9.RAY OPTICS AND OPTICAL INSTRUMENTS

Single Correct Answer Type

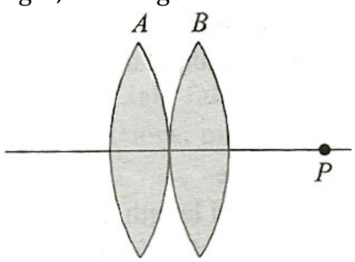
1. A bird is flying up at angle $\sin^{-1}(3/5)$ with the horizontal. A fish in a pond looks at that bird. When it is vertically above the fish. The angle at which the bird appears to fly (to the fish) is [$n_{\text{water}} = 4/3$]

   a) $\sin^{-1}(3/5)$ b) $\sin^{-1}(4/5)$ c) $45°$ d) $\sin^{-1}(9/16)$

2. A ray of light passes from glass, having a refractive index of 1.6, to air. The angle of incidence for which the angle of refraction is twice the angle of incidence is

   a) $\sin^{-1}\left(\frac{4}{5}\right)$ b) $\sin^{-1}\left(\frac{3}{5}\right)$ c) $\sin^{-1}\left(\frac{5}{8}\right)$ d) $\sin^{-1}\left(\frac{2}{5}\right)$

3. Two convex lenses placed in contact form the image of a distant object at P. If the lens B is moved to the right, the image will



   a) Move to the left
   b) Move to the right
   c) Remain at P
   d) Move either to the left or right, depending upon focal lengths of the lenses

4. A plane glass mirror of thickness 3 cm of material of $\mu = 3/2$ is silvered on the back surface. When a point object is placed 9 cm from the front surface of the mirror, then the position of the brightest image from the front surface is

   a) 9 cm b) 11 cm c) 12 cm d) 13 cm

5. The graph between object distance $u$and image distance v for lens is given below. The focal length of the lens is

   a) 5 ± 0.1 b) 5 ± 0.05 c) 0.5 ± 0.1 d) 0.5 ± 0.05

6. A plano-convex lens fits exactly into a plano-concave lens. Their plane surfaces are parallel to each other. If the lenses are made of different material of refractive indices μ_1 and μ_2 and R is the radius of curvature of the curved surface of the lenses, then focal length of the combination is

   a) $\frac{R}{\mu_1 - \mu_2}$ b) $\frac{2R}{\mu_2 - \mu_1}$ c) $\frac{R}{2(\mu_1 - \mu_2)}$ d) $\frac{R}{2 - (\mu_1 + \mu_2)}$

7. Light from a denser medium 1 passes to a rarer medium 2. When the angle of incidence is θ the partially reflected and refracted rays are mutually perpendicular. The critical angle will be

   a) $\sin^{-1}(\cot\theta)$ b) $\sin^{-1}(\tan\theta)$ c) $\sin^{-1}(\cos\theta)$ d) $\sin^{-1}(\sec\theta)$

8. Refractive index of a prism is $\sqrt{7/3}$ and the angle of prism is $60°$. The minimum angle of incidence of a ray

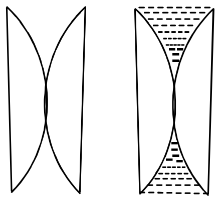
that will be transmitted through the prism is

a) 30° b) 45° c) 15° d) 50°

9. A convex lens of power +6 dioptre is placed in contact with a concave lens of power −4 dioptre. What will be the nature and focal length of this combination?

a) Concave, 25 cm b) Convex, 50 cm c) Concave, 20 cm d) Convex, 100 cm

10. Figure (a) shows two plano-convex lenses in contact as shown. The combination has focal length 24 cm. Figure (b) shows the same with a liquid introduced between them. If refractive index of glass of the lenses is 1.50 and that of the liquid is 1.60, the focal length of system in figure(b) will be



a) −120 cm b) 120 cm c) −24 cm d) 24 cm

11. A real object is placed in front of a convex mirror (fixed). The object is moving toward the mirror. If v_0 is the speed of object and v_i is the speed of image, then

a) $v_i < v_0$ always b) $v_i > v_0$ always

c) $v_i > v_0$ initially and then $v_0 > v_i$ d) $v_i < v_0$ initially and then $v_i > v_0$

12. In the above question, if the second car is overtaking at a relative speed of 314 ms^{-1}, how fast will the image be moving?

a) -1 ms^{-1} b) 0.5 ms^{-1} c) 0.3 ms^{-1} d) -0.032 ms^{-1}

13. The apparent thickness of a thick plano-convex lens is measured once with the plane face upward and then with the convex face upward. The value will be

a) More in the first case

b) Same in the two cases

c) More in the second case

d) Any of the above depending on the value of its actual thickness

14. Two thin lenses are placed 5 cm apart along the same axis and illuminated with a beam of light parallel to that axis. The first lens in the path of the beam is a converging lens of focal length 10 cm whereas the second is a diverging lens of focal length 5 cm. If the second lens is now moved toward the first, the emergent light

a) Remains parallel b) Remains convergent

c) Remains divergent d) Changes from parallel to divergent

15. A luminous object and a screen are at a fixed distance D apart. A converging lens of focal length f is placed between the object and screen. A real image of the object in formed on the screen for two lens positions if they are separated by a distance d equal to

a) $\sqrt{D(D+4f)}$ b) $\sqrt{D(D-4f)}$ c) $\sqrt{2D(D-4f)}$ d) $\sqrt{D^2+4f}$

16. For a prism kept in air, it is found that for an angle of incidence 60°, the angle of refraction 'A', angle of deviation 'δ' and angle of emergence 'e' become equal. Then, the refractive index of the prism is

a) 1.73 b) 1.15 c) 1.5 d) 1.33

17. A concave mirror is placed on a horizontal table with its axis directed vertically upwards. Let O be the pole of the mirror and C its centre of curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be

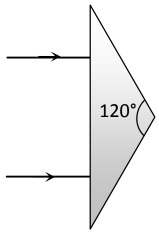
a) Real and will remain at C

b) Real, and located at a point between C and ∞

c) Virtual and located at a point between C and O

d) Real, and located at a point between C and O

18. An isosceles prism of angle 120° has a refractive index of 1.44. Two parallel monochromatic rays enter the prism parallel to each other in air as shown. The rays emerging from the opposite faces

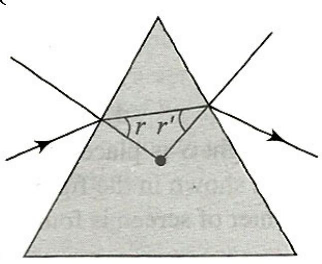


a) Are parallel to each other
b) Are diverging
c) Make an angle $2\sin^{-1}(0.72)$ with each other
d) Make an angle $2\{\sin^{-1}(0.72) - 30°\}$ with each other

19. When an object is kept at a distance of 30 cm from a concave mirror, the image is formed at a distance of 10 cm. If the object is moved with a speed of 9 cm s^{-1} the speed with which the image moves is
a) 0.1 ms^{-1}
b) 1 ms^{-1}
c) 3 ms^{-1}
d) 9 ms^{-1}

20. A point object 'O' is at the centre of curvature of a concave mirror. The mirror starts to move at a speed u, in a direction perpendicular to the principal axis. Then, the initial velocity of the image is
a) $2u$, in the direction opposite to that of mirror's velocity
b) $2u$, in the direction same as that of mirror's velocity
c) Zero
d) u, in the direction same as that of mirror's velocity

21. Let r and r' denote the angles inside an equilateral prism, as usual, in degrees. Consider that during some time interval from $t = 0$ to $t = t, r'$ varies with time as $r' = 10 + t^2$. During this time, r will vary as (assume that r and r' are in degree)



a) $50 - t^2$
b) $50 + t^2$
c) $60 - t^2$
d) $60 + t^2$

22. In the arrangement shown below, the image of the extended object as seen by the observer is

a) Real and inverted
b) Real and erect
c) Virtual and inverted
d) Virtual and erect

23. An object is placed 1 m in front of the curves surface of a plano-convex lens whose plane surface is silvered. A real image is formed in front of the lens at a distance of 120 cm. Then, the focal length of the lens is
a) 100 cm
b) 120 cm
c) 109.1 cm
d) 110.0 cm

24. A ray of light is incident on a glass sphere of refractive index 3/2. What should be the angle of incidence so that the ray which enters the sphere does not come out of the sphere?
a) $\tan^{-1}(2/3)$
b) 60°
c) 90°
d) 30°

25. A mango tree is at the bank of a river and one of the branch of tree extends over the river. A tortoise lives in the river. A mango falls just above the tortoise. The acceleration of the mango falling from tree as it appears to the tortoise is (refractive index of water is 4/3 and the tortoise is stationary)
a) g
b) $3g/4$
c) $4g/3$
d) None of these

26. For the same statement as above, the ratio of the two image sizes for these two positions of the lens is

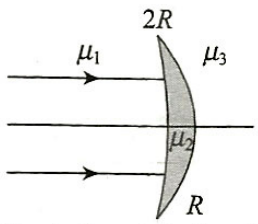
a) $\left[\frac{D-d}{D+d}\right]^2$ b) $\left[\frac{D+d}{D-d}\right]^2$ c) $\left[\frac{D-2d}{D+2d}\right]^2$ d) $\left[\frac{D+2d}{D-2d}\right]^2$

27. Consider the situation shown in figure. Water ($\mu = 4/3$) is filled in a breaker upto a height of 10 cm

A plane mirror is fixed at a height of 5 cm from the surface of water. Distance of image from the mirror after reflection from it of an object O at the botton of the breaker is

a) 15 cm b) 12.5 cm c) 7.5 cm d) 10 cm

28. The diagram shows a concavo-convex lens μ_2. What is the condition on the refractive indices so that the lens is diverging?



The refractive index of the lens is μ_2

a) $2\mu_3 < \mu_1 + \mu_2$ b) $2\mu_3 > \mu_1 + \mu_2$ c) $\mu_3 > 2(\mu_1 - \mu_2)$ d) None of these

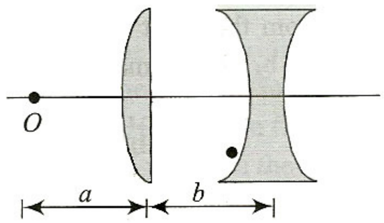
29. A cubical block of glass, refractive index 1.5, has a spherical cavity of radius $r = 9$ cm inside it as shown in figure. A luminous point object O is at a distance of 18 cm from the cube (see figure). What is the apparent position of O as seen from A?

a) 17 cm, left of S_4 b) 25 cm, right of S_4 c) 13 cm, left of S_4 d) 10 cm, right of S_4

30. The given lens is broken into four parts rearranged as shown. If the initial focal length is f, then after rearrangement the equivalent focal length is

a) f b) $f/2$ c) $f/4$ d) $4f$

31. A plano-convex glass lens ($\mu_g = 3/2$) of radius of curvature $R = 10$ cm is placed at a distance of 'b' from a concave lens of focal length 20 cm



What should be the distance 'a' of a point object O from the plano-convex lens so that the position of final image is independent of 'b'?

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

32. A thin equiconvex lens ($\mu = 3/2$) of focal length 10 cm is cut and separated and a material of refractive index 3 is filled between them. What is the focal length of the combination?

a) -10 cm b) $-10/4$ cm c) $-10/3$ cm d) None of these

33. A concave mirror of focal length 10 cm and a convex mirror of focal length 15 cm are placed facing each other 40 cm apart. A point object is placed between the mirrors, on their common axis and 15 cm from the concave mirror. Find the position and nature of the image produced by successive reflections, first at the concave mirror and then at the convex mirror

a) 12 cm behind convex mirror, real b) 9 cm behind convex mirror, real
c) 6 cm behind convex mirror, virtual d) 3 cm behind convex mirror, virtual

34. Light is incident normally on face AB of a prism as shown in figure. A liquid of refractive index μ is placed on face AC of the prism. The prism is made of glass of refractive index 3/2

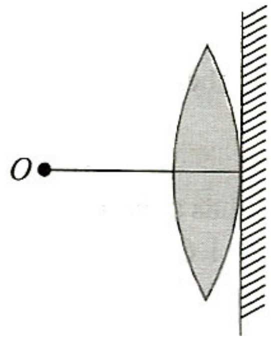
The limit of μ for which total internal reflection takes place on face AC is

a) $\mu > \frac{3}{4}$ b) $\mu < \frac{3\sqrt{3}}{4}$ c) $\mu > \sqrt{3}$ d) $\mu < \frac{\sqrt{3}}{2}$

35. An object is approaching a fixed plane mirror with velocity 5 ms^{-1} making an angle of 45° with the normal. The speed of image w.r.t. the mirror is

a) 5 ms^{-1} b) $5/\sqrt{2}$ ms^{-1} c) $5\sqrt{2}$ ms^{-1} d) 10 ms^{-1}

36. Behind a thin converging lens having both the surfaces of the same radius 1 cm, a plane mirror has been placed. The image of an object at a distance of 40 cm from the lens is formed at the same position. What is the refractive index of the lens?



a) 1.5 b) 5/3 c) 9/8 d) None of these

37. In an experiment to determine the focal length (f) of a concave mirror by the $u - v$ method, a student places the object pin Aon the principle axis at a distance x from the pole P. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with PA. When the student shifts his/her eye towards left, the image appears to the right of the object pin. Then

a) $x < f$ b) $f < x < 2f$ c) $x = 2f$ d) $x > 2f$

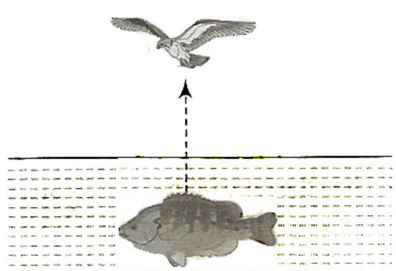
38. A ray of light is incident on a medium with angle of incidence i and refracted into a second medium with angle of refraction r. The graph of $\sin(i)$ vs $\sin(r)$ is as shown in figure. Then, the velocity of light in the first medium in n times the velocity of light in the second medium. What should be the value of n?

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

39. A candle placed 20 cm from the surface of a convex mirror and a plane mirror is also placed so that the virtual images in the two mirrors coincide. If the plane mirror is 12 cm away from the object, what is the focal length of the convex mirror?

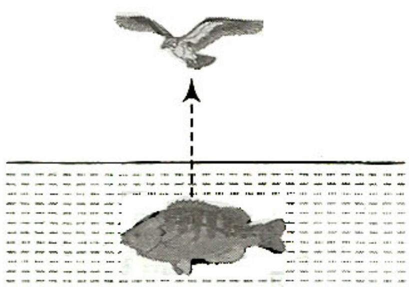
a) 20 cm b) 15 cm c) 10 cm d) 5 cm

40. A fish rising vertically up toward the surface of water with speed $3 ms^{-1}$ observes a bird diving vertically down towards it with speed $9 ms^{-1}$. The actual velocity of bird is



a) $4.5 ms^{-1}$ b) $5.4 ms^{-1}$ c) $3.0 ms^{-1}$ d) $3.4 ms^{-1}$

41. A fish is vertically below a flying bird moving vertically down toward water surface. The bird will appear to the fish to be

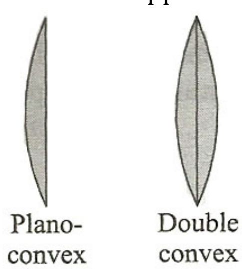


a) Moving faster than its speed and also away from the real distance
b) Moving faster than its real speed and nearer than its real distance
c) Moving slower than its real speed and also nearer than its real distance
d) Moving slower than its real speed and away from the real distance

42. In a side show programme, the image on the screen has an area 900 times that of the slide. If the distance between the slide and the screen is x times the distance between the slide and the projector lens, then
a) $x = 30$ b) $x = 31$ c) $x = 500$ d) $x = 1/30$

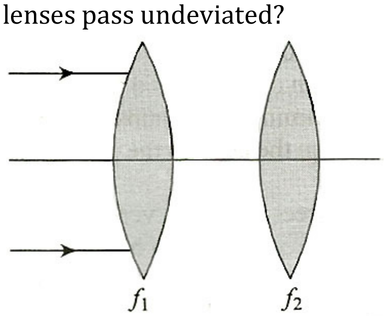
43. A light ray I is incident of a plane mirror M. The mirror is rotated in the direction as shown in the figure by an arrow at frequency $9/\pi$ rps. The light reflected by the mirror is received on the wall W at a distance 10 m from the axis of rotation. When the angle of incidence becomes 37°, the speed of the spot (a point) on the wall is
a) 10 ms^{-1} b) 1000 ms^{-1} c) 500 ms^{-1} d) None of these

44. You are given two identical plano-convex lenses. When you place an object 20 cm to the left of a single plano-convex lens, the image appears 40 cm to the right of the lens. You then arrange the two plano-convex lenses back to back to form a double convex lens. If the object is 20 cm to the left of this new lens, what is the approximate location of the image?



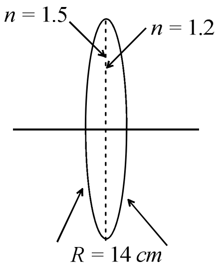
a) 10 cm to the right of the lens b) 20 cm to the right of the lens
c) 80 cm to the right of the lens d) 80 cm to the left of the lens

45. A parallel beam of light is incident on the system of two convex lenses of focal lengths $f_1 = 20$ cm and $f_2 = 10$ cm. What should be the distance between two lenses so that rays after refraction from both the lenses pass undeviated?



a) 60 cm b) 30 cm c) 90 cm d) 40 cm

46. A bi-convex lens is formed with two thin plano-convex lenses as shown in the figure. Refractive index n of the first lens is 1.5 and that of the second lens is 1.2. Both the curved surfaces are of the same radius of curvature $R = 14\ cm$. For this bi-convex lens, for an object distance of $40cm$, the image distance will be



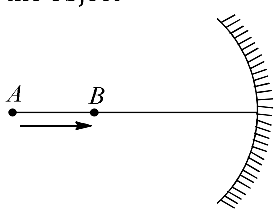
a) $-280.0cm$ b) $40.0\ cm$ c) $21.5\ cm$ d) $13.3\ cm$

47. A ray of monochromatic light is incident on the refracting face of a prism (angle 75°). It passes through the prism and is incident on the other face at the critical angle. If the refractive index of the prism is $\sqrt{2}$, then the angle of incidence on the first face of the prism is
a) 15° b) 30° c) 45° d) 60°

48. A point objects is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of the virtual image from the surface of the sphere is
a) 2 cm b) 4 cm c) 6 cm d) 12 cm

49. An object is placed at a distance of 25 cm from the pole of a convex mirror and a plane mirror is set at a distance 5 cm from convex mirror so that the virtual images formed by the two mirrors do not have any parallax. The focal length of the convex mirror is
a) 37.5 cm b) −7.5 cm c) −37.5 cm d) +7.5 cm

50. A linear object AB is placed along the axis of a concave mirror. The object is moving towards the mirror with speed U. The speed of the image of the point A is $4U$ and the speed of the image of B is also $4U$ but in opposite direction. If the center of the line AB is at a distance L from the mirror then find out the length of the object



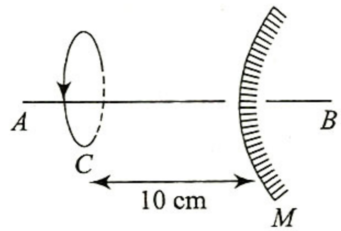
a) $3L/2$ b) $5L/3$ c) L d) None of these

51. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is 60°).In the position of minimum deviation, the angle of refraction will be
a) 30° for both the colours b) Greater for the violet colour
c) Greater for the red colour d) Equal but not 30° for both the colours

52. Refraction takes place at a concave spherical boundary separating glass-air medium. For the image to be real, the object distance ($\mu_g = 3/2$)
a) Should be greater than three times the radius of curvature of the refracting surface
b) Should be greater than two times the radius of curvature of the refracting surface
c) Should be greater than the radius of curvature of the refracting surface
d) Is independent of the radius of curvature of the refracting surface

53. A fish looks upward at an unobstructed overcast sky. What total angle does the sky appear to subtend? (Take refractive index of water as $\sqrt{2}$)
a) 180° b) 90° c) 75° d) 60°

54. A particle revolves in clockwise direction (as seen from point A) in a circle C of radius 1 cm and completes one revolution in 2 sec. The axis of the circle and the principal axis of the mirror M coincide, call it AB. The radius of curvature of the mirror is 20 cm. Then, the direction of revolution (as seen from A) of the image of the particle and its speed is



a) Clockwise, 1.57 cms^{-1} b) Clockwise, 3.14 cms^{-1}
c) Anticlockwise, 1.57 cms^{-1} d) Anticlockwise, 3.14 cms^{-1}

55. A cube of side 2 m is placed in front of a concave mirror of focal length 1 m with its face A at a distance of 3 m and face B at a distance of 5 m form the mirror. The distance between the images of faces A and B and heights of images of A and B are, respectively,

a) 1 m, 0.5 m, 0.25 m b) 0.5 m, 1 m, 0.25 m c) 0.5 m, 0.25 m, 1 m d) 0.25 m, 1 m, 0.5 m

56. The focal lengths of the objective and the eye-piece of a compound microscope are 2.0 cm and 3.0 cm respectively. The distance between the objective and the eye-piece is 15.0 cm. The final image formed by the eye-piece is at infinity. The two lenses are thin. The distances in cm of the object and the image produced by the objective measured from the objective lens are respectively

a) 2.4 and 12.0 b) 2.4 and 15.0 c) 2.3 and 12.0 d) 2.3 and 3.0

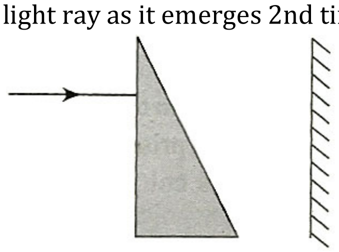
57. The distance between an object and the screen is 100 cm. A lens produces an image on the screen when the lens is placed at either of the positions 40 cm apart. The power of the lens is nearly

a) 3 diopter b) 5 diopter c) 2 diopter d) 9 diopter

58. A convex lens of focal length 20 cm and a concave lens of focal length f are mounted coaxially 5 cm apart. Parallel beam of light incident on the convex lens emerges from the concave lens as a parallel beam. Then, f in cm is

a) 35 b) 25 c) 20 d) 15

59. A right-angled prism of apex angle 4° and refractive index 1.5 is located in front of a vertical plane mirror as shown in figure. A horizontal ray of light is falling on the prism. Find the total deviation produced in the light ray as it emerges 2nd time from the prism



a) 8° CW b) 6° CW c) 180° CW d) 174° CW

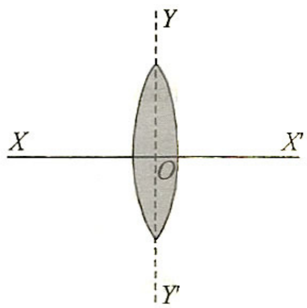
60. A U-shaped wire is placed before a concave mirror having radius of curvature 20 cm as shown in figure. Find the total length of the image

a) 2 cm b) 10 cm c) 8 cm d) 14 cm

61. Choose the correct mirror image of figure given below

a) b) c) d)

62. An equiconvex lens is cut into two halves along (i) XOX' and (ii) YOY'' as shown in figure. Let f, f', f'' be the focal length of the lens, of each half in case (i), and of each half in case (ii), respectively



Choose the correct statement from the following:
a) $f' = f, f'' = 2f$
b) $f' = 2f, f'' = f$
c) $f' = f, f'' = f$
d) $f' = 2f', f'' = 2f$

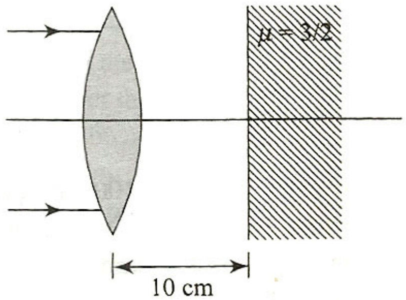
63. A focal length of a thin biconvex lens is 20 cm. When an object is moved from a distance of 25cm in front of it to 50cm, the magnification of its image changes from m_{25} to m_{50}. The ration $\frac{m_{25}}{m_{50}}$ is
a) 6 b) 7 c) 8 d) 9

64. An object is put at a distance of 5 cm from the first focus of a convex lens of focal length 10 cm. If a real image is formed, its distance from the lens will be
a) 15 cm b) 20 cm c) 25 cm d) 30 cm

65. A light beam is travelling from Region I to Region IV (refer figure). The refractive index in Region I, II, III and IV are $n_0, \frac{n_0}{2}, \frac{n_0}{6}$ and $\frac{n_0}{8}$, respectively. The angle of incidence θ for which the beam just misses entering Region IV is

a) $\sin^{-1}\left(\frac{3}{4}\right)$ b) $\sin^{-1}\left(\frac{1}{8}\right)$ c) $\sin^{-1}\left(\frac{1}{4}\right)$ d) $\sin^{-1}\left(\frac{1}{3}\right)$

66. Focal length of a thin convex lens is 30 cm. At a distance of 10 cm from the lens, there is a plane refracting surface of refractive index 3/2. Where will the parallel rays incident on the lens converge?



a) At a distance of 27.5 cm from the lens
b) At a distance of 25 cm from the lens
c) At a distance of 45 cm from the lens
d) At a distance of 40 cm from the lens

67. A convex lens of focal length 10 cm is painted black at the middle portion as shown in figure. An object is placed at a distance of 20 cm from the lens

Then,
a) Only one image will be formed by the lens
b) The distance between the two images formed by such a lens is 6 mm
c) The distance between the images is 4 mm
d) The distance between the images is 2 mm

68. A gun of mass m_1 fires a bullet of mass m_2 with horizontal speed v_0. The gun is fitted with a concave mirror of focal length f facing toward a receding bullet. Find the speed of separation of the bullet and the image just after the gun was fired
a) $\left(1+\frac{m_2}{m_1}\right)v_0$
b) $2\left(1-\frac{m_2}{m_1}\right)v_0$
c) $2\left(1+\frac{2m_2}{m_1}\right)v_0$
d) $2\left(1+\frac{m_2}{m_1}\right)v_0$

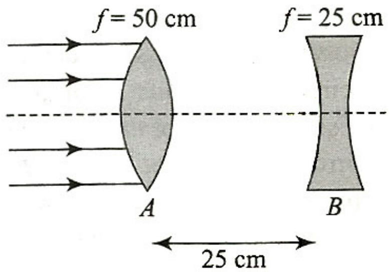
69. A rod made of glass, refractive index 1.5 and of square cross section, is bent into the shape shown in figure. A parallel beam of light falls normally on the plane flat surface A. Referring to the diagram, d is the width of a side and R is the radius of inner semicircle. Find the maximum value of ratio d/R so that all light entering the glass through surface A emerges from the glass through surface B

a) 1/2
b) 1/5
c) 1/4
d) 2/3

70. An object is placed in front of a convex mirror at a distance of 50 cm. A plane mirror is introduced covering the lower half of the convex mirror. If the distance between the object and the plane mirror is 30 cm, it is found that there is no parallax between the images formed by the two mirrors. What is the radius of curvature of the convex mirror?
a) 25 cm
b) 7 cm
c) 18 cm
d) 27 cm

71. With a concave mirror, an object is placed at a distance x_1 from the principal focus, on the principal axis. The image is formed at a distance x_2 from the principal focus. The focal length of the mirror is
a) x_1x_2
b) $(x_1+x_2)/2$
c) $\sqrt{x_1/x_2}$
d) $\sqrt{x_1x_2}$

72. Two lenses shown are illuminated by a beam of parallel light from the left. Lens B is then moved slowly toward lens A. The beam emerging from lens B is



a) Always diverging
b) Initially parallel and then diverging
c) Always parallel
d) Initially converging and then parallel

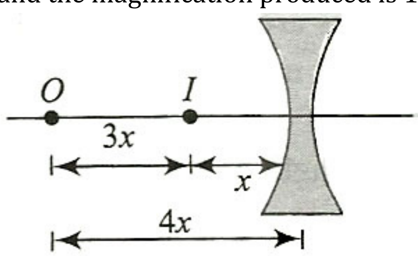
73. A biconvex lens of focal length f forms a circular image of radius r of sun in focal plane. Then which option is correct?
a) $\pi r^2 \propto f$
b) $\pi r^2 \propto f^2$
c) If lower half part is covered by black sheet, then area of the image is equal to $\pi r^2 / 2$
d) If f is doubled, intensity will increase

74. Two thin symmetrical lenses of different nature and of different material have equal radii of curvature $R = 15$ cm. The lenses are put close together and immersed in water ($\mu_w = 4/3$). The focal length of the system in water is 30 cm. The difference between refractive indices of the two lenses is
a) 1/2
b) 1/4
c) 1/3
d) 3/4

75. One of the refracting surfaces of a prism of angle 30° is silvered. A ray of light incident at angle of 60° retraces its path. The refractive index of the material of prism is
a) $\sqrt{2}$
b) $\sqrt{3}$
c) 3/2
d) 2

76. A spherical convex surface separates object and image spaces of refractive indices 1.0 and 4/3. If radius of curvature of the surface is 10 cm, find its power
a) 3.5 dioptre
b) 2.5 dioptre
c) 25 dioptre
d) 1.5 dioptre

77. A concave lens forms the image of an object such that the distance between the object and image is 10 cm and the magnification produced is 1/4. The focal length of the lens will be



a) 8.6 cm
b) 6.2 cm
c) 10 cm
d) 4.4 cm

78. Critical angle of glass is θ_1 and that of water is θ_2. The critical angle for water and glass surface would be ($\mu_g = 3/2, \mu_w = 4/3$)
a) Less than θ_2
b) Between θ_1 and θ_2
c) Greater than θ_2
d) Less than θ_1

79. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is
a) Virtual and at a distance of 16 cm from the mirror
b) Real and at a distance of 16 cm from the mirror
c) Virtual and at a distance of 20 cm from the mirror
d) None of the above

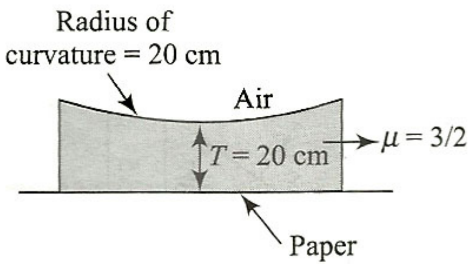
80. When an object is placed 15 cm from a lens, a virtual image is formed. Mark the correct statements
a) The lens may be convex or concave
b) If the lens is diverging, the image distance has to be less than 15 cm
c) If the lens is converging, then its focal length has to be greater than 15 cm
d) All of the above

81. In figure, ABC is the cross section of a right-angled prism and $ACDE$ is the cross section of a glass slab. The

value of θ so that light incident normally on the face AB deos not cross the face AC is (given $\sin^{-1}(3/5) = 37°$)

a) $\theta \leq 37°$ b) $\theta < 37°$ c) $\theta \leq 53°$ d) $\theta < 53°$

82. A plano-concave lens is placed on a paper on which a flower is drawn. How far above its actual position does the flower appear to be?



a) 10 cm b) 15 cm c) 50 cm d) None of these

83. A ray of light travelling in water is incident on its surface open to air. The angle of incidence isθ, which is less than the critical angle. Then there will be
a) Only a reflected ray and no reflected ray
b) Only a reflected ray and no reflected ray
c) A reflected ray and a refracted ray and the angle between then would be less than $108° - 2\theta$
d) A reflected ray and a refracted ray and the angle between then would be greater than $108° - 2\theta$

84. In the figure shown, a point object O is placed in air. A spherical boundary separates two media. AB is the principal axis. The refractive index above AB is 1.6 and below AB is 2.0. The separation between the images formed due to refraction at the spherical surface is

a) 12 m b) 20 m c) 14 m d) 10 m

85. An object is placed at a distance of 15 cm from a convex lens of focal length 10 cm. On the other side of the lens, a convex mirror is placed at its focus such that the image formed by the combination coincides with the object itself. The focal length of the convex mirror is
a) 20 cm b) 10 cm c) 15 cm d) 30 cm

86. In figure, find the total magnification after two successive reflections first on M_1 and then on M_2

a) +1 b) −2 c) +2 d) −1

87. When light is refracted from air into glass
a) Its wavelength and frequency both increase
b) Its wavelength increases but frequency remains unchanged

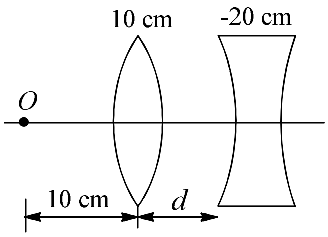
c) Its wavelength decreases but frequency remains unchanged
d) Its wavelength and frequency both decrease

88. A circular beam of light of diameter $d = 2$ cm falls on a plane surface of glass. The angle of incidence is 60° and refractive index of glass is $\mu = 3/2$. The diameter of the refracted beam is
a) 4.00 cm b) 3.0 cm c) 3.26 cm d) 2.52 cm

89. An object is placed 30 cm to the left of a diverging lens whose focal length is of magnitude 20 cm. Which one of the following correctly states the nature and position of the virtual image formed?

Nature of image	Distance form lens		
a) Inverted, enlarged	60 cm to the right	b) Erect, diminished	12 cm to the left
c) Inverted, enlarged	60 cm to the left	d) Erect, diminished	12 cm to the right

90. What should be the value of distance d so that final image is formed on the object itself. (Focal lengths of the lenses are written on the lenses)



a) 10 cm b) 20 cm c) 5 cm d) None of these

91. In the above question, the magnification is
a) 4/9 b) −4/9 c) 9/4 d) 8/13

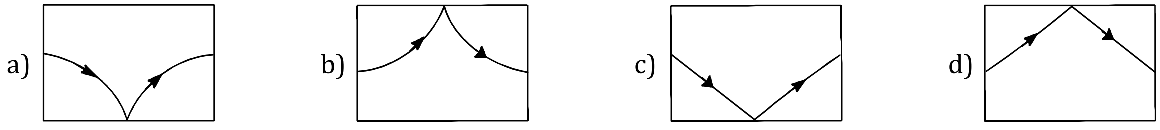
92. A glass prism has refractive index $\sqrt{2}$and refracting angle 30°. One of the refracting surface of the prism is silvered. A beam of monochromatic light will retrace it path if its angle of incidence on the unsilvered refracting surface of the prism is
a) 0 b) $\pi/6$ c) $\pi/4$ d) $\pi/3$

93. A point object is placed at a distance of 25 cm from a convex lens of focal length 20 cm. If a glass slab of thickness t and refractive index 1.5 is inserted between the lens and the object, the image if formed at infinity. The thickness t is
a) 10 cm b) 5 cm c) 20 cm d) 15 cm

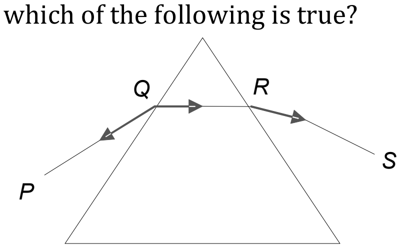
94. A lens forms a virtual, diminished image of an object placed at 2 m from it. The size of image is half of the object. Which one of the following statements is correct regarding the nature and focal length of the lens?
a) Concave, $|f| = 1$ m b) Convex, $|f| = 1$ c) Concave, $|f| = 2$ m d) Convex, $|f| = 2$ m

95. A convex lens forms an image of an object placed 20 cm away from it at a distance of 20 cm on the other side of the lens. If the object is moves 5 cm toward the lens, the image will be
a) 5 cm toward the lens b) 5 cm away from the lens
c) 10 cm toward the lens d) 10 cm away from the lens

96. A cubic container is filled with a liquid whose refractive index increases linearly from top to bottom. Which of the following represents the path of a ray of light inside the liquid?



97. A ray of light is incident on an equilateral glass prism placed on a horizontal table. For minimum deviation which of the following is true?

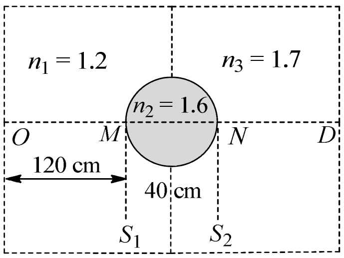


a) PQ is horizontal b) QR is horizontal

c) RS is horizontal
d) Either PQ or RS is horizontal

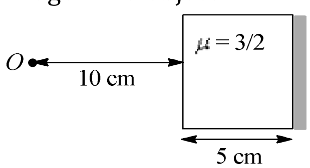
98. A plane mirror is placed at origin parallel to y-axis, facing the positive x-axis. An object starts from (2 m, 0, 0) with a velocity of $(2\hat{i} + 2\hat{j})\text{ms}^{-1}$. The relative velocity of the image with respect to the object is along
a) Positive x-axis
b) Negative x-axis
c) Positive y-axis
d) Negative y-axis

99. A transparent sphere of radius 20 cm and refractive index 1.6 is fixed in a hole of the partition separating the two media: A (refractive index $n_1 = 1.2$) and B(refractive index $n_3 = 1.7$). A luminous point object is placed 120 cm from the surface of the sphere in medium A. It is viewed from D in medium B in a direction normal to the sphere. Find the position of the image formed by the rays, from point N



a) 304 cm, left side of N
b) 175 cm, right side of N
c) 204 cm, right side of N
d) 220 cm, left side of N

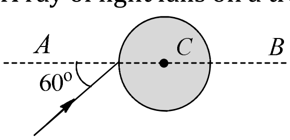
100. A point object is placed in front of a thick plane mirror as shown in figure below. Find the location of final image w.r.t. object



a) 15/2 cm
b) 15 cm
c) 40/3 cm
d) 80/3 cm

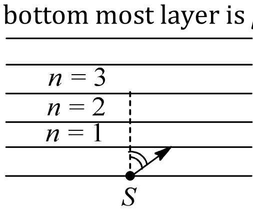
101. An object is kept at a distance of 16 cm from a thin lens and the image formed is real. If the object is kept at a distance of 6 cm from the same lens, the image formed is virtual. If the sizes, of the images formed are equal, the focal length of the lens will be
a) 15 cm
b) 17 cm
c) 21 cm
d) 11 cm

102. A ray of light falls on a transparent sphere with centre at C as shown in figure



The ray emerges from the sphere parallel to line AB. The refractive index of the sphere is
a) $\sqrt{2}$
b) $\sqrt{3}$
c) 3/2
d) 1/2

103. A point source S is placed at the bottom of different layers as shown in figure. The refractive index of the bottom most layer is μ_0. The refractive index of any other upper layer is



$\mu(n) = \mu_0 - \frac{\mu_0}{4n-18}$, where $n = 1, 2, ...$

A ray of light starts from the source S as shown. Total internal reflection takes place at the upper surface of a layer having n equal to
a) 3
b) 5
c) 4
d) 6

104. A ray of light from a denser medium strikes a rarer medium at an angle of incidence i. The reflected and refracted rays make an angle of $\pi/2$ with each other. If the angles of reflection and refraction are r and r',

then the critical angle will be

a) $\tan^{-1}(\sin i)$ b) $\sin^{-1}(\sin r)$ c) $\sin^{-1}(\tan i)$ d) $\sin^{-1}(\tan r)$

105. A cubical room is formed with six plane mirrors. An insect moves along the diagonal of the floor with uniform speed. The velocities of its image in two adjacent walls are $20\sqrt{2}\text{cm s}^{-1}$. Then, the velocity of the image formed by the roof is

a) 20 cm s^{-1} b) $20\sqrt{2}\text{cm s}^{-1}$ c) 40 cm s^{-1} d) $10\sqrt{2}\text{cm s}^{-1}$

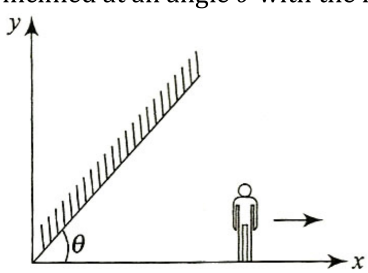
106. A liquid of refractive index 1.6 is contained in the cavity of a glass specimen of refractive index 1.5 as shown in figure. If each of the curved surfaces has a radius of curvature of 0.20 m, the arrangement behaves as a

a) Converging lens of focal length 0.25 m b) Diverging lens of focal length 0.25 m
c) Diverting lens of focal length 0.17 m d) Converging lens of focal length 0.72 m

107. A concave spherical refractive surface with radius R separates a medium of refractive index $5/2$ from air. As an object is approaching the surface from far away from the surface along the central axis, its image

a) Always remains real
b) Always remains virtual
c) Changes from real to virtual at a distance $2R/3$ from the surface
d) Changes from virtual to real at a distance $2R/3$ from the surface

108. A man is walking under an inclined mirror at a constant velocity $V\text{ ms}^{-1}$ along the X-axis. If the mirror is inclined at an angle θ with the horizontal, then what is the velocity of the image?



a) $V\sin\theta\hat{\imath} + V\cos\theta\,\hat{\jmath}$ b) $V\cos\theta\,\hat{\imath} + V\sin\theta\,\hat{\jmath}$ c) $V\sin 2\theta\hat{\imath} + V\cos 2\theta\,\hat{\jmath}$ d) $V\cos 2\theta\,\hat{\imath} + V\sin 2\theta\,\hat{\jmath}$

109. A spherical mirror forms an image of magnification 3. The object distance, if local length of mirror is 24 cm, may be

a) 32 cm, 24 cm b) 32 cm, 16 cm c) 32 cm only d) 16 cm only

110. A concave refractive surface of a medium having refractive index μ produces a real image of an object (located outside the medium) irrespective of its location. Choose the correct option from the following

a) Always
b) May be if refractive index of surrounding medium is greater than μ
c) May be if refractive index of surrounding medium less than μ
d) None of the above

111. The table below shows object and image distances for four objects placed in front of mirrors. For which one is the image formed by a convex spherical mirror. [Positive and negative signs are used in accordance with standard sign convention]

Object distance	Image distance		
a) −7.10 cm	−18.0 cm	b) −25.0 cm	−16.7 cm
c) −5.0 cm	+1.0 cm	d) −20.0 cm	+5.71 cm

112. The refractive index of a prism is 2. The prism can have a maximum refracting angle of

a) 90° b) 60° c) 45° d) 30°

$\sum$ is a screen. The intensity at the centre of screen is found to be I

If the mirror is removed, then the intensity at the center of screen would be

a) I b) $10I/9$ c) $9I/10$ d) $2I$

114. The refracting angle of a prism is A and refractive index of the material of prism is $\cot(A/2)$. The angle of minimum deviation will be

a) $180° - 3A$ b) $180° + 3A$ c) $90° - 3A$ d) $180° - 2A$

115. A point object is kept in front of a plane mirror. The plane mirror is doing SHM of amplitude 2 cm. The plane mirror moves along the x-axis which is normal to the mirror. The amplitude of the mirror is such that the object is always in front of the mirror. The amplitude of SHM of the image is

a) 0 b) 2 cm c) 4 cm d) 1 cm

116. An eye specialist prescribes spectacles having a combination of convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm. The power of this lens combination in dioptres is

a) $+1.5$ b) -1.5 c) $+6.67$ d) -6.67

117. The lateral magnification of the lens with an object located at two different positions u_1 and u_2 are m_1 and m_2 respectively. Then the focal length of the lens is

a) $f = \sqrt{m_1 m_2}(u_2 - u_1)$ b) $f = \sqrt{m_1 m_2}(u_2 - u_1)$ c) $\dfrac{(u_2 - u_1)}{\sqrt{m_2 m_1}}$ d) $\dfrac{(u_2 - u_1)}{(m_2)^{-1} - (m_1)^{-1}}$

118. In a thick glass slab of thickness l, and refractive index n_1, a cuboidal cavity of thickness 'm' is carved as shown in the fig and is filled with a liquid of R.I. $n_2 (n_1 > n_2)$. The ratio l/m, so that shift produced by this slab is zero when an observer A observes an object B with paraxial rays is

a) $\dfrac{n_1 - n_2}{n_2 - 1}$ b) $\dfrac{n_1 - n_2}{n_2(n_1 - 1)}$ c) $\dfrac{n_1 - n_2}{n_1 - 1}$ d) $\dfrac{n_1 - n_2}{n_1(n_2 - 1)}$

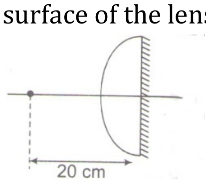
119. A ray of light enters a rectangular glass slab of refractive index $\sqrt{3}$ at an angle of incidence 60°. It travels a distance of 5 cm inside the slab and emerges out of the slab. The perpendicular distance between the incident and the emergent rays is

a) $5\sqrt{3}$cm b) $\dfrac{5}{2}$cm c) $5\sqrt{3/2}$cm d) 5 cm

120. A convex lens is in contact with concave lens. The magnitude of the ratio of their focal length is 2/3. Their equivalent focal length is 30 cm. What are their individual focal lengths?

