Light-Reflection and Refraction

NCERT Exercises (Questions-Solutions)

Intext Questions

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1. Define the principal focus of a concave mirror.

Ans. A point on the principal axis where the parallel rays of light after reflecting from a concave mirror meet.

2. The radius of curvature of a spherical mirror is 20 cm. What is its focal length?

Ans. Radius of curvature, R = 20 cm

$\therefore$ Focal length, $f = \frac{R}{2} = \frac{20}{2} = 10\,\text{cm}$

3. Name a mirror that can give an erect and enlarged image of an object.

Ans. A concave mirror gives an erect and enlarged image of an object held between pole and principal focus of the mirror.

4. Why do we prefer a convex mirror as a rear-view mirror in vehicles?

Ans. This is because a convex mirror forms an erect and diminished (small in size) images of the objects behind the vehicle and hence the field of view behind the vehicle is increased.

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1. Find the focal length of a convex mirror whose radius of curvature is 32 cm.

Ans. Given, R = + 32 cm

$\therefore$ $f = \frac{R}{2} = \frac{32}{2} = +16$

Thus, the focal length of the convex mirror = + 16 cm.

2. A concave mirror produces three times magnified real image of an object placed at 10 cm in front of it. Where is the image located?

Ans. Here, linear magnification (m) = - 3 (Negative sign for real image, which is inverted)

Object distance $(u) = -10$ cm

Image distance $(\upsilon) = ?$

As $m = -\frac{\upsilon}{u} \Rightarrow -3 = \frac{-\upsilon}{-10} \quad \therefore \upsilon = -30\ cm$

The image is located at 30 cm in front of the mirror.

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

Ans.: When a ray of light travels from air into water obliquely, it bends towards the normal. This is because water is optically denser than air. On entering water, speed of light decreases and the light bends towards normal.

2. Light enters from air to glass having refractive index 1.5. What is the speed of light in glass? The speed of light in vacuum is $3\times10^{8}\ m\ s^{-1}$.

Ans.: Here, refractive index, n = 1.5, speed of light in vacuum $= c = 3\times10^{8}\ m\ s^{-1}$ speed of light in glass, $\upsilon = ?$

From, $n = \frac{c}{\upsilon} \quad \Rightarrow \upsilon = \frac{c}{n} = \frac{3\times10^{8}}{1.5} = 2\times10^{8} m\ s^{-1}$

3. Find out, from table, the medium having highest optical density. Also find the medium with lowest optical density.

Ans. Absolute refractive index of some material media.

Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Canada Balsam	1.53
Ice	1.31	Rock salt	1.54
Water	1.33	Carbon disulphide	1.63
Kerosene	1.44	Dense flint glass	1.65
Fused quartz	1.46	Ruby	1.71
Turpentine oil	1.47	Sapphire	1.77
Benzene	1.50	Diamond	2.42
Crown glass	1.52		

The medium with highest refractive index will have highest optical density. So, diamond has highest optical density.
The medium with lowest refractive index will have lowest optical density. So, air has lowest optical density.

4. You are given kerosene, turpentine and water. In which of these does the light travel fastest?

Ans.: We know from the definition of refractive index, that the speed of light is higher in a medium with lower refractive index. So, the light travels fastest in water relative to kerosene and turpentine.

5. The refractive index of diamond is 2.42. What is the meaning of this statement?

Ans.: This statement means that the speed of light in diamond is lower by a factor of 2.42 relative to that in vacuum.

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1. Define 1 dioptre of power of a lens.

Ans.: The power of a lens whose focal length is one metre (1 m) is one dioptre.

2. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object ? Also, find the power of the lens.

Ans.: Distance of the image from the lens, $v = 50\ cm$

Distance of the object from the lens, $u = ?$

Size of the image, $I =$ Size of the object, O

From the definition, if h is the height of the image and that of the object,

Magnification $= \frac{I}{O} = \frac{-h}{h} = -1$ [$\because$ The image is inverted]

For a lens, magnification $= \frac{v}{u}$

So, $\frac{v}{u} = -1 \Rightarrow u = -v = -50\ cm$

So, the needle (the object) is placed at a distance of 50 cm in front of the lens.

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

$$\Rightarrow \quad \frac{1}{f} = \frac{1}{50\ cm} - \frac{1}{-50\ cm} = \frac{1}{50\ cm} + \frac{1}{50\ cm} = \frac{2}{50\,cm} = \frac{1}{25\ cm}$$

$$\therefore \quad f = 25\ cm$$

Then, power of the lens $= \frac{100}{f\,(cm)} D = \frac{100}{25} D = 4D$

3. Find the power of a concave lens of focal length 2 m.

Ans.: Focal length of the concave lens = - 2 m

So, power of the concave lens $= \frac{1}{-2} D = -0.5D$

Exercises Questions

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1. Which one of the following materials cannot be used to make a lens?

(a) Water (b) Glass

(c) Plastic (d) Clay

Ans.: The correct answer is (d), because clay is opaque.

2. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

(a) Between the focus and the centre of curvature

(b) At the centre of curvature

(c) Beyond the centre of curvature

(d) Between the pole of the mirror and its focus

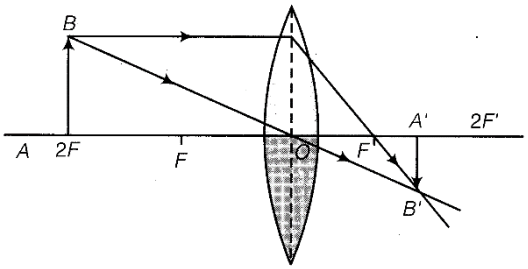
Ans.: (d) For virtual, erect and larger image, the object must lie between the pole of the mirror and its focus.

3. Where should an object be placed in front of a convex lens to get a real image of the size of object?

(a) At the principal focus of lens (b) At twice the focal length

(c) At infinity (d) Between optical centre of lens and its principal focus

Ans.: (b) To set the real image of the size of the object. It should be placed at twice the focal length of a convex lens.



4. A spherical mirror and a thin spherical lens have each a focal length of – 15 cm. The mirror and lens are likely to be

(a) Both concave (b) Both convex

(c) Mirror is concave and lens is convex (d) Mirror is convex and lens is concave

Ans.: (a) The focal length is taken as negative for both concave mirror and concave lens.

