Date: 24/9/2021

Q1. What is light?

Q2. What is a ray of light?

Q3. What are the values of (a) the angle of incidence, and (b) the angle of reflection of normal incidence on a plane mirror surface?

Q4. Can an image given by a convex mirror be taken on a screen?

Q5. Why do we see our image in a shining spoon?

Q6. Define real image of an object.

Q7. What do you mean by pole of a spherical mirror?

Q8. What is the centre of curvature of spherical mirror?

Q9. Define principal axis of a spherical mirror.

Q10. Define radius of curvature of a spherical mirror.

Q11. A ray of light moving along the principal axis is falling on a concave mirror. In which direction is it reflected?

Q12. An object is placed in front of a concave mirror between the pole and the focus of the mirror, what is the nature of the image formed by the mirror?

Q13. An object is placed in front of a concave mirror between the pole and the focus of the mirror. State whether the image is enlarged or diminished.

Q14. Where will the image be formed by a concave mirror when an object is placed between the pole and the focus point of the mirror?

Q15. At what position the object be placed in front of a concave mirror to form a real image of the same size?

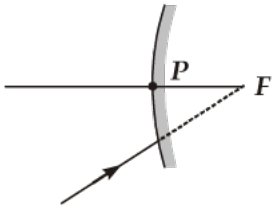
Q16. What is the minimum distance between an object and its real image in case of a concave mirror?

Q17. Where will the image be formed by a convex mirror if the object is placed between infinity and the pole of the mirror?

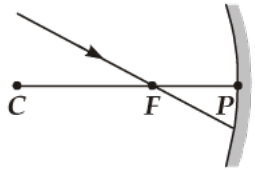
Q18. When a mirror is held close to the face by a person a diminished and erect image of the face is seen, what type of mirror is this?

Q19. Can a concave mirror form real, inverted and diminished image? If yes, under which condition?

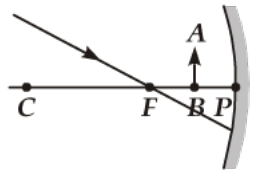
Q20. Complete the path of ray of light after reflection at the mirror in the given diagram



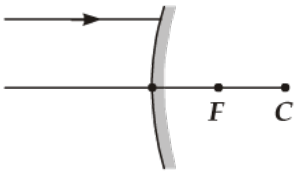
Q21. Copy the figure in your answer book and show the direction of the light ray after reflextion.



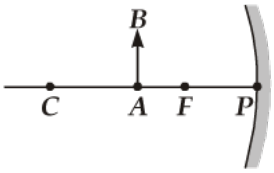
Q22. Draw the following diagram (see figure) in your answer book and show the formation of image of the object *AB* with the help of suitable rays.



Q23. A ray of light is incident on a convex mirror as shown in figure. Redraw the diagram after completing the path of the light ray after reflection from the mirror.



Q24. Draw the following diagram (see figure) in your answer book and show the formation of image of the object *AB* with the help of suitable rays.



Q25. Draw the following diagram (see figure) in your answer book and show the formation of image of the object *AB* with the help of suitable rays.

Q26. From the mirror equation $\frac{1}{v}+\frac{1}{u}=\frac{2}{R}$, show that the image in a plane mirror is as far behind the mirror as the object is in front of it.

Q27. What happens when the rays of sun are focussed at a point on the paper by using concave mirror?

Q28. What is the SI unit of refractive index?

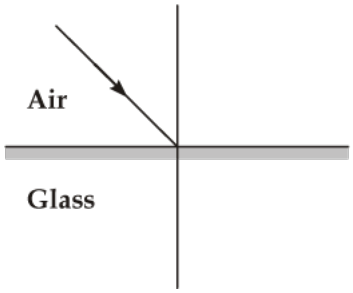
Q29. Give a formula to find refractive index of a glass slab in terms of angle of incidence and angle of refraction.

Q30. Define refractive index of a medium.

Q31. Refractive index of water with respect to air is 1.33. What is the refractive index of air with respect to water?

Q32. How does refractive index of one medium with respect to another depend on their absolute refractive indices?

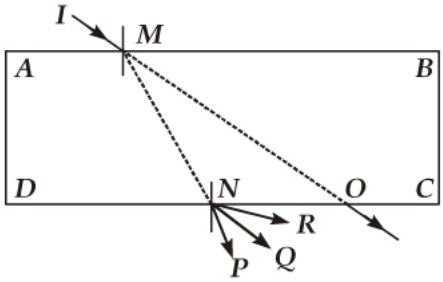
Q33. Complete the following diagram.



Q34. A ray of light strikes the glass slab at an angle of 90° from its surface. What is the angle of incidence and the angle of refraction?

Q35. Why does a ray of light bend from its path when it travels from one medium to another?

Q36. If a light ray *IM* is incident on the surface *AB* as shown, identify the correct emergent ray.



Q37. For the same angle of incidence of 45°, the refraction angle in two transparent media *P* and *Q* is 20° and 30°, respectively. Which medium is optically denser out of *P* and *Q* and why?

Q38. A ray of light travelling from a medium *X* enters obliquely into another medium *Y*. If it bends away from the normal then state which one of the two is relatively optically denser? Why?

Q39. What is lateral displacement of a light ray passing through a glass slab?

Q40. What are the two factors on which the lateral displacement of an emergent ray from a glass slab depends?

Q41. For the same angle of incidence of 45°, the refraction angle in three transparent media *A*, *B* and *C* are 25°, 30° and 35°, respectively. In which medium is the speed of light minimum and in which medium maximum.

Q42. The refractive indices of four media *A*, *B*, *C* and *D* are given in the following table:

Medium	*A*	*B*	*C*	*D*
Refractive index	1.33	1.50	1.52	2.40

If light travels from one medium to another, in which case the change in speed will be (a) minimum, (b) maximum?

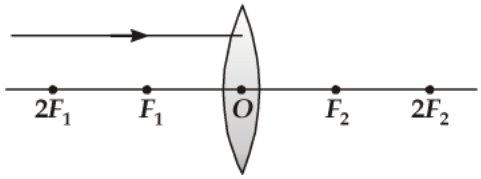
Q43. When a convex lens is focussed on a distant object, where will the image be formed?

Q44. Define power of a lens and write its SI unit.

Or

Write the relationship between the SI unit of the power of a lens and SI unit of focal length.

Q45. Redraw the given diagram and show the path of the refracted ray.

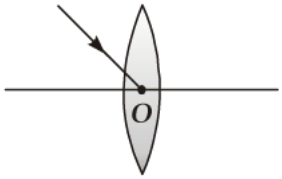


Q46. A virtual image is formed by a convex lens. Where is the object placed?

Q47. An image of the same size of an object is formed in a convex lens. Where is the object situated and where is the image formed?

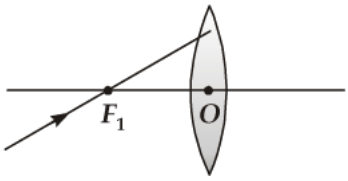
Q48. Name the type of lens used to obtain (a) an erect, enlarged and virtual image of an object, (b) an erect, diminished and virtual image of an object.

Q49. Redraw the given diagram and show the path of the refracted ray.



Q50. State the condition under which a light ray passes undeviated through a lens.

Q51. Redraw the given diagram and show the path of the refracted ray



Q52. Two thin lenses of powers P_1 and P_2 are placed in contact. What is the power of the combination?

Q53. A convex lens of focal length + 30 cm is combined with a concave lens of focal length – 30 cm. What is the power of the combined lens?

Q54. What is the difference between virtual image of an object formed by a convex lens and that formed by a concave lens?

Q55. The power of a lens is – 4.0 D. What is the nature of the lens?

Q56. State the two laws of reflection of light.

Q57. List four properties of the image formed by a plane mirror.

Q58. Differentiate between a real and virtual image. Write any two points.

Q59. Define a spherical mirror. State its types. Name the type which always produces virtual image irrespective of the position at which object is placed in front of it.

Q60. Distinguish between a concave mirror and a convex mirror. Write any two points.

Q61. Draw neat ray diagrams to illustrate the formation of images due to a beam of light incident parallel to the principal axis of a (a) concave mirror, (b) convex mirror. What is the nature of image formed in each case?

Q62. How can you identify the three types of mirrors without touching?

Q63. What do you mean by principal focus and focal length of a concave mirror? Draw a diagram too.

Q64. Name the mirror that

(a) can give real as well as virtual image of an object.

(b) will always give virtual image of same size of an object.

(c) will always give virtual and diminished image of an object.

(d) is used by a doctor in examining teeth.

Q65. How can you experimentally determine the value of focal length of a concave mirror?

Q66. Define principal focus of a convex spherical mirror. Draw a diagram too.

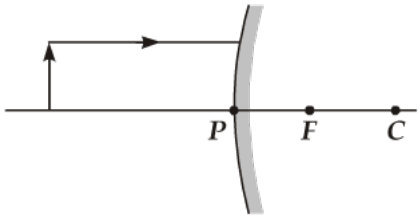
Q67. What is meant by radius of curvature of a spherical mirror? How is it related to the focal length of the mirror?

Q68. A ray of light moving along principal axis is falling on a concave mirror. Draw the path of reflected ray. Also state the values of angle of incidence and reflection in this case.

Q69. What is mirror formula? State its mathematical expression. Under what conditions is it true?

Q70. An object is placed between infinity and the pole of a convex mirror. Draw a ray diagram and also state the position, the relative size and the nature of the image formed.

Q71. Complete the following ray diagram (see figure). Is image real or virtual?



Q72. Obtain an expression for magnification of an image formed by a concave mirror.

Q73. State the nature, position and relative size of the image formed by a convex mirror when object is (a) at infinity and (b) between infinity and pole of the mirror.

Q74. What are your observations when you try to see the image of a large size distant object (say a distant tree) formed by a (a) concave mirror, (b) plane mirror, and (c) convex mirror?

Q75. (a) How can we obtain an erect and enlarged image of an object using a mirror?

(b) The radius of curvature of a spherical mirror is 20 cm, what is its focal length?

Q76. The radius of curvature of a concave mirror is 50 cm. Where should an object be placed from the mirror so as to form its image at infinity? Justify your answer.

Q77. An object is placed at a distance of 12 cm in front of a concave mirror. It forms a real image 4 time larger than the object. Calculate the distance of the image from the mirror.

Q78. Where should an object be placed in front of a concave mirror of focal length 20 cm so as to obtain a two times magnified real image?

Q79. A dentist uses a mirror in front of a decayed tooth at a distance of 4 cm from the tooth to get a four times magnified erect image in the mirror. Use mirror formula to find the focal length and nature of the mirror used.

Q80. State Snell's law of refraction and show it geometrically.

Q81. (a) During its passage from one medium to another, where does a light ray change its path?

(b) Define the term absolute refractive index of a medium.

Q82. (a) The refractive index of glass is 1.5, what is meant by this statement?

(b) Refractive indices of glass, kerosene and water are 1.5, 1.44 and 1.33 respectively. Arrange them in ascending order of their optical density.

Q83. (a) What happens to a ray of light when it travels from one medium to another having equal refractive index?

(b) State the cause of refraction of light.

Q84. A beam of light passes from air to a substance X. If angle of incidence is 45° and angle of refraction is 30°, calculate the refractive index of the substance X.

Given, $\sin 30° = \frac{1}{2}$, $\sin 45° = \frac{1}{\sqrt{2}}$.

Q85. Light enters from air into water which has a refractive index of 1.33. Calculate the speed of light in water. The speed of light in air is 3.0×10^8 m/s.

Q86. With respect to air the refractive indices of water and benzene are 1.33 and 1.50 respectively. Calculate the refractive index of benzene with respect to water.

Q87. The absolute refractive indices of benzene and kerosene are 1.50 and 1.44 respectively. What is the refractive index of benzene with respect to kerosene?