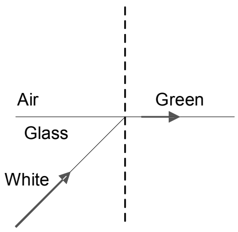
a) -75, 50 b) -10, 15 c) 75, 50 d) -15, 10

121. A point object is placed at distance of 20 cm from a thin planoconvex lens of focal length 15 cm. The plane surface of the lens is now silvered. The image created by the system is at



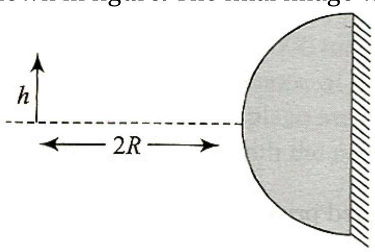
a) 60 cm to the left of the system
b) 60 cm to the right of the system
c) 12 cm to the left of the system
d) 12 cm to the right of the system

122. While light is incident on the interface of glass and air as shown in the figure. If green light is just totally internally reflected then the emerging ray in air contains



a) Yellow, orange, red
b) Violet,indigo,blue
c) All colours
d) All colours except green

123. A glass hemisphere of radius R and of material having refractive index 1.5 is silvered on its flat face as shown in figure. A small object of height h is located at a distance $2R$ from the surface of hemisphere as shown in figure. The final image will form



a) At a distance of R from silvered surface, on the right side
b) On the object itself
c) At hemisphere surface
d) At a distance of $2R$ from the silvered surface, on left side

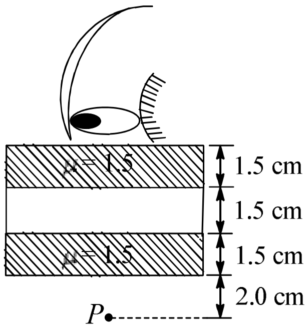
124. Light of wavelength 500 nm travelling with a speed of $2.0 \times 10^8 \text{ms}^{-1}$in a certain medium enters another medium of refractive index 5/4 times that of the first medium. What are the wavelength and speed in the second medium?

	Wavelength (nm)	speed (ms^{-1})
a)	400	1.6×10^8
b)	400	2.5×10^8
c)	500	2.5×10^8
d)	625	1.6×10^8

125. A ray of light passes through a rectangular glass block placed in a homogeneous medium. It is refracted and totally reflected. Which diagram shows a possible path of this ray?

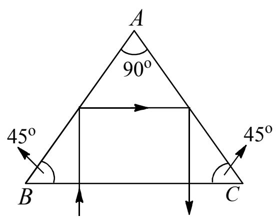
a) b) c) d)

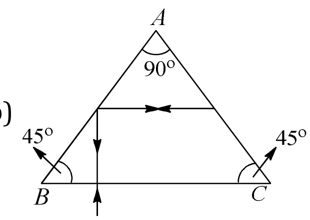
126. The image of point P when viewed from top of the slabs will be

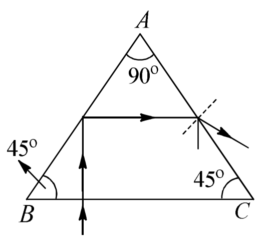


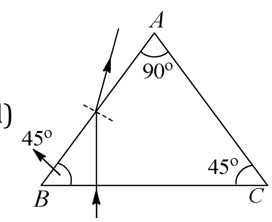
a) 2.0 cm above P b) 1.5 cm above P c) 2.0 cm below P d) 1 cm above P

127. The refractive index of material of a prism of angles 45°, −45°, and −90° is 1.5. The path of the ray of light incident normally on the hypotenuse side is shown in

a) 

b) 

c) 

d) 

128. A concave mirror has a focal length of 20 cm. The distance between the two positions of the object for which the image size is double of the object size is

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

129. In the above question, the breadth and height of the second car seen in the mirror of the first car are, respectively,

a) 5.79 cm and 6.9 cm b) 6.45 cm and 5.16 cm c) 2.7 cm and 4.8 cm d) 0.1 m and 0.3 m

130. A concave lens made of water ($\mu = 1.33$) is placed inside a glass slab ($\mu = 1.5$) for an object placed between the focus and twice the focus. The image formed is

a) Virtual
b) Real, inverted, and magnified
c) Virtual, inverted, and magnified
d) Real, inverted, and diminished

131. Image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from $\frac{25}{3}$ m to $\frac{50}{7}$ m in 30 s. What is the speed of the object in kmh^{-1}?

a) 3 b) 4 c) 5 d) 6

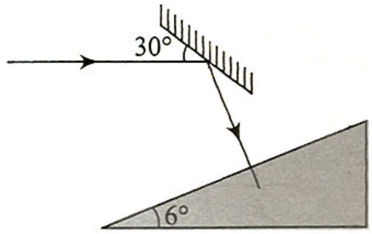
132. A convex spherical refracting surface with radius R separates a medium having refractive index 5/2 from air. As an object is moved towards the surface from far away from the surface along the principle axis, its image

a) Changes from real to virtual when it is at a distance R from the surface
b) Changes from virtual to real when it is at a distance R from the surface
c) Changes from real to virtual when it is at a distance $2R/3$ from the surface
d) Changes from virtual to real when it is at a distance $2R/3$ from the surface

133. A convex lens of focal length 1.0 m and a concave lens of focal length 0.25 m are 0.75 m apart. A parallel beam of light is incident on the convex lens. The beam emerging after refraction from both lenses is

a) Parallel to the principle axis
b) Convergent
c) Divergent
d) None of the above

134. Find the net deviation produced in the incident ray for the optical instrument shown in figure below. (Take refractive index of the prism material as 2.)



a) 66° CW b) 66° ACW c) 54° ACW d) 54° CW

135. Two point sources S_1 and S_2 are 24 cm apart. Where should a convex lens of focal length 9 cm be placed in between them so that the image of both sources are formed at the same place?

a) 6 cm from S_1 b) 15 cm from S_1 c) 10 cm from S_1 d) 12 cm from S_1

136. A hallow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 or L_2 having refractive indices n_1 and n_2, respectively $(n_2 > n_1 > 1)$. The lens will diverge parallel beam of light if it is filled with

a) Air and placed in air b) Air and immersed in L_1

c) L_1 and immersed in L_2 d) L_2 and immersed in L_1

137. A lens forms a real image of an object. The distance from the object to the lens is x cm and that from the lens to the image is y cm. the graph (see figure) shows the variation of y with x

It can be deduced that the lens is

a) Converging and of focal length 10 cm b) Converging and of focal length 20 cm

c) Converging and of focal length 40 cm d) Diverging and of focal length 20 cm

138. Figure shows the graph of angle of deviation δ versus angle of incidence i for a light ray striking a prism. The prism angle is

a) 30° b) 45° c) 60° d) 75°

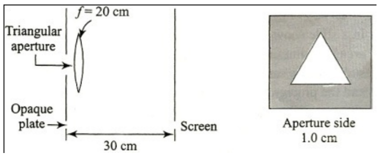
139. A point source of light B is placed at a distance L in front of the center of a mirror of width d hung vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance $2L$ from it as shown in figure. the greatest distance over which he can see the image of the light source in the mirror is

a) $d/2$ b) d c) $2d$ d) $3d$

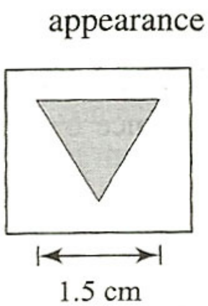
140. If ε_0 and μ_0 are respectively, the electric permittivity and the magnetic permeability of free space, ε and μ the corresponding quantities in a medium, the refractive index of the medium is

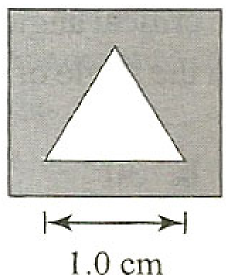
a) $\sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$ b) $\frac{\mu\varepsilon}{\mu_0\varepsilon_0}$ c) $\sqrt{\frac{\mu_0\varepsilon_0}{\mu\varepsilon}}$ d) $\sqrt{\frac{\mu\mu_0}{\varepsilon\,\varepsilon_0}}$

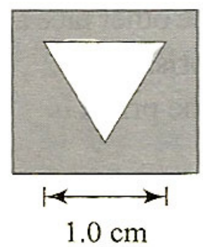
141. A parallel beam of light falls axially on a thin converging lens of focal length 20 cm. The emergent light falls or a screen placed 30 cm beyond the lens. An opaque plate with a triangular aperture, side 1 cm, is in contact with the lens. (see figure)

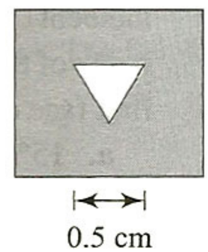


Which one of the following diagrams best shows to appearance of the patch of light seen on the screen?

a) 

b) 

c) 

d) 

142. A light ray travelling in glass medium is incident on glass-air interface at an angle of incidenceθ. The reflected (R) and transmitted (T) intensities, both as function of θ, are plotted. The correct sketch is

a) b) c) d)

143. A concave mirror is placed on a horizontal table with its axis directed vertically upward. Let O be the pole of the mirror and C its center of curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be

a) Real and will remain at C

b) Real and located at a point between C and ∞

c) Real and located at a point between O and C

d) Real and located at a point between C and O

144. Two identical glass ($\mu_g = 3/2$) equiconvex lenses of focal length f are kept in contact. The space between the two lenses is filled with water ($\mu_w = 4/3$). The focal length of the combination is

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

145. A glass sphere of radius $R = 10$ cm is kept inside water. A point object O is placed at 20 cm from A as shown in figure. Find the position and nature of the image when seen from other side of the sphere. Given $\mu_g = 3/2$ and $\mu_w = 4/3$

a) 200 cm, virtual b) 100 cm, real c) 100 cm, virtual d) 300 cm, virtual

146. A concave lens of glass, refractive index 1.5, has both surfaces of same radius of curvature R. On immersion in a medium of refractive index 1.75, it will behave as a

a) Convergent lens of focal length 3.5 R b) Convergent lens of focal length 3.0 R

c) Divergent lens of focal length 3.5 R d) Divergent lens of focal length 3.0 R

147. A point source of light is placed in front of a plane mirror as shown in figure

Determine the length of reflected path of light on the screen Σ

a) L b) $2L$ c) $3L/2$ d) $L/2$

148. The critical angle for light going from medium X into medium Y is θ. The speed of light in medium X is v. The speed of light in medium Y is

a) $v\cos\theta$ b) $v/\cos\theta$ c) $v\sin\theta$ d) $v/\sin\theta$

149. A given ray of light suffers minimum deviation in an equilateral prism P?

Additional prisms Q and R of identical shape and of the same material as P are now added as shown in figure. The ray will suffer:

a) Greater deviation b) No deviation
c) Same deviation as before d) Total internal reflection

150. A ball is dropped from a height of 20m above the surface of water in a lake. The refractive index of water is $\frac{4}{3}$. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, when the ball is 12.8 m above the water surface, the fish sees the speed of ball as

a) 9 ms^{-1} b) 12 ms^{-1} c) 16 ms^{-1} d) 21.33 ms^{-1}

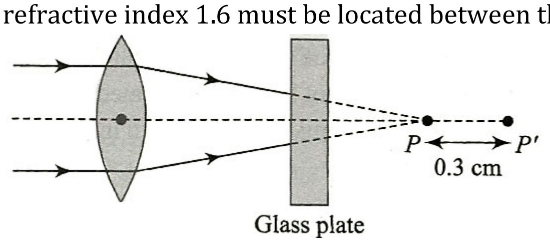
151. A beam of light passes from medium 1 to medium 2 to medium 3 as shown in figure. What may be concluded about the three indices of refraction, n_1, n_2 and n_3?

a) $n_3 > n_1 > n_2$ b) $n_1 > n_3 > n_2$ c) $n_2 > n_3 > n_1$ d) $n_2 > n_1 > n_3$

152. What is the angle of incidence for an equilateral prism of refractive index $\sqrt{3}$ so that the ray is parallel to the base inside the prism?

a) 30° b) 45° c) 60° d) Either 30°or60°

153. Rays from a lens are converging toward a point P, as shown in figure. How much thick glass plate having refractive index 1.6 must be located between the lens and point P, so that the image will be formed at P'?



a) 0.8 cm b) 1.6 cm c) 5 cm d) 2.4 cm

154. For a prism kept in air, it is found that for an angle of incidence 60°, the angle of refraction 'A', angle of deviation 'δ', and angle of emergence 'e' become equal. The minimum angle of incidence of a ray that will be transmitted through the prism is

a) 1.73 b) 1.15 c) 1.5 d) 1.33

155. A square $ABCD$ of side 1 mm is kept at distance 15 cm in front of the concave mirror as shown in figure. The focal length of the mirror is 10 cm. The length of the perimeter of its image will be

a) 8 mm b) 2 mm c) 12 mm d) 6 mm

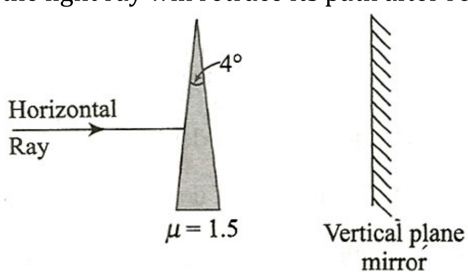
156. In question 118, if m_1 and m_2 are the magnifications for two positions of the lens, then

a) $f = \dfrac{d}{m_1 + m_2}$ b) $f = \dfrac{2d}{m_1 + m_2}$ c) $f = \dfrac{3d}{m_1 - m_2}$ d) $f = \dfrac{d}{m_1 - m_2}$

157. A glass sphere, refractive index 1.5 and radius 10 cm, has a spherical cavity of radius 5 cm concentric with it. A narrow beam of parallel light is directed into the sphere. Find the final image and its nature

a) 25 cm left of S_4, virtual b) 25 cm right of S_4, real
c) 15 cm left of S_4, virtual d) 20 cm right of S_4, virtual

158. For the situations shown in the figure, determine the angle by which the mirror should be rotated, so that the light ray will retrace its path after refraction through the prism and reflection from the mirror?



a) 1° ACW b) 1° CW c) 2° ACW d) 2° CW

159. The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30 cm is 2 cm. If a concave lens of focal length 20 cm is placed between the convex lens and the image at a distance of 26 cm from the convex lens, calculate the new size of the image

a) 1.25 cm b) 2.5 cm c) 1.05 cm d) 2 cm

160. A convex lens A of focal length 20 cm and a concave lens G of focal length 5 cm are kept along the same axis with the distance d between them. If a parallel beam of light falling on A leaves B as a parallel beam, then distance d in cm will be

a) 25 b) 15 c) 30 d) 50

161. An object 15 cm high is placed 10 cm from the optical centre of a thin lens. Its image is formed 25 cm from the optical center on the same side of the lens as the object. The height of the image is

a) 2.5 cm b) 0.2 cm c) 16.7 cm d) 37.5 cm

162. Consider an equiconvex lens of radius of curvature R and focal length f. If $f > R$, the refractive index μ of the material of the lens

a) Is greater than zero but less than 1.5 b) Is greater than 1.5 but less than 2.0
c) Is greater than 1 but less than 1.5 d) None of these

163. The velocity of light in a medium is half its velocity in air. If a ray of light emerges from such a medium into air, the angle of incidence, at which it will be totally internally reflected, is

164. Light is incident on a glass block as shown in figure. If θ_1 is increased slightly, what happens to θ_2?

a) θ_2 also increases slightly
b) θ_2 is unchanged
c) θ_2 decreases slightly
d) θ_2 changes abruptly, since the ray experiences total internal reflection

165. A spherical surface of radius of curvature R separates air (refractive index 1.0) from glass (refractive index 1.5). The centre of curvature is in the glass. A point object P placed in air is found to have a real image Q in the glass. The line PQ cuts the surface at a point O, and $\mathrm{PO} = \mathrm{OQ}$. The distance PO is equal to

a) 5 R b) 3 R c) 2 R d) 1.5 R

166. A ray of light travelling in glass ($\mu = 3/2$) is incident on a horizontal glass-air surface at the critical angle θ_C. If a thin layer of water ($\mu = 4/3$) is now poured on the glass-air surface, the angle at which the ray emerges into air at the water-air surface is

a) 60° b) 45° c) 90° d) 180°

167. Consider an equiconvex lens of radius of curvature R and focal length f. If $f > R$, the refractive index μ of the material of the lens

a) Is greater than zero but less than 1.5
b) Is greater than 1.5 but less than 2.0
c) Is greater than 1.0 but less than 1.5
d) None of these

168. If a prism having refractive index $\sqrt{2}$ has angle of minimum deviation equal to the angle of refraction of the prism, then the angle of refraction of the prism is

a) 30° b) 45° c) 60° d) 90°

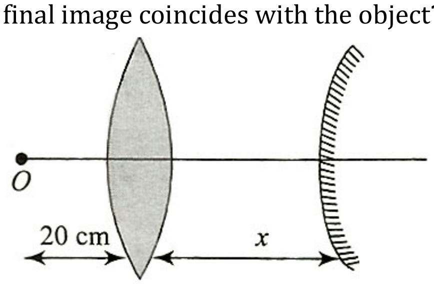
169. A car is fitted with a convex mirror of focal length 20 cm. A second car 2 m broad and 1.6 m high is 6 m away from the first car. The position of the second car as seen in the mirror of the first car is

a) 19.35 cm b) 17.45 cm c) 21.48 cm d) 5.49 cm

170. A small piece of wire bent into an L shape, with upright and horizontal portions of equal lengths, is placed with the horizontal portion along the axis of the concave mirror whose radius of curvature is 10 cm. If the bent is 20 cm from the pole of the mirror, then the ratio of the lengths of the images of the upright and horizontal portions of the wire is

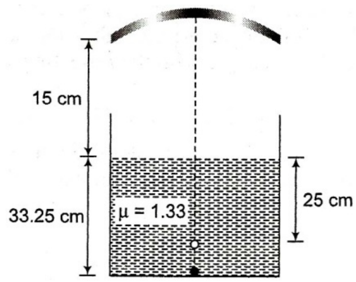
a) 1:2 b) 3:1 c) 1:3 d) 2:1

171. A point object O is placed at a distance of 20 cm from a convex lens of focal length 10 cm as shown in figure. At what distance x from the lens should a concave mirror of focal length 60 cm, be placed so that final image coincides with the object?



a) 10 cm
b) 40 cm
c) 20 cm
d) Final image can never coincide with the object in the given conditions

172. A container is filled with water(μ = 1.33) up to a height of 33.25 cm. A concave mirror is placed 15 cm above the water level and the image of an object placed at the bottom is formed 25 cm below the water level. The focal length of the mirror is



a) 10 cm b) 15 cm c) 20 cm d) 25 cm

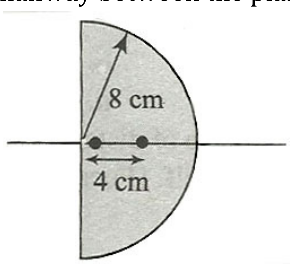
173. A, B, and C are three optical media of respective critical angles C_1, C_2, and C_3. Total internal reflection of light can occur from A and B, also from B to C but not from C to A. Then, the correct relation between the critical angles is

a) $C_1 < C_2 < C_3$ b) $C_3 < C_1 < C_2$ c) $C_1 < C_2 < C_3$ d) $C_1 < C_2 < C_3$

174. A person is looking at the image of his face in a mirror by holding it close to his face. The image is virtual. When he moves the mirror away from his face, the image is inverted. What type of mirror is he using?

a) Plane mirror b) Concave mirror
c) Convex mirror d) Combination of mirror and lenses

175. A plastic hemisphere has a radius of curvature of 8 cm and an index of refraction of 1.6. On the axis halfway between the plane surface and the spherical one (4 cm from each) is a small object O



The distance between the two images when viewed along the axis from the two sides of the hemisphere is approximately

a) 1.0 cm b) 1.5 cm c) 3.75 cm d) 2.5 cm

176. A plano-convex lens when silvered on the plane side behaves like a concave mirror of focal length 60 cm. However, when silvered on the convex side, it behaves like a concave mirror of focal length 20 cm. Then, the refractive index of the lens is

a) 3.0 b) 1.5 c) 1.0 d) 2.0

177. For statement of question 118, if the heights of the two images are h_1 and h_2, respectively, then the height of the object (h) is

a) $h_1 + h_2$ b) $h_1 h_2$ c) $\sqrt{h_1 h_2}$ d) h_1/h_2

178. A convex mirror and a concave mirror of radius 10 cm each are placed 15 cm apart facing each other. An object is placed midway between them. If the reflection first takes place in the concave mirror and then in convex mirror, the position of the final image is

a) On the pole of the convex mirror
b) On the pole of the concave mirror
c) At a distance of 10 cm from the convex mirror
d) At a distance of 5 cm from the concave mirror

179. A convex mirror of radius of curvature 1.6 m has an object placed at a distance of 1 m from it. The image is formed at a distance of

a) 8/13 m in front of the mirror b) 8/13 m behind the mirror
c) 4/9 m in front of the mirror d) 4/9 m behind the mirror

180. The image of an object placed on the principal axis of a concave mirror of focal length 12 cm is formed at a point which is 10 cm more distance from the mirror than the object. The magnification of the image is

a) 8/3 b) 2.5 c) 2 d) -1.5

immersed in a liquid of refractive index $\mu_1 = 2$, then
a) It behaves like a convex lens of 80 cm focal length
b) It behaves like a convex lens of 20 cm focal length
c) Its focal length becomes 60 cm
d) Nothing can be said

182. Light travelling through three transparent substances follows the path shown in figure. Arrange the indices of refraction in order from smallest to largest. Note that total internal refraction does occur on the bottom surface of medium 2

a) $n_1 < n_2 < n_3$ b) $n_2 < n_1 < n_3$ c) $n_1 < n_3 < n_2$ d) $n_3 < n_1 < n_2$

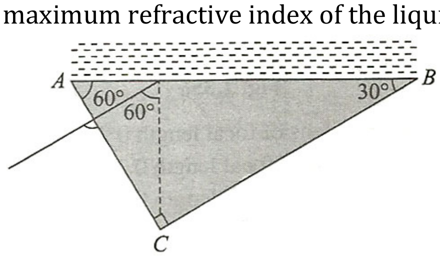
183. An equiconvex lens is made from glass of refractive index 1.5. If the radius of each surface is changed from 5 cm to 6 cm, then the power
a) Remains unchanged b) Increases by 3.33 D c) Decreases by 3.33 D d) Decreases by 5.5 D

184. A diver in a swimming pool wants to signal his distress to a person standing on the edge to the pool by flashing his water proof flash light
a) He must direct the beam vertically upward
b) He has to direct the beam horizontal
c) He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection
d) He has to direct the beam at an angle to the vertical which is slightly more than the critical angle of incidence for the total internal reflection

185. An object $ABED$ is placed in front of a concave mirror beyond the center of curvature C as shown in figure. State the shape of the image

a) $|m_{AB}| < 1$ and $|m_{ED}| < 1$
b) $|m_{AB}| > 1$ and $|m_{ED}| < 1$
c) $|m_{AB}| < 1$ and $|m_{ED}| > 1$
d) $|m_{AB}| > 1$ and $|m_{ED}| > 1$

186. ACB is right-angled prism with other angles as 60° and 30°. Refractive index of the prism is 1.5. AB has thin layer of liquid on it as shown. Light falls normally on the face AC. For total internal reflections, maximum refractive index of the liquid is



a) 1.4 b) 1.3 c) 1.2 d) 1.6

187. A large glass slab $\left(\mu = \frac{5}{3}\right)$ of thickness 8 cm is placed over a point source of light on a plane surface. It is seen that light emerges out of the top surface of the slab from a circular area of radius R cm. What is the value of R?
a) 6 cm b) 7 cm c) 8 cm d) 9 cm

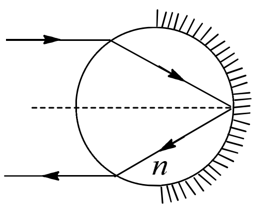
188. The focal length of the lens used in question 118 is

a) $\dfrac{D^2+d^2}{2D}$ b) $\dfrac{D^2-d^2}{4D}$ c) $\dfrac{D^2-d^2}{2D}$ d) $\dfrac{D^2+d^2}{d}$

189. A converging lens is used to form an image on a screen. When upper half of the lens is covered by an opaque screen
a) Half the image will disappear
b) Complete image will be formed of same intensity
c) Half image will be formed of same intensity
d) Complete image will be formed of decreased intensity

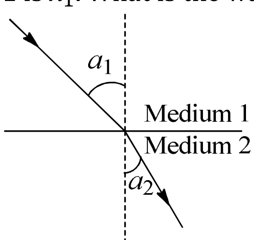
190. A clear transparent glass sphere ($\mu = 1.5$) of radius R is immersed in a liquid of refractive index 1.25. A parallel beam of light incident on it will converge to a point. The distance of this point from the center will be
a) $-3R$ b) $+3R$ c) $-R$ d) $+R$

191. A transparent cylinder has its right half polished so as to act as a mirror. A paraxial light ray incident from left, that is parallel to the principal axis, exits parallel to the incident ray as shown. The refractive index n of the material of the cylinder is



a) 1.2 b) 1.5 c) 1.8 d) 2.0

192. A beam of light propagates through a medium 1 and falls onto another medium 2, at an angle α_1 as shown in figure. After that, it propagates in medium 2 at an angle α_2 as shown. The light's wavelength in medium 1 is λ_1. What is the wavelength of light in medium 2?



a) $\dfrac{\sin\alpha_1}{\sin\alpha_2}\lambda_1$ b) $\dfrac{\sin\alpha_2}{\sin\alpha_1}\lambda_1$ c) $\dfrac{\cos\alpha_1}{\cos\alpha_2}\lambda_1$ d) $\dfrac{\cos\alpha_2}{\cos\alpha_1}\lambda_1$

193. A point object O is placed on the principle axis of a convex lens of focal length 20 cm at a distance of 40 cm to the left of it. The diameter of the lens is 10 cm. If the eye is placed 60 cm to the right of the lens at a distance h below the principal axis, then the maximum value of h to see the image will be
a) 0 b) 5 cm c) 2.5 cm d) 10 cm

194. The image produced by a concave mirror is one-quarter the size of object. If the object is moved 5 cm closer to the mirror, the image will only be half the size of the object. The focal length of mirror is
a) $f = 5.0$ cm b) $f = 2.5$ cm c) $f = 7.5$ cm d) $f = 10$ cm

195. Angle of minimum deviation is equal to the angle of prism A of an equilateral glass prism. The angle of incidence at which minimum deviation will be obtained is
a) 60° b) 30° c) 45° d) $\sin^{-1}(2/3)$

Multiple Correct Answers Type

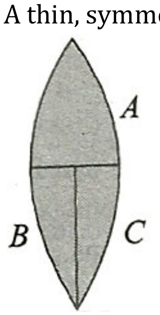
196. An isosceles prism of angle 120° has a refractive index 1.44. Two parallel monochromatic rays enter the prism parallel to each other in air as shown. The rays emerging from the opposite faces

a) Are parallel to each other
b) Are diverging
c) Make an angle of $2[\sin^{-1}(0.72) - 30°]$ with each other
d) Make an angle of $2\sin^{-1}(0.72)$ with each other

197. A luminous point object is placed at O, whose image is formed at I as shown in the figure. Line AB is the optical axis. Which of the following statement is/are correct?

a) If a lens is used to obtain the image, then it must be a converging lens and its optical center will be the intersection point of line AB and OI
b) If a lens is used to obtain the image, then it must be a diverging lens and its optical center will be the intersection point of line AB and OI
c) If a mirror is used to obtain the image, then the mirror must be concave and the object and image subtend equal angles at the pole of the mirror
d) I is a real image

198. A thin, symmetric double convex lens of power P is cut into three parts A, B, and C as shown. The power of



a) A is P b) A is $2P$ c) B is $P/2$ d) C is $P/4$

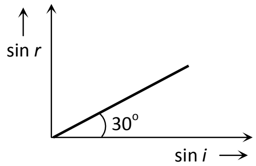
199. A fish F, in the pond is at a depth of 0.8 m from the water surface and is moving vertically upward with velocity 2ms^{-1}. At the same instant, a bird B is at a height of 6 m from the water and is moving downward with velocity 3 ms^{-1}. At this instant, both are on the same vertical line as shown in the figure. Which of the following statements are correct?

a) Height of B, observed by F (from itself), is equal to 5.30 m
b) Depth of F, observed by B (from itself), is equal to 6.60 m
c) Height of B, observed by F (from itself), is equal to 8.80 m
d) None of the above

200. A thin prism P_1 with angle 4° and made from glass of refractive index 1.54 is combined with another thin prism P_2 made from glass of refractive index 1.72 to produce dispersion without deviation. The angle of the prism P_2 is

a) 5.33° b) 4° c) 3° d) 2.6°

201. When light is incident on a medium at angle i and refracted into a second medium at an angle r, the graph of $\sin i$ vs sinr is as shown in the graph. From this, one can conclude that



a) Velocity of light in the second medium is 1.73 times the velocity of light in the I medium
b) Velocity of light in the I medium is 1.73 times the velocity in the II medium
c) The critical angle for the two media is given by $\sin i_c = \frac{1}{\sqrt{3}}$
d) $\sin i_c = \frac{1}{2}$

202. A lens of focal length 'f' is placed in between an object and screen at a distance 'D'. The lens forms two real images of object on the screen for two of its different positions, a distance 'x' apart. The two real images have magnifications m_1 and m_2, respectively $(m_1 > m_2)$. Then,
a) $f = x/(m_1 - m_2)$ b) $m_1 m_2 = 1$ c) $f = (D^2 - x^2)/4D$ d) $D \geq 4f$

203. A hallow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 or L_2 having refractive indices μ_1 and μ_2 respectively $(\mu_2 > \mu_1 > 1)$. The lens will diverge a parallel beam of light if it is filled with
a) Air and placed in air b) Air and immersed in L_1
c) L_1 and immersed in L_2 d) L_2 and immersed in L_1

204. When a real object is placed 25 cm from a lens, a real image is formed. Mark the correct statement(s) from the following:
a) The lens is a converging lens
b) The image may be magnified or diminished
c) The focal length of the lens is less than 25 cm
d) The focal length of the lens may be greater than 25 cm

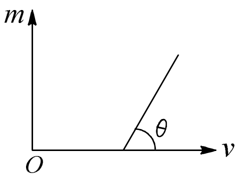
205. A point object is at 30 cm from a convex glass lens $\left(\mu_s = \frac{3}{2}\right)$ of focal length 20 cm. The final image of object will be formed at infinity if
a) Another concave lens of focal length 60 cm is placed in contact with the previous lens
b) Another convex lens of focal length 60 cm is placed at a distance of 30 cm from the first lens
c) The whole system is immersed in a liquid of refractive index 4/3
d) The whole system is immersed in a liquid of refractive index 9/8

206. A real point source is 5 cm away from a plane mirror whose reflecting ability is 50%, while the eye of an observer (pupil diameter 5 mm) is 10 cm away from the mirror. Assume that both source and eye are on the same line perpendicular to the surface and reflected rays have no effect on intensity. Then,
a) The area of the mirror used in observing the image of source is $(25\pi/36)\text{mm}^2$
b) The area of the mirror used in observing the image of source is 25π mm^2
c) The ratio of the intensities of light as received by the observer in the presence to that in the absence of mirror is (10/9)
d) The ratio of the intensities of light as received in the presence to that in the absence of mirror is 19/18

207. Mark the correct statement(s) from the following:
a) Image formed by a convex mirror can be real
b) Image formed by a convex mirror can be virtual
c) Image formed by a convex mirror can be magnified
d) Image formed by a convex mirror can be inverted

208. In a compound microscope, the intermediate image is
a) Virtual, erect, and magnified b) Real, erect, and magnified
c) Real, inverted, and magnified d) Virtual, erect, and reduced

209. Figure shows variation of magnification m (produced by a thin convex lens) and distance v of image from pole of the lens. Which of the following statements are correct?



a) Focal length of the lens is equal to intercept on v-axis

b) Focal length of the lens is equal to inverse of slope of the line

c) Magnitude of intercept on m-axis is equal to unity

d) None of the above

210. A converging lens of focal length f_1 is placed in front of and coaxially with a convex mirror of focal length f_2. Their separation is d. A parallel beam of light incident on the lens returns as a parallel beam from the arrangement. Then,

a) The beam diameters of the incident and reflected beams must be the same

b) $d = f_2 - 2|f_2|$

c) $d = f_1 - |f_2|$

d) If the entire arrangement is immersed in water, the conditions will remain unaltered

211. Mark the correct statement(s) w.r.t. a concave spherical mirror

a) For real extended object, it can form a diminished virtual image

b) For real extended object, it can form a magnified virtual image

c) For virtual extended object, it can form a diminished real image

d) For virtual extended object, it can form a magnified real image

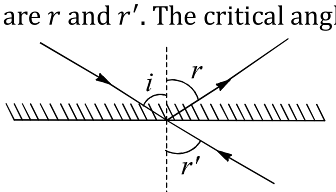
212. Two coherent monochromatic light beams of intensities I and $4I$ are superposed. The maximum and minimum possible intensities in the resulting beam are

a) $5I$ and I b) $5I$ and $3I$ c) $9I$ and I d) $9I$ and $3I$

213. A ray of light travelling in a transparent medium falls on a surface separating the medium from air, at an angle of incidence of 45°. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible values of n from the following

a) 1.3 b) 1.4 c) 1.5 d) 1.6

214. A ray of light from a denser medium strikes a rarer medium at an angle of incidence i (see figure). The reflected and refracted rays make an angle of 90° with each other. The angles of reflection and refraction are r and r'. The critical angle is



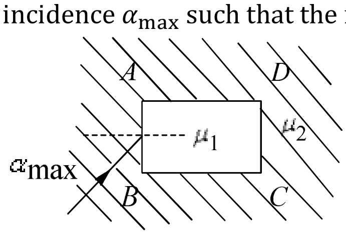
a) $\sin^{-1}(\tan r)$

b) $\sin^{-1}(\tan i)$

c) $\sin^{-1}(\tan r')$

d) $\tan^{-1}(\sin i)$

215. A rectangular glass slab $ABCD$ of refractive index n_1 is immersed in water of refractive index $n_2 (n_1 < n_2)$. A ray of light is incident at the surface AB of the slab as shown. The maximum value of the angle of incidence $\alpha_{\max}$ such that the ray comes out from the other surface CD is given by



a) $\sin^{-1}\left[\frac{n_1}{n_2}\cos\left(\sin^{-1}\left(\frac{n_2}{n_1}\right)\right)\right]$ b) $\sin^{-1}\left[n_1\cos\left(\sin^{-1}\left(\frac{1}{n_2}\right)\right)\right]$

c) $\sin^{-1}\left(\frac{n_1}{n_2}\right)$ d) $\sin^{-1}\left(\frac{n_2}{n_1}\right)$

216. Two lenses, one concave and the other convex of same power are placed such that their principal axes coincide. If the separation between the lenses is x, then
a) Real image is formed for $x = 0$ only
b) Real image is formed for all values of x
c) System will behave like a glass plate for $x = 0$
d) Virtual image is formed for all values of x other than zero

217. A real image of a distant object is formed by a plano-convex lens on its principal axis. Spherical aberration
a) Is absent
b) Is smaller if the curved surface of the lens faces the object
c) Is smaller if the plane surface of the lens faces the object
d) Is the same whichever side of the lens faces the object

218. The object distance u, the image distance v and the magnification m in a lens follow certain linear relations. These are
a) $\frac{1}{u}$ versus $\frac{1}{v}$ b) m versus u c) u versus v d) m versus v

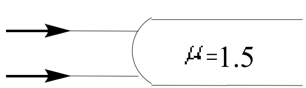
219. Which of the following statements is/are correct about the refraction of light from a plane surface when light ray is incident in denser medium. [C is critical angle]
a) The maximum angle of deviation during refraction is $(\pi/2) - C$, it will be at angle of incidence C
b) The maximum angle of deviation for all angles of incidence is $\pi - 2C$, when angle of incidence is slightly greater than C
c) If angle of incidence is less than C, then deviation increases if angle of incidence is also increased
d) If angle of incidence is greater than C, then angle of deviation decreases if angle of incidence is increased

220. A glass prism of refractive index 1.5 is immersed in water (refractive index 4/3). A light beam normally on the face AB is totally reflected to reach on the face BC if

a) $\sin\theta \geq \frac{8}{9}$ b) $\frac{2}{3} < \sin\theta \geq< \frac{8}{9}$ c) $\sin\theta \leq \frac{2}{3}$ d) $\sin\theta \leq \frac{8}{9}$

221. An eye specialist prescribes spectacles having combination of convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm. The power of this lens combination in diopters is
a) +1.5 b) −1.5 c) +6.67 d) −6.67

222. Parallel rays of light are falling on convex spherical surface of radius of curvature $R = 20$ cm as shown. Refractive index of the medium is $\mu = 1.5$. After refraction from the spherical surface parallel rays



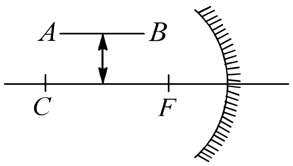
a) Actually meet at some point
b) Appears to meet after extending the refracted rays backwards
c) Meet (or appears to meet) at a distance of 30 cm from the spherical surface
d) Meet (or appears to meet) at a distance of 60 cm from the spherical surface

223. In displacement method, the distance between object and screen is 96 cm. The ratio of lengths of two images formed by a converging lensplaced between them is 4. Then,

a) Ratio of the length of object to the length of shorter image is 2
b) Distance between the two positions of the lens is 32 cm
c) Focal length of the lens is 64/3 cm
d) When the shorter image is formed on screen, distance of the lens from the screen is 32 cm

224. When a ray of light enters a glass slab from air
a) Its wavelength decreases
b) Its wavelength increases
c) Its frequency increases
d) Neither its wavelength not its frequency changes

225. An object AB is placed parallel and close to the optical axis between focus F and center of curvature C of a converging mirror of focal length f as shown in figure. Then,

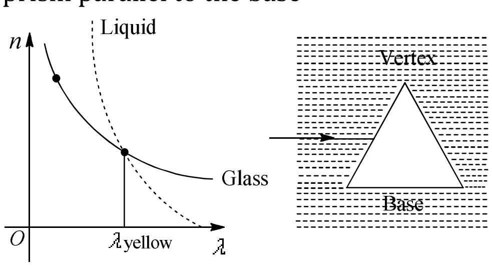


a) Image of A will be closer than that of B from the mirror
b) Image of AB will be parallel to the optical axis
c) Image of AB will be a straight line inclined to the optical axis
d) Image of AB will not be a straight line

226. In the previous question,
a) Velocity of B, observed by F (relative to itself), is equal to 4.25 ms^{-1}
b) Velocity of B, observed by F (relative to itself), is equal to 6 ms^{-1}
c) Velocity of B, observed by F (relative to itself), is equal to 5.50 ms^{-1}
d) Velocity of F, observed by B (relative to itself), is equal to 4.50 ms^{-1}

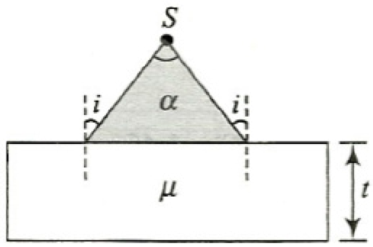
227. The focal lengths of the objective and the eyepiece of a compound microscope are 2.0 cm and 3.0 cm, respectively. The distance between the objective and the eyepiece is 15.0 cm. The final image formed by the eyepiece is at infinity. The two lenses are thin. The distance, in cm, of the object and the image produced by the objective, measured from the objective lens, are respectively
a) 2.4 and 12.0 b) 2.4 and 15.0 c) 2.0 and 12.0 d) 2.0 and 3.0

228. A glass prism is immersed in a hypothetical liquid. The curves showing the refractive index n as a function of wavelength λ for glass and liquid are as shown in figures. When a ray of white light is incident on the prism parallel to the base



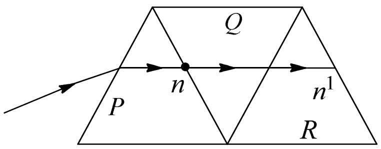
a) Yellow ray travels without deviation
b) Blue ray is deviated toward the vertex
c) Red ray is deviated toward the base
d) There is no dispersion

229. A diverging beam of light from a point source S having divergence angle α, falls symmetrically on a glass slab as shown. The angle of incidence of the two extreme rays are equal. If the thickness of the glass slab is t and the refractive index n, then the divergence angle of the emergent beam is



a) Zero
b) α
c) $\sin^{-1}\left(\frac{1}{n}\right)$
d) $2\sin^{-1}\left(\frac{1}{n}\right)$

230. A given ray of light suffers minimum deviation in an equilateral prism P. Additional prism Q and R of identical shape and of the same material as P are now added as shown in the figure. The ray will now suffer

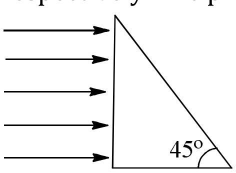


a) Greater deviation
b) No deviation
c) Same deviation as before
d) Total internal reflection

231. A spherical surface of radius of curvature R separates air (refractive index 1.0) from glass (refractive index 1.5). The center of curvature is in the glass. A point object P placed in air is found to have a real iamge Q in the glass. The line PQ cuts the surface at a point O, and $PO = OQ$. The distance PO is equal to

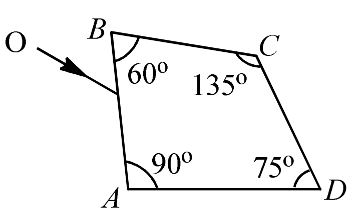
a) $5R$
b) $3R$
c) $2R$
d) $1.5R$

232. A beam of light consisting of red, green, and blue colors is incident on a right-angled prism. The refractive indices of the material of the prism for the above red, green, and blue wavelength are 1.39, 1.44, and 1.47 respectively. The prism will



a) Separate part of the red color from the green and blue colors
b) Separate part of the blue color from the red and green colors
c) Separate all the three colors from one another
d) Not separate even partially any color from the other two colors

233. A ray OP of monochromatic light is incident on the face $AB$of prism $ABCD$near vertex$B$at an incident angle of 60° (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) correct?