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5. No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be

(a) Plane (b) Concave

(c) Convex (d) Either plane or convex

Ans.: (d) The image is erect in a plane mirror and also in a convex mirror, for all positions of the object.

6. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

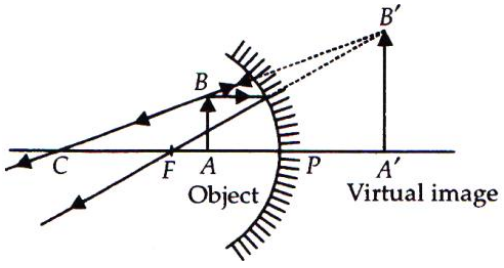
(a) A convex lens of focal length 50 cm (b) A concave lens of focal length 50 cm

(c) A convex lens of focal length 5 cm (d) A concave lens of focal length 5 cm

Ans.: For reading small letters in a dictionary, we need to use a convex lens of smaller focal length. Choice (c) is correct.

7. We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

Ans.: A concave mirror produces an erect image if the object is placed between the pole and the focus of the concave mirror. Thus, object may be placed at any position whose distance is less than 15 cm from the concave mirror. The image is virtual and erect. The image is larger than the object. The ray diagram is shown below.



8. Name the type of mirror used in the following situations.

(a) Headlights of a car

(b) Side/rear-view mirror of a vehicle

(c) Solar furnace

Support your answer with reason.

Ans.: (a) For head lights of a car, we use a concave mirror. The light source is held at the focus of the mirror. On reflection, a strong parallel beam of light emerges.

(b) A convex mirror is used as side rear view mirror, because its field of view is larger and it forms virtual, erect and diminished images of objects behind.

(c) For solar furnace, we use a concave mirror. Light from the sun, on reflection from the mirror, is concentrated at the focus of the mirror, producing heat.

9. One half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

Ans.: Yes, it will produce a complete image of the object, as shown in figure. This can be verified experimentally by observing the image of a distance object like tree on a screen, when lower half of the lens is covered with a black paper. However, the intensity or brightness of image will reduce.

10. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed.

Ans.: Here, object size , $h_1 = 5$ cm

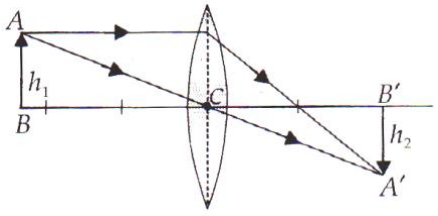
object distance, $u = -25\ cm$

focal length of lens, $f = 10\ cm$

image distance, $\upsilon = ?$

image size, $h_2 = ?$

As $\frac{1}{\upsilon} - \frac{1}{u} = \frac{1}{f}$ $\quad \therefore \quad \frac{1}{\upsilon} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50}$



$\Rightarrow \quad \upsilon = \frac{50}{3} = 16.67\ cm$

As υ is positive, the image formed is real; on the right side of the lens, as shown in figure above.

As $\quad m = \frac{h_2}{h_1} = \frac{\upsilon}{u}$

$\therefore \quad \frac{h_2}{5} = \frac{50/3}{-25} = \frac{-2}{3} \Rightarrow = -\frac{10}{3} = -3.3\ cm$

Negative sign shows that the image is inverted.

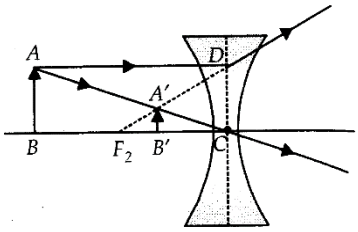
11. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

Ans.: Here, focal length of lens, $f = -15\ cm$

image distance, $\upsilon = -10\ cm$

object distance, $u = ?$

As $\frac{1}{f} = \frac{1}{\upsilon} - \frac{1}{u} \Rightarrow \frac{1}{u} = \frac{1}{\upsilon} - \frac{1}{f} = \frac{1}{-10} + \frac{1}{15} = \frac{-3+2}{30} = \frac{-1}{30}$



Now, ray diagram of image :

12. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

Ans.: Here, object distance (u) = - 10 cm, focal length (f) = 15 cm, image distance $(\upsilon) = ?$

As $\frac{1}{\upsilon} + \frac{1}{u} = \frac{1}{f}$

$\Rightarrow \frac{1}{\upsilon} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} + \frac{1}{10} = \frac{5}{30} = \frac{1}{6}$

$\therefore \upsilon = 6\ cm$

Here, + sign of *u* indicates that image is at the back of the mirror. It must be virtual, erect and smaller in size than the object

13. The magnification produced by a plane mirror is $m = +1$. What does this mean?

Ans.: As $m = \frac{h_2}{h_1} = +1 \Rightarrow h_2 = h_1$

i.e., size of image is equal to size of the object. Further, + sign of m indicates that the image is erect and hence virtual.

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

Ans.: Here, object size $(h_1) = 5.0\ cm$, object distance $(u) = -20\ cm$

radius of curvature (R) = 30 cm, image distance $(\upsilon) = ?$

As $\frac{1}{\upsilon} + \frac{1}{u} = \frac{1}{f} = \frac{2}{R}$

$\Rightarrow \frac{1}{\upsilon} = \frac{2}{R} - \frac{1}{u} = \frac{2}{30} + \frac{1}{20} = \frac{4+3}{60} = \frac{7}{60}$

$\therefore \upsilon = \frac{60}{7} = 8.57\ cm$

Positive sign of *u* indicates that image is at the back of the mirror. It must be virtual and erect.

As $m = \frac{h_2}{h_1} = -\frac{\upsilon}{u}$

$\Rightarrow \frac{h_2}{5.0} = -\frac{60/7}{-20} = \frac{3}{7} \qquad \therefore \qquad h_2 = \frac{3}{7} \times 5.0 = \frac{15.0}{7} = 2.1\ cm$

This is the size of the erect image.

15. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focused image can be obtained? Find the size and the nature of the image.

