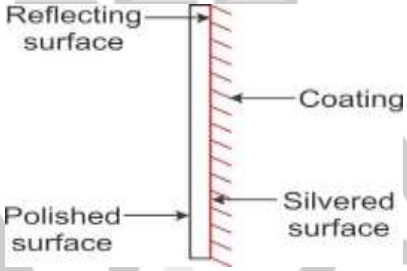
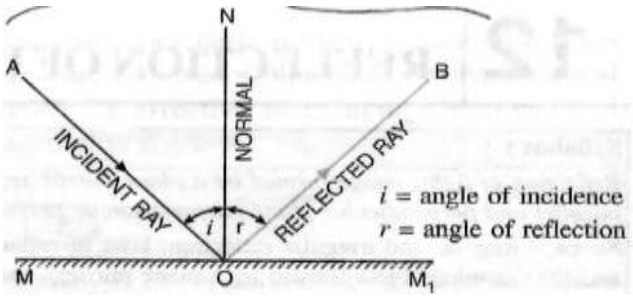
7	Reflection of light at a plane surface	Book: Selina

Exercise A

1. **What do you mean by reflection of light?**
   The return of light into the same medium, after striking a surface is called reflection
2. **State which surface of a plane mirror – the front smooth surface or the back silvered surface, reflects most of the light incident on it.**
   Back silvered surface
3. **Explain the following terms: (a) a plane mirror. (b). incident ray, (c) reflected ray, (d) angle of incidence, and (e) angle of reflection. Draw diagram/diagrams to show them**
   (a) A plane mirror – A plane mirror is made from a few mm thick glass plate. One surface of glass plate is polished to a high degree of smoothness which forms the front surface of the mirror and the other (or back) surface is silvered.

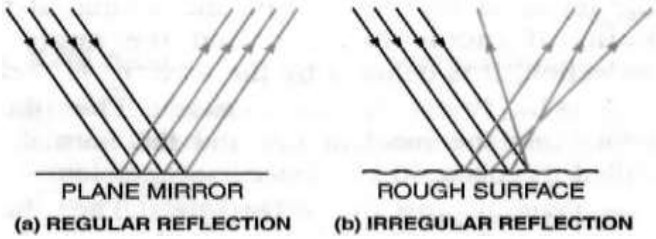


   (b) Incident ray – The light ray striking a reflecting surface is called the incident ray.
   (c) Reflected ray – The light ray obtained after reflection from the surface, in the same medium in which the incident ray is travelling is called the reflected ray.
   (d) Angle of incidence – The angle which the incident ray makes with the normal at the point of incidence, is called the angle of Incidence. It is denoted by the letter *i*.
   (e) Angle of reflection – The angle which the reflected ray makes with the normal at the point of incidence, is called the angle of reflection, it is denoted by the letter r.



4. **With the help of diagrams, explain the difference between the regular and irregular reflection.**
   There are two kinds of reflection: Regular reflection, and Irregular reflection.
   (1) Regular reflection – Regular reflection occurs when a beam of light falls on a smooth and polished surface, such as a plane mirror. In; Fig. 12.2(a), a parallel beam of light is incident; on a plane mirror, the reflected beam is also parallel and it is in a fixed direction. This is called the regular reflection

(2) Irregular reflection – Irregular reflection occurs when a beam of light falls on a rough surface such as walls of a room, page of a book or any other object. The walls of a room or page of a book may appear smooth, but If it is examined under a microscope, it appears quite uneven having many small projections over it. When light rays strike at different parts of a rough surface, each ray gets reflected from different points of the rough surface, obeying the laws of reflection of light. Due to uneven surface, the light rays get reflected in different directions and give rise to the diffused or irregular reflection.



5. Differentiate between reflection of light from plane mirror and that from a plane sheet of paper.

Plane mirror is highly polished surface so it shows regular reflection where as plane paper has uneven small projections that make it rough and so it shows irregular reflection.

6. State the two laws of reflection of light.

(1) The angle of incidence *i* is equal to the angle of reflection r (i.e. □ *i* = □ *r*).

(2) The incident ray, the reflected ray and the normal at the point of incidence, lie in, the same plane.

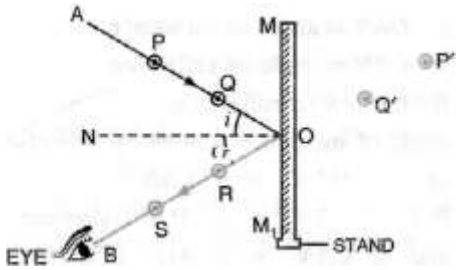
7. State the laws of reflection and describe an experiment to verify it.

The angle of incidence *i* is equal to the angle of reflection r (i.e. □ *i* = □ *r*).

Experiment:

Fix a sheet of white paper on a drawing board and draw a line MM_1 as shown in Fig. 12.5. On this line, take a point O nearly at the middle of it and draw a line OA such that □MOA is less than 90 (say, 60). Then draw a normal ON on line MM_1 at the point O. Now set a small plane mirror vertical by means of a stand with its silvered surface along MM_1.

Now fix two pins P and Q at some distance apart vertically on the line OA, on the board. Keeping the eye on the other side of the normal (but on die .same side of mirror), see clearly the images P' and O' of the pins P and Q. Now fix a pin R such that it is in line with the images of pins P and Q as observed in the mirror. Now fix one more pin S such that the pin S is in line with the pin R and the images P' and Q' of pins P and Q. Draw small circles on the paper around the position of the pins. Remove the pins and draw a line OB joining the pin points S and R, which meets the surface of the mirror at O.



