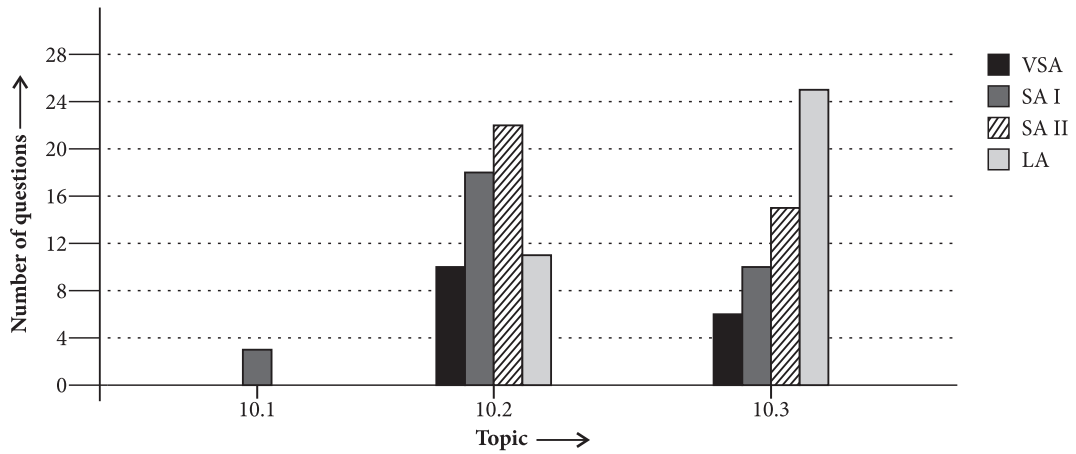
Chapter

10

Light-Reflection and Refraction

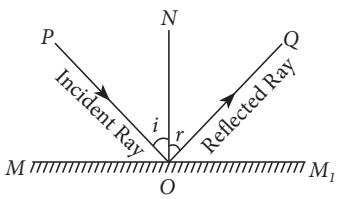
Topicwise Analysis of Last 10 Years' CBSE Board Questions (2017-2008)



- Maximum weightage is of *Refraction of Light.*
- Maximum VSA type questions were asked from *Spherical Mirrors.*
- Maximum SA II type questions were asked from *Spherical Mirrors.*
- Maximum LA type questions were asked from *Refraction of Light.*

QUICK RECAP

Reflection : When light falls on a surface and gets back into the same medium, it is called reflection.



- In reflection, the frequency, speed and wavelength do not change but a phase change may occur depending on the nature of reflecting surface.

Laws of reflection

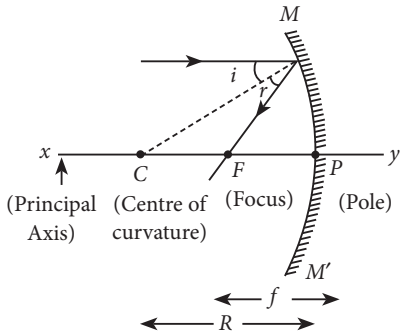
- The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.
- The angle of reflection (r) and the angle of incidence (i) are equal.

Plane mirror : A plane mirror always forms an erect, virtual, size to size image at the same distance as the object is, but at the back of the mirror.

- Its magnification is +1.
- It forms a laterally inverted image.
- When a plane mirror is turned by an angle θ, the reflected ray will turn by an angle of 2θ.
- The radius of curvature of a plane mirror is infinity. Its focal length is therefore infinity.
- To see full size image of a person, he needs a mirror of length half his height.

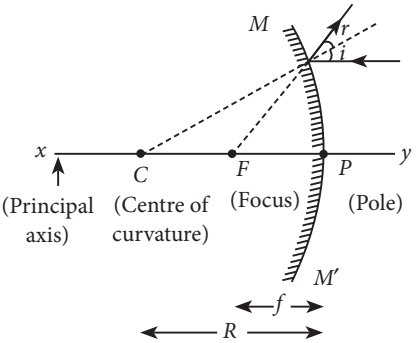
Spherical mirror : A reflecting surface which is of the form of a sphere in which inner or outer surface is reflecting.

- **Concave mirror :** If the outer surface is silvered and reflection takes place from inner surface, the mirror is called concave mirror.



Concave Mirror

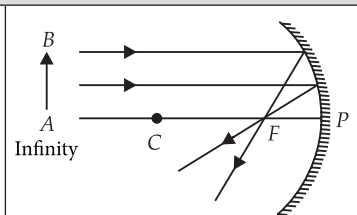
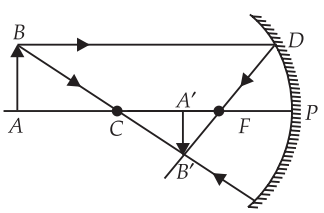
- **Convex mirror :** If the inner surface is silvered and reflection takes place from outer surface, the mirror is called convex mirror.

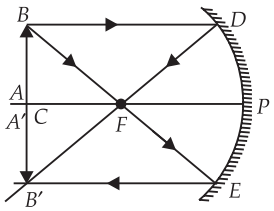
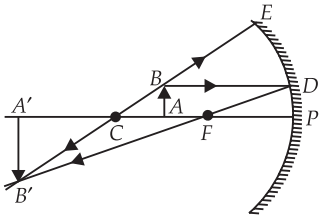
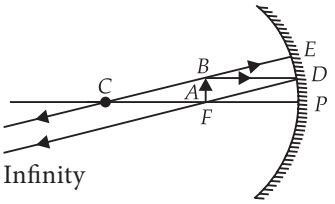
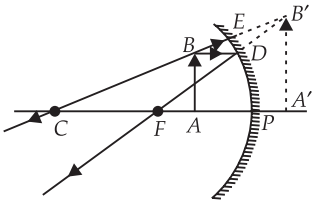


Convex Mirror

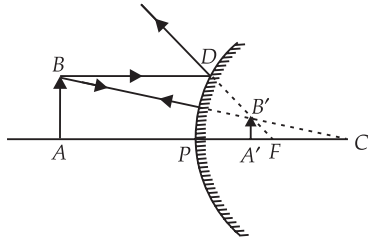
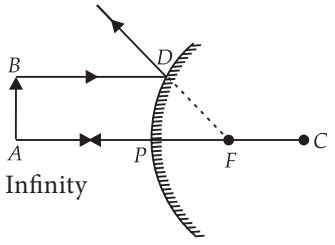
- **Rules to draw the ray diagram :** Any two of the rules are used in order to draw the ray diagram.
  - The rays of light passing parallel to the principal axis will converge at the focus after reflection.
  - The rays of light passing through the focus will emerge parallel to the principal axis after reflection.
  - The rays of light passing through the centre of curvature will all retrace their path after reflection.
  - The rays of light falling at the pole gets reflected at the same angle on the other side of principal axis.

- **Image formation by spherical mirrors :**

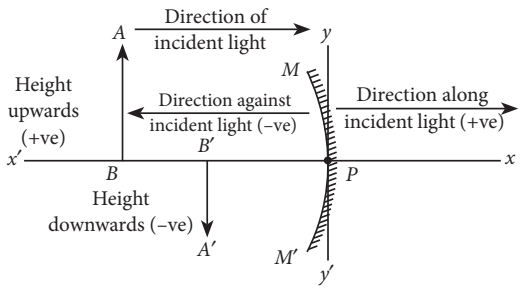
Concave mirror				
Ray diagram		**Object position**	**Image position**	**Nature of image**
(a)		At infinity	At the focus *F*	Real, inverted and point-sized
(b)		Between infinity and the centre of curvature *C*	Between *F* and *C*	Real, smaller than the object and inverted

(c)		At *C*	At *C*	Real, same size and inverted
(d)		Between *C* and *F*	Between *C* and infinity	Real, enlarged and inverted
(e)		At *F*	At infinity	Real, infinitely large and inverted
(f)		Between the pole *P* and *F*	Behind the mirror	Virtual, enlarged and erect

Convex mirror

Ray diagram		Object position	Image position	Nature of image
(a)		Between infinity and the pole	Behind the mirror between the focus and the pole	Virtual, smaller and erect
(b)		At infinity	Behind the mirror at the focus *F*	Virtual, point-sized and erect

- **Sign conventions :**



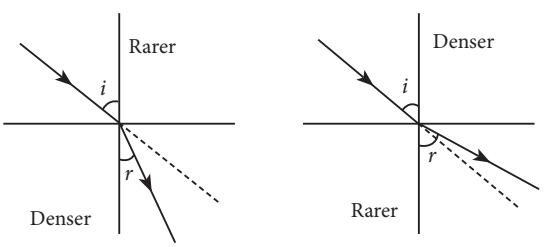
- **Mirror formula :** $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$

  Where f, u and v are the focal length, object distance and image distance respectively.
- **Magnification :** It is defined as the ratio of size of image to the size of object.

  $$m=\frac{\text{Size of object } (h_I)}{\text{Size of image } (h_0)}=-\frac{v}{u}$$

  Magnification is always (+ve) for convex mirror while it depends on position of object for concave mirror.
- **Uses of concave mirror :** It is used
  - as a shaving mirror.
  - in a reflecting type astronomical telescope.
  - in search light, headlight of automobile.
- **Uses of convex mirror :** It is used
  - as rear view mirrors in automobiles.
  - as a device to check theft in shops.
  - to bring view of corners which are not directly visible.

Refraction : Bending of light when it passes obliquely from one medium to another medium is called refraction.



- **Laws of refraction :** The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.
- The ratio of the sine of the angle of incidence to the sine of angle of refraction is a constant, *i.e.*, $\frac{\sin i}{\sin r}$ = constant, for the light of a given colour and for a given pair of media.

Refractive index : $\frac{\sin i}{\sin r}$ is called refractive index (n) of one medium with respect to another medium. It has no unit.

- **Absolute refractive index :** The ratio of speed of light in vacuum or air to the speed of light in the medium is called the absolute refractive index.

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

- **Relative refractive index :** The relative refractive index is defined as the ratio of refractive index of medium 2 to the refractive index of medium 1.

  $$n_{21}=\frac{c/v_2}{c/v_1}=\frac{n_2}{n_1}$$

- **Relative refractive index of two media :**

  For air-water interface, $n_{wa}=\frac{\sin i}{\sin r_1}$ ...(i)

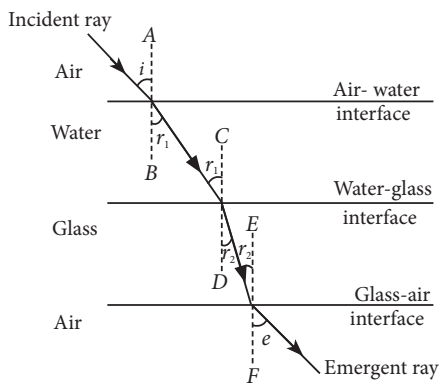
  For water-glass interface, $n_{gw}=\frac{\sin r_1}{\sin r_2}$ ...(ii)

  For glass-air interface, $n_{ag}=\frac{\sin r_2}{\sin e}$ ...(iii)

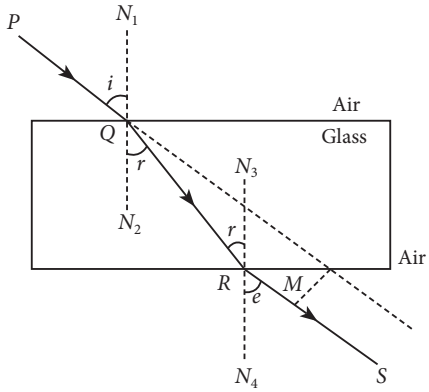
  From eqns. (i), (ii) and (iii)

  $$n_{wa}\times n_{gw}\times n_{ag}=\frac{\sin i}{\sin r_1}\times\frac{\sin r_1}{\sin r_2}\times\frac{\sin r_2}{\sin e}=1$$

  $\therefore \quad \angle i=\angle e$

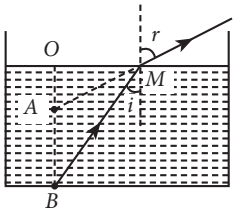


- **Lateral displacement :** The perpendicular distance (M) between the original path of incident ray and the emergent ray coming out of a glass slab is called lateral displacement of the emergent ray of light.



Lateral displacement is
- directly proportional to the thickness of the slab.
- directly proportional to the incident angle.
- directly proportional to the refractive index of the glass slab.
- inversely proportional to the wavelength of incident light.

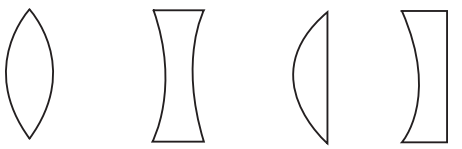
- **Apparent position of object :** Due to refraction, the original depth of a tank cannot be known. The apparent depth of the tank is $1/n$ times the original depth of the tank.



$$n = \frac{\text{real depth}}{\text{apparent depth}} = \frac{OB}{OA}$$

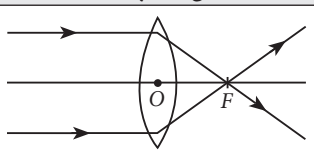
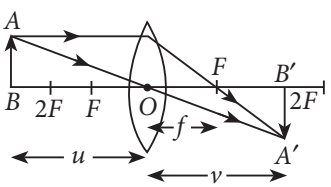
- The bottom of the tank, filled with water appears to be raised.
- A coin placed at the bottom of water filled glass tumbler appears to be raised.
- When a straight rod, partly immersed in water, viewed from the sides, it appeared to be broken.
- A lemon kept in a bowl viewed from side, it appears larger than its actual size.
- The part of the rod inside water appears thick, if viewed from side.

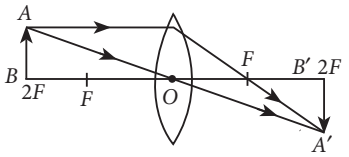
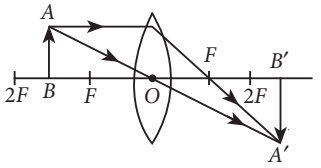
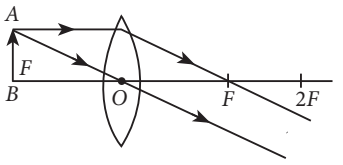
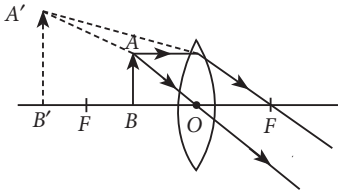
Lens : A piece of transparent medium bounded by at least one spherical surface is called lens.