Ans.: Here, object size $(h_1) = 7.0\ cm$, object distance $(u) = -27\ cm$

focal length $(f) = -18\ cm$, image distance $(\upsilon) = ?$

As $\dfrac{1}{\upsilon} + \dfrac{1}{u} = \dfrac{1}{f}$

$\Rightarrow$ $\dfrac{1}{\upsilon} = \dfrac{1}{f} - \dfrac{1}{u} = -\dfrac{1}{18} + \dfrac{1}{27} = \dfrac{-3+2}{54} = -\dfrac{1}{54}$

$\therefore$ $\upsilon = -54\ cm$

Therefore, the screen should be held in front of the mirror at a distance of 54 on from the mirror. The image obtained on the screen will be real.

As $m = \dfrac{h_2}{h_1} = -\dfrac{\upsilon}{u} \Rightarrow \dfrac{h_2}{7.0} = -\dfrac{-54}{-27}$

$\therefore$ $h_2 = -14.0 cm$

Negative sign of h_2 shows that the image is inverted.

16. Find the focal length of a lens of power – 2.0 D. What type of lens is this?

Ans.: Here, focal length, $f = ?$, power, P = – 2.0 D

As $f = \dfrac{100}{P} \Rightarrow f = \dfrac{100}{-2.0} = -50\ cm$

As power of lens is negative, the lens must be concave.

17. A doctor has prescribed a corrective lens of power + 1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

Ans.: Power of the lens, $P = +1.5\ D = +1.5\ m^{-1}$

$\therefore$ Focal length of the lens, $f = \dfrac{1}{+1.5 m^{-1}} 0.667\ m = 66.7 cm$

Thus, the focal length of the lens is 66.7 cm

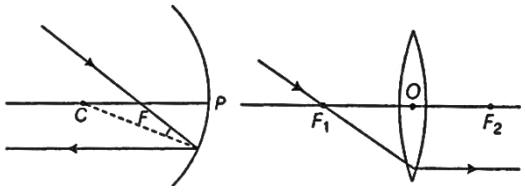
Since the focal length of the lens is positive, hence the given lens is a converging lens.

Multiple Choice Questions (MCQs)

1. Which of the following can make a parallel beam of light when light from a point source is incident on it?

(a) Concave mirror as well as convex lens
(b) Convex mirror as well as concave lens
(c) Two plane mirrors placed at 90° to each other
(d) Concave mirror as well as concave lens

Ans. **(A)** A ray passing through the principal focus of a concave mirror or convex tens, after reflection/refraction, will emerge parallel to the principal axis.



2. A 10 mm long awl pin is placed vertically in front of a concave mirror. A 5 mm long image of the awl pin is formed at 30 cm in front of the mirror. The focal length of this mirror is

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

Ans. **(B)** Given, object size, $h = +10.0$ mm
($\because$ 1 cm= 10 mm)
= + 1.0cm
Image size, h' =5.0 mm = 0.5 m
Image distance, v = -30 cm (For real image)
Focal length, f = ?

Also, magnification, $m = \frac{h'}{h}\frac{(\text{Image Size})}{(\text{object size})}$

As, magnification, $\mathrm{m} = \frac{-\mathrm{v}}{\mathrm{u}} \Rightarrow \frac{\mathrm{h}'}{\mathrm{h}} = \frac{-\mathrm{v}}{\mathrm{u}}$

$\frac{0.5}{1} = \frac{-30}{u} \Rightarrow u = -60$ cm

Using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\Rightarrow \frac{1}{f} = \frac{1}{-30} - \frac{1}{60} = \frac{-2-1}{60} = \frac{-3}{60}$

$\Rightarrow f = -20\,\text{cm}$

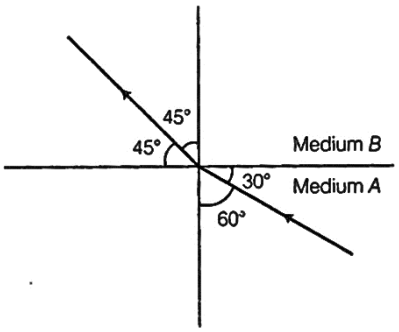
3. Under which of the following conditions, a concave mirror can form an image larger than the actual object?

(a) When the object is kept at a distance equal to its radius of curvature.
(b) When object is kept at a distance less than its focal length

(c) When object is placed between the focus and centre of curvature
(d) When object is kept at a distance greater than its radius of curvature

Ans. **(c)** A concave mirror can form an image enlarged, real and inverted than the actual object, beyond centre of curvature (C) when object is placed between the focus (F) and centre of curvature.

4. Figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is

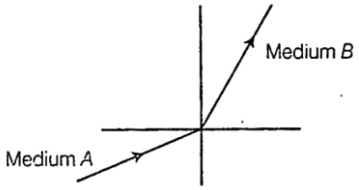


(a) $\frac{\sqrt{3}}{2}$ (b) $\frac{\sqrt{2}}{\sqrt{3}}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\sqrt{2}$

Ans. **(A)** Given, angle of incidence, i = 60°, angle of refraction, r = 45°
Refractive index of the medium B relative to medium A,

$$\mu_{BA} = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 45°} = \frac{\left(\frac{\sqrt{3}}{2}\right)}{\left(\frac{1}{\sqrt{2}}\right)} = \frac{\sqrt{3}}{\sqrt{2}}$$

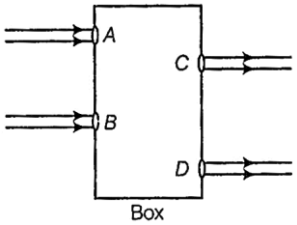
5. A light ray enters from medium A to medium B as shown in the figure. The refractive index of medium 6 relative to A will be



(a) greater than unity (b) less than unity
(c) equal to unity (d) zero

Ans. **(A)** Since light rays in the medium 6 goes towards normal. So it has greater refractive index and lesser velocity of light w.r.t. medium/A. So refractive index of medium B w.r.t. medium A is greater than unity.

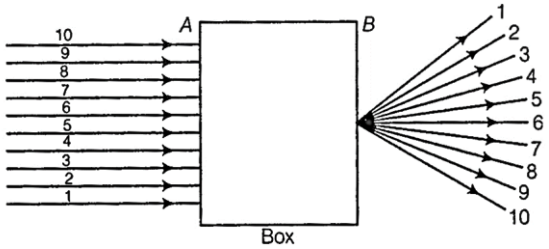
6. Beams of light are incident through the holes A and B and emerge out of box through the holes C and D respectively as shown in the figure. Which of the following could be inside the box?