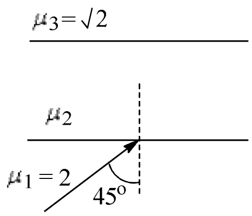
a) The ray gets totally internally reflected at face CD
b) The ray comes out through face AD
c) The angle between the incident ray and the emergent ray is 90°
d) The angle between the incident ray and the emergent ray is `

234. An image of a bright square is obtained on a screen with the aid of a convergent lens. The distance between the square and the lens is 40 cm. The area of the image is nine times larger than that of the square. Select the correct statement(s):

a) Image is formed at a distance of 120 cm from the lens

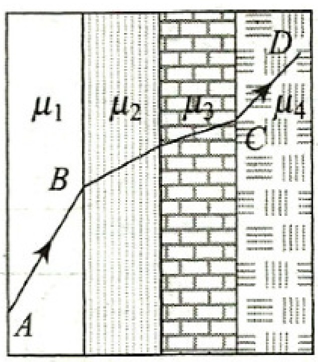
b) Image is formed at a distance of 360 cm from the lens
c) Focal length of the lens is 30 cm
d) Focal length of the lens is 36 cm

235. In the diagram shown, a light ray is incident on the lower medium boundary at an angle if 45°with the normal. Which of the following statements is/are true?



a) If $\mu_2 > \sqrt{2}$, then angle of deviation is 45°
b) If $\mu_2 < \sqrt{2}$, then angle of deviation is 90°
c) If $\mu_2 < \sqrt{2}$, then angle of deviation is 135°
d) If $\mu_2 > \sqrt{2}$, then angle of deviation is 0°

236. A ray of light passes through four transparent media with refractive indices μ_1, μ_2, μ_3, and μ_4 as shown in figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have

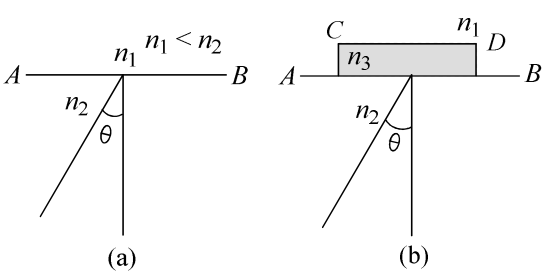


a) $\mu_1 = \mu_2$
b) $\mu_2 = \mu_3$
c) $\mu_3 = \mu_4$
d) $\mu_4 = \mu_1$

237. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen
a) Half the image will disappear
b) Complete image will be formed
c) Intensity of the image will increase
d) Intensity of the image will decrease

238. A concave mirror is placed on a horizontal table, with its axis directed vertically upward. Let O be the pole of the mirror and C its center of curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be
a) Real, and will remain at C
b) Real, and located at a point between C and ∞
c) Virtual, and located at a point between C and O
d) Real, and located at a point between C and O

239. In figure, light is incident at an angle θ which is slightly greater than the critical angle. Now, keeping the incident angle fixed a parallel slab of refractive index n_3 is placed on surface AB. Which of the following statements are correct?



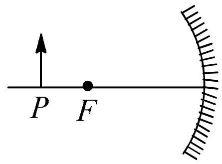
a) Total internal reflection occurs at AB for$n_3 < n_1$
b) Total internal reflection occurs at AB for$n_3 > n_1$

c) The ray will return back to the same medium for all values of n_3
d) Total internal reflection occurs at CD for $n_3 < n_1$

240. Two light source with equal luminous intensity are lying at a distance of 1.2 m from each other. Where should a screen be placed between them such that illuminance on one of its faces is four times that on another face

a) 0.2 m b) 0.4 m c) 0.8 m d) 1.6 m

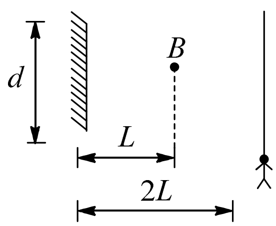
241. The diagram below shows an object located at point P, 0.25 meter from concave spherical mirror with principal focus F. The focal length of the mirror is 0.10 m



How does the image change if the object is moved from point P toward point F?

a) Its distance from the mirror decreases b) The size of image decreases
c) Its distance from the mirror increases d) The size of image increases

242. A point source of light B is placed at a distance L in front of the center of a mirror of width 'd' hung vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance $2L$ from it as shown in figure. The greatest distance over which he can see the image of the light source in the mirror is



a) $d/2$ b) d c) $2d$ d) $3d$

243. A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. The power of the combination is

a) −1.5 dioptres b) −6.5 dioptres c) +6.5 dioptres d) +6.67 dioptres

244. Spherical aberration in a thin lens can be reduced by

a) Using a monochromatic light
b) Using a doublet combination
c) Using a circular annular mark over the lens
d) Increasing the size of the lens

245. Which of the following form(s) a virtual and erect image for all positions of the object

a) Convex lens b) Concave lens c) Convex mirror d) Concave mirror

246. A diminished image of an object is to be obtained on a screen 1.0 m from it. This can be achieved by appropriately placing

a) A concave mirror of suitable focal length
b) A convex mirror of suitable focal length
c) A convex lens of focal length less than 0.25 m
d) A concave lens of suitable focal length

247. A ray of light travelling in transparent medium falls on a surface separating the medium from air at an angle of incidence of 45°. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible value(s) of n from the following:

a) 1.3 b) 1.4 c) 1.5 d) 1.6

248. A planet is observed by an astronomical refracting telescope having an objective of focal length 16 m and an eyepiece of focal length 2 cm. Then,

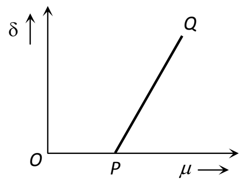
a) The distance between the objective and the eyepiece is 16.02 m
b) The angular magnification of the planet is −800

c) The image of the planet is inverted
d) The objective is larger than the eyepiece

249. Which of the following form(s) a virtual and erect image for all positions of the object?
a) Convex lens b) Concave lens c) Convex mirror d) Concave mirror

250. There are three optical media, 1,2 and 3 with their refractive indices $\mu_1 > \mu_2 > \mu_3$. (TIR-total internal reflection)
a) When a ray light travels from 3 to 1 no TIR will take place
b) Critical angle between 1 and 2 is less than the critical angle between 1 and 3
c) Critical angle between 1 and 2 is more than the critical angle between 1 and 3
d) Chances of TIR are more when ray of light travels from 1 to 3 compare to the case when it travel from 1 to 2

251. For a small angled prism, angle of prism A, the angle of minimum deviation (δ) varies with the refractive index of the prism as shown in the graph



a) Point P corresponds to $\mu = 1$
b) Slope of the line $PQ = A/2$
c) Slope $= A$
d) None of the above statements is true

252. In Young's double slit experiment, the separation between the slits is halved and the distance between the slits and the screen is doubled. The fringe width is
a) Unchanged b) Halved c) Doubled d) Quadrupled

253. A beam of light of wavelength 600 nm from a distance source falls on a single slit 1 mm wide and a resulting diffraction pattern is observed on a screen 2 m away. The distance between the first dark fringes on either side of central bright fringe is
a) 1.2 cm b) 1.2 mm c) 2.4 cm d) 2.4 mm

254. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen
a) Half the image will disappear
b) Complete image will be formed
c) Intensity of the image will increase
d) Intensity of the image will decrease

255. Two converging lenses of focal lengths$f_1 = 10$ cm and $f_2 = 20$ cm are placed at some separation. A parallel beam of light is incident on 1st lens. Then,
a) For emergent beam from 2nd lens to be parallel, the separation between the lenses has to be 30 cm
b) For emergent beam from 2nd lens to be parallel, the separation between the lenses has to be 60 cm
c) If lenses are placed at such a separation that emergent beam from 2nd lens is parallel, then the emergent beam width is 2 cm if original beam has a width of 1 cm
d) If lenses are placed at such a separation that emergent beam from 2nd lens is parallel, then the emergent beam width is 4 cm if original beam width is 1 cm

256. A diverging lens of focal length f_1 is placed in front of and coaxially with a concave mirror of focal length f_2. Their separation is d. A parallel beam of light incident on the lens returns as a parallel beam from the arrangement. Then,
a) The beam diameters of the incident and reflected beams must be the same
b) $d = 2|f_2| - |f_1|$
c) $d = |f_2| - |f_1|$
d) If the entire arrangement is immersed in water, the conditions will remain unaltered

257. A concave lens of glass, refractive index 1.5, has both surfaces of same radius of curvature R. On immersion in a medium of refractive index 1.75, it will behave as a
a) Convergent lens of focal length 3.5 R
b) Convergent lens of focal length 3.0 R
c) Divergent lens of focal length 3.5 R
d) Divergent lens of focal length 3.0 R

258. A planet is observed by an astronomical refracting telescope having an objective of focal length 16 m and

an eyepiece of focal length 2 cm

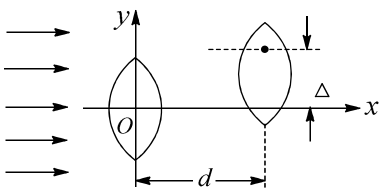
a) The distance between the objective and the eyepiece is 16.02 m

b) The angular magnification of the planet is −800

c) The image of the planet is inverted

d) The objective is larger than the eyepiece

259. Two thin convex lenses of focal length f_1 and f_2 are separated by a horizontal distance d (where $d < f_1, d < f_2$) and their centers are displaced by a vertical separation Δ as shown in the figure



Taking the origin of coordinates O at the center of the first lens, the x and y coordinates of the focal point of this lens system, for a parallel beam of rays coming from the left, are given by:

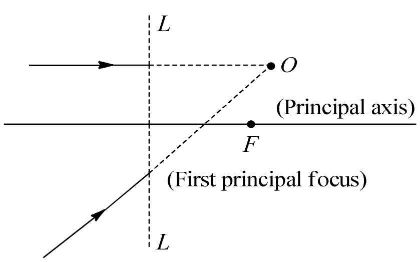
a) $x = \frac{f_1 f_2}{f_1 + f_2}, y = \Delta$

b) $x = \frac{f_1(f_2 + d)}{f_1 + f_2 - d}, y = \frac{\Delta}{f_1 + f_2}$

c) $x = \frac{f_1 f_2 + d(f_1 - d)}{f_1 + f_2 - d}, y = \frac{\Delta(f_1 - d)}{f_1 + f_2 - d}$

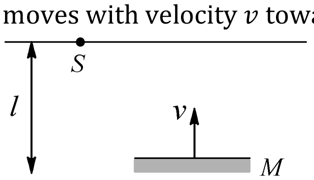
d) $x = \frac{f_1 f_2 + d(f_1 - d)}{f_1 + f_2 - d}, y = \frac{\Delta(f_1 - d)}{f_1 + f_2 - d}$

260. Consider the rays shown in the diagram as paraxial. The image of the virtual point object O formed by the lens LL is



a) Virtual
b) Real
c) Located below the principal axis
d) Located to the left of the lens

261. A plane mirror$M$ is arranged parallel to a wall W at a distance l from it. The light produced by a point source S kept on the wall is reflected by the mirror and produces a patch of light on the wall. The mirror moves with velocity v towards the wall



Which of the following statement(s) is/are correct?

a) The patch of light will move with speed v on the wall

b) The patch of light will not move on the wall

c) As the mirror comes closer, the patch of light will become larger and shift away from the wall with speed larger than v

d) The size of the patch of light on the wall remains the same

262. For which of the pairs of u and f for a mirror image is smaller in size

a) $u = -10$ cm, $f = 20$ cm
b) $u = -20$ cm, $f = -30$ cm
c) $u = -45$ cm, $f = -10$ cm
d) $u = -60$ cm, $f = 30$ cm

263. The distance between an electric lamp and a screen is $d = 1$ m. A convergent lens of focal length $f = 21$

cm is placed between the lamp and the lens such that a sharp image of the lamp filament is formed on the screen

a) The positions of the lens from the lamp for which sharp images are formed on the screen are 35 cm and 65 cm
b) The positions of the lens from the lamp for which sharp images are formed on the screen are 30 cm and 70 cm
c) Magnitude of the difference in magnification is 40/21
d) The size of the lamp filament for which there are two sharp images of 4.5 cm and 2 cm, is 3 cm

264. A plane mirror reflecting a ray of incident light is rotated through an angle θ about an axis through the point of incidence in the plane of the mirror perpendicular to the plane of incidence, then

a) The reflected ray does not rotate
b) The reflected ray rotates through an angle θ
c) The reflected ray rotates through an angle 2θ
d) The incident ray is fixed

265. Which of the following statements are correct?

a) A ray of light is incident on a plane mirror and gets reflected. If the mirror is rotated through an angle θ, then the reflected ray gets deviated through angle 2θ
b) A ray of light gets reflected successively from two mirrors which are mutually inclined. Angular deviation suffered by the ray does not depend upon angle of incidence on first mirror
c) A plane mirror cannot form real image of a real object
d) If an object approaches toward a plane mirror with velocity v, then the image approaches the object with velocity $2v$

266. A real object is moving towards a fixed spherical mirror. The image

a) Must move away from the mirror
b) May move away from the mirror
c) May move toward the mirror if the mirror is concave
d) Must move toward the mirror if the mirror is convex

267. In an astronomical telescope, the distance between the objective and the eyepiece is 36 cm and the final image formed at infinity. The focal length f_0 of the objective and the focal length f_e of the eyepiece are

a) $f_0 = 45$ cm and $f_e = -9$ cm
b) $f_0 = 50$ cm and $f_e = 10$ cm
c) $f_0 = 7.2$ cm and $f_e = 5$ cm
d) $f_0 = 30$ cm and $f_e = 6$ cm

268. A short linear object of length b lies along the axis of a concave mirror of focal length f at a distance u from the pole of the mirror. The size of the image is approximately equal to

a) $b\left(\frac{u-f}{f}\right)^{1/2}$
b) $b\left(\frac{b}{u-f}\right)^{1/2}$
c) $b\left(\frac{u-f}{f}\right)$
d) $b\left(\frac{f}{u-f}\right)^{2}$

269. A student performed the experiment of determination of focal length of a concave mirror by u-v method using an optical bench of length 1.5 meter. The focal length of the mirror used is 24 cm. The maximum error in the location of the image can be 0.2 cm. The 5 sets of (u, v) values recorded by the student (in cm) are : (42, 56), (48, 48), (60, 40), (66, 33), (78, 39). The data set(s) that cannot come from experiment and is (are) incorrectly recorded, is (are)

a) (42, 56)
b) (48, 48)
c) (66, 33)
d) (78, 39)

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 270 to 269. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

270

Statement 1: The cloud in sky generally appear to be whitish

Statement 2: Diffraction due to cloud is efficient in equal measure at all wavelengths

271

Statement 1: Glass is transparent but its powder seems opaque. When water is poured over it, it becomes transparent.

Statement 2: Light gets refracted through water.

272

Statement 1: A convex lens of focal length $f(\mu = 1.5)$ behaves as a diverging lens when immersed in carbon di-sulphide of higher refractive index $(\mu = 1.65)$

Statement 2: The focal length of a lens does not depend on the color of light used

273

Statement 1: An empty test tube dipped into water in a beaker appears silver, when viewed from a suitable direction

Statement 2: Due to refraction of light, the substance in water appears silvery

274

Statement 1: The resolving power of an electron microscope is higher than that of an optical microscope

Statement 2: The wavelength of electron is more than the wavelength of visible light

275

Statement 1: Blue colour of sky appears due to scattering of blue colour

Statement 2: Blue colour has shortest wave length in visible spectrum

276

Statement 1: Critical angle of light passing from glass to air is minimum for violet colour

Statement 2: The wavelength of violet light is greater than the light of other colours

277

Statement 1: The mirrors used in search lights are parabolic and not concave spherical.

Statement 2: In a concave spherical mirror the image formed is always virtual.

278

Statement 1: Keeping a point object fixed, if a plane mirror is moved, the image will also move

Statement 2: In case of a plane mirror, distance of object and its image is equal from any point on the mirror

279

Statement 1: The refractive index of a prism depends only on the kind of glass of which it is made of and the colour of light

Statement 2: The refractive index of a prism depends upon the refracting angle of the prism and the angle of minimum deviation

280

Statement 1: The setting sun appears to be red

Statement 2: Scattering of light is directly proportional to the wavelength

281

Statement 1: The stars twinkle while the planets do not

Statement 2: The stars are much bigger in size than the planets

282

Statement 1: We cannot produce a real image by plane or convex mirrors under any circumstances

Statement 2: The focal length of a convex mirror is always taken as positive

283 At what distance from itself will the fish see the image of the eye by direct observation?

Statement 1: $H\left(\frac{1}{2}+\mu\right)$

Statement 2: $H\left(\frac{1}{2}-\mu\right)$

284

Statement 1: In optical fibre, the diameter of the core is kept small

Statement 2: This smaller diameter of the core ensures that the fibre should have incident angle more than the critical angle required for total internal reflection

285

Statement 1: Just before setting, the sun may appear to be elliptical. This happens due to refraction

Statement 2: Refraction of light ray through the atmosphere may cause different magnification in mutually perpendicular directions

286

Statement 1: The frequencies of incident, reflected and refracted beam of monochromatic light incident from one medium to another are same

Statement 2: The incident, reflected and refracted rays are coplanar

287

Statement 1: We cannot produce a real image by plane or convex mirrors under any circumstances

Statement 2: The focal length of a convex mirror is always taken as positive

288

Statement 1: The colour of the green flower seen through red glass appears to be dark

Statement 2: Red glass transmits only red light

289

Statement 1: The focal length of a lens does not depend on the medium in which it is submerged

Statement 2: $\frac{1}{f}=\frac{\mu_2-\mu_1}{\mu_1}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

290

Statement 1: Angle of deviation depends on the angle of prism.

Statement 2: For thin prism $\delta=(\mu\text{-}1)A$ Where $\delta=$ angle of deviation $\mu=$refractive index $A=$ angle of prism

291

Statement 1: A red object appears dark in the yellow light

Statement 2: A red colour is scattered less

292

Statement 1: The resolving power of a telescope is more if the diameter of the objective lens is more

Statement 2: Objective lens of large diameter collects more light

293

Statement 1: Propagation of light through an optical fibre is due to total internal reflection taking place at the core-clad interface.

Statement 2: Refractive index of the material of the core of the optical fibre is greater than that of air.

294

Statement 1: The images formed by total internal reflections are much brighter than those formed by mirrors or lenses

Statement 2: There is no loss of intensity in total internal reflection

295

Statement 1: There is no dispersion of light refracted through a rectangular glass slab

Statement 2: Dispersion of light is the phenomenon of splitting of a beam of white light into its constituent colours

296

Statement 1: The speed of light in a rarer medium is greater than that in a denser medium

Statement 2: One light year equals to $9.5\times 10^{12}km$

297

Statement 1: Dispersion of light occurs because velocity of light in a material depends upon its colour

Statement 2: The dispersive power depends only upon the material of the prism, not upon the refracting angle of the prism

298

Statement 1: The air bubble shines in water

Statement 2: Air bubble in water shines due to refraction of light

299

Statement 1: Diamond glitters brilliantly

Statement 2: Diamond does not absorb sunlight

300

Statement 1: By increasing the diameter of the objective of telescope, we can increase its range

Statement 2: The range of a telescope tells us how far away a star of some standard brightness can be spotted by telescope

301

Statement 1: If the angles of the base of the prism are equal, then in the position of minimum deviation, the refracted ray will pass parallel to the base of prism

Statement 2: In the case of minimum deviation, the angle of incidence is equal to the angle of emergence

302

Statement 1: The polar caps of earth are cold in comparison to equatorial plane

Statement 2: The radiation absorbed by polar caps is less than the radiation absorbed by equatorial plane

303

Statement 1: The fluorescent tube is considered better than an electric bulb

Statement 2: Efficiency of fluorescent tube is more than the efficiency of electric bulb

304

Statement 1: The formula connecting u, v and f for a spherical mirror is valid only for mirrors whose sizes are very small compared to their radii of curvature.

Statement 2: Laws of reflection are strictly valid for plane surfaces, but not for large spherical surfaces.

305

Statement 1: For the sensitivity of a camera, its aperture should be reduced

Statement 2: Smaller the aperture , image focusing is also sharp

306

Statement 1: The focal length of lens does not change when red light is replaced by blue light

Statement 2: The focal length of lens does not depends on colour of light used

307

Statement 1: Owls can move freely during night

Statement 2: They have large number of rods on their retina

308

Statement 1: A virtual image can be photographed

Statement 2: Only a real image can be formed on a screen

309

Statement 1: If objective and eye lenses of a microscope are interchanged then it can work as telescope

Statement 2: The objective of telescope has small focal length

310

Statement 1: A ray is incident from outside on a glass sphere surrounded by air as shown. This ray may suffer total internal reflection at the second interface

Statement 2: For a ray going from a denser to rarer medium, the ray may suffer total internal reflection

311

Statement 1: A beam of light rays has been reflected from a rough surface

Statement 2: Amplitude of incident and reflected rays would be different

312

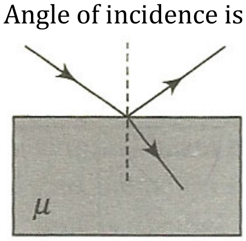
Statement 1: It is impossible to photograph a virtual image

Statement 2: The rays which appear diverging from a virtual image fall on the camera and a real image is captured

313

Statement 1: A light ray is incident on a glass slab. Some portion of it is reflected and some is refracted. Refracted and reflected rays are always perpendicular to each other

Statement 2: Angle of incidence is equal to angle of reflection



314

Statement 1: In a movie, ordinarily 24 frames are projected per second from one end to the other of the complete film

Statement 2: The image formed on retina of eye is sustained upto 1/10 second after the removal of stimulus

315

Statement 1: If a plane glass slab is placed on the letters of different colours all the letters appear to be raised up to the same height

Statement 2: Different colours have different wavelengths

316

Statement 1: The images formed by total internal reflections are much brighter than those formed by mirror or lenses

Statement 2: There is no loss of intensity in total internal reflection

317

Statement 1: Lights of different colours travel with different speeds in vacuum

Statement 2: Speed of light depends on medium

318

Statement 1: Convergent lens property of converging remain same in all mediums

Statement 2: Property of lens whether the ray is diverging or converging depends on the surrounding medium

319

Statement 1: The illuminance of an image produced by a convex lens is greater in the middle and lens towards the edges

Statement 2: The middle part of image is formed by undeflected rays while outer part by inclined rays

320

Statement 1: Using Huygen's eye-piece measurements cab be taken but are not correct.

Statement 2: The cross wires, scale and final image are not magnified proportionately because the image of the object is magnified be two lenses, whereas the cross wire scale is magnified by one lens only. Identify the correct one of the following

321

Statement 1: The focal length of the mirror is f and distance of the object from the focus is u, the magnification of the mirror is f/u

Statement 2: Magnification $= \frac{\text{Size of image}}{\text{Size of object}}$

322

Statement 1: Different colours travel with different speed in vacuum

Statement 2: Wavelength of light depends on refractive index of medium

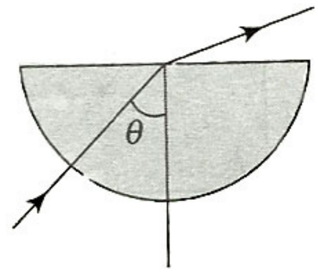
323

Statement 1: The focal length of the refractive of the telescope is larger than that of eye piece

Statement 2: The resolving power of telescope increases when the aperture of objective is small

324

Statement 1: A beam of white light enters the curved surface of a semicircular piece of glass along the normal. The incoming beam is moved clockwise (so that the angle θ increases), such that the beam always enters along the normal to the curved side. Just before the refracted beam disappears, it becomes predominantly red



Statement 2: The index of refraction for light at the red end of the visible spectrum is more than at the violet end

325

Statement 1: When a light wave travels from a rarer to a denser medium, it loses speed. The reduction in speed implies a reduction in energy carried by the light wave

Statement 2: The energy of a wave is proportional to wave frequency

326

Statement 1: A double convex lens ($\mu = 1.5$) has focal length 10 cm. When the lens is immersed in water ($\mu = 4/3$) its focal length becomes 40 cm

Statement 2: $\frac{1}{f} = \frac{\mu_1 - \mu_m}{\mu_m}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

327

Statement 1: A short sighted person cannot see objects clearly when placed beyond 50 cm. He should use a concave lens of power 2 D.

Statement 2: Concave lens should form image of an object at infinity placed at a distance of 50 cm.

328

Statement 1: A concave mirror and convex lens both have the same focal length in air. When they are submerged in water, they will still have the same focal length

Statement 2: The refractive index of water is greater than the refractive index of air

329

Statement 1: All the materials always have the same colour, whether viewed by reflected light or through transmitted light

Statement 2: The colour of material does not depend on nature of light

330

Statement 1: The reflective index of diamond is $\sqrt{6}$ and that liquid is $\sqrt{3}$. If the light travels from diamond to the liquid, it will initially reflected when the angle of incidence is 30°

Statement 2: $\mu = \frac{1}{\sin C}$ where μ is the refrective index of diamond with respect to liquid

331

Statement 1: By roughening the surface of a glass sheet its transparency can be reduced

Statement 2: Glass sheet with rough surface absorbs more light

332

Statement 1: Within a glass slab, a double convex air bubble is formed. This air bubble behaves like a converging lens

Statement 2: Refractive index of air is more than the refractive index of glass

333

Statement 1: Although the surfaces of goggle lenses are curved, it does not have any power

Statement 2: In case of goggle, both the curved surfaces have equal radii of curvature and have centre of curvature on the same side

334

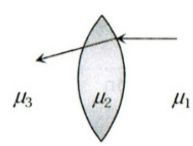
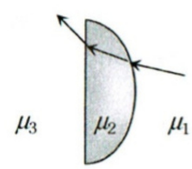
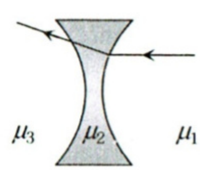
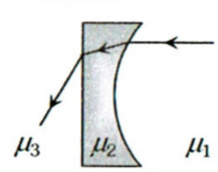
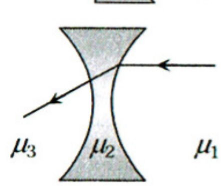
Statement 1: A short sighted person cannot see objects clearly when placed beyond 30 cm. He should use a concave lens of power 2 D

Statement 2: Concave lens should form image of an object at infinity placed at a distance of 50 cm

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II.**

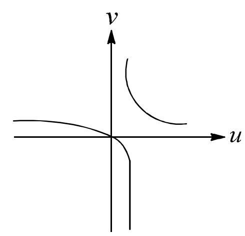
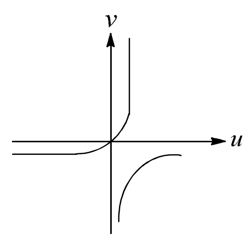
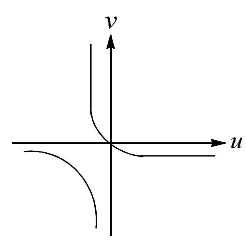
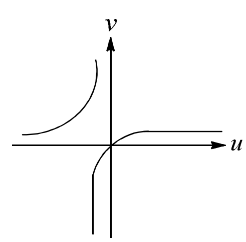
335. Two transparent media of refractive indices μ_1 and μ_3 have a solid lens shaped transparent material of refractive index μ_2 between them as shown in figures in Column-II. A ray traversing these media is also shown in the figures. In column-I different relationships between μ_1, μ_2 and μ_3 are given. Match them to the ray diagrams shown in Column-II

Column-I	Column- II
(A) $\mu_1 < \mu_2$	(p) 
(B) $\mu_1 > \mu_2$	(q) 
(C) $\mu_2 = \mu_3$	(r) 
(D) $\mu_2 > \mu_3$	(s) 
	(t) 

CODES :

	A	B	C	D
a)	P,r	q,s,t	p,r,t	q,s
b)	q,s,t	p,r	q,s	p,r,t
c)	p,r,t	q,s	p,r	q,s,t
d)	q,s	p,r,t	q,s,t	p,r

336. Match the correct $u - v$ graph with optical system using Cartesian sign conventions

Column-I	Column- II
(A) Convex mirror	(p) 
(B) Convex lens	(q) 
(C) Concave mirror	(r) 
(D) Concave lens	(s) 

CODES :

	A	B	C	D
a)	p	s	r	q
b)	s	r	q	p
c)	r	q	p	s
d)	q	p	s	r

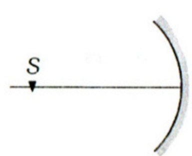
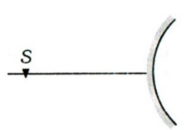
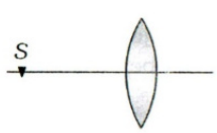
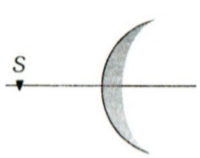
337.

Column-I		Column- II	
(A)	Object placed between optic center and 1st principal focus in a diverging lens	(p)	Image is inverted
(B)	Object placed between optic center and 1st principal focus of a converging lens	(q)	Image is erect
(C)	Object placed between optic center and 2nd principal focus of a diverging lens	(r)	Image is of greater size than the object
(D)	Object placed between optic center and 2nd principal focus of a converging lens	(s)	Image is of smaller size than the object

CODES :

	A	B	C	D
a)	Q,r	q,s	q,s	q,r
b)	q,r	q,r	q,s	q,s
c)	p,q	r,s	r,s	p,q
d)	r,s	r,s	p,q	p,q

338. An optical component and an object S placed along its optic axis are given in Column I. The distance between the object and the component can be varied. The properties of images are given in Column II. Match all the properties of images from Column II with the appropriate components given in Column I

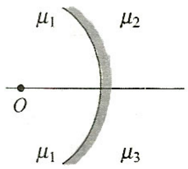
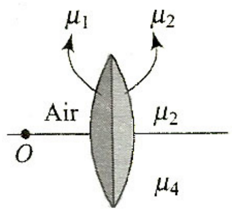
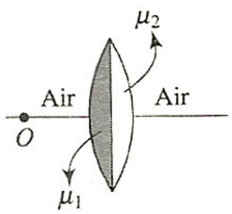
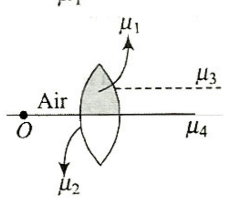
Column-I		Column- II	
(A)		(p)	Real image
(B)		(q)	Virtual image
(C)		(r)	Magnified image
(D)		(s)	Image at infinity

CODES :

	A	B	C	D
a)	P,q,r	p	q	r,s
b)	p,q,r,s	q	p,q,r,s	p,q,r,s
c)	r,s	p,q	q	p,q,r,s

d)	p,q	p,q,r,s	r,s	q

339. Match the entries of column I with entries of column II:

	Column-I		Column- II
(A)		(p)	Number of images formed is 1
(B)		(q)	Number of images formed is 2
(C)		(r)	Number of images formed is 3
(D)		(s)	Number of images formed is 4

CODES :

	A	B	C	D
a)	p	q	p	r
b)	q	p	r	p
c)	s	p	r	q
d)	q	s	r	p

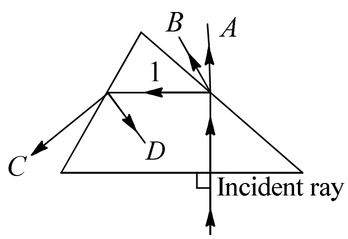
340. A small particle is placed at the pole of a concave mirror and then moved along the principal axis to a large distance. During the motion, the distance between the pole of the mirror and the image is measured. The procedure is then repeated with a convex mirror, a concave lens, and a convex lens. The graph is plotted between image distance and object distance. Match the curves shown in the graph with the mirroror lens that is corresponding to it. (Curve 1 has two segments)

Column-I		Column- II	
(A)	Converging lens	(p)	1
(B)	Converging mirror	(q)	2
(C)	Diverging lens	(r)	3
(D)	Diverging mirror	(s)	4

CODES :

	A	**B**	**C**	**D**
a)	s	p	p	r
b)	p	s	s	r
c)	p	p	q	q
d)	r	s	p	q

341. A white light ray is incident on a glass prism, and it create four refracted rays A, B, C and D. Match the refracted rays with the colors given (1 and D are rays due to total internal reflection):



Column-I		Column- II	
(A)	A	(p)	Red
(B)	B	(q)	Green
(C)	C	(r)	Yellow
(D)	D	(s)	Blue

CODES :

	A	**B**	**C**	**D**
a)	r	q	s	p
b)	q	s	p	r
c)	s	p	r	q
d)	p	r	q	s

342. Match the following:

Column-I		Column- II	
(A)	Real object, Real image	(p)	Concave mirror

(B)	Virtual object, Virtual image	(q)	Convex mirror
(C)	Real object, virtual image	(r)	Plane mirror
(D)	Virtual object, Real image	(s)	Refraction from a plane surface

CODES :

	A	**B**	**C**	**D**
a)	q	p,q,r	p,q,r,s	p
b)	p,q	s	r	q
c)	s,r	p	q	p,q
d)	p	q	p,q,r,s	p,q,r,s

343. Match List I with List II and select the correct answer using the codes given below the lists

	Column-I		Column- II
(A)	An object is placed at focus before a convex mirror	(p)	Magnification is $-\infty$
(B)	An object is placed at centre of curvature before a concave mirror	(q)	Magnification is 0.5
(C)	An object is placed at focus before a concave mirror	(r)	Magnification is $+1$
(D)	An object is placed at centre of curvature before a convex mirror	(s)	Magnification is -1
		(t)	Magnification is 0.33

CODES :

	A	**B**	**C**	**D**
a)	B	d	a	e
b)	a	d	c	b
c)	c	b	a	e
d)	b	e	d	c

344. Match the List *I* with the List *II* from the combinations shown

	Column-I		Column- II
(A)	Presbyopia	(p)	Sphero-cylindrical lens
(B)	Hypermetropia	(q)	Convex lens of proper power may be used close do the eye
(C)	Astigmatism	(r)	Concave lens of suitable focal length
(D)	Myopia	(s)	Bifocal lens of suitable focal length

CODES :

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

345. A simple telescope used to view distant objects has eyepiece and objective lenses of focal lengths f_e and f_0 respectively. Then

	Column-I		Column- II
(A)	Intensity of light received by lens	(p)	Radius of aperture
(B)	Angular magnification	(q)	Dispersion of lens
(C)	Length of telescope	(r)	Focal length of objective lens and eyepiece lens
(D)	Sharpness of image	(s)	Spherical aberration

CODES :

	A	B	C	D
a)	P,q,r	p,b	r	r
b)	r	p,q,r	r	p,b
c)	p,b	r	r	p,q,r
d)	r	p,b	p,q,r	r

346. Match the following:

	Column-I		Column- II
(A)	A convex lens in a denser medium will behave like a	(p)	Converging lens
(B)	A concave lens in a rarer medium will behave like a	(q)	Diverging lens
(C)	A plano-convex lens silvered on its curved surface and placed in air will behave like a	(r)	Concave mirror
(D)	A planoconcave lens silvered on its plane surface and placed in air will behave like a	(s)	Convex mirror

CODES :

	A	B	C	D
a)	q	p	r	s
b)	q	q	r	s
c)	s	p	q	r
d)	p	q	s	r

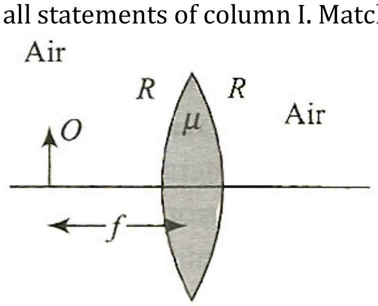
347. Four particles are moving with different velocities in front of a stationary plane mirror (lying in $y-z$ plane). At $t=0$, velocity of A is $\vec{v}_A = \hat{\imath}$, velocity of B is $\vec{v}_B = -\hat{\imath}+3\hat{\jmath}$, velocity of C is $\vec{v}_C = 5\hat{\imath}+6\hat{\jmath}$, velocity of D is $\vec{v}_D = 3i - 3\hat{\jmath}$. Acceleration of particle A is $\vec{a}_A = 2\hat{\imath}+\hat{\jmath}$ and acceleration of particle C is $\vec{a}_C = 2t\hat{\jmath}$. The particles B and D move with uniform velocity (Assume no collision to take place till $t=2$ seconds). All quantities are in S.I. units. Relative velocity of image of object A with respect to object A is denoted by $\vec{v}_{\text{A,A}}$. Velocities of images relative to corresponding object are given in column I and their values are given in column II at $t=2$ second. Match column I with corresponding values in column II

Column-I	Column- II
(A) $\vec{V}_{\text{A,A}}$	(p) $2\hat{\imath}$
(B) $\vec{V}_{\text{B}',\text{B}}$	(q) $-6\hat{\imath}$
(C) $\vec{V}_{\text{C}',\text{C}}$	(r) $-12\hat{\imath}+4\hat{\jmath}$
(D) $\vec{V}_{\text{D}',\text{D}}$	(s) $-10\hat{\imath}$

CODES :

	A	**B**	**C**	**D**
a)	q	r	p	s
b)	r	p	s	q
c)	s	p	s	q
d)	p	q	r	s

348. An object O (real) is placed at focus of an equi-biconvex lens as shown in figure. The refractive index of the lens is $\mu = 1.5$ and the radius of curvature of either surface of lens is R. The lens is surrounded by air. In each statement of column I, some changes are made to situation given above and information regarding final image formed as a result is given in Column II. The distance between lens and object is unchanged in all statements of column I. Match the statements in column I with resulting image in column II



Column-I	Column- II
(A) If the refractive index of the lens is doubled (that is, made 2μ,) then	(p) Final image is real
(B) If the radius of curvature is doubled	(q) Final image is virtual

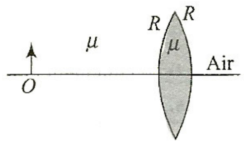
(that is, made $2R$,) then

(C) If a glass slab of refractive index $\mu = 1.5$ is introduced between the object and lens as shown, then

(r) Final image becomes smaller in size in comparison to size of image before the change was made

(D) If the left side of lens is filled with a medium of refractive index $\mu = 1.5$ as shown, then

(s) Final image is of same size as the object



CODES :

	A	B	C	D
a)	P,r	q,r	q,r	q,r
b)	p	q	r	s
c)	s	p	q	r
d)	q	r	p	s

Linked Comprehension Type

This section contain(s) 39 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 349 to -349

The power of a convex lens depends on the radius of curvature and refractive index of lens material and is given by

$P_a = ({}_a\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, when lens is in air

The refractive index of material is roughly given by

$\mu = A + \frac{B}{\lambda^2}$ (Cauchy's formula)

If a lens is dipped in a liquid, its power is changed and is given by

$$P_1 = ({}_l\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

349. A lens ($\mu_g = 1.5$) in air has a power +2 D. When lens is dipped in water of refrective index 4/3, its power will become/ remain

a) +4 D b) +8 D c) +2 D d) −4 D

Paragraph for Question Nos. 350 to - 350

Total internal reflection is the phenomenon of reflection of light into denser medium at the interface of denser medium with a rarer medium. Light must travel from denser to rarer and angle of incidence in denser medium must be greater than critical angle (C) for the pair of media in contact. We can show that

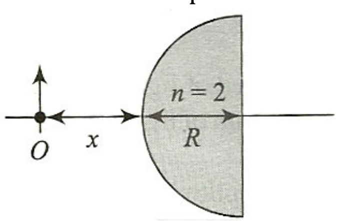
$\mu = \frac{1}{\sin C}$

350. Critical angle for water air interface is 48.6°. What is the refractive index of water?

a) 1 b) 3/2 c) 4/3 d) 3/4

Paragraph for Question Nos. 351 to - 351

Consider a transparent hemisphere ($n = 2$) in front of which a small object is placed in air ($n = 1$) as shown

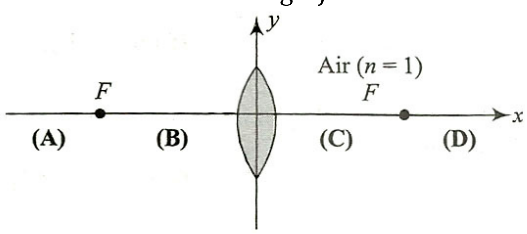


351. For which value of x, of the following, will the final image of the object at O be virtual?

a) $2R$ b) $3R$ c) $R/2$ d) $1.5R$

Paragraph for Question Nos. 352 to - 352

This question concerns a symmetrical lens shown, along with its two focal points. It is made of plastic with $n = 1.2$and has focal length$f$. Four different regions are shown:



Here,

A. $-\infty\ x < -f$B. $-f < x < 0$

C. $0 < x < f$D. $f < x < \infty$

352. If an object is placed somewhere in region (A), in which region does the image appear?

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

Paragraph for Question Nos. 353 to - 353

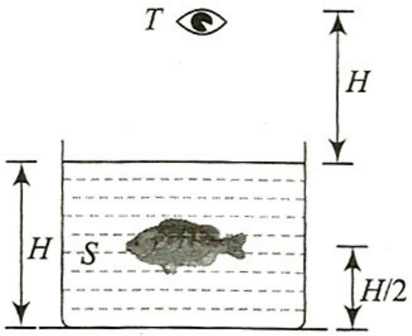
A point object O is placed in front of a concave mirror of focal length 10 cm. A glass slab of refractive index $\mu = 3/2$ and thickness 6 cm is inserted between the object and mirror