In fig. 12.5, AO is the incident ray, OB is the reflected ray, ∠AON = *i* is the angle of incidence and ∠BON = *r* is the angle of reflection. The angles AON and BON are measured and we find that in each case the angle of incidence and the angle of reflection are equal. This verifies the first law of reflection.

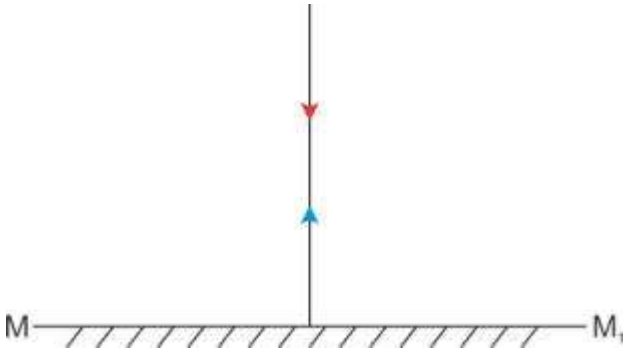
8. A light ray is incident normally on a plane mirror.

(a) What is its angle of incidence?

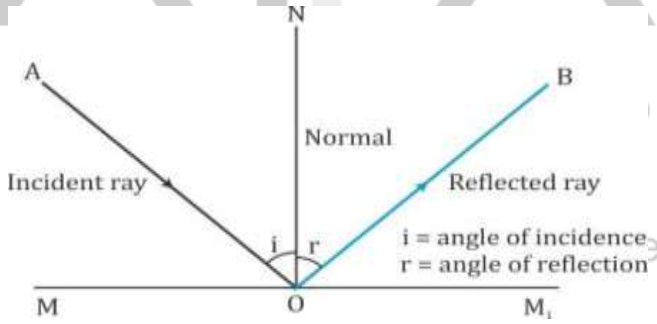
0°

(b) What is the direction of the reflected ray? Show it on a diagram.

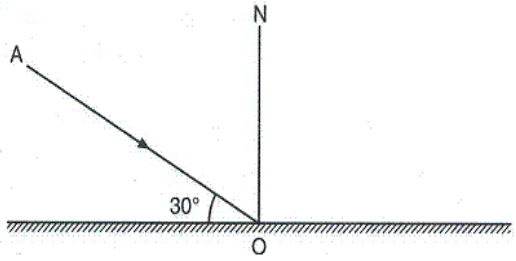
same as incident ray



9. Draw a diagram to show the reflection of a ray of light using a plane mirror. In the diagram, label the incident ray, the reflected ray, the normal, the angle of incidence and the angle of reflection.



10. Fig. shows an incident ray AO and the normal ON on a plane mirror. The angle of incidence is 60°. Draw the reflected ray and then find the angle between the incident and reflected rays.

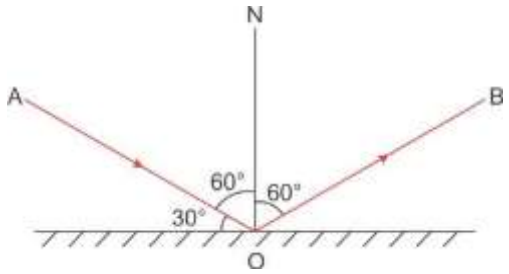


(a) Angle of incidence = $90^o - 30^o = 60^o$

(b) Angle between the incident ray and reflected ray = Angle of incidence + Angle of reflection

Angle of reflection = Angle of incidence = 60^o

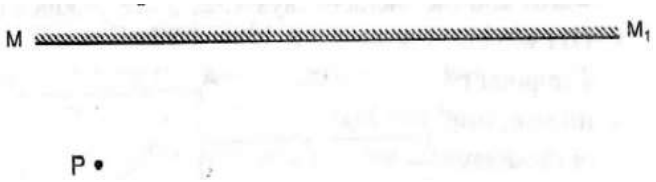
Therefore, Angle between the incident ray and reflected ray = $60^o + 60^o = 120^o$



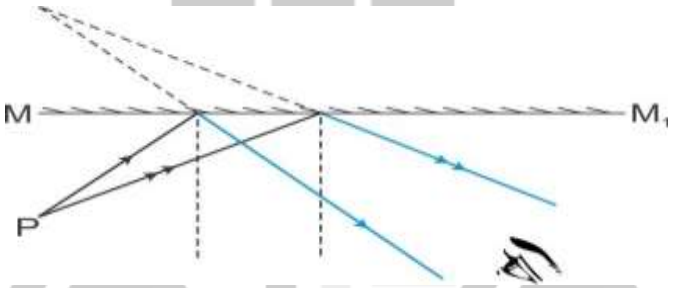
11. The diagram below in Fig. shows a point object P in front of a plane mirror MM_1.

(a) Complete the diagram by taking two rays from the point P to show the formation of its image.

(b) In the diagram, mark the position of eye to see the image.



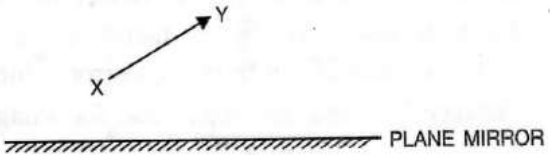
Answer



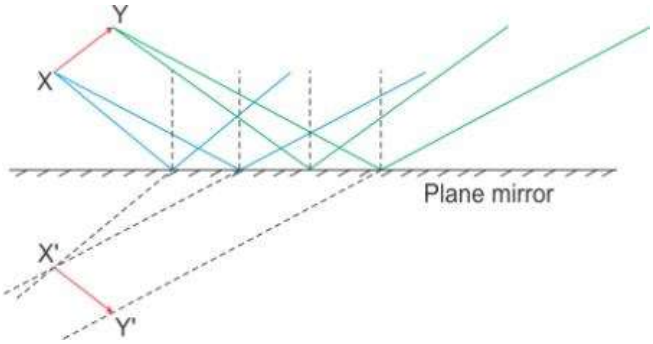
(c) Is the image formed real or virtual? Explain why?