(a) A rectangular glass slab (b) A convex lens
(c) A concave lens (d) A prism

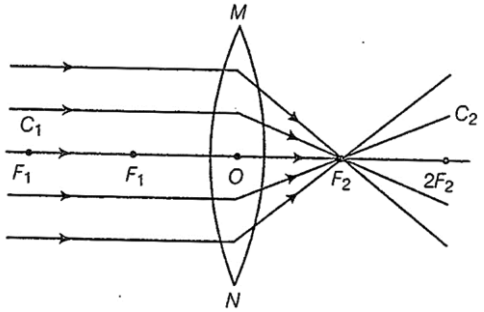
Ans. **(A)** Here, the emergent rays are parallel to the direction of the incident ray. Therefore, a rectangular glass slab could be inside the box as the extent of bending of light ray at the opposite parallel faces AB (air-glass interface) and CD (glass-air interface) of the rectangular glass slab are equal and opposite, This is why the ray emerges parallel to the incident ray.

7. A beam of light is incident through the holes on side A and emerges out of the holes on the other face of the box as shown in the figure. Which of the following could be inside the box?



(a) Concave lens (b) Rectangular glass slab
(c) Prism (d) Convex lens

Ans. **(D)** Since in the diagram all the parallel rays converge at a point. So inside the box there will be a convex lens.



8. Which of the following statements is true?

(a) A convex lens has 4 dioptre power having a focal length 0.25 m
(b) A convex lens has 4 dioptre power having a focal length -0.25 m
(c) A concave lens has 4 dioptre power having a focal length 0.25 m
(d) A concave lens has 4 dioptre power having a focal length - 0.25 m

Ans. **(A)** The power P of a lens of focal length f is given by $P = \frac{1}{f}$, where f is the focal length in metre and power in dioptre.

$P = \frac{1}{f}$ or $f = \frac{1}{P} = \frac{1}{4} = 0.25$ m

9. Magnification produced by a rear view mirror fitted in vehicles

(a) is less than one
(b) is more than one
(c) is equal to one
(d) can be more than or less than one depending upon the position of the object in front of it.

Ans. **(A)** The convex mirror forms virtual, erect and diminished image of the object and rear view mirror also form some type of image. Therefore, magnification (m) produced by a rear view mirror fitted in vehicles is less than one i.e., m < 1.

10. Rays from sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object?

(a) 15 cm in front of the mirror
(b) 30 cm in front of the mirror
(c) between 15 cm and 30 cm in front of the mirror
(d) more than 30 cm in front of the mirror

Ans. **(B)** The rays from sun i.e., from infinity, are parallel to principal axis after reflection converge at a point, known as focus. Therefore, focal length (F) of concave mirror is 15 cm. And we know that, same size, real and inverted image is formed by concave mirror when object is placed at focus 2 F or centre of curvature so to form same size image object will be placed at 15 x 2 = 30 cm.

11. A full length image of a distant tall-building can definitely be seen by using

(a) a concave mirror (b) a convex mirror
(c) a plane mirror (d) both concave as well as plane mirror

Ans. **(B)** The convex mirror forms virtual, erect and diminished image of the objects. So, it can form full length image of a distant tall building.

12. In torches, search lights and headlights of vehicles, the bulb is placed

(a) between the pole and the focus of the reflector
(b) very near to the focus of the reflector
(c) between the focus and centre of curvature of the reflector
(d) at the centre of curvature of the reflector

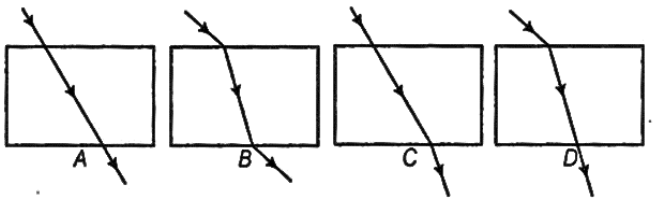
Ans. **(B)** Concave mirrors are commonly used in torches, search lights and vehicles headlights to get powerful parallel beams of light.
Here the bulb is placed very near to the focus of the reflector as the incident rays, which passes-through the focus of concave mirror, after reflection become parallel to the principal axis of the mirror.

13. The laws of reflection hold good for

(a) plane mirror only (b) concave mirror only
(c) convex mirror only (d) all mirrors irrespective of their shape

Ans. **(D)** The laws of reflection holds good-for light reflected from any smooth surface i.e., all mirrors regardless of its shape.

14. The path of a ray of light coming from air passing through a rectangular glass slab traced by four students shown as A, B, C and D in the figure.
Which one of them is correct?



(a) A (b) B (c) C (d) D

Ans. **(B)** In a rectangular glass slab, the emergent rays are parallel to the direction of the incident ray, because the lateral daviation of bending of the ray of light at the opposite parallel faces (air-glass interface) and (glass-air

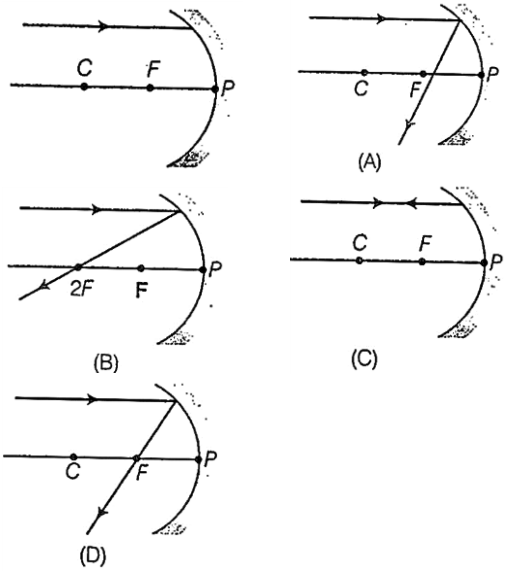
interface) of the rectangular glass slab are equal and opposite. This is why the ray emerges are parallel to the incident ray.

15. You are given water, mustard oil, glycerine and kerosene. In which of these media, a ray of light incident obliquely at same angle would bend the most?

(a) Kerosene (b) Water (c) Mustard oil (d) Glycerine

Ans. **(D)** The given material having their refractive index as kerosene is 1.44, water is 1.33. musterd oil is 1.46 and glycerine is 1.74. Thus, glycerine is most optically denser and hence have the largest refractive index. Therefore, ray of light bend most in glycerine.