353. Find the position and nature of the final image when the distance x shown in figure, is 5 cm

a) 11 cm, virtual b) 17 cm, real c) 14 cm, real d) 20 cm, virtual

Paragraph for Question Nos. 354 to - 354

Consider the situation in the figure. The bottom of the pot is a reflecting plane mirror, S is a small fish, and T is a human eye. Refractive index of water is μ



354. At what distance from itself will the fish see the image of the eye by direct observation?

a) $H\left(\frac{1}{2}+\mu\right)$ b) $H\left(\frac{1}{2}-\mu\right)$ c) $\frac{H}{2}\left(\frac{1}{2}+\mu\right)$ d) $H\left(\frac{1-\mu}{2}\right)$

Paragraph for Question Nos. 355 to - 355

A glass sphere of radius $2R$ and refractive index $n$has a spherical cavity of radius R, concentric will it

355. When viewer is on left side of the hollow sphere, what will be the shift in position of the object?

a) $\frac{(n+1)}{(n-1)}$ R, right b) $\frac{(n-1)}{(n+1)}$ R, right c) $\frac{(2n-1)}{(2n+1)}R$, left d) $\frac{2(n-1)}{(n+1)}R$, left

Paragraph for Question Nos. 356 to - 356

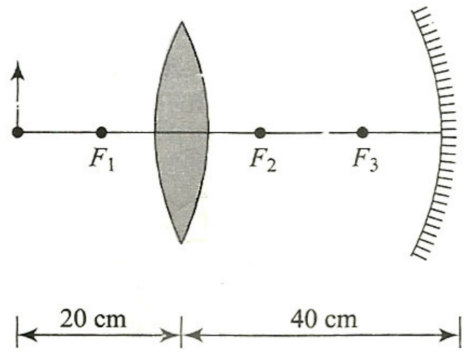
A thin equiconvex lens of refractive index 3/2 is placed on a horizontal plane mirror as shown in figure. The space between the lens and the mirror is filled with a liquid of refractive index 4/3. It is found that when a point object is placed 15 cm above the lens on its principal axis, the object coincides with its own image

356. The radius of curvature of the convex surface is

a) 10 cm b) 15 cm c) 20 cm d) 25 cm

Paragraph for Question Nos. 357 to - 357

An equiconvex lens, $f_1 = 10$ cm, is placed 40 cm in front of a concave mirror, $f_2 = 7.50$ cm, as shown in figure. An object, 2 cm high, is placed 20 cm to the left of the lens

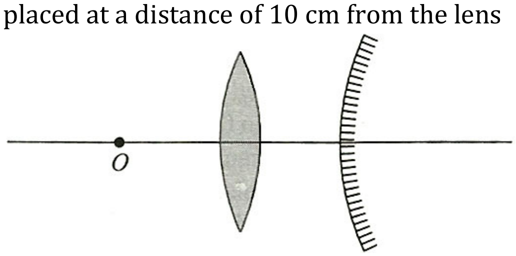


357. The image formed by the lens as rays travel to the right is

a) Real and erect b) Virtual and erect c) Real and inverted d) Virtual and inverted

Paragraph for Question Nos. 358 to - 358

A biconvex lens, $f_1 = 20$ cm, is placed 5 cm in front of a convex mirror, $f_2 = 15$ cm. An object of length 2 cm is placed at a distance of 10 cm from the lens



358. Nature of the image formed by the lens as the rays travel to the right is

a) Real, inverted, and magnified
b) Real, erect, and magnified
c) Virtual, inverted, and magnified
d) Virtual, erect, and magnified

Paragraph for Question Nos. 359 to - 359

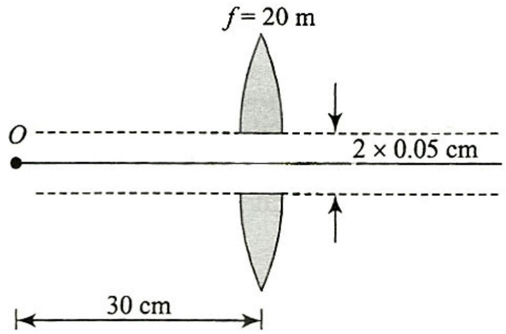
A thin plano-convex lens of focal length f is split into two halves. One of the halves is shifted along the optical axis. The separation between the object and image planes is 1.8 m. The magnification of the image formed by one of the half lenses is 2

359. Find the focal length of the lens used

a) 0.4 m b) 0.6 m c) 1 m d) 2 m

Paragraph for Question Nos. 360 to - 360

A point object O is placed at a distance of 0.3 m from a convex lens (focal length 0.2 m) cut into two halves each of which is displaced by 0.0005 m as shown in the figure



360. What will be the location of the image?
   a) 30 cm, right of lens b) 60 cm, right of lens c) 70 cm, left of lens d) 40 cm, left of lens

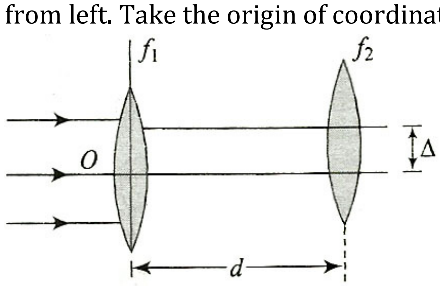
Paragraph for Question Nos. 361 to - 361

The convex surface of a thin concavo-convex lens of glass of refractive index 1.5 has a radius of curvature 20 cm. The concave surface has a radius of curvature 60 cm. The convex side is silvered and placed on a horizontal surface

361. Where should a pin be placed on the optic axis such that its image is formed at the same place?
   a) $x = 5$ cm b) $x = 20$ cm c) $x = 15$ cm d) $x = 25$ cm

Paragraph for Question Nos. 362 to - 362

Two thin convex lenses of focal lengths f_1 and f_2 are separated by a horizontal distance d ($d < f_1$and $d < f_2$) and their centers are displaced by a vertical separation as shown in the figure. A parallel beam of rays coming from left. Take the origin of coordinates O at the center of first lens

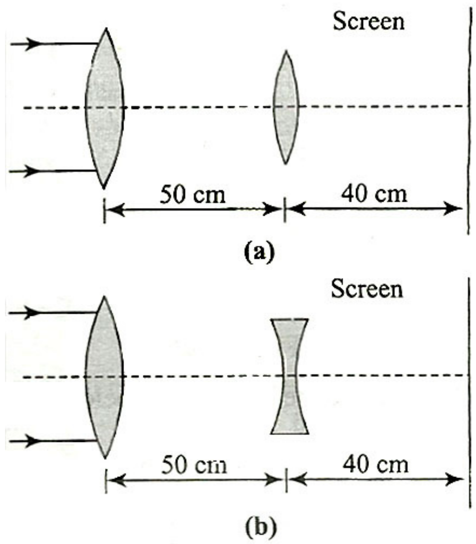


362. Find the y-coordinate of the focal point of this lens system

a) $\frac{(f_1+d)\Delta}{(f_1+f_2-d)}$ b) $\frac{2(f_1+d)}{(f_1+f_2-d)}$ c) $\frac{2(f_1-d)\Delta}{(f_1+f_2+d)}$ d) $\frac{(f_1-d)\Delta}{(f_1+f_2-d)}$

Paragraph for Question Nos. 363 to - 363

A parallel beam of light falls successively on a thin convex lens of focal length 40 cm and then on a thin convex lens of focal length 10 cm as shown in figure(a)



In figure (b) the second lens is an equiconcave lens of focal length 10 cm and made of a material of refractive index 1.5. In both the cases, the second lens has an aperture equal to 1 cm

363. Compare the area illuminated by the beam of light on the screen, which passes through the second lens in the two cases. The ratio (A_2/A_1) will be
a) 72/5 b) 81/4 c) 56/3 d) 29/2

Paragraph for Question Nos. 364 to - 364

Two identical plano-convex lenses $L_1(\mu_1 = 1.4)$ and $L_2(\mu_2 = 1.5)$ of radii of curvature $R = 20$ cm are placed as shown in the figure

364. Find the position of the image of the parallel beam of light relative to the common principal axis
a) 100/7 cm b) 200/9 cm c) 31.2 cm d) 21.8 cm

Paragraph for Question Nos. 365 to - 365

A beam of light converges towards a point O , behind a convex mirror of focal length 20 cm

365. Find the magnification and nature of the image when point O is 10 cm behind the mirror

a) 2(virtual, inverted) b) 3(real, inverted) c) 5(real, erect) d) 2(real, erect)

Paragraph for Question Nos. 366 to - 366

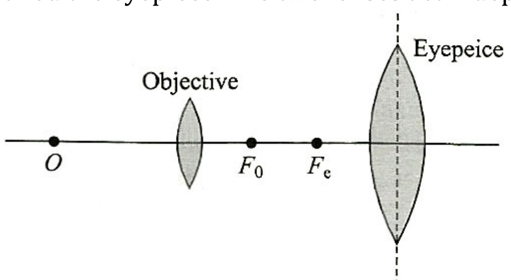
A ray of light is incident normally at face AB of a glass prism $n = 3/2$. Find the largest value for the angle ϕ so that the ray is totally reflected at face AC if the prism is immersed:

366. In air

a) $\cos^{-1}(2/3)$ b) $\cos^{-1}(3/4)$ c) $\sin^{-1}(3/5)$ d) $\sin^{-1}(5/8)$

Paragraph for Question Nos. 367 to - 367

The schematic diagram of a compound microscope is shown in the adjacent figure. Its main components are two convex lenses: one acts as the main magnifying lens and is referred to as the objective, and another lens called the eyepiece. The two lenses act independently of each other when bending light rays



F_0 = focal point of objective
F_e = focal point of eyepeice

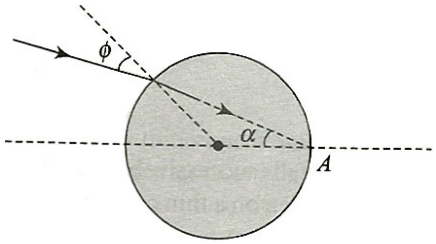
Light from the object (O) first passes through the objective and an enlarged, inverted first image is formed. The eyepiece then magnifies this image. Usually, the magnification of the eyepiece is fixed (either $\times$ 10 or $\times$ 15) and three rotating objective lenses are used: $\times$ 10,$\times$ 40 and $\times$ 60. Angular magnification is defined as the angle subtended by the final image at the eye to the angle subtended by the object placed at least distance of distinct vision ($\approx$ 25 cm) when viewed by the naked eye

367. Based on the passage, what type of image would have to be produced by the objective?

a) Either virtual or real
b) Virtual
c) Real
d) It depends on the focal length of the lens

Paragraph for Question Nos. 368 to - 368

A ray of light enters a spherical drop of water of refractive index μ as shown in the figure



368. Select the correct statement:
   a) Incident rays are partially reflected at point A
   b) Incident rays are totally reflected at point A
   c) Incident rays are totally transmitted through A
   d) None of these

Paragraph for Question Nos. 369 to - 369

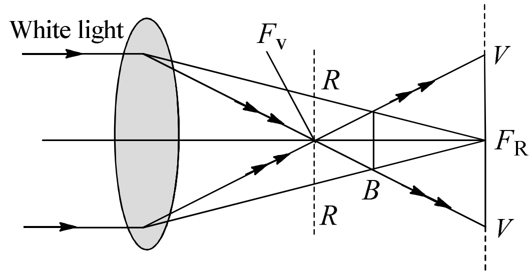
The ciliary muscles of eye control the curvature of the lens in the eye and hence can alter the effective focal length of the system. When the muscles are fully relaxed, the focal length is maximum. When the muscles are strained, the curvature of lens increases. That means, radius of curvature decreases and focal length decreases. For a clear vision, the image must be on the retina. The image distance is therefore fixed for clear vision and it equals the distance of retina from eye lens. It is about 2.5 cm for a grown up person

A person can theoretically have clear vision of an object situated at any large distance from the eye. The smallest distance at which a person can clearly see is related to minimum possible focal length. The ciliary muscles are most strained in this position. For an average grown up person, minimum distance of the object should be around 25 cm
A person suffering from eye defects uses spectacles (eye glass). The function of lens of spectacles is to form the image of the objects within the range in which the person can see clearly. The image of the spectacle lens becomes object for the eye lens and whose image is formed on the retina
The number of spectacle lens used for the remedy of eye defect is decided by the power of the lens required and the number of spectacle lens is equal to the numerical value of the power of lens with sign. For example, if power of the lens required is +3D (converging lens of focal length 100/3 cm), then number of lens will be +3
For all the calculations required, you can use the lens formula and lensmaker's formula. Assume that the eye lens is equiconvex lens. Neglect the distance between the eye lens and the spectacle lens

369. Minimum focal length of eye lens of a normal person is
   a) 25 cm   b) 2.5 cm   c) 25/9 cm   d) 25/11 cm

Paragraph for Question Nos. 370 to - 370

The image of a white object in white light formed by a lens is usually colored and blurred. This defect of image is called chromatic aberration and arises due to the fact that focal length of a lens is different for different colours. As μ of lens is maximum for violet while minimum for red, violet is focused nearest to the lens while red farthest from it as shown in figure



As a result of this, in case of convergent lens if a screen is placed at F_V center of the image will be violet and focused while sides are red and blurred. While at F_R, reverse is the case, i.e., center will be red and focused while sides violet and blurred. The difference between F_V and F_R is a measure of the longitudinal chromatic aberration (L.C.A), i.e.,

L.C.A.$= F_R - F_V = -dF$ with $dF = F_V - F_R$ (i)

However, as for a single lens,

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{(ii)}$$

$$\Rightarrow \frac{df}{f^2} = d\mu\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{(iii)}$$

Dividing Eq. (iii) by Eq. (ii), we get

$$-\frac{df}{f} = \frac{d\mu}{(\mu - 1)} = \omega$$

$\left[\omega = \frac{d\mu}{(\mu-1)}\right]$ = dispersive power (iv)

And hence, from Eqs. (i) and (iv)

L.C.A. $= -dF = \omega f$

Now, as for a single lens neither f nor ω can be zero, we cannot have a single lens free from chromatic aberration

Condition of Achromatism:

In case of two thin lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}; \text{ i.e. } -\frac{dF}{F^2} = \frac{df_1}{f_1^2} - \frac{df_2}{f_2^2}$$

The combination will be free from chromatic aberration if $dF = 0$

i.e., $\frac{df_1}{f_1^2} + \frac{df_2}{f_2^2} = 0$, i.e., $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$ (v)

The condition is called condition of achromatism (for two thin lenses in contact) and the lens combination which satisfies this condition is called achromatic lens. From this condition, i.e., from Eq. (v), it follows that:

(i) The two lenses must be of different materials

Since, if $\omega_1 = \omega_2, \frac{1}{f_1} + \frac{1}{f_2} = 0$

i.e., the combination will not behave as a lens, but as a plane glass plate

(ii) As ω_1 and ω_2 are positive quantities, for Eq.(v) to hold, f_1 and f_2 must be of opposite nature, i.e., if one of the lenses is converging, the other must be diverging

(iii) If the achromatic combination is convergent,

$f_c < f_D$ and as $-\frac{f_C}{f_D} = \frac{\omega_C}{\omega_D} \Rightarrow \omega_C < \omega_D$

i.e., in a convergent achromatic doublet, convex lens has lesser focal length and dispersive power than the divergent one

370. Chromatic aberration in the formation of image by a lens arises because:

a) Of non-paraxial rays

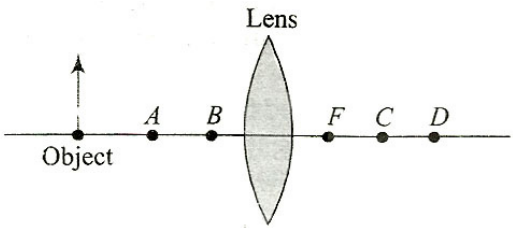
b) The radii of curvature of the two sides are not same

c) Of the defect in grinding

d) The focal length varies with wavelength

Paragraph for Question Nos. 371 to - 371

The figure is a scaled diagram of an object and a converging lens surrounded by air. F is the focal point of lens as shown



371. At which of the labeled points will image be formed?

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

Paragraph for Question Nos. 372 to - 372

Most materials have the refractive index, $n > 1$. So, when a light ray from air enters a naturally occurring material, then by Snell's law, $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$, it is understood that the refracted ray bends towards the normal. But it never emerges on the same side of the normal as the incident ray. According to electromagnetism, the refractive index of the medium is given by the relation, $n = \left(\frac{c}{v}\right) = \pm\sqrt{\varepsilon_r \mu_r}$ where c is the speed of electromagnetic waves in vaccum, v its speed in the medium, ε_r and μ_r are the relative permittivity and permeability of the medium respectively. In normal materials, both ε_r and μ_r are positive, implying positive n. for the medium. When both ε_r and μ_r are negative, one must choose the negative root of n. Such negative refractive index materials can now be artificially prepared and are called meta-materials can now be artificially prepared and are called meta-materials. They exhibit significantly different optical behavior, without violating any physical laws. Since n is negative, it results in a change in the direction of propagation of the refracted light. However, similar to normal materials, the frequency of light remains unchanged upon refraction even in meta-materials

372. Choose the correct statement

a) The speed of light in the meta-material is $v = c|n|$

b) The speed of light in the meta-material is $v = \frac{c}{|n|}$

c) The speed of light in the meta-material is $v = c$

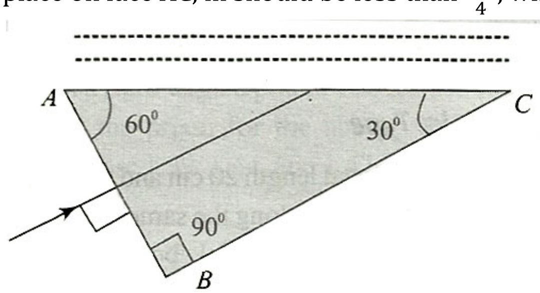
d) The wavelength of the light in the metal-material (λ_m) is given by $\lambda_m = \lambda_{air}|n|$, where λ_{air} is the wavelength of the light in air

Integer Answer Type

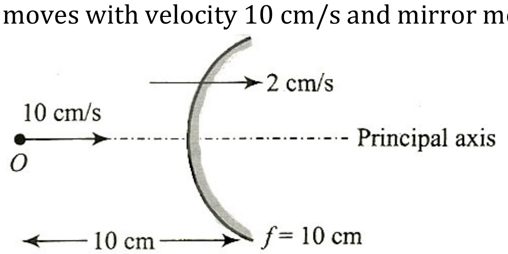
373. Water $\left(\text{with refractive index } = \frac{4}{3}\right)$ in a tank is 18 cm deep. Oil of refractive index $\frac{7}{4}$ lies on water making a convex surface of radius of curvature 'R = 6 cm'' as shown. Consider oil to act as a thin lens. An object 'S' is placed 24 cm above water surface. The location of its image is at '$x''cm$ above the bottom of the tank. Then 'x' is

374. A ray of light is incident at an angle of 60° on one face of a prism which has refracting angle of 30°. The ray emerging out of the prism makes an angle of 30° with the incident ray. If the refractive index of the material of the prism is $\mu = \sqrt{a}$, find the value of a
375. A point object is placed at a distance of 25 cm from a convex lens. Its focal length is 22 cm. A glass slab of refractive index 1.5 is inserted between the lens and the object, then the image is formed as infinity. Find the thickness of the glass slab (in cm)
376. Where should a convex lens of focal length 9 cm be placed (in cm) between two point sources S_1 and S_2 which are 24 cm apart, so that images of both the sources are formed at the same place. You have to find distance of lens from S_1orS_2 whichever is lesser
377. The magnification of an object placed in front of a convex lens is +2. The focal length of the lens is 2.0 metres. Find the distance by which object has to be moved to obtain a magnification of −2 (in metres)
378. A point object is placed at a distance 25 cm from a convex lens of focal length 20 cm. If a glass slab of thickness t and refractive index 1.5 is inserted between the lens and object, image is formed at. Thickness t is found to be K times of 5 cm. Find K
379. An object is placed 50 cm from a screen as shown

A converging is moved such that line MN is its principal axis. Sharp images are formed on the screen in two positions of lens separated by 30 cm. Find the focal length of the lens in cm
380. A container of uniform cross-section ahs a height of 14 m. Upto what height (in metre) water of refractive index 4/3 should be filled behind the container so that container seems to be half filled for normal viewing
381. As shown in the figure, light is incident normally on one face of the prism. A liquid of refractive index μ is placed on the horizontal face AC. The refractive index of prism is 3/2. If total internal reflection taken place on face AC, m should be less than $\frac{I\sqrt{3}}{4}$, where I is an integer. Find the value of I



382. What is the velocity (in cm/s) of image in situation shown below. (O=object, f =focal length). Object moves with velocity 10 cm/s and mirror moves with velocity 2 cm/s as shown



383. An extended object of size 2 mm is placed on the principal axis of a converging lens of focal length 10 cm. It is found that when the object is placed perpendicular to the principal axis the image formed is 4 mm in

size. The size of image when it is placed along the principal axis is ____________ mm

: ANSWER KEY :

1)	c	2)	b	3)	b	4)	d	189)	d	190)	b	191)	d	192)	b
5)	b	6)	a	7)	b	8)	a	193)	c	194)	b	195)	a	1)	d
9)	b	10)	a	11)	a	12)	d		2)	a,c,d	3)	a,c	4)	b,c	
13)	c	14)	d	15)	b	16)	a	5)	c	6)	b,c	7)	a,b,c,d	8)	d
17)	d	18)	d	19)	b	20)	b	9)	a,b,c	10)	a,d	11)	a,d	12)	
21)	a	22)	d	23)	c	24)	c		a,b,c,d						
25)	c	26)	b	27)	b	28)	b	13)	c	14)	a,b,c	15)	a,b	16)	
29)	a	30)	b	31)	d	32)	c		b,c						
33)	c	34)	c	35)	a	36)	c	17)	c	18)	c,d	19)	a	20)	a
37)	b	38)	a	39)	d	40)	a	21)	b,c	22)	b	23)	a,d	24)	
41)	a	42)	b	43)	b	44)	a		a,b,c,d						
45)	b	46)	b	47)	c	48)	c	25)	a	26)	b	27)	a,d	28)	
49)	a	50)	c	51)	a	52)	a		a,b,c,d						
53)	b	54)	a	55)	d	56)	a	29)	a	30)	a,c	31)	b,d	32)	a
57)	b	58)	d	59)	d	60)	b	33)	a,b,c	34)	b	35)	c	36)	a
61)	c	62)	a	63)	a	64)	d	37)	a	38)	a,b,c	39)	a,c	40)	
65)	b	66)	d	67)	a	68)	d		a,b						
69)	a	70)	a	71)	d	72)	b	41)	d	42)	b,d	43)	d	44)	
73)	b	74)	c	75)	b	76)	b		a,c						
77)	d	78)	c	79)	b	80)	d	45)	b,c	46)	c,d	47)	d	48)	a
81)	b	82)	a	83)	c	84)	a	49)	c	50)	b,c	51)	c	52)	
85)	b	86)	c	87)	c	88)	c		c,d						
89)	b	90)	a	91)	a	92)	c	53)	a,b,c,d	54)	b,c	55)	a,c,d	56)	
93)	d	94)	c	95)	d	96)	a		a,c						
97)	b	98)	b	99)	c	100)	d	57)	d	58)	d	59)	b,d	60)	
101)	d	102)	b	103)	c	104)	c		a,c						
105)	c	106)	b	107)	b	108)	d	61)	a,b	62)	a	63)	a,b,c,d	64)	c
109)	b	110)	d	111)	d	112)	b	65)	a,c,d	66)	b,d	67)	a,c,d	68)	
113)	c	114)	d	115)	c	116)	b		b,c						
117)	d	118)	b	119)	b	120)	d	69)	c,d	70)	a,b,c,d	71)	b,c,d	72)	
121)	c	122)	a	123)	b	124)	a		a,b						
125)	b	126)	d	127)	a	128)	a	73)	d	74)	c,d	1)	c	2)	a
129)	b	130)	b	131)	a	132)	c		3)	b	4)	c			
133)	a	134)	d	135)	a	136)	d	5)	c	6)	a	7)	c	8)	c
137)	a	138)	b	139)	a	140)	a	9)	d	10)	c	11)	c	12)	b
141)	d	142)	c	143)	d	144)	d	13)	d	14)	a	15)	a	16)	a
145)	c	146)	a	147)	c	148)	d	17)	b	18)	e	19)	a	20)	d
149)	c	150)	c	151)	d	152)	c	21)	A	22)	b	23)	a	24)	b
153)	a	154)	a	155)	c	156)	d	25)	a	26)	b	27)	b	28)	b
157)	a	158)	d	159)	b	160)	b	29)	c	30)	b	31)	b	32)	a
161)	d	162)	c	163)	b	164)	c	33)	c	34)	a	35)	c	36)	c
165)	a	166)	c	167)	c	168)	d	37)	d	38)	c	39)	b	40)	d
169)	a	170)	b	171)	c	172)	c	41)	d	42)	b	43)	e	44)	d
173)	a	174)	b	175)	d	176)	b	45)	c	46)	e	47)	a	48)	d
177)	c	178)	a	179)	d	180)	d	49)	d	50)	a	51)	c	52)	a
181)	a	182)	d	183)	c	184)	c	53)	e	54)	d	55)	c	56)	d
185)	a	186)	b	187)	a	188)	b	57)	a	58)	b	59)	d	60)	d

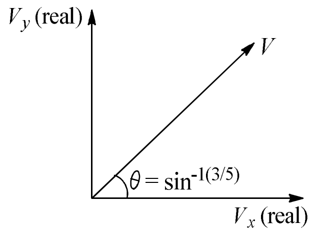
61)	a	62)	c	63)	d	64)	a
65)	a	1)	a	2)	a	3)	b
	4)	b					
5)	a	6)	c	7)	d	8)	d
9)	a	10)	c	11)	c	12)	b
13)	c	14)	a	1)	b	2)	c
	3)	c	4)	d			
5)	b	6)	a	7)	b	8)	a

9)	c	10)	a	11)	a	12)	b
13)	c	14)	c	15)	b	16)	b
17)	d	18)	a	19)	c	20)	a
21)	d	22)	d	23)	c	24)	b
1)	2	2)	3	3)	9	4)	6
5)	2	6)	3	7)	8	8)	8
9)	3	10)	0	11)	8		

: HINTS AND SOLUTIONS :

1 **(c)**

Let y-axis be vertically upward and x-axis be horizontal



$V_y(\text{app.}) = \frac{V_y(\text{real})}{\left(\frac{1}{\mu}\right)}$

$V_y(\text{app.}) = V_x(\text{real.})$

$\tan\phi = \frac{V_y(\text{app})}{V_x(\text{app})} = \frac{4}{3}\tan\theta = \frac{4}{3}\times\frac{3}{4} = 1$

2 **(b)**

${}_g\mu_a = \frac{\sin i}{\sin r}$

$\frac{1}{{}_a\mu_g} = \frac{\sin i}{\sin 2i}$

$\frac{1}{16} = \frac{\sin i}{2\sin i\cos i}$ or $\frac{1}{\cos i}\frac{1}{10} = \frac{5}{8}$

or $\frac{1}{\cos i} = \frac{5}{4}$ or $\cos i = \frac{4}{5}$

Now, $\sin i = \sqrt{1-\cos^2 i}$

or $\sin i = \sqrt{1-\frac{16}{25}} = \sqrt{\frac{9}{25}} = \frac{3}{5}$

or $i = \sin^{-1}\left(\frac{3}{5}\right)$

3 **(b)**

Power of the system decreases due to separation between the lenses. So, the focal length increases

4 **(d)**

A thick glass mirror produces a number of images

There is an apparent shift of actual silvered surface toward the unsilvered face

Effective distance of the reflecting surface from unsilvered face $= \frac{d}{\mu} = \frac{3}{3/2}$ cm $= 2$ cm

Distance of the point object from effective reflecting surface $= 9$ cm $+ 2$ cm $= 11$ cm

Distance of image from the point object $= 11$ cm $+ 11$ cm $= 22$ cm

Distance of image from unsilvered face $= (22-9)$ cm $= 13$ cm

5 **(b)**

From the lens formula

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ *we have,*

$\frac{1}{f} = \frac{1}{10} - \frac{1}{-10}$

or $f = +5$

Further, $\Delta u = 0.1$

And $\Delta v = 0.1$(from the graph)

Now, differentiating the lens formula we have,

$\frac{\Delta f}{f^2} = \frac{\Delta v}{v^2} + \frac{\Delta u}{u^2}$

or $\Delta f = \left(\frac{\Delta v}{v^2} + \frac{\Delta u}{u^2}\right) f^2$

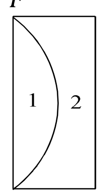
Substituting the values we have

$\Delta f = \left(\frac{0.1}{10^2} + \frac{0.1}{10^2}\right)(5)^2 = 0.05$

$\therefore f \pm \Delta f = 5 \pm 0.05$

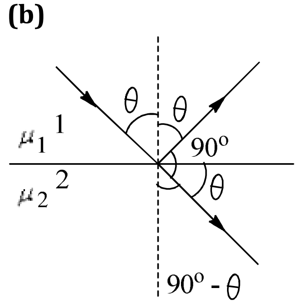
6 **(a)**

$\frac{1}{F} = (\mu-1)\left(\frac{1}{\infty} + \frac{1}{R}\right) + (\mu_2-1)\left(\frac{1}{-R} - \frac{1}{\infty}\right)$



$= \frac{\mu_1 - \mu_2}{R}$ or $F = \frac{R}{\mu_1 - \mu_2}$

7 **(b)**



$\mu_1 \sin\theta = \mu_2 \times \sin(90° - \theta)$

$\Rightarrow \frac{\mu_1}{\mu_2} = \tan\theta$

For $\theta_C \Rightarrow \mu_1 \times \sin\theta_C = \mu_2 \times \sin(90°)$

$\sin\theta_C = \frac{\mu_1}{\mu_2} = \tan\theta$

$\Rightarrow \theta_C = \sin^{-1}(\tan\theta)$

8 **(a)**

$r_2 < \theta_C; A - r_1 < \theta_C$

$r_1 > A - \theta_c$
$\sin r_1 > \sin(A - \theta_c)$
$\frac{\sin i}{\mu} > \sin(A - \theta_c)$
$\sin i > \mu\,(\sin A \cos\theta_c - \cos A \sin\theta_c)$
$\sqrt{\frac{7}{3}}\left(\frac{\sqrt{3}}{2}\sqrt{1-\frac{3}{7}} - \sqrt{\frac{3}{7}}.\frac{1}{2}\right) = 1 - \frac{1}{2} = \frac{1}{2}$
$\sin i > \frac{1}{2}$ or $i > 30°$

9 **(b)**
Power of combination $= (6-4)\text{D} = 2D$
Power $= \frac{100}{f(\text{in cm})}$
$2 = \frac{100}{f}(\text{in cm})$
Or $f(\text{in cm}) = 50$
Since the net power is positive, therefore the combination shall behave like a convex lens

10 **(a)**
Since the refractive index of the liquid is greater than the refractive index of glass, therefore the focal length of the system has to be negative. So, options (b) and (d) are excluded
Now, $\frac{1}{24} = (1.5-1)\frac{2}{R}$
Or $R = 24$ cm
Again, for liquid concave lens,
$\frac{1}{f} = -(1.6-1)\left(\frac{2}{24}\right)$
$\frac{1}{f} = -\frac{3}{5} \times \frac{1}{12}$
Or $\frac{1}{f} = -\frac{1}{20}$ or $f = -20$ cm
Now, $\frac{1}{F} = \frac{1}{24} - \frac{1}{20} = \frac{5-6}{120}$
Or $F = -120$ cm

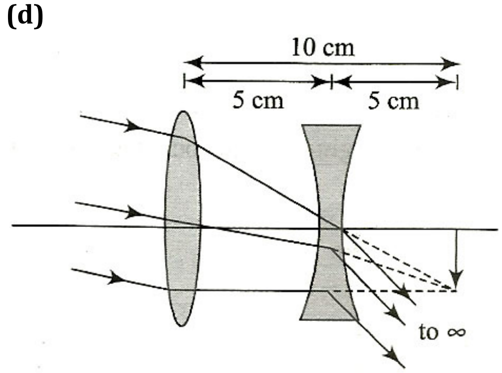
11 **(a)**
As object moves from infinity to the pole of convex mirror, image moves from focus to pole, so, $v_i < v_0$, always

12 **(d)**
$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$
$-\frac{1}{u^2}\frac{du}{dt} - \frac{1}{v^2}\frac{dv}{dt} = 0$
or $\frac{du}{dt} = \frac{v^2}{u^2}\frac{du}{dt} = -\frac{1}{31\times 31} \times 31 = -0.032\ \text{ms}^{-1}$

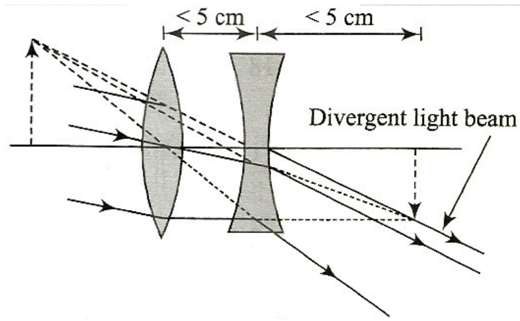
13 **(c)**
$\frac{\mu_2}{-\mu} + \frac{\mu_1}{v} = \frac{\mu_1 - \mu_2}{R} = 0$
In the first case,
$\frac{\mu}{-d} + \frac{1}{-v} = \frac{\mu_1 - \mu_2}{\infty} = 0$
Or $\frac{1}{-v} = \frac{\mu}{d}$
Or $v = -\frac{d}{\mu}$

In the second case,
$\frac{\mu}{-d} + \frac{1}{-v'} = \frac{1-\mu}{-R}$
Or $\frac{1}{-v'} = \frac{\mu}{-d} - \frac{1-\mu}{-R}$
Or $\frac{1}{-v'} = \frac{1}{-v} + \frac{1-\mu}{-R}$

Clearly, $\frac{1}{-v'} > \frac{1}{-v}$
Or $\frac{1}{-v'} < \frac{1}{-v}$
Or $v' > v$

14 **(d)**


At 5 cm from the lens, the second lens has a virtual object (image of the first lens) at its focal length. The emergent rays are therefore parallel



When the second lens is closer than 5 cm to the first lens, its object is outside the focal length of the diverging second lens. This produces a virtual image outside $2f$ of the second lens. The emergent rays are therefore *divergent*

15 **(b)**

Let the object distance be x. Then, the image distance is $D-x$

From lens equation,

$$\frac{1}{x}+\frac{1}{D-x}=\frac{1}{f}$$

On algebraic rearrangement, we get

$$x^2-Dx+Df=0$$

On solving for x, we get

$$x_1=\frac{D-\sqrt{D(D-4f)}}{2}$$

$$x_2=\frac{D+\sqrt{D(D-4f)}}{2}$$

The distance between the two object positions is

$$d=x_2-x_1=\sqrt{D(D-4f)}$$

16 **(a)**

Given $i=60°A=\delta=e$

$\delta=i+e-A \Rightarrow \delta=1\ (\because e=A)$

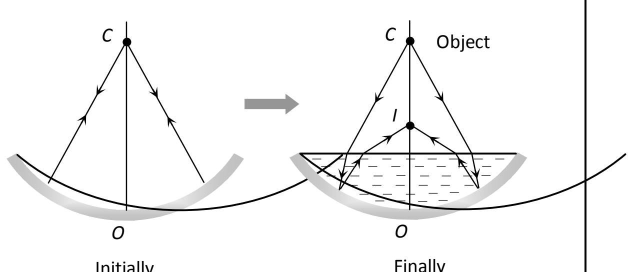
$$\mu=\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

Here, angle of deviation is minimum ($\because i=e$)

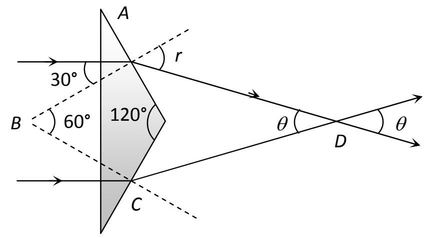
$$\mu=\frac{\sin\left(\frac{60^0+60^0}{2}\right)}{\sin(60^0/2)}=1.73$$

17 **(d)**

From the following figures it is clear that real image (I) will be formed between C and O



At point $A.\ \frac{\sin 30°}{\sin r}=\frac{1}{1.44}$



$\Rightarrow r=\sin^{-1}(0.72)$ also $\angle BAD=180°-\angle r$

In rectangular $ABCD, \angle A+\angle B+\angle C+\angle D=360°$

$\Rightarrow (180°-r)+60°+(180°-r)+\theta=360°$

$\Rightarrow \theta=2[\sin^{-1}(0.72)-30°]$

19 **(b)**

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

$$-\frac{du}{u^2}-\frac{dv}{v^2}=0 \text{ or } -\frac{dv}{v^2}-\frac{du}{u^2}$$

Or $dv=-\frac{v^2}{u^2}du$

$$=-\frac{10\times 10}{30\times 30}\times 9\text{ms}^{-1}=-1\text{ ms}^{-1}$$

20 **(b)**

Image velocity (w.r.t. mirror)$=-m\times$ object velocity (w.r.t. mirror)

Here $m=1$

21 **(a)**

In a prism : $r+r'=A \ \Rightarrow\ r=A-r'$

$\therefore r=60°-(10+t^2)=50-t^2$

22 **(d)**

Ray diagram for image formation is as shown in the figure

23 **(c)**

$u = -100$ cm

$v = -120$ cm

$F = ?$

$$\frac{1}{F} + \frac{1}{u} + \frac{1}{v} = \frac{1}{-100} + \frac{1}{-120}$$

$$\frac{1}{F} = -\frac{6+5}{600} = -\frac{11}{600}$$

Now, $\frac{1}{F} = \frac{2}{f_1} + \frac{1}{f_m} = \frac{2}{f_1}$

Or $f_1 = 2F$

Or $f_1 = 2 \times \frac{600}{11}$

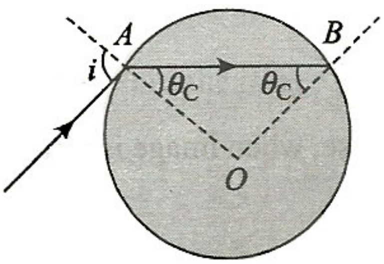
[Negative sign is not to be used here]

Or $f_1 = \frac{1200}{11} = 109.1$ cm

24 **(c)**

$\angle ABO = \angle OAB = \theta_C$

$$\sin\theta_c = \frac{1}{\mu} = \frac{2}{3}$$



Applying Snell's law at A

$$\frac{\sin i}{\sin\theta_c} = \frac{3}{2}$$

$$\sin i = \left(\frac{3}{2}\right)\left(\frac{2}{3}\right) = 1$$

Or $i = 90°$

25 **(c)**

$$\frac{x}{1} = \frac{x_{rel}}{\mu} \Rightarrow X_{rel} = \mu x$$

$$\frac{d^2x_{rel}}{dt^2} = \mu\frac{d^2x}{dt^2} \Rightarrow a_{rel} = \mu g$$

26 **(b)**

If the object is at $u = x_1$,

$$m_1 = \frac{I_1}{O} = \frac{D - x_1}{x_1}$$

Now, $x_1 = \frac{1}{2}(D-d)$,

Where $d = \sqrt{D(D-4f)}$

$$m_1 = \frac{D-(D-d)/2}{(D+d)/2} = \left(\frac{D+d}{D-d}\right)$$

Similarly, when the object is at x_2, the magnification is

$$X_2 = \frac{1}{2}(D+d)$$

$$m_2 = \frac{I_2}{O} = \frac{D-x_2}{x_2} = \frac{D-(D+d)/2}{(D+d)/2} = \frac{D-d}{D+d}$$

The ratio of magnification is

$$\frac{m_2}{m_1} = \frac{(D-d)(D+d)}{(D+d)(D-d)} = \left(\frac{D-d}{D+d}\right)^2$$

27 **(b)**

Distance of first image (I_1) formed after refraction from the plane surface of water is

$$\frac{10}{4/3} = 7.5 \text{ cm}$$

From water surface $\left(d_{app} = \frac{d_{actual}}{\mu}\right)$

Now, distance of this image is $5 + 7.5 = 12.5$ cm from the plane mirror. Therefore, distance of second image (I_2) will also be equal to 12.5 cm from the mirror

28 **(b)**

$$\frac{\mu_2}{V} - \frac{\mu_1}{-u_0} = \frac{\mu_2 - \mu_1}{-2R}$$

$$\frac{\mu_3}{V_f} - \frac{\mu_2}{V} = \frac{\mu_3 - \mu_2}{-R}$$

$$\frac{\mu_3}{V_f} + \frac{\mu_1}{u_0} = \frac{\mu_1 - \mu_2}{2R} + \frac{\mu_2 - \mu_3}{R}$$

$$\therefore \frac{\mu_1 - \mu_2}{2} < \mu_3 - \mu_2 \Rightarrow \mu_1 - \mu_2 < 2\mu_3 - 2\mu_2$$

$$\Rightarrow \mu_1 + \mu_2 < 2\mu_3$$

29 **(a)**

We have to consider four refractions at S_1, S_2, S_3, and S_4 respectively. At each refraction, we will apply single surface refraction equation

For refractive at first surface S_1:

$$\frac{3/2}{v_1} - \frac{1}{(-18)} = 0$$

$v_1 = -27$ cm

First image lies to the left of S_1

For refractive at second surface S_2:

$$\frac{1}{v_2} - \frac{3/2}{-(27+9)} = \frac{(1-3/2)}{+9}$$

$$v_2 = -\frac{72}{7} \text{cm}$$

Note that origin of Cartesian coordinate system lies at vertex of surface S_2. The object distance is $(27+9)$ cm. The second image lies to left of S_2

For refractive at third surface S_3

$$u_3 = -\left(\frac{72}{7} + 18\right) = -\frac{198}{7}$$

$$\frac{1.5}{v_3} - \frac{1}{(-198/7)} = \frac{(1.5-1)}{(-9)}$$

$v_3 = -16.5$ cm

For refractive at fourth surface S_4:

$u_4 = -(16.5 + 9) = -25.5$ cm

$$\frac{1}{v_4} - \frac{3/2}{(-25.5)} = \frac{(1-3/2)}{\infty} = 0$$

$v_4 = -17$ cm

The final image lies at 17 cm to the left of surface S_4

30 **(b)**

Cutting a lens in transverse direction doubles their focal length, i.e., $2f$

Using the formula of equivalent focal length,

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \frac{1}{f_4}$$

We get equivalent focal length as $\frac{f}{2}$

31 **(d)**

Focal length of plano convex lens is

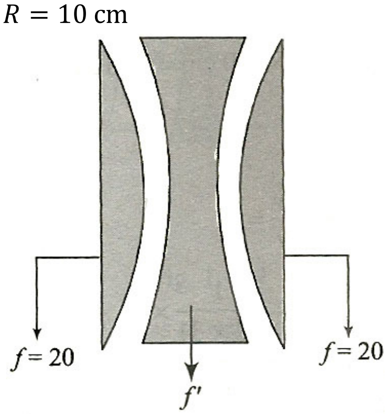
$$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{10} - \frac{1}{\infty}\right) \text{ or } f = 20 \text{ cm}$$

If point object O is placed at a distance of 20 cm from the plano-convex lens, rays become parallel and final image is formed at second focus or 20 cm from concave lens which is independent of b

32 **(c)**

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$R = 10$ cm



$$f' = (3-1)\left(\frac{1}{-10} - \frac{1}{10}\right)$$

$$f' = \frac{-10}{4}$$

$$\frac{1}{f_{eq}} = \frac{1}{20} - \frac{4}{10} + \frac{1}{20} = \frac{2}{20} - \frac{4}{10}$$

$f_{eq} = -10/3$ cm

33 **(c)**

According to given problem, for concave mirror, $u = -15$ cm and $f = -10$ cm

$$\frac{1}{v} + \frac{1}{-15} = \frac{1}{-10}, \text{ i.e., } v = -30 \text{ cm}$$

i.e., concave mirror will form real, inverted, and enlarged image I_1 of object O at a distance of 30 cm from it, i.e., at a distance $40 - 30 = 10$ cm from the convex mirror

For convex mirror, the image I_1 will act as an object and so for it $u = -10$ cm and $f = +15$ cm

$$\frac{1}{v} + \frac{1}{-10} = \frac{1}{15}, \text{ i.e., } v = +6 \text{ cm}$$

So, final image I_2 is formed at a distance of 6 cm behind the convex mirror and is virtual as shown in figure

34 **(c)**

Critical angle between glass and liquid face is

$$\sin\theta_c = \frac{3/2}{\mu} = \frac{3}{2\mu} \text{(i)}$$

Angle of incidence at face AC is 60°

i.e., $i = 60°$

For total internal reflection to take place,

$i > \theta_c$

Or $\sin i > \sin\theta_c$

Or $\sin 60° > \frac{3}{2\mu}$

Or $\frac{\sqrt{3}}{2} > \frac{3r}{2\mu}$

Or $\mu > \sqrt{3}$

35 **(a)**

Speed of image w.r.t. mirror

$$= \sqrt{\left(\frac{5}{\sqrt{2}}\right)^2 + \left(\frac{5}{\sqrt{2}}\right)^2} = 5 \text{ m/s}^{-1}$$

36 **(c)**

"O" act as the focal point

Also, $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

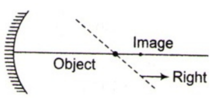
$$\Rightarrow \frac{1}{40} = (\mu - 1)\left(\frac{1}{10} + \frac{1}{10}\right)$$

$$\frac{1}{40} = (\mu - 1)\left(\frac{2}{10}\right)$$

$\Rightarrow \ \mu = 9/8$

37 **(b)**

Since object and image move in opposite directions, the positioning should be as shown in the figure. Object lies between focus and center of curvature $f < x < 2f$.