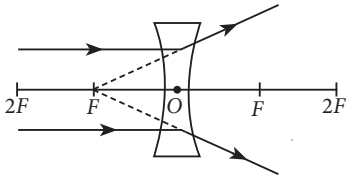
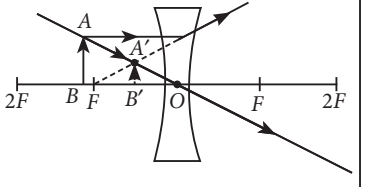
Convex or converging lens | Concave or diverging lens | Plano-convex lens | Plano-concave lens

- **Image formation by lenses :**

Convex lens				
	Ray diagram	**Position of object**	**Position of image**	**Nature of image**
(a)	 u = –ve, v = +ve and f = +ve	At infinity	At F	Real, inverted and highly diminished
(b)	 u = –ve, v = +ve and f = +ve	Between infinity and $2F$	Between F and $2F$	Real, inverted and diminished

(c)	 u = –ve, v = +ve and f = +ve	At 2F	At 2F	Real, inverted and same sized
(d)	 u = –ve, v = +ve and f = +ve	Between F and 2F	Beyond 2F	Real, inverted and enlarged
(e)	 u = –ve, v = +ve and f = +ve	At F	At infinity	Real, inverted and enlarged
(f)	 u = –ve, v = –ve and f = +ve	Between F and O	On the same side of the lens	Virtual, erect and enlarged

Concave lens

	Ray diagram	Position of object	Position of image	Nature of image
(a)	 u = –ve, v = –ve and f = –ve	At infinity	At F	Virtual, erect and highly diminished
(b)	 u = –ve, v = –ve and f = –ve	Between infinity and O	Between F and O	Virtual, erect and diminished

- **Lens formula and magnification :**

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

This formula gives the relationship between object distance (u), image distance (v) and the focal length (f).

The ratio of the height of the image and the height of the object is magnification of lens.

$$m = \frac{\text{Size of image } (h')}{\text{Size of object } (h)} = \frac{v}{u}$$

Magnification of inverted image is taken as (–)ve and for erect image, it is taken as (+)ve.

- **Power of a lens :** The ability of a lens to converge or diverge is called power (P) of the lens.

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

The SI unit of power is dioptre.
1 dioptre = 1 m^{-1}

Power of a convex lens is taken as (+)ve while the power of concave lens is taken as (–)ve.

- **Lenses in combination :** When two or more lenses are used in combination, the diverging or converging power varies.

The equivalent focal length in combination is given as $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

The power of the combination, $P = P_1 + P_2$
The magnification of combination,
$m = m_1 \times m_2 \times m_3 \ldots\ldots m_n$

Previous Years' CBSE Board Questions

10.1 Reflection of Light

SA I (2 marks)

1. List four characteristics of the images formed by plane mirrors. *(Delhi 2015)*

2. State the two laws of reflection of light. *(Delhi 2011)*

3. State any four characteristics of the image of an object formed by a plane mirror. *(AI 2011)*

10.2 Spherical Mirrors

VSA (1 mark)

4. What is the magnification of the images formed by plane mirrors and why? *(Delhi 2015)*

5. Explain why a ray of light passing through the centre of curvature of a concave mirror gets reflected along the same path. *(Delhi 2010)*

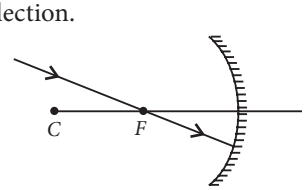
6. What is the nature of the image formed by a concave mirror if the magnification produced by the mirror is +3? *(Delhi 2010)*

7. A object is kept at a distance of 4 m in front of a spherical mirror which forms its erect image at a distance of 1.0 m from the mirror. What is the magnification? Is the mirror concave or convex? *(Foreign 2010)*

8. What kind of mirrors are used in big shopping stores to watch activities of customers? *(Foreign 2009)*

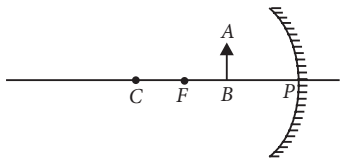
9. Draw a ray diagram to determine the position of image formed of an object placed between the pole and the focus of a concave mirror. *(Foreign 2009)*

10. Copy this figure in your answer-book and show the direction of the light ray after reflection.



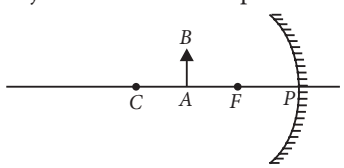
(Delhi 2008)

11. Draw the following diagram in your answer book and show the formation of image of the object *AB* with the help of suitable rays.



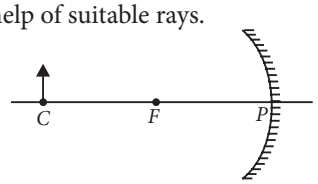
(AI 2008)

12. Draw the following diagram in your answer book and show the formation of image of the object *AB* with the help of suitable rays.



(AI 2008)

13. Draw the following diagram in your answer book and show the formation of image with the help of suitable rays.



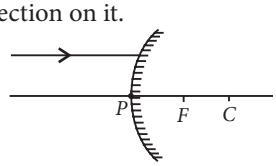
(AI 2008)

SA I (2 marks)

14. An object is placed at a distance of 30 cm in front of a convex mirror of focal length 15 cm. Write four characteristics of the image formed by the mirror. *(Delhi 2017)*

15. An object is placed at a distance of 12 cm in front of a concave mirror of radius of curvature 30 cm. List four characteristics of the image formed by the mirror. *(Delhi 2017)*

16. A ray of light is incident on a convex mirror as shown. Redraw the diagram and complete the path of this ray after reflection from the mirror. Mark angle of incidence and angle of reflection on it.

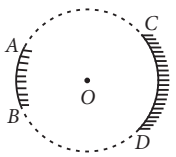


(Delhi 2016)

17. Name the type of mirrors used in the design of solar furnaces. Explain how high temperature is achieved by this device. *(AI 2016)*

18. "The magnification produced by a spherical mirror is –3". List four informations you obtain from this statement about the mirror/ image. *(AI 2016)*

19. *AB* and *CD*, two spherical mirrors, from parts of a hollow spherical ball with its centre at *O* as shown in the diagram. If arc $AB = \frac{1}{2}$ arc *CD*, what is the ratio of their focal lengths? State which of the two mirrors will always form virtual image of an object placed in front of it and why?



(Foreign 2016)

20. List two properties of the images formed by convex mirrors. Draw ray diagram in support of your answer. *(Foreign 2016)*

21. The linear magnification produced by a spherical mirror is +3. Analyse this value and state the (i) type of mirror and (ii) position of the object with respect to the pole of the mirror. Draw a ray diagram to show the formation of image in this case. *(Foreign 2016)*

22. List four specific characteristics of the images of the objects formed by convex mirrors. *(Delhi 2015)*

23. Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray which is directed towards the principal focus of a convex mirror. Mark on it the angle of incidence and the angle of reflection. *(Delhi 2014)*

24. Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray which is directed parallel to the principal axis of a convex mirror, Mark on it the angle of incidence and the angle of reflection. *(Delhi 2014)*

25. Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray of light parallel to the principal axis of a concave mirror. Mark the angle of incidence and angle of reflection on it. *(Delhi 2014)*

26. List two possible ways in which a concave mirror can produce a magnified image of an object placed in front of it. State the difference if any between these two images. *(AI 2014)*

27. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should the position of the object be relative to the mirror? Draw ray diagram to justify your answer. *(AI 2014)*

28. The linear magnification produced by a spherical mirror is +1/3. Analysing this value state the (i) type of mirror and (ii) position of the object with respect to the pole of the mirror. Draw any diagram to justify your answer. *(AI 2014, Foreign 2014)*

29. The linear magnification produced by a spherical mirror is –1. Analysing this value state the (i) type of mirror and (ii) position of the object with respect to the pole of the mirror. Draw any diagram to justify your answer. *(Foreign 2014)*

30. The linear magnification produced by a spherical mirror is –1/5. Analysing this value state the (i) type of spherical mirror and (ii) the position of the object with respect to the pole of the mirror. Draw ray diagram to justify your answer. *(Foreign 2014)*

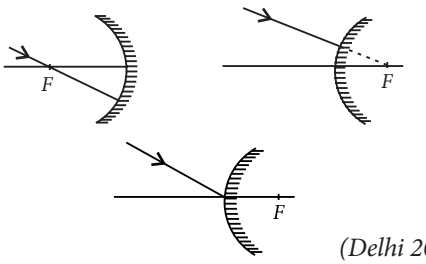
31. What is the minimum number of rays required for locating the image formed by a concave mirror for an object? Draw a ray diagram to show the formation of a virtual image by a concave mirror. *(Delhi 2009)*

SA II (3 marks)

32. The image of a candle flame placed at a distance of 30 cm from a mirror is formed on a screen placed in front of the mirror at a distance of 60 cm from its pole. What is the nature of the mirror? Find its focal length. If the height of the flame is 2.4 cm, find the height of its image. State whether the image formed is erect or inverted. *(Delhi 2017)*

33. An object 4 cm in height, is placed at 15 cm in front of a concave mirror of focal length 10 cm. At what distance from the mirror should a screen be placed to obtain a sharp image of the object. Calculate the height of the image. *(Delhi 2017)*

34. Draw the following diagram in which a ray of light is incident on a concave/convex mirror, on your answer sheet. Show the path of this ray, after reflection, in each case.



(Delhi 2016)

35. The image of an object formed by a mirror is real, inverted and is of magnification –1. If the image is at a distance of 40 cm from the mirror, where is the object placed? Where would the image be if the object is moved 20 cm towards the mirror? State reason and also draw ray diagram for the new position of the object to justify your answer. *(AI 2016)*

36. The image formed by a spherical mirror is real, inverted and its magnification is –2. If the image is at a distance of 30 cm from the mirror, where is the object placed? Find the focal length of the mirror. List two characteristics of the image formed if the object is moved 10 cm towards the mirror. *(AI 2016)*

37. If the image formed by mirror for all positions of the object placed in front of it is always virtual and diminished, state the type of the mirror. Draw a ray diagram in support of your answer. Where are such mirrors commonly used and why? *(Foreign 2016)*

38. To construct a ray diagram we use two rays of light which are so chosen that it is easy to determine their directions after reflection from the mirror. Choose these two rays and state the path of these rays after reflection from a concave mirror. Use these two rays to find the nature and position of the image of an object placed at a distance of 15 cm from a concave mirror of focal length 10 cm. *(Delhi 2015, AI 2012)*

39. If the image formed by a mirror for all positions of the object placed in front of it is always erect and diminished, what type of mirror is it? Draw a ray diagram to justify your answer. Where and why do we generally use this type of mirror? *(AI 2015)*

40. Draw a ray diagram to show the path of the reflected ray in each of the following cases. A ray of light incident on a convex mirror :
(a) strikes at its pole making an angle θ from the principal axis.
(b) is directed towards its principle focus.
(c) is parallel to its principal axis.
(Foreign 2015)

41. A spherical mirror produces an image of magnification –1 on a screen placed at a distance of 50 cm from the mirror.
(a) Write the type of mirror.
(b) Find the distance of the image from the object.
(c) What is the focal length of the mirror?
(d) Draw the ray diagram to show the image formation in this case.
(Delhi 2014, AI 2014)

42. A spherical mirror produces an image of magnification –1 on a screen placed at a distance of 40 cm from the mirror.
(i) Write type of mirror.
(ii) What is the nature of the image formed?
(iii) How far is the object located from the mirror?
(iv) Draw the ray diagram to show the image formation in this case. *(Delhi 2014)*

43. A spherical mirror produces an image of magnification –1.0 on a screen placed at a distance of 30 cm from the pole of the mirror.
(i) Write the type of mirror in this case.
(ii) What is the focal length of the mirror?
(iii) What is the nature of the images formed?
(iv) Draw the ray diagram to show the image formation in this case? *(Delhi 2014)*

44. A student wants to project the image of a candle flame on a screen 48 cm in front of a mirror by keeping the flame at a distance of 12 cm from its pole.
(a) Suggest the type of mirror he should use.
(b) Find the linear magnification of the image produced.
(c) How far is the image from its object?
(d) Draw ray diagram to show the image formation in this case. *(AI 2014)*

45. A student wants to obtain an erect image of an object using a concave mirror of 12 cm focal length. What should be the range of distance of the candle flame from the mirror? State the nature and size of the image he is likely to observe. Draw a ray diagram to show the image formation in this case.
(Foreign 2014)

46. A student wants to obtain an erect image of a candle flame using a concave mirror of focal length 15 cm. What should be the range of distance of the candle flame from the mirror? State the nature and size of the image he is likely to observe. Draw a ray diagram to show the image formation in this case.
(Foreign 2014)

47. A student has a concave mirror of 20 cm focal length and he wants to see an erect image of his face in the mirror. What should be the range of distance of the mirror from his face? State the nature and size of the image he is likely to observe. Draw a ray diagram to justify your answer. *(Foreign 2014)*

48. Mention the types of mirrors used as (i) rear view mirrors, (ii) shaving mirrors. List two reasons to justify your answer in each case.
(Delhi 2013, Delhi 2012)

49. Calculate the magnification of the image of an object placed perpendicular to the principal axis of a concave mirror of focal length 15 cm. The object is at a distance of 20 cm from the mirror. *(Delhi 2013)*

50. To construct ray diagram we use two light rays which are so chosen that it is easy to know their directions after reflection from the mirror. List these two rays and state the path of these rays after reflection. Use these rays to locate the image of an object placed between centre of curvature and focus of a concave mirror. *(AI 2012)*

51. State the types of mirrors used for (i) headlights and (ii) rear view mirrors, in motorcycles. Give reason to justify your answer in each case. *(AI 2012)*

52. 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.
(AI 2011)

53. With the help of a ray diagram explain why a convex mirror is preferred for rear view mirrors in the motor cars. *(Foreign 2011)*

LA (5 marks)

54. (a) To construct a ray diagram we use two rays which are so chosen that it is easy to know their directions after reflection from the mirror. Use these two rays and draw ray diagram to locate the image of an object placed between pole and focus of a concave mirror.
(b) A concave mirror produces three times magnified image on a screen. If the objects placed 20 cm in front of the mirror, how far is the screen from the object? *(Delhi 2017)*

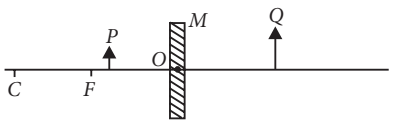
55. (a) If the image formed by a mirror for all positions of the object placed in front of it is always diminished, erect and virtual, state the type of the mirror and also draw a ray diagram to justify your answer. Write one use such mirrors are put to and why?
(b) Define the radius of curvature of spherical mirrors. Find the nature and focal length of a spherical mirror whose radius of curvature is +24 cm. *(AI 2017)*

56. (a) Define the following terms in the context of spherical mirrors:
(i) Pole
(ii) Centre of curvature

(iii) Principal axis
(iv) Principal focus

(b) Draw ray diagrams to show the principal focus of a
(i) Concave mirror
(ii) Convex mirror

(c) Consider the following diagram in which M is a mirror and P is an object and Q is its magnified image formed by the mirror.



State the type of the mirror M and one characteristic property of the image Q.

(Delhi 2016)

57. It is desired to obtain an erect image of an object, using concave mirror of focal length of 12 cm.

(i) What should be the range of distance of a object placed in front of the mirror?

(ii) Will the image be smaller or larger than the object. Draw ray diagram to show the formation of image in this case.