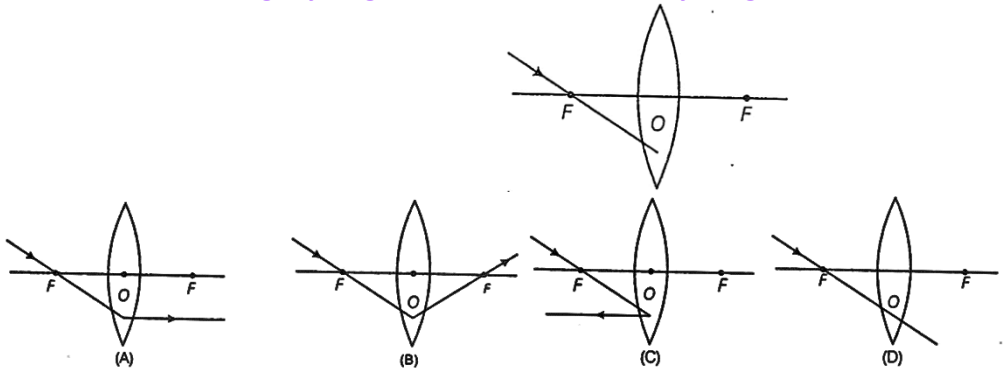
16. Which of the following ray diagrams is correct for the ray of light incident on a concave mirror as shown in figure?



(a) A (b) B (c) C (d) D

Ans. **(D)** A ray parallel to the principal axis, after reflection will pass through the principal focus in case of a concave mirror.

17. Which of the following ray diagrams is correct for the ray of light incident on a lens shown in figure?



(a) A (b) B (c) C (d) D

Ans. **(A)** A ray of light passing through the principal focus of a convex lens after refraction from a convex lens, will emerge parallel to the principal axis.

18. **A child is standing -in front of a magic mirror. She finds the image of her head bigger, the middle portion of her body of the same size and that of the legs smaller. The following is the order of combinations for the magic mirror from the top.**

(a) Plane, convex and concave (b) Convex, concave and plane

(c) Concave, plane and convex (d) Convex, plane and concave

Ans. **(C)** Concave mirrors (of large focal length) can be used to see a larger image of the head, the plane mirror for middle portion to see her body of the same size and convex mirror to see the diminished image of leg. Hence, the combinations for magic mirror from the top is concave mirror, plane mirror and convex mirror.

19. **In which of the following, the image of an object placed at infinity will be highly diminished and point sized?**

(a) Concave mirror only

(b) Convex mirror only

(c) Convex lens only

(d) Concave mirror, convex mirror, concave lens and convex lens

Ans. **(D)** The incident rays which comes from an object placed at infinity will be parallel and the rays parallel to the principal axis, after reflection/refraction by concave mirror, convex mirror, concave lens and convex lens, will pass or appear to pass through the principal focus. Hence, image will be highly diminished and point sized.

Short Answer Type Questions

20. **Identify the device used as a spherical mirror or lens in following cases, when the image formed is virtual and erect in each case.**

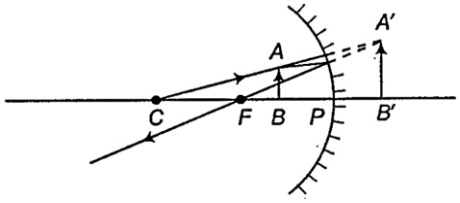
(a) Object is placed between device and its focus, image formed is enlarged and behind it

(b) Object is placed between the focus and device, image formed is enlarged and on the same side as that of the object

(c) Object is placed between infinity and device, image formed is diminished and between focus and optical centre on the same side as that of the object

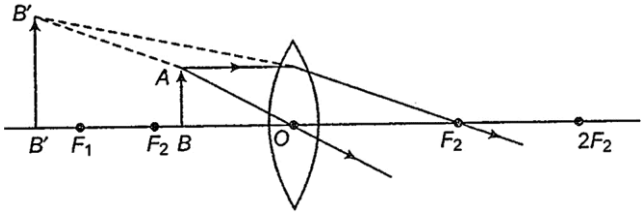
(d) Object is placed between infinity and device, image formed is diminished and between pole and focus, behind it

Ans. **(A)** The spherical mirror is used as concave mirror.



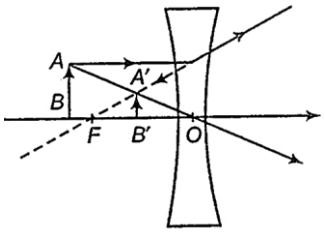
Object between F and P

(b) The spherical lens is used as convex lens.



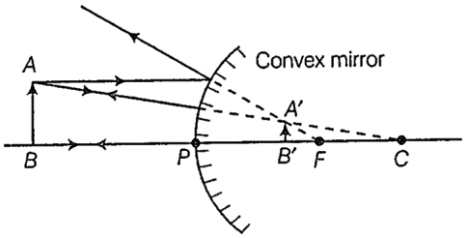
Object between focus (F) and device (O)

(c) The spherical lens is used as concave lens,



Object between infinity and device (O)

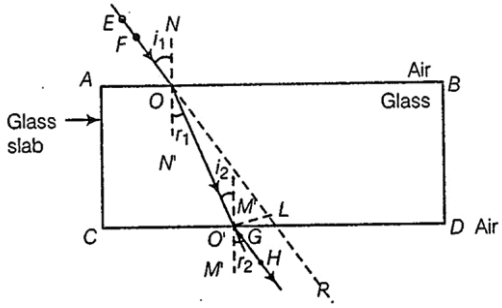
(d) The spherical mirror is used as convex mirror.



Object between infinity and device (P)

21. Why does a light ray incident on a rectangular glass slab immersed in any medium emerges parallel to itself? Explain using a diagram.

Ans. In the given figure, £0 is the incident ray, OO' is the refracted ray and O'H is the emergent ray



The extent of bending of the ray of light at the opposite parallel faces AB (air-glass interface) and CD (glass-air interface) of the rectangular glass slab is equal and opposite. This is why the ray emerges parallel to the incident ray on a rectangular glass slab. However, the light ray is shifted sideward slightly. When glass slab in immersed in any medium the interface AB (medium-glass) and CD glass medium are equal and opposite so, the emergent ray will always be parallel to the incident ray.