Q88. (a) In refraction of light through a rectangular glass slab, the emergent ray is parallel to the direction of incident ray, why?

(b) What happens when a light ray is incident normally on one of the faces of a rectangular glass slab?

Q89. What is a lens? What are two kinds of lenses?

Q90. Define optical centre of a lens. What happens when a ray of light passes through the optical centre of lens?

Q91. For a spherical lens, define the terms centre of curvature and principal axis.

Q92. Define principal focus and focal length of lens. Draw ray diagram to show the position of principal focus of a lens.

Q93. Describe an activity to determine the rough focal length of a convex lens.

Q94. What do you mean by a converging and a diverging lens? Which lens behaves as a converging lens and which lens a diverging lens?

Q95. With the help of ray diagrams, differentiate between a converging and a diverging lens.

Q96. Draw ray diagrams to show image formed by a concave lens for the object placed (a) at infinity, (b) between infinity and optical centre of lens. State characteristics of image in each case.

Q97. We wish to obtain a real, inverted image of the same size as that of the object by a thin convex lens of focal length 20 cm. Where should the object be placed? Draw the ray diagram to show the image formation.

Q98. Draw a labelled ray diagram to locate the image of an object formed by a convex lens of focal length 20 cm when the object is placed 30 cm away from the lens.

Q99. What should be the position of an object in respect of focus of a convex lens of focal length 20 cm so that its real and magnified image is formed? Draw a ray diagram to show the image formation.

Q100. An object 5.0 cm tall is placed on principal axis of a convex lens. Its 2.0 cm tall image is formed on the screen placed at a distance of 10 cm from the lens. Calculate the focal length of the lens.

Q101. Draw ray diagram to represent the nature, position and relative size of the image formed by a convex lens for the object placed:

(a) at $2F_1$,

(b) between F_1 and the optical centre O of the lens.

Q102. Define power of a lens. Write its SI unit.

You are provided with two convex lenses of focal length 15 cm and 25 cm respectively. Which of the two is of larger power? Give reason for your answer.

Q103 Define magnification produced by a lens. How is it related to the object distance and image distance?

Q104 With the help of neat ray diagrams show the path of reflected ray formed on reflection from a spherical mirror, when

(a) incident ray passes through (or directed towards) the principal focus of mirror.

(b) incident ray passes through (or directed towards) the centre of curvature of the mirror.

Q105 Draw the ray diagram and also state the position, the relative size and the nature of image formed by a concave mirror when the object is placed at the centre of curvature of the mirror.

Q106 Draw ray diagrams to show the formation of images when the object is placed in front of a concave mirror: (a) between its pole and focus point, (b) between its centre of curvature and focus point.

Q107 To construct ray diagram we use two light rays which are so chosen that it is easy to know their direction after reflection from the mirror. List these two rays and state the path of these rays after reflections. Use these rays to locate the image of an object placed between centre of curvature and focus of a concave mirror.

Q108 An object of 5 cm is placed at a distance of 25 cm from the pole of a concave mirror of radius of curvature 20 cm. Calculate the distance and size of the image so formed. What will be the nature of the image?

Q109 A convex mirror used for rear view on an automobile has radius of curvature of 3.00 m. If a bus is located at 5.0 m from the mirror, find the position, nature and size of the image.

Q110 An object 2.0 cm high is placed 20.0 cm in front of a concave mirror of focal length 10.0 cm. Find the distance from the mirror at which a screen should be placed in order to obtain a sharp image. What will be the size and nature of the image formed?

Q111 An object 2 cm is size is placed 30 cm in front of a concave mirror of focal length 15 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? What will be the nature and the size of the image formed? Draw a ray diagram to show the formation of the image in this case.

Q112 An object 4.0 cm in size, is placed 25.0 cm in front of a concave mirror of focal length 15.0 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and the size of the image.

Q113 State the type of mirror preferred as (a) rear view mirror in vehicles, (b) shaving mirror. Justify your answer giving two reasons in each case.

Q114 State the types of mirrors used for (a) headlights and (b) rear view mirrors, in cars and motorcyles. Give reason to justify your answer in each case.

Q115 Draw a ray diagram to show refraction through a rectangular glass slab. How is the emergent ray related to incident ray? What is its lateral displacement?

Or

A ray of light is incident obliquely on a glass slab. Draw a ray diagram showing the path of the light ray. Clearly mark angle of incidence, angle of refraction, angle of emergence and lateral displacement of the ray.

Q116 Describe an activity to show that an ink mark on a piece of paper appears to be raised on placing a glass slab over it. How would you explain it? Draw a ray diagram.

Q117 Show the path of a refracted ray formed on refraction through a spherical lens, when (a) incident ray is parallel to the principal axis of lens, (b) incident ray passes through principal focus (or is directed towards the principal focus) of lens. Draw ray diagrams too.

Q118. (a) The refractive index of diamond is 2.42. What is the meaning of this statement?

(b) Name a liquid whose mass density is less than that of water but it is optically denser than water.

Q119. Define refractive index of a transparent medium. What is its units? Which has a higer refractive index, glass or water?

Q120. What is the principle of reversibility of light? Show that the incident ray of light is parallel to the emergent ray of light when light falls obliquely on a side of a rectangular glass slab.

Q121. A 4 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 24 cm. The distance of the object from the lens is 16 cm. Find the position, size and nature of the image formed, using the lens formula.

Q122. A 2.0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 10 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. Also find its magnification.

Q123. A 5 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 30 cm. Find the (a) position, (b) nature, and (c) size of the image fomed.

Q124. A convex lens has a focal length of 10 cm. At what distance from the lens should the object be placed so that it forms a real and inverted image 20 cm away from the lens? What would be the size of the image formed if the object is 2 cm high? With the help of a ray diagram show the formation of the image by the lens in this case.

Q125. An object 3 cm high is placed at a distance of 24 cm in front of convex lens of focal length 16 cm. Find the position, nature and size of the image fomed.

Q126. What do you mean by power of a lens? How does it depend upon the focal length? What is the meaning of positive and negative powers?

Q127. 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 this lens if the image is equal to the size of the object? Also find power of the lens.

Q128. A concave lens has focal length of 20 cm. At what distance from the lens a 5 cm tall object be placed so that it forms an image at 15 cm from the lens? Also calculate the size of the image formed.

Q129. An object placed on a metre scale at 8 cm mark was focussed on a white screen placed at 92 cm mark, using a converging lens placed on the scale at 50 cm mark.

(a) Find the focal length of the converging lens.

(b) Find the position of the image formed if the object is shifted towards the lens at a position of 29 cm.

(c) State the nature of the image formed if the object is further shifted towards the lens.

Q130. (a) Draw a ray diagram to show the formation of image of an object placed between infinity and optical centre of a concave lens.

(b) A concave lens of focal length 15 cm forms an image 10 cm from the lens. Calculate (i) the object distance, (ii) the nature and magnification of the image formed.

Q131. The image of a candle flame placed at a distance of 45 cm from a spherical lens is formed on a screen placed at a distance of 90 cm from the lens. Identify the type of lens and calculate its focal length. If the height of the flame is 2 cm, find the height of its image.

Q132. Two lenses of power +3.5 D and –1.5 D are placed in contact. What is the power and focal length of the combination? If an object be placed at a distance of 0.8 m from the lens combination, where is the image formed?

Q133. A 2 cm high candle flame is placed at a distance of 80 cm from a white screen. On placing a convex lens exactly at the mid-point of the candle and the screen. A distinct image of the flame is seen on the screen. What is the focal length of the lens and the size of the candle flame image formed? Draw a ray diagram to show the formation of the image in this case.

Q134. List the sign conventions for reflection of light by spherical mirrors. Draw a diagram and apply these conventions in the determination of focal length of a spherical mirror which forms a three times magnified real image of an object placed 16 cm in front of it.

Q135. Draw neat diagrams to show changes in images formed by a concave mirror, as an object is brought closer to it from infinity to just near its pole. Write the nature and size of the image in each case.

Q136. List the new Cartesian sign convention for reflection of light by spherical mirrors. Draw a diagram and apply these conventions for calculating the focal length and nature of a spherical mirror which forms a $\frac{1}{3}$ times magnified virtual image of an object placed 18 cm in front of it.

Q137. With the help of a ray diagram, state what is meant by refraction of light. State Snell's law for refraction of light and also express it mathematically.

The refractive index of air with respect to glass is $\frac{2}{3}$ and the refractive index of water with respect to air is $\frac{4}{3}$. If the speed of light in glass is $2 \times 10^8 \text{ m s}^{-1}$, find the speed of light in (a) air, (b) water.

Q138. State the law of refraction of light that defines the refractive index of a medium with respect to the other. Express it mathematically. How is refractive index of any medium *A* with respect to a medium *B* related to the speed of propagation of light in two media *A* and *B*? State the name of this constant when one medium is vacuum or air?

The refractive indices of glass and water with respect to vacuum are $\frac{3}{2}$ and $\frac{4}{3}$ respectively. If the speed of light in glass is $2 \times 10^8 \text{ m s}^{-1}$, find the speed of light in (a) vacuum, (b) water.

Q139. Can you obtain the nature, position and relative size of images formed by a lens by drawing the ray diagrams? If yes, draw neat ray diagrams to find different types of images formed by a convex lens.

Or

Describe the formation of different types of images by a convex lens.

Q140. (a) One-half of a convex lens is covered with a black paper. Will such a lens produce an image of the complete object? Support your answer with a ray diagram.

(b) An object 5 cm high held 25 cm away from a converging lens of focal length 10 cm. (i) draw the ray diagram and (ii) calculate the position and size of the image formed. (iii) What is the nature of the image?

Q141. (a) What is meant by 'power of a lens'?

(b) State and define the SI unit of power of a lens.

(c) A convex lens of focal length 25 cm and a concave lens of focal length 10 cm are placed in close contact with each other. Calculate the lens power of this combination.

Date: 24/9/2021

S1. Light is that form of energy which provides us the sensation of sight.

S2. The straight line path of light is indicated as a ray of light.

S3. Values of both (a) the angle of incidence $\angle i$, and (b) angle of reflection $\angle r$ zero for normal incidence.

S4. No (virtual images cannot be taken on a screen but they can be photographed).

S5. The shining surface of spoon behaves like a curved mirror, hence we can see our image in it.

S6. Real image of an object is that point where light rays from the object after reflection/refraction from mirror/lens/prism etc., actually converge to.

S7. The centre point of the reflecting surface of a spherical mirror is called the pole.

S8. The centre of curvature of spherical mirror is the centre of the sphere, of which the mirror forms a part.

S9. A straight line passing through the pole and the centre of curvature of a spherical mirror is called its principal axis.

S10. It is the radius of the sphere, of which given mirror is a part. Alternately, the distance of centre of curvature of a spherical mirror from its pole equal to the radius of curvature (R) of the given mirror.

S11. The ray is reflected back along the principal axis of mirror because here $\angle r = \angle i = 0°$.

S12. Virtual, erect and magnified one.

S13. Enlarged.

S14. Behind the mirror.

S15. At the centre of curvature (or at $2F$).

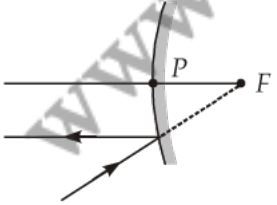
S16. Zero.

S17. Behind the mirror between its pole and principal focus.

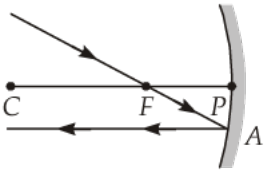
S18. Convex.

S19. Yes, when the object is placed away from the centre of curvature of given concave mirror.