Virtual because the reflected rays meet when they are produced backwards

12. The diagram below in Fig. 12.23 shows an object XY in front of a plane mirror. Draw on the diagram, the image of the object formed by the mirror. Trace the path of two rays from a point on the object to show the formation of image.



Answer



13. (a) Write three characteristics of the image formed by a plane mirror?

Three characteristics of image formed by plane mirror

(1) Image formed in erect (upright)

(2) Image formed is virtual

(3) Image formed is of the same size as the object

(b) How is the position of image related to the position of object?

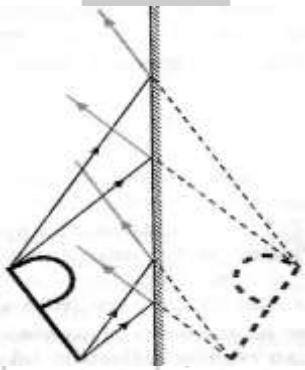
The image is situated at same perpendicular distance behind the mirror as the object in front of it

14. Differentiate between a real and a virtual image.

	Real image		Virtual image
1	A real image is formed due to actual intersection of the reflected rays.	1	A virtual image is formed when the reflected rays meet if they are produced backwards.
2	A real image can be obtained on a screen.	2	A virtual image cannot be obtained on screen.
3	A real image is inverted with respect to the object.	3	A virtual image is erect with respect to the object.

15. What is meant by lateral inversion of an image in a plane mirror? Explain it with the help of a ray diagram

The interchange of the left and right sides in the image of an object in a plane mirror is called the lateral inversion. Figure below shows the image formation of a letter P in a plane mirror. The letter P appears in the plane mirror as ꟼ.



16. The letters on the front of an ambulance are written laterally inverted like ƎɔИAJUBMA. Give reason

It is due to lateral inversion of the image formed in a plane mirror that it becomes difficult to read the text of a page from its image formed by reflection from a plane mirror. Therefore, the leters on the front of an ambulance are written laterally inverted like ƎɔИAJUBMA. The driver ofthe vehicle moving on road ahead of the ambulance reads these words laterally inverted as AMBULANCE in his rear view mirror and so he gives side to pass the ambulance first.

17. Why is it difficult to read me image or text of a Page formed due to reflection by a plane mirror?

Due to lateral inversion, , it becomes difficult to read the image of the text of a page formed due to reflection by a plane mirror.

18. Multiple choice type :

(1) According to the law of reflection: $i = r$.

(2) The image formed by a plane mirror is: erect and of same size.

(3) The image formed by a plane mirror is: virtual with lateral inversion.

Exercise B

1. **Two plane mirrors are placed making an angle θ in between them. Write an expression for the number of images formed of an object placed in between mirrors. State the condition, if any.**

   If two mirrors make an angle θ with each other and object is placed in between the two mirrors, the number of images formed is n or (n - 1) depending upon $n = 360^o / \theta^o$ is odd or even.

   (a) If $n = 360^o / \theta^o$ is odd.

   (i) The number of images formed is n, when the object is placed asymmetrically between the mirrors.

   (ii) The number of images formed is n-1, when object is placed symmetrically between the mirrors.

   (b) If $n = 360^o / \theta^o$ is even, the number of images is always n-1.

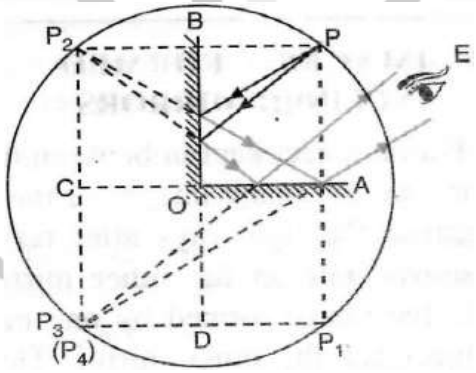
2. **Two plane mirrors are placed making an angle θ° in between them. For an object placed in between the mirrors, if angle is gradually increased from 0 to 180, how will the number of images change: increase, decrease or remain unchanged.**

   The number of images formed is given as

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

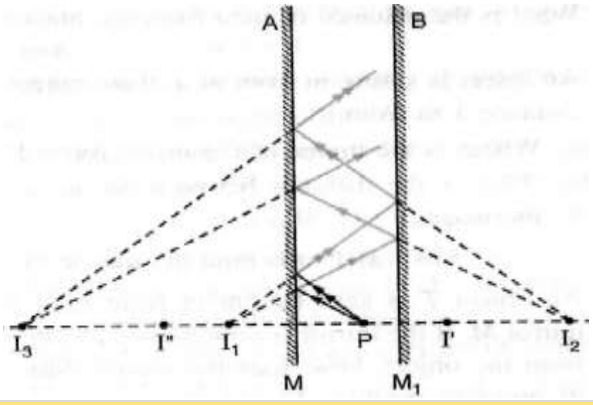
   So, if θ is gradually increased, n decreases.

3. **How many images are formed for a point source kept in between the two plane mirrors M_1 and M_2, at right angles to each other? Show them by drawing a ray diagram.**



4. **Two plane mirrors are arranged parallel and facing each other at some separation. How many images are formed for a point, source kept in between them? Show the formation of images with the help of a ray diagram.**

Infinite



5. State two uses of a plane mirror.

(1) As a looking glass.

