed at a distance of 10 *cm* from a concave mirror of radius of curvature 30 *cm* The size of the image is

(a) 9.2 *cm* (b) 10.5 *cm* (c) 5.6 *cm* (d) 7.5 *cm*

36. A diminished virtual image can be formed only in

(a) Plane mirror (b) A concave mirror (c) A convex mirror (d) Concave-parabolic mirror

37. A point object is placed at a distance of 30 *cm* from a convex mirror of focal length 30*cm*. The image will form at

(a) Infinity (b) Focus (c) Pole (d) 15 *cm* behind the mirror

38. The focal length of a convex mirror is 20 *cm* its radius of curvature will be

(a) 10 *cm* (b) 20 *cm* (c) 30 *cm* (d) 40 *cm*

39. A concave mirror of focal length 15 *cm* forms an image having twice the linear dimensions of the object. The position of the object when the image is virtual will be

(a) 22.5 *cm* (b) 7.5 *cm* (c) 30 *cm* (d) 45 *cm*

40. Under which of the following conditions will a convex mirror of focal length *f* produce an image that is erect, diminished and virtual

(a) Only when $2f > u > f$ (b) Only when $u = f$ (c) Only when $u < f$ (d) Always

41. A concave mirror gives an image three times as large as the object placed at a distance of 20 *cm* from it. For the image to be real, the focal length should be

(a) 10 *cm* (b) 15 *cm* (c) 20 *cm* (d) 30 *cm*

42. A point object is placed at a distance of 10 *cm* and its real image is formed at a distance of 20*cm* from a concave mirror. If the object is moved by 0.1*cm* towards the mirror, the image will shift by about

(a) 0.4 *cm* away from the mirror (b) 0.4 *cm* towards the mirror

(c) 0.8 *cm* away from the mirror (d) 0.8 *cm* towards the mirror

43. The minimum distance between the object and its real image for concave mirror is

(a) *f* (b) 2*f* (c) 4*f* (d) Zero

44. An object is placed at 20 *cm* from a convex mirror of focal length 10 *cm*. The image formed by the mirror is

(a) Real and at 20 *cm* from the mirror (b) Virtual and at 20 *cm* from the mirror

(c) Virtual and at 20/3 *cm* from the mirror (d) Real and at 20/3 *cm* from the mirror

45. An object is placed 40 *cm* from a concave mirror of focal length 20 *cm*. The image formed is

(a) Real, inverted and same in size (b) Real, inverted and smaller

(c) Virtual, erect and larger (d) Virtual, erect and smaller

46. Match List I with List II and select the correct answer using the codes given below the lists

List I (Position of the object)	List II (Magnification)
(I) An object is placed at focus before a convex mirror	(A) Magnification is $-\infty$
(II) An object is placed at centre of curvature before a concave mirror	(B) Magnification is 0.5
(III) An object is placed at focus before a concave mirror	(C) Magnification is + 1
(IV) An object is placed at centre of curvature before a convex mirror	(D) Magnification is – 1
	(E) Magnification is 0.33

Codes :

(a) I-B, II-D, III-A, IV-E (b) I-A, II-D, III-C, IV-B (c) I-C, II-B, III-A, IV-E (d) I-B, II-E, III-D, IV-C

47. In a concave mirror experiment, an object is placed at a distance x_1 from the focus and the image is formed at a distance x_2 from the focus. The focal length of the mirror would be

(a) $x_1 x_2$ (b) $\sqrt{x_1 x_2}$ (c) $\frac{x_1 + x_2}{2}$ (d) $\sqrt{\frac{x_1}{x_2}}$

48. Which of the following forms a virtual and erect image for all positions of the object

(a) Convex lens (b) Concave lens (c) Convex mirror (d) Concave mirror

49. A convex mirror has a focal length *f*. A real object is placed at a distance *f* in front of it from the pole produces an image at

(a) Infinity (b) f (c) $f/2$ (d) $2f$

50. Radius of curvature of concave mirror is 40 *cm* and the size of image is twice as that of object, then the object distance is

(a) 60 *cm* (b) 20 *cm* (c) 40 *cm* (d) 30 *cm*

51. All of the following statements are correct except

(a) The magnification produced by a convex mirror is always less than one

(b) A virtual, erect, same-sized image can be obtained using a plane mirror

(c) A virtual, erect, magnified image can be formed using a concave mirror

(d) A real, inverted, same-sized image can be formed using a convex mirror

52. Radius of curvature of convex mirror is 40 *cm* and the size of object is twice as that of image, then the image distance is

(a) 10 *cm* (b) 20 *cm* (c) 40 *cm* (d) 30 *cm*

53. If an object is placed 10 *cm* in front of a concave mirror of focal length 20 *cm*, the image will be

(a) Diminished, upright, virtual (b) Enlarged, upright, virtual (c) Diminished, inverted, real(d)

54. An object 1 *cm* tall is placed 4 *cm* in front of a mirror. In order to produce an upright image of 3 *cm* height one needs a