(iii) Where will the image of this object be, if it is placed 24 cm in front of the mirror? Draw ray diagram for this situation also to justify your answer.

Show the positions of pole, principal focus and the centre of curvature in the above ray diagrams. *(AI 2016)*

58. Suppose you have three concave mirrors A, B and C of focal lengths 10 cm, 15 cm and 20 cm. For each concave mirror you perform the experiment of image formation for three values of object distances of 10 cm, 20 cm and 30 cm. By giving reason, answer the following:

(a) For the three object distances, identify the mirror/mirrors which will form an image of magnification –1.

(b) Out of the three mirrors, identify the mirror which would be preferred to be used for shaving purposes/make up.

(c) For the mirror B draw ray diagram for image formation for object distances 10 cm and 20 cm. *(Foreign 2016)*

59. A student has focused the image of a candle flame on a white screen using a concave mirror. The situation is a given below :
Length of the flame = 1.5 cm
Focal length of the mirror = 12 cm
Distance of flame from the mirror = 18 cm
If the flame is perpendicular to the principal axis of the mirror, then calculate the following:

(a) Distance of the image from the mirror

(b) Length of the image

If the distance between the mirror and the flame is reduced to 10 cm, then what would be observed on the screen? Draw ray diagram to justify your answer from this situation.

(Foreign 2015)

60. A student wants to project the image of a candle flame on the walls of school laboratory by using a mirror.

(a) Which type of mirror should he use and why?

(b) At what distance in terms of focal length 'f' of the mirror should he place the candle flame so as to get the magnified image on the wall?

(c) Draw a ray diagram to show the formation of image in this case.

(d) Can he use this mirror to project a diminished image of the candle flame on the same wall? State 'how' if your answer is 'yes' and 'why not' if your answer is 'no'

(Delhi 2014)

61. Define the following terms in case of a concave mirror:

(a) Pole

(b) Radius of curvature

(c) Principal axis

(d) Principal focus

Suppose you want to observe an erect image of a candle flame using a concave mirror of focal length 20 cm. State the range of distance of the candle flame from the mirror. List two other characteristics of the observed image. Draw a ray diagram to show the formation of image in this case. *(Delhi 2013)*

62. 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 infront of it.

(Delhi 2012)

63. 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 1/3 times magnified virtual image of an object placed 18 cm in front of it. *(AI 2012)*

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

(i) Headlights of a car

(ii) Rear-view mirror of vehicle

(iii) Solar furnace

Support your answer with reason.

(Foreign 2012)

10.3 Refraction of Light

VSA (1 mark)

65. What is meant by power of a lens?

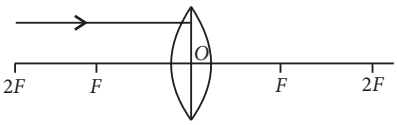
(Delhi 2015)

66. How should a ray of light be incident on a rectangular glass slab so that it comes out from the opposite side of the slab without being displaced? *(Foreign 2010)*

67. A girl was playing with a thin beam of light from her laser torch by directing it from different directions on a convex lens held vertically. She was surprised to see that in a particular direction the beam of light continues to move along the same direction after passing through the lens. State the reason for this observation. *(Foreign 2010)*

68. Why does a ray of light bend when it travels from one medium into another? *(Delhi 2009)*

69. Draw the given diagram in your answer book and complete it for the path of ray of light beyond the lens.



(Delhi 2009)

70. The refractive index of diamond is 2.42. What is the meaning of this statement in relation to speed of light? *(Delhi 2008)*

SA I (2 marks)

71. An object is placed at a distance of 15 cm from a convex lens of focal length 20 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. *(AI 2017)*

72. What is meant by power of a lens? What does its sign (+ve or –ve) indicate? State its S.I. unit related to focal length of a lens? *(Delhi 2016)*

73. The refractive indices of glass and water with respect to air are 3/2 and 4/3 respectively. If speed of light in glass is 2×10^8 m/s, find the speed of light in water. *(AI 2016)*

74. The absolute refractive indices of glass and water are 4/3 and 3/2 respectively. If the speed of light in glass is 2×10^8 m/s, calculate the speed of light in (i) vacuum, (ii) water.

(AI 2015)

75. "A ray of light incident on a rectangular glass slab immersed in any medium emerges parallel to itself." Draw labelled ray diagram to justify the statement". *(Delhi 2013)*

76. The absolute refractive indices of glass and water are 1.5 and 1.33 respectively. In which medium does light travel faster? Calculate the ratio of speeds of light in the two media.

(Delhi 2013 C)

77. To construct a ray diagram we use two light rays which are so chosen that it is easy to know their directions after refraction from the lens. List these two rays and state the path of these rays after refraction. Use these two rays to locate the image of an object placed between 'f' and '$2f$' of a convex lens.

(Foreign 2012)

78. The refractive index of water is 1.33 and the speed of light in air is 3×10^8 m s^{-1}. Calculate the speed of light in water. *(Foreign 2009)*

79. Explain with the help of a diagram, why a pencil partly immersed in water appears to be bent at the water surface. *(Delhi 2008)*

80. 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 optical centre O of lens
(AI 2008)

SA II (3 marks)

81. Draw ray diagrams to show the formation of three times magnified (a) real, and (b) virtual image of an object by a converging lens. Mark the positions of O, F and $2F$ in each diagram. *(AI 2017)*

82. (a) Draw a diagram to show the refraction of light through a glass slab and mark angle of refraction and the lateral shift suffered by a ray of light while passing through the slab.
(b) If the refractive index of glass for light going from air to glass is 3/2, find the refractive index of air for light going from glass to air. *(Delhi 2016)*

83. The image of an object formed by a lens is of magnification –1. If the distance between the object and its image is 60 cm, what is the focal length of the lens? If the object is moved 20 cm towards the lens, where would the image be formed? State reason and also draw a ray diagram in support of your answer. *(AI 2016)*

84. (a) Define focal length of a spherical lens.
(b) A divergent lens has a focal length of 30 cm. At what distance should an object of height 5 cm from the optical centre of the lens be placed so that its image is formed 15 cm away from the lens? Find the size of the image also?
(c) Draw a ray diagram to show the formation of image in the above situation.
(AI 2016)

85. If the image formed by a lens for all positions of the object placed in front of it is always virtual, erect and diminished, state the type of the lens. Draw a ray diagram in support of your answer. If the numerical value of focal length of such a lens is 20 cm, find its power in new cartesian sign conventions.
(Foreign 2016)

86. State the laws of refraction of light. If the speed of light in vacuum is 3×10^8 m/s, find the absolute refractive index of a medium in which light travels with a speed of 1.4×10^8 m/s. *(Foreign 2015)*

87. State the laws of refraction of light. If the speed of light in vacuum is 3×10^8 m s^{-1}, find the speed of light in a medium of absolute refractive index 1. 5 *(Delhi 2014, AI 2014)*

88. The image of a candle flame placed at a distance of 40 cm from a spherical lens is formed on a screen placed on the other side of the lens at a distance of 40 cm from the lens. Identify the type of lens and write its focal length. What will be the nature of the image formed if the candle flame is shifted 25 cm towards the lens? Draw a ray diagram to justify your answer. *(Foreign 2014)*

89. An object of height 6 cm is placed perpendicular to the principal axis of a concave lens of focal length 5 cm. Use lens formula to determine the position, size and nature of the image if the distance of the object from the lens is 10 cm. *(Delhi 2013)*

90. Draw ray diagram to show the path of the refracted ray in each of the following cases. A ray of light incident on a concave lens (i) is parallel to its principal axis, (ii) is passing through its optical centre and (iii) is directed towards its principal focus. *(Delhi 2013 C)*

91. What is the principle of reversibility of light? Show that the incident of light is parallel to the emergent ray of light when light falls obliquely on a side of a rectangular glass slab.
(AI 2011)

92. What is understood by lateral displacement of light? Illustrate it with the help of a diagram. List any two factors on which the lateral displacement in a particular substance depends. *(Foreign 2011)*

93. At what distance should an object be placed from a convex lens of focal length 18 cm to obtain an image at 24 cm from it on the other side. What will be the magnification produced in this case? *(Delhi 2010)*

94. The image of an object placed at 60 cm in front of a lens is obtained on a screen at a distance of 120 cm from it. Find the focal length of the lens. What would be the height of the image if the object is 5 cm high? *(Foreign 2010)*

95. For which position of the object does a convex lens form a virtual and erect image? Explain with the help of a ray diagram. *(AI 2009)*

LA (5 marks)

96. Analyse the following observation table showing variation of image distance (v) with object distance (u) in case of a convex lens and answer the questions that follows, without doing any calculations :

S. No.	Object distance u (cm)	Image distance v (cm)
1	− 90	+ 18
2	− 60	+ 20
3	− 30	+ 30
4	− 20	+ 60
5	− 18	+ 90
6	− 10	+ 100

(a) What is the focal length of the convex lens? Give reason in support of your answer.

(b) Write the serial number of that observation which is not correct. How did you arrive at this conclusion?

(c) Take an appropriate scale to draw ray diagram for the observation at S. No. 4 and the approximate value of magnification. *(Delhi 2017)*

97. Analyse the following observation table showing variation of image-distance (v) with object-distance (u) in case of a convex lens and answer the questions that follow without doing any calculations.

S. No.	Object Distance u(cm)	Image Distance v(cm)
1	–100	+25
2	–60	+30
3	–40	+40
4	–30	+60
5	–25	+100
6	–15	+120

(a) What is the focal length of the convex lens? Give reason to justify your answer.

(b) Write the serial number of the observation which is not correct. On what basis have you arrived at this conclusion?

(c) Select an appropriate scale and draw a ray diagram for the observation at S. No. 2. Also find the approximate value of magnification. *(AI 2017)*

98. (a) Draw a ray diagram to show the formation of image by a convex lens when an object is placed in front of the lens between its optical centre and principal focus.

(b) In the above ray diagram mark the object distance (u) and the image distance (v) with their proper sign (+ve or –ve as per the new Cartesian sign convention) and state how these distances are related to the focal length (f) of the convex lens in this case.

(c) Find the power of a convex lens which forms a real and inverted image of magnification –1 of an object placed at a distance of 20 cm from its optical centre. *(Delhi 2016)*

99. (a) Draw a ray diagram to show the formation of image by a concave lens when an object is placed in front of it.

(b) In the above diagram mark the object distance (u) and the image distance (v) with their proper sign (+ve or –ve as per the new Cartesian sign convention) and state how these distances are related to the focal length (f) of the concave lens in this case.

(c) Find the nature and power of a lens which forms a real and inverted image of magnification –1 at a distance of 40 cm from its optical centre. *(Delhi 2016)*

100. (a) Define optical centre of a spherical lens.
(b) A divergent lens has a focal length of 20 cm. At what distance should an object of height 4 cm from the optical centre of the lens be placed so that its image is formed 10 cm away from the lens. Find the size of the image also.
(c) Draw a ray diagram to show the formation of image in above situation. *(AI 2016)*

101. (a) Define focal length of a divergent lens.
(b) A divergent lens has a focal length of 30 cm forms the image of an object of size 6 cm on the same side as the object at a distance of 15 cm from its optical centre. Use lens formula to determine the distance of the object from the lens and the size of the image formed.
(c) Draw a ray diagram to show the formation of image in the above situation. *(AI 2016)*

102. At what distance from a concave lens of focal length 20 cm a 6 cm tall object be placed so as to obtain its image at 15 cm from the lens? Also calculate the size of the image formed. Draw a ray diagram to justify your answer for the above situation and label it. *(Foreign 2016)*

103. At what distance from a concave lens of focal length 25 cm a 10 cm tall object be placed so as to obtain its image at 20 cm from the lens. Also calculate the size of the image formed. Draw a ray diagram to justify your answer for the above situation and label it. *(Foreign 2016)*

104. "A convex lens can form a magnified erect as well as magnified inverted image of an object placed in front of it". Draw ray diagram to justify this statement stating the position of the object with respect to the lens in each case.
An object of height 4 cm is placed at a distance of 20 cm from a concave lens of focal length 10 cm. Use lens formula to determine the position of the image formed. *(Delhi 2015)*

105. The image of a candle flame placed at a distance of 30 cm from a spherical lens is formed on a screen placed on the other side of the lens at a distance of 60 cm from the optical centre of the lens. Identify the type of lens and calculate its focal length. If the height of the flame is 3 cm, find the height of its image. *(Delhi 2015)*

106. (a) State the laws of refraction of light. Explain the term absolute refractive index of a medium and write an expression to relate it with the speed of light in vacuum.
(b) The absolute refractive indices of two media *A* and *B* are 2.0 and 1.5 respectively. If the speed of light in medium *B* is 2×10^8 m/s, calculate the speed of light in
(i) vacuum
(ii) medium *A* *(Delhi 2015)*

107. What is meant by power of a lens? Define its S.I. unit.
You have two lenses *A* and *B* of focal lengths +10 and –10 cm respectively. State the nature and power of each lens. Which of the two lenses will form a virtual and magnified image of an object placed 8 cm from the lens? Draw a ray diagram to justify your answer. *(AI 2015)*

108. One half of a convex lens of focal length 10 cm is covered with a black paper. Can such a lens produce an image of a complete object placed at a distance of 30 cm from the lens? Draw a ray diagram to justify your answer.
A 4 cm tall object is placed perpendicular to the principal axis of a concave lens of focal length 20 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. *(AI 2015)*

109. What is meant by the power of a lens ? What is its S.I. unit ? Name the type of lens whose power is positive.
The image of an object formed by a lens is real, inverted and of the same size as the object. If the image is at a distance of 40 cm from the lens, what is the nature and power of the lens? Draw ray diagram to justify your answer. *(Foreign 2015)*

110. (a) Explain the following terms related to spherical lenses:
(i) optical centre
(ii) centres of curvature
(iii) principal axis (iv) aperture

(v) principal focus (vi) focal length

(b) A converging lens has focal length of 12 cm. Calculate at what distance should the object be placed from the lens so that it forms an image at 48 cm on the other side of the lens. *(AI 2014)*

111. Explain the following terms related to spherical lenses

(a) Centres of curvature

(b) Principal axis

(c) Optical centre (d) Principal focus

At what distance from a concave lens of focal length 20 cm, should a 6 cm tall object be placed so that it forms an image at 15 cm from the lens? Also determine the size of the image formed. *(AI 2014)*

112. What is meant by power of a lens? Name and define its S.I. unit.

One student uses a lens of focal length +50 cm and another of –50 cm. State the nature and find the power of each lens. Which of the two lenses will always give a virtual and diminished image irrespective of the position of the object? *(Foreign 2014)*

113. (a) State the laws of refraction of light. Give an expression to relate the absolute refractive index of a medium with speed of light in vacuum.

