Ray optics-CBSE

1 Mark Questions

1. Define the power of a lens. Write its SI unit.
2. Why does sun appear red at sunrise and sunset?
3. Why does bluish colour predominate in a clear sky?
4. A concave lens of refractive index 1.5 is immersed in a medium of refractive index 1.65. What is the nature of the lens?
5. When an object is placed between f and $2f$ of a concave mirror, would the image formed be (i) real or virtual and (ii) diminished or magnified?
6. A biconvex lens made of a transparent material of refractive index 1.25 is immersed in a water of refractive index 1.33. Will the lens behave as a converging or a diverging lens? Give reason.
7. A biconvex lens made of a transparent material of refractive index 1.5 is immersed in a water of refractive index 1.33. Will the lens behave as a converging or a diverging lens? Give reason.
8. A convex lens is placed in contact with a plane mirror. A point object at a distance of 20 cm on the axis of this combination has its image coinciding with itself. What is the focal length of the lens?
9. Write the relationship between angle of incidence i, angle of prism A and angle of minimum deviations from a triangular prism.
10. When red light passing through a convex lens is replaced by light of blue colour, how will the focal length of the lens change?
11. How does focal length of a lens change when red light incident on it is replaced by violet light? Give reason for your answer.
12. Under what condition, does a biconvex lens of glass having a certain refractive index act as a plane glass sheet when immersed in a liquid?
13. For the same value of angle of incidence, the angles of refraction in three media A, B and C are 15°, 25° and 35° respectively. In which medium, would the velocity of light be minimum?
14. When monochromatic light travels from one medium to another, its wavelength changes but frequency remains the same. Explain

15. The refractive index of diamond is much greater than that of glass. How does a diamond cutter make use of this fact?

16. If a ray of light propagates from a rarer to a denser medium, how does its frequency change?

17. State the criteria for the phenomenon of total internal reflection of light to take place.

18. A lens behaves as a converging lens in air and a diverging lens in water ($\mu = 4/3$). What will be the condition on the value of refractive index (μ) of the material of the lens?

19. A converging lens axially in contact with a diverging lens; both the lenses being of equal focal lengths. What is the focal length of the combination?

20. A glass lens of refractive index 1.45 disappears when immersed in a liquid. What is the value of refractive index of the liquid?

21. Calculate the speed of light in a medium whose critical angle is 30°.

22. Why does the sky appear blue?

23. Under what condition does the formation of rainbow occur?

24. Two thin lenses of power + 6D and – 2D are in contact. What is the focal length of the combination?

25. Two thin lenses of power + 4D and – 2D are in contact. What is the focal length of the combination?

26. Two thin lenses of power + 5D and – 2.5 D are in contact. What is the focal length of the combination?

2 Marks Questions

27. Calculate the radius of curvature of an equi-concave lens of refractive index 1.5, when it is kept in a medium of refractive index 1.4, to have a power of – 5 D ?

28. An equilateral glass prism has a refractive index 1.6 in air. Calculate the angle of minimum deviation of the prism, when kept in a medium of refractive index $4\frac{\sqrt{2}}{5}$.

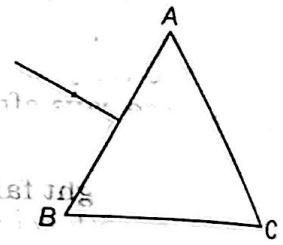
29. Under what conditions does the phenomenon of total internal reflection take place? Draw a ray diagram showing how a ray of light deviates by 90° after passing through a right-angled isosceles prism.

30. A beam of light converges at a point P. Draw ray diagrams to show where the beam will converge if (i) a convex lens and (ii) a concave lens is kept in the path of the beam.

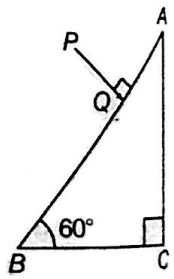
31. State, with the help of a ray diagram the working principle of optical fibres. Write one important use of optical fibres.

32. Explain the following
(i) Sky appears blue.
(ii) The Sun appears reddish at (a) sunset and (b) sunrise.

33. The figure shows a ray of light falling normally on the face AB of an equilateral glass prism having refractive index 3/2, placed in water of refractive index 4/3. Will this ray suffer total internal reflection on striking the face AC? Justify your answer.