(a) Convex mirror of radius of curvature 12 *cm* (b) Concave mirror of radius of curvature 12 *cm*

(c) Concave mirror of radius of curvature 4 *cm* (d) Plane mirror of height 12 *cm*

55. The image formed by a convex mirror of a real object is larger than the object

(a) When $u < 2f$ (b) When $u > 2f$ (c) For all values of u (d) For no value of u

56. An object 5 *cm* tall is placed 1 *m* from a concave spherical mirror which has a radius of curvature of 20 *cm*. The size of the image is

(a) 0.11 *cm* (b) 0.50 *cm* (c) 0.55 *cm* (d) 0.60 *cm*

57. A virtual image three times the size of the object is obtained with a concave mirror of radius of curvature 36 *cm*. The distance of the object from the mirror is

(a) 5 *cm* (b) 12 *cm* (c) 10 *cm* (d) 20 *cm*

58. Given a point source of light, which of the following can produce a parallel beam of light

(a) Convex mirror (b) Concave mirror

(c) Concave lens (d) Two plane mirrors inclined at an angle of 90°

59. A convex mirror is used to form the image of an object. Then which of the following statements is wrong

(a) The images lies between the pole and the focus (b) The image is diminished in size

(c) The images is erect (d) The image is real

60. A boy stands straight infront of a mirror at a distance of 30 *cm* away from it. He sees his erect image whose height is $\frac{1}{5}^{th}$ of his real height. The mirror he is using is

(a) Plane mirror (b) Convex mirror (c) Concave mirror (d) Plano-convex mirror

61. For the largest distance of the image from a concave mirror of focal length 10*cm*, the object should be kept at

(a) 10 *cm* (b) Infinite (c) 40 *cm* (d) 60 *cm*

62. A dentist uses a small mirror that gives a magnification of 4 when it is held 0.60 *cm* from a tooth. The radius of curvature of the mirror is

(a) 1.60 *cm* (convex) (b) 0.8 *cm* (concave) (c) 1.60 *cm* (concave) (d) 0.8 *cm* (convex)

63. A dice is placed with its one edge parallel to the principal axis between the principal focus and the centre of the curvature of a concave mirror. Then the image has the shape of

(a) Cube (b) Cuboid (c) Barrel shaped (d) Spherical

Advance Level

64. A short linear object of length l lies along the axis of a concave mirror of focal length f at a distance u form the pole of the mirror. The size of the image is approximately equal to

(a) $l\left(\frac{u-f}{f}\right)^{1/2}$ (b) $l\left(\frac{u-f}{f}\right)^{2}$ (c) $l\left(\frac{f}{u-f}\right)^{1/2}$ (d) $l\left(\frac{f}{u-f}\right)^{2}$

65. A point object is moving on the principal axis of a concave mirror of focal length 24 *cm* towards the mirror. When it is at a distance of 60 *cm* from the mirror, its velocity is 9 *cm/sec*. What is the velocity of the image at that instant

(a) 5 *cm/sec* towards the mirror (b) 4 *cm/sec* towards the mirror

(c) 4 *cm/sec* away from the mirror (d) 9 *cm/sec* away from the mirror

66. A convex mirror of focal length 10 *cm* forms an image which is half of the size of the object. The distance of the object from the mirror is

(a) 10 *cm* (b) 20 *cm* (c) 5 *cm* (d) 15 *cm*

67. A concave mirror is used to focus the image of a flower on a nearby well 120 *cm* from the flower. If a lateral magnification of 16 is desired, the distance of the flower from the mirror should be

(a) 8 *cm* (b) 12 *cm* (c) 80 *cm* (d) 120 *cm*

68. A thin rod of 5 *cm* length is kept along the axis of a concave mirror of 10 *cm* focal length such that its image is real and magnified and one end touches the rod. Its magnification will be

(a) 1 (b) 2 (c) 3 (d) 4

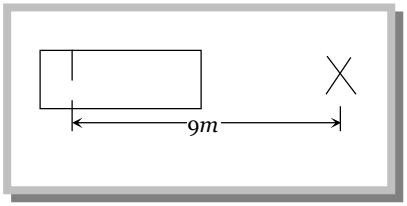
69. A luminous object is placed 20 *cm* from surface of a convex mirror and a plane mirror is set so that virtual images formed in two mirrors coincide. If plane mirror is at a distance of 12 *cm* from object, then focal length of convex mirror, is

(a) 5 *cm* (b) 10 *cm* (c) 20 *cm* (d) 40 *cm*

70. A rear mirror of a vehicle is cylindrical having radius of curvature 10 *cm*. The length of arc of curved surface is also 10 *cm*. If the eye of driver is assumed to be at large distance, from the mirror, then the field of view in radian is

(a) 0.5 (b) 1 (c) 2 (d) 4

71. A vehicle has a driving mirror of focal length 30 *cm*. Another vehicle of dimension $2 \times 4 \times 1.75\ m^3$ is 9 *m* away from the mirror of first vehicle. Position of the second vehicle as seen in the mirror of first vehicle is