(b) The refractive indices of water and glass with respect to air are 4/3 and 3/2 respectively. If the speed of light in glass is 2×10^8 m s^{-1}, find the speed of light in (i) air, (ii) water. *(Delhi 2013)*

114. 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. *(Delhi 2012)*

115. 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 3/2 and 4/3 respectively. If the speed of light in glass is 2×10^8 m/s, find the speed of light in (i) vacuum, (ii) water. *(Delhi 2012)*

116. A 4 cm tall object is placed perpendicular to the principal axis of 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. *(AI 2012, Foreign 2012)*

117. 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 2/3 and the refractive index of water with respect to air is 4/3. If the speed of light in glass is 2×10^8 m/s, find the speed of light in (a) air, (b) water. *(AI 2012)*

118. List the sign conventions that are followed in case of refraction of light through spherical lenses. Draw a diagram and apply these conventions in determining the nature and focal length of a spherical lens which forms three times magnified real image of an object placed 16 cm from the lens. *(Foreign 2012)*

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

(b) State and define the S.I 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. *(AI 2011)*

120. (a) Under what condition with a glass lens placed in a transparent liquid become invisible.

(b) Describe and illustrate with a diagram, how we should arrange two converging lenses so that a parallel beam of light entering one lens emerges as a parallel beam after passing through the second lens.

(c) An object is placed at a distance of 3 cm from a concave lens of focal length 12 cm. Find the (i) position and (ii) nature of the image formed. *(Foreign 2011)*

Detailed Solutions

1. Characteristics of the image formed by a plane mirror are
(i) image distance is same as that of object distance
(ii) image formed is virtual and erect
(iii) image formed is of the same size as that of the object
(iv) image formed is laterally inverted (left appears right and right appears left).

2. Laws of reflection of light states that
(i) The angle of incidence is equal to the angle of reflection.
(ii) The incident ray, the reflected ray and the normal to the mirror at the point of incidence all lie in the same plane.

3. *Refer to answer 1.*

4. Magnification of images formed by plane mirrors is unity because for plane mirrors, the size of the image formed is equal to that of the object.

5. A ray passing through centre of curvature of a concave mirror gets reflected along the same path because it acts as a normal to the surface of mirror, and we know that any ray passing through normal reflects along the same path.

6. Since, the sign of given magnification of the image is positive (+ ve) and greater than one so the image formed is virtual, erect and enlarged.

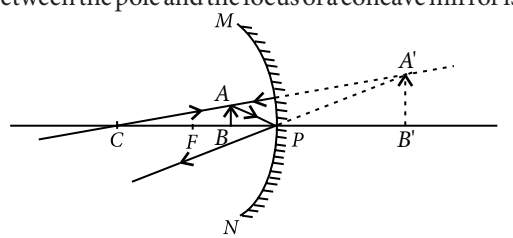
7. Here, object distance, $u = -4$ m
Image distance, $v = 1.0$ m

$$\text{Magnification, } m = \frac{-v}{u} \qquad \text{So, } m = \frac{-1}{-4} = \frac{1}{4}$$

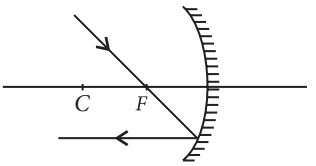
Since, the magnification is positive and less than one therefore, the given mirror is convex mirror.

8. Convex mirrors are used in big shopping stores to watch activities of customers.

9. Image formed by an object when it is kept between the pole and the focus of a concave mirror is



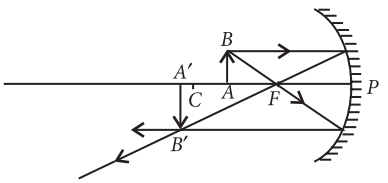
10.



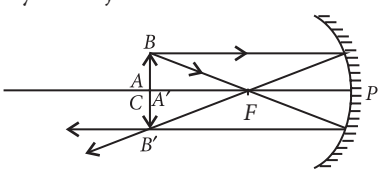
The incident ray passing through focus, goes parallel to the principal axis after the reflection through the given mirror.

11. *Refer to answer 9.*

12. In the given diagram, object is placed between centre of curvature (C) and focus (F). Image of the object AB can be obtained as follows:



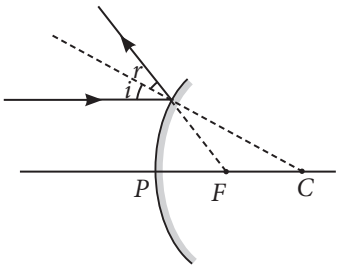
13. In the given diagrams object is placed at centre of curvature of a concave mirror. Image formed by the object can be drawn as



14. Four characteristics of the image formed by the given convex mirror of focal length 15 cm are :
(i) Virtual
(ii) Erect
(iii) Diminished
(iv) Image is always formed behind the mirror between pole and focus.

15. Radius of curvature (R) = 30 cm, object distance is 12 cm in front of the mirror. Thus we can say that object is placed between focus and pole. Four characteristics of the image formed by the given concave mirror are :
(i) Virtual
(ii) Erect
(iii) Enlarged
(iv) Image is formed behind the mirror

16.



17. Concave mirrors are used in the designing of solar furnaces.

When a solar furnace is placed at the focus of a large concave mirror, it focuses a parallel beam of light on the furnace. Therefore, a high temperature is attained at the point after some time.

18. Negative sign of magnification indicates that the image is real and inverted. Since the image is real and inverted, the mirror is concave and magnification of –3 indicates that the image is magnified.

19. Focal length of a mirror is given by

$$\text{Focal length} = \frac{\text{Radius of curvature}}{2}$$

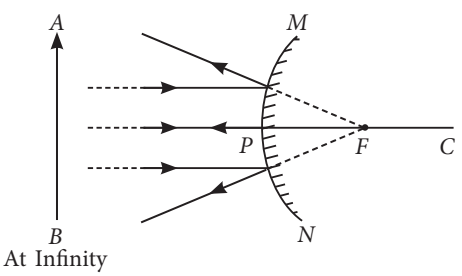
Since both the mirrors have same radius of curvature, therefore focal length of the two mirrors will be same, *i.e.*,

$$\frac{f_1}{f_2} = \frac{1}{1}$$

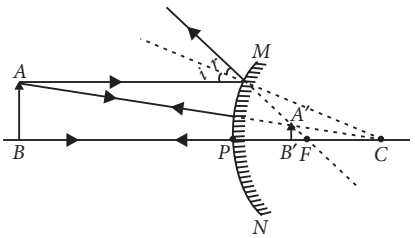
Since virtual image is always formed by convex mirror. The mirror *AB* will always form virtual image.

20. Convex mirrors always form diminished, virtual and erect images.

(a) Object placed at infinity



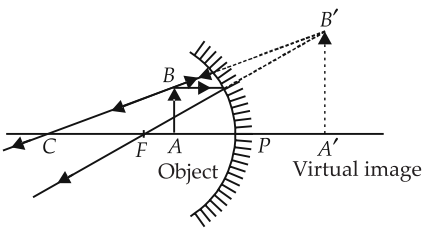
(b) Object placed between infinity and the pole *P* of the mirror



21. Positive value of the magnification indicates that image is virtual and erect.

(i) Since the image is magnified, the mirror is concave.

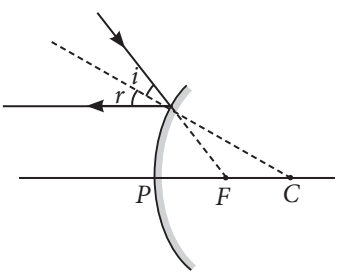
(ii) The object is between pole and focus of the mirror as shown



22. Characteristics of image formed by convex mirrors :

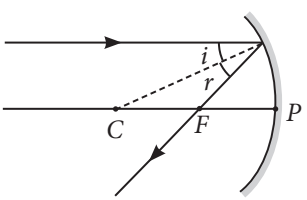
- Diminished
- Virtual and erect
- The image formed is closer to the mirror than the object placed
- Image is formed behind the mirror.

23.



24. *Refer to answer 16.*

25.

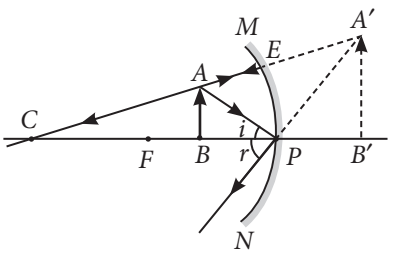


26. A concave mirror can produce a magnified image of an object when object is placed :

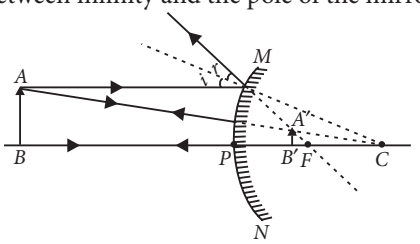
(1) In between its pole and its focus,

(2) In between its focus and its centre of curvature.
Difference between these two images :
The image produced in first case will be virtual and erect.
The image produced in second case will be real and inverted.

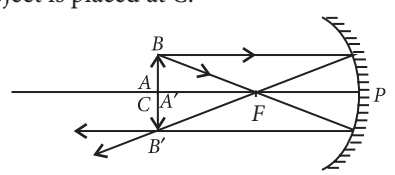
27. The position of the object should be between *P* and *F*



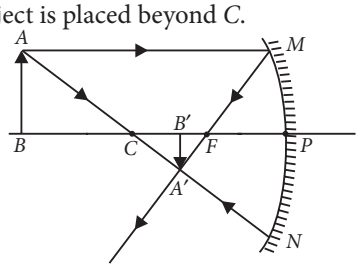
28. (i) Convex mirror
(ii) Between infinity and the pole of the mirror.



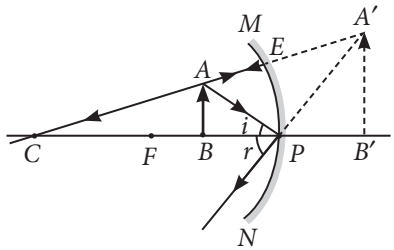
29. (i) Concave mirror because the image is real, inverted.
(ii) Object is placed at *C*.



30. (*i*) Concave mirror
(ii) Object is placed beyond *C*.



31. At least two rays are required for locating the image formed by a concave mirror for an object. Virtual image is formed when object is placed between pole and focus of concave mirror.



32. Given :
Object distance, $u = -30$ cm, image size, $h' = ?$
Image distance, $v = -60$ cm,
Object size , $h = 2.4$ cm,
Focal length, $f = ?$
Using mirror formula,

$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u} \quad \text{or} \quad \frac{1}{f}=\frac{-1-2}{60}=\frac{-3}{60}=-\frac{1}{20}$$

or $f = -20$ cm
Hence, focal length is 20 cm
Also, magnification, $m=\frac{h'}{h}=\frac{-v}{u}$

or, $m=-\frac{(-60)}{(-30)}=-2$ or $\frac{h'}{h}=-2$

$h' = -2 \times 2.4 = -4.8$ cm
As the image formed is real, therefore the mirror is concave.
The height of the image is 4.8 cm.
The image formed is enlarged and inverted.

33. Given : object distance, $u = -15$ cm,
object height, $h = 4$ cm, focal length, $f = -10$ cm;
Image distance, $v = ?$
Using mirror formula,

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

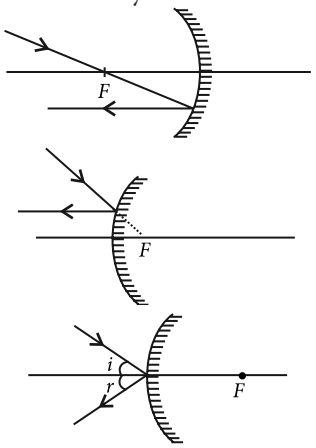
or $$\frac{1}{v}=\frac{10-15}{150}=\frac{-5}{150}=\frac{-1}{30} \text{ or } v = -30 \text{ cm}$$

In order to obtain a sharp image of the object on the screen, screen should be placed at a distance of 30 cm in front of the mirror.
Also, magnification, $m=\frac{h'}{h}=\frac{-v}{u}$

or $\frac{h'}{4}=-\frac{(-30)}{(-15)}$ or $h'=\frac{-(30)\times 4}{(15)}=-2\times 4$

or $h' = -8$ cm
Thus, the height of the image is 8 cm.

34. The path of the rays are shown below.

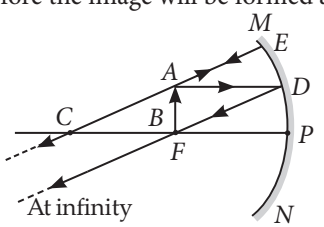


35. Since the image formed by the mirror is real and inverted, therefore the mirror is concave and magnification of the mirror will be

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

i.e., object and image both are formed at the centre of curvature, *i.e.*, 40 cm from the mirror.

Now, if the object is moved 20 cm towards the mirror, the object will be at the focus of the mirror and therefore the image will be formed at infinity.



36. Since the image formed is real and inverted, the mirror is concave.

$$\text{Magnification, } m = \frac{-v}{u} \Rightarrow -2 = \frac{-v}{u} \Rightarrow v = 2u$$

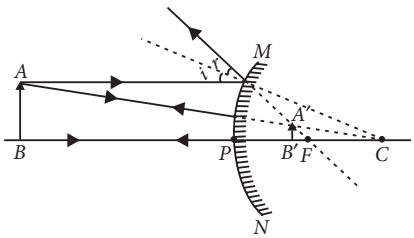
Now, if $v = -30$ cm then $u = -15$ cm

As focal length of the mirror is

$$f = \frac{uv}{u+v} = \frac{-15 \times -30}{-15-30} = f = \frac{450}{-45} = -10 \text{ cm}$$

If the object is shifted 10 cm the mirror, then the object is between principal focus and the optical centre and the image formed will be virtual and erect.

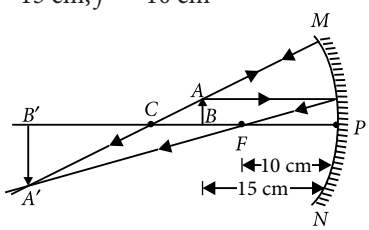
37. If the image formed is always virtual and diminished then the mirror used is convex.



Convex mirrors are widely used as rear view mirrors in cars, motorcycles etc. It produces an erect image that is smaller in size than the object hence giving a wide view.

38. We use two rays of light, one passing through the centre of curvature of a concave mirror, and another is parallel to the principal axis. After reflection, the ray passing through the centre of a concave mirror is reflected back along the same path and the ray parallel to the principal axis will pass through the principal focus.

$u = -15$ cm, $f = -10$ cm

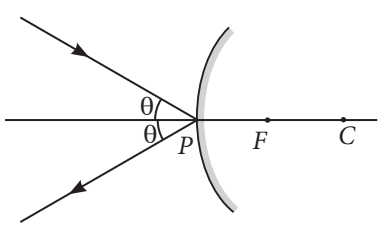


From ray diagram, $v = -30$ cm, *i.e.*, beyond *C*

Nature of image is real, inverted and magnified.

39. *Refer to answer 37.*

40. (a)



(b) *Refer to answer 23.*

(c) *Refer to answer 16.*

41. (a) Concave mirror

(b) Magnification, $m = -\frac{v}{u}$ or $-1 = \frac{-v}{(-50)}$

$\therefore$ Distance of the image from the object is, $v = -50$ cm

(c) As the image is formed at centre of curvature *i.e.*, $v = R$.