38 **(a)**

From Snell's law,

$$\mu_1 \sin i = \mu_2 \sin r \ \Rightarrow \frac{\mu_2}{m_1} = \frac{\sin i}{\sin r}$$

From the graph,

$$\tan 60° = \frac{\sin i}{\sin r} \Rightarrow \frac{\sin i}{\sin r} = \sqrt{3} = \frac{\mu_2}{\mu_1}$$

$$\mu = \frac{c}{v} \Rightarrow = \frac{\mu_1}{\mu_2} = \frac{v_2}{v_1}$$

$$v_1 = \left(\frac{\mu_2}{\mu_1}\right) v_2 \ \Rightarrow v_1 = \sqrt{3} v_2$$

39 **(d)**

For convex mirror, $u + v = 12 \times 2 = 24$ cm (because for plane mirror, distance of object=distance of image). Also, here for the convex mirror $u = 20$ cm, therefore $v = 4$ cm. Hence, using

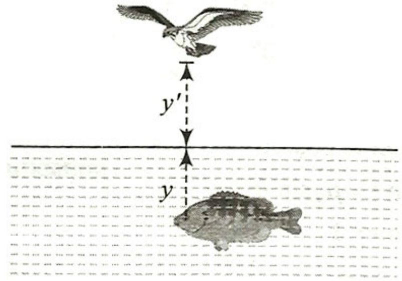
$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

We find $f = 5$ cm

40 **(a)**

Effective height of the bird as seen by the fish,

$Y = y + \mu y'$



$$\frac{dY}{dt} = \frac{dy}{dt} + \mu \frac{dy'}{dt}$$

$$9 = 3 + \frac{4}{3}\frac{dy'}{dt}$$

Or $\frac{dy'}{dt} = \frac{6 \times 3}{4} = \frac{18}{4}$

$$= \frac{9}{2} = 4.5 \text{ ms}^{-1}$$

Therefore, actual velocity of bird $= 4.5 \text{ ms}^{-1}$

41 **(a)**

$$\frac{\mu_1}{-u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$$

For a plane surface, $R = \infty$

$$\therefore \frac{\mu_1}{-u} + \frac{\mu_2}{v} = 0$$

or $\frac{\mu_2}{v} - \frac{\mu_1}{u}$ or $\frac{\mu}{v} - \frac{1}{u}$

or $v = \mu_2 u$

Clearly, to the fish, the bird appears farther than its actual distance

Again, $\frac{dv}{dt} = \mu \frac{du}{dt}$

or Apparent speed of bird

= refractive index × actual speed of bird

42 **(b)**

$m = 30$

$v + u = xu$

Or $\frac{v}{u} + 1 = x$ or $\ m + 1 = x$

Or $x = 31$

43 **(b)**

When mirror is rotated with angular speed ω, the reflected ray rotates with angular speed $2\omega (= 36 \text{ rads}^{-1})$

Speed of the spot $= \left|\frac{dh}{dt}\right| = \left|\frac{d}{dt}(10 \cot \theta)\right|$

$$= \left|-10 \operatorname{cosec}^2 \theta \frac{d\theta}{dt}\right| = \left|-\frac{10}{(0.6)^2} \times 36\right|$$

$= 1000 \text{ms}^{-1}$

44 **(a)**

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

$$\Rightarrow \frac{1}{f} = \frac{1}{40} - \frac{1}{(-20)}$$

$$\Rightarrow f = \frac{40}{3}$$

Focal length for the combination,

$$f_{eq} = \frac{20}{3}$$

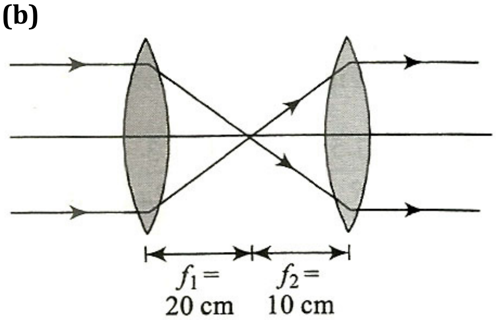
$$\frac{1}{f_{eq}} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \frac{30}{20} = \frac{1}{v} + \frac{1}{20}$$

$$\Rightarrow \frac{1}{v} = \frac{3}{20} - \frac{1}{20}$$

$v = 10$ cm (to the right)

45 **(b)**



As shown in figure the distance between the lenses should be 30 cm

46 **(b)**

$$\frac{1}{f_1}(\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{f_1} = (1.5 - 1)\left[\frac{1}{14} - \frac{1}{\infty}\right]$$

$$\frac{1}{f_1} = \frac{0.5}{14}$$

$$\frac{1}{f_2} = (1.2 - 1)\left[\frac{1}{\infty} - \frac{1}{-14}\right]$$

$$\frac{1}{f_2} = \frac{0.2}{14}$$

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{0.5}{14} + \frac{0.2}{14}$$

$$\Rightarrow \frac{1}{f} = \frac{0.7}{14}$$

$$\frac{1}{v} = \frac{7}{140} - \frac{1}{40} = \frac{1}{20} - \frac{1}{40}$$

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

$$\Rightarrow v = 40\ cm$$

47 **(c)**

$\sin i_c = \frac{1}{\sqrt{2}} i_c = 45°$

Now, $75° = r + 45°$

Or $r = 30°$

Now, $\frac{\sin i}{\sin 30°} = \sqrt{2}$

Or $\sin i = \sqrt{2} \times \frac{1}{2} = \frac{1}{\sqrt{2}}$

$\therefore\ i = 45°$

48 **(c)**

When the object is placed at the center of the glass sphere, the rays from the object fall normally on the surface of the sphere and emerge undeviated.

49 **(a)**

Clearly, the distance of I from P is 15 cm

Now, $u = -25$ cm, $v = 15$ cm, $f = ?$

$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ or $\frac{1}{f} = \frac{1}{-25} + \frac{1}{15}$

Or $\frac{1}{f} = \frac{-3+5}{75}$ or $f = \frac{75}{2}$ cm $= 37.5$ cm

50 **(c)**

For concave mirror, if x and y are object distance and image and distance, respectively, we have

$$-\frac{1}{x} - \frac{1}{y} = -\frac{1}{|f|}$$

$$\Rightarrow \frac{1}{x} + \frac{1}{y} = \frac{1}{|f|}$$

$$\Rightarrow -\frac{1}{x^2}\frac{dx}{dt} - \frac{1}{y^2}\frac{dy}{dt} = 0$$

$$\Rightarrow \left|\frac{V_x}{V_y}\right| = \frac{x^2}{y^2}$$

For $\left|\frac{V_x}{V_y}\right| = \frac{1}{4}, \frac{x}{y} = \pm 2$

For $\frac{x}{y} = 2$, we get $x = \frac{3|f|}{2}$[for point A]

and For $\frac{x}{y} = -2$, we get $x = \frac{|f|}{2}$[for point B]

As the middle point happens to be focus of the mirror, we get

$|f| = L$

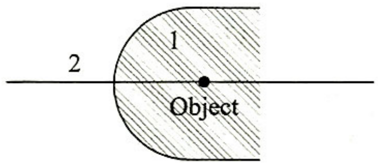
51 **(a)**

At minimum deviation $(\delta = \delta_m)$

$r_1 = r_2 = \frac{A}{2} = \frac{60°}{2} = 30°$ (for both colours)

52 **(a)**

Applying $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$



$$\frac{1}{v} - \frac{1.5}{(-u)} = \frac{1-(1.5)}{-R} \quad \text{or} \frac{1}{v} + \frac{3}{2u} = \frac{1}{2R}$$

For v to be positive, $\frac{1}{2R} > \frac{3}{2u}$

Or $u > 3R$

53 **(b)**

The fish can observe the sky only if refraction takes place. If TIR takes place, then image of sky cannot be observed

i.e., $i < i_c$ and $i_c = 45°$

So, angle subtended $= \frac{\pi}{2}$

54 **(a)**

By mirror formula : $\frac{1}{v} + \frac{1}{-10} = \frac{1}{10}$

$\Rightarrow v = +5$ cm

$\therefore m = +\frac{1}{2}$

The image revolves in a circle of radius $\frac{1}{2}$ cm.

Image of a radius is erect $\Rightarrow$ particle will revolve in the same direction as the particle. The image will complete one revolution in the same time 2 s

Velocity of image v is

$$\omega r = \frac{2\pi}{2} \times \frac{1}{2} = \frac{\pi}{2} \text{cms}^{-1} = 1.57 \text{ cms}^{-1}$$

55 **(d)**

For A:

$u = -3\ m, v_1 = ?, f = -1$ m

$$\frac{1}{u_1} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-1} - \frac{1}{-3} = \frac{1}{3} - 1 = -\frac{2}{3}$$

Or$v_1 = -\frac{3}{2}$

For B:

$\frac{1}{v_2} = \frac{1}{-1} - \frac{1}{-5}or\frac{1}{v_2} = \frac{1}{5} - 1 = -\frac{4}{5}$

Or$v_2 = -\frac{5}{4}$ m

Now, $v_1 - v_2 = \frac{3}{2} - \left(-\frac{5}{4}\right)$

$$= -\frac{3}{2} + \frac{5}{4} = -\frac{1}{4}\text{m} = -0.25 \text{ m}$$

Again, $\frac{l_1}{O} = -\frac{v_1}{u}$

Or$l_1 = -\frac{v_1}{u}O = -\left(\frac{-3}{2}\right)\left(\frac{-1}{3}\right) = -1$ m

Again, $\frac{l_2}{O} = -\frac{v_2}{u}$

Or$l_2 = -\left(-\frac{5}{4}\right)\left(\frac{1}{-5}\right)2 = -0.5$ m

56 **(a)**

When final image is formed at infinity, length of the tube $= v_o + f_e$

$\Rightarrow 15 = v_o + 3 \Rightarrow v_o = 12\ cm$

For objective lens $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$

$$\Rightarrow \frac{1}{(+2)} = \frac{1}{(+12)} - \frac{1}{u} \Rightarrow u_o = -2.4\ cm$$

57 **(b)**

At first position of lens, let the distance of lens from object and screen be x and y, respectively

$\therefore x + y = 100$ (i)

$\therefore$ At second position of lens, the distance of lens from object and screen shall be y and x, respectively

$\therefore\ y - x = 40$ (ii)

Solving Eqs. (i) and (ii), we get

$y = 70 \text{ cm} = \frac{700}{100}$ m and $x = 30 \text{ cm} = \frac{30}{100}$ m

Therefore, the power of lens is

$$\frac{1}{f} = \frac{1}{y} + \frac{1}{x} = \frac{100}{70} + \left(\frac{100}{30}\right) = \frac{100}{21} \approx 5 \text{ diopter}$$

58 **(d)**

Clearly, power of system is zero

$$\therefore 0 = \frac{1}{20} + \frac{1}{f} - \frac{5}{20f}$$

Or $-\frac{1}{20} = \frac{15}{20f}$ or $f = -15$ cm

59 **(d)**

Deviation produced by prism is

$\delta_1 = (\mu - 1)A = 2°$ CW

Angle of incidence for mirror is δ_1, so deviation produced by the mirror is

$\delta_2 = \pi - 2\delta_1 = 176°$ CW

Deviation produced by the prism for 2nd refraction is

$\delta_3 = 2°$ ACW

Net deviation $= 174°$ CW

60 **(b)**

For part MN,

$u = -30$ cm, $f = -10$ cm

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$
$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{-10}-\frac{1}{-30}=-\frac{1}{10}+\frac{1}{30}$$
$$\frac{1}{v}=\frac{-3+1}{30}=\frac{-2}{30}$$
$V=-15$ cm
$$m=\frac{I}{O}=-\frac{v}{u}$$
$$\Rightarrow \frac{I}{10}=-\frac{(-15)}{(-30)}=-\frac{1}{2} \Rightarrow I=5 \text{ cm}$$
For image of ST,

$u=-40$ cm
$f=-10$ cm
$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$
$$\frac{1}{v}+\frac{1}{(-40)}=\frac{1}{(-10)}$$
$$\frac{1}{v}=-\frac{1}{10}+\frac{1}{40}$$
$$\frac{1}{v}=-\frac{-4+1}{40}=\frac{-3}{40}$$
$$V=-\frac{40}{3}\text{ cm}$$
For length of image of ST,
$$m=\frac{I}{O}=-\frac{v}{u}$$
$$\frac{I}{10}=-\left(\frac{-40/3}{-40}\right) \Rightarrow I=-\frac{10}{3}\text{ cm}$$
Length of image of NT,
$$T'N'=15-\frac{40}{3}=\frac{5}{3}\text{ cm}$$
Length of wire in image $=5+\frac{10}{3}+\frac{5}{3}=10$ cm

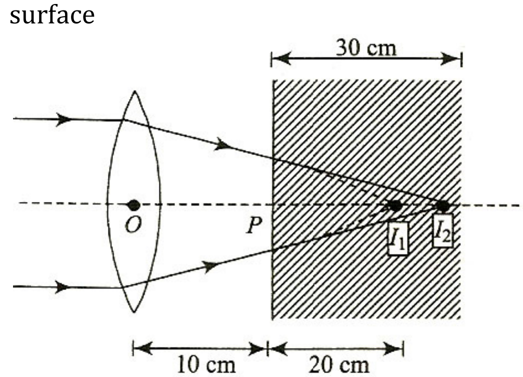
62 **(a)**
In the first case, neither the radii of curvature nor the material of the lens is affected. In the second case,
$$\frac{1}{f''}=(\mu-1)\left(\frac{1}{R}\right) \text{ or}$$
$$\frac{1}{f''}=\frac{1}{2}(\mu-1)\left(\frac{2}{R}\right)=\frac{1}{2f}$$
or $f''=2f$

63 **(a)**
$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$
$$\text{Or } \frac{u}{v}-1=\frac{u}{f}$$
$$\text{Or } \frac{u}{v}=\left(\frac{u+f}{f}\right)$$
$$m=\frac{v}{u}=\left(\frac{f}{u+f}\right)$$
$$\frac{m_{25}}{m_{50}}=\frac{\left(\frac{20}{-25+20}\right)}{\left(\frac{20}{-50+20}\right)}=6$$

64 **(d)**
$$\frac{1}{v}-\frac{1}{u}=-\frac{1}{f}$$
$$\frac{1}{v}-\frac{1}{-15}=\frac{1}{f}$$
$$\text{Or } \frac{1}{v}-\frac{1}{15}+\frac{1}{10} \text{ or } \frac{1}{v}=\frac{-2+3}{30}$$
Or $v=30$ cm

65 **(b)**
Critical angle from region III to region IV
$$\sin\theta_C=\frac{n_0/8}{n_0/6}=\frac{3}{4}$$
Now applying Snell's law in region I and region III
$$n_0\sin\theta=\frac{n_0}{6}\sin\theta_C$$
$$\text{Or } \sin\theta=\frac{1}{6}\sin\theta_C=\frac{1}{6}\left(\frac{3}{4}\right)=\frac{1}{8}$$
$$\therefore \theta=\sin^{-1}\left(\frac{1}{8}\right)$$

66 **(d)**
The lens will converge the rays at its focus, i.e., 30 cm from the lens or 20 cm from the refracting surface



$PI_1=20$ cm
$$\therefore PI_2=\mu(PI_1)=\frac{3}{2}\times 20=30 \text{ cm}$$
So, the rays will converge at a distance of 40 cm from the lens

67 **(a)**
Only one image will be formed by this lens system

because optic axis of both the parts coincide. Two images would have formed if their optic axis were different

68 **(d)**

Let v_1 be the speed of gun (or mirror) just after the firing of bullet. From conservation of linear momentum,

$m_2 v_0 = m_1 v_1$

$v_1 = \frac{m_2 v_0}{m_1}$ (i)

Now rate at which distance between mirror and bullet is increasing,

$\frac{du}{dt} = v_1 + v_0$ (ii)

$$\frac{dv}{dt} = \left(\frac{v^2}{u^2}\right)\frac{du}{dt}$$

Here, $\frac{v^2}{u^2} = m^2 = 1$

(as at the time of firing, the bullet is at pole)

$\frac{dv}{dt} = \frac{du}{dt} = v_1 + v_0$ (iii)

Here, dv/dt is the rate at which distance between image (of bullet) and mirror is increasing. So, if v_2 is the absolute velocity of image (towards right), then

$$v_2 - v_1 = \frac{dv}{dt} = v_1 + v_0$$

Or $v_2 = 2v_1 + v_0$ (iv)

Therefore, speed of separation of the bullet and the image will be

$v_r = v_2 + v_o = 2v_1 + v_o + v_o$

$v_r = 2(v_1 + v_o)$

Subtracting value of v_1 from Eq. (i), we have

$$v_r = 2\left(1 + \frac{m_2}{m_1}\right)v_0$$

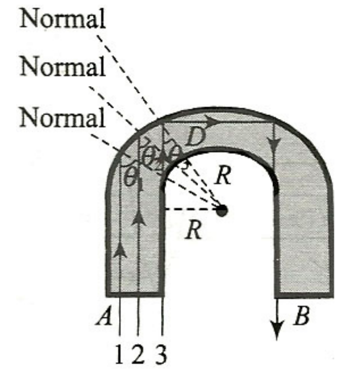
69 **(a)**

Figure shows three rays 1,2,3 incident on plane face A. We can see that angle of incidence at curved surface is least for ray 3. If ray 3 reflects at the curved surface, then all the rays will reflect as their angle of incidence is greater than angle θ_3

$\theta_3 \geq \theta_{\text{critical}}$

$$\sin\theta_{\text{critical}} = \frac{1}{\mu} = \frac{2}{3}$$

From geometry of figure, we have



$$\sin\theta_3 = \frac{R}{d+R}$$

$\sin n\theta_3 \geq \sin\theta_{\text{cirtical}}$

$$\frac{R}{d+R} \geq \frac{2}{3}$$

$$\frac{d}{R} \leq \frac{1}{2}$$

Therefore, $\left(\frac{d}{R}\right)_{\text{maximum}} = \frac{1}{2}$

70 **(a)**

As shown in figure, the plane mirror will form erect and virtual image of same size at a distance of 30 cm behind it. So, the distance of image formed by plane mirror from convex mirror will be

$PI = MI - MP$

But as, $MI = MO$

$PI = MO - MP = 30 - 20 = 10$ cm

Now, as this image coincides with the image formed by convex mirror, therefore for convex mirror,

$u = -50$ cm; $v = +10$ cm

So, $\frac{1}{+10} + \frac{1}{-50} = \frac{1}{f}$, i.e., $f = \frac{50}{4} = 12.5$ cm

So, $R = 2f = 2 \times 12.5 = 25$ cm

71 **(d)**

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

$\frac{1}{f-x_1} + \frac{1}{f-x_2} = \frac{1}{f}$ or $\frac{f-x_2+f-x_1}{(f-x_1)(f-x_2)} = \frac{1}{f}$

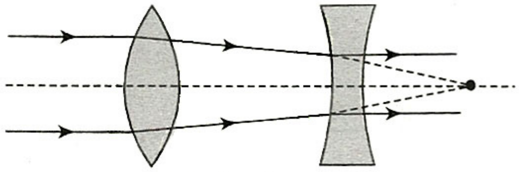
Or $f^2 - fx_2 - fx_1 + x_1x_2 = 2f^2 - f(x_1 + x_2)$

Or $f^2 = x_1x_2$ or $f = \sqrt{x_1x_2}$

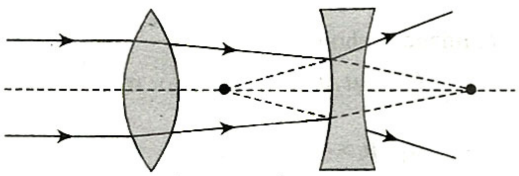
This in Newton's mirror formula

72 **(b)**

Initially, the object for lens B (the image formed by lens A) is at its focus, so rays are parallel
As the separation between A and B decreases, the object for B is lying away from focus and hence, the rays are diverged



Initial position



Later position

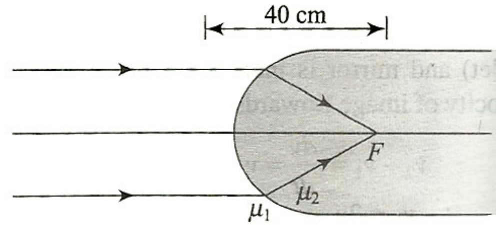
73 **(b)**
$r = f tan\theta$
Or $r \propto f$
$\therefore \quad \pi r^2 \propto f^2$

74 **(c)**
Let f_1 and f_2 be the focal length in water
Then
$$\frac{1}{f_1} = \left(\frac{\mu_1}{\mu_w} - 1\right)\left(\frac{1}{R} + \frac{1}{R}\right) = \left(\frac{\mu_1}{\mu_w} - 1\right)\left(\frac{2}{R}\right) \text{(i)}$$
$$\frac{1}{f_2} = \left(\frac{\mu_2}{\mu_w} - 1\right)\left(-\frac{1}{R} - \frac{1}{R}\right) = \left(\frac{\mu_2}{\mu_w} - 1\right)\left(\frac{-2}{R}\right) \text{(ii)}$$
Adding (i) and (ii), we get $\frac{1}{f_1} + \frac{1}{f_2} = \frac{2(\mu_1 - \mu_2)}{\mu_w R}$
Or $\frac{1}{30} = \frac{2(\mu_1 - \mu_2)}{\mu_w R}$
$$\therefore (\mu_1 - \mu_2) = \frac{\mu_w R}{60}$$
Substituting the values,
$$(\mu_1 - \mu_2) = \frac{4 \times 15}{3 \times 60} = \frac{1}{3}$$

75 **(b)**
$r_2 = 0°$

$r_1 = A = 30°$
and $i_1 = 60°$
$$\mu = \frac{\sin i_1}{\sin r_1} = \frac{\sin 60°}{\sin 30°} = \sqrt{3}$$

76 **(b)**
Let us see where does the parallel rays converge focus and the corresponding length the focal length f. Using



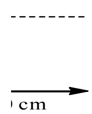
$$\frac{\mu_1}{v} - \frac{\mu_2}{u} = \frac{\mu_2 - \mu_1}{R}$$
With proper values and signs, we have
$$\frac{4/3}{f} - \frac{1.0}{\infty} = \frac{4/2 - 1.0}{+10}$$
Or $f = 40 \text{ cm} = 0.4 \text{ m}$
Since the rays are converging, its power should be positive. Hence,
$P(\text{in dioptre}) = \frac{+1}{f(\text{meter})} = \frac{1}{0.4}$
Or $P = 2.5$ dioptre

77 **(d)**
Concave lens forms the virtual image of a real object. So, let
$u = -4x$ and $v = -x$
Then, $3x = 10$ cm
Or $x = \frac{10}{3}$cm
$\therefore\ u = -\frac{40}{3}$ cm and $v = -\frac{10}{3}$ cm
Subtracting in $\frac{1}{f} = \frac{-3}{10} + \frac{3}{40}$
Or $f = -\frac{40}{9}$
Or $f = -4.4$ cm

78 **(c)**
$$\sin\theta_1 = \frac{1}{\mu_g} \text{and } \sin\theta_2 = \frac{1}{\mu_w}$$
Since $\mu_g > \mu_w,\ \theta_1 < \theta_2$
Critical angle θ between glass and water will be given by
$$\sin\theta = \frac{\mu_w}{\mu_g}$$
Or $\theta > \theta_2$
Note: Critical angle increases as the relative refractive index is decreased

79 **(b)**
Object is placed at distance $2f$ from the lens. So first image I will be formed at distance $2f$ on other side. This image I_1 will behave like a virtual object for mirror. The second image I_2 will be formed at distance 20 cm in front of the mirror, or at distance 10 cm to the left hand side of the lens. Now applying lens formula

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



$$\therefore \frac{1}{v}-\frac{1}{+10}=\frac{1}{+15}$$

or $v = 16$ cm

Therefore, the final image is at distance 16 cm from the mirror. But, this image will be real. This is because ray of light is travelling from right to left.

80 **(d)**

Both the lenses (convex or concave) form virtual image of a real extended object. In both the cases, image would be erect

For convex lens, virtual image will form when object is in-between focus and optical center

For concave lens, virtual image will form for any location of object, and corresponding image is lying between focus and optical center

81 **(b)**

$A = 90° - \theta \Rightarrow r_2 = A = 90° - \theta > \theta_c$

$\cos\theta > \sin\theta_c = \frac{6/5}{2/3} = \frac{4}{5}$ (θ_C is critical angle)

$\theta < \cos^{-1}\frac{4}{5} = 37°$

82 **(a)**

Considering refraction at the curved surface,

$u = -20$; $\mu_2 = 1$

$\mu_1 = 3/2$; $R = +20$

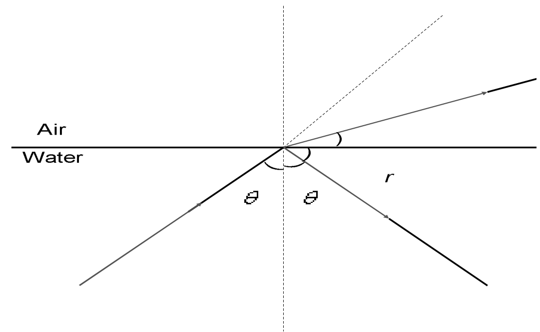
Applying $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$$\frac{1}{v}-\frac{3/2}{-20}=\frac{1-3/2}{20} \Rightarrow v = -10$$

i.e., 10 cm below the curved surface or 10 cm

83 **(c)**

Since $\theta < \theta_C$, both reflection and refraction will take place. From the figure we can see that angle between reflected and refracted rays α is less than $180° - 2\theta$.



84 **(a)**

Use refraction formulae separately; that is for air and $\mu = 1.6$; and for air and $\mu = 2.0$ and positions of the two images

85 **(b)**

$$\frac{1}{v}-\frac{1}{-15}=\frac{1}{10}$$

Or $\frac{1}{v} = \frac{1}{10} - \frac{1}{15}$ or $\frac{1}{v} = \frac{3-2}{30}$

Or $v = 30$ cm

Clearly, the rays coming from the convex lens should fall normally on the convex mirror. In other words, the rays should be directed toward the center of curvature of the convex mirror

$\therefore 2f = 20$ cm or $f = 10$ cm

86 **(c)**

For $M_1: V = -60, m_1 = -2$

For $M_1: u = +20, F = 10$

$$\frac{1}{V} = \frac{1}{20} = \frac{1}{10} \Rightarrow V = 20$$

$$\therefore M_2 = -\frac{20}{20} = -1$$

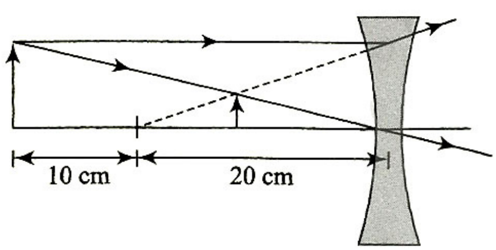
$\therefore M = m_1 \times m_2 = +2$

88 **(c)**

Let d' be the diameter of refracted beam

Then,
$d = PQ \cos 60°$
and $d' = PQ \cos r$
i. e. $\frac{d'}{d} = \frac{\cos r}{\cos 60°} = 2 \cos r$
or $d' = 2d \cos r$
$\sin r = \frac{\sin i}{\mu} = \frac{\sqrt{3}/2}{3/2} = \frac{1}{\sqrt{3}}$
$\therefore \cos r = \sqrt{1 - \sin^2 r} = \sqrt{\frac{2}{3}}$
$\therefore d' = (2)(2)\sqrt{\frac{2}{3}}$
$= 4\sqrt{\frac{2}{3}}$ cm ≈ 3.26 cm

89 **(b)**



When an object is placed between $2f$ and f (focal length) of the diverging lens, the image is virtual, erect, and diminished as shown in the graph. To compute the distance of the image from the lens, we apply
$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{-20} = \frac{1}{v} - \frac{1}{30}$
$\Rightarrow v = \frac{(20)(30)}{20 + 30}$
$= -12$ cm (to the left of the diverging lens)

91 **(a)**
$m = -\frac{v}{u} = -\frac{\frac{4}{9}}{-1} = \frac{4}{9}$

92 **(c)**
$A = r_1 + r_2$
$30° = r_1 + 0$
Or $r_1 = 30°$

Now, $\frac{\sin i}{\sin 30°} = \sqrt{2}$
Or $\sin i = \sqrt{2} \times \frac{1}{2}$
Or $i = 45°$

93 **(d)**
Image will be formed at infinity if object is placed at focus of the lens, i.e., at 20 cm from the lens. Hence,
Shift $= 25 - 20 = \left(1 - \frac{1}{\mu}\right)\mu$
Or $5\left(1 - \frac{1}{1.5}\right) t$or $t = \frac{5 \times 1.5}{0.5} = 15$ cm

94 **(c)**
$m = \frac{f}{f+u}, \frac{1}{2} = \frac{f}{f-2}$; or $2f = f - 2$ or $f = -2$ m
$|f| = 2$ metre. Since the image is virtual as well as diminished, therefore the lens is concave

95 **(d)**
Clearly, $2f = 20$ cm
Or $f = 10$ cm
Now, $u = -15$ cm, $v = ?$
$f = 10$ cm
$\frac{1}{v} - \frac{1}{-15} = \frac{1}{10}$
Or $\frac{1}{v} + \frac{1}{15} = \frac{1}{10}$ or $\frac{1}{v} = \frac{1}{10} - \frac{1}{15}$
Or $\frac{1}{v} = \frac{3-2}{30} = \frac{1}{30}$
Or $v = 30$ cm
The change in image distance is $(30 - 20)$ cm, i.e., 10 cm

96 **(a)**
Since the refractive index is changing, the light cannot travel in a straight line in the liquid as shown in options (c) and (d). Initially, it will bend towards normal and after reflecting from the bottom it will bend away from the normal as shown below

97 **(b)**
During minimum deviation the ray inside the prism is parallel to the base of the prism in case of an equilateral prism.

$|\vec{V}_0| = |\vec{V}_0| = \sqrt{(2)^2 + (2)^2} = 2\sqrt{2}\text{ms}^{-1}$

Relative velocity of image with respect to object is in negative x-direction as shown in figure

99 **(c)**

We will have to consider two refractions: first at surface S_1 and the second at surface S_2

For refraction at surface S_1:

$$\frac{1.6}{v_1} - \frac{1.2}{(-120)} = \frac{(1.6-1.2)}{20}, v_1 = +160 \text{ cm}$$

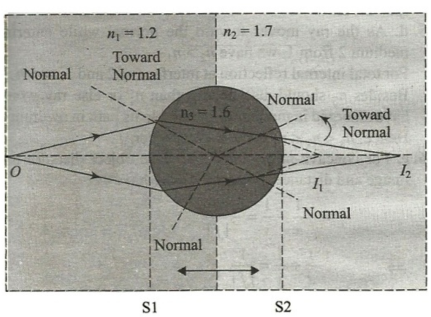
The positive sign implies that first image is formed to the right of S_1

For refraction at surface S_2:

The first image is object for refraction at second surface, $v_2 = +(160 - 40)$ cm

$$\frac{1.7}{v_2} - \frac{1.6}{+(160-40)} = \frac{1.6-1.7}{(-20)}, v_2 = +204 \text{ cm}$$

The final image is formed at 204 cm from vertex and on the right side



100 **(d)**

Mirror can be shifted to new position $C'D'$.

Distances are shown in the figure

Image will be at equal distance from the mirror $C'D'$ as the object is

Image distance from $C'D'$ is

$$10 + \frac{5}{3/2} = 10 + \frac{10}{3} = \frac{40}{3} \text{ cm}$$

Separation between object and image is $\frac{80}{3}$ cm

101 **(d)**

Only convex lens can form a real well as virtual image. So, the given lens is a convex lens

Let f is the focal length of the lens and n the magnitude of magnification

In the first case, when the image is real:

$\mu v = -16$

$v = +16n$

So, applying $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{16n} + \frac{1}{16} = \frac{1}{f}$$

Or $1 + \frac{1}{n} = \frac{16}{f}$ (i)

In the second case, when image is virtual:

$u = -6$

$v = -6\text{n}$

$f = +f$

$$\therefore \frac{1}{-6n} + \frac{1}{6} = \frac{1}{f}$$

$\therefore 1 - \frac{1}{n} = \frac{6}{f}$ (ii)

Adding (i) and (ii), we get

$2 = \frac{22}{f}$ or $f = 11$ cm

102 **(b)**

Deviation by a sphere is $2(i - r)$

Here, deviation $\delta = 60° = 2(i - r)$

Or $i - r = 30°$

$\therefore r = i - 30° = 60° - 30° = 30°$

$$\therefore \mu = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 30°} = \sqrt{3}$$

103 **(c)**

When $n = 1$,

$$\mu(1) = \mu_0 - \frac{\mu_0}{4 \times 1 - 18}$$

$\mu(1) > \mu_0$

When $n = 2$

$$\mu(2) = \mu_0 - \frac{\mu_0}{4 \times 2 - 18}$$

$\mu(2) > \mu_0$

When $n = 4$,

$$\mu(4) = \mu_0 - \frac{\mu_0}{4 \times 4 - 18}$$

$\mu(4) > \mu_0$

When $n = 5$

$$\mu(5) = \mu_0 - \frac{\mu_0}{5 \times 4 - 18}$$

$\mu(5) < \mu_0$

Clearly, the total internal reflection shall take place at the top of a layer having $n = 4$

104 **(c)**

$$\mu = \frac{\sin r'}{\sin i}$$

But $r' + r = 90°$

Or $r' = 90° - r$

$r = 90° - r$

$$\therefore \ \mu = \frac{\cos i}{\sin i}$$

Or $\frac{1}{\sin i_c} = \frac{1}{\tan i}$

Or $i_c = \sin^{-1}(\tan i)$

105 **(c)**

$v \cos 45° = 20\sqrt{2}$

Or $\frac{v}{\sqrt{2}} = 20\sqrt{2}$ or $v = 40 \text{ cm s}^{-1}$

The velocity of the image formed by the roof is the same as the velocity of insect

So, (c) is the correct choice

106 **(b)**

Power of liquid lens

$$= (1.6 - 1)\left(\frac{2}{0.20}\right) = \frac{6}{10} \times 10 = 6 \text{ D}$$

Power of concave lens

$= -(1.5 - 1) = -0.5 \times 10$ D

Total power of two concave lenses $= -10$ D

Power of system

$= -10 \text{ D} + 6 \text{ D} = -4$ D

Focal length $= \frac{1}{-4} = -0.25$ m

107 **(b)**

$$\frac{2.5}{v} - \frac{1}{-u} = \frac{1.5}{-R}$$

$$v = -\frac{2.5u\,R}{1.5u + R}$$

$v < 0$ for all values of u, so the image remains virtual

108 **(d)**

Component of V perpendicular to the mirror gets reversed while that parallel to it remains same.

Thus, velocity vector of image becomes

$V \cos 2\theta \hat{\imath} + V \sin 2\theta \, \hat{\jmath}$

109 **(b)**

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

$$3 = \frac{-24}{-24 - u}$$

Or $-24 - u = -8$ or $u + 24 = 8$

Or $u = (8 - 24)\text{cm} = -16$ cm

If $m = -3$, then

$$-3 = \frac{-24}{-24 - u}$$

$u + 24 = -8$

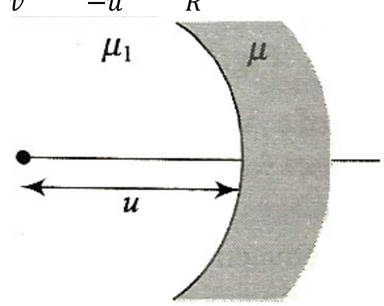
Or $u = -32$ cm

Note that the magnification is greater than 1, so mirror cannot be convex

110 **(d)**

We have $\frac{\mu}{v} - \frac{\mu_1}{-u} = \frac{\mu - \mu_1}{-R}$

$$\frac{\mu}{v} = -\frac{\mu_1}{-u} + \frac{\mu_1 - \mu}{R}$$



Radius $= R$

$$\frac{\mu}{v} = \frac{-\mu_1 R + \mu_1 u - \mu u}{uR}$$

$$v = \frac{\mu u R}{(\mu_1 - \mu)u - \mu_1 R}$$

For real image, v should be positive

So, $(\mu_1 - \mu_2)\mu - \mu_1 R > 0$ for real image

i.e., $\mu_1 - \mu > \frac{\mu_1 R}{u}$

or $\mu_1 \left(1 - \frac{R}{u}\right) > \mu$

$\mu_1 > \mu\left[1 - \frac{R}{u}\right]^{-1}$

Which depends upon the location of object

111 **(d)**

For (a) and (b), object and image are on the same side, so image is real as the object is real

For (c), image is virtual but $|m| > 1$. So concave mirror

For (d), $|m| < 1$ and image is also virtual, so in (d) image is formed in a convex mirror

112 **(b)**

Critical angle $\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$

$= \sin^{-1}\left(\frac{1}{2}\right) = 30°$

If $A > 2\theta_c$, the ray does not emerge from the prism. So, maximum angle can be 60°

113 **(c)**

Let power of light source be P, then intensity at any point on the screen is due to light rays directly received from source and that due to light rays after reflection from the mirror

$I = \frac{P}{4\pi a^2} + \frac{P}{4\pi \times (3a)^2}$

When mirror is taken away,

$I_1 = \frac{P}{4\pi a^2} = \frac{9I}{10}$

114 **(d)**

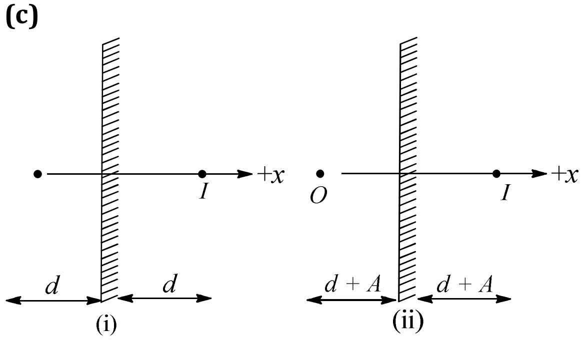
From $\sin\left(\frac{A+\delta_m}{2}\right) = \mu \sin\frac{A}{2}$

$\sin\left(\frac{A+\delta_m}{2}\right) = \frac{\cos\frac{A}{2}}{\sin\frac{A}{2}} \times \sin\frac{A}{2}$

$\frac{A+\delta_m}{2} = \frac{\pi}{2} - \frac{A}{2}$

$\delta_m = \pi - 2A = 180° - 2A$

115 **(c)**



From figure (i) and (ii), it is clear that if the mirror moves distance 'A', then the image moves a distance '$2A$'

116 **(b)**

Power of convex lens $P_1 = \frac{100}{40} = 2.5\ D$

Power of concave lens $P_2 = -\frac{100}{25} = -4\ D$

Now $P = P_1 + P_2 = 2.5\ D - 4\ D = -1.5\ D$

117 **(d)**

For lens $\frac{1}{f} = \frac{1}{v_1} - \frac{1}{u_1}$

$\frac{u_1}{f} = \frac{u_1}{v_1} - 1 \Rightarrow m_1 = \frac{v_1}{u_1} = \frac{f}{u_1 + f}$

And $m_2 = \frac{f}{u_2 + f}$

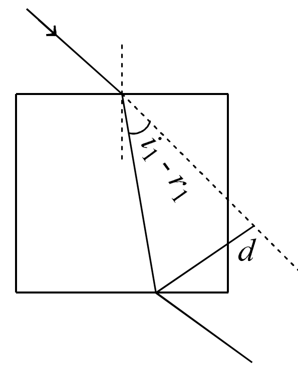
$\frac{1}{m_2} - \frac{1}{m_1} = \frac{(u_2 - u_1)}{f} \Rightarrow f = \frac{(u_2 - u_1)}{(m_2)^{-1} - (m_1)^{-1}}$

118 **(b)**

Shift $= (\ell - m)\left(1 - \frac{1}{n_1}\right) + m\left(1 - \frac{1}{n_2}\right) = 0$

119 **(b)**

$\frac{\sin 60°}{\sin r_1} = \sqrt{3}$



Or $\sin r_1 \frac{\sin 60°}{\sqrt{3}}$

Or $\sin r_1 = \frac{\sqrt{3}}{2} \times \frac{1}{\sqrt{3}} = \frac{1}{2}$

Or $r_1 = 30°$

Now, $\sin(i_1 - r_1) = \frac{d}{5}$

Or $d = 5\sin(i_1 - r_1)$

Or $d = 5\sin(60° - 30°) = 5\sin 30° = \frac{5}{2}$ cm

120 **(d)**

Let focal length of convex lens is $+f$ then focal length of concave lens would be $-\frac{3}{2}f$.