34. A ray PQ incident normally on the refracting face BA is refracted in the prism BAC made of material of refractive index 1.5. Complete the path of ray through the prism. From which face will the ray emerge? Justify your answer.

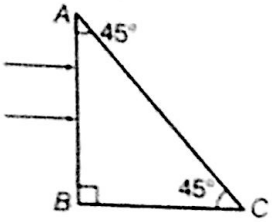


35. Use the mirror equation to show that an object placed between F and $2F$ of a concave mirror produces a real image beyond $2F$.

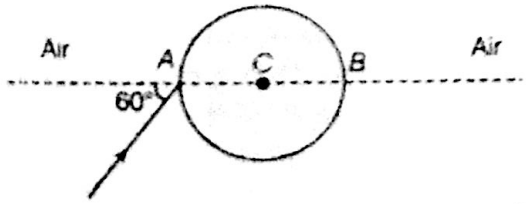
36. How does the refractive index of a transparent medium depend on the wavelength of incident light used? Velocity of light in glass is 2×10^8 m/s and in air is 3×10^8 m/s. If the ray of light passes from glass to air, calculate the value of critical angle.

37. An eq convex lens of focal length f is cut into two identical plane convex lenses. How will the power of each part be related to the focal length of the original lens?
A double convex lens of + 5 D is made of glass of refractive index 1.55 with both faces of equal radii of curvature. Find the value of its radius of curvature.

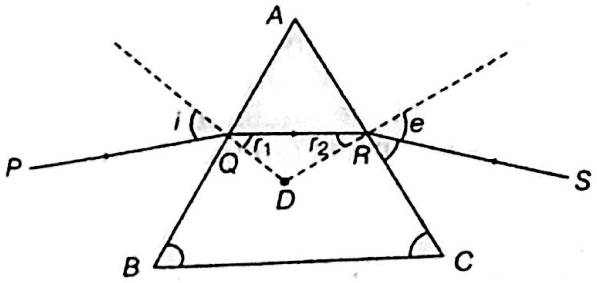
38. Two monochromatic rays of light are incident normally on the face AB of an isosceles right-angled prism ABC. The refractive indices of the glass prism for the two rays 1 and 2 are respectively 1.35 and 1.45. Trace the path of these rays after entering through the prism.



39. A ray of light falls on a transparent sphere with centre C as shown in the figure. The ray emerges from the sphere parallel to the line AB. Find the angle of refraction of A if the refractive index of material of sphere is $\sqrt{3}$.

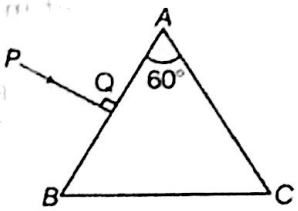


40. Figure shows a ray of light passing through a prism. If the refracted ray QR is parallel to the base BC, show that
(i) $r_1 = r_2 = A/2$ and
(ii) Angle of minimum deviation, $D_m = 2i - A$



41. Write the conditions for observing a rainbow. Show by drawing suitable diagram how one understands the formation of a rainbow.

42. A ray PQ is incident normally on the face AB of a triangular prism of refracting angle of 60° made of a transparent material of refractive index $2/\sqrt{3}$ as shown in the figure. Trace the path of the ray as it passes through the prism. Also, calculate the angle of emergence and angle of deviation.



43. A convex lens of focal length f_1 is kept in contact with a concave lens of focal length f_2. Find the focal length of the combination.

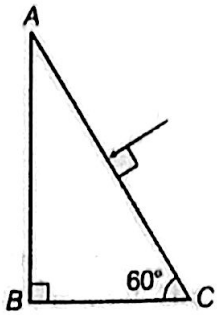
44. When monochromatic light travels from a rarer to a denser medium, explain the following giving reasons.
(i) Is the frequency of reflected and refracted light same as the frequency of incident light?
(ii) Does the decrease in speed imply a reduction in the energy carried by light wave?

45. (i) Write the necessary conditions for the phenomenon of total internal reflection to occur.

(ii) Write the relation between the refractive index and critical angle for a given pair of optical media.