$\therefore$ focal length of the mirror, $f = \frac{-50}{2} = -25$ cm

(d) *Refer to answer 29 (ii).*

42. (i) This is a concave mirror.

(ii) The image is real and inverted and of same size.

(iii) As $m = -1$

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

Hence, object is located at centre of curvature *i.e.*, at distance of 40 cm from the pole of the mirror.

(iv) *Refer to answer 29(ii).*

43. (i) The mirror is concave mirror.

(ii) Distance the image from the object = – 30 cm

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

Here $m = -1$ and $v = -30$ cm

$$-1 = -\frac{(-30)}{u}$$

$\therefore$ $u = -30$ cm

As $v = u$, object is placed at centre of curvature.

Therefore, focal length of the mirror,

$$f = \frac{-30}{2} = -15 \text{ cm}$$

(iii) Image formed is real and inverted and of the same size of the object.

(iv) *Refer to answer 29 (ii).*

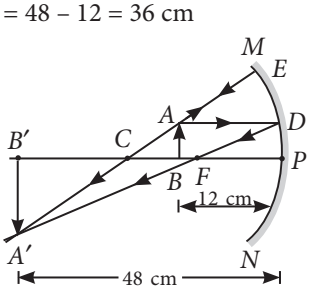
44. (a) Concave mirror

(b) Linear magnification,

$$m = \frac{-v}{u} = \frac{-(-48)}{-12} = -4$$

(c) The distance between the image and the object = 48 – 12 = 36 cm

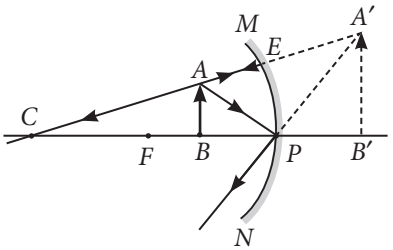
(d)



45. To obtain an erect image, the object is placed in between pole and the focus of the concave mirror. So range of distance of the candle flame from the mirror is in between 12 cm.

Nature of the image = Virtual and erect.

Size of the image = Enlarged



46. To obtain an erect image of an object, the object should be placed in between pole and focus. Range of distance of the candle flame from the mirror is in between 15 cm.

Nature of the image = Virtual and erect

Size of the image = Enlarged

For ray diagram, *refer to answer 45*.

47. Focal length of a concave mirror = 20 cm

Range will be in between 20 cm.

Nature of the image = Virtual and erect

Size of the image = Enlarged

For ray diagram, *refer to answer 45*.

48. (i) Convex mirror is used as rear view mirror because

(a) it gives erect image.

(b) it gives diminished image thus provides wider view of traffic behind the vehicle.

(ii) Concave mirror is used as shaving mirror because

(a) it gives erect image when mirror is close to the face.

(b) it gives enlarged image of the face so that a person can shave safely.

49. Given, focal length of concave mirror,

$f = -15$ cm

Object distance, $u = -20$ cm

Image distance, $v = ?$

Using mirror formula,

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

$$\text{or} \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15} - \frac{1}{-20} = \frac{-4+3}{60}$$

$$\frac{1}{v} = \frac{-1}{60} \quad \text{or} \quad v = -60 \text{ cm}$$

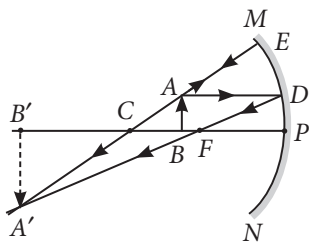
Using magnification formula,

$$m = -\frac{v}{u} = -\left(\frac{-60}{-20}\right) \quad \text{or} \quad m = -3$$

So, the magnification, $m = -3$.

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

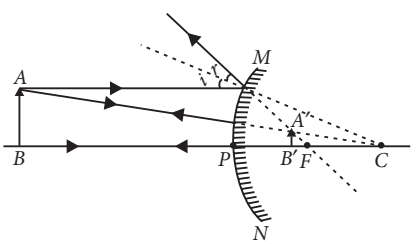
A ray passing through the centre of a curvature of a concave mirror or directed in the direction of the centre of curvature of a convex mirror, after reflection, is reflected back along the same path. The light rays come back along the same path because the incident rays fall on the mirror along the normal to the reflecting surface.



51. (i) Concave mirrors are used in headlights of cars to get powerful beams of light.

(ii) Convex mirrors are used as rear-view mirrors of vehicle to get a wider field of view and and erect image of traffic behind.

52.

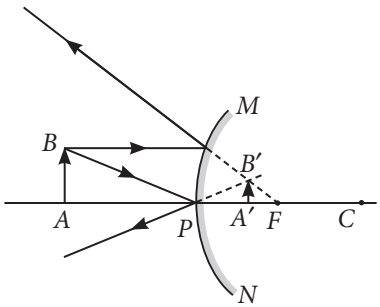


Position : Image is formed between pole and principal focus of the mirror.

Relative size : Image formed is diminished.

Nature : Image formed is virtual and erect.

53. Convex mirror is preferred for rear view mirrors in motor cars because no matter where the object is located infront of convex mirror, it always gives erect and diminished image of the object, so that driver is able to see the large traffic view in small area and the image is erect. This can be interpreted from the following diagram.



54. (a) Two lights rays whose path of reflection are priorly known are :

(i) When the incident ray passes through the centre of curvature of a concave mirror, it gets reflected in the same path.

(ii) When the ray is incident obliquely to the principal axis, towards the pole of mirror, it gets reflected back by making equal angles with the principal axis (laws of reflections).

Suppose an object is placed between focus and pole of the concave mirror. Then by using the above two rays, the image of the object can be located as

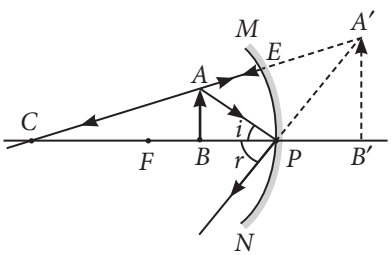


Image formed is virtual, erect, magnified and it is formed behind the mirror.

(b) Given : Magnification, $m = -3$

Object-distance, $u = -20$ cm

Magnification, $m = \frac{-v}{u}$ or $-3 = \frac{-v}{-20}$

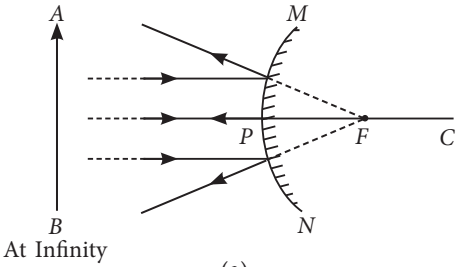
or $v = -60$ cm

The screen is placed in front of the mirror at a distance of 60 cm from the pole.

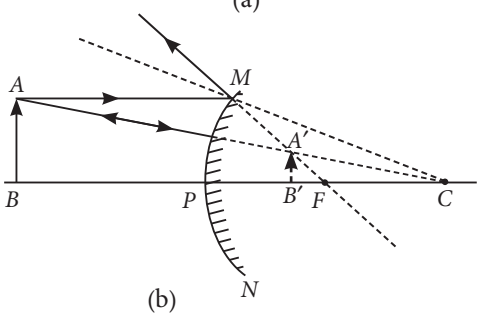
Thus, the screen is placed (= 60 cm – 20 cm) 40 cm away from the object.

55. (a) If the image formed by a mirror for all positions of the object placed in front of it is always diminished, erect and virtual then the mirror is convex mirror.

The ray diagrams for the formation of image by a convex mirror for the first position when the object is at infinity and the second position when the object is at a finite distance from the mirror is shown.



(a)



(b)

Uses of Convex Mirrors

Convex mirrors are commonly used as rear-view (wing) mirrors in vehicles because they always give an erect, though diminished, image. Also, they have a wider field of view as they are curved outwards. Thus, convex mirrors enable the driver to view a large area.

(b) Radius of Curvature : The radius of the sphere of which the reflecting surface of a spherical mirror forms a part, is called the radius of curvature of the mirror. It is represented by the letter *R*.

∵ The radius of curvature is equal to twice the focal length.

∴ $R = 2f$

If $R = +24$ cm ∴ $f = \frac{R}{2} = \frac{24}{2} = 12$ cm

Since the radius of curvature is positive. Then the mirror is convex mirror. Hence the nature of the image is virtual and erect.

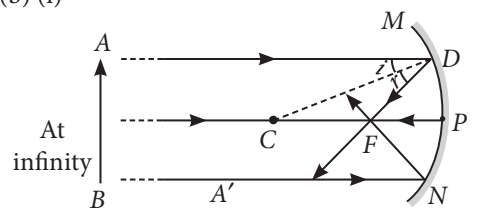
56. (a) (i) Pole : The centre of the reflecting surface of a spherical mirror is a point called the pole. It lies in the surface of the mirror and its represented by the letter *P*.

(ii) Centre of curvature : The reflecting surface of a spherical mirror is a part of a sphere which has a centre. This point is called the centre of curvature of spherical mirror and is represented by the letter *C*.

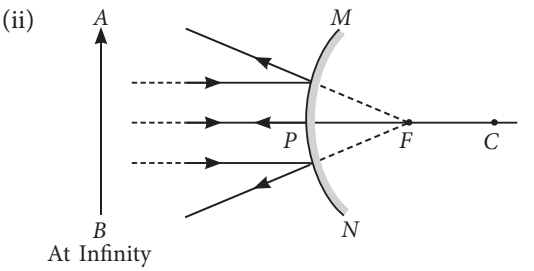
(iii) Principal axis : An imaginary line passing through the pole and the centre of curvature of a spherical mirror and normal to the mirror at its pole is called principal axis.

(iv) Principal focus : Incident rays parallel to principal axis, after reflection either converge to as appear to diverge from a fixed point on the principal axis known as principal focus of the spherical mirror.

(b) (i)



(ii)



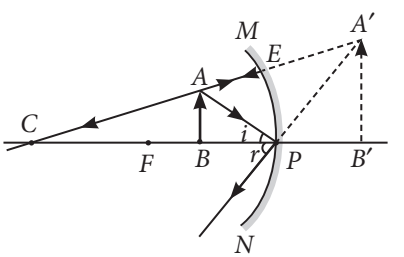
(c) The object is placed between focus and pole of the mirror and a magnified image is formed behind the mirror.

∴ The mirror is concave and image formed is virtual and erect.

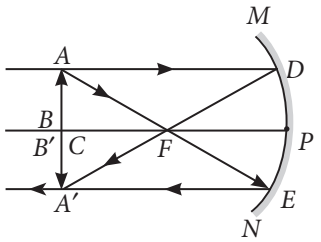
57. Given : focal length of the concave mirror $f = 12$ cm

(i) If the object is placed between the pole and focus of the concave mirror, then the image formed is virtual and erect. Therefore, the range of distance of the object should be $0 < u < 12$ cm.

(ii) The image formed will be enlarged as shown below.



(iii) If the object is placed 24 cm in front of the mirror *i.e.*, at the centre of the curvature then the image will also be formed at the centre of the curvature.



58. Given : $f_a = 10$ cm, $f_b = 15$ cm, $f_c = 20$ cm
$u_a = 10$ cm, $u_b = 20$ cm, $u_c = 30$ cm

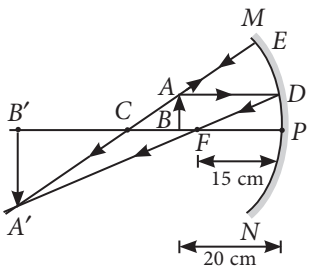
(a) Magnification of –1 implies that size of image is same as that of object or image is formed at the same distance as of the object. This is the case when the object distance, $u = 2f$, *i.e.*, when the object is at the centre of the curvature.

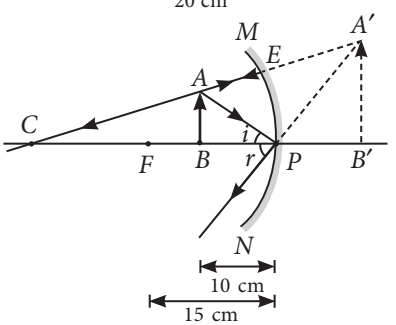
For f_a , u_b and for f_b, u_c , we get magnification – 1.

(b) Concave mirror forms virtual, erect and magnified image when the object is between focus and pole of the mirror, *i.e.*, direct distance should be less than the focal length of the mirror.

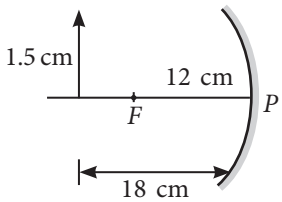
For object distance 10 cm, mirrors of focal length $f_b = 15$ cm and $f_c = 20$ cm can be used.

(c)





59. Given: focal length of the concave mirror,
$f = -12$ cm
Length of the flame, $h = 1.5$ cm
Distance of flame from the mirror, $u = -18$ cm



(a) As, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

or $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-12} - \frac{1}{-18} = \frac{-3+2}{36} = \frac{-1}{36}$

or $v = -36$ cm

(b) Let h' be the length of the image.

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

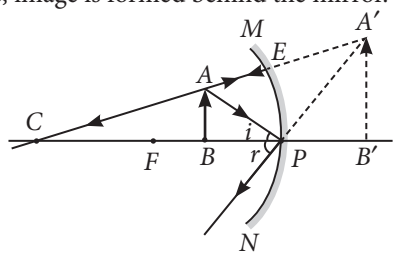
$\therefore \quad h' = \frac{-v \times h}{u} = \frac{-(-36) \times 1.5}{-18} = -3$ cm

If the distance between the mirror and the flame is reduced to 10 cm, then

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-12} - \frac{1}{-10} = \frac{1}{60}$

$\therefore \quad v = 60$ cm

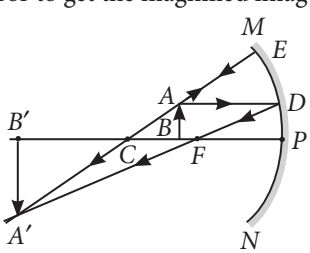
Hence, image is formed behind the mirror.



60. (a) He should use concave mirror to get image of candle flame on the walls of school laboratory. Because concave mirror is a converging mirror and produce real image.

(b) He should place the candle flame in between centre of curvature *C* and principal focus *F* of the mirror to get the magnified image on the wall.

(c)

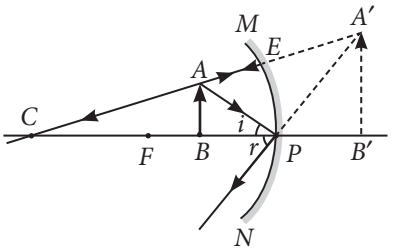


(d) Yes, he can use concave mirror to project a diminished image of the candle flame on the same wall. He has to place the candle flame beyond centre of curvature to get diminished image.