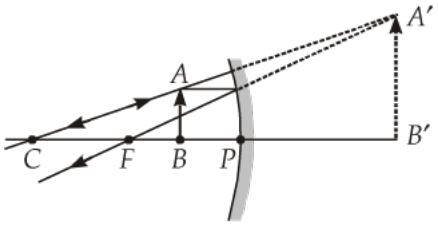
S20. The completed path has been shown in figure.



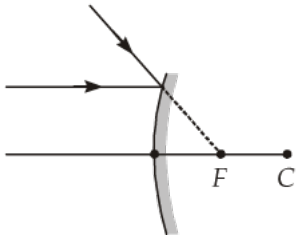
S21. The reflected ray travels parallel to the principal axis of mirror as shown in figure.



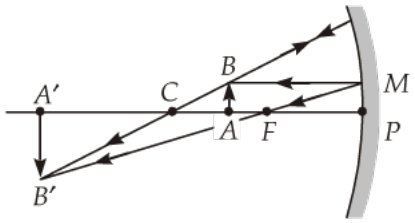
S22. The image formation has been shown in figure. The image is virtual, erect and enlarged one.



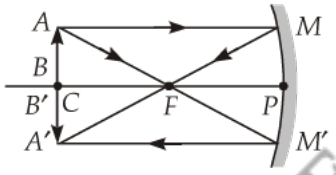
S23. Completed path of light ray has been shown in figure.



S24. Formation of image has been shown in figure. The image is real, enlarged and inverted.



S25. The image formation has been shown in figure. The image is real, inverted and of same size.



S26. Since $R = \infty$ for a plane mirror, hence $\frac{1}{v} + \frac{1}{u} = \frac{2}{\infty}$ or $\frac{1}{v} = -\frac{1}{u}$ or $v = -u$.

S27. Paper starts burning due to heat produced on concentration of sunlight at a point on the paper.

S28. Refractive index is a unitless quantity.

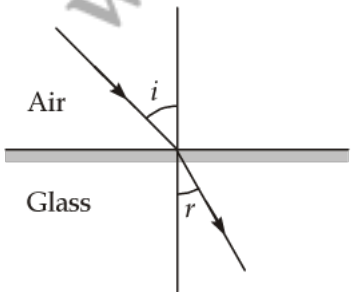
S29. Refractive index $n = \frac{\sin i}{\sin r}$, where i = angle of incidence in air and r = angle of refraction in galss slab.

S30. Refractive index of a medium $n = \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in given medium } (v)}$.

S31. $n_{aw} = \frac{1}{n_{wa}} = \frac{1}{1.33} = 0.75$.

S32. $n_{21} = \frac{n_2}{n_1}$.

S33. The completed diagram is as given below



S34. Angle of incidence 'i' and angle of refraction 'r' both are equal to zero degree.

S35. A ray of light bends from its path on entering into second medium because speed of light in second medium is different from that in 1st medium.

S36. The correct emergent ray is NQ which is parallel to the incident ray IM but is laterally displaced.

S37. Medium P is optically denser than Q because in it the ray is bending more towards the normal (As $\angle r_P < \angle r_Q$).

S38. A light ray bends away from the normal when it passes from an optically denser medium to an optically rarer medium. Hence, medium X is optically denser and Y is optically rare.

S39. The shifting of the light ray sideways (though in the direction of original ray) on emergence from a rectangular glass slab is called "lateral displacement".

S40. Lateral displacement depends on (a) thickness of glass slab and (b) angle of incidence.

S41. Speed of light is minimum in medium A and maximum in medium C.

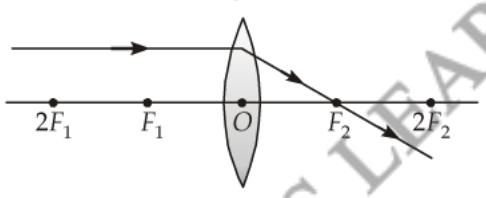
S42. (a) Change in speed of light will be minimum for media B to C or vice-versa because difference in their refractive indices is least.

(b) Change in speed of light will be maximum for media A to D or vice-versa because difference in their indices is maximum.

S43. The image is formed on the principal focus of convex lens on opposite side of the distant object.

S44. Reciprocal of focal length of a lens, expressed in metre, is called the power of that lens. Its SI unit is 1 dioptre (1 D), where $1\,D = 1\,m^{-1}$.

S45. Path of the refracted ray has been shown in figure below. The refracted ray passed through F_2.

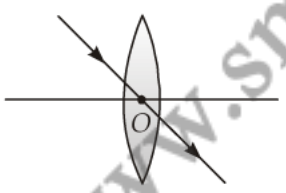


S46. Between the optical centre and the focus.

S47. At $2F$. As $v = 2f$.

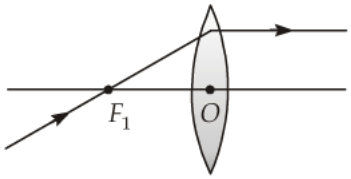
S48. (a) A convex lens, (b) A concave lens.

S49. Path of the refracted ray is as shown in figure. As the ray is passing through optical centre, it goes straight, undeviated from its path.



S50. When the incident ray passes through the optical centre of a lens, it passes undeviated.

S51. The refracted ray has been shown in figure below.



S52. Power of combination lens. $P = P_1 + P_2$.

S53. Zero.

S54. Virtual image formed by a convex lens is always magnified but that formed by a concave lens is diminished one.

S55. The lens is a diverging lens.

S56. Two basic laws of reflection of light are:

(a) The angle of incidence (i) is equal to the angle of reflection (r).

(b) The incident ray, the normal to the mirror at the point of incidence, and the reflected ray, all lie in the same plane.

S57. Image of an extended object formed by a plane mirror has the following characteristics:

(a) The image formed is virtual and erect. (b) The image is of same size as the object.

S58.

Real image	Virtual image
1. The reflected/refracted rays actually meet at a point in real image.	1. The reflected/refracted rays appear to diverge from a point in a virtual image.
2. Real image can be obtained on a screen.	2. Virtual image cannot be obtained on a screen.
3. Real image is an inverted image.	3. Virtual image is an erect image.

S59. A mirror, whose reflecting surfact is a part of a sphere, is called a spherical mirror.

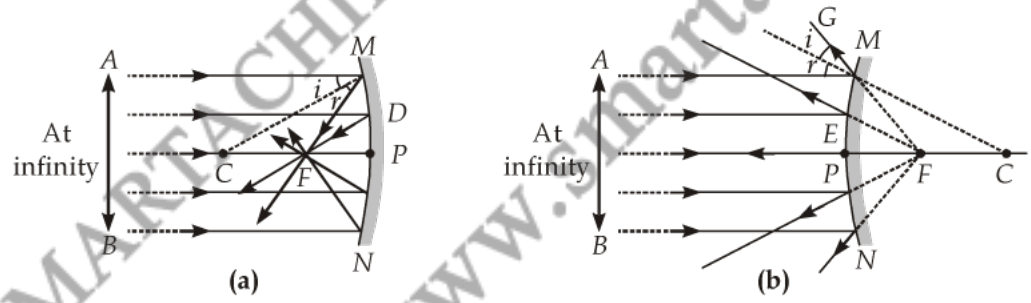
Spherical mirrors are two types, namely (a) concave mirror in which reflection takes place from inner (depressed) surface, and (b) convex mirror in which reflection takes place from outer (bulged out) surface.

A convex mirror always forms a virtual image irrespective of the position of object.

S60.

Concave mirror	Convex mirror
1. Its reflecting surface is curved inward and its centre of curvature and principal focus are situated in front of it.	1. Its reflecting surface is curved outward and its centre of curvature and principal focus lie behind the mirror.
2. It can form real or virtual image of an object depending on the position of the object.	2. It can form only virtual image of an object irrespective of its position.

S61. Ray diagrams have been shown in following figures (a) and (b).



The image formed is a real image for a concave mirror. Image formed by convex mirror is a virtual image.

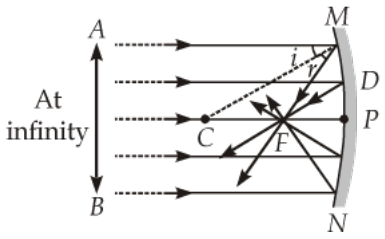
S62. Stand in front of mirror near it and look to your image.

(a) If the image is erect and of same size and size of image does not change even if you move forward or backward, the mirror is a plane mirror.

(b) If the image is erect and diminished one, the mirror is a convex mirror.

(c) If the image is erect and magnified and becomes inverted if one moves away from the mirror, the mirror is a concave mirror.

S63. Principal focus of a concave mirror is a point situated on its principal axis, where light rays coming parallel to the principal axis converge after reflection from the mirror. In figure, point F is the principal focus of a concave mirror.

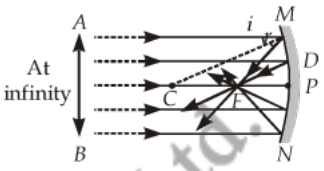


Focal length of a concave mirror is the distance between pole and principal focus of mirror. Thus, focal length $f = PF$.

S64. (a) Concave mirror (b) Plane mirror (c) Convex mirror (d) Concave mirror.

S65. To locate the principal focus point we take a concave mirror. Hold the concave mirror in your hand with its reflecting surface towards the sun. Adjust a paper sheet close to the mirror so as to receive the reflected light. Move the paper sheet back and forth till a sharp, bright spot of light is obtained on it. It is the principal focus of given concave mirror. Distance from mirror to this point is the focal length of given concave mirror.

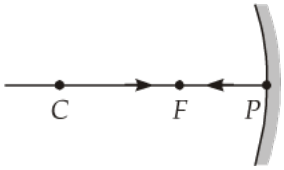
S66. The principal focus of a convex mirror is a point on its primcipal axis, from where light rays incident parallel to the principal axis of mirror, after reflection, appear to diverge from. As shown in figure, principal focus F is a point behind the convex mirror.



S67. Radius of curvature of a spherical mirror is the radius of the sphere of which the mirror forms a part.

Radius of curvature of a spherical mirror is twice of its focal length that is $R = 2f$.

S68. The path of reflected ray is shown in figure. Here, angle of incidence i = angle of reflection $r = 0°$.

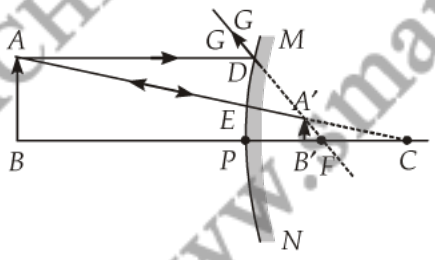


S69. Mirror formula is a relation between the object-distance (u), the image-distance (v) and the focal length (f) (or the radius of curvature R) of the mirror. According to mirror formula:

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \quad \text{or} \quad \frac{1}{v}+\frac{1}{u}=\frac{2}{R}$$

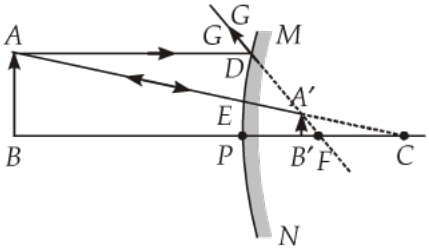
The mirror formula is true for concave and convex mirrors both, irrespective of the fact whether the image formed is real or virtual. However, proper sign for u, v, f and R be applied as per sign convention followed.

S70. Image is drawn in figure given below:



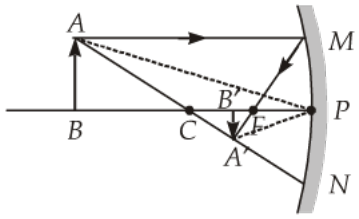
The image formed is virtual, erect and diminished one. Moreover, the image is formed behind the mirror between P and F.

S71. The completed ray diagram is shown in figure. The image is a virtual image.