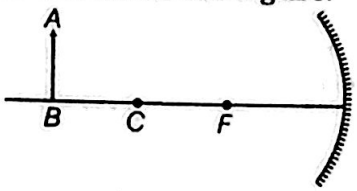
46. A convex lens of focal length 25 cm is placed coaxially in contact with a concave lens of focal length 20 cm. Determine the power of the combination. Will the system be converging or diverging in nature?

47. Trace the path of a ray of light passing through a glass prism *ABC* as shown in the figure. If the refractive index of glass is $\sqrt{3}$, then find out the value of the angle of emergence from the prism.



48. A ray of light incident on an equilateral glass prism ($\mu_g = \sqrt{3}$) moves parallel to the base line of the prism inside it. Find the angle of incidence for this ray.

49. An object *AB* is kept in front of a concave mirror as shown in the figure.



(i) Complete the ray diagram showing the image formation of the object.

(ii) How will the position and intensity of the image be affected if the lower half of the mirror's reflecting surface is painted black?

50. (i) Plane and convex mirrors are known to produce virtual images of the objects. Draw a ray diagram to show how, in the case of convex mirrors, virtual objects can produce real images.

(ii) Why are convex mirrors used as side view mirrors in vehicles?

51. (i) Draw a ray diagram for a convex mirror showing the image formation of an object placed anywhere in front of the mirror.

(ii) Use this ray diagram to obtain the expression for its linear magnification.

52. How does focal length of a lens change when red light incident on it is replaced by violet light? Give, reason for your answer.

53. Two thin lenses of power – 4 D and 2 D are placed in contact coaxially. Find the focal length of the combination.

54. Draw a ray diagram to show the image formation by a concave mirror.

When the object is kept between its focus and the pole. Using this diagram, derive the magnification formula for the image formed.

55. A beam of light converges at a point *P*. A concave lens of focal length 16 cm is placed in the path of this beam 12 cm from *P*. Draw a ray diagram and find the location of the point at which the beam would now converge.

56. Draw a diagram showing the formation of primary rainbow and explain at what angles the primary rainbow is visible.

57. The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. If focal length of the lens is 12 cm, find the refractive index of the material of the lens.

58. A biconvex lens has a focal length 2/3 times the radius of curvature of either surface. Calculate the refractive index of lens material.

59. (i) Why does the sun appear reddish at sunset or sunrise?

(ii) For which colour, the refractive index of prism material is maximum and minimum?

60. Find the radius of curvature of the convex surface of a plano-convex lens, whose focal length is 0.3 m and the refractive index of the material of the lens is 1.5

61. The following table gives the values of the angle of deviation for different values of the angle of incidence for a triangular prism.

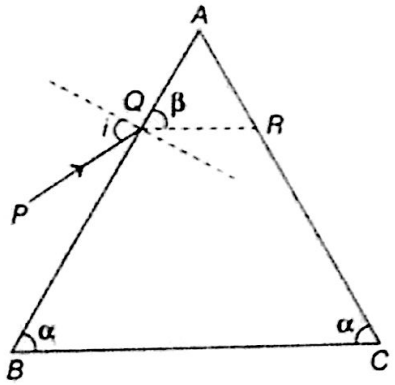
Angle of incidence	33°	38°	42°	52°	60°	71°
Angle of deviation	60°	50°	46°	40°	43°	50°

(i) For what value of the angle of incidence, is the angle of emergence likely to be equal to the angle of incidence itself?

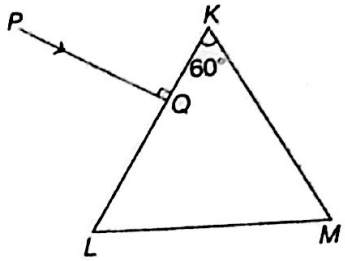
(ii) Draw a ray diagram showing the passage of a ray of light through this prism when the angle of incidence has the above value.

3 Marks Questions

62. A ray of light incident on the face AB of an isosceles triangular prism makes an angle of incidence i and deviates by angle β as shown in the figure. Show that in the position of minimum deviation $\angle\beta = \angle\alpha$. Also find out the condition, when the refracted ray QR suffer total internal reflection.