(2) In the optician s room to increase the effective length of the room by keeping a plane mirror on the front wall and the sign board on the opposite wall behind the patient. For the patient, the sign board is at double the length of the room.

(3) In the barber's shop for seeing the hair at the back of the head, two mirrors facing each other, are fixed on the opposite walls at the front and back of the viewer.

(4) In a periscope, two plane mirrors each inclined at 45 with the vertical and facing each other, are kept parallel to each other.

(5) In a kaleidoscope, three plane mirrors inclined with each other at 60° are used.

(6) In the solar heating devices such as solar cooker etc. plane mirror is used to reflect the light rays incident from sun on the substance to be heated.

6. Multiple choice type :

(1) Two plane mirrors are placed making an angle 60° in between them. For an object placed in between the minors, the number of images formed with be : 5.

(2) The image formed in a periscope is : virtual without lateral inversion.

Exercise C

1. What is a spherical mirror?

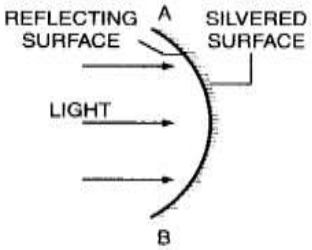
A reflecting surface which is a part of a sphere is called a spherical mirror.

2. Name the two kinds of spherical mirrors and distinguish between them.

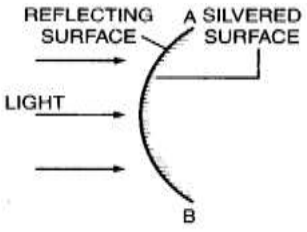
Depending upon which (inner or outer) surface of the sphere is silvered, we get spherical mirrors of two types: (i) the concave mirror, and (ii) the convex mirror

(1) Concave mirror – A concave mirror is made by silvering the outer(or the bulging surface) of the hollow sphere such that the reflection takes place from the hollow (or concave) surface.

(2) Convex mirror – A convex mirror is made by silvering the inner surface of the hollow sphere such that the reflection takes place from the outer (or bulging) surface.



(a) CONCAVE MIRROR



(b) CONVEX MIRROR

3. Define terms pole, principal axis and centre of curvature with reference to a spherical mirror.

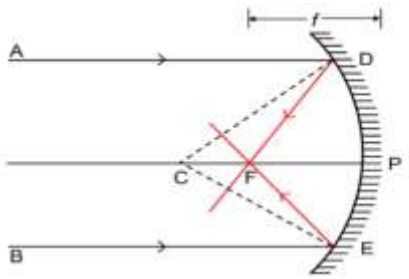
(1) Pole – The geometric centre of the spherical surface of the mirror is called the pole of the mirror.

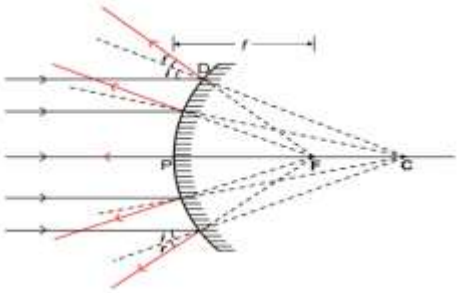
(2) Principal axis – It is the straight line joining the pole of the mirror to its centre of curvature.

(3) Centre of curvature – The centre of curvature of a mirror is the centre of the sphere of which the mirror is a part.

4. **Draw suitable diagrams to illustrate the action of (i) concave mirror, and (ii) convex mirror, on a beam of light incident parallel to the principal axis.**

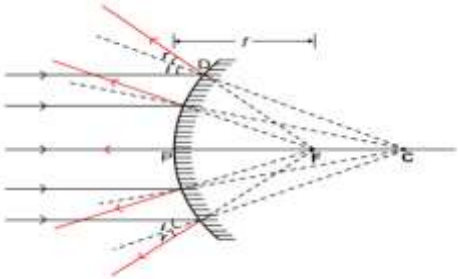
When a beam of light incident parallel to the principal axis on concave mirror or convexmirror, after reflection either passes or appears to pass through focus.





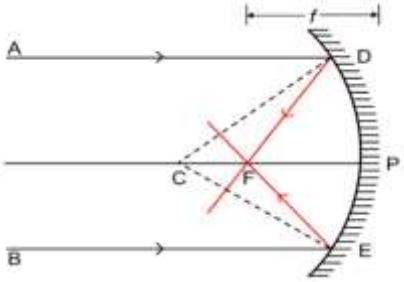
5. **Name the spherical mirror which (i) diverges (ii) converges the beam of light incident on it. Justify your answer by drawing a ray diagram in each case.**

(i) Convex mirror diverges a beam of light falling on it.



In Figure, rays of light are incident on a spherical convex mirror parallel to its principal axis. Each ray is reflected from the mirror obeying the law of reflection (i.e., angle of incidence i = angle of reflection r) for which the dotted line joining the point of incidence to the centre of curvature C act as normal at the point of incidence. We note that, the convex mirror diverges the rays on reflection.

(ii) Concave mirror converges a beam of light falling on it.

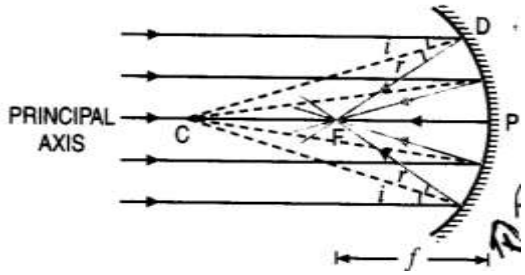


In Figure, the rays of light are incident on a spherical convex mirror parallel to its principal axis. Each ray is reflected from the mirror obeying the law of reflection (i.e., angle of incidence i = angle of reflection r) for which the dotted line joining the point of incidence to the centre of curvature C act as the normal at the point of incidence. We note that in Figure, the concave mirror converges the rays on reflection.