S72. Consider the formation of the image $A'B'$ of an object AB by a concave mirror. As shown in figure the right angled triangles ABP and $A'B'P'$ are similar triangles, hence

$$\frac{A'B'}{AB} = \frac{PB'}{PB}$$



As per sign convention followed, $PB = -u$, $PB' = -v$, AB = size of the object = $+h$ and $A'B'$ = size of the image = $-h'$. Hence, we have

$$-\frac{h'}{h} = \frac{-v}{-u} \quad \text{or} \quad \frac{h'}{h} = -\frac{v}{u}$$

Thus, by definition of magnification of image, we have

$$\text{Magnification, } m = \frac{h'}{h} = -\frac{v}{u}.$$

S73. Image formed by a convex mirror.

Sl. No	Position of the object	Position of the image	Size of the image	Nature of the image
1.	At infinity	At principal focus (F) behind the mirror	Point sized (highly diminished)	Virtual and erect
2.	Between infinity and the pole (F) of the mirror	Between pole (P) and principal focus (F) behind the mirror	Diminished	Virtual and erect

S74. Our observations are as given below:

(a) The concave mirror forms an inverted and diminished image of distant tree. Moreover, image of whole tree is not seen at a time.

(b) The plane mirror forms an erect image of a small part of distant tree and whole tree cannot be seen in the image at a time.

(c) The convex mirror forms an erect and diminished image of the distant tree as a whole.

S75. (a) We can obtain an erect and enlarged image of an object if the object is placed between the pole and principal focus of a concave mirror.

(b) $\because$ Radius of curvature of spherical mirror $R = 20\,\text{cm}$.

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

S76. $\because$ Radius of curvature of concave mirror $R = 50\,\text{cm}$, hence focal length of the mirror $f = \frac{R}{2} = 25\,\text{cm}$.

To form an image at infinity the object should be placed in the focal plane of the concave mirror.

$\therefore$ Distance of object from the concave mirror $u = f = 25\,\text{cm}$.

S77. Here, $u = -12\,\text{cm}$ and $m = -4$ (real image)

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

$\therefore$ $$-4 = -\frac{v}{(-12)} \quad \Rightarrow \quad v = -48\,\text{cm}$$

Thus, a real image is formed in front of concave mirror at a distance of 48 cm.

S78. Here focal length of concave mirror $f = -20$ cm and magnification of real image $m = -2$. Hence $m = -\frac{v}{u} = -2$ $\Rightarrow v = 2u$.

As per mirror formula $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$, we have

$$\frac{1}{2u} + \frac{1}{u} = \frac{1}{(-20)}$$

$$\Rightarrow \quad \frac{3}{2u} = \frac{1}{-20} \quad \Rightarrow \quad u = -\frac{3 \times 20}{2} = -30 \text{ cm}$$

Thus, the object be placed 30 cm in front of the mirror.

S79. Here distance of object from the mirror $u = -4$ cm and magnification of erect image $m = +4 = -\frac{v}{u}$. Hence, $v = -4u = -4(-4)$ cm $= +16$ cm.

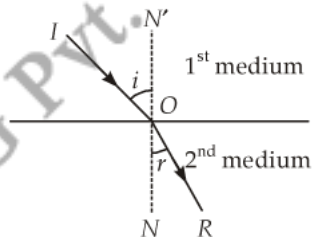
$$\therefore \quad \frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \Rightarrow \quad \frac{1}{(+16)} + \frac{1}{(-4)} = -\frac{3}{16}$$

$$\Rightarrow \quad f = -5.3 \text{ cm},$$

The – ve sign of f suggests that the mirror is a concave mirror.

S80. According to Snell's law of refraction the ratio of sine of angle of incidence (i) in 1st medium to the sine of angle of refraction (r) in 2nd medium is constant and this constant is called the refractive index of the second medium w.r.t., first medium (n_{21}). Mathematically,

$$\frac{\sin i}{\sin r} = n_{21}.$$



S81. (a) During its passage from one medium to another the light ray changes its path at the boundary face separating the two surfaces.

(b) Absolute refractive index n of a given medium is defined as:

$$n = \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in given medium } (v)}.$$

S82. (a) When we say that refractive index of glass is 1.5, we mean that speed of light in glass

$$= \frac{c}{n} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ m s}^{-1}.$$

(b) In ascending order of optical density the three substances are:

Water < kerosene < glass.

S83. (a) When a ray of light travels from one medium to another having equal refractive index, the light ray travels straight without any bending.

(b) The cause of refraction is change in speed of light as it enters from one medium to another.

S84. Refractive index of substance $X = \frac{\sin i}{\sin r} = \frac{\sin 45^\circ}{\sin 30^\circ} = \frac{1/\sqrt{2}}{1/2} = \sqrt{2}$.

S85. It is given that speed of light in air $c = 3.0 \times 10^8$ m/s and refractive index of water $n_w = 1.33$

$$\therefore \quad \text{Speed of light in water } v_w = \frac{c}{n_w} = \frac{3.0 \times 10^8}{1.33} = 2.25 \times 10^8 \text{ m/s}.$$

S86. Here, refractive index of water $n_w = 1.33$ and refractive index of benzene $n_b = 1.50$

$\therefore$ Refractive index of benzene w.r.t. water $n_{bw} = \frac{n_b}{n_w} = \frac{1.50}{1.33} = 1.13.$

S87. Here, refractive index of benzene $n_b = 1.50$ and refractive index of kerosene $n_k = 1.44$

$\therefore$ Refractive index of benzene w.r.t. kerosene $n_{bk} = \dfrac{n_b}{n_k} = \dfrac{1.50}{1.44} = 1.04.$

S88. (a) The emergent ray is parallel to the incident ray because the extent of bending of light at refraction at two opposite parallel surfaces of glass slab is equal but opposite.

(b) If the light ray is incident normally on one of faces of a rectangular glass slab, it travels straight through the glass slab without any deviation and there is no lateral shift.

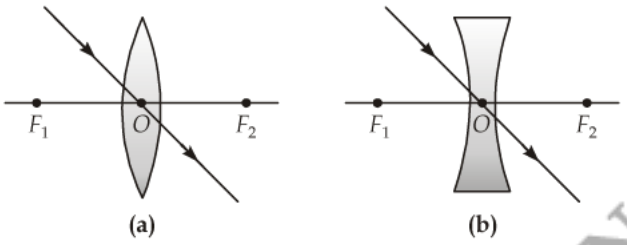
S89. A lens is a transparent material bound by two surfaces, of which one or both surfaces are spherical. There are two type of lenses as follows:

(a) **Convex lens:** A convex lens is thicker at the middle and thin at the edges. It converges the light rays.

(b) **Concave lens:** A concave lens is thin at the middle and thick at the edges. It diverges the light rays.

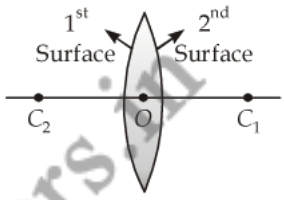
S90. The optical centre of a thin lens is a point on its principal axis, a ray of light passing through which goes straight without any bending (or deviation).

For a thin biconvex or biconcave lens, the optical centre of the lens is generally central point. In figure, the point O is the optical centre.



(a) (b)

S91. **Centre of curvature:** A lens has two surfaces and each surface forms a part of a sphere. The centres of curvatue C_1 and C_2 are the centres of the spheres, from which the two surfaces of lens are formed.



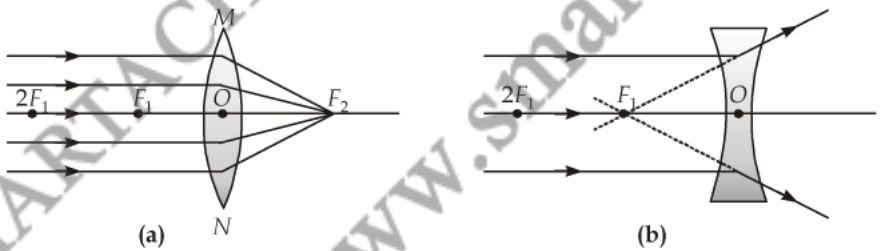
Principal axis: An imaginary straight line passing through the two centres of curvature of a lens is called its principal axis.

In figure, the line C_2OC_1 is the principal axis of given lens.

S92. **Principal focus** of a lens is a point where a light beam incident parallel to the principal axis of the lens, after refraction, actually converges to (in case of a convex lens) or diverges from (in case of a concave lens). Since a lens has two refracting surfaces, a lens has two principal foci. These are represented by F_1 an F_2 respectively.

The distance of principal focus of lens from its optical centre is called its focal length. f.

Thus, $f = OF_1 = OF_2$.



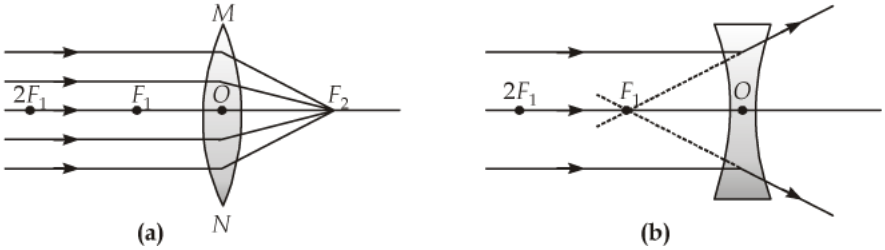
(a) (b)

S93. To determine the rough focal length of a given convex lens we hold the lens so that sunlight directly falls on it. Place a sheet of paper on the other side of lens normaly. Adjust the position of lens or paper till a sharp bright and diminished image of the sun is formed on the paper. The distance of lens from sheet of paper in this situation is equal to the rough focal length of lens. It can be measured by using a scale.

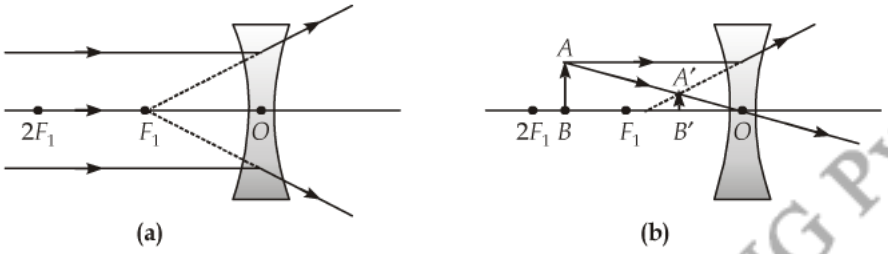
S94. A **converging lens** is that in which a parallel light beam, after refraction, actually conberges to point. A convex lens behaves as a converting lens. A converging lens, generally, forms real images which cannot be obtained on a screen.

A **diverging lens** is that in which a parallel beam of light, after refraction appears to diverge from a point. A concave lens behaves as a diverging lens. A diverging lens forms virtual image only, which cannot be obtained on a screen.

S95. The diagrams shown in below: (Fig. (a) is a converging lens but the lens shown in Fig. (b) is a diverging lens).



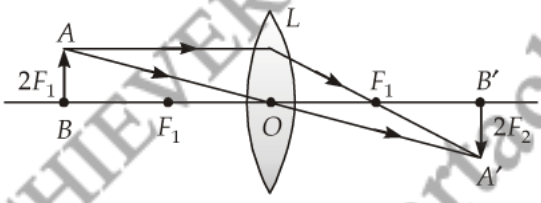
S96. The ray diagrams are shown in figure (a) and (b) respectively.