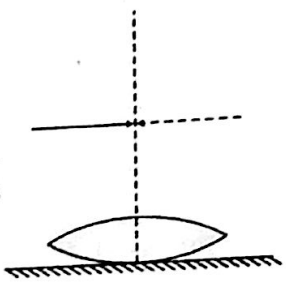
63. A triangular prism of refracting angle 60° is made of a transparent material of refractive index $2/\sqrt{3}$. A ray of light is incident normally on the face KL as shown in the figure. Trace the path of the ray as it passes through the prism and calculate the angle of emergence and angle of deviation.



64. (i) With the help of a ray diagram, show how a concave mirror is used to obtain an erect and magnified image of an object.

(ii) Using the above ray diagram, obtain the mirror formula and the expression for linear magnification.

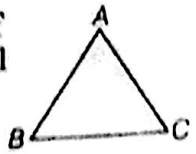
65. A symmetric biconvex lens of radius of curvature R and made of glass of refractive index 1.5, is placed on a layer of liquid placed on the top of a plane mirror as shown in the figure. An optical needle with its tip on the principal axis of the lens is moved along the axis until its real, inverted image coincides with the needle itself. The distance of the needle from the lens is measured to be x. On removing the liquid layer and repeating the experiment, the distance is found to be y. Obtain the expression for the refractive index of the liquid in terms of x and y.



66. (i) Monochromatic light of wavelength 589 nm is incident from air on a water surface. If μ for water is 1.33, find the wavelength, frequency and speed of the refracted light.

(ii) A double convex lens is made of a glass of refractive index 1.55 with both faces of the same radius of curvature. Find the radius of curvature required, if the focal length is 20 cm.

67. (i) A ray of light incident of face AB of an equilateral glass prism, shows minimum deviation of 30°. Calculate the speed of light through the prism.

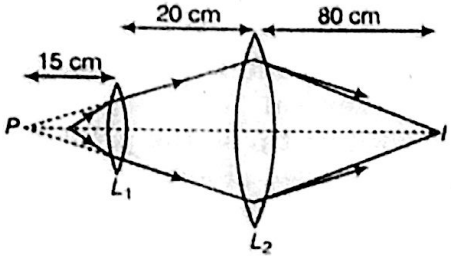


(ii) Find the angle of incidence at face AB, so that the emergent ray grazes along the face AC.

68. (i) Calculate the distance of an object of height h from a concave mirror of radius of curvature 20cm, so as to obtain a real image of magnification 2. Find the location of image also.

(ii) Using mirror formula, explain why does a convex mirror always produce a virtual image?

69. In the following diagram, an object 'O' is placed 15cm in front of a convex lens L_1 of focal length 20 cm and the final image is formed at I at a distance of 80 cm from the second lens L_2. Find the focal length of the lens L_2.



70. (i) A mobile phone lies along the principal axis of a concave mirror. Show with the help of a suitable diagram, the formation of its image. Explain why magnification is not a uniform.

(ii) Suppose the lower half of the concave mirror's reflecting surface is covered with an opaque material. What effect this will have on the image of the object? Explain

71. A convex lens of focal length 20 cm is placed coaxially with a convex mirror of radius of curvature 20 cm. The two are kept at 15 cm from each other. A point object lies 60 cm in front of the convex lens. Draw a ray diagram to show the formation of the image by the combination. Determine the nature and position of the image formed.

72. A convex lens of focal length 20 cm is placed coaxially with a concave mirror of focal length 10 cm at a distance of 50 cm apart from each other. A beam of light coming parallel to the principal axis is incident on the convex lens. Find the position of the final image formed by this combination. Draw the ray diagram showing the formation of the image.

73. Define the term 'critical angle' for a pair of media. A point source of monochromatic light 'S' is kept at the centre of the bottom of a cylinder of radius 15.0 cm. The cylinder contains water (refractive index 4/3) to a height of 7.0 cm. Draw the ray diagram and calculate the area of water surface through which the light emerges in air.

74. A small bulb (assumed to be a point source) is placed at the bottom of a tank containing water to a depth of 80 cm. Find out the area of the surface of water through which light from the bulb can emerge. Take the value of the refractive index of water to be 4/3.