6. **Define terms focus and focal length of a concave mirror. Draw diagram to illustrate answer.**

(1) Focus – The focus of a concave mirror is a point on the principal axis through which the light rays incident parallel to the principal axis pass after reflection from the mirror.

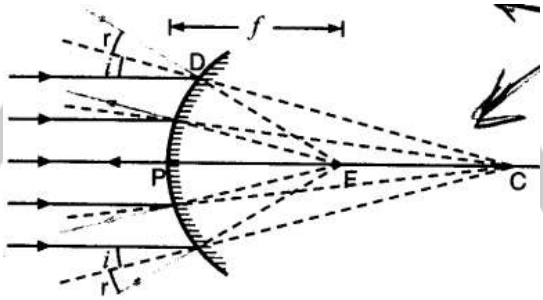
(2) Focal length – The distance of focus from the pole of the mirror is called the focal length of the mirror.



In case of a concave mirror, the rays after reflection passes through a point F on the principal axis. This point is called the focus of the concave mirror. Thus a concave mirror has the real focus because the reflected rays

actually meet at this point. The distance of focus F from the pole P of the mirror is called its focal length, i.e., focal length f = PR.

7. Explain the meaning of the terms focus and focal length in case of a convex mirror, with the help of suitable ray diagram.



In case of convex mirror, the reflected rays do not meet at any point, but they appear to come from a point F on the principal axis, behind the mirror. This point is called the focus of the convex mirror. This point is obtained when the reflected rays are produced backwards. Thus a convex mirror has the virtual focus. The distance of focus F from the pole P of the mirror is called its focal length i.e., focal length f = PF

8. State the direction of the incident ray which after reflection from the spherical mirror retraces its path. Give a reason to your answer.

Incident ray is directed towards the centre of curvature Reason : The ray is normal to the spherical mirror, so $\angle i = \angle r = 0$.

9. (i) Name the mirrors shown in Fig. (a) and (b).

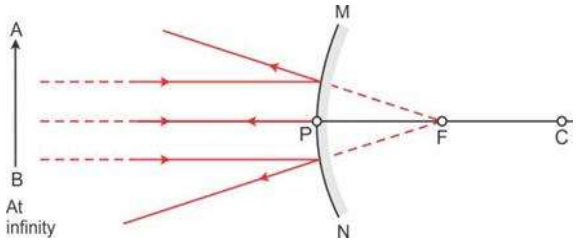
(ii) In each case (a) and (b), draw reflected rays for the given incident rays and mark focus by the symbol F.

(a) **(b)**

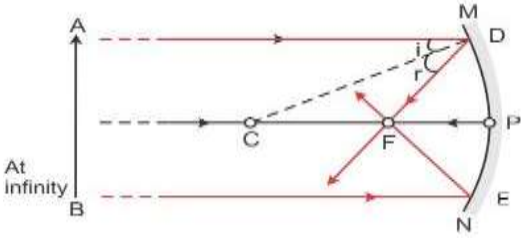
Answer

(i) In figure (a) a convex mirror is shown

In figure (b) a concave mirror is shown. (ii) (a)

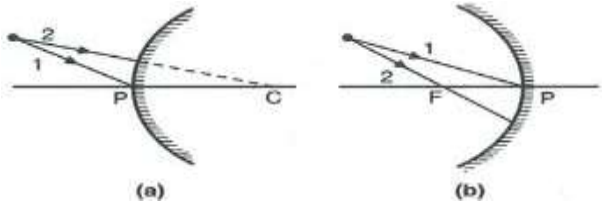


(a)



(b)

10. Complete the following diagrams in Fig. by drawing the reflected rays for the incident rays 1 and 2.



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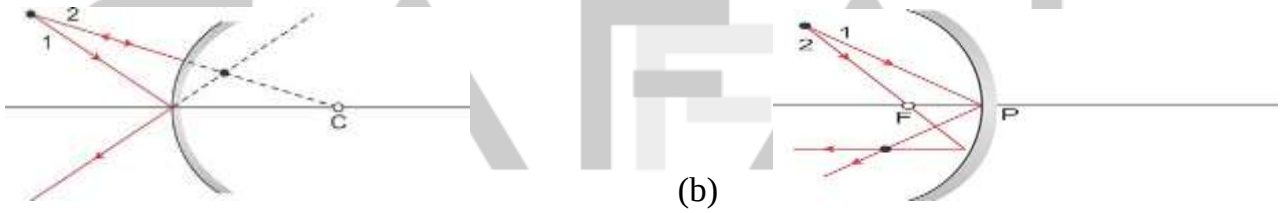
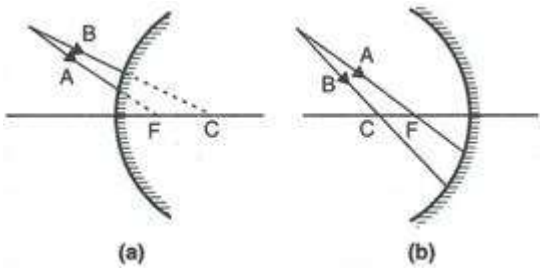
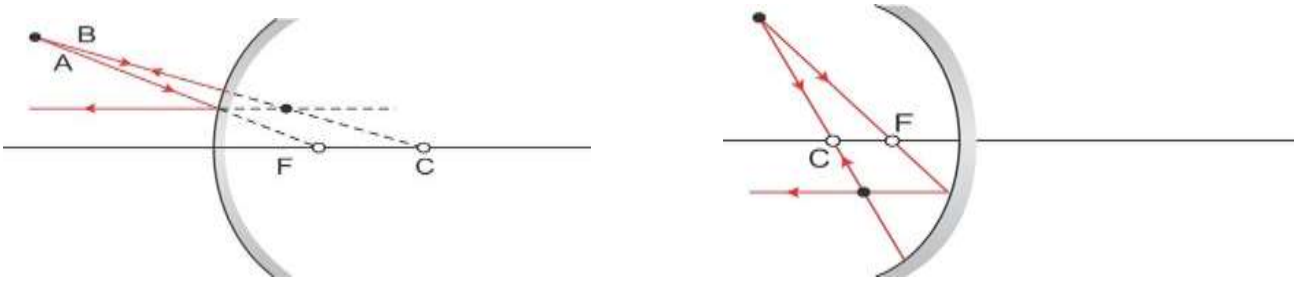