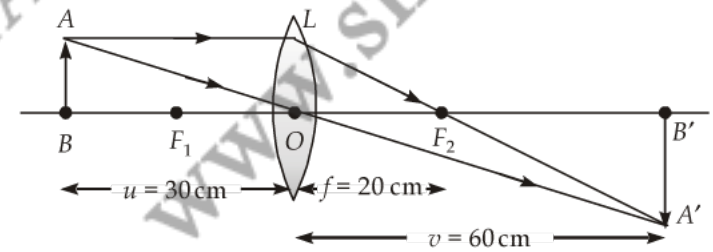
Characteristics of images formed by a concave lens are as given in following table:

Sl. No	Position of the object	Position of the image	Size of the image	Natural of the image
1.	At infinity	At principal focus (F_1)	Point sized (highy diminished)	Virtual and erect
2.	Between infinity and	Between optical centre	Diminished	Virtual and erect

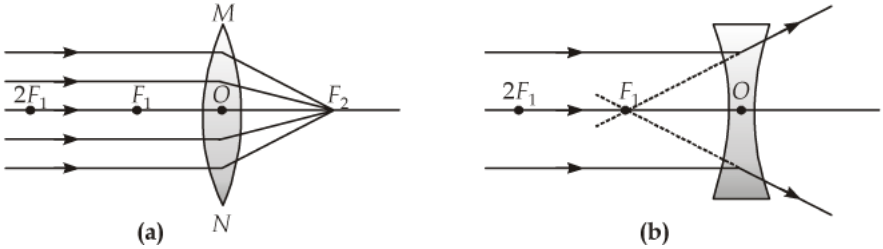
S97. As real, inverted image of same size is to be formed, hence the object should be placed at $2F$, *i.e.*, $u = 2f = 2 \times 20 = 40\,\text{cm}$. The ray diagram is shown below in figure.



S98. The labelled ray diagram showing the image formation is given in figure. On measurement we find that image is formed at a distance of 60 cm from the convex lens.



S99. To form a real and magnified image the object be placed somewhere between F and $2F$ of the given convex lens. As here $f = 20$ cm, hence the object should be placed at a distance more than 20 cm but less than 40 cm from the convex lens. The ray diagram to show image formation is given in figure, where object is taken to be situated at 30 cm from lens.



S100. Here, $h = 5.0$ cm, $h' = 2.0$ cm and $v = 10$ cm. As image is formed on the screen, it is real, and inverted image. Hence $h' = -2.0$ and $v = +10$ cm.

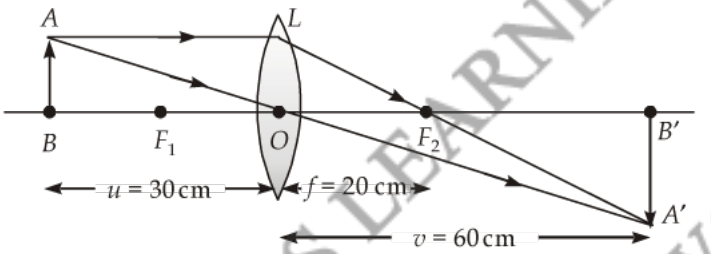
As magnification $$m = \frac{h'}{h} = \frac{v}{u}$$

$\Rightarrow$ $$u = \frac{vh}{h'} = \frac{(10)(5.0)}{(-2.0)} = -25 \text{ cm}$$

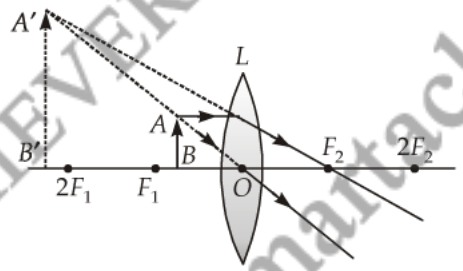
From lens formula $$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{10} - \frac{1}{(-25)} = \frac{1}{10} + \frac{1}{25} = \frac{5+2}{50} = \frac{7}{50}$$

$\Rightarrow$ $$f = \frac{50}{7} \text{ cm} = 7.1 \text{ cm}$$

S101. (a) The image is formed at $2F_2$ and is a real and inverted image (see figure). Size of the image is same as that of object.



(b) The image is formed on the same side of lens and is a virtual, erect and enlarged image (see figure).



S102. The power (P) of a lens is defined as the reciprocal of its focal length (f).

Thus, $$P = \frac{1}{f}.$$

SI unit of power is dioptre (D) where $1\text{ D} = 1\text{ m}^{-1}$. The power of a convex (converging) lens is positive and that of a concave (diverging) lens is negative.

Power of convex lens of focal length 15 cm is more because its focal length is less.

S103. The magnification produced by a lens is defined as the ratio of the height of image (h') to the height of object (h).

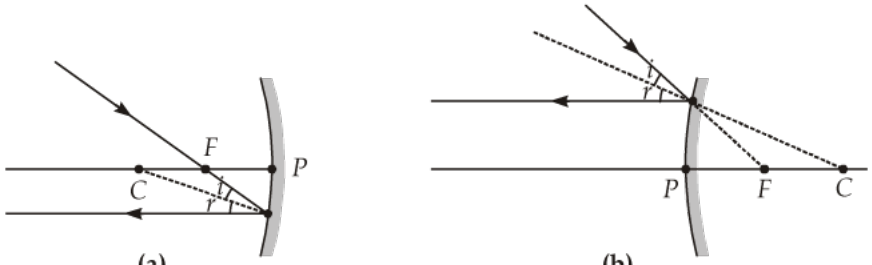
$$\text{Magnification } (m) = \frac{\text{Height of the image}}{\text{Height of the object}} = \frac{h'}{h}$$

Magnification produced by a lens is related to distances u and v as:

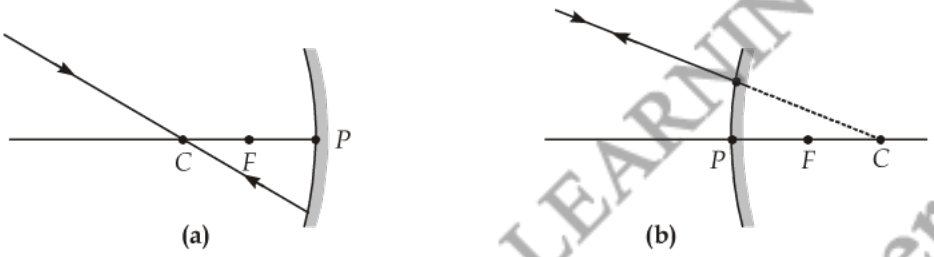
$$\text{Magnification } (m) = \frac{h'}{h} = \frac{\text{Distance of image from the lens } (v)}{\text{Distance of object from the lens } (u)}$$

Magnification of real, inverted image is negative. Magnification of virtual, erect image is positive.

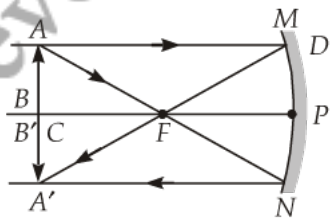
S104. (a) If an incident ray passes through the principal focus of a concave mirror or is directed towards the principal focus of a convex mirror, then the reflected ray will travel parallel to the principal axis of the mirror. It is shown below:



(b) An incident light ray passing through the centre of curvature of a concave mirror is reflected back along the same path. Again light rays directed in the direction of the centre of curvature of a convex mirror is reflected back along the same path as shown below:

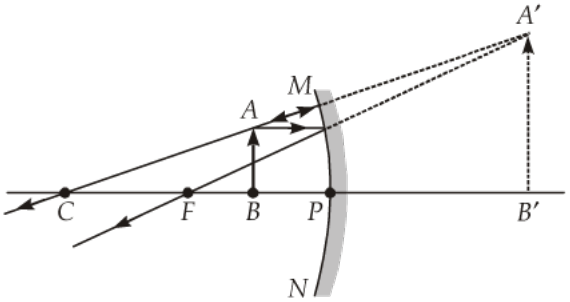


S105. Let an object AB be placed normally to the principal axis of a concave mirror at its centre of curvature C. When we draw a ray diagram (see figure) to locate the image formed, we find that the image $A'B'$ is formed at the centre of curvature C itself.

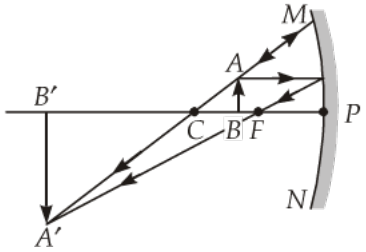


The image is real, inverted image. Size of the image is exactly equal to the size of the object. It means that magnification of the image is – 1.

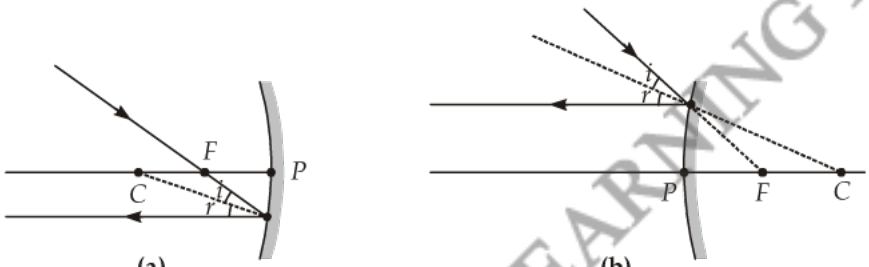
S106. (a) The image is formed as shown in figure. The image is virtual, erect and magnified. The image is formed behind the concave mirror.



(b) The ray diagram is shown in figure. The image is real, inverted and magnified. The image is formed beyond centre of curvature C of the concave mirror.

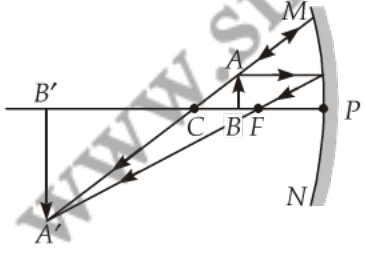


S107. (a) If an incident ray passes through the principal focus of a concave mirror or is directed towards the principal focus of a convex mirror, then the reflected ray will travel parallel to the principal axis of the mirror. It is shown below:



(b) An incident light ray passing through the centre of curvature of a concave mirror is reflected back along the same path. Again light rays directed in the direction of the centre of curvature of a convex mirror is reflected back along the same path as shown below:

The image of an object placed between C and F of a concave mirror is shown below:



S108. Here, $h = +5$ cm and $u = -25$ cm, R = – 30 cm

As per mirror formula $\frac{1}{v} = \frac{2}{R} - \frac{1}{u} = \frac{2}{(-30)} - \frac{1}{(-25)} = \frac{-2}{30} + \frac{1}{25} = \frac{-10+6}{150} = \frac{-4}{150}$

$\therefore \quad v = -\frac{150}{4} = -37.5$ cm

Again as $m = \frac{h'}{h} = -\frac{v}{u}$

Hence, size of the image $h' = -\frac{v}{u}(h) = -\frac{(-37.5)(5)}{(-25)} = -7.5$ cm

Thus, the image is diminished in size.

S109. Here, $R = +3.0$ m and $u = -5.0$ m

$\therefore \quad \frac{1}{v} = \frac{2}{R} - \frac{1}{u} = \frac{2}{(3.0)} - \frac{1}{(-5.0)} = \frac{2}{3} + \frac{1}{5} = \frac{10+3}{15} = \frac{13}{15}$

$\therefore \quad v = \frac{15}{13}$ m $= +1.16$ m

+ ve sign of image distance v means that the image is virtual and formed behind the mirror.

Moreover magnification $m = -\frac{v}{u} = \frac{-(1.16)}{(-5.0)} = +0.23.$

Thus, the image is diminished in size.

S110. Here, $h = 2.0$ cm, $u = -20.0$ cm and $f = -10.0$ cm.

$\therefore \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-10)} - \frac{1}{(-20)} = \frac{-1}{10} + \frac{1}{20} = -\frac{1}{20}$

$\Rightarrow \quad v = -20$ cm

Thus, distance of screen from the mirror should be 20 cm.