From the given condition,

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

$\therefore\ f = 10$ cm

Therefore, focal length of convex lens = + 10 cm and that of concave lens = -15 cm.

121 **(c)**

Refraction from lens

$\frac{1}{v_1} = \frac{1}{-20} = \frac{1}{15}$

$\therefore\quad v = 60\ cm + ve$ direction

Ie, first image is formed at 60 cm to the right of lens system.

Reflection from mirror After reflection from the mirror, the second image will be formed at a distance of 60 cm to the left of lens system.

Refraction from lens $\frac{1}{v_3} - \frac{1}{60} = \frac{1}{15} +$ ve direction

Or $v_3 = 12\ cm$

Therefore, the final image is formed at 12 cm to the left of the lens system.

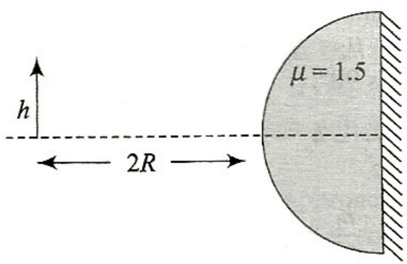
122 **(a)**

Critical angel $\theta_C = \sin^{-1}\left(\frac{1}{\mu}\right)$

Wavelength increases in the sequence of VIBGYOR. According to Cauchy's formula refractive index (μ) decreases as the wavelength increases. Hence, the refractive index will increase in the sequence of ROYGBIV. The critical angle θ_C will thus increase in the same order VIBGYOR. For green light the incidence angle is just equal to the critical angle. For yellow, orange and red the critical angle will be greater than the incidence angel. So these colours will emerge from the glass air interface.

123 **(b)**

Here, three optical phenomena take place-first refraction, then reflection, and finally refraction



For 1st refraction, $\frac{1.5}{v} - \frac{1}{-2R} = \frac{1.5-1}{R}$

$\frac{1.5}{v} = 0 \Rightarrow v \infty 0$

i.e., rays after refraction get parallel to the axis and strike the mirror normally, get retraced back, and final image is formed at the same place where the object is and of same size. Image would be real

124 **(a)**

The refractive index, ${}_1n_2$ (from medium 1 to medium 2) for two given media 1 and 2 is given by

$${}_1n_2 = \frac{\text{speed of light in medium 1 } (c_1)}{\text{speed of light in medium 2 } (c_2)}$$

$$= \frac{\text{wavelength of light in medium 1 } (\lambda_1)}{\text{wavelength of light in medium 2 } (\lambda_2)}$$

Now, ${}_1n_2 = \frac{n_2}{n_1} = \frac{5}{4}$

$c_1 = 2.0 \times 10^{-8}\text{ms}^{-1}$

$\lambda_1 = 500$ nm

$\therefore \frac{5}{4} = \frac{2.0 \times 10^8}{c_2} = \frac{500}{\lambda_2}$

Hence, $\lambda_1 = 400$ nm

$c_2 = 1.6 \times 10^8\text{ms}^{-1}$

125 **(b)**

Options (c) and (d) are not possible because ray diagram shows that the R.I. of surrounding of glass is more.a. is wrong because angle of incidence seem to be small as compared to critical angle (≈ 41°). Therefore (b) is correct

126 **(d)**

The two slabs will shift the image a distance

$$d = 2\left(1 - \frac{1}{\mu}\right)t = 2\left(1 - \frac{1}{1.5}\right)(1.5) = 1.0\text{cm}$$

Therefore, final image will be 1 cm above point P

127 **(a)**

$$\sin i_c = \frac{1}{1.5} = \frac{2}{3}$$

$$i_c = \sin^{-1}\left(\frac{2}{3}\right) = \sin^{-1}(0.6667) = 41.8°$$

The angle of incidence of face AC is 45° which is clearly greater than 41.8°

128 **(a)**

For real image:

$u = -v_1, v = -2u_1, f = -20$ cm

Subtracting in $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$,

We get $\frac{1}{-2u_1} - \frac{1}{u_1} = -\frac{1}{20}$

Or $u_1 = 30$ cm

For virtual image:

$u = -u_2, v = 2u_2, f = -20$ cm

$$\therefore \frac{1}{2u_2} - \frac{1}{u_2} = -\frac{1}{20}$$

Or $u_2 = 10$ cm

Therefore, distance between two positions of the object are $u_1 - u_2$ or 30 cm − 10cm = 20 cm

129 **(b)**

$$m = -\frac{v}{u} = -\frac{600}{31} \times \frac{1}{-600} = \frac{1}{31}$$

Breadth of image $= \frac{1}{31} \times 200$ cm=6.45 cm

Height of image $= \frac{1}{31} \times 160$ cm=5.16 cm

130 **(b)**

Since the surrounding medium is denser than the material of the lens, therefore the concave lens shall behave like a convex lens

131 **(a)**

Using mirror formula,

$$\frac{1}{+25/3} + \frac{1}{-u_1} = \frac{1}{+10}$$

Or $\frac{1}{u_1} = \frac{3}{25} - \frac{1}{10}$

Or $u_1 = 50$ m

And $\frac{1}{(+50/7)} + \frac{1}{-u_1} = \frac{1}{+10}$

$$\therefore \frac{1}{u_2} = \frac{7}{50} - \frac{1}{10}$$

Speed of object $= \frac{u_1 - u_2}{\text{time}}$
$= \dfrac{25}{30} \text{ms}^{-1}$
$= 3 \text{ kmh}^{-1}$

132 **(c)**

$\dfrac{2.5}{v} - \dfrac{1}{-u} = \dfrac{2.5-1}{R}$
$\dfrac{2.5}{v} = \dfrac{1.5}{R} - \dfrac{1}{u}$
$v = \dfrac{2.5uR}{1.5u - R}$
$v = \infty$ at $1.5\,u - R = 0$
$u = \dfrac{R}{3}$

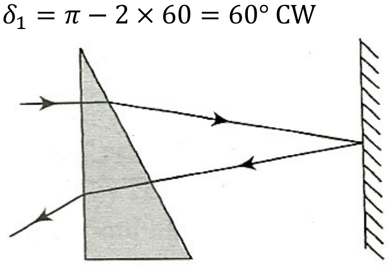
For $u < \frac{2R}{3}, v = 0$ virtual image
$u > \frac{2R}{3}, v = 0$,real image
So, image is changing from real to virtual at
$u = \frac{2R}{3}$

133 **(a)**

Power of system
$\dfrac{1}{f_1} + \dfrac{1}{f_2} - \dfrac{d}{f_1 f_2} = \dfrac{1}{1} + \dfrac{1}{-0.25} - \dfrac{0.75}{(1)(-0.25)}$
Since power of the system is zero, therefore the incident parallel beam of light will remain parallel after emerging from the system

134 **(d)**

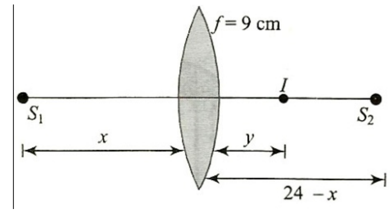
Deviation produced by the mirror is
$\delta_1 = \pi - 2 \times 60 = 60°$ CW



Deviation produced by the prism is
$\delta_2 = (1-2) \times 6 = 6°$ ACW
So, net deviation, $\delta = \delta + \delta_2$
$= (60° - 6°)\text{CW} = 54°$ CW

135 **(a)**

In this case, one of the image will be real and the other virtual. Let us assume that image of S_1 is real and that of S_2 is virtual
Applying $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$



For S_1: $\frac{1}{y} + \frac{1}{x} = \frac{1}{9}$ (i)
For S_2: $\frac{1}{y} + \frac{1}{24-x} = \frac{1}{9}$ (ii)
Solving Eqs. (i) and (ii), we get
$x = 6$ cm

136 **(d)**

If the refractive index of the material of the lens is greater than the refractive index of the surrounding medium, then a concave lens would behave as a concave lens

137 **(a)**

A diverging lens is ruled out because both x and y are positive values. Both x and y equal 20 cm at their smallest sum, which occurs when
$x + y = 40 \text{ cm} = 4f$
$\therefore f = 10$ cm
This indicates a converging lens of focal length =10 cm

138 **(b)**

$\delta = e + i - A$
$30° = 15° + 60° - A$
$\Rightarrow A = 45°$

139 **(a)**

Δs IAB and ICD are similar

$\dfrac{CD}{AB} = \dfrac{IE}{IF} = \dfrac{3L}{L} = 3$
$CD = 3AB = 3d$

140 **(a)**

$\mu = \dfrac{c}{v} = \dfrac{1/\sqrt{\mu_o \varepsilon_o}}{1/\sqrt{\mu\varepsilon}} = \sqrt{\dfrac{\mu\varepsilon}{\mu_o \varepsilon_o}}$

141 **(d)**

The image on the screen is real and inverted

The size of the image on the screen has aperture size given by

Size $= 1.0\left(\frac{10}{20}\right) = 0.5$ cm

Hence, the path of light on the screen is best represented by diagram (d)

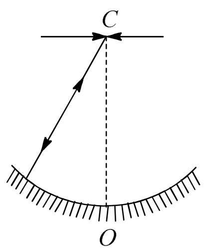
142 **(c)**

After critical angle reflection will be 100% and transmission is 0 %. Options (b) and (c) satisfy this condition. But option (c) is the correct option. Because in option (b) transmission is given 100% at $\theta = 0°$, which is not true

$\therefore$ Correct answer is (c).

143 **(d)**

When there is no water in the mirror, the rays of light are incident normally on the mirror and retrace their path. So, we get an image coincident with the object as shown in the figure



When the mirror is filled with water, then the equivalent focal length F is given by

$$\frac{1}{F} = \frac{1}{f_{\text{water lens}}} + \frac{1}{f_{\text{concave mirror}}} + \frac{1}{f_{\text{water lens}}}$$

Or $\frac{1}{F} = 2 \times -\frac{1}{f_{\text{water lens}}} + \frac{1}{f_{\text{concave mirror}}}$

Or $\frac{1}{F} = 2(\mu - 1)\left(\frac{1}{R}\right) + \frac{1}{R}$

Or $\frac{1}{F} = \frac{2(\mu-1)}{R} + \frac{2}{R}$

Or $\frac{1}{F} = \frac{2\mu}{R}$ or $F = \frac{R}{2\mu}$

Clearly, focal length of the new optical system in less than the original. So, the object is effectively at a distance greater than twice the focal length. So, the real image will be formed between F and $2F$

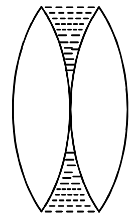
144 **(d)**

Let R be the radius of curvature of each surface. Then

$$\frac{1}{f} = (1.5 - 1)\left(\frac{1}{R} + \frac{1}{R}\right)$$

For the water lens,

$$\frac{1}{f'} = \left(\frac{4}{3} - 1\right)\left(-\frac{1}{R} + \frac{1}{R}\right) = \frac{1}{3}\left(-\frac{2}{f}\right); \frac{1}{f'} = -\frac{2}{3f}$$



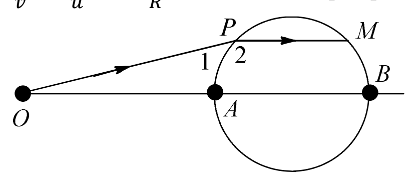
Now, using $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$, we have

$$\frac{1}{F} = \frac{1}{f} + \frac{1}{f} + \frac{1}{f'} = \frac{2}{f} - \frac{2}{3f} = \frac{4}{3f}$$

$$\Rightarrow F = \frac{3f}{4}$$

145 **(c)**

A ray of light starting from O gets refracted twice. The ray of light is travelling in a direction from left to right. Hence, the distances measured in this direction are taken positive. Applying $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$, twice with proper signs



We have, $\frac{3/2}{v} - \frac{4/3}{-20} = \frac{3/2-4/3}{10}$

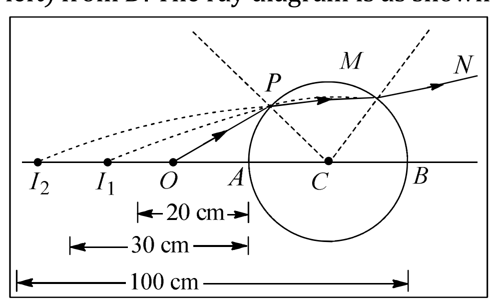
Or, $v = -30$ cm

Now, the first image I_1 acts as an object for the second surface, where

$BI_1 = u = -(30 + 20) = -50$ cm

$$\frac{4/3}{v'} - \frac{3/2}{-50} = \frac{4/3 - 3/2}{-10}$$

$\therefore v' = -100$ cm, i.e., the final image I_3 is virtual and is formed at a distance of 100 cm (toward left) from B. The ray diagram is as shown



Following points should be noted while drawing the ray diagram

1. At P, the ray travels from a rarer to a denser medium. Hence, it will bend toward normal MC

2. PM ray when extended backward meets at I_1 and MN ray when extended meets at I_2

146 **(a)**

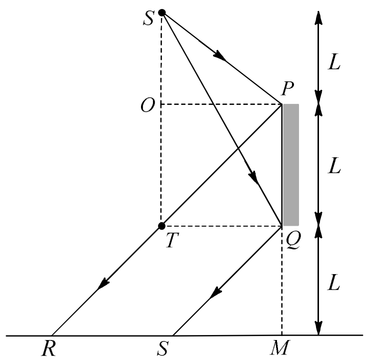
$$\frac{f_l}{f_a}=\frac{{}_a\mu_g-1}{{}_l\mu_g-1}=\frac{1.5-1}{\frac{1.5}{1.75}-1}=-\frac{1.75\times 0.50}{0.25}=-3.5$$

$\therefore f_l=-3.5\,f_a \Rightarrow f_l=+3.5R\ [\because f_a=R]$

Hence on immersing the lens in the liquid, it behaves as a converging lens of focal length 3.5 R

147 **(c)**

Ray diagram is as shown in the figure below:



Here, $\frac{SO}{OP}=\frac{PM}{RM} \Rightarrow RM=2L$

Also, $\frac{ST}{TQ}=\frac{QM}{SM} \Rightarrow SM=\frac{L}{2}$

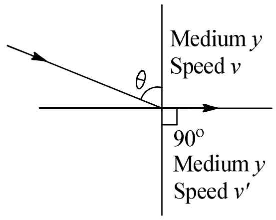
$$RS=RM-SM=\frac{3L}{2}$$

148 **(d)**

Clearly, x is denser medium

Now, $\frac{\sin\theta}{\sin 90°}=\frac{1}{{}_Y\mu_X}={}_X\mu_Y=\frac{v}{v'}$

Or $v'=\frac{v}{\sin\theta}$



149 **(c)**

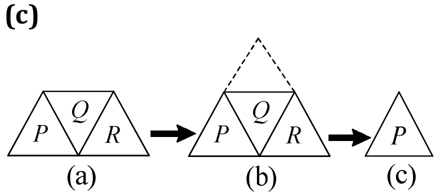


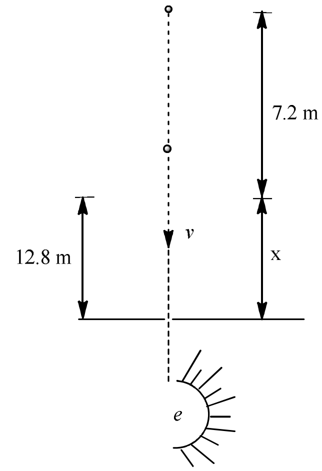
Figure (a) is part of an equilateral prism of figure (b) which is a magnified image of figure (c). Therefore, the ray will suffer the same deviation in figure (a) and figure (c)

150 **(c)**

$v=\sqrt{2gh}=\sqrt{2\times 10\times 7}$

$=12\ \text{ms}^{-1}$

In this case when eye is inside water,



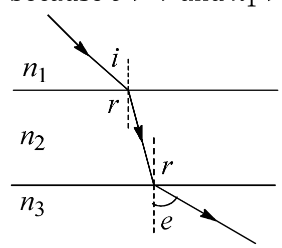
$x_{\text{app.}}=\mu x$

$\therefore \frac{dx_{\text{app.}}}{dt}=\mu.\frac{dx}{dt}$

Or $v_{\text{app.}}=\mu v=\frac{4}{3}\times 12=16\ \text{ms}^{-1}$

151 **(d)**

Using Snell's law, $n_2>n_1$ because $i>r, n_2>n_3$ because $e>r$ and $n_1>n_3$, because $e>i$



152 **(c)**

$$\sqrt{3}=\frac{\sin\left(\frac{60°+\delta_m}{2}\right)}{\sin\left(\frac{60°}{2}\right)}$$

$$\sqrt{3}=\sin\left(\frac{60°+\delta_m}{2}\right)$$

$$\sin 60°=\sin\left(\frac{60°+\delta_m}{2}\right)$$

or $\frac{60°+\delta_m}{2}=60°$

or $\delta_m=60° \Rightarrow i=\frac{A+\delta_m}{2}=\frac{60°+60°}{2}=60°$

153 **(a)**

Due to the insertion of glass plate, the image has to be shifted by 0.3 cm

Shift produced by a glass slab of thickness t and refractive index μ is given by $\left(1-\frac{1}{\mu}\right)$

So, $t\left[1-\frac{1}{1.6}\right]=0.3 \Rightarrow t=0.8$ cm

154 **(a)**

Given $i=60°, A=\delta=e$

$\delta=i+e-A \Rightarrow \delta=1$

$(\because e=A)$and $\delta=i=e$

$$\mu=\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

Here, angle of deviation is minimum ($\because i = e$)

$$\mu = \frac{\sin\left(\frac{60^0+60^0}{2}\right)}{\sin(60^0/2)} = \sqrt{3}$$

155 **(c)**

$v = -30, m = -\frac{v}{u} = -2$

$\Rightarrow A'B' = CD = 2 \times 1 = 2$ mm

Now, $\frac{B'C'}{BC} = \frac{A'D'}{AD} = \frac{v^2}{u^2} = 4$

$\Rightarrow B'C' = A'D' = 4$ mm

$\therefore$ Length$= 2 + 2 + 4 + 4 = 12$ mm

156 **(d)**

As $m_1 - m_2 = \frac{D+d}{D-d} - \frac{D-d}{D+d} = \frac{4Dd}{D^2-d^2}$

Hence, $m_1 - m_2 = \frac{d}{f}$

$$f = \frac{d}{m_1 - m_2}$$

157 **(a)**

We will have single surface refractions successively at the four surfaces S_1, S_2, S_3, and S_4. Do not forget to shift origin to the vertex of respective surface

Refractive at first surface S_1: Light travels from air to glass

$$\frac{1.5}{v_1} - \frac{1}{\infty} = \frac{(1.5-1)}{(+10)}$$

$v_1 = 30$ cm

First image is object for the refraction at second surface

For refraction at surface S_2: Light travels from glass to air

$$\frac{1}{v_2} - \frac{1.5}{(+25)} = \frac{1-1.5}{(+5)}$$

$v_2 = -25$ cm

For refraction at surface S_3: Light travels from air to glass

$$\frac{1.5}{v_3} - \frac{1}{(-35)} = \frac{(1.5-1)}{(-5)}$$

$v_3 = -35/3$ cm

For refraction at surface S_4: Light travels from glass to air

$$\frac{1}{v_4} - \frac{1.5}{-(35/3+5)} = \frac{1-1.5}{-10}$$

$v_4 = -25$ cm

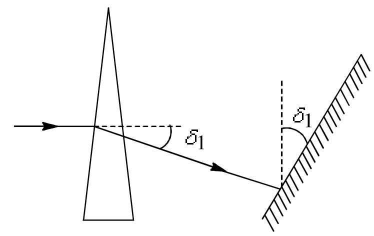
$The\ final\ image\ is\ virtual, formed\ at\ 25\ cm\ to\ le$

158 **(d)**

For light to retrace the path, the light ray falling on the mirror should be along the normal

Deviation produced by prism

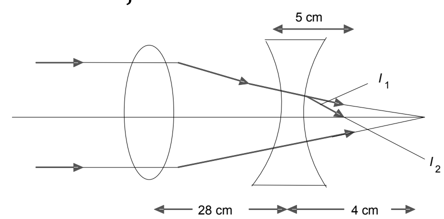
$\delta_1 = (1.5-1)4 = 2°$ CW



So, mirror has to be rotated by 2° in CW direction

159 **(b)**

Image formed by convex lens at I_1 will act as a virtual object for concave lens. For concave lens



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

$$or\ \frac{1}{v} - \frac{1}{4} = \frac{1}{-20}$$

Or $v = 5$cm

Magnification for concave lens

$$m = \frac{v}{u} = \frac{5}{4} = 1.25$$

As size of the image at I_1 is 2 cm. Therefore, size of image at I_2 will be $2 \times 1.25 = 2.5$ cm.

160 **(b)**

$$P = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$$0 = \frac{1}{20} - \frac{1}{5} - \frac{d}{20(-5)}$$

$$\frac{d}{100} = \frac{1}{5} - \frac{1}{20} = \frac{4-1}{20} = \frac{3}{20}$$

Or $d = 15$ cm

161 **(d)**

$$\frac{I}{O} = \frac{v}{u}$$

$$\frac{I}{15} = \frac{-25}{-10}$$

$I = 15 \times 2.5$ cm $= 37.5$ cm

162 **(c)**

$\frac{1}{f} = (\mu - 1)\left(\frac{2}{R}\right)$ or $f = \frac{R}{2(\mu-1)}$

Now, $f > R$

$\therefore \frac{R}{2(\mu-1)} > R$ or $\frac{1}{2(\mu-1)} > 1$ or $2(\mu-1) < 1$

Or $\mu - 1 < \frac{1}{2}$; or $\mu < \left(1 + \frac{1}{2}\right)$; or $\mu < 1.5$

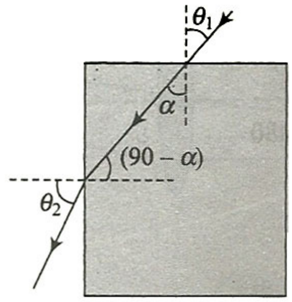
163 **(b)**

$$v_{\mathrm{m}} = \frac{1}{2}c$$

$\mu = \frac{c}{V_{\mathrm{m}}} = \frac{c}{\frac{1}{2}c} = 2$ or $\frac{1}{\sin i_{\mathrm{c}}} = 2$

Or $\sin i_c = \frac{1}{2}$ or $i_c = 30°$

164 **(c)**



As θ_1 increases, α also increases. So, $(90-\alpha)$ decreases and hence θ_2 decreases

165 **(a)**

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{1.5}{+OQ} - \frac{1}{(-OP)} = \frac{(1.5-1)}{+R}$$

On putting $OQ = OP, OP = 5R$

166 **(c)**

$\mu_g \sin\theta_c = \mu_1 \sin 90°$

Or $\mu_g \sin\theta_c = 1$

When water is poured,

$\mu_w \sin r = \mu_g \sin\theta_c$

Or $\mu_w \sin r = 1$

Again, $\mu_a \sin\theta = \mu_w \sin r$

Or $\mu_a \sin\theta = 1$

Or $\sin\theta = 1$or $\theta = 90°$

167 **(c)**

$$\frac{1}{f} = (\mu - 1)\left(\frac{2}{R}\right)$$

Or$f = \frac{R}{2(\mu-1)}$

Now, $f > R$

$$\therefore \frac{R}{2(\mu-1)} > R$$

Or$\frac{1}{2(\mu-1)} > 1$ or $2(\mu-1) < 1$

Or$\mu - 1 < \frac{1}{2}$or$\mu < \left(1 + \frac{1}{2}\right)$or $\mu < 1.5$

168 **(d)**

Put $A = \delta_{\min}$and $\mu = \sqrt{2}$

The relation $\mu = \frac{\sin\left(\frac{A+\delta_{\min}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

And solve for A

169 **(a)**

$$\frac{1}{v} + \frac{1}{-600} = \frac{1}{20}$$

Or$\frac{1}{v} = \frac{31}{600}$

Or$v = \frac{600}{31}$ cm =19.35 cm

170 **(b)**

For upright portion,

$$m = \frac{f}{f-u} = \frac{\frac{-10}{2}}{\frac{-10}{2} - (-20)} = \frac{-5}{-5+20}$$

$$= \frac{-5}{15} = -\frac{1}{3}$$

For horizontal portion, magnification is $\left(-\frac{1}{3}\right)^2$ i.e., $\frac{1}{9}$

Required ratio is $\frac{-1/3}{1/9} = -3:1$

171 **(c)**

Object is placed at a distance of $2f$ from the lens (f =focal length of lens), i.e., the image formed by the lens will be at a distance of $2f$ or 20 cm from the lens. So, if the concave mirror is placed in this position, the first image will be formed at its pole and it will reflect all the rays symmetrically to other side and the final image will coincide with the object

172 **(c)**

Distance of object from mirror = $15 + \frac{33.25}{1.33} =$ 40 cm

Distance of image from mirror = $15 + \frac{25}{1.33} =$ 33.8 cm

For the mirror, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\therefore \frac{1}{-33.8} + \frac{1}{-40} = \frac{1}{f}$$

$\therefore f = -18.3$ cm

$\therefore$ Most suitable answer is (c).

173 **(a)**

Clearly, A is denser than B and B is denser than C

$\therefore \mu_1 > \mu_2 > \mu_3$

$\therefore C_1 < C_2 < C_3$

174 **(b)**

Clearly, plane mirror and convex mirror cannot produce inverted image

175 **(d)**

Distance of image from the plane surface is as follows:

$$x_1 = \frac{4}{1.6} = 2.5 \text{ cm} \left(d_{app} = \frac{d_{actual}}{\mu}\right)$$

For the curved side

$$\frac{1.6}{4} + \frac{1}{x_2} = \frac{1-1.6}{8}$$

$\therefore\ x_2 \approx -3.0$ cm

The minus sign means the image is on the object side

$\therefore I_1I_2 = (8-2.5-3.0)$ cm $= 2.5$ cm

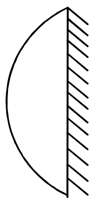
176 **(b)**

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_1}+\frac{1}{f_{\text{m}}}$$

$$\frac{1}{F}=\frac{2}{f_1}+\frac{2}{f_{\text{m}}}$$

Or$\frac{1}{F}=2(\mu-1)\left(\frac{1}{R}\right)+\frac{1}{\infty}$

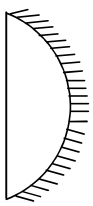
Or$F=\frac{R}{2\mu(-1)}$



Now, $-60=\frac{R}{2(\mu-1)}$

Or$120(\mu-1)=R$ (i)

Again,$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_1}+\frac{1}{f_{\text{m}}}$



Or$\frac{1}{F}=\frac{2}{f_1}+\frac{1}{R/2}$

Or$\frac{1}{F}=2(\mu-1)\left(\frac{1}{R}\right)+\frac{2}{R}$

Or$\frac{1}{F}=\frac{2}{R}(\mu-1+1)$

Or$F=\frac{R}{2\mu}$

Now, $-20=\frac{-R}{2\mu}$

Or$40\mu=R$ (ii)

Dividing (i) by (ii), we get

$$\frac{120(\mu-1)}{40\mu}=\frac{R}{R}=1$$

Or$120(\mu-1)=40\mu$

Or$120\mu-40\mu=120$

Or$80\mu=120$

Or$\mu=\frac{120}{80}=\frac{3}{2}=1.5$

177 **(c)**

As, $m_1=\frac{I_1}{O}=\frac{v_1}{u_1}$

And $m_2=\frac{I_1}{O}=\frac{v_2}{u_2}$

$$m_1\times m_2=\frac{I_1I_2}{O^2}=\frac{v_1}{u_1}\times\frac{v_2}{u_2}=1$$

Hence, $O=\sqrt{I_1I_2}\ \Rightarrow\ \sqrt{h_1h_2}$

178 **(a)**

For a concave mirror,

$$u=-\frac{15}{2}\text{cm}, v=?$$

$$f=-\frac{10}{2}\text{cm}=-5\text{ cm}$$

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{-5}-\frac{1}{-15/2}$$

$$=-\frac{1}{5}+\frac{2}{15}=\frac{-1}{15}$$

Or $v=-15$ cm

Clearly, the position of the final image is on the pole of the convex mirror

179 **(d)**

$$f=\frac{1.6}{2}\text{m}=0.8\text{m}, u=-1\text{m}$$

$$\frac{1}{v}=\frac{1}{0.8}-\frac{1}{-1}=\frac{10}{8}+1=\frac{18}{8}=\frac{9}{4}$$

Or $v=\frac{4}{9}$m

180 **(d)**

Let $u=-x$

$$\frac{1}{-x}+\frac{1}{-x-10}=-\frac{1}{12}$$

Or $\frac{1}{x}+\frac{1}{x+10}=\frac{1}{12}$

Or $\frac{x+10+x}{x(x+10)}=\frac{1}{12}$

Or $\frac{2x+10}{x^2+10x}=\frac{1}{12}$

Or $x^2+10x=24x+120$

Or $x^2-14x-120=0$

$x^2-20x+6x-120=0$

Or $x(x-20)+6(x-20)=0$

Here $u=-20$ cm

$v=-(20+10)$ cm

$=-30$ cm

Then magnification

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

$$=-\left(\frac{-30}{-20}\right)$$

$=-1.5$

181 **(a)**

$$-\frac{1}{40}=(1.5-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{R_1}-\frac{1}{R_2}=-\frac{1}{20}$$

Now, $\frac{1}{f}=\left(\frac{1.5}{2}-1\right)\left(-\frac{1}{20}\right)$

Or $\frac{1}{f}=-\frac{0.5}{2}\left(-\frac{1}{20}\right)$

Or $\frac{1}{f}=\frac{1}{80}$or $f=80$ cm

It behaves like a convex lens of focal length 80 cm

182 **(d)**

As the ray moves toward the normal while

entering medium 2 from 1, we have $n_2 > n_1$
For total internal reflection at interface of 2 and 3, $n_2 > n_3$. Besides n_3 should also be less than n_1 or else ray would have emerged in medium 3, parallel to its path in medium 1. Hence,
$n_3 > n_1 > n_2$ is the correct order

183 **(c)**

$$P = (1.5-1)\left(\frac{200}{5}\right) = 20\text{ D}$$

$$P' = (1.5-1)\left(\frac{200}{5}\right) = 16.67\text{ D}$$

Decrease in power $= 20\text{ D} - 16.67\text{ D} = 3.33\text{ D}$

184 **(c)**

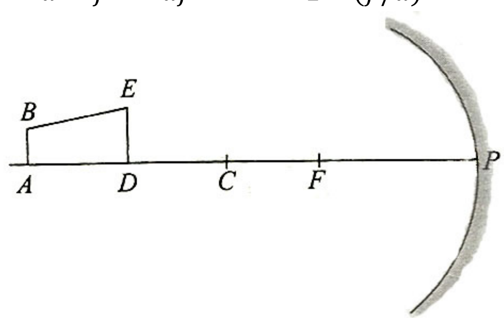
1. Is ruled out because the person is standing on the edge of the pool
2. Is ruled out because the signal would not move out of the pool
3. Is ruled out because of total internal reflection

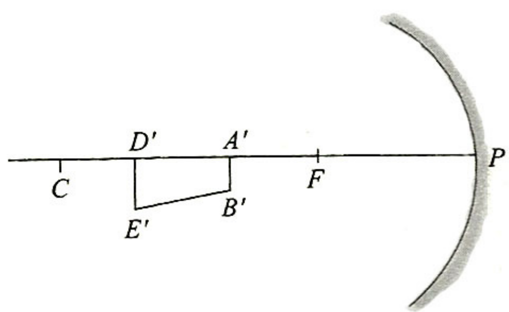
185 **(a)**

Object is placed beyond C. Hence, the image will be real and it will lie between C and F. Further u, and v are negative, hence the mirror formula will become

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

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}=\frac{u-f}{uf} \text{ or } v=\frac{f}{1-(f/u)}$$





Now $u_{\text{AB}} = u_{\text{ED}}$
$\therefore v_{\text{AB}} < v_{\text{ED}}$

$|m_{\text{AB}}| < |m_{\text{ED}}| \left(\text{as } m = -\frac{v}{u}\right)$
Therefore, shape of the image will be as shown in figure
Also, note that, $v_{\text{AB}} < u_{\text{AB}}$ and $v_{\text{ED}} < u_{\text{ED}}$
So, $|m_{\text{AB}}| < 1$and $|m_{\text{ED}}| < 1$

186 **(b)**

Clearly, $i_c \le 60°$
So, maximum possible value of i_c is 60°
Now, ${}_1\mu_g = \frac{1}{\sin i_c}$

$$\frac{\mu_g}{\mu_1} = \frac{1}{\sin i_c}$$

Or $\mu_1 = \mu_g \sin i_c = 1.5 \sin 60° = 1.5 \times \frac{\sqrt{3}}{2}$
$= 1.5 \times 0.866 = 1.299 = 1.3$

187 **(a)**

$\frac{R}{t} \tan\theta_C$

Or $R = t(\tan\theta_C)$
But, $\sin\theta_C = \frac{1}{\mu} = \frac{3}{5}$

$$\therefore \tan\theta_C = \frac{3}{4}$$

$$R = \frac{3}{4}t = \frac{3}{4}(8\text{ cm}) = 6\text{ cm}$$

Hence, the answer is 6.

188 **(b)**

As $d = \sqrt{D(D-4f)}$
$d^2 = D^2 - 4Df$

$$f = \frac{D^2 - d^2}{4D}$$

189 **(d)**

Because to form the complete image only two rays are to be passed through the lens and moreover, since the total amount of light released by the object is not passing through the lens, therefore image is faint (intensity in decreased)

190 **(b)**

$$\frac{\mu_1}{-u}+\frac{\mu_2}{v}=\frac{\mu_2-\mu_1}{R}$$

$\frac{1.25}{\ldots} + \frac{1.5}{\ldots} = \frac{1.5-1.25}{\ldots}$ or $\frac{1.5}{\ldots} = \frac{0.25}{\ldots}$

Or $v=\frac{1.5R}{0.25}=6R$

Again, $\frac{\mu_2}{-u}+\frac{\mu_1}{v}=\frac{\mu_1-\mu_2}{R}$

$$\frac{1.5}{-4R}+\frac{12.5}{v}=\frac{1.25-1.5}{-R}$$

Or $\frac{1.25}{v}=\frac{1}{4R}+\frac{1.5}{4R}=\frac{2.5}{4R}$

Or $=\frac{1.25\times4R}{2.5}=\frac{5R}{2.5}$

Or $v=2R$

Distance from the center $=3R$

191 **(d)**

For spherical surface,

Using $\frac{n_2}{v}-\frac{n_1}{u}=\frac{n_2-n_1}{R}$

$$\Rightarrow \frac{n}{R}-\frac{1}{\infty}=\frac{n-1}{R}$$

$\Rightarrow n=2n-2 \;\Rightarrow n=2$

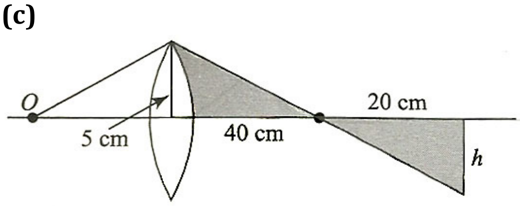
192 **(b)**

$\mu_1\sin\alpha=\mu_2\sin\alpha_2$

$$\frac{c}{v_1}\sin a_1=\frac{c}{v_2}\sin a_2$$

$$\frac{\sin a_1}{f\lambda_1}=\frac{\sin a_2}{f\lambda_2}$$

193 **(c)**



$$\frac{h}{20}=\frac{5}{40}=\frac{1}{8}$$

Or $h=\frac{20}{8}$ cm $=\frac{5}{2}$ cm $=2.5$ cm

194 **(b)**

In first case, if object distance is x, image distance $=x/4$

While it is 2nd case, object distance becomes $(x-5\text{ cm})$ and image distance $(x-5\text{ cm})/2$.