(a) (b)

11. Complete the following diagrams shown in Fig. by drawing the reflected ray for each of the incident ray A and B.



Answer

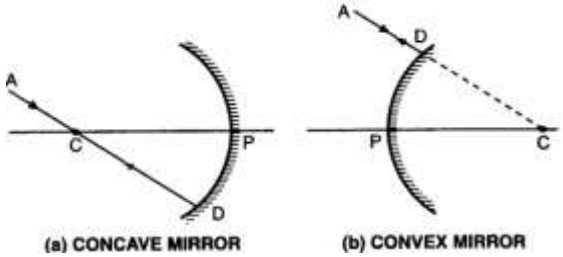


(a) **(b)**

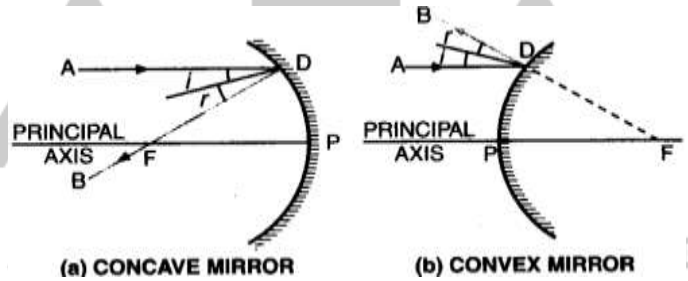
12. State the two convenient rays that are chosen to construct the image by a spherical mirror for a given object? Explain your answer with the help of suitable ray diagrams.

In order to find the position and nature of the image formed due to reflection from a spherical mirror by drawing, we need to consider at least two rays incident on the mirror from the same point of the object. Although from each point of the object, infinite number of rays travel in all directions, but two rays are chosen according to the convenience. Any two of the following rays are taken as the convenient incident rays.

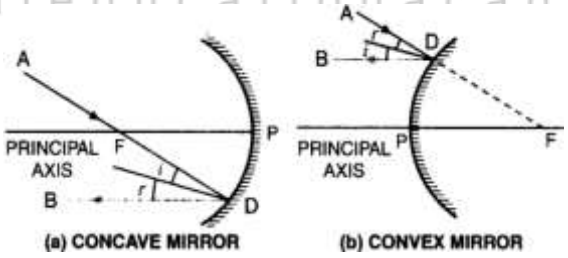
(1) A ray passing through the centre of curvature – A ray passing through or directed towards the centre of curvature is reflected back along its own path.



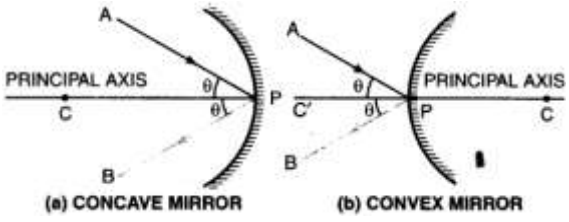
(2) A ray parallel to the principal axis – A ray incident parallel to principal axis, after reflection either passes or appears to pass through focus



(3) A ray passing through the focus – A ray either incident from the focus or converging at the focus, after reflection becomes parallel to the principal axis.

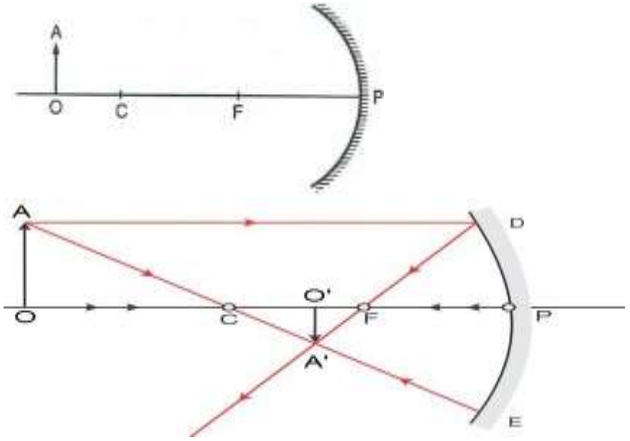


(4) A ray incident at the pole – A ray incident at the pole is reflected obeying the law of reflection and treating the principal axis as normal.

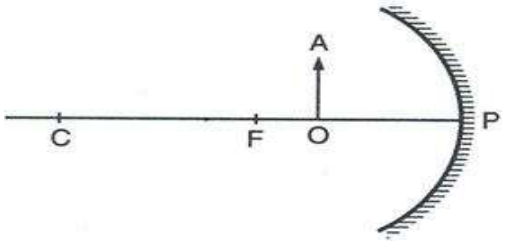


13. Fig. shows a concave mirror with its pole at *P*, focus *F* and centre of curvature C. Draw ray diagram to show the formation of image of an object *OA*.