Again $\frac{h'}{h} = -\frac{v}{u}$

$\Rightarrow \quad h' = -\frac{v}{u} \cdot h = -\frac{(-20)}{(-20)} \times 2.0 = -2.0$ cm

Hence, the image is of length 2.0 cm. The – ve sign of v and h show that the image is real and inverted image.

S111. Here, $h = 2$ cm, $u = -30$ and $f = -15$ cm

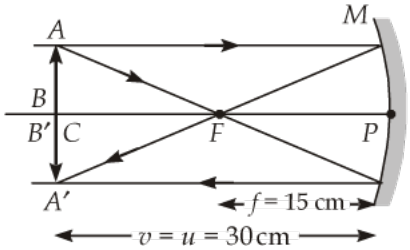
$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15} - \frac{1}{-30} = \frac{1}{-15} + \frac{1}{30} = \frac{-1}{30}$$

$$v = -30 \text{ cm}$$

$$\frac{h'}{h} = -\frac{v}{u}$$

$$h' = -\frac{v}{u} \cdot h = -\frac{(-30)}{(-30)} \times 2.0 = -2.0 \text{ cm}$$

On solving we find that $v = -30$ cm, $h = -2$ cm. Thus, image is real and inverted image of same size as the object. The ray diagram is given in figure.



S112. Object-size, $h = +4.0$ cm, Object-distance, $u = -25.0$ cm. Focal length, $f = -15.0$ cm, Image-distance, $v = ?$, Image-size, $h' = ?$

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

hence, $$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-15)} - \frac{1}{(-25)} = -\frac{1}{15} + \frac{1}{25}$$

or $$\frac{1}{v} = \frac{-5+3}{75} = \frac{-2}{75} \quad \text{or} \quad v = -37.5 \text{ cm}$$

The screen should be placed at 37.5 cm from the mirror in front of the mirror. Image is real.

Also, Magnification, $m = \frac{h'}{h} = -\frac{v}{u}$

or $$h' = -\frac{vh}{u} = -\frac{(-37.5 \text{ cm})(+4.0 \text{ cm})}{(-25 \text{ cm})}$$

or Image-size, $h' = -6.0$ cm.

The image is inverted and enlarged in size.

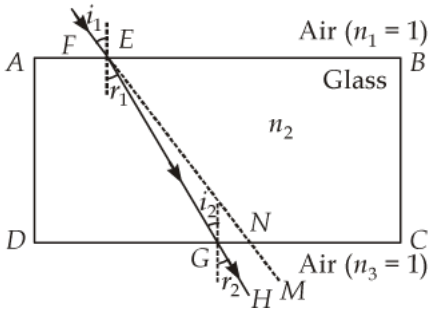
S113. (a) We use a convex mirror as a rear view mirror in vehicles. It is because a convex mirror gives an erect and diminished image of the vehicles coming from behind. Thus, the mirror helps the driver to have much wider field of view.

(b) We use a concave mirror as a shaving mirror. When a person is situated between pole and focus point of a concave mirror, his magnified and erect image is formed behind the mirror. Due to this property the person can see his face very clearly while shaving and can shave better.

S114. (a) We use a concave mirror in headlights of cars and motorcycles and the headlight lamp is fitted just at the focus of the concave mirror. As a result, a powerful, parallel beam of light comes out of headlight and the driver can see objects situated in front/ahead of him clearly.

(b) We use a convex mirror as a rear view mirror in vehicles. It is because a convex mirror gives an erect and diminished image of the vehicles coming from behind. Thus, the mirror helps the driver to have much wider field of view.

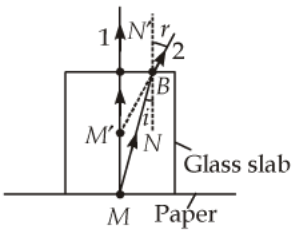
S115. A ray diagram showing refraction through a rectangular glass slab has been shown in adjoining in figure.



The emergent ray *GH* is exactly parallel to the incident ray *FENM*. It means that $\angle r_2 = \angle i_1$.

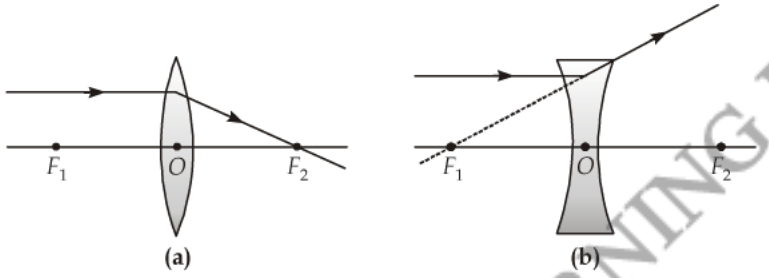
However, the emergent ray is laterally (side ways) displaced as compared to the original path of light ray. In ray diagram, the lateral displacement is *GN*. Its value increases on increasing the width of glass slab.

S116. Let us take a white piece of paper and put a corss-mark *M* with ink in the middle of paper. Put a glass slab over this cross-mark. Now look the ink mark from above the glass slab. The ink mark appears to be raised to position *M'*.

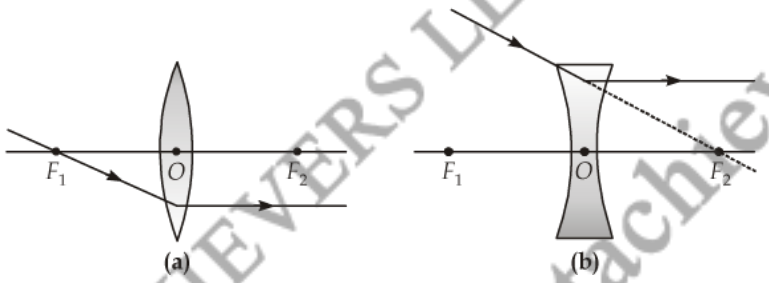


The cause of our observation is the fact that light rays bend away from the normal, when refraction takes place from glass (an optically denser medium) to air (an optically rarer medium). The refraction has been shown in figure.

S117. (a) As shown in figure (a), an incident ray coming parallel to the principal axis of convex lens, after refraction, passes through its principal focus F_2, on the other side of lens. In case of a concave lens, as shown in figure (b), the refracted ray appears to diverge from the principal focus F1 located on the same side of lens.



(b) For a convex lens, a light ray passing through its principal focus F_1 (figure (a)), will emerge parallel to the principal axis after refraction. In case of a concave lens, a light ray appearing to meet at principal focus F_2 (figure (b)), will emerge parallel to the principal axis after refraction.



S118. (a) When we say that the refractive index of diamond is 2.42, we mean that speed of light in diamond is $\frac{1}{2.42}$ times the speed of light in vacuum.

Thus, Speed of light in diamond = $\frac{3 \times 10^8}{2.42}\ \text{m s}^{-1} = 1.24 \times 10^8\ \text{m s}^{-1}$.

(b) Kerosene oil is a liquid whose mass density is less than that of water (*i.e.*, kerosene oil is lighter than water) but it is optically denser than water (*i.e.*, refractive index of kerosene oil is more than that of water.)

S119. The refractive index (n) of a transparent medium is defined as:

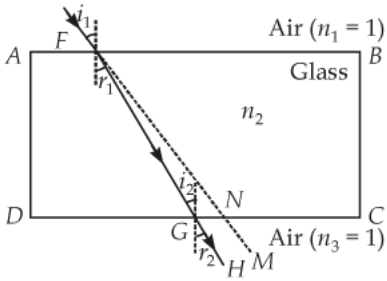
$$\text{Refractive index } (n) = \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in given medium } (v)}.$$

Refractive index is a unitless quantity.

Glass has a higher value of refractive index $\left(n_g = \frac{3}{2}\right)$ than that of water $\left(n_w = \frac{4}{3}\right)$.

S120. According to the principle of reversibility of light, if path of a light ray is reversed at a point then the entire path of light ray is reversed. An important consequence of this property is

$$n_{12} = \frac{1}{n_{21}}$$



where n_{12} = refractive index of medium 1 with respect to medium 2 and n_{21} = refractive index of medium 2 with respect to medium 1.

Consider refraction through a glass slab as shown in figure.

At the first surface $n_1 = 1$, hence from Snell's law, we have

$$\frac{\sin i_1}{\sin r_1} = \frac{n_2}{1} \quad \text{or} \quad \sin i_1 = n_2 \sin r_1 \qquad \ldots \text{(i)}$$

For refraction at the second surface $i_2 = r_1$ (being alternate angles) and $n_3 = 1$ for air. Hence,

$$\frac{\sin i_2}{\sin r_2} = \frac{\sin i_1}{\sin r_2} = \frac{n_3}{n_2} = \frac{1}{n_2}$$

or $$\sin r_2 = n_2 \sin r_1 \qquad \ldots \text{(ii)}$$

A simple comparison of (i) and (ii) shows that $\sin r_2 = \sin i_1$. It means that angle of emergence r_2 is equal to angle of incidence i_1 at the glass slab.

S121. As per question $f = +24$ cm, $u = -16$ cm, $h = +4$ cm

As per formula $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$, we have

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{(-16)} + \frac{1}{(+24)} = \frac{-3+2}{48} = -\frac{1}{48}$$

$\Rightarrow$ $$v = -48 \text{ cm}$$

Thus, image is formed at a distance of 48 cm from the lens and is a virtual image.

Again $$m = \frac{h'}{h} = \frac{v}{u}$$

$\therefore$ Size of image, $$h' = \frac{v}{u} \cdot h = \frac{(-48)}{(-16)} \times (+4) = +12 \text{ cm}$$

Thus, the image is 12 cm tall and erect.

S122. It is given that Object-size $h = +2.0$ cm, Focal length $f = +10$ cm, Object-distance $u = -15$ cm.

Using lens formula, we have

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{(-15)} + \frac{1}{10} = -\frac{1}{15} + \frac{1}{10} = \frac{-2+3}{30} = +\frac{1}{30}$$

or $$v = +30 \text{ cm}$$

The positive sign of v shows that the image is formed at a distance of 30 cm to the other side of the optical centre of the lens.

$$\text{Magnification, } m = \frac{h'}{h} = \frac{v}{u} = \frac{+30 \text{ cm}}{-15 \text{ cm}} = -2$$

$$\text{Image-size, } h' = (+2.0)\,(+30/-15) = -4.0 \text{ cm}$$

+ ve sign of v and – ve sign of h' suggest that the image is real and inverted one.

S123. Here $h = +5$ cm, $f = +20$ cm, $u = -30$ cm

(a) Using lens formula $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$, we have

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{(20)} + \frac{1}{(-30)} = \frac{3-2}{60} = \frac{1}{60}$$

$\therefore$ $v = +60$ cm

(b) + ve sign of v means that image is being formed on the other side of lens *i.e.*, the image is a real image.

(c) As $m = \frac{h'}{h} = \frac{v}{u}$

$\therefore$ $h' = \frac{v}{u} \cdot h = \frac{(+60)}{(-30)} \times (+5) = -10$ cm

S124. It is given that $f = +10$ cm, $v = +20$ cm and $h = 2$ cm.

$\because$ $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, hence $\frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{20} - \frac{1}{10} = -\frac{1}{20}$

$\Rightarrow$ $u = -20$ cm

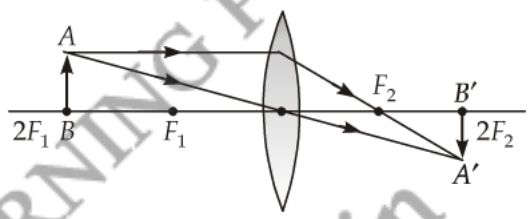
Thus, object should be placed at a distance of 20 cm from the lens.

Again $m = \frac{h'}{h} = \frac{v}{u}$

$\therefore$ Size of image, $h' = \frac{v}{u} \cdot h = \frac{(+20)}{(-20)} \times 2 = -2$ cm .

Hence, length of image is 2 cm.