75. Define power of a lens. Write its units. Deduce the relation $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$ for two thin lenses kept in contact coaxially.

76. You are given three lenses L_1, L_2 and L_3 each of focal length 10 cm. An object is kept at 15 cm in front of L_1 as shown. The final real image is formed at the focus I of L_3. Find the separation between L_1, L_2 and L_3.

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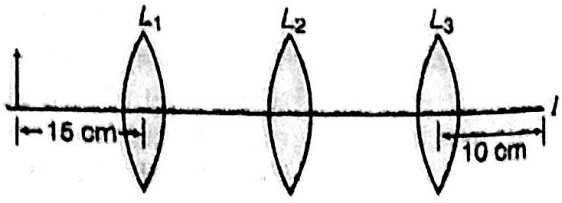
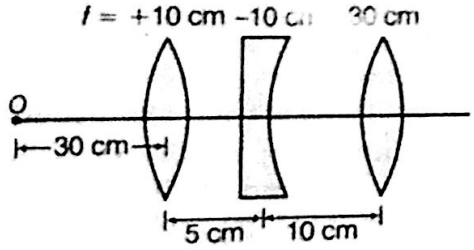


77. Draw a ray diagram to show the formation of the image of an object placed on the axis of a convex refracting surface of radius of curvature 'R', separating the two media of refractive indices 'μ_1' and 'μ_2' ($\mu_2 > \mu_1$). Use this diagram to deduce the relation $\mu_2/v - \mu_1/u = \mu_2 - \mu_1/R$, where u and v represent respectively the distance of the object and the image formed.

78. A convex lens made up of a glass of refractive index 1.5 is dipped in
   (i) a medium of refractive index 1.65
   (ii) a medium of refractive index 1.33
      (a) Will it behave as a converging lens or a diverging lens in the two cases?
      (b) How will its focal length change in the two media?

79. Use the mirror equation to show that
   (i) An object placed between f and $2f$ of a concave mirror produces a real image beyond $2f$.
   (ii) A convex mirror always produces a virtual image independent of the location of the object.
   (iii) An object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

80. Find the position of the image formed of the object O by the lens combination given in the figure.



81. A converging lens has a focal length of 20 cm in air. It is made of a material of refractive index 1.6. It is immersed in a liquid of refractive index 1.3. Calculate its new focal length.

82. State the necessary conditions for producing total internal reflection of light. Draw ray diagrams to show how specially designed prisms make use of total internal reflection to obtain inverted image of the object by deviation of rays
   (i) through 90° and
   (ii) through 180°.

83. With the help of a suitable ray diagram, derive a relation between the object distance (u), image distance (v) and radius of curvature R for the convex spherical surface when a ray of light travels from a rarer to denser medium.

84. A ray of light is incident on one face of a glass prism and emerges out from the other face. Trace the path of the ray and derive an expression for refractive index of the glass prism.

85. The image obtained with a convex lens is erect and its length is four times the length of the object.

   If the focal length of the lens is 20 cm, calculate the object and image distances.

86. A convex lens is used to obtain a magnified image of an object on a screen 10 cm from the lens. If the magnification is 19, find the focal length of the lens.

87. An illuminated object and a screen are placed 90 cm apart. Determine the focal length and nature of the lens required to produce a clear image on the screen, twice the size of the object.

88. (i) How is the focal length of a spherical mirror affected when the wavelength of the light used is increased?
   (ii) A convex lens has 20 cm focal length in air. What is its focal length in water? (Refractive index of air-water = 1.33, refractive index of air-glass = 1.5).

89. (i) How is the focal length of a spherical mirror affected when it is immersed in water?

(ii) A convex lens has 10 cm focal length in air. What is its focal length in water? (Refractive index of air-water = 1.33, refractive index of air-glass = 1.5).

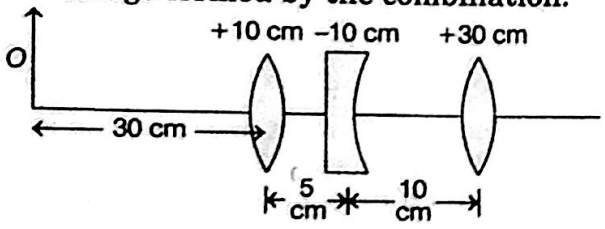
90. An object of 3 cm height is placed at a distance of 60 cm from a convex mirror of focal length 30 cm. Find the nature, position and size of the image formed.