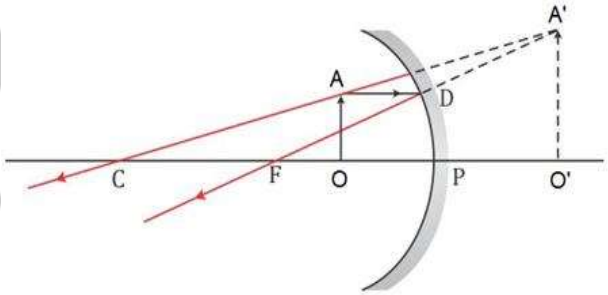
Answer



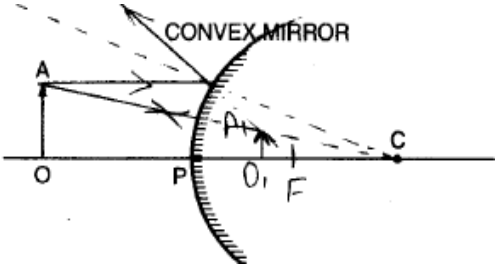
14. Fig. shows a concave mirror with its pole at *P*, focus *F* and centre of curvature C. Draw ray diagram to show the formation of image of an object *OA*.



Answer



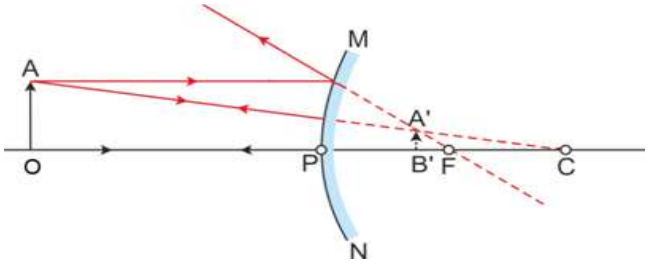
15. The diagram below in Fig., shows a convex mirror. C is its centre of curvature and F is its focus. (i) Draw two rays from A and hence locate the position of image of object OA. Label the image IB. (ii) State three characteristics of the image



Answer

The ray diagram shows two light rays from A.

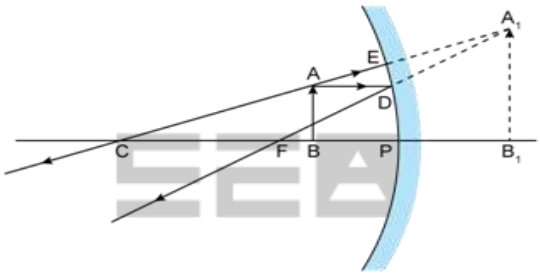
The image of the object OA is formed between the focus and the pole on the other side of the mirror.



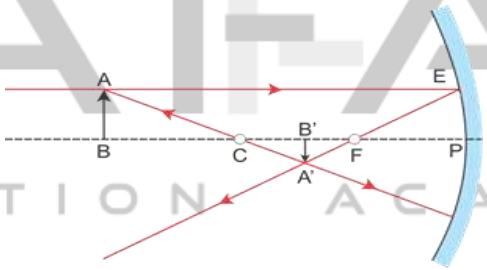
The image so formed is erect, virtual and diminished.

16. **Draw a ray diagram to show the formation of image by a concave mirror for an object placed between its pole and focus. State three characteristic of the image.**

When the object is placed between focus F and pole P, the image is formed behind the mirror. The image so formed is virtual, upright and magnified.

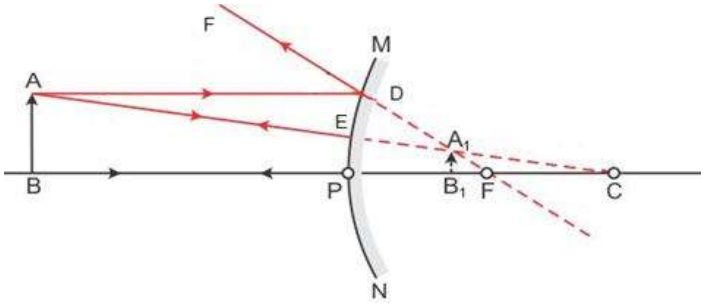


17. **Draw a ray diagram to show the formation of image by a concave mirror for an object beyond its centre of curvature. State three characteristic of the image.**



When the object is placed beyond the centre of curvature C, the image is formed between focus F and centre of curvature C. The image so formed is real, inverted and diminished.

18. **Draw a ray diagram to show the formation of image of an object kept in front of a convex mirror. State three characteristic of the image.**



The image formed is virtual, erect and diminished.

19. **Name the mirror which always produces an erect and virtual image. How is the size of image related to the size of object?**

A convex mirror always produces an erect and virtual image. The size of the image is shorter than the size of the object.

20. (a) For what position of object, the image formed by a concave mirror is magnified and erect?

If the object is placed between the pole and focus of a concave mirror, the image formed is magnified and erect

(b) State whether the image in part (a) is real or virtual?

The image is virtual.

21. (a) State the position of object for which the image formed by a concave mirror is of same size.

If the object is placed at centre of curvature of a concave mirror, image formed is of same size.

(b) Write two more characteristics of the image.

The image formed is real and inverted.

22. (a) What is a real image?

An image which can be obtained on a screen is called a real image.

(b) What type of mirror can be used to obtain a real image of an object?

A concave mirror can be used to obtain a real image of an object.

(c) Does the mirror mentioned in part (b) form real image for all locations of the object?

No, it does not form real image for all locations of the object.

23. Discuss the position and nature of image formed by a concave mirror when an object is moved from infinity towards the pole of mirror.