22. A pencil when dipped in water in a glass tumbler appears to be bent at the interface of air and water. Will the pencil appear to be bent to the same extent, if instead of water we use liquids like, kerosene or turpentine? Support your answer with reason.

As it is based on refraction of light.

Ans. A pencil partly immersed in water in a glass tumbler, it appears to be displaced at the interface of air and water. The light reaching out from the portion of the pencil inside water seems to come from a different direction, compared to the part above water due to refraction of light.

The pencil appear to be bent to the different extent, if instead of water, liquids like, kerosene or turpentine are used as their refractive indices are different which in turn produces deviation from incident ray by different extent.

23. How is the refractive index of a medium related to the speed of light? Obtain an expression for refractive index of a medium with respect to another in terms of speed of light in these two media?

Ans. The refractive index of the medium is defined as the ratio of speed of light in vacuum to the speed of light in the medium. It is expressed as

$$\text{Refractive index}, \mu = \frac{\text{speed of light in vacum, c}}{\text{speed of light in medium, v}}$$

μ_1 = refractive index of first medium

μ_2 = refractive index of second medium

v_1 = velocity in first medium

v_2 = velocity in second medium

For medium 1, we have $\mu_1 = \frac{c}{v_1}$

For medium 2, we have $\mu_2 = \frac{c}{v_2}$

$$\therefore \ \mu_{21} = \frac{\mu_2}{\mu_1} = \frac{\frac{c}{v_2}}{\frac{c}{v_1}} = \frac{v_1}{v_2}$$

24. Refractive index of diamond with respect to glass is 1.6 and absolute refractive index of glass is 1.5. Find out the absolute refractive index of diamond.

Ans. Given, refractive index of diamond with respect to glass, ${}_g\mu_d = 1.6 = \frac{\mu_d}{\mu_g}$

Absolute refractive index of glass,

${}_a\mu_g = 1.5 = \mu_g / \mu_a$

Absolute refractive index of diamond, ${}_a\mu_d = \mu_d / \mu_a = ?$

$${}_g\mu_d = \frac{{}_a\mu_d}{{}_a\mu_g}$$

$$\Rightarrow {}_a\mu_d = {}_g\mu_d \times {}_a\mu_g = 1.6 \times 1.5 = 2.4$$

25. A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?

Ans. Yes, the statement is correct. The convex lens of focal length 20 cm can produce a magnified, virtual as well as real image. The object should be placed

(i) Between focus F_1 and optical centre O (i.e., a distance less than 20 cm from the lens) for magnified, virtual and erect image.

(ii) Between (c and 2F, (;.e., at a distance between 20 cm to 40 cm) for real, inverted and enlarged image.

26. Sudha finds out that the sharp image of the window pane of her science laboratory is formed at a distance of 15 cm from the lens. She now tries to focus the building visible to her outside the window instead of the

window pane without disturbing the lens. In which direction will she move the screen to obtain a sharp image of the building? What is the approximate focal length of this lens?

Ans. Sudha should move the screen towards the lens to obtain a sharp image of the building because window pane was lying beyond focus 2F or centre of curvature and convex lens forms its image, on the other side between F and 2F and when she tries to focus the building visible to her outside the window (i.e., at distant object at infinity), then lens forms the image of building at a distance of focal length.
The approximate focal length of this lens is 15 cm.

27. How are power and focal length of a lens related? You are provided with two lenses of focal length 20 cm and 40 cm, respectively. Which lens will you use to obtain more convergent light?

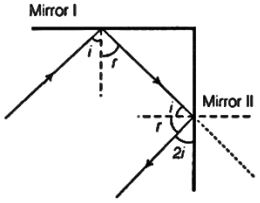
Ans. The power of a lens is related to its focal length as

$$P = \frac{1}{f\,(\text{in m})}$$

For greater convergent light, lens of higher power and smaller focal length is needed i.e., the lens of focal length 20 cm is needed for the same.

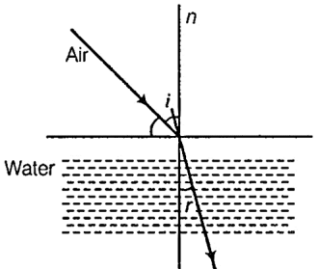
28. Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence. Show the same with the help of diagram.

Ans. When two plane mirrors are placed at right angle with each other, then incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence.

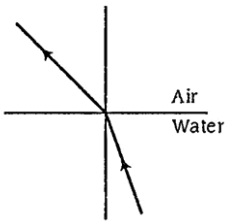


29. Draw a ray diagram showing the path of rays of light when it enters with oblique incidence (i) from air into water; (ii) from water into air.

Ans. (i) When ray of light enters with oblique incidence from air into water, then it goes from optical rarer medium to optical denser medium and velocity of light decreases which in turn bends the incident light towards the normal. Also, i > r



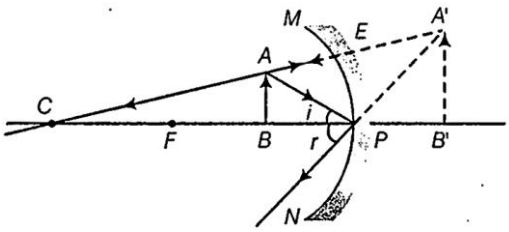
(ii) When ray of light enters with oblique incidence from water into air, then it goes from optical denser medium to optical rarer medium and velocity of light increases which in turn bends the incident light away from the normal. Also, i < r.



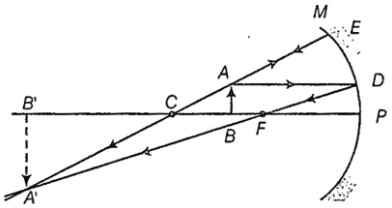
Long Answer Type Questions

30. **Draw ray diagrams showing the image formation by a concave mirror when an object is placed**
(a) between pole and focus of the mirror
(b) between focus and centre of curvature of the mirror
(c) at centre of curvature of the mirror
(d) a little beyond centre of curvature of the mirror at infinity

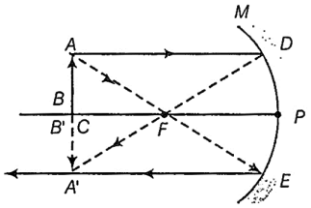
Ans. **(A)** The enlarged, virtual and erect image forms behind the mirror when the object is placed between pole and focus of the mirror.