61. (a) *Refer to answer 56 (a) (i).*
(b) *Refer to answer 55 (b).*
(c) *Refer to answer 56 (a) (ii).*
(d) *Refer to answer 56 (a) (iv).*
If we want to get an erect image of a candle flame using concave mirror of focal length 20 cm, then we must place the object between a pole and focus of the mirror. If u is the image distance, then

$0 < u < 20$ cm

Other two characteristics of the observed image are
(i) Image is virtual and erect
(ii) Image is enlarged
The ray diagram for this situations can be drawn as follows:



62. Sign Convention for Reflection by Spherical Mirrors : While dealing with the reflection of light by spherical mirrors, we shall follow a set of sign conventions called the New Cartesian Sign Convention. The conventions are as follows:

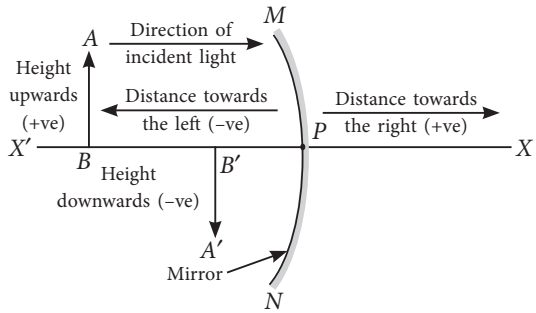
(i) The object is always placed to the left of the mirror. This implies that the light from the object falls on the mirror from the left-hand side.

(ii) All distances parallel to the principal axis are measured from the pole of the mirror.

(iii) All the distances measured to the right of the origin (along + x-axis) are taken as positive while those measured to the left of the origin (along – x-axis) are taken as negative.

(iv) Distances measured perpendicular to and above the principal axis (along + y-axis) are taken as positive.

(v) Distances measured perpendicular to and below the principal axis (along-y-axis) are taken as negative.



The New Cartesian Sign Convention for spherical mirrors

Given that : $m = -3$ (real image), $u = -16$ cm

Magnification, $m = \dfrac{-v}{u}$

$\therefore \quad -3 = \dfrac{-v}{-16}$ or $v = -48$ cm

Mirror formula : $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$

$\therefore \quad \dfrac{1}{(-48)} + \dfrac{1}{(-16)} = \dfrac{1}{f}$

or $\dfrac{-1-3}{48} = \dfrac{1}{f}$ or $\dfrac{-4}{48} = \dfrac{1}{f}$ or $f = -12$ cm

63. *Refer to answer 62.*

Given that $m = +\dfrac{1}{3}$ (virtual image), $u = -18$ cm

Magnification, $m = -\dfrac{v}{u}$

$\dfrac{1}{3} = \dfrac{-v}{-18} \quad \Rightarrow \quad v = 6$ cm

Mirror formula : $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$

$\dfrac{1}{6} - \dfrac{1}{18} = \dfrac{1}{f} \quad \Rightarrow \quad \dfrac{3-1}{18} = \dfrac{1}{f} \quad \Rightarrow f = 9$ cm

As the value of focal length is positive, the mirror used is convex mirror.

64. (i) *Refer to answer 51 (i).*
(ii) *Refer to answer 51 (ii).*
(iii) Concave mirrors are used in solar furnaces to concentrate sunlight to produce heat.

65. Power is the degree of convergence or divergence of light rays achieved by a lens.
It is defined as the reciprocal of its focal length.

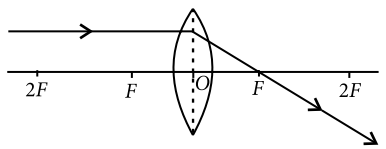
i.e., $P = \dfrac{1}{f}$

66. A ray of light should be incident perpendicular to the surface of the rectangular glass slab so that it comes out from the opposite side of the slab without being displaced.

67. The girl playing with a thin beam of light from her laser torch must incident the laser beam of light through optical centre of the convex lens.
A ray of light though the optical centre of a lens passes without suffering any deviation.

68. A ray of light bends when it travels from one medium into another because of the change in speed of light from one medium to another.

69.



An incident light coming parallel to the principal axis after refraction through convex lens passes through focus.

70. The refractive index of diamond is 2.42. This means the ratio of speed of light in vacuum to the speed of light in diamond is 2.42.

71. Given : Object distance, $u = -15$ cm
Focal length, $f = +20$ cm
Using lens formula, As $|u| < |f|$
The object is placed between F and optical centre of lens.
Thus, the four characteristics of the image formed by the convex lens are :
(i) Erect, (ii) Virtual, (iii) Enlarged image, (iv) Image is formed on the same side of the lens as the object.

72. *Refer to answer 65.*
Positive sign (+) of power indicates that lens is convex and negative sign (–) of power indicates that lens is concave.
If focal length (f) is expressed in metres, then, power is expressed in dioptres. The SI unit of power is dioptre. Thus, 1 dioptre is the power of lens whose focal length is 1 metre. 1 D = 1m^{-1}

73. Given : $_an_g = \frac{3}{2}$, $_an_w = \frac{4}{3}$

Speed of light in glass, $v = 2 \times 10^8$ m/s

We know, $_an_g = \dfrac{\text{speed of light in air}}{\text{speed of light in medium}}$

$$\Rightarrow \frac{3}{2} = \frac{c}{2\times10^8} \Rightarrow c = 3\times10^8 \text{ m/s}$$

$$\text{Now, } {}_an_w = \frac{\text{speed of light in air}}{\text{speed of light in water}}$$

$$\Rightarrow \frac{4}{3} = \frac{3\times10^8}{v}$$

$$\Rightarrow v = \frac{9}{4}\times10^8 \text{ m/s} = 2.25\times10^8 \text{ m/s}$$

74. Given that : $n_g = \frac{4}{3}$, $n_w = \frac{3}{2}$, $v_g = 2\times10^8$ m/s

Absolute refractive index of a medium, $n_m = \frac{c}{v}$
where, c is the speed of light in vacuum and v is the speed of light in medium.

(i) $\therefore\ n_g = \frac{c}{v_g}$

or $c = n_g \times v_g = \frac{4}{3}\times2\times10^8 = \frac{8}{3}\times10^8$ m/s

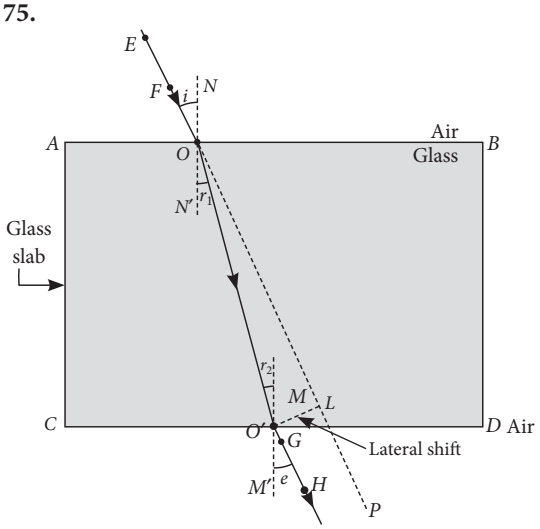
(ii) As, $n_{gw} = \frac{n_g}{n_w} = \frac{v_w}{v_g}$

$$\therefore \frac{4/3}{3/2} = \frac{v_w}{2\times10^8} \text{ or } v_w = \frac{8}{9}\times2\times10^8$$

$$\Rightarrow v_w = \frac{16}{9}\times10^8 \text{ m/s}$$

Note : The values given in question are not correct as the speed of light in vacuum is 3×10^8 m/s

75.



76. Given : refractive index of glass, $n_g = 1.5$
Refractive index of water, $n_w = 1.33$
Since, refractive index of medium,

$$n = \frac{\text{speed of light in air } (c)}{\text{speed of light in medium } (v)}$$

For glass, $n_g = \frac{c}{v_g}$ ... (i)

For water, $n_w = \frac{c}{v_w}$ ... (ii)

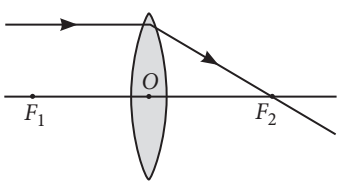
Since velocity of light in medium is inversely proportional to its refractive index, the light will travel faster in optically rarer medium *i.e.*, water.
Dividing (i) by (ii),

$$\frac{n_g}{n_w} = \frac{v_w}{v_g} \quad \text{or} \quad \frac{v_g}{v_w} = \frac{n_w}{n_g}$$

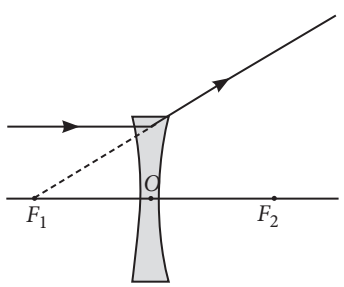
$$\frac{v_g}{v_w} = \frac{1.33}{1.5}$$

So, the ratio of v_g and v_w is 1.33 : 1.5.

77. The two rays are :
(i) A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of the lens and in case of concave lens, a ray appears to diverge from the principal focus located on the same side of the lens.

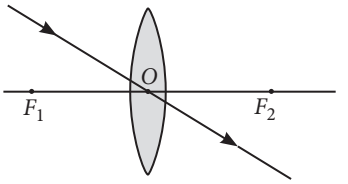


(a)

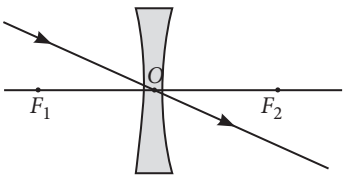


(b)

(ii) A ray of light passing through the optical centre of a lens will emerge without any deviation.

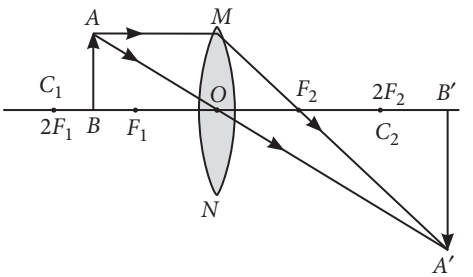


(a)



(b)

When object is placed between F and $2F$.



78. Refractive index of water, $n_w = 1.33$
Speed of light in air, $c = 3 \times 10^8$ m/s
As we know that refractive index of medium,

$$n_m = \frac{\text{speed of light in air}}{\text{speed of light in medium}} = \frac{c}{v_m}$$

Here, our medium is water.

So, $n_w = \frac{c}{v_w}$

where, v_w is the speed of light in water.

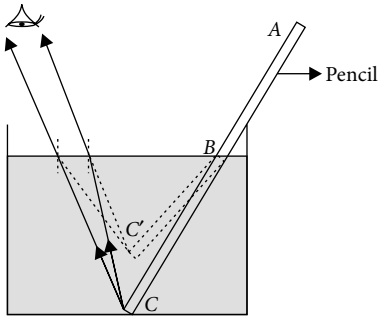
$$\therefore \quad 1.33 = \frac{3 \times 10^8}{v_w} \text{ m/s}$$

$$\therefore \quad v_w = \frac{3 \times 10^8}{1.33} \text{ m/s} = 2.25 \times 10^8 \text{ m/s}$$

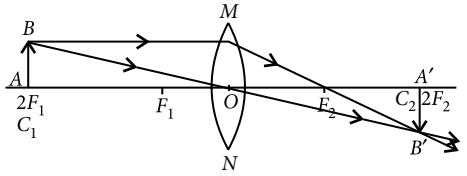
$\therefore$ Speed of light in water is 2.25×10^8 m/s.

79. This phenomenon is due to refraction of light at the interface of two media. Light rays coming from the immersed end C of the pencil bend away from the normal at the interface on reaching there as the rays are travelling from optically denser to a rarer medium. As shown in the diagram, when viewed from above, they appear to come from the

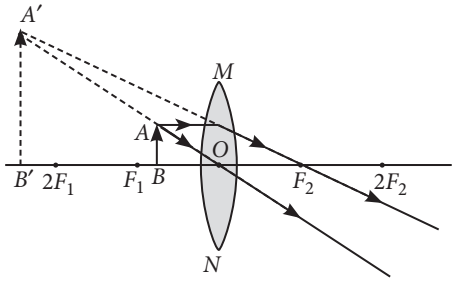
point C′, slightly raised. This way, all the rays from the immersed portion of the pencil bend and as a result it appears to be raised. Hence the pencil appears to be bend at the interface.



80. (a) Ray diagrams of an object placed at $2F_1$ infront of convex lens can be drawn as follows:

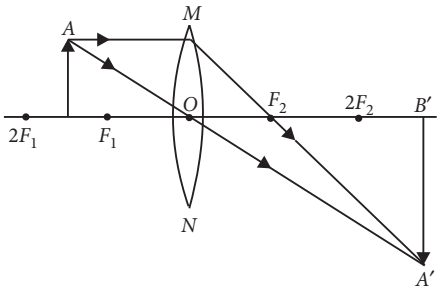


(i) Thus image formed is real and inverted.
(ii) Image is formed at $2F_2$.
(iii) Image formed is of same size as that of the object.
(b) Ray diagrams of an object placed between F_1 and optical centre O of lens can be drawn as follows:



(i) The image formed is virtual and erect.
(ii) Image is formed infront of the lens.
(iii) Image formed is enlarged.

81. (a)



(b) *Refer to answer 80 (b).*

82. (a) *Refer to answer 75.*

(b) Refractive index of glass w.r.t air is

$$_gn_a = \frac{3}{2}$$

Now, refractive index of air w.r.t glass will be

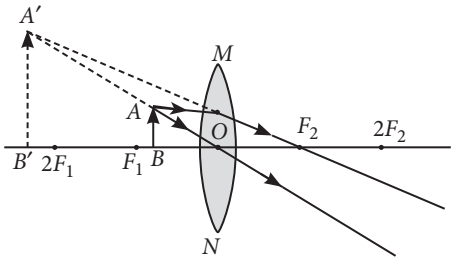
$$_an_g = \frac{1}{_gn_a} = \frac{1}{(3/2)} = \frac{2}{3}$$

83. Magnification of –1 indicates that the image is real and inverted and is of the same size as of the object. The object must be at $2f$ and image also at $2f$ on the other side.

Total distance between image and object

Also $4f = 60$ cm $\Rightarrow$ $f = 15$ cm

If object is moved 20 cm towards the lens, then the object will be between focus and optical centre of the lens and image formed will be virtual and erect and on the same side of the lens.



84. (a) Distance between the optical centre and the focus of the lens is known as the focal length of the lens.