(a) 30 *cm*

(b) 60 *cm*

(c) 90 *cm*

(d) 9 *cm*

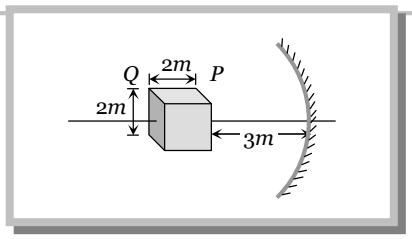
72. A cube of side 2 *m* is placed in front of a concave mirror focal length 1*m* with its face *P* at a distance of 3 *m* and face *Q* at a distance of 5 *m* from the mirror. The distance between the images of face *P* and *Q* and height of images of *P* and *Q* are

(a) 1 *m*, 0.5 *m*, 0.25 *m*

(b) 0.5 *m*, 1 *m*, 0.25 *m*

(c) 0.5 *m*, 0.25 *m*, 1*m*

(d) 0.25 *m*, 1*m*, 0.5 *m*



73. A concave mirror of radius of curvature 60 *cm* is placed at the bottom of tank containing water upto a height of 20 *cm*. The mirror faces upwards with its axis vertical. Solar light falls normally on the surface of water and the image of the sun is formed. If ${}_a\mu_w = \frac{4}{3}$ then with the observer in air, the distance of the image from the surface of water is

(a) 30 *cm* (b) 10 *cm* (c) 7.5 *cm* above (d) 7.5 *cm* below

74. A concave mirror forms an image of the sun at a distance of 12 *cm* from it

(a) The radius of curvature of this mirror is 6 *cm*

(b) To use it as a shaving mirror, it must be held at a distance of 8-10 *cm* from the face

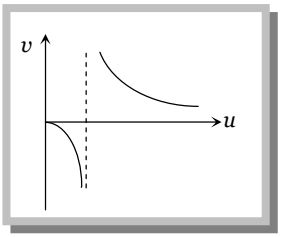
(c) If an object is kept at a distance of 12 *cm* from it, the image formed will be of the same size as the object

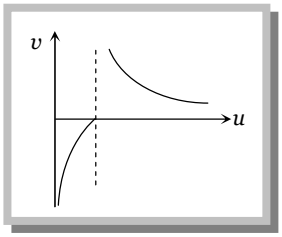
(d) All the above a alternatives are correct

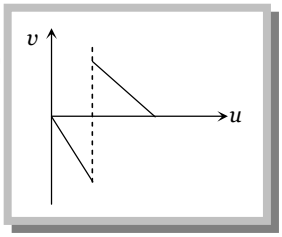
75. A small piece of wire bent into an *L* shape with upright and horizontal portions of equal lengths, is placed with the horizontal portion along the axis of the concave mirror whose radius of curvature is 10 *cm*. If the bend is 20 *cm* from the pole of the mirror, then the ratio of the lengths of the images of the upright and horizontal portions of the wire is

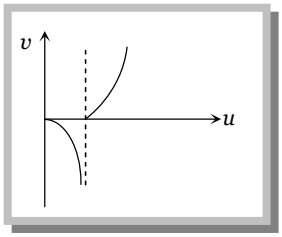
(a) 1 : 2 (b) 3 : 1 (c) 1 : 3 (d) 2 : 1

76. As the position of an object (u) reflected from a concave mirror is varied, the position of the image (v) also varies. By letting the u changes from 0 to $+\infty$ the graph between v versus u will be

(a) 

(b) 

(c) 

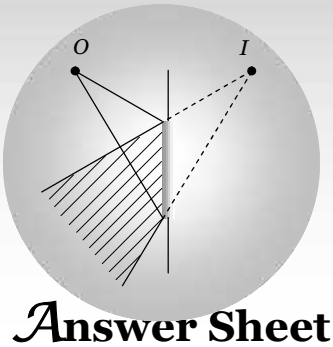
(d) 

77. A concave mirror has a focal length 20 *cm*. The distance between the two positions of the object for which the image size is double of the object size is

(a) 20 *cm* (b) 40 *cm* (c) 30 *cm* (d) 60 *cm*

78. A concave mirror of focal length 10 *cm* and a convex mirror of focal length 15 *cm* are placed facing each other 40 *cm* apart. A point object is placed between the mirrors, on their common axis and 15 *cm* from the concave mirror. Find the position and nature of the image produced by the successive reflections, first at concave mirror and then at convex mirror

(a) 2 *cm* (b) 4 *cm* (c) 6 *cm* (d) 8 *cm*



Answer Sheet

Assignments

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
c	c	c	c	c	b	b	b	b	c	b	b	a	b	c	b	d	d	c	b
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
d	a	b	b	c	c	b	a	c	d	b	a	d	c	d	c	d	d	b	d
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
b	a	d	c	a	a	b	b, c	c	d	d	a	b	b	d	c	b	b	d	b
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78		
a	c	b	d	c	a	a	a	a	b	a	d	c	b	b	a	a	c		