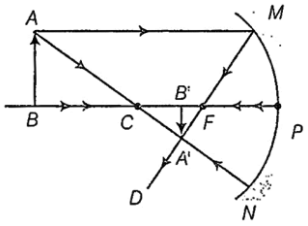
(b) The enlarged, real and inverted image forms beyond centre of curvature when the object is placed between focus and centre of curvature of the mirror.



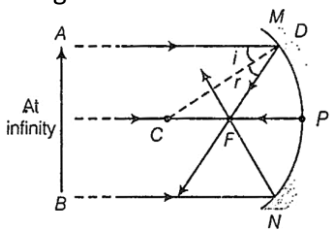
(c) The real and inverted image equal to the size of object forms at centre of curvature when the object is placed at the centre of curvature of the mirror.



(d) The diminished, real and inverted image forms between centre of curvature and focus when the object is placed a little beyond centre of curvature of the mirror.



(e) The real, inverted and highly reduced image forms at focus F when the object is placed at infinity.



31. Draw ray diagrams showing the image formation by a convex lens when an object is placed

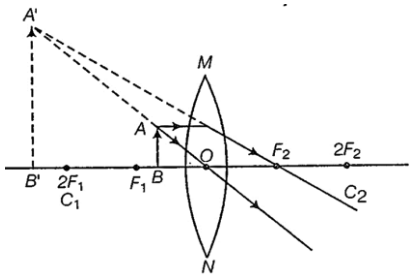
(a) between optical centre and focus of the lens

(b) between focus and twice the focal length of the lens

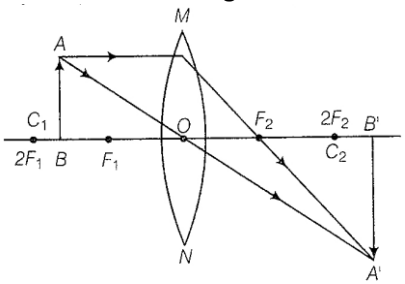
(c) at twice the focal length of the lens at infinity

(d) at the focus of the lens

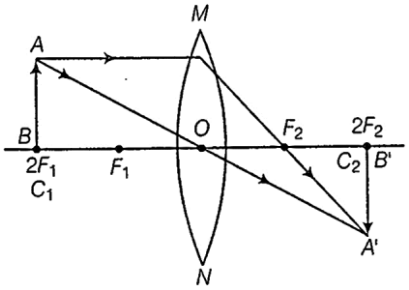
Ans. **(A)** The enlarged, virtual and erect image forms beyond $2F_1$, in the same side of object when the object is placed between optical centre and focus F_1 of the lens.



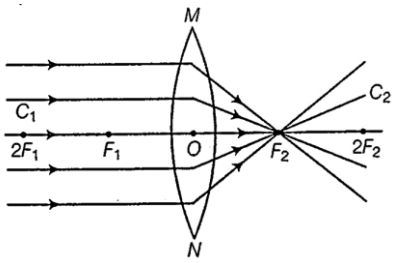
(b) The enlarged, real and inverted image forms beyond focus $2F_2$ on the other side of the object when the object is placed between focus F_1 and twice the focal length of the lens.



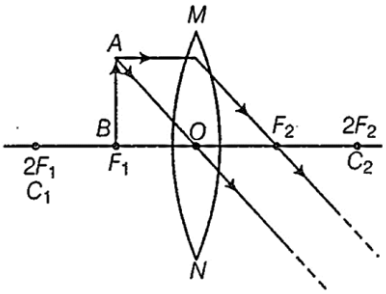
(c) The real and inverted image of equal to the size of object forms at focus $2F_2$ on the other side of the object when the object is placed at twice the focal length of the lens.



(d) The real, inverted and highly reduced image forms at focus F_2 on the other side of the object when the object is placed at infinity.



(e) The real, inverted and highly magnified image forms at infinity on the other side of the object when the object is placed at the focus of the lens.



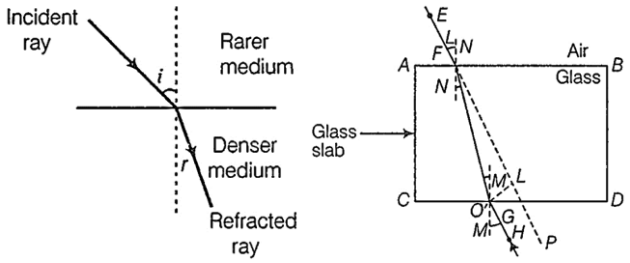
32. Write laws of refraction. Explain the same with the help of ray diagram, when a ray of light passes through a rectangular glass slab.

Ans. The following are the laws of refraction of light

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

(ii) The ratio of sine of angle of incidence to the sine of angle of refraction is constant, for the light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction. And the constant is called refractive index.

The ray diagram is as shown.



In a rectangular or glass slab, the emergent rays are parallel to the incident ray because the extant of bending of the ray of light at the opposite parallel faced of rectangular glass slab are equal and opposite, so that emergent ray is parallel to incident ray.

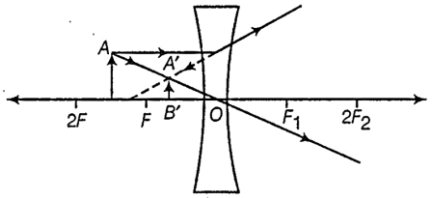
33. Draw ray diagrams showing the image formation by a concave lens when an object is placed

(a) at the focus of the lens

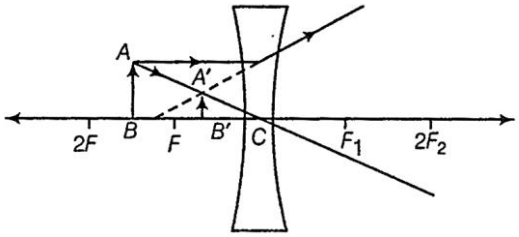
(b) between focus and twice the focal length of the lens

(c) beyond twice the focal length of the lens

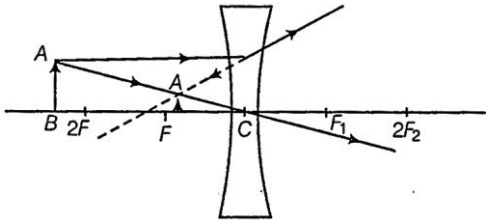
Ans. **(A)** The image formed is virtual, erect, diminished in size and between and F when the object is placed at focus



(b) The image formed is virtual, erect, diminished in size and between optical centre and focus F when the object is placed between focus and twice the focal length of the lens.