When an object is moved from infinity towards the pole of mirror, the image formed moves away from the mirror. The image formed is real and inverted.

The image formed moves away from the concave mirror when an object is moved from infinity towards the pole of mirror. The image is diminished when the object is beyond centre of curvature, but it becomes magnified as the object comes within the centre of curvature. The image is of the same size of the object when the object is at the centre of curvature. For the object situated beyond focus, the image is always real and inverted, whereas for the object situated between the focus and pole the image is upright and virtual.

The table below shows the position, size and nature of the image formed by a concave mirror for different positions of the object.

No.	Position of the object	Position of the image	Size of the image	Nature of the image
1	At infinity	At the focus	Diminished to a point	Real and inverted
2	At very far distance	In focal plane	Highly diminished	Real and inverted
3	Beyond the centre of curvature	Between the centre of curvature and focus	Diminished	Real and inverted

4	At the centre of curvature	At the centre of curvature	Same size	Real and inverted
5	Between the centre of curvature and focus	Beyond the centre of curvature	Magnified	Real and inverted
6	At focus	At infinity	Highly magnified	Real and inverted
7	Between the focus and the pole	Behind the mirror	Magnified	Virtual and upright

24. Discuss the position and nature of image formed by a convex mirror when an object is moved from infinity towards the pole of mirror.

In a convex mirror, the image formed is always virtual, upright and diminished. It is always situated between it's pole and focus irrespective of the distance of object in front of the mirror.

As the object comes closer to the mirror from infinity towards the pole, it's image shifts from focus towards the pole and increase in size.

The table below shows the position, size and nature of the image formed by a convex mirror

No.	**Position of the object**	**Position of the image**	**Size of the image**	**Nature of the image**
1	At infinity	At the focus	Diminished to a point	Virtual and upright
2	At any other point	Between focus and pole	Diminished	Virtual and upright

25. Name the kind of the mirror used to obtain:

(a) a real and enlarged image,

Concave

(b) a virtual and enlarged image,

Concave

(c) a virtual and diminished image,

Convex

(d) a real and diminished image.

Concave

26. How is the focal length of a spherical mirror related to its radius of curvature?

Focal length is half the radius of curvature of a spherical mirror.

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

27. Write the spherical mirror's formula and explain the meaning of each symbol used in it.

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

Here, u is the object distance, v is the image distance and f is the focal length of the mirror.

28. What is meant by magnification? Write its expression. What is its sign for the (a) real (b) virtual, image?

Magnification is the ratio of the length of image to the length of the object.

$$m = \frac{I}{O}$$

It is also given as

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

Where, u and v is the object and image distance, respectively.

Hence, we have

For real image: u and v are negative. So, m is negative.

For virtual image: u is negative and v is positive. So, m is positive.

29. What maximum distance from the pole the image in a convex mirror can be obtained? What will be the location of object then?

The image formed by a convex mirror is always between pole and focus. Hence, the maximum distance that can be obtained in convex mirror is the focal length. For this case the object has to be at infinity.

30. What maximum distance from a concave mirror, the image can be obtained? What will be the location of object for it?

The maximum distance that can be obtained in concave mirror is infinity. For this case the object has to be at focus.

31. How will you distinguish between a plane mirror, a concave mirror and a convex mirror, without touching them?

To distinguish between a plane mirror, concave mirror and convex mirror, the given mirror is held near the face and image is seen. There can be following three cases:

(i) If the image is upright, of same size and it does not change in size by moving the mirror towards or away from the face, the mirror is plane.

(ii) If the image is upright and magnified, and increases in size on moving the mirror away, the mirror is concave.

(iii) If the image is upright and diminished and decreases in size on moving the mirror away, the mirror is convex.

32. State two uses of a concave mirror.

Two uses of concave mirror

(i) It is used as a shaving mirror

(ii) It is used as reflector in torch, head light of automobiles etc.

33. State the kind of mirror used (a) By a dentist, (b) As a search-light reflector.

(a) Concave mirror, (b) Concave mirror

34. (a) When a concave mirror is used as a shaving mirror, where is the person's face in relation to the focus of mirror?

The person's face is between the pole and focus of the mirror.

(b) State *three* characteristics of the image seen in part (a).

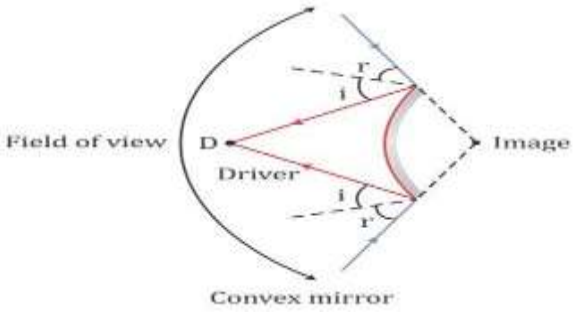
The image formed is erect, virtual and magnified.

35. Which mirror will you prefer to use as a rear view mirror in a truck: plane mirror or convex mirror? Give one reason.

A convex mirror is preferred as a rear view mirror because it has a wider field of view as compared to a plane mirror of same size.

36. Why does a driver use a convex mirror instead of a plane mirror as a rear view mirror? Illustrate your answer with the help of a ray diagram.

A convex mirror diverges the incident beam and always forms a virtual, small and erect image between its pole and focus. Thus, a driver can see all the traffic approaching from behind. This fact enables the driver to use it as a rear view in vehicles to see all the traffic approaching from behind



37. Multiple Choice type

(1) For an incident ray directed towards centre of curvature of a spherical mirror the reflected ray: Retraces its path

(2) The image formed by a convex mirror is Erect and diminished.

(3) A real and enlarged image can be obtained by using a Concave mirror.