(b) Given : $f = -30$ cm, $v = -15$ cm, $h = 5$ cm

From the lens formula,

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

$$\Rightarrow \quad \frac{-1}{u} = \frac{-1}{30} + \frac{1}{15} = \frac{-1+2}{30} = \frac{1}{30} \Rightarrow u = -30 \text{ cm}$$

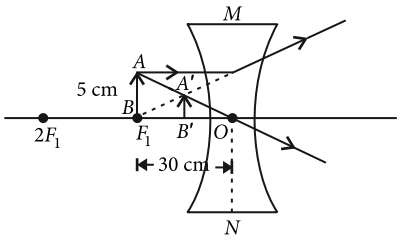
Object should be placed 30 cm from the optical centre.

$$\text{Also} \quad m = \frac{h'}{h} = \frac{v}{u} \Rightarrow h' = h\left(\frac{v}{u}\right)$$

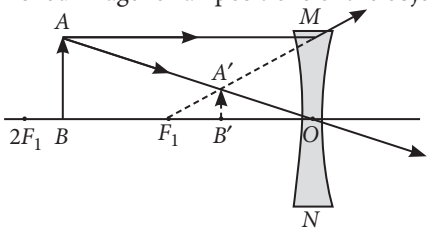
$$\text{or} \quad h' = 5 \times \frac{-15}{-30} = 2.5 \text{ cm}$$

Size of image formed is 2.5 cm

(c)



85. Concave lens always forms virtual, erect and diminished image for all positions of the object.



Focal length of the concave lens,

$$f = -20 \text{ cm} = \frac{-20}{100} \text{ m}$$

$$\text{Power of the lens, } P = \frac{1}{f(\text{in m})} = \frac{-100}{20 \text{ m}} = -5\text{D}$$

86. The following are the laws of refraction of light

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

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

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

where i is the angle of incidence and r is the angle of refraction.

The speed of light in vacuum = 3×10^8 m/s

The speed of light in a medium = 1.4×10^8 m/s

$\therefore$ Absolute refractive index

$$= \frac{\text{Speed of light in vacuum}}{\text{Speed of light in a medium}}$$

$$n = \frac{3 \times 10^8 \text{ m/s}}{1.4 \times 10^8 \text{ m/s}} = 2.14$$

87. *Refer to answer 86.*

The speed of light in vacuum = 3×10^8 m/s

Absolute refractive index = 1.5

$\therefore$ The speed of light in a medium

$$= \frac{\text{Speed of light in vacuum}}{\text{Absolute refractive index}} = \frac{3 \times 10^8 \text{ m/s}}{1.5}$$

$$= 2 \times 10^8 \text{ m/s}$$

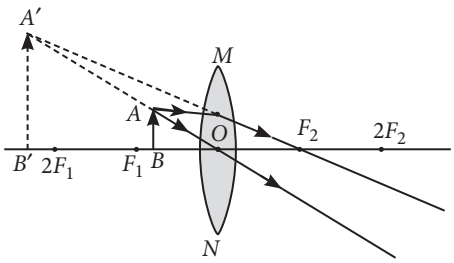
88. Given : $u = -40$ cm, $v = 40$ cm

$$\frac{1}{f} = \frac{1}{40} + \frac{1}{40} = \frac{2}{40} \quad \Rightarrow \quad f = 20 \text{ cm}$$

Type of lens : Convex lens

Focal length = 20 cm

Nature of the image will be virtual and erect if the candle flame is shifted 25 cm towards the lens.



89. Focal length of given concave lens, $f = -5$ cm

Distance, $u = -10$ cm, object size, $h = 6$ cm

Image distance, v = ?

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

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{-5} + \frac{1}{-10} = \frac{-3}{10}$$

$$v = -\frac{10}{3} = -3.33 \text{ cm}$$

So, the image is located 3.33 cm from the lens.

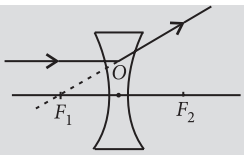
Magnification (m) of lens is given by

$$m = \frac{v}{u} = \frac{-\frac{10}{3}}{-10} = \frac{1}{3} = 0.33$$

m is positive implies that image is virtual and erect. Also, magnitude of m is less than one implies that image is diminished.

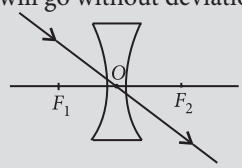
Since, $m = \frac{v}{u} = \frac{h'}{h} \quad \Rightarrow \quad \frac{10/3}{10} = \frac{h'}{6}$ or $h' = 2$ cm

90. (i) A ray of light incident on a concave lens is parallel to its principal axis, the diagram can be drawn as follows :

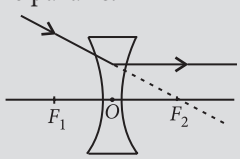


The refracted ray appears to pass through focus on the same side of the lens.

(ii) If a ray of light incident on a concave lens is passing through its optical centre then the refracted ray will go without deviation.



(iii) If a ray of light incident on a concave lens is directed towards its principal axis then it will go parallel to principal axis.

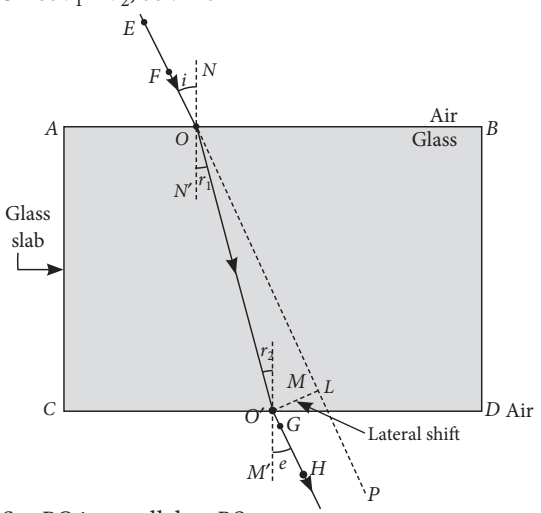


91. Principle of reversibility of light states that the light will follow exactly the same path if the direction is reversed.

Using Snell's law of refraction,

$$\frac{\sin i}{\sin r_1} = \frac{\sin e}{\sin r_2}$$

Since $r_1 = r_2$, so $i = e$



So, PQ is parallel to RS.

So, we conclude that incident ray is parallel to the emergent ray.

92. When a ray of light is incident obliquely on a parallel sided glass slab, the emergent ray shifts laterally. The perpendicular distance between the direction of the incident ray and emergent ray is called lateral shift.

The factors on which the lateral displacement depends are:

(i) thickness of the refracting material.

(ii) the refractive index of the material.

Figure : *Refer to answer 75.*

93. Focal length of convex lens, $f = +18$ cm

Image distance from the lens, $v = +24$ cm

By using lens formula,

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

$$\therefore \quad \frac{1}{u} = \frac{1}{+24} - \frac{1}{18} = \frac{3-4}{72} = \frac{-1}{72}$$

$\therefore \quad u = -72$ cm

Magnification, $m = \dfrac{v}{u} = \dfrac{24}{-72} = \dfrac{-1}{3}$

94. Since the image can be obtained on a screen so image is real and real image is formed by convex lens so the lens in convex lens.

Given,

Object distance, $u = -60$ cm

Image distance, $v = +120$ cm

Using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \text{(here } f \text{ is the focal length of the lens)}$$

$$= \frac{1}{120} - \frac{1}{-60} = \frac{1+2}{120} = \frac{3}{120}$$

$$\frac{1}{f} = \frac{1}{40}$$

$\therefore \quad f = 40$ cm

So, the focal length of the lens is 40 cm

Now, height of object, $h = 5$ cm

Height of image, $h' = ?$

$$\text{Since, } m = \frac{v}{u} = \frac{h'}{h}$$

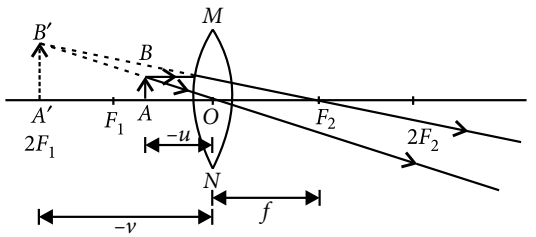
$$\text{So, } \frac{120}{-60} = \frac{h'}{5}$$

$h' = -2 \times 5$

$h' = -10$ cm

So, the image height is 10 cm.

95. When an object is placed between F_1 and optical centre, O of a convex lens, it forms a virtual and erect image. The ray diagram for this situation can be drawn as follows:



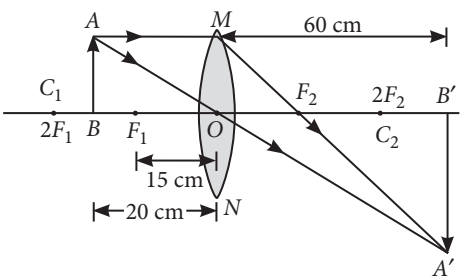
96. (a) When an object placed at the 2F from a convex lens, then its image is formed on the other side of the lens at the same distance from the lens. Thus from S.No.(3) we can say that.

$$\therefore \quad f = v/2 \Rightarrow f = \frac{30}{2} = +15 \text{ cm}$$

Thus, the focal length is + 15 cm.

(b) In this case S.No. (6) is incorrect as the object distance is between focus and pole, for such case, the image formed is virtual and on the same side as the object, hence image distance is negative.

(c) The approximate value of magnification for object distance –20 cm and image distance + 60 cm is –3.

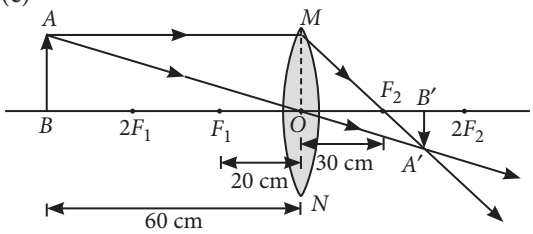


97. (a) When an object is placed at 2F from the convex lens, then its image is formed on the other side of the lens at the same distance from the lens. Thus from S.No. (3), we can say that

$$\therefore \quad f = \frac{v}{2} = \frac{40}{2} = 20 \text{ cm}$$

(b) In this case, S.No. (6) is incorrect as the object distance is between focus and optical centre for such cases, the image formed is virtual and image distance is negative.

(c)



The approximate value of magnification for object distance –60 cm and image distance +30 cm is –1/2.

98. (a) *Refer to answer 95.*

(b) The lens formula is given as

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

(c) Magnification of the lens is given by

$$m = \frac{v}{u} \quad \Rightarrow \quad -1 = \frac{v}{-20} \qquad [\because \ u = -20 \text{ cm}]$$

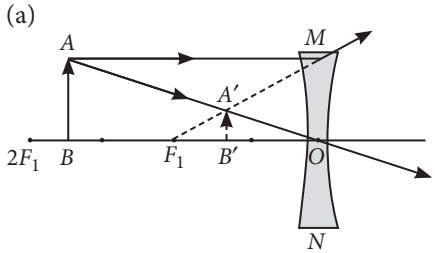
$\therefore \quad v = 20$ cm

As $v = u$ then

$$\therefore \quad f = \frac{20}{2} \text{ cm} = 10 \text{ cm} = 0.1 \text{ m}$$

$$\text{Power of the lens, } P = \frac{1}{f(\text{in m})} \text{D} = \frac{1}{0.1} \text{D} = 10 \text{ D}$$

99. (a)



(b) The lens formula is given by

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

(c) Since, the nature of the image is real and inverted therefore the lens is convex.

Now magnification of the lens is

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

Now, from lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \Rightarrow \frac{1}{40} - \frac{1}{(-40)} = \frac{1}{f}$$

$$\Rightarrow \quad f = 20 \text{ cm} \quad \Rightarrow \quad f = 0.2 \text{ m}$$

$$\text{Power of the lens, } P = \frac{1}{f(\text{in m})} = \frac{1}{0.2 \text{ m}} = 5 \text{ D}$$

100. (a) Optical centre is the central part of the lens through which a ray of light passes without suffering any deviation. It is usually represented by the letter *O*.

(b) Given : $f = -20$ cm, $h = 4$ cm, $v = -10$ cm

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

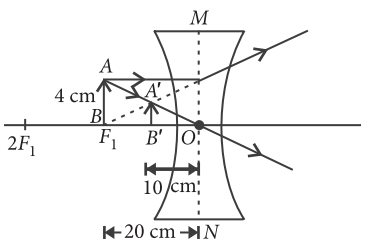
$$\frac{1}{-10} - \frac{1}{u} = \frac{1}{(-20)}$$

$$\Rightarrow \quad \frac{1}{u} = \frac{-1}{10} + \frac{1}{20} \quad \Rightarrow \quad u = -20 \text{ cm}$$

Also, magnification of the lens,

$$m = \frac{h'}{h} = \frac{v}{u} \quad \Rightarrow \quad h' = \frac{10}{20} \times 4 \Rightarrow h' = 2 \text{ cm}$$

(c)



101. (a) Distance between the principal focus and the optical centre is known as the focal length of the lens.

(b) Given, $f = -30$ cm, $v = -15$ cm, $h = 6$ cm

Now, from lens formula,

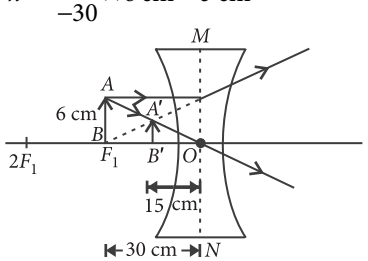
$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \Rightarrow \quad \frac{-1}{30} = \frac{-1}{15} - \frac{1}{u}$$

$$\frac{1}{u} = \frac{-1}{15} + \frac{1}{30} \Rightarrow u = -30 \text{ cm}$$

$$m = \frac{h'}{h} = \frac{v}{u} \quad \Rightarrow \quad h' = \left(\frac{v}{u}\right)h$$

$$\Rightarrow \quad h' = \frac{-15}{-30} \times 6 \text{ cm} = 3 \text{ cm}$$

(c)



102. Focal length of concave lens, $f = -20$ cm

Height of the object, $h = 6$ cm

Image distance, $v = -15$ cm

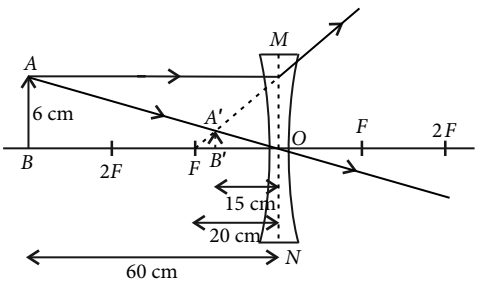
From lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-15} - \frac{1}{u} = \frac{1}{-20}$$

$$\Rightarrow \quad -\frac{1}{u} = -\frac{1}{20} + \frac{1}{15} = \frac{1}{60} \quad \Rightarrow \quad u = -60 \text{ cm}$$

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

$$\Rightarrow \quad h' = h\left(\frac{v}{u}\right) = 6 \times \left(\frac{-15}{-60}\right) = \frac{3}{2} \text{ cm} \Rightarrow h' = 1.5 \text{ cm}$$