The ray diagram is as shown in figure.



S125. Here, $h = +3$ cm, $u = -24$ cm, $f = 16$ cm

Using lens formula $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$, we have

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{16} + \frac{1}{(-24)} = \frac{3-2}{48} = \frac{1}{48}$$

$\therefore$ $v = +48$ cm

+ ve sign of v means that image is being formed on the other side of lens *i.e.*, the image is a real image.

As $m = \frac{h'}{h} = \frac{v}{u}$

$\therefore$ $h' = \frac{v}{u} \cdot h = \frac{48}{-24} \times 3 = -6$ cm

The image is a real and inverted image.

S126. The power of a lens is a measure of its ability to converge or diverge light rays. The degree of convergence or divergence of light rays achieved by a lens is expressed in terms of its power.

The power (P) of a lens is the reciprocal of its focal length (f) Thus,

$$P = \frac{1}{f}$$

As focal length of a convex lens is + ve, its power is also considered positive. The power of a concave lens is similarly taken as – ve.

S127. As image is real, inverted and equal to the size of the object, hence

$$m = -1 = \frac{v}{u} \quad \Rightarrow \quad v = -u$$

As per question $v = 50$ cm, so $u = 50$ m. But as per sign convention $u = -50$ cm and $v = +50$ cm

$$\therefore \qquad \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{50} - \frac{1}{(-50)} = \frac{1+1}{50} = \frac{2}{50} = \frac{1}{25}$$

$$\therefore \qquad f = 25 \text{ cm} = 0.25 \text{ m}$$

$$\therefore \qquad \text{Power of lens, } P = \frac{1}{f(\text{m})} = \frac{1}{0.25} = 4.0 \text{ D.}$$

S128. Here $f = -20$ cm (concave lens), $h = 5$ cm and $v = -15$ cm (image formed by concave lens is virtual).

$$\therefore \qquad \frac{1}{v} - \frac{1}{u} = \frac{1}{f}, \quad \text{hence} \quad \frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{(-15)} - \frac{1}{(-20)}$$

$$\Rightarrow \qquad \frac{1}{u} = \frac{-1}{15} + \frac{1}{20} = \frac{-4+3}{60} = \frac{-1}{60}$$

or $u = -60$ cm, *i.e.*, object is placed at a distance of 60 cm from the lens.

Again $$m = \frac{h'}{h} = \frac{v}{u}$$

Hence, $$h' = \frac{v}{u} \cdot h = \frac{(-15)}{(-60)} \times 5 = 1.25 \text{ cm}.$$

S129. (a) Here position of object on metre scale = 8 cm, position of converging (convex) lens = 50 cm and position of screen = 92 cm.

$$\therefore \qquad u = (50 - 8) = 42 \text{ cm} \quad \text{and} \quad v = (92 - 50) = 42 \text{ cm}$$

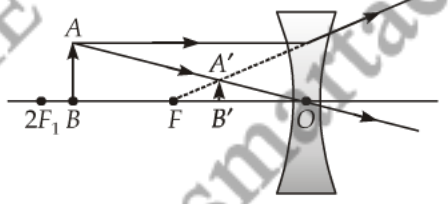
As per sign convention $u = -42$ cm and $v = +42$ cm

$$\therefore \qquad \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{(+42)} - \frac{1}{(-42)} = \frac{1}{42} + \frac{1}{42} = \frac{1}{21} \quad \Rightarrow \quad f = 21 \text{ cm}$$

(b) If the object is shifted to a position 29 cm, then $u' = (50 - 29)$ cm = 21 cm, *i.e.*, the object is situated at first focus F_1 of the lens. Hence, its real and inverted image is formed at infinity.

(c) If the object is further shifted towards the lens then $|u| < f$ and hence a virtual and erect image of the object will be formed.

S130. (a)



(b) Here, $f = -15$ cm, $v = -10$ cm

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

$$\frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{(-10)} - \frac{1}{(-15)} = \frac{1}{-10} + \frac{1}{15} = -\frac{1}{30}$$

$$\Rightarrow \qquad u = -30 \text{ cm}$$

Thus, the object is placed at a distance of 30 cm from the concave lens.

(ii) Image formed by concave lens is virtual and erect and magnification is positive, where

$$\text{Magnification, } m = \frac{v}{u} = \frac{(-10)}{(-30)} = \frac{1}{3} = 0.33.$$

S131. As the image is being formed on a screen, the image must be a real image and the lens used must be a convex lens.

As per question with sign convention : $u = -45$ cm, $v = +90$ cm and $h = +2$ cm.

$$\therefore \quad \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{(+90)} - \frac{1}{(-45)} = \frac{1}{90} + \frac{1}{45} = \frac{1+2}{90} = \frac{3}{90} = \frac{1}{30}$$

$$\Rightarrow \quad f = +30 \text{ cm}$$

If height of the image be h', then $\frac{h'}{h} = \frac{v}{u}$

$$\Rightarrow \quad h' = \frac{v}{u} \cdot h = \frac{(+90)}{(-45)} \times 2 = -4 \text{ cm}$$

The – ve sign signifies that the image of the flame is an inverted image.

S132. It is given that $P_1 = +3.5$ D, $P_2 = -1.5$ D

$\therefore$ Power of the combination $P = P_1 + P_2 = (+3.5 - 1.5)$ D $= +2.0$ D

$\therefore$ Focal length of the combination $f = \frac{1}{P} = \frac{1}{+2.0 \text{ D}} = +0.5$ m.

As distance of object from the lens combination $u = -0.8$ m, hence using lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we have

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{(-0.8)} + \frac{1}{(+0.5)} = \frac{-0.5 + 0.8}{0.8 \times 0.5} = \frac{0.3}{0.8 \times 0.5}$$

$$\Rightarrow \quad v = \frac{0.8 \times 0.5}{0.3} = +1.33 \text{ m.}$$

S133. Here $h = +2$ cm, Distance of screen from candle

$$D = |u + v| = 80 \text{ cm.}$$

As lens is placed exactly at mid-point, hence $|u| = |v|$

$$= \frac{80}{2} \text{ cm} = 40 \text{ cm.}$$

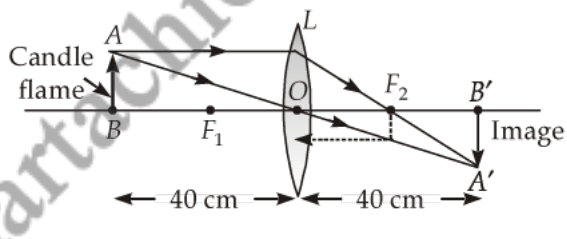
As per sign convention $u = -40$ cm and $v = +40$ cm

$$\therefore \quad \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{40} - \frac{1}{(-40)} = \frac{1}{40} + \frac{1}{40} = \frac{1}{20}$$

$$\Rightarrow \quad f = +20 \text{ cm}$$

Again $\frac{h'}{h} = \frac{v}{u}$, hence $h' = \frac{v}{u} \cdot h = \frac{40}{(-40)} \times 2 = -2$ cm.

Image formation as shown in figure.



S134. While considering reflection from spherical (curved) mirrors, we follow the New Cartesian Sign Convention. According to this convention:

(a) The object is taken on the left of the mirror, *i.e.*, the incident ray strikes the mirror from left hand side.

(b) All the distance parallel to the principal axis are measured from the pole of the mirror.

(c) Distances in the direction of the incident light are taken positive and in the opposite direction negative. In other words, distances right to the pole are taken positive and distances left to the pole negative.

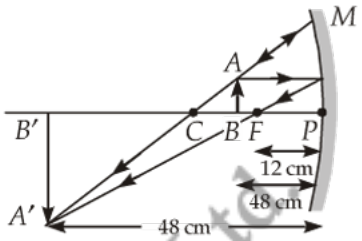
(d) The heights measured upwards (*i.e.*, above the principal axis) are taken positive and the heights measured downwards (below the principal axis) are taken negative.

As per question and using the sign convention followed $u = -16$ cm and magnification $m = -3$ (because image is real).

$$\therefore \quad m = -\frac{v}{u} = -3 \quad \Rightarrow \quad v = 3u = 3 \times (-16) = -48 \text{ cm}$$

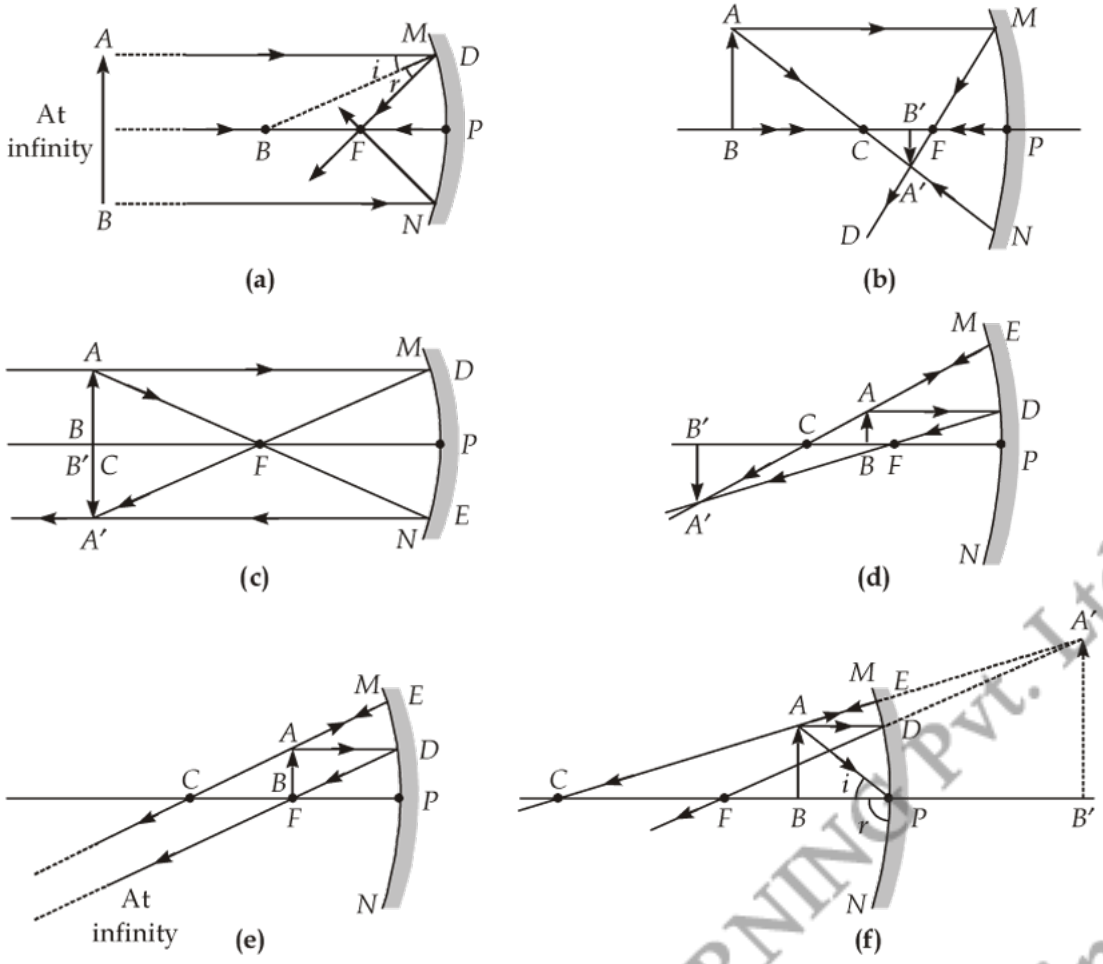
$$\therefore \quad \frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{(-48)} + \frac{1}{(-16)} = \frac{1+3}{(-48)} = -\frac{4}{48} = -\frac{1}{12}$$

$$\Rightarrow \quad f = -12 \text{ cm}$$



The – ve sign of 'f' shows that the mirror is a concave mirror. The diagram is shown in figure.