91. An object of 2 cm height is placed at a distance of 30 cm from a convex mirror of focal length 15 cm. Find the nature, position and size of the image formed.

5 Marks Questions

92. (i) Under what conditions is the phenomenon of total internal reflection of light observed? Obtain the relation between the critical angle of incidence and the refractive index of the medium.

(ii) Three lenses of focal lengths +10 cm, −10 cm and +30 cm are arranged coaxially as in the figure given below. Find the position of the final image formed by the combination.



93. (i) When a convex lens of focal length 30 cm is in contact with a concave lens of focal length 20 cm, find out if the system is converging or diverging.

(ii) Obtain the expression for the angle of incidence of a ray of light which is incident on the face of a prism of refracting angle A, so that it suffers total internal reflection at the other face. (Given the refractive index of the glass of the prism is μ).

94. (i) Draw a ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object.

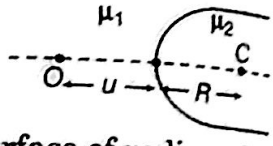
(ii) Obtain the mirror formula and write the expression for the linear magnification.

(iii) Explain two advantages of a reflecting telescope over a refracting telescope.

95. (i) Derive the mathematical relation between refractive indices μ_1 and μ_2 of two radii and radius of curvature R for refraction at a convex spherical surface. Consider the object to be a point source lying on the principal axis in rarer medium of refractive index μ_1 and a real image formed in the denser medium of refractive index μ_2. Hence, derive lens maker's formula.

(ii) Light from a point source in air falls on a convex spherical glass surface of refractive index 1.5 and radius of curvature 20 cm. The distance of light source from the glass surface is 100 cm. At what position is the image formed?

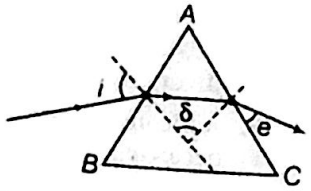
96. (i) A point object O is kept in a medium of refractive index μ_1 in front of a convex spherical surface of radius of curvature R which separates the second medium of refractive index μ_2 from the first one, as shown in the figure.



Draw the ray diagram showing the image formation and deduce the relationship between the object distance and the image distance in terms of μ_1, μ_2 and R.

(ii) When the image formed above acts as a virtual object for a concave spherical surface separating the medium μ_2 from $\mu_1 (\mu_2 > \mu_1)$, draw this ray diagram and write the similar [similar to (i)] relation. Hence, obtain the expression for the lens maker's formula.

97. (i) A ray PQ of light is incident on the face AB of a glass prism ABC (as shown in the figure) and emerges out of the face AC. Trace the path of the ray. Show that $\angle i + \angle e = \angle A + \angle \delta$ where, δ and e denote the angle of deviation and angle of emergence respectively.



Plot a graph showing the variation of the angle of deviation as a function of angle of incidence. State the condition under which $\angle\delta$ is minimum.

(ii) Find out the relation between the refractive index (μ) of the glass prism and $\angle A$ for the case, when the angle of prism (A) is equal to the angle of minimum deviation (δ_m). Hence, obtain the value of the refractive index for angle of prism $A = 60°$.

98. (i) A point object is placed in front of a double convex lens (or refractive index $\mu = \mu_2/\mu_1$ with respect to air) with its spherical faces of radii of curvature R_1 and R_2. Show the path of rays due to refraction at first and subsequently at the second surface to obtain the formation of the real image of the object.

Hence, obtain the lens maker's formula for a thin lens.

(ii) A double convex lens having both faces of the same radius of curvature has refractive index 1.55. Find out the radius of curvature of the lens required to get the focal length of 20 cm.

99. Draw a ray diagram showing the formation of the image by a point object on the principal axis of a spherical convex surface separating two media of refractive indices μ_1 and μ_2, when a point source is kept in rarer medium of refractive index μ_1. Derive the relation between object and image distance in terms of refractive index of the medium and radius of curvature of the surface. Hence, obtain the expression for lens Maker's formula in the case of thin convex lens.