Using mirror formula we get,

In first case, $=\frac{1}{f}=-\frac{5}{x}$

In second case, $\frac{1}{f}=-\frac{3}{(x-5)}$

Solving we get, $x=12.5$ cm and $f=-2.5$ cm and hence $|f|=2.5$ cm

195 **(a)**

$A=\delta_m=60°$

At minimum deviation $i=\left(\frac{A+\delta_m}{2}\right)=60°$

196 **(d)**

Applying Snell's law at $P, \mu=\frac{\sin r}{\sin 30°}\sin r=\frac{1.44}{2}=0.72$

$\therefore\; \delta=r-30°=\sin^{-1}(0.72)-30°$

Therefore, the rays make an angle of $2\delta=[\sin -1(0.72)-30]$ with each other

d. Is the correct option

197 **(a,c,d)**

d. Image is inverted, so it should be real

198 **(a,c)**

In case of part A, radii of the two surfaces will remain same. Hence, focal length of part A will be same as that of complete lens, i.e., power of part A will remain unchanged, i.e., power of A is P

In case of part B, radius of one surface will remain same while that of other plane surface will be ∞. Hence, focal length of part B will be double that of whole lens, i.e., power of part B is $P/2$

199 **(b,c)**

If an object is at a distance x from a plane refracting surface and is viewed normally, then it appears at a distance x/μ from the surface, where μ is refractive index of that medium (in which it is situated) with respect to the medium in which observer is situated

Suppose height of bird from water surface is x and depth of fish from the surface is y, then depth of fish, as observed by the bird, will be equal to

$r_1=x+\frac{y}{\mu}$ (i)

Where μ is refractive index of water with respect

to air
$r_1 = 6.60$ m
Hence, option (b) is correct
Height of bird, as observed by the fish, will be equal to
$r_2 = \frac{x}{\mu} + y$ (ii)
Where μ' is refractive index of air with respect to water
Now, $\mu' = \frac{1}{\mu} = \frac{3}{4}$
Hence, $r_2 = 8.80$ m
Hence, option (a) is wrong while (c) is correct

200 **(c)**
The angle of deviation for the first prism
$P_1, \delta_1 = (\mu_1 - 1)A_1$
The angle of deviation for the second prism
$P_2, \delta_2 = (\mu_2 - 1)A_2$
Since total deviation is to be zero, therefore
$\delta_1 + \delta_2 = 0 \Rightarrow (\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 = 0$
$$A_2 = \frac{(1.54 - 1)}{(1.72 - 1)} 4° = 3°$$
a. Is the correct option

201 **(b,c)**
From graph $\tan 30° = \frac{\sin r}{\sin i} = \frac{1}{{}_1\mu_2}$
$$\Rightarrow {}_1\mu_2 = \sqrt{3} \Rightarrow \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2} = 1.73 \Rightarrow v_1 = 1.73 v_2$$
Also from $\mu = \frac{1}{\sin C} \Rightarrow \sin C = \frac{1}{{}_{Rarer}\mu_{Denser}}$
$$\Rightarrow \sin C = \frac{1}{{}_1\mu_2} = \frac{1}{\sqrt{3}}$$

202 **(a,b,c,d)**
$v + u = D$
and $v - u = x \Rightarrow v = \frac{D+x}{2}, u = \frac{D-x}{2}$ and
$f = \frac{D^2 - x^2}{4D}$
$$m_1 = \frac{D+x}{D-x}, m_2 = \frac{D-x}{D+x}$$

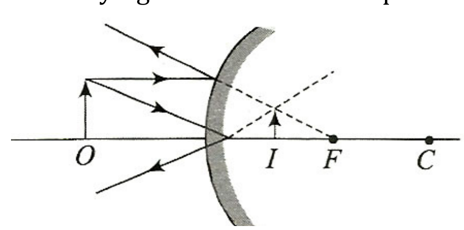
203 **(d)**
We have that $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
For divergent, $\mu_2 > \mu_1$
Here, $\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ is negative
Therefore, **d.** is the correct option

204 **(a,b,c)**
For a real object, a real image can be formed by convex lens only (and not by concave lens) and depending on the location of object from infinity to focus, the image can be enlarged or diminished. But when object is in between focus and optical center, image would be virtual. So, $f \leq 25$ cm

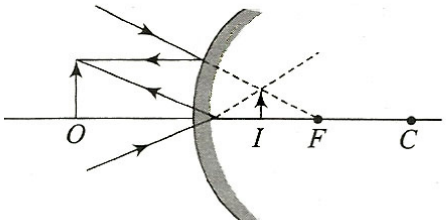
205 **(a,d)**
Final image is formed at infinity if the combined focal length of the two lenses (in contact) becomes 30 cm
Or $\frac{1}{30} = \frac{1}{20} + \frac{1}{f}$
ie, when another concave lens of focal length 60 cm is kept in contact with the first lens. Similarly, let μ be the refractive index of a liquid in which focal length of the given lens becomes 30 cm. Then
$\frac{1}{20} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ...(i)
$\frac{1}{30} = \left(\frac{3/2}{\mu} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ...(ii)
From Eqs. (i) and (ii), we get
$$\mu = \frac{9}{8}$$

206 **(a,d)**
Here, $\frac{OP}{5 \text{ cm}} = \frac{2.5 \text{ mm}}{15 \text{ cm}}$
$$OP = \frac{5}{6} \text{mm}$$
Area of mirror used in reflection is
$$\pi \times OP^2 = \frac{25\pi^2}{36} \text{ mm}^2$$
Let the power of source be P.
Intensity in absence of mirror is
$$I_1 = \frac{P}{4\pi \times (5)^2}$$
Intensity in presence of mirror is
$$I_2 = \frac{P}{4\pi \times (5)^2} + \frac{P/2}{4\pi \times (5)^2}$$
$$\frac{I_2}{I_1} = \frac{19}{18}$$

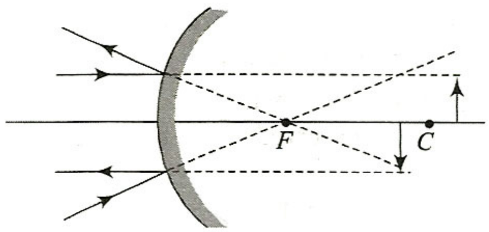
207 **(a,b,c,d)**
For a real extended object, image formed by convex mirror would be virtual, diminished, erect, and be lying between focus and pole



For a virtual object, lying between focus and pole, image formed by a convex mirror would be real, magnified, erect, and lying in front of mirror



For a virtual object beyond focus, image formed by a convex mirror would be virtual, inverted, magnified or diminished (depending on the location of object), andwill lie on the same side of mirror



208 **(c)**

The intermediate image in compound microscope is real, inverted, and magnified

209 **(a,b,c)**

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

$1-\frac{v}{u}=\frac{v}{f}$ (i)

Since m is positive in the given figure, therefore m represents magnitude of the magnification. In fact, if a real image is formed by a convex len, then the image and object will be on opposite sides of the lens. It means, if v is positive, then u will be negative. Therefore,

$$m=\left|\frac{v}{u}\right|=-\frac{v}{u}$$

Hence, Eq. (i) becomes

$m=\frac{v}{f}-1$ (ii)

It means, the graph between m and v will be a straight line having intercept -1 on m-axis and slope of the line $\tan\theta$ is equal to $(1/f)$. Hence, options (b) and (c) are correct. Putting $m=0$ in Eq. (ii), $v=f$. Hence, (a) is also correct. Obviously, (d) is wrong

212 **(c)**

Let $I_1=I$ and $I_2=4I$

We know that Intensity $\propto$ (amplitude)^2

Let $I\propto a^2$

$\therefore I_1\propto a^2$ and $I_2\propto(2a)^2$

Maximum amplitude $=a+2a=3a$

$\Rightarrow I_{\max}\propto 9I$

Minimum Amplitude $=2a-a=a$

$\therefore I_{\min}\propto a^2 \Rightarrow I_{\min}\propto I$

c. is the correct option

213 **(c,d)**

As $\mu\geq\frac{1}{\sin C}>\frac{1}{\sin 45°}>\frac{1}{1/\sqrt{2}}\geq\sqrt{2}=1.414$

$\therefore$ Possible value of μ are 1.5 and 1.6

214 **(a)**

${}_1^2\mu=\frac{\sin 90°}{\sin C}=\frac{1}{\sin C}$ [For critical angle]

$\therefore C=\sin^{-1}=\left(\frac{1}{{}_1^2\mu}\right)$ (i)

Applying Snell's law at P, we get

$${}_1^2\mu=\frac{\sin r'}{\sin i}=\frac{\sin(90-r)}{\sin r}$$

$[\because i=r; r'+r=90°]$

$\therefore {}_1^2\mu=\frac{\cos r}{\sin r}$ (ii)

From (i) and (ii), $C=\sin^{-1}(\tan r)$

215 **(a)**

See figure. The ray will come out form CD if it suffers total internal reflection at surface AD, i.e., it strikes the surface AD at critical angle C (the limiting case). Applying Snell's law at P,

$n_1\sin C=n_2$ or $\sin C=\frac{n_2}{n_1}$

Applying Snell's law at Q, $n_2\sin\alpha=n_1\cos C$;

$$\sin\alpha=\frac{n_1}{n_2}\cos\left\{\sin^{-1}\left(\frac{n_2}{n_1}\right)\right\}$$

or $\alpha=\sin^{-1}\left[\frac{n_1}{n_2}\cos\left\{\sin^{-1}\left(\frac{n_2}{n_1}\right)\right\}\right]$

$\therefore$**a**. is the correct option

216 **(b,c)**

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{x}{f_1f_2}=\frac{1}{f_1}+\frac{x}{f_1^2}$$

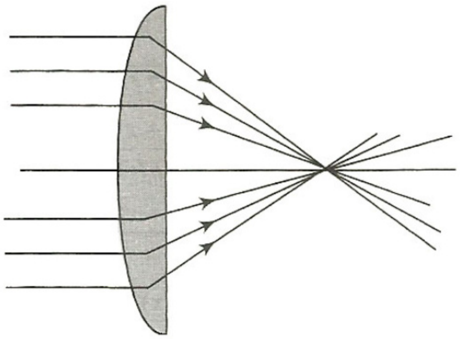
$\frac{1}{f}=\frac{x}{f_1^2}\Rightarrow f>0$ for every x

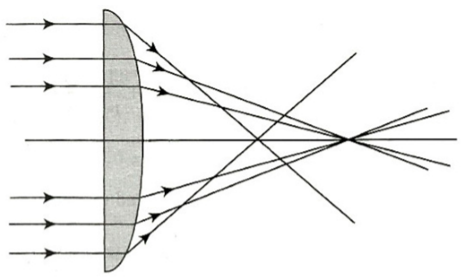
For $x=0, f=\infty$

Hence, for $x=0$, system will behave like a glass plate

217 **(b)**

In this case, the total deviation is shared between the two surfaces





218 **(a,d)**

For a lens $\frac{1}{f}=\frac{1}{v}-\frac{1}{u} \Rightarrow \frac{1}{v}=\frac{1}{u}+\frac{1}{f}$ ...(i)

Also $m=\frac{f-v}{f}=1-\frac{v}{f} \Rightarrow m=\left(-\frac{1}{f}\right)v+1$ ...(ii)

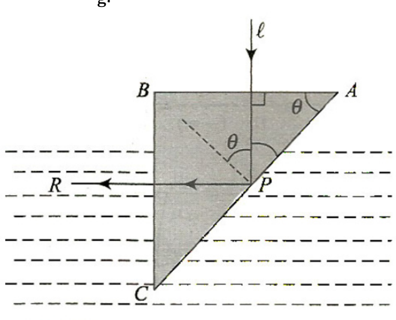
On comparing equations (i) and (ii) with $y=mx+c$

It is clear that relationship between $\frac{1}{v}$ vs $\frac{1}{u}$ and m vs v is linear

220 **(a)**

The phenomenon of total internal reflection takes place during reflection at P,

$\sin\theta=\frac{1}{{}^{w}_{g}\mu}$ (i)



Where θ is the angle of incidence at P

Now, ${}^{w}_{g}\mu=\frac{{}^{a}_{g}h}{{}^{a}_{g}\mu}=\frac{1.5}{4/3}=1.125$

Putting in (i),

$\sin\theta=\frac{1}{1.125}=\frac{8}{9}$

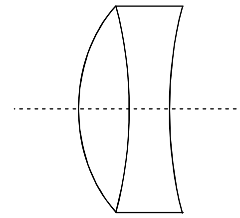
Therefore, $\sin\theta$ should be greater than $\frac{8}{9}$

221 **(b)**

$f_1=+40$ cm (for convex lens)=0.4 m

$f_2=-25$ (for concave lens) $=-0.25$ m

Therefore, focal length (f) of the combination,



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

$$=\frac{1}{0.40}-\frac{1}{0.25}=\frac{0.25-0.4}{0.40\times0.25}$$

$$=-\frac{0.15}{0.1}=-1.5 \text{ dioptre}$$

$$\Rightarrow P=\frac{1}{f}=-1.5 \text{ dioptre}$$

b. Is the correct option

222 **(a,d)**

Using, $\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$, we get

$$\frac{1.5}{v}-\frac{1.0}{\infty}=\frac{1.5-1.0}{20}$$

Or $v=\pm60$ cm

223 **(a,b,c,d)**

$$\frac{h_1}{h_2}=4$$

$$\frac{h_1}{h_2}\times\frac{h_2}{h_0}=1=\Rightarrow\frac{h_2}{h_0}=0$$

When shorter image is formed, magnification =2

$\Rightarrow \left|\frac{v}{u}\right|=2$ and $|v|+|u|=96$

$\Rightarrow |v|=64$ and $|u|=32$

Hence, object distance =32 cm and second lens position can be $96-32=64$ cm

Distance between two positions = 32 cm

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

$$\frac{1}{64}-\frac{1}{(-32)}=\frac{1}{f} \Rightarrow f=\frac{64}{3}\text{cm}$$

224 **(a)**

$$\lambda=\frac{v}{f}$$

In moving from air to glass, f remains unchanged while v decreases. Hence, λ should decrease

225 **(a,c)**

The image of a point closer to the focus will be farther. As the transverse magnification of B will be more than A, the image of AB will be inclined to the optical axis

226 **(b,d)**

In the previous question, velocity of fish, observed by the bird, will be equal to dr_1/dt. Therefore, differentiating Eq.(i), we get

$$\frac{dr_1}{dt} = \frac{dx}{dt} + \frac{1}{\mu}\frac{dy}{dt} = 4.50 \text{ ms}^{-1}$$

Hence, option (d) is correct. Similarly, velocity of bird, as observed by the fish, will be equal to $\frac{dr_2}{dt}$

$$\frac{dr_2}{dt} = \frac{1}{\mu'}\frac{dx}{dt} + \frac{dy}{dt} = 6.0 \text{ ms}^{-1}$$

Hence, option (b) is correct

227 **(a)**

Here, $f_v = 2$ cm and $f_e = 3$ cm

Using lens formula for eyepiece, $-\frac{1}{u} + \frac{1}{v_1} = \frac{1}{f_e}$

$$\Rightarrow \frac{-1}{u} + \frac{1}{\propto} = \frac{1}{3} \Rightarrow u_1 = -3 \text{ cm } [\because i = 0]$$

But the distance between objective and eyepiece is 15 cm (given)

Therefore, distance of image formed by the objective, $v = 15 - 3 = 12$ cm. Let u be the object distance from the objective, then for objective lens $-\frac{1}{u} + \frac{1}{v} = \frac{1}{f_0}$ or $\frac{-1}{u} + \frac{1}{12} = \frac{1}{2}$

$$\Rightarrow \frac{-1}{u} = \frac{1}{2} - \frac{1}{12} = \frac{5}{12} \quad u = -\frac{12}{5} = 2.4 \text{ cm}$$

a. Is the correct option

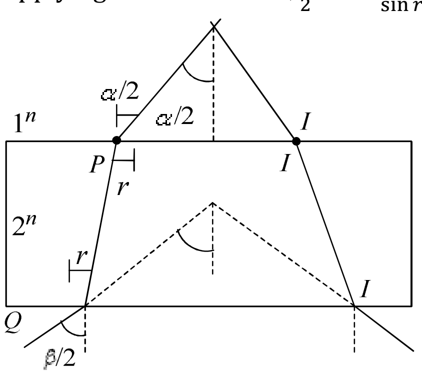
228 **(a,b,c)**

n for liquid $= n$ for Glass/yellow light but n for liquid $< n$ for glass (red light), so it will deviated toward base, for blue light n (liquid)$> n$ (glass) so it will deviate towards vertex

229 **(b)**

The path of rays become parallel to initial direction as they emerge

Applying Snell's law at $P, \frac{1}{2}n = \frac{\sin \alpha/2}{\sin r}$ (i)



Applying Snell's law at $Q, \frac{1}{2}n = \frac{\sin \beta/2}{\sin r}$ (ii)

From Eqs. (i) and (ii), $\alpha = \beta$

Therefore, **b.** is the correct answer

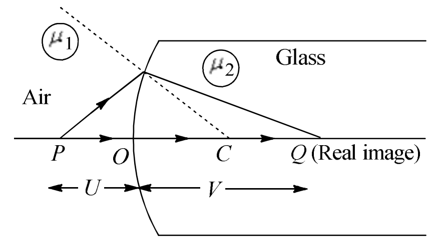
230 **(c)**

Since there will be no refraction from P to Q and then from Q to R (all being identical). Hence, the ray will now have the same deviation as before the point n, n' being same for the ray. Correct option is (c)

231 **(a)**

The formula for spherical refracting surface is

$$\frac{-\mu_1}{\mu} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$$



Here, $u = -x, v = +x, R = +R, \mu_1 = 1, \mu_2 = 1.5$

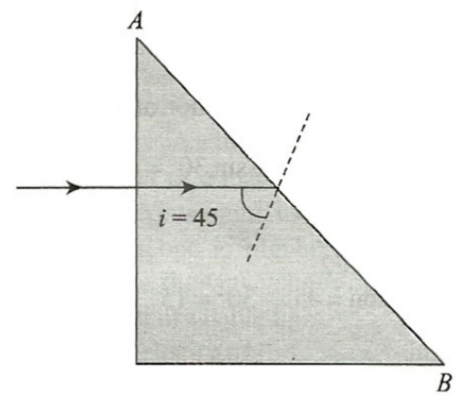
$$\frac{-1}{-x} + \frac{1.5}{x} = \frac{1.5 - 1}{R}$$

$\Rightarrow x = 5R$

232 **(a)**

For total internal reflection, $\mu = \frac{1}{\sin C} = \frac{1}{\sin 45°} =$ 1.414

i.e., for an angle of incidence of that color will suffer total internal reflection for which the refractive index is less than 1.414



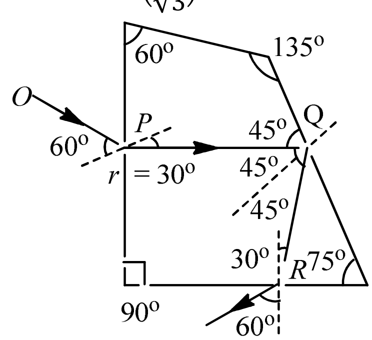
Therefore, red light will be refracted at interface AB whereas blue and green light will be reflected

233 **(a,b,c)**

$$\sqrt{3} = \frac{\sin 60°}{\sin r}$$

$\therefore r = 30°$

$$\theta_C = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$$



Or $\sin \theta_C = \frac{1}{\sqrt{3}} = 0.577$

At point Q, angle of incidence inside the prism is $i = 45°$

Since $\sin i = \frac{1}{\sqrt{2}}$ is greater than $\sin\theta_C = \frac{1}{\sqrt{2}}$, ray gets totally internally reflected at face CD. Path of ray of light after point Q is shown in figure.

From the figure, we can see that angle between incident ray OP and emergent ray RS is 90°.

Therefore, correct options are (a), (b) and (c).

234 **(a,c)**

$$\frac{v}{u} = \frac{3}{1} \Rightarrow v = 3u$$

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

$f = 30$ cm

235 **(a,b)**

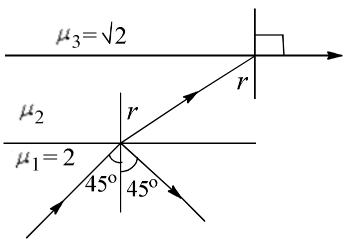
For $\mu_2 > \sqrt{2}$ (TIR will not take place)

$2\sin 45° = \mu_2 \sin r$

$\mu_2 \sin r = \sqrt{2}\sin e$

$e = 90°$

Hence, deviation is 45°



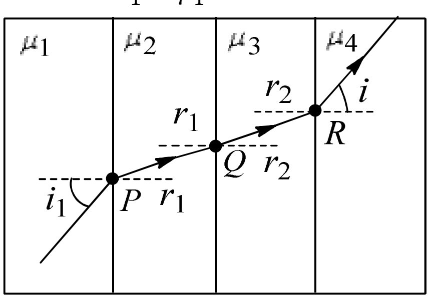
$\mu_2 < \sqrt{2}$. TIR will take place

Deviation is 90°

236 **(d)**

Applying Snell's law at P,

$${}^1\mu_2 = \frac{\sin i}{\sin r_1} = \frac{\mu_2}{\mu_1} \text{ (i)}$$



Applying Snell's law at Q,

$${}^2\mu_3 = \frac{\sin r_1}{\sin r_2} = \frac{\mu_3}{\mu_2} \text{ (ii)}$$

Again, applying Snell's law at R,

$${}^3\mu_4 = \frac{\sin r_2}{\sin i} = \frac{\mu_4}{\mu_3} \text{ (iii)}$$

Multiplying (i), (ii), and (iii), we get

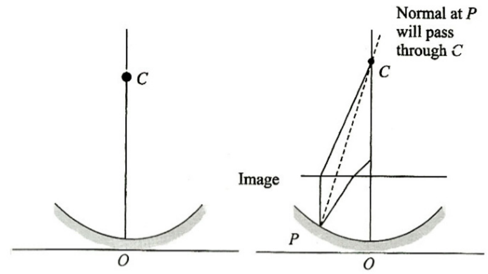
$\mu_4 = \mu_1$

Correct option is (d)

237 **(b,d)**

The image formed will be complete because light rays from all parts of the object will strike on the lower half. But since the upper half light rays are cut off, the intensity will reduce

238 **(d)**



The ray diagram is shown in the figure. Therefore, the image will be real and between C and O

239 **(a,c)**

(a)→ $n_3 < n_1$ so critical angle decreases. Therefore, TIR will take place at AB

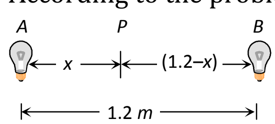
(b)→ $n_3 > n_1$, so critical angle increases. Therefore, TIR will not take place

(c)→ If $n_3 > n_2$, then TIR will take place at CD and if $n_3 > n_1$, then TIR will take place at AB

(d)→TIR will not take place at face CD for $n_3 < n_1$ because ray is going from rarer to denser medium

240 **(b,c)**

According to the problem



$$\frac{I_A}{x^2} = 4\frac{I_B}{(1.2 - x)^2}$$

$$\Rightarrow \frac{1}{x^2} = \frac{4}{(1.2 - x)^2}$$

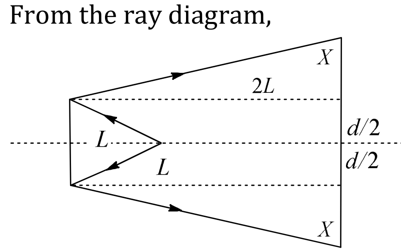
$$\Rightarrow \frac{1}{x} = \frac{2}{1.2 - x} \Rightarrow x = 0.4\ m \text{ and } 1.2 - x = 0.8\ m$$

241 **(c,d)**

As long as the object moves towards the mirror, image moves away from the mirror (for $u > f$) and $m = -v/u (v > u)$, so image size increases

242 **(d)**

From the ray diagram,



In ΔANM and ΔADC,

$\angle ADC = \angle ANM = 90°$ $[MN \perp AD]$

$\angle MAN = \angle CAN$ (law of reflection)

$\Rightarrow$ ΔANM is similar to ΔADC

$\therefore \frac{x}{2L}=\frac{d/2}{L}$ or $x=d$

So, required distance $= d+d+d=3d$

Therefore, **d.** is the correct option

243 **(a)**

$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}=\frac{1}{0.4}+\frac{1}{-0.25}=\frac{1}{0.4}-\frac{1}{0.25}$

$=\frac{0.25-0.4}{0.4\times0.25}=\frac{-0.15}{0.4\times0.25}$

$\frac{1}{f}=\frac{-0.15}{0.4\times0.25}=-1.5$

$\Rightarrow P=\frac{1}{f}=-1.5$ dioptre

244 **(c)**

Spherical abberation occurs due to the inability of a lens to converge marginal rays of the same wavelength to the focus, as it converges the paraxial rays. This defect can be removed by blocking marginal rays. This can be done by using a circular annular mask over the lens

245 **(b,c)**

Convex mirror and concave lens form virtual image for all positions of object

246 **(c)**

A convex mirror and a concave lens always produce semi image for the objects. Therefore, option (b) and (d) are not correct. The image by a convex lens is diminished when the object is placed beyond $2f$

Let $u=2f+x$

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

$\Rightarrow \frac{1}{v}-\frac{1}{-(2f+x)}=\frac{1}{f}\Rightarrow \frac{1}{v}=\frac{1}{f}-\frac{1}{2f+x}$

$=\frac{2f+x-f}{f(2f+x)}=\frac{(f+x)}{f(2f+x)}$

But $u=v=1$ (given) $(2f+x)+\frac{f(2f+x)}{f+x}\le 1$

$\Rightarrow 2f=x\left[1+\frac{f}{f+x}\right]\le 1 \Rightarrow \frac{(2f+x)^2}{f+x}\le 1$

$\Rightarrow (2f+x)^2\le f+x$

The above is true for $f<0.25$ m

c. Is the correct answer

247 **(c,d)**

For total internal reflection to take place: Angle of incidence, $i>$ critical angle, $\theta_c\left[\text{where} \sin\theta_c=\frac{1}{n}\right]$

or $\sin 45°>\frac{1}{n}$or $\frac{1}{\sqrt{2}}>\frac{1}{n}or>\sqrt{2}$or $n>1.414$

Therefore, possible values of n can be 1.5 or 1.6 in the given options

248 **(a,b,c,d)**

In case of an astronomical telescope, the distance between the objective lens and eyepiece lens $=f_0+f_e=16+0.02=06.02$ m. The angular magnification$=\frac{f_{\text{objective}}}{f_{\text{eye piece}}}=\frac{-16}{0.2}$

$=-800$

The image seen by the astronomical telescope is inverted. Also, the objective lens is larger than the eyepiece lens

249 **(b,c)**

Concave lens and convex mirror are diverging in nature. Therefore, the refracted/reflected rays do not meet and are produced to make them meet. Therefore, the image formed is virtual and erect

250 **(a,c,d)**

Total internal reflection takes place when ray of light travels from denser to rarer medium

Further, $\sin\theta_{12}=\frac{\mu_2}{\mu_1}$ and $\sin\theta_{13}=\frac{\mu_3}{\mu_1}$

Since, $\frac{\mu_3}{\mu_1}>\frac{\mu_3}{\mu_1}$

$\theta_{12}>\theta_{13}$

Smaller the value of critical angle more the chance of total internal reflection

251 **(a,c)**

At $P,\delta=0=A(\mu-1)\Rightarrow\mu=1$

Also $\delta_m=(\mu-1)A=A\mu_m-A$

Comparing it with $y=mx+c$

Slope of the line $=m=A$

252 **(d)**

$\omega=\frac{\lambda D}{d}$

D is halved and D is doubled

Therefore, fringe width ω will become four times

$\therefore$ Correct option is (d)

253 **(d)**

The distance between the first dark fringe on either side of the central bright fringe=width of central maximum $=\frac{2D\lambda}{a}$

$=\frac{2\times2\times600\times10^{-9}}{10^{-3}}=2.4\times10^{-3}\text{m}=2.4$ mm

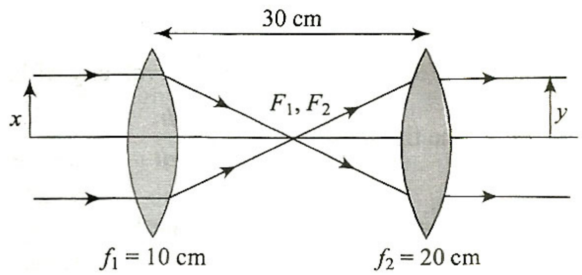
d. Is the correct option

254 **(b,d)**

Due to blocking only intensity is going to decrease. Each part of reflection mean by put it

255 **(a,c)**

Here, $\frac{x}{10}=\frac{y}{20}$



$y = 2x$

So, if $x = 1$ cm, $y = 2$ cm

257 **(a)**

According to lensmaker's formula,

$$\frac{1}{f} = ({}_{g}^{m}\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Now, ${}_{g}^{m}\mu = \frac{{}_{g}\mu}{{}_{m}\mu} = \frac{1.5}{1.75}$

For concave lens, as shown in figure, in this case $R_1 = -R$ and $R_2 = +R$

$$\therefore \frac{1}{f} = \left(\frac{1.5}{1.75} - 1\right)\left(-\frac{1}{R} - \frac{1}{R}\right) = +\frac{0.25 \times 2}{1.75R}$$

$\Rightarrow f = +3.5R$

The positive sign shows that the lens behaves as a convergent lens

a. is the correct option

258 **(a,b,c,d)**

Tube length $= f_0 + f_e$

Angular magnification $= f_0/f_e$

Thus $f_0 + f_e = 16 + 0.02 = 16.02\, m$

Angular magnification $= f_0/f_e = -16/0.02 = -800$

Objective lens is larger than eyepiece in aperture focal length

All the option (a), (b), (c), (d) are correct

259 **(c)**

The image I' of parallel rays formed by lens 1 will act as a virtual object

Applying lens formula for lens 2,

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

$$\Rightarrow \frac{1}{v} - \frac{1}{f_1 - d} = \frac{1}{f_2}$$

$$\Rightarrow v = \frac{f_2(f_1 - d)}{f_2 + f_1 - d}$$

The horizontal distance of the image I from O is

$$x = d + \frac{f_2(f_1 - d)}{f_2 + f_1 - d}$$

$$= \frac{df_2 - df_1 - d^2 + f_2 f_1 - df_2}{f_2 + f_1 - d}$$

$$= \frac{f_1 f_2 + d(f_1 - d)}{f_2 + f_1 - d}$$

To find the y-coordinate, we use magnification formula for lens 2,

$m = \frac{v}{u} = \frac{\frac{f_2(f_1 - d)}{f_1 + f_2 - d}}{f_1 - d} = \frac{f_2}{f_1 + f_2 - d}$. Also

$$m = \frac{h^2}{\Delta} \Rightarrow h_2 = \frac{\Delta \times f_2}{f_1 + f_2 - d}$$

Therefore, the y-coordinate,

$$y = \Delta - h_2$$

$$= \Delta - \frac{\Delta f_2}{f_1 + f_2 - d}$$

$$= \frac{\Delta f_1 + \Delta f_2 - \Delta d - \Delta f_2}{f_1 + f_2 - d} == \frac{\Delta(f_1 - d)}{f_1 + f_2 - d}$$

261 **(b,d)**

From the above ray diagram, it is clear that the options (b) and (d) are correct

262 **(a,c,d)**

For convex mirror (positive focal length) image is always smaller in size. For concave mirror (negative focal length) image is smaller when object lies beyond $2f$

263 **(b,c)**

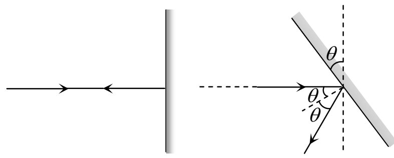
$$\frac{1}{100 - x} = \frac{1}{-x} = \frac{1}{21}$$

$\Rightarrow x$, The distance of object from the lens is 30 cm, 70 cm

$m_1 = \frac{70}{-30}, m_2 = \frac{30}{-70} \quad \therefore |m_1 - m_2| = \frac{40}{21}$

264 **(c,d)**

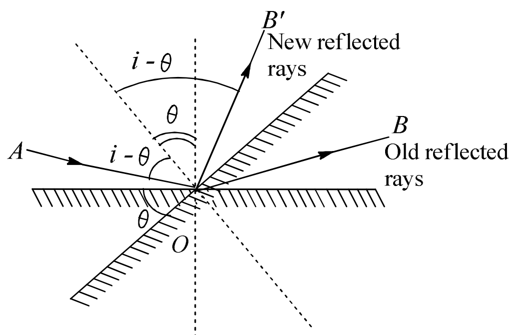
By keeping the incident ray is fixed, if plane mirror rotates through an angle θ reflected ray rotates through an angle 2θ



265 **(a,b,c,d)**

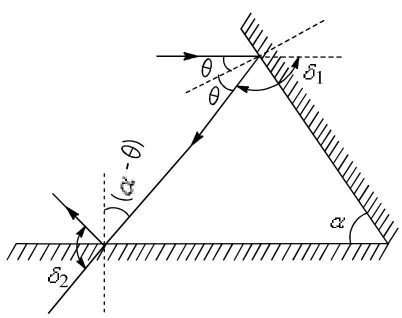
a. Angle $BOB' = \angle AOB' - \angle AOB'$

$= 2i - (2i - 2\theta) = 2\theta$



b. Total deviation $\delta = \delta_1 + \delta_2$

$= (180° - 2\theta) + 180° - 2(\alpha - \omega) = 360° - 2\alpha$



Which is independent of angle of incidence

c. Power of a plane mirror is zero

d. Velocity of the image toward the object $= v + v = 2v$

266 **(b,c,d)**

If the mirror is concave and a real object is approaching it, the image will move away from the mirror for object distance greater than focal length. If object distance is less than the focal length, virtual image will be formed which moves towards the mirror

If mirror is convex, as object is approaching the mirror, image will move from focus to pole, i.e., toward the mirror

267 **(a,b)**

Using $M = \frac{f_0}{f_e}$ and $L = f_0 + f_e$

268 **(d)**

Is the correct option

269 **(c,d)**

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

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

For $|u| = 66\ cm, |f| = 24\ cm$

$|v| = \frac{(66)(24)}{66-24} \approx 36\ cm$ which is not in the permissible limit

So, (66, 33), is incorrect recorded

For $|u| = 78, |f| = 24\ cm$

$|v| = \frac{(78)(24)}{78-24} \approx 32\ cm$ which is also not in the permissible limit

So, (78, 39) is incorrect recorded

270 **(c)**

The clouds consist of dust particles and water droplets. Their size is very large as compared to the wavelength of the incident light from the sun. So there is very little scattering of light. Hence the light which we receive through the clouds has all the colours of light. As a result of this, we receive almost white light. Therefore, the cloud are generally white

272 **(b)**

Since $\mu = \frac{\mu_g}{\mu_{cs}} = \frac{1.5}{1.65} \angle 1$

From $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \Rightarrow f < 0$

Therefore, the lens behaves as a diverging lens

Hence, (b) is correct option

273 **(c)**

The ray of light incident on the water air interface suffers total internal reflections, in that case the angle of incidence is greater than the critical angle. Therefore, if the tube is viewed from suitable direction (so that the angle of incidence is greater than the critical angle), the rays of light incident on the tube undergoes total internal reflection. As a result, the test tube appears as highly polished $i.e.$ silvery

274 **(c)**

The wavelength of wave associated with electron (de Broglie waves) is less than that of visible light. We know that resolving power is inversely proportional to wavelength of wave used in microscope. Therefore the resolving power of an electron microscope is higher than that of an optical microscope

275 **(a)**

I (scattering of light) $\propto \frac{1}{\lambda^4}$, blue light has small wavelength and order of wavelength of blue light is nearly equal to size of scattered particle of sky and blue scattered most not violet even violet has smallest wavelength in visible spectrum

276 **(c)**

$\mu \propto \frac{1}{\lambda} \propto \frac{1}{C}.\lambda_V$ is least so C_V is also least. Also the greatest wavelength is for red colour

278 **(d)**

If the mirror is shifted parallel to itself such that the velocity of the mirror is parallel to its surface, the image shall not shift. Hence, Statement I is false

280 **(c)**

The sun and its surroundings appears red during sunset or sunrise because of scattering of light. The amount of scattered light is inversely proportional to the fourth power of wavelength of light, $i.e., I \propto \frac{1}{\lambda^4}$

281 **(b)**

The stars twinkle while the planets do not. It is due to variation in density of atmospheric layer. As the stars are very far and giving light continuously to us. So, the light coming from stars is found to change their intensity continuously. Hence they are seen twinkling. Also stars are much bigger in size than planets but it has nothing to deal with twinkling phenomenon

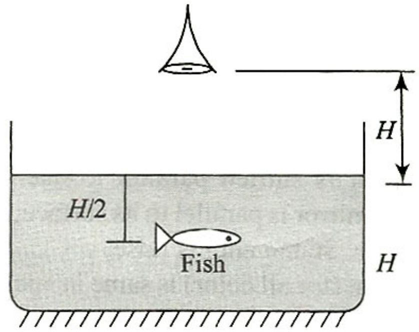
282 **(d)**

We can produce a real image by a plane or convex mirror

Focal length of a convex mirror is taken positive

283 **(a)**

Fish observing eye:



(i)Direct observation

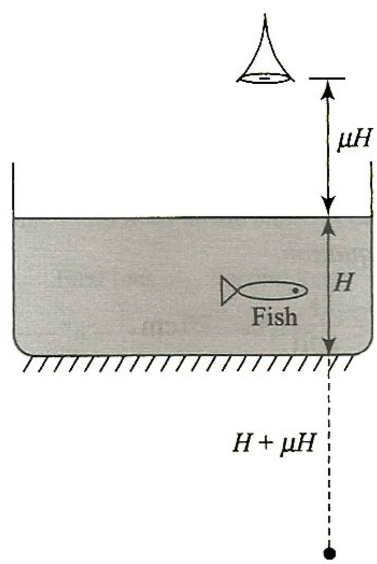
$$H_1 = \frac{H}{2} + \mu H$$

$$H_1 = H\left(\frac{1}{2} + \mu\right)$$

(ii)Fish observing image of eye by mirror. Hence, distance of the eye image from fish,

$$H_2 = \mu H + H + \frac{H}{2}$$

$$H_2 = H\left(\frac{3}{2} + \mu\right)$$



Eye observing fish:

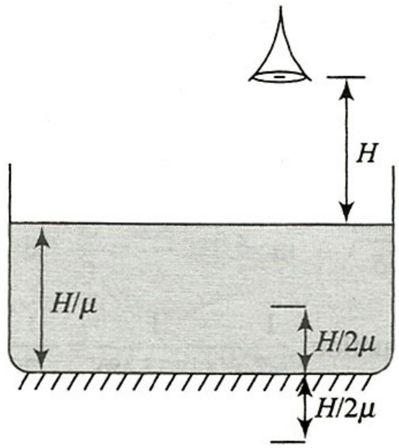
(i)Direct observation

$$H_1 = H + \frac{H}{2\mu} = H\left(1 + \frac{1}{2\mu}\right)$$

(ii)Eye observing image of the fish

$$H_2' = H + \frac{H}{\mu} + \frac{H}{2\mu} = H\left(1 + \frac{2}{2\mu}\right)$$

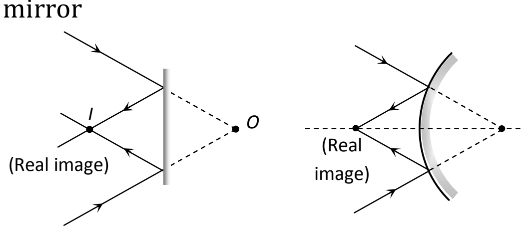
$$H_2' = H + \frac{3}{2\mu}$$



284 **(a)**
For smaller diameter incident angle at $A(i'')$ will be greater than critical angle to cause total internal reflection

285 **(a)**
When the sun is close to setting, refraction will effect the top part of the sun differently from the bottom half. The top half will radiate its image truly, while the bottom portion will send an apparent image. Since the bottom portion of sun is being seen through thicker, more dense atmosphere. The bottom image is being bent intensely and gives the impression of being squashed or "flattened" or elliptical shape

287 **(e)**
We can produce a real image by plane or convex mirror



Focal length of convex mirror is taken positive

288 **(a)**
Red glass transmits only red light and absorbs all the colours of which light. Thus, when green flower is seen through red glass it absorbs the green colour, so it appears to be dark

289 **(d)**
As can be seen from the expression of f, it depends upon the refractive index of the medium in which the lens is submerged

290 **(A)**
The relation between angle of deviation δ for a thin prism, an angle of prism and refractive index of material of prism is given by δ = (μ-1)A

292 **(a)**
Resolving power $= \frac{a}{1.22\lambda}$

294 **(a)**
In TIRE, 100% of incident light is reflected back into the same medium, and there is no loss of intensity, while in reflection from mirrors and refraction from lenses, there is always some loss of intensity. Therefore, image formed by total internal reflection are much brighter than those formed by mirrors or lenses

295 **(b)**
After refraction at two parallel faces of a glass slab, a ray of light emerges in a direction parallel to the direction of incidence of white light on the slab. As rays of all colours emerge in the same direction (of incidence of white light), hence there is no dispersion, but only lateral displacement

297 **(b)**
The velocity of light in a material medium depends upon it's colour (wavelength). If a ray of white light incident on a prism, then on emerging, the different colours are deviated through different angles

Also dispersive power $\omega = \frac{(\mu_V - \mu_R)}{(\mu_Y - 1)}$

$i.e., \omega$ depends upon only μ

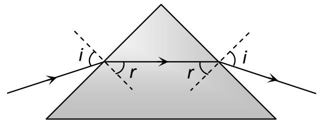
298 **(c)**
Shining of air bubble in water is on account of total internal reflection

299 **(b)**
Diamond glitters brilliantly because light enters in diamond suffers total internal reflection. All the light entering in it comes out of diamond after number of reflections and so light is absorbed by it

300 **(b)**
The light gathering power (or brightness) of a telescope $\propto (diameter)^2$. So by increasing the objective diameter even far off stars may produce

301 **(a)**

In case of minimum deviation of a prism $\angle i = \angle e$



so $\angle r_1 = \angle r_2$

302 **(c)**

Polar caps receives almost the same amount of radiation as the equatorial plane. For the polar caps angle between sun rays and normal (to polar caps) tends to 90°. As per Lambert's cosine law, $E \propto \cos\theta$, therefore E is zero. For the equatorial plane, $\theta = 0°$, therefore E is maximum. Hence polar caps of earth are so cold. (where E is radiation received)

303 **(a)**

The efficiency of fluorescent tube is about 50 $lumen/watt$, whereas efficiency of electric bulb is about 12 $lumen/watt$. Thus for same amount of electric energy consumed, the tube gives nearly 4 times more light than the filament bulb

304 **(c)**

Laws reflection can be applied to any type of surface.

305 **(c)**

Very large apertures gives blurred images because of aberrations. By reducing the aperture the clear image is obtained and thus the sensitivity of camera increases. Also the focussing of object at different distance is achieved by slightly altering the separation of the lens from the film

306 **(d)**

Focal length of the lens depends upon it's refractive index as $\frac{1}{f} \propto (\mu - 1)$

Since $\mu_b > \mu_r$ so $f_b < f_r$

Therefore, the focal length of a lens decreases when red light is replaced by blue light

307 **(c)**

Owls can move freely during night, because they have large number of cones on their retina which help them to see in night

308 **(b)**

The rays of light are diverging out from a virtual image. These can be easily converged onto the film of a concave lens by convergent action of its lens

309 **(d)**

We cannot interchange the objective and eye lens of a microscope to make a telescope. The reason is that the focal length of lenses in microscope are very small, of the order of mm or a few cm and the difference $(f_o - f_e)$ is very small, while the telescope objective have a very large focal length as compared to eye lens of microscope

310 **(d)**

From symmetry, the ray shall not suffer TIR at second interface, because the angle of incidence at first interface equals to angle of emergence at second interface. Hence, Statement I is false

311 **(b)**

Reflection of light rays takes place on rough as well as smooth surfaces. Some light energy would be absorbed by rough surface, so amplitude of reflected ray is less than that of incident ray

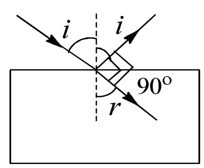
313 **(d)**

$1 \times \sin i = \mu \sin r = \mu \sin(90 - i)$

$\sin i = \mu \cos i$

$\Rightarrow \tan i = \mu$

So, reflected and refracted rays are perpendicular if $\tan i = \mu$



314 **(c)**

After the removal of stimulus the image formed on retina is sustained up to 1/6 second

315 **(e)**

Apparent shift for different coloured latter is

$d = h\left(1 - \frac{1}{\mu}\right) \Rightarrow \lambda_R > \lambda_V$ so $\mu_R < \mu_V$

Hence $d_R < d_V$ $i.e.$ red coloured letter raised least

316 **(a)**

In total internal reflection, 100% of incident light is reflected back into the same medium, and there is no loss of intensity, while in reflection from mirrors and refraction from lenses, there is always some loss of intensity. Therefore images formed by total internal reflection are much brighter than those formed by mirrors or lenses

317 **(d)**

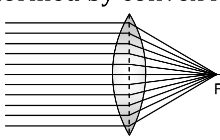
Speed of light (for all color) is same in vacuum, equal to $3 \times 10^8 \text{ms}^{-1}$

Speed of light is a property of medium

318 **(d)**
In air or water, a convex lens made of glass behaves as a convergent lens but when it is placed in carbon disulfide, it behaves as a divergent lens. Therefore, when a convergent lens is placed inside a transparent medium of refractive index greater than that of material of lens, it behave as a divergent lens.

It simply concludes that property of a lens whether the ray is diverging or converging depends on the surrounding medium

319 **(a)**
Image formed by convex lens



320 **(c)**
Using Huygen's eye-piece, measurements can be taken but not accurately due to the reason given.

321 **(a)**
Magnification produced by mirror $m = \frac{I}{O} = \frac{f}{f-u} = \frac{f}{x}$ x is distance from focus

322 **(e)**
The velocity of light of different colours (all wavelengths) is same in vacuum and $\mu \propto \frac{1}{\lambda}$

323 **(d)**
The magnifying power of telescope in relaxed state is $m = \frac{f_0}{f_e}$

So, for high magnification, the focal length of objective length should be larger than of eye-piece

Resolving power of a telescope $= \frac{d}{1.22\,\lambda}$

For high resolving power. Diameter (d) of objective should be higher

324 **(c)**
The index of refraction of light at the red end of the visible spectrum is lesser than at the violet end. Statement II is false

325 **(d)**
When a light wave travels from a rarer to a denser medium it loses speed, but energy carried by the wave does not depend on its speed

326 **(a)**
Focal length of lens immersed in water is four times the focal length of lens in air. It means
$f_\omega = 4f_a = 4 \times 10 = 40\ cm$

327 **(b)**
We know that power of lens is a reciprocal of its focal length, hence $P = \frac{1}{f} = \frac{1}{\frac{50}{100}} = 2\text{D}$

Since, lens is concave hence, its power will be 2D. If the object is placed at infinity then

$\mu = \infty, \text{v} = ?, f = 50 \text{ cm}$

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

$$\frac{1}{\text{v}} - \frac{1}{\infty} = \frac{1}{-50}$$

$$\text{v} = -50 \text{ cm}$$

Thus, concave lens will form an image of the object at infinity at a distance of 50 cm.