S135. Depending on the position of the object, six different types of images are formed by a concave mirror. Ray diagrams for these images have been drawn in figure



A concave mirror may form either a real or virtual image depending upon the position of the object. The different possibilities are as given in the following table

Position of the object	Position of the image	Size of the image	Nature of the image
(a) At infinity	At the principal focus F	Highly diminished or point sized	Real and inverted
(b) Beyond the centre of curvature C	Between F and C	Diminished	Real and inverted
(c) At centre of curvature C	At centre of curvature C	Same size	Real and inverted
(d) Between C and F	Beyond C	Enlarged	Real and inverted
(e) At principal focus F	At infinity	Infinitely large or highly enlarged	Real and inverted
(f) Between pole P and focus F	Behind the mirror	Enlarged	Virtual and erect

S136. While considering reflection from spherical (curved) mirrors, we follow the New Cartesian Sign Convention. According to this convention:

(a) The object is taken on the left of the mirror, *i.e.*, the incident ray strikes the mirror from left hand side.

(b) All the distance parallel to the principal axis are measured from the pole of the mirror.

(c) Distances in the direction of the incident light are taken positive and in the opposite direction negative. In other words, distances right to the pole are taken positive and distances left to the pole negative.

(d) The heights measured upwards (*i.e.*, above the principal axis) are taken positive and the heights measured downwards (below the principal axis) are taken negative.

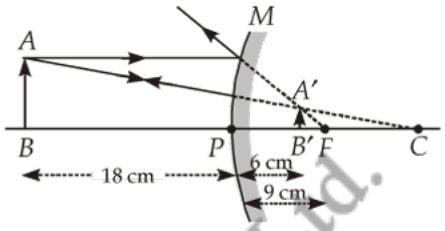
As per question and using the sign convention followed $u = -18$ cm and magnification $m = +\frac{1}{3}$ (because image is a virtual image).

$$\therefore \quad m = -\frac{v}{u} = +\frac{1}{3}$$

$$\Rightarrow \quad v = -\frac{u}{3} = -\frac{(-18)}{3} = +6 \text{ cm}$$

$$\therefore \quad \frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{(+6)} + \frac{1}{(-18)} = \frac{3-1}{18} = \frac{2}{18} = \frac{1}{9}$$

$$\Rightarrow \quad f = +9 \text{ cm}$$

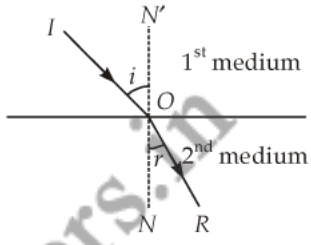


The + ve sign of 'f' signifies that the mirror is a convex mirror. The ray diagram is shown in figure.

S137. Refraction of light is the phenomenon of bending of a light ray from its straight path when a light ray passes obliquely from one transparent medium to another.

According to Snell's law of refraction the ratio of sine of angle of incidence (i) in 1st medium to the sine of angle of refraction (r) in 2nd medium is constant and this constant is called the refractive index of the second medium w.r.t., first medium (n_{21}). Mathematically,

$$\frac{\sin i}{\sin r} = n_{21}.$$



As per question $n_{ag} = \frac{2}{3}$, hence $n_{ga} = \frac{1}{n_{ag}} = \frac{3}{2}$ and $n_{wa} = \frac{4}{3}$. Further $v_g = 2 \times 10^8 \text{ m s}^{-1}$.

(a) $\therefore \quad v_a = c = v_g \times n_{ga} = 2 \times 10^8 \times \frac{3}{2} = 3 \times 10^8 \text{ m s}^{-1}$.

(b) $\therefore \quad v_w = \frac{v_a}{n_w} = \frac{3 \times 10^8}{4/3} = 2.25 \times 10^8 \text{ m s}^{-1}$.

S138. Snell's law defines the refractive index of a medium with respect to the other.

Two basic laws of refraction of light are:

(a) The incident ray, the refracted ray and the normal to the separating surface at the point of incidence, all lie in the same plane.

(b) The ratio of sine of the angle of incidence (i) to the sine of angle of refraction (r) is a constant. It is known as Snell's law. Thus, according to Snell's law

$$\frac{\sin i}{\sin r} = \text{a constant} = n_{21}.$$

Refractive index of a medium A with respect to a medium B (n_{AB})

$$= \frac{\text{Speed of light in medium } B\ (v_B)}{\text{Speed of light in medium } A\ (v_A)}$$

If one medium is air or vacuum then this constant is known as the refractive index of the other medium. Thus,

$$\text{Refractive index of a medium } (n) = \frac{\text{Speed of light in vacuum/air } (c)}{\text{Speed of light in the medium } (v)}$$

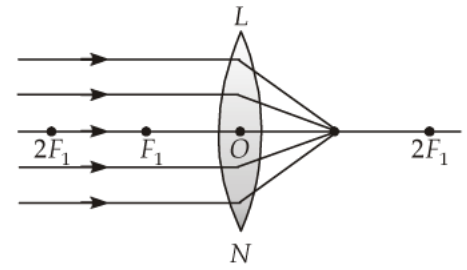
As per question $n_g = \frac{3}{2}$ and $n_w = \frac{4}{3}$ and $v_g = 2 \times 10^8\ \text{m s}^{-1}$.

(a) $\because\ n_g = \frac{c}{v_g}$, hence speed of light in vacuum $= n_g \cdot v_g = \frac{3}{2} \times 2 \times 10^8 = 3 \times 10^8\ \text{m s}^{-1}$.

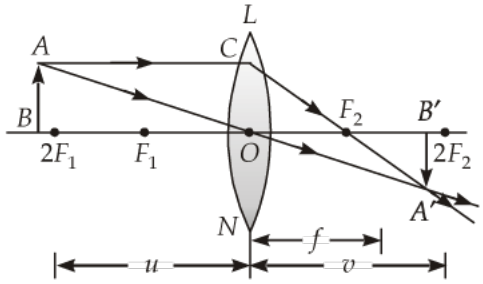
(b) Speed of light in water $v_w = \frac{c}{n_w} = \frac{3 \times 10^8}{4/3} = 2.25 \times 10^8\ \text{m s}^{-1}$.

S139. We can easily obtain the nature, position and relative size of image formed by a lens by drawing the ray diagram using rays whose refracted paths can be drawn easily.

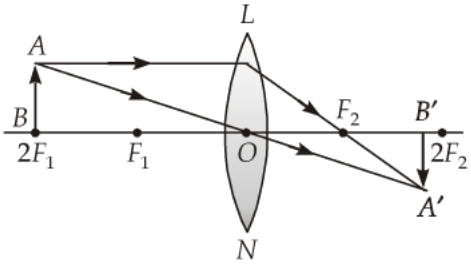
A convex lens may form six different types of images depending upon the position of the object relative to the lens. Ray diagrams for these have been drawn in figure.



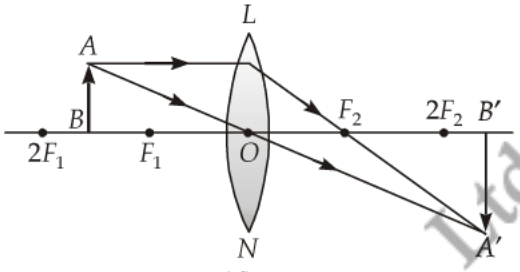
(a)



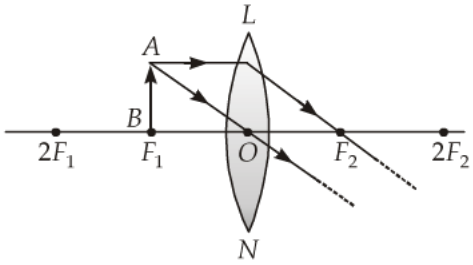
(b)



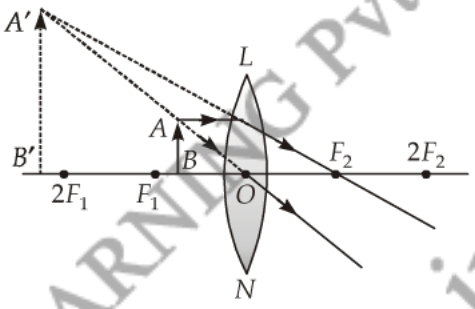
(c)



(d)



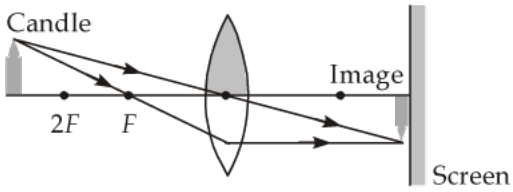
(e)



(f)

S140.(a) When one-half of a convex lens is covered with a balck paper, this lens produces a complete image of the object. To prove it we perform an experiment as given below:

Take a convex lens and cover half part of it by using a black paper. Place it vertically in a stand. On one side of it place a burning candle. On opposite side of the lens fix a white screen as shown in figure. Adjust the position of candle or screen till clear image of burning candle is fomed on the screen. We observe that the image is a complete image of the object (burning candle).



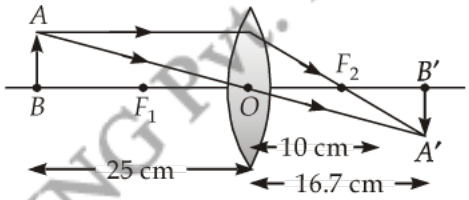
From the experimental observations, we find that image formation does not depend upon the size of a lens. A smaller lens can also form complete image of an object placed in front of it. However, brightness of the image decreases when some part of lens is blocked. It is because now lesser number of rays pass through the lens.

(b) The ray diagram is drawn below (see figure).

Here, $f = +10\,\text{cm}$, $u = -25\,\text{cm}$, and $h = 5\,\text{cm}$.

From lens formula $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f} \Rightarrow \dfrac{1}{v} - \left(\dfrac{1}{-25}\right) = \dfrac{1}{10} \Rightarrow \dfrac{1}{v} = \dfrac{1}{10} - \dfrac{1}{25} = \dfrac{3}{50}$

$\therefore$ $v = 50/3\,\text{cm} = 16.7\,\text{cm}$. The image is real and is formed at a distance of 16.7 cm from the lens on opposite side.



As magnification $m = \dfrac{h'}{h} = \dfrac{v}{u}$

$\therefore$ $\dfrac{h'}{5\,\text{cm}} = \dfrac{+50/3}{-25} = -\dfrac{2}{3}$

$\Rightarrow$ $h' = \dfrac{-2}{3} \times 5 = -\dfrac{10}{3}\,\text{cm}$

Hence, the image is inverted and diminished in size.

S141.(a) The power (P) of a lens is defined as the reciprocal of its focal length (f)

Thus, $P = \dfrac{1}{f}$

(b) SI unit of power is dioptre (D), where $1\ \text{D} = 1\ \text{m}^{-1}$. The power of a convex (converging) lens is positive and that of a concave (diverging) lens is negative.

(c) Focal length of convex lens $f_1 = +25\ \text{cm} = +0.25\ \text{m}$

$\therefore$ Power of convex lens $P_1 = \dfrac{1}{f_1\ \text{in m}} = \dfrac{1}{0.25\ \text{m}} = +4.0\ \text{D}$

Again focal length of concave lens $f_2 = -10\ \text{cm} = -0.1\ \text{m}$

$\therefore$ Power of concave lens $P_2 = \dfrac{1}{f_2\ \text{in m}} = \dfrac{1}{(-0.10)\ \text{m}} = -10.0\ \text{D}$

$\therefore$ Power of the lens combination $P = P_1 + P_2 = +4.0 - 10.0 = -6.0\ \text{D}$

The –ve sign signifies that the lens combination behaves as a concave (diverging) lens.