(c) The image formed is virtual, erect, diminished in size and between optical centre and focus F when the object is placed beyond twice the focal length of the lens.

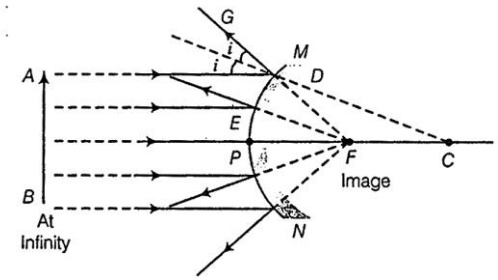


34. Draw ray diagrams showing the image formation by a convex mirror when an object is placed

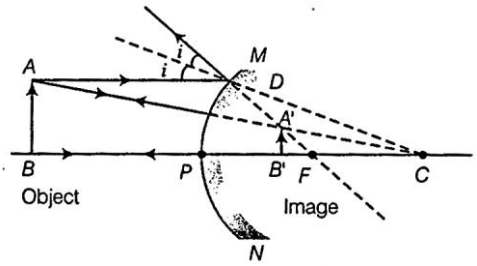
(a) at infinity

(b) at finite distance from the mirror

Ans. **(A)** The virtual, erect and highly diminished image of the object forms at focus F behind the mirror when the object is placed at infinity.



(b) The virtual, erect and diminished image forms between focus F and pole P behind the mirror when the object is placed at finite distance from the mirror.



35. The image of a candle flame formed by a lens is obtained on a screen placed on the other side of the lens. If the image is three times the size of the flame and the distance between lens and image is 80 cm, at what distance should the candle be placed from the lens? What is the nature of the image at a distance of 80 cm and the lens?

Concept Involved

Using magnification find the object distance. Then, using lens formula, calculate the value of focal length. Using sign of convention nature of lens can be identified.

Ans. The image is real as only the real image can be taken on the screen.
Here, image distance v = + 80cm
Magnification, m = - 3
Object distance, u =?

Since, magnification, $m = \frac{v}{u} \Rightarrow -3 = \frac{80}{u}$

Nature of image
$\rightarrow$ Real, inverted
$\rightarrow$ magnified
$\rightarrow$ formed beyond 2F
Using lens formula, we have

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

$$\frac{1}{f} = \frac{1}{80} - \frac{3}{-80} = \frac{4}{80} = \frac{1}{20}$$

$$\Rightarrow f = 20\,\text{cm}$$

Positive focal length denotes that lens is convex.

36. Size of image of an object by a mirror having a focal length of 20 cm is observed to be reduced to 1/3rd to its size. At what distance, the object has been placed from the mirror? What is the nature of the image and the mirror?

Concept Involved

Solve object distance for both concave mirror and convex mirror using the relation of magnification and mirror formula.

Ans. Here, considering (the case for both type of possible spherical mirrors
For concave mirror

Focal length, $f = -20$ cm

Magnification, $m = -\frac{1}{3}$

Since, magnification, $m = -\frac{v}{u}$

$\therefore$ Magnification, $m = -\frac{1}{3} = -\frac{v}{u}$

$v = \frac{u}{3}$

Using mirror formula, we have

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{1}{u} + \frac{3}{u} = \frac{4}{u}$

$\Rightarrow u = 4f = 4(-20) = -80$ cm

The object should be placed at a distance 80 cm from the concave mirror.

For convex mirror,

Focal length, f = + 20cm

Magnification, $m = +\frac{1}{3}$

Since, magnification, $m = -\frac{v}{u}$

Magnification, $m = \frac{1}{3} = -\frac{v}{u}$

$v = -\frac{u}{3}$

Using mirror formula, we have

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

$\frac{1}{f} = \frac{-3}{u} + \frac{1}{u} = \frac{-2}{u}$

$u = -2f = -2(20) = -40$ cm

The object should be placed at a distance 40 cm from the convex mirror to form virtual, erect and diminished image.

37. Define power of a lens. What is its unit? One student uses a lens of focal length 50 cm and another of -50 cm. What is the nature of the length and its power used by each of them?

Ans. Power of lense is defined as the ability of a lens to bend the rays of light. It is given by the reciprocal of focal length in metre. Its unit is dioptre.

If focal length, (f) = 50cm, then $P = \frac{100}{f} = \frac{100}{50} = 2D$, lens is convex.

If focal length, (f) = - 50 cm, then $P = \frac{100}{f} = \frac{100}{-50} = -2D$, lens is concave.

38. A student focussed the image of a candle flame on a white screen using a convex lens. He noted down the position of the candle, screen and the lens as under

position of candle =12.0 cm

position of convex lens = 50.0 cm

position of the screen = 88.0 cm

(i) What is the focal length of the convex lens?

(ii) Where will the image be formed, if he shifts the candle towards the lens at a position of 31.0 cm?

(iii) What will be the nature of the image formed, if he further shifts the candle towards the lens?

(iv) Draw a ray diagram to show the formation of the image in case as said above.

Ans. Object distance u = Position of the convex lens - Position of candle

= 50 – 12 = 38 cm

By sign convention, u = -38 cm

Similarly, image distance, v = position of the screen - position of convex lens

= 88 – 50 = 38 cm

By sign convention, v = + 38 cm

(i) Using lens formula, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{f}=\frac{1}{38}-\frac{1}{-38}=\frac{2}{38}=\frac{1}{19}$$

$$f=19\,\text{cm}$$

The focal length of the convex lens is 19 cm.

(ii) After shifting the candle towards the lens at a position of 31.0 cm, then object distance u = position of convex lens - position of candle = 50 – 31 =19

By sign convention, u = - 19cm, but here focal length of the convex lens is also 19 cm.

So, the candle lies at the focus of lens, hence its image forms at infinity.

(iii) When student further shifts the candle towards the lens i.e., candle lies between optical centre and focus of convex lens, then lens forms enlarged, virtual and erect image of the candle.

(iv) The ray diagram showing the formation of image