328 **(d)**
If a mirror is placed in a medium other than air its focal length does not change as $f = R/2$, but for the lens

$$\frac{1}{f_a} = ({}_an^g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

and $\frac{1}{f_w} = ({}_wn^g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

As ${}_wn^g < {}_an^g$, hence focal length of lens in water increases. The refractive index of water is $4/3$ and that of air is 1. Hence, $\mu_w > \mu_a$

329 **(d)**
It is not necessary for a material to have same colour in reflected and transmitted light. A material may reflect one colour strongly and transmit some other colour. For example, some lubricating oils reflect green colour and transmit red. Therefore, in reflected light, they will appear green and in transmitted light, they will appear red

330 **(a)**
Reflection index of diamond w.r.t. liquid
${}_l\mu_d = \frac{1}{\sin C}$

$\therefore \frac{\sqrt{6}}{\sqrt{3}} = \frac{1}{\sin C}$

Or $\sin C = \frac{1}{\sqrt{2}} = \sin 45°$

$\therefore C = 45°$

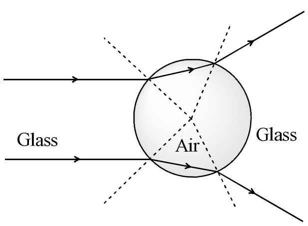
331 **(c)**

When glass surface is made rough, then light incident on it is scattered in different directions. Due to which its transparency decreases

There is no effect of roughness on absorption of light

332 **(d)**

The air bubble would behave as a diverging lens, because refractive index of air is less than refractive index of glass. However, the geometrical shape of the air bubble shall resemble a double convex lens



333 **(a)**

Both statements are true and Statement II is the correct explanation of Statement I

The focal length of a lens is given by, $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

For goggle, $R_1 = R_2$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = 0$$

Therefore, power $P = \frac{1}{f} = 0$

334 **(a)**

We know that power of lens is a reciprocal of its focal length, hence

$$P = \frac{1}{f} = \frac{1}{\frac{50}{100}} = 2\text{D}$$

Since, lens is concave hence, its power will be 2D. If the objective is placed at infinity then

$u = \infty, v = ?, f = 50$ cm

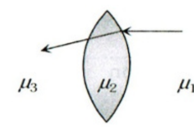
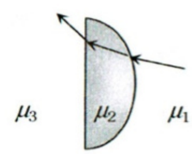
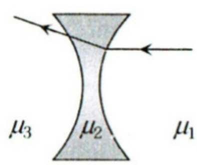
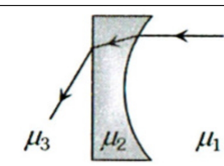
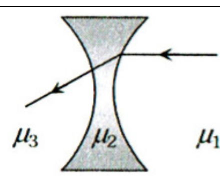
From the formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \frac{1}{\infty} = \frac{1}{-50}$$

$v = -50$ cm

Thus, concave lens will form an image of the object at infinity at a distance of 50 cm

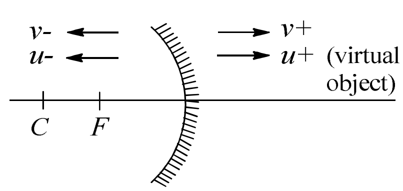
335 **(a)**

(p)		$\mu_2 = \mu_3$ As there is no deviation. As the light bends towards normal in denser medium $\mu_2 > \mu_1$ p → A and C
(q)		As light bends away from normal $\mu_2 < \mu_1$ and $\mu_3 < \mu_2$ q → B and D
(r)		$\mu_2 = \mu_3$ (As no deviation) $\mu_2 > \mu_1$ (As light bends – towards normal) r → C and A
(s)		$\mu_2 < \mu_1$ $\mu_3 < \mu_2$ As light bends away from normal s → B and D
(t)		$\mu_2 = \mu_3$ As no deviation of light $\mu_2 < \mu_1$ As light bends away from normal t → C and B

336 **(a)**

a. Concave mirror:

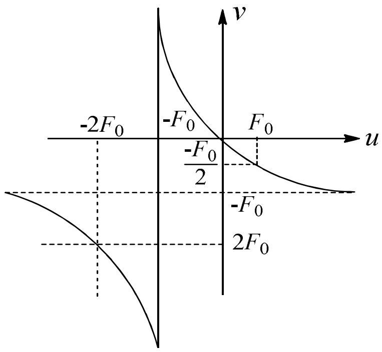
$v = \frac{uf}{u-f}$, f is negative let $f = -F_0 LL$



u	$-\infty$	$-2F_0$	$-F_0$	0	F_0	∞

v	$-F_0$	$-2F_0$	$\pm\infty$	0	$\frac{-F_0}{2}$	F_0

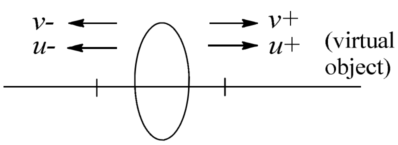
$$v = \frac{-uF_0}{u + F_0}$$



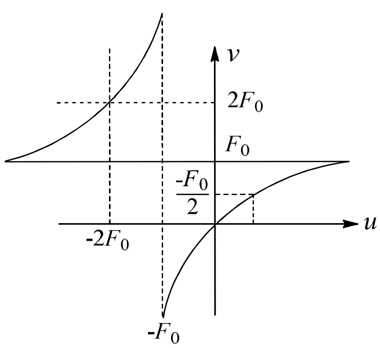
b. Convex lens:

$v = \frac{uf}{u+f}$, f is positive, let $f = F_0$

$$v = \frac{uF_0}{u + F_0}$$



u	$-\infty$	$-2F_0$	$-F_0$	0	F_0	∞
v	F_0	$2F_0$	$\pm\infty$	0	$\frac{-F_0}{2}$	F_0

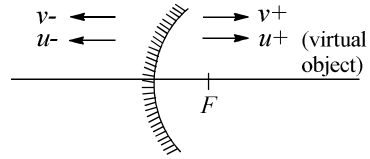


c. Convex mirror:

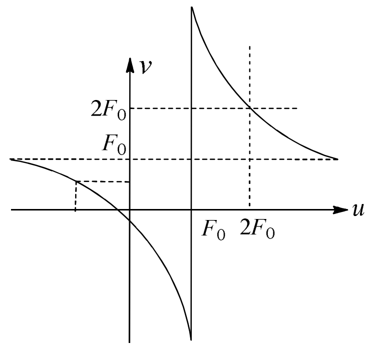
$$v = \frac{uf}{u - f}$$

f is positive, let $f = F_0$

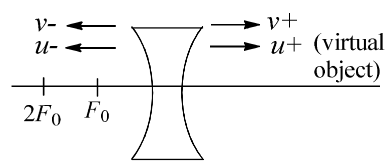
$$v = \frac{uf_0}{u - f_0}$$



u	$-\infty$	$-F_0$	0	F_0	$2F_0$	∞
v	F_0	$\frac{F_0}{2}$	0	$\pm\infty$	$2F$	F



d. Concave lens:

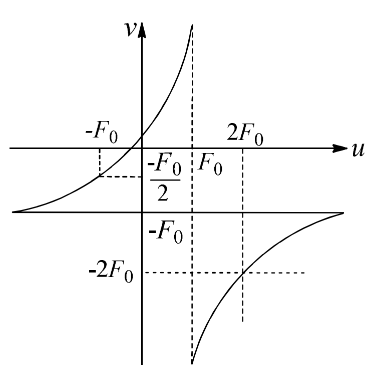


$$v = \frac{uf}{u + f}$$

f is negative, let $f = -F_0$

$$v = \frac{-uf_0}{u - f}$$

u	$-\infty$	$-F_0$	0	F_0	2
v	$-F_0$	$\frac{-F_0}{2}$	0	$\pm\infty$	$-$



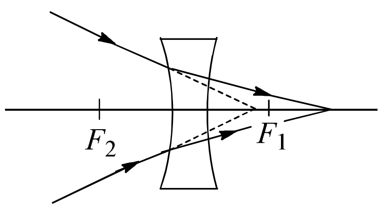
337 **(b)**

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

$$m=\frac{f}{u+f}$$

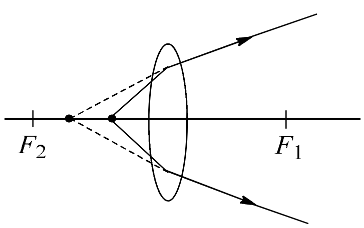
Here, f is negative, u is positive and less than f

So v will also be positive $m>1$, so image is erect and its size is greater than object. Here object is virtual



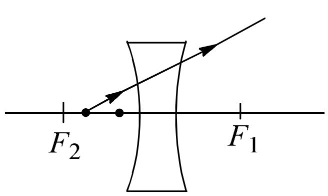
b. $\frac{1}{v}=\frac{1}{u}+\frac{1}{f}$

$$m=\frac{f}{u+f}$$



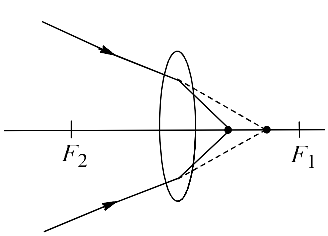
f is positive, u is negative and less than f. So v is negative.$m>1$, so image is erect and its size is greater than object. Here, object is real

c. u is negative, f is negative u is less than f



$o<m<1$, object is real

d. u is positive, f is +positive



339 **(a)**

1. The focal length of mirror is independent of refractive index of the surrounding medium and hence from mirror formula, only one image can be confirmed

2. Lens can be considered as two thin plano-convex lenses in contact. Since two media on other side of lens are present, two distinct focal lengths are possible and hence two images

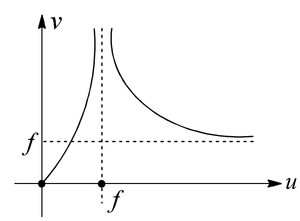
3. Same reasoning as for (b), but since only one medium is present on the other side, only one image is formed

4. Lens can be considered as two half lenses having different focal lengths and medium on the other side of upper lens is of two types while for lower lens is of only one type. So, a total of 3 images are possible

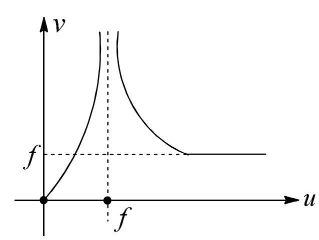
340 **(c)**

a. Converging lens or convex lens,

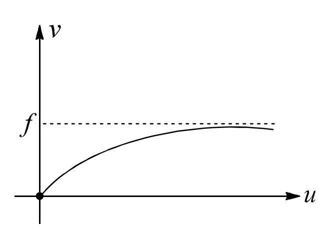
$$v=\frac{uf}{u+f}$$



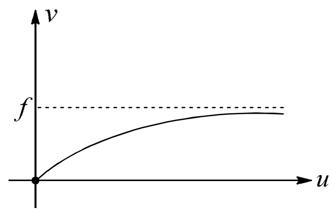
b. Converging mirror or concave mirror,



c. Diverging lens or concave lens,



d. Diverging mirror or convex mirror,



341 **(d)**

$\mu_{\text{blue}} > \mu_{\text{green}} > \mu_{\text{yellow}} > \mu_{\text{red}}$

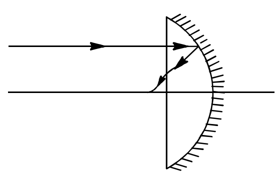
342 **(d)**

A plane surface or a mirror always gives a real object for a point image and vice-versa. For a concave mirror, a virtual image for a virtual object is not possible; for a convex mirror, a real image of a real object is not possible

346 **(b)**

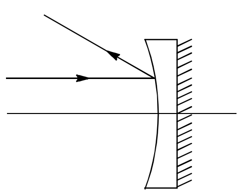
a. A convex lens in a denser medium will behave like a concave lens or diverging lens

b. A concave lens in a rarer medium will behave like a concave lens or diverging lens



c.

Behaves like concave mirror



d.

Behaves like convex mirror

347 **(c)**

$\vec{v}_{\text{A}} = \hat{\imath} + at = \hat{\imath} + (2\hat{\imath} + \hat{\jmath})(2) = 5\hat{\imath} + 2\hat{\jmath}$

$\vec{v}_{\text{A}'} = -5\hat{\imath} + 2\hat{\jmath}$

$\vec{v}_{\text{A}',\text{A}} = \vec{v}_{\text{A}'} - \vec{v}_{\text{A}} = -10\hat{\imath}$

$\vec{v}_{\text{B}} = (-\hat{\imath} + 3\hat{\jmath}), \vec{v} + 3\hat{\jmath}$so $\vec{v}_{\text{B}',\text{B}} = 2\hat{\imath}$

For particle C:

$\frac{dv_{\text{y}}}{dt} = 21 \Rightarrow v_{\text{y}} - 6 = t^2$

$\Rightarrow v_{\text{y}} = 6 + 4 = 10$

$\vec{v}_{\text{C}} = 3\hat{\imath} - \hat{\jmath}, \vec{v}_{\text{D}'} = -3\hat{\imath} - \hat{\jmath}, \vec{v}_{\text{D}',\text{D}} = -6\hat{\imath}$

348 **(a)**

Initially, the image is formed at infinity

1. As m is increased, the focal length decreases. Hence, the object is at a distance larger than the focal length. Therefore, final image is real. Also, final image becomes smaller in size in comparison to the size of image before the change was made

2. If the radius of curvature is doubled, the focal length decreases. Hence, the object is at a distance lesser than the focal length. Therefore, final image is virtual. Also, final image becomes smaller in size in comparison to the size of image before the change was made

3. Due to insertion of slab, the effective object for lens shifts rightward. Hence, final image is virtual. Also, final image becomes smaller in size in comparison to the size of image before the change was made

4. The object comes to center of curvature of right spherical surface. Hence, the final image is virtual. Also, final image becomes smaller in size in comparison to the size of image before the change was made

349 **(b)**

In air

$$P = \frac{1}{f} = (1.5 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = 2$$

$$\therefore \left(\frac{1}{R_1}\frac{1}{R_2}\right) = \frac{2}{0.5} = 4$$

In water $P'' = \left(\frac{1.5}{4/3} - 1\right) \times 4 = \frac{4.5-4}{4} \times 4 = 0.5\text{D}$

350 **(c)**

$$\mu = \frac{1}{\sin C} = \frac{1}{\sin 48.6} = \frac{1}{0.75} = \frac{4}{3}$$

351 **(c)**

(i) $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

Taking refraction first at curved surface,

$$\frac{2}{v_1} + \frac{1}{x} = \frac{1}{R} \Rightarrow v_1 = \frac{2Rx}{x - R}$$

For plane surface,

$$v' = v_1 - R \Rightarrow v' = \frac{xR + R^2}{x - R}$$

$$\Rightarrow \frac{1}{v} - \frac{2(x - R)}{R(x + R)} = 0$$

$$\frac{1}{v} = \frac{2(x-R)}{R(x+R)}$$

For virtual image,

$$\frac{1}{v} < 0 \;\; \Rightarrow \frac{2(x-R)}{R(x+R)} < 0$$

$x < R$

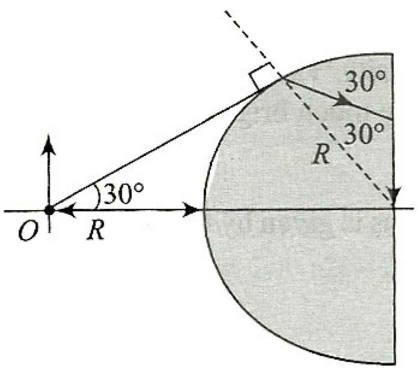
(ii) For $x = 2R$

$$V_1 = \frac{4R^2}{R} = 4R \;\; \Rightarrow \;\; u = -2R$$

$$m_1 = \frac{\mu_1}{\mu_2}, \frac{v}{u} = \frac{1}{2}, \frac{4R}{(-2R)} = -1$$

$m_2 = 1 \;\; \Rightarrow \;\; m_1 m_2 = -1$

Image is real, inverted, and of same size



(iii)

Hence, correct answer is 90°

352 **(d)**

From the formula of equivalent focal length of thin lenses in contact, we get

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f} - \frac{1}{3f} \text{ or } F = \frac{3f}{2}$$

353 **(b)**

The normal shift produced by a glass slab is,

$$\Delta x = \left(1 - \frac{1}{\mu}\right) t = \left(1 - \frac{2}{3}\right)(6) = 2 \text{ cm}$$

i.e., for the mirror, the object is placed at a distance $(32 - \Delta x) = 30$ cm from it

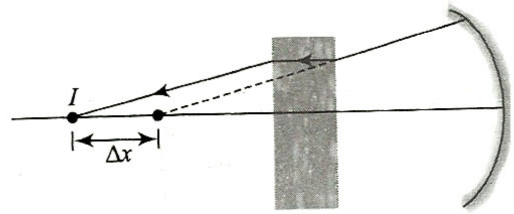
Applying mirror formula,

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

$$\frac{1}{v} + \frac{1}{30} = -\frac{1}{10}$$

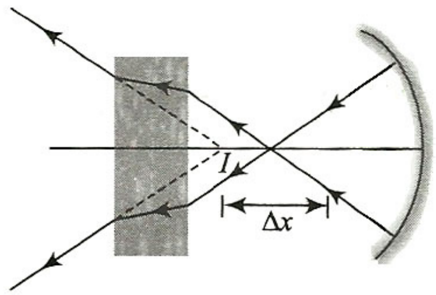
Or $v = -15$ cm

a. When $x = 5$ cm: The light falls on the slab on its return journey as shown. But the slab will again shift it by a distance



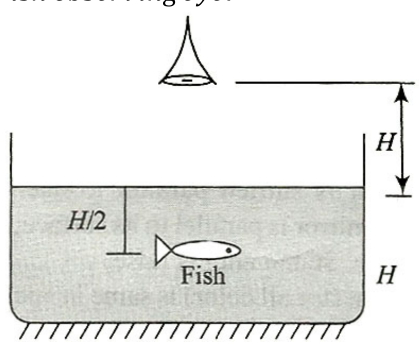
$\Delta x = 2$ cm. Hence, the final real image is formed at a distance $(15 + 2) = 17$ cm from the mirror

b. When $x = 20$ cm: This time also the final image is at a distance of 17 cm from the mirror but it is virtual as shown



354 **(a)**

Fish observing eye:



(i) Direct observation

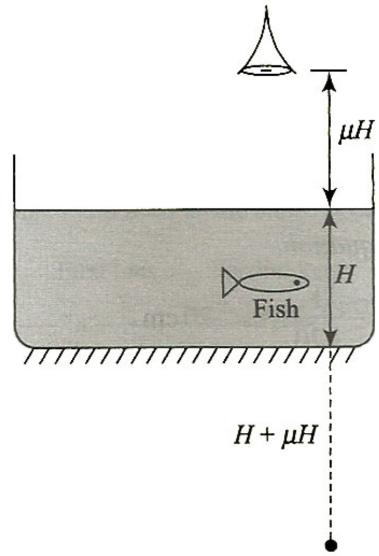
$$H_1 = \frac{H}{2} + \mu H$$

$$H_1 = H\left(\frac{1}{2} + \mu\right)$$

(ii) Fish observing image of eye by mirror. Hence, distance of the eye image from fish,

$$H_2 = \mu H + H + \frac{H}{2}$$

$$H_2 = H\left(\frac{3}{2} + \mu\right)$$



Eye observing fish:

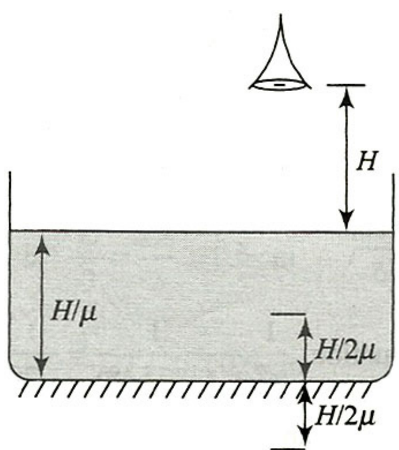
(i) Direct observation

$$H_1 = H + \frac{H}{2\mu} = H\left(1 + \frac{1}{2\mu}\right)$$

(ii) Eye observing image of the fish

$$H_2'''' = H + \frac{H}{\mu} + \frac{H}{2\mu} = H\left(1 + \frac{2}{2\mu}\right)$$

$$H_2'''' = H + \frac{3}{2\mu}$$



355 **(b)**

(i) Viewer on the left of hallow sphere: Single refraction takes place at surface S. From the single surface refraction equation, we have

$$\frac{1}{v} - \frac{n}{(-R)} = \frac{(1-n)}{(-2R)}$$

Which on solving for v yields

$$v = -\left(\frac{2R}{n+1}\right)$$

Image is on the right of refracting surface S

Shift=Real depth−Apparent depth

$$= R - \left(\frac{2R}{n+1}\right) = \frac{(n-1)}{(n+1)}\,R$$

(ii) When the viewer is on the right, two refractions take place at surfaces S_1 and S_2

For refraction at surfaceS_1:

$$\frac{n}{v_1} - \frac{1}{(-2R)} = \frac{(n-1)}{(-R)}$$

Which on solving for v_1 yields

$$v_1 = -\frac{2nR}{2n-1}$$

The first lies to the left of S_1 and acts as object for refraction at the second surface. We have to shift the origin of Cartesian coordinate system to the vertex of S_2. The object distance for the second surface is

$$u_2 = -\left[\frac{2nR}{2n-1} + R\right] = -\left(\frac{4n-1}{2n-1}\right)R$$

$$\frac{1}{v_2} = -\frac{n}{-\left[\frac{4n-1}{2n-1}\right]\,R} = \frac{1-n}{-2R}$$

On solving for v_2, we get

$$v_2 = -\frac{2(4n-1)}{(3n-1)}\,R$$

The minus sign shows that image is virtual and lies to the left to S_2

Shift=Real depth − Apparent depth

$= 3R - \frac{2(4n-1)R}{(3n-1)} \Rightarrow = \frac{(n-1)}{(3n-1)}R$

356 **(a)**

The light retraces its path if it is incident normally on a mirror. The ray after refraction through the lens and the liquid are parallel. We will apply the general thin lens equation with parameters
$n_1 = 1, n_2 = 3/2, n_3 = 4/3, u = -15$ cm,
and$v = \infty$

$\frac{n_3}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R} + \left(\frac{n_3 - n_2}{R}\right)$

$\frac{n_3}{\infty} - \frac{1}{(-15)} = \frac{(3/2) - 1}{R} - \frac{[(4/3) - (3/2)]}{R}$

On solving for R, we get $R = 10$ cm. Similarly, when second liquid is filled, we have

$\frac{n_3'}{\infty} - \frac{1}{(-25)} = \frac{(3/2) - 1}{10} - \frac{n_3' - (3/2)}{10}$

On solving for n_3', we get,$n_3' = 1.6$

357 **(c)**

From lens equation,

$\frac{1}{v} - \frac{1}{(-20)} = \frac{1}{10} \Rightarrow v = +20$ cm

Magnification, $m_1 = \frac{v}{u} = \left(\frac{+20}{-20}\right) = -1$

Image is real, inverted, and same size as object

The first image acts as object for concave mirror.
Object distance for mirror is $(40 - 20)$ cm
From mirror equation,

$\frac{1}{v'} + \frac{1}{(-20)} = \frac{1}{(-7.5)} \Rightarrow v = -12$ cm

Magnification, $m_2 = -\left(\frac{u'}{v'}\right) = -\left(\frac{-12}{-20}\right) = -0.6$

The second image is 12*cm to the left of the mir*
(*that is reinverte*)

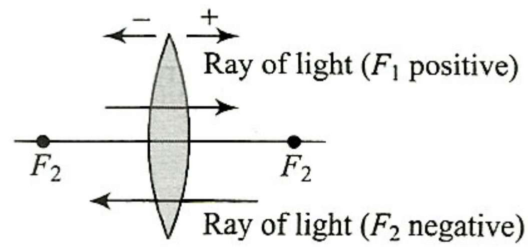
The second image acts as object for the lens. The object distance for second refraction at the lens, $u'' = +28$ cm
From lens equation,

$\frac{1}{v''} - \frac{1}{(+28)} = \frac{1}{-10} \Rightarrow v'' = -15.6$ cm

Note the sign convention for f and u

Magnification, $m_3 = \frac{v''}{u''} = \left(\frac{-15.6}{+28}\right) = -0.556$

Final image is real, inverted, and lies 15.6 *cm to*



Overall magnification,
$m = m_1 \times m_2 \times m_3$
$= (-1) \times (0.6) \times (-0.556) = -0.333$

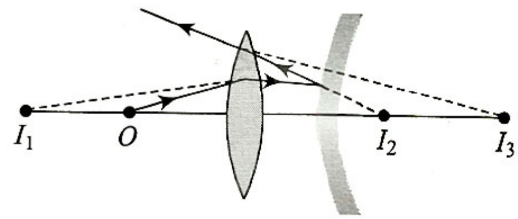
358 **(a)**

From lens equation,

$\frac{1}{v} - \frac{1}{(-10)} = -\frac{1}{+20}, v = -20$ cm

Magnification, $m_1 = \left(\frac{-20}{-10}\right) = +2$

Image is virtaul, erect and magnified



The first image acts as an object for the convex
=(20 + 5) = 25 *cm*
From mirror equation,

$\frac{1}{v'} + \frac{1}{(-25)} = \frac{1}{+15} \Rightarrow u' = +\frac{75}{8}$ cm

Magnification, $m_2 = \left(\frac{+75/8}{-25}\right) = \frac{3}{8}$

Image is virtaul (*to the right of the mirror*), *ere*
The obejct distnace for second refraction at th

$= \frac{75}{8} + 5 = \frac{115}{8}$

From lens equation,$\frac{1}{v''} - \frac{1}{(+115/8)} = \frac{1}{-20}$,

$v'' = \frac{460}{9} = +51.1$ cm

Magnification, $m_3 = \left(\frac{+460/9}{115/8}\right) = \frac{32}{9}$

Overall magnification, $m = m_1 \times m_2 \times m_3$is

$(2) \times \left(\frac{3}{8}\right) \times \left(\frac{32}{9}\right) = \frac{8}{3}$

Hence, size of image is

$\left(\frac{8}{3} \times 2\right)$ cm = 5.33 cm

Final image is to the right of the lens at a distance of 51.1 cm from the lens; real, erect and magnified

359 **(a)**

Splitting of a lens in two parts does not affect the position of the image. Each half forms an image at the same position but of reduced intensity. The previous problem shows that for a fixed object which the image is formed at the same position

Let the object and image distances for the two lenses be u, v and u'', v'', respectively. In accordance with principle of reversibility of light, $u'' = v$ and $v'' = u$

Hence, $u + d + v'' = u + d + u = D$

$$u = \frac{D - d}{2}$$

Also $v = D - u = \frac{D+d}{2}$

As $m = \frac{v}{u} = \frac{D+d}{D-d} = 2$ (given)

$$d = \frac{D}{3} = \frac{1.8}{3} = 0.6 \text{ cm}$$

Hence, $u = \frac{1}{2}(D - d) = 0.6$ cm

And $v = \frac{1}{2}(D + d) = 1.2$ cm

From lens equation,

$$\frac{1}{1.2} - \frac{1}{-(0.6)} = \frac{1}{f}$$

$f = 0.4$ cm

360 **(b)**

As explained in the previous problem, each half lens will form an image in the same plane. The optic axes of the lenses are displaced

$$\frac{1}{v} - \frac{1}{(-30)} = \frac{1}{20}, v = 60 \text{ cm}$$

From similar triangles OI_1I_2 and OP_1P_2, we have

$$\frac{I_1I_2}{P_1P_2} = \frac{u + v}{u} I_1I_2 = \frac{90}{30}(2 \times 0.05) = 0.3 \text{ cm}$$

Thus, the two images are 0.33 *cm apart*

Alternatively, imagine two arrows (see figure) that act as objects for the lens

Magnification, $m = \frac{v}{u} = \frac{(+60)}{(-30)} = -2$

Image of height of arrow is

$y = 2 \times (0.05) = 0.10$ cm

Thus, two inverted images are formed whose tips are at I_1 and I_2, respectively

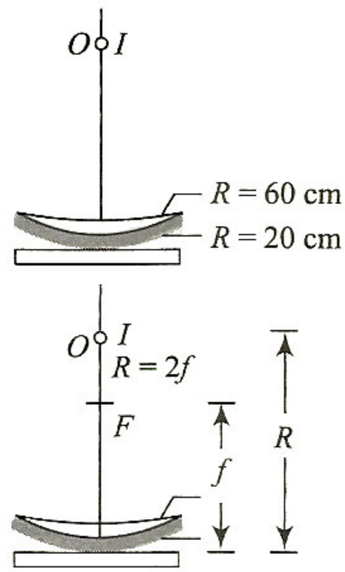
Thus, $I_1I_2 = 2y + \Delta = (2 \times 0.1) + 0.1 = 0.3$ cm

361 **(c)**

Method 1: The optical arrangement is equivalent to the concave mirror of focal length F given by

$$\frac{1}{F} = \frac{1}{f_g} + \frac{1}{f_m} + \frac{1}{f_g}$$

Where f_x is the focal length of the lens without silvering and f_m is the focal length of the mirror



$$\frac{1}{f_g} = (n - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$= (1.5 - 1)\left(\frac{1}{20} - \frac{1}{+60}\right) = \frac{1}{60}$$

$f_g = 60$ cm

$f_g = R_1/2 = 20/2 = 10$ cm

$$\frac{1}{F} = \frac{1}{60} + \frac{1}{10} + \frac{1}{60} = \frac{8}{60}$$

$$F = \frac{60}{8} = 7.5 \text{ cm}$$

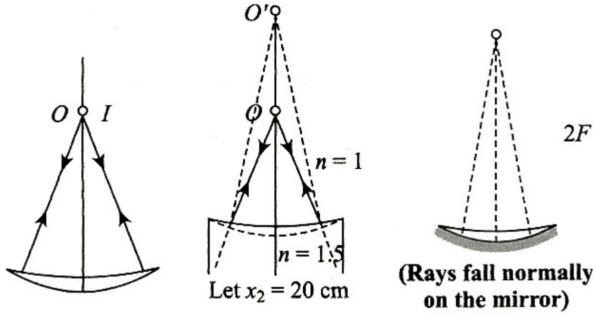
For the image to be formed at the place of the object,

$X = R = 2F = 7.5 \times 2 = 15$ cm

Method 2: We use the relation

$$\frac{n_2}{x_2} - \frac{n_1}{x_1} = \frac{n_2 - n_1}{R}$$

For the object and the image to coincide, the rays fall normal on the reflection surface, i.e., on the silvered face of the lens



Then, the rays retrace backward and meet at the object point again (optical reversibility)

For the refraction at the upper surface of the lens, $n_1 = 1.0, n_2 = 1.5, x_1 = 20, R = +60$

($x_2 = +20$ ensures that the rays fall on the silvered face normally)

$$\frac{1.5}{20} - \frac{1.0}{x_1} = \frac{1.5 - 1.0}{+60}$$

$$\frac{1.0}{x_1} = \frac{1.5}{20} - \frac{0.5}{60} = \frac{3.0}{60}$$

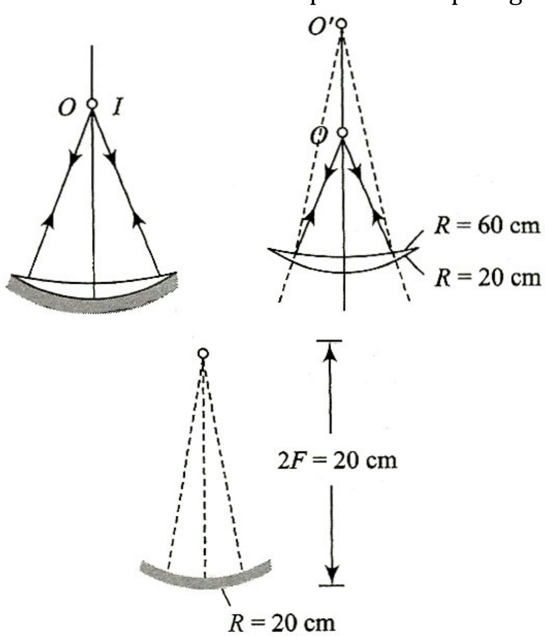
$x_1 = 15$ cm

Method 3: We use lensmaker's formula and the equation

$$\frac{1}{f} = \frac{1}{x_2} - \frac{1}{x_1}$$

The given optical arrangement can be visualised as a convex lens of focal length 60 cm and a concave mirror of focal length 10 cm kept in contact as shown in the figure

If the rays fall normally on the mirror after the refraction through the lens, they will retrace backward and meet at the point of the pin again



For the lens, $x_1 = ?$

$x_2 = +20$ (for normal incidence on the mirror)

$f = -60$ (using cartesian-coordinate sign convention)

$$\frac{1}{-60} = \frac{1}{+20} - \frac{1}{x_1}$$

362 **(c)**

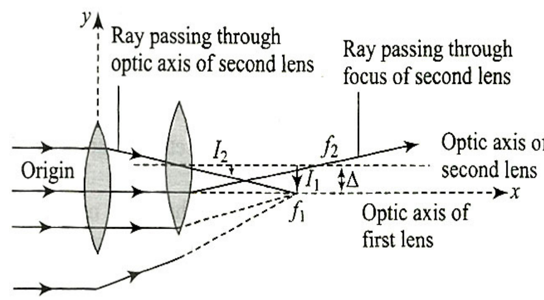
The parallel rays will be focussed at the focal point of the first lens. The first image lies at I, at a distance f_1 from the origin. This image I_1 will act as an object for refraction through the second lens. The object distance for the second lens, $u = (f_1 - d)$

From lens equation, $\frac{1}{v} - \frac{1}{+(f_1 - d)} = \frac{1}{f_2}$

$$v = \frac{f_2(f_1 - d)}{(f_1 + f_2 - d)}$$

Hence, the x-coordinate of final image I_2 is

$$x = d + u = \frac{d + f_2(f_1 - d)}{(f_1 + f_2 - d)} = \frac{d(f_1 - d) + f_1 f_2}{(f_1 + f_2 - d)}$$



Imagine an arrow tip is at f_1: its image from lens f_1 is the final image

Magnification, $m = \frac{v}{u} = \frac{I_2}{O} = \frac{I_2}{\Delta}$

$$I_2 = \left(\frac{v}{u}\right)\Delta = \frac{f_2}{(f_1 + f_2 - d)}\Delta$$

Thus, y −coordinate of tip of I_2 is

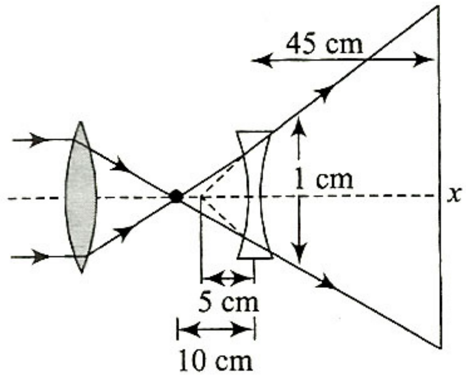
$$\Delta - I_2 = \Delta\left[1 - \frac{f_2}{(f_1 + f_2 - d)}\right] = \frac{(f_1 - d)\Delta}{(f_1 + f_2 - d)}$$

363 **(b)**

In case (a), the incident parallel beam emerges as a parallel beam. So area illuminated,

$A_1 = \pi(1)^2 = \pi$ cm^2

In case (b), let x be the diameter of the area illuminated



Then,

$\frac{x}{45} = \frac{1}{5} \Rightarrow x = 9$ cm

$A_2 = \pi\left(\frac{9}{2}\right)^2 = \frac{81}{4}\pi$ cm^2

$\frac{A_2}{A_1} = \frac{81}{4}$

When liquid of refractive index μ is filled to the right of this lens, the first surface of the lens (radius of curvature=10 cm) forms the image at the object only. Considering the refraction at the second surface

$\frac{\mu}{\infty} - \frac{1.5}{-10} = \frac{\mu-1.5}{10}$ (therefore, same are $\Rightarrow v \to \infty$

$\Rightarrow \mu = 3$

364 **(b)**

a. Focal lengths of lenses L_1 and L_2 are, respectively, given by

$$\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right) \Rightarrow f_1 = 50 \text{ cm}$$

$$\frac{1}{f_2} = (\mu - 1)\left[\frac{1}{\infty} - \left(-\frac{1}{R}\right)\right] \Rightarrow f_2 = 40 \text{ cm}$$

The equivalent focal length f of the combination is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow f = \frac{200}{9} \text{cm}$$

Hence, the image of the parallel beam is forme

distnace of 22.22 *cm from the combination on t*

b. Image formed by L_1 is at distance of 50 cm behind the lens. This image lies on the principal axis of L_1 and will act as an object for L_2

For L_2, object distance, $u = +50$ cm

$f_2 = +40$ cm

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \mu = \frac{200}{9} \text{cm}$$

Magnification caused by L_2, $m = \frac{v}{u} = \frac{4}{9}$

For L_2, object I_1 is at a distance of 4.5 mm above its principal axis

Hence, distnace of image I_2 of the obejct (virtu
/9) $\times$ 4.5
$=$ 2 *mm above the principal axis of L_2[$\because$ height*
$= m \times$ *height of object*]

Hence, final image is at a distance of 22.22 cm behind the combination at a distance of 2.5 mm below the principal axis of L_1

365 **(d)**

a. For this situation, object will be virtual as shown in the figure

Here, $u = +10$ cm and$f = +20$ cm

So, $\frac{1}{v} + \frac{1}{+10} = \frac{1}{+20}$ $\Rightarrow$ i.e., $v = -20$ cm

i.e., the image will be at a distance of 20 cm in front of the mirror and will be real, erect and enlarged with $m = -(20/10) = +2$

b. For this situation also, object will be virtual as shown in the figure

Here, $u = +30$ cm

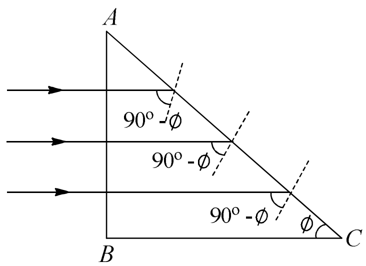
And $f = +20$ cm

$\frac{1}{v} + \frac{1}{+30} = \frac{1}{+20}$ i. e., $v = +60$ cm

i.e., the image will be at a distance of 60 cm behind the mirror and will be virtual, inverted, and enlarged with $m = -(+60/30) = -2$

366 **(a)**

No deviation occurs at face AC; hence the angle of incidence at surface AC is $90° - f$. For total internal reflection at the second surface,



$n_g \sin(90° - \phi) \geq n_a$

$n_g \cos\phi \geq n_a$

As f increases from zero, $\cos\phi$ decreases. Thus, f has the largest value when

$n_g \cos\phi = n_a$

$\cos\phi = \left(\frac{n_a}{n_g}\right)$

$\phi = \cos^{-1}\left(\frac{n_a}{n_g}\right) = \cos^{-1}\left(\frac{2}{3}\right)$

b. If the prism is immersed in water,

$\phi = \cos^{-1} = \left(\frac{n_w}{n_g}\right) = \cos^{-1}\left(\frac{8}{9}\right)$

367 **(c)**

The objective lens must form a real image for eyepiece to magnify it

368 **(a)**

From Snell's law,

$\mu \sin\alpha = \sin\phi$

$\sin\alpha = \frac{1}{\mu}\sin\varphi < \frac{1}{\mu}$

α is less than critical angle

369 **(d)**

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

Here $v = 2.5$ (distance of retina as position of image is fixed)

$u = -x$

$\frac{1}{f} = \frac{1}{2.5} + \frac{1}{x}$

For $f_{\min}$: x is minimum $\frac{1}{f_{\min}} = \frac{1}{2.5} + \frac{1}{25}$

370 **(d)**

From passage, (d) is correct

371 **(c)**

As object is between infinity and $2F$, image will be between F and $2F$ and the point C is lying in this region

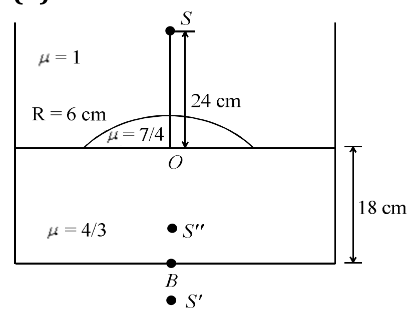
372 **(b)**

$n = \frac{c}{v}$

For meta materials

$v = \frac{c}{|n|}$

373 **(2)**



$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$\frac{7}{4v} - \frac{1}{-24} = \frac{\frac{7}{4} - 1}{6}$

$\frac{7}{4v} = \frac{3}{24} - \frac{1}{24} = \frac{2}{24} = \frac{1}{12}$

$\frac{7 \times 12}{4} = v = 21\ cm$

$\frac{21}{QS''} = \frac{7/4}{4/3} \Rightarrow \frac{21}{OS''} = \frac{7}{4} \times \frac{3}{4} \Rightarrow OS'' = 16$

$\therefore BS'' = 2cm$

374 **(3)**

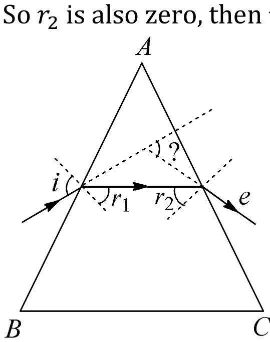
Given $i = 60°, \delta = 30°$ and $A = 30°$

We have $\delta = i + e - A$

From Eq. (i), we get

$30° = 60° + e - 30°$ or $e = 0$

So r_2 is also zero, then $r_1 = A = 30°$



So $\mu = \frac{\sin i}{\sin r_1} = \frac{\sin 60°}{\sin 30°} = \sqrt{3}$

Hence the value of $a = 3$

375 **(9)**

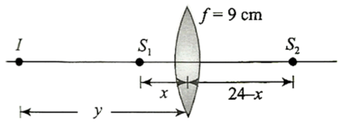
When object is placed at the focus of the lens, i.e., at 22 cm from the lens, image will be formed at infinity. Shift in the position of object:

$$25-22=\left(1-\frac{1}{\mu}\right)t \Rightarrow 3=\left[1-\frac{1}{1.5}\right]t$$

$$t=\frac{(3)(1.5)}{0.5}=9 \text{ cm}$$

376 **(6)**

Let both the images are formed at I. For S_1, the image is virtual and for S_2, the image is real



For S_1: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{-y}-\frac{1}{-x}=\frac{1}{9}$ (i)

For S_2: $\frac{1}{y}-\frac{1}{-(24-x)}=\frac{1}{9}$ (ii)

From (i) and (ii) $\frac{1}{x}+\frac{1}{24-x}=\frac{2}{9}$

$\Rightarrow x^2-24x+108=0$

$\Rightarrow x=6$ cm and 18 cm

But $x<f$. So answer is 6 cm

377 **(2)**

For magnification $+2, u=-x, v=-2x$ and $f=2.0$ m

From $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$, we have $\frac{1}{-2x}+\frac{1}{x}=\frac{1}{z}$

$x=1.0$ m

For magnification of $-2, u=-y, v=+2y, f=2.0$ m

We have $\frac{1}{2y}+\frac{1}{y}=\frac{1}{2} \Rightarrow y=3.0$ m

So distance to be moved$=y-x=3-1=2$ m

378 **(3)**

Image is at ∞, so apparent position of object is at focus.$d_{AC}=25$ cm

Shift$=5 \text{ cm}=\left(\frac{\mu-1}{\mu}\right)t \Rightarrow t=15$ cm

379 **(8)**

$$f=\frac{D^2-d^2}{4D}=\frac{50^2-30^2}{4\times 50}=8 \text{ cm}$$

380 **(8)**

$A'B'$ is the apparent position of bottom of container, at a distance h/μ from water surface

If the container seems to be half filled. Then

$$14-h=\frac{h}{\mu} \Rightarrow 14-h=\frac{3h}{4} \Rightarrow h=8 \text{ m}$$

381 **(3)**

Critical angle between glass and liquid

$$\sin\theta_C=\frac{\mu}{(3/2)}=\frac{2\mu}{3}$$

Angle of incidence on $AC=60°$