100. (i) Draw a ray diagram to show refraction of a ray of monochromatic light passing through a glass prism. Deduce the expression for the refractive index of glass in terms of angle of prism and angle of minimum deviation.

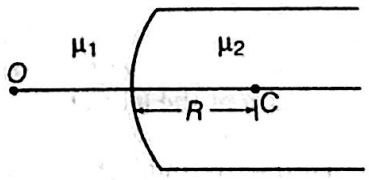
(ii) Explain briefly how the phenomenon of total internal reflection is used in fibre optics.

101. (i) Obtain lens maker's formula using the expression, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{(\mu_2 - \mu_1)}{R}$

Here, the ray of light propagating from a rarer medium of refractive index (μ_1) to a denser medium of refractive index (μ_2) is incident on the convex side of spherical refracting surface of radius of curvature R.

(ii) Draw a ray diagram to show that image formation by a concave mirror when the object is kept between its focus and the pole. Using this diagram, derive the magnification formula for the image formed.

102. Figure shows a convex spherical surface with centre of curvature C separating the two media of refractive indices μ_1 and μ_2. Draw a ray diagram showing the formation of the image of a point object O lying on the principal axis. Derive the relationship between the object and image distance in terms of refractive indices of the media and the radius of curvature R of the surface.



Objective Questions

(For Complete Chapter)

1 Mark Questions

1. To get three images of single object, one should have two plane mirrors at an angle of
(a) 60° (b) 90° (c) 120° (d) 30°

2. A person standing in front of a mirror finds his image larger than himself. This implies that the mirror is
(a) convex (b) parabolic
(c) plane (d) concave

3. A plane mirror produces a magnification of
(a) zero (b) –1
(c) +1 (d) between 0 and +1

4. When light passes from one medium to other, then which will not change?
(a) Frequency (b) Wavelength
(c) Amplitude (d) Velocity

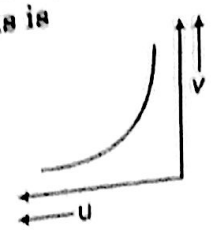
5. Maximum lateral displacement of a ray of light incident on a slab of thickness t is
(a) $\frac{t}{2}$ (b) $\frac{t}{3}$ (c) $\frac{t}{4}$ (d) t

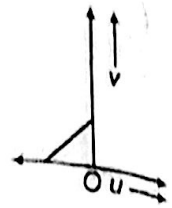
6. A plane glass slab is kept over various colour letters, the letter which appears least raised is
(a) red (b) violet (c) green (d) blue

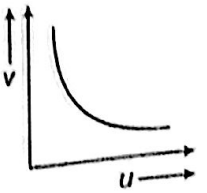
7. Which one of the following is not associated with the total internal reflection?
(a) The mirage formation
(b) Optical fibre communication
(c) The glittering of diamond
(d) Scattering of light

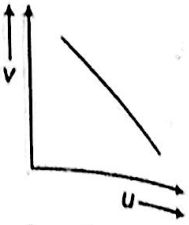
8. In optical fibres, the refractive index of the core is
(a) greater than that of the cladding
(b) equal to that of the cladding
(c) smaller than that of the cladding
(d) independent of that of the cladding

9. The graph between the image distance (v) and object distance (u) from the convex lens is

(a) 

(b) 

(c) 

(d) 

10. When a biconvex lens of glass having refractive index 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index
(a) equal to that of glass
(b) less than one
(c) greater than that of glass
(d) less than that of glass

11. What will be the colour of the sky as seen from the Earth if there were no atmosphere?
(a) Black (b) Blue (c) Orange (d) Red

12. Red colour is used for danger signals, because
(a) it causes fear
(b) it undergoes least scattering
(c) it undergoes maximum scattering
(d) it is in accordance with international convention

13. Astigmatism is corrected using
(a) cylindrical lens
(b) plano-convex lens
(c) plano-concave lens
(d) convex lens

14. The intermediate image formed by the objective of a compound microscope is
(a) real, inverted and magnified
(b) real, erect and magnified
(c) virtual, erect and magnified
(d) virtual, inverted and magnified

15. If the focal length of the eyepiece of a telescope is doubled, its magnifying power (m) will be

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