103. Focal length of concave lens , $f = -25$ cm

Image distance, $v = -20$ cm

Height of the object, $h = 10$ cm

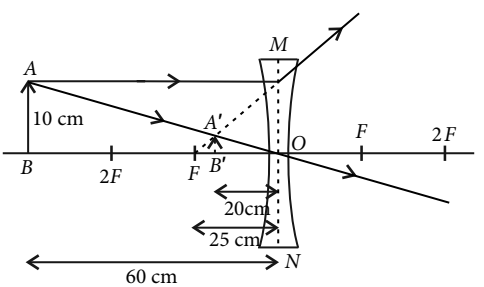
Now, from lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow -\frac{1}{20} - \frac{1}{u} = -\frac{1}{25} \quad \Rightarrow \quad -\frac{1}{u} = -\frac{1}{25} + \frac{1}{20}$$

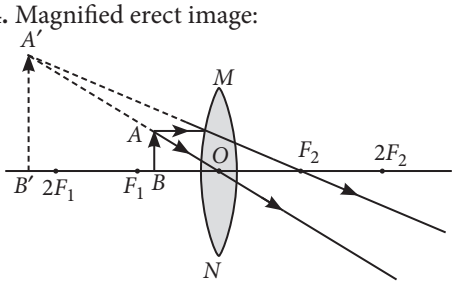
$$= -\frac{1}{u} = \frac{-4+5}{100} \quad \Rightarrow \quad u = -100 \text{ cm}$$

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

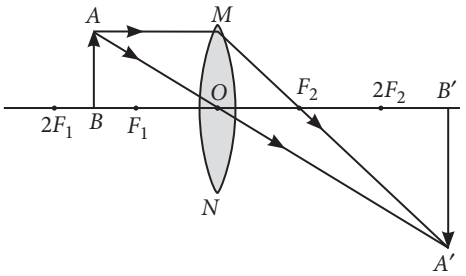
$$\Rightarrow \quad h' = h\left(\frac{v}{u}\right) = 10\left(\frac{-20}{-100}\right) = 2 \text{ cm}$$



104. Magnified erect image:



Magnified inverted image :



Given that $h = 4$ cm, $u = -20$ cm, $f = -10$ cm

Lens formula :

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

$$\text{or } \frac{1}{v}=\frac{-1}{10}-\frac{1}{20}=\frac{-2-1}{20}=\frac{-3}{20} \text{ or } v=\frac{-20}{3}\text{ cm}$$

105. Given that $u = -30$ cm, $v = 60$ cm, $h = 3$ cm

Lens Formula :

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \quad \therefore \quad \frac{1}{60}-\frac{1}{(-30)}=\frac{1}{f}$$

$$\Rightarrow \quad \frac{1+2}{60}=\frac{1}{f}=\frac{3}{60}=\frac{1}{20} \quad \text{or} \quad f = 20 \text{ cm}$$

As focal length is positive, hence lens is convex lens.

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

$$\therefore \quad \frac{60}{-30}=\frac{h'}{3} \text{ or } h'=\frac{-60\times 3}{30}=-6 \text{ cm}$$

$\Rightarrow$ The height of image is 6 cm and negative sign shows that the image is real and inverted.

106. (a) Laws of refraction of light :

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

(ii) The ratio of sine of angle of incidence to the sine of the angle of refraction is constant, for the light of a given colour and for the given pair of media.

This law is also known as Snell's law of refraction.

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

where i is the angle of incidence and r is the angle of refraction.

This constant value is called refractive index of the second medium with respect to the first.

$$\Rightarrow \quad \text{constant} = n_{21}=\frac{v_1}{v_2} \quad \therefore \quad \frac{\sin i}{\sin r}=\frac{v_1}{v_2}$$

If n is the absolute refractive index of the medium, c is the velocity of light in vacuum and v is the speed of light in given medium, then $n = c/v$.

(b) Given that $n_A = 2.0$, $n_B = 1.5$, $v_B = 2 \times 10^8$ m/s

(i) $n_B=\frac{c}{v_B}$, where c is the speed of light in vacuum

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

(ii) $n_{AB}=\frac{n_A}{n_B}=\frac{v_B}{v_A}$

$$\therefore \quad \frac{2.0}{1.5}=\frac{2\times 10^8}{v_A} \quad \text{or} \quad v_A=1.5\times 10^8 \text{ m/s}$$

107. *Refer to answer 72.*

Given that :

Focal length of lens A, $f_A = +10$ cm

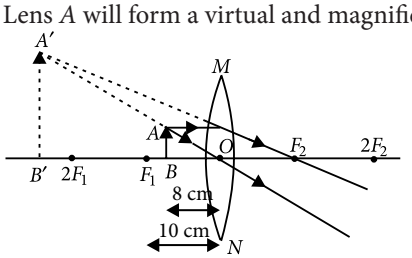
Focal length of lens B, $f_B = -10$ cm

Lens A is convex lens . Lens B is concave lens,

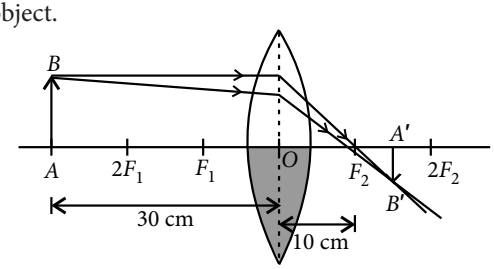
$$\text{Power of lens } A = \frac{100}{f_A(\text{in cm})}=\frac{100}{10}=+10 \text{ D}$$

$$\text{Power of lens } B=\frac{100}{f_B(\text{in cm})}=\frac{100}{-10}=-10 \text{ D}$$

Lens A will form a virtual and magnified image.



108. Yes, the lens will produce an image of complete object.



Given that $h = 4$ cm, $f = 20$ cm, $u = -15$ cm

$$\text{Lens formula : } \frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$\therefore \quad \frac{1}{v}-\frac{1}{(-15)}=\frac{1}{20}$ or $\frac{1}{v}=\frac{1}{20}-\frac{1}{15}=\frac{-1}{60}$

$\Rightarrow \quad v = -60$ cm

$$\text{Magnification, } m=\frac{v}{u}=\frac{-60}{-15}=4$$

Nature of image: Virtual, erect and enlarged

Position of image : In front of lens 60 cm from the lens

Size of image : Four times of object, *i.e.*,

(4×4) cm = 16 cm

109. *Refer to answer 72.*

Convex lens has positive power. Since the image of an object formed by a lens is real, inverted and of the same size as the object.

Given: Size of object = Size of image and $h' = -h$

$\therefore$ Magnification, $m = \frac{h'}{h}=\frac{-h}{h}=-1$

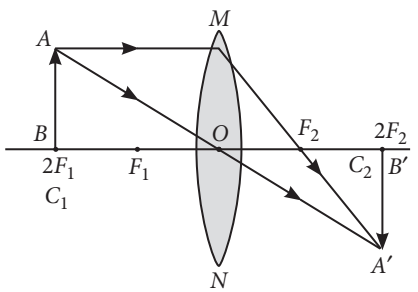
$\therefore \quad -1=\frac{v}{u}$ or $v = -u$

Focal length of the lens,

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u} \Rightarrow \frac{1}{f}=\frac{1}{40}-\frac{1}{-40}=\frac{2}{40}$$

$$\therefore \quad f = 20\,\text{cm} = \frac{20}{100}\ \text{m}$$

$$\text{Power of the lens, } P = \frac{1}{f\,(\text{in m})}=\frac{100}{20}\ \text{D} = 5\ \text{D}$$



110. (a) (i) Optical centre : The centre point of a lens is known as the optical centre. It always lies inside the lens. A light beam passing through the optical centre without any deviation.

(ii) Centre of curvature : It is defined as the centre of the sphere of which the lens is originally a part of. Because the spherical lens consists of two spherical surfaces, the lens has two centre of curvature.

(iii) Principal axis : A straight line passing through the optical centre and principal focus of a spherical lens. This line is called the principal axis.

(iv) Aperture : The diameter of the reflecting surface of spherical lens is called its aperture.

(v) Principal focus : A number of rays parallel to the principal axis are falling on a lens.

These rays, after refraction from the lens, are appearing to converge to or diverge from a point on the principal axis. This point on the principal axis is called the principal focus of the lens.

(vi) Focal length : The distance between the optical centre and the principal focus of a spherical lens is called the focal length. It is represented by the letter *f*.

(b) Given $f = 12$ cm, $v = 48$ cm, $u = ?$

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

$$\frac{1}{12}=\frac{1}{u}+\frac{1}{48} \quad \text{or} \quad \frac{1}{12}-\frac{1}{48}=\frac{1}{u}$$

$$\Rightarrow \quad \frac{4-1}{48}=\frac{1}{u}=\frac{3}{48} \quad \text{or} \quad u = 16\ \text{cm}$$

111. *Refer to answer 110.*

Given, $f = -20$ cm, $v = -15$ cm, $h = 6$ cm

Lens formula : $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$

$$\frac{1}{u}=\frac{1}{v}-\frac{1}{f}=\frac{-1}{15}+\frac{1}{20}$$

$$\frac{1}{u}=\frac{-4+3}{60}=\frac{-1}{60} \quad \text{or} \quad u = -60\ \text{cm}$$

$$\text{Size of image} = h'=\frac{hv}{u}=6\times\frac{15}{60}=1.5\ \text{cm}$$

112. *Refer to answer 72.*

A convex lens has the focal length +50 cm.

$$\therefore \quad \text{power} = \frac{1}{f}=\frac{+100}{50}=+2\ \text{D}$$

A concave lens has the focal length –50 cm.

$$\therefore \quad \text{power} = \frac{1}{f}=\frac{-100}{50}=-2\ \text{D}$$

Concave lens always gives a virtual, erect and diminished image irrespective of the position of the object.

113. (a) *Refer to answer 106.*

(b) *Refer to answer 73.*

114. Given that $u = -45$ cm, $v = +90$ cm, $h = 2$ cm (as the image is formed on the screen, the image is real and hence image is formed by convex lens on the other side of the lens).

Type of the lens used : Convex lens

Lens formula : $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$\therefore \quad \frac{1}{90}-\frac{1}{(-45)}=\frac{1}{f}=\frac{3}{90} \quad$ or $\quad f=30$ cm

Focal length, $f = 30$ cm

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

$\therefore \quad \frac{h'}{2}=\frac{90}{-45} \quad$ or $\quad h'=-4$ cm

$\Rightarrow$ height of image = 4 cm (inverted)

115. *Refer to answer 106 and 73.*

116. Given that : $u = -16$ cm, $f = 24$ cm, $h = 4$ cm

Lens formula : $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$\therefore \quad \frac{1}{v}-\frac{1}{(-16)}=\frac{1}{24}$

or $\quad \frac{1}{v}=\frac{1}{24}-\frac{1}{16}=\frac{2-3}{48}=\frac{-1}{48} \quad$ or $\quad v = -48$ cm

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

$\therefore \quad \frac{h'}{4}=\frac{-48}{-16} \quad$ or $\quad h'=12$ cm

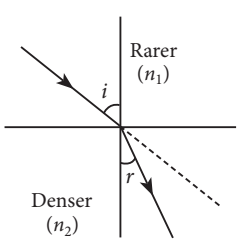
Nature of image : virtual and erect, enlarged

117. (a) When travelling obliquely from one medium to another, the direction of propagation of light in the second medium changes. This phenomenon is known as refraction of light.

The ratio of sine of angle of incidence to the sine of the angle of refraction is constant, for the light of a given colour and for the given pair of media.

This law is also known as Snell's law of refraction.

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



where i is the angle of incidence and r is the angle of refraction.

Given that : $n_{ag} = 2/3$, $n_{wa} = 4/3$, $v_g = 2 \times 10^8$ m/s

(a) $n_{ga}=\frac{c}{v_g}$, where c is the speed of light in vacuum.

$\therefore \quad n_{ag}=\frac{v_g}{c}$

$\Rightarrow \quad \frac{2}{3}=\frac{2\times10^8}{c} \quad$ or $\quad c=3\times10^8$ m/s

Speed of light in vacuum is 3×10^8 m/s.

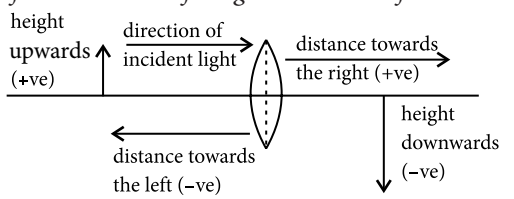
(b) $n_{wa}=\frac{c}{v_w}$

$\therefore \quad v_w=\frac{c}{n_{wa}}=\frac{3\times10^8}{4/3}=2.25\times10^8$ m/s

Speed of light in water is 2.25×10^8 m/s.

118. For lenses, we follow sign convention, similar to one used for spherical mirrors. We apply the rules for signs of distances, except that all measurements are taken from the optical centre of the lens.

Refer to answer 62 for sign convention of mirror.



$u = -16$ cm, $m = -3$ (real)

As, $m=\frac{v}{u} \qquad \therefore \quad -3=\frac{v}{-16} \quad$ or $\quad v = 48$ cm

Lens formula : $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$\therefore \quad \frac{1}{48}-\frac{1}{-16}=\frac{1}{f} \quad$ or $\quad \frac{1+3}{48}=\frac{1}{f} \Rightarrow \frac{1}{f}=\frac{1}{12}$

or $f = 12$ cm

Spherical lens is convex lens or converging lens of focal length 12 cm.

119. (a) *Refer to answer 72.*

(b) *Refer to answer 72.*

(c) Power of convex lens of focal length 25 cm is

$$P_1 = \frac{100}{25 \text{ (in m)}} = 4 \text{ D}$$

Power of concave lens of focal length 10 cm is

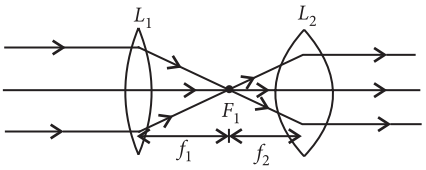
$$P_2 = \frac{100}{-10 \text{ (in m)}} = -10 \text{ D}$$

$\therefore$ Power of the combination = $P = P_1 + P_2$

$\therefore P = 4 - 10 = -6$ D

120. (a) If the refractive index of glass lens is equal to the refractive index of liquid then of the glass lens is placed in a transparent liquid will become invisible.

(b) Suppose we have two converging lens of focal lengths f_1 and f_2. We will keep the two converging lens at a distance of $f_1 + f_2$ so that a parallel beam of light entering one lens emerges as a parallel beam after passing through the second lens.



Here the focus of the two lenses should coincide.

(c) (i) Focal length of concave lens, $f = -12$ cm

Object distance, $u = -3$ cm

Image distance, $v = ?$

Using lens formula,

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

$$\frac{1}{v} = \frac{1}{-12} + \frac{1}{-3} = \frac{-1}{12} - \frac{1}{3} \quad \Rightarrow \quad \frac{1}{v} = \frac{-1-4}{12} = \frac{-5}{12}$$

So, $v = \frac{12}{-5} = -2.4$ cm

So, the image is formed at 2.4 cm from the concave lens.

(ii) Using magnification formula,

$$m = \frac{v}{u} = \frac{-2.4}{-3} = +0.8$$

Since m is +ve and magnitude of m is less than 1, so the image formed is virtual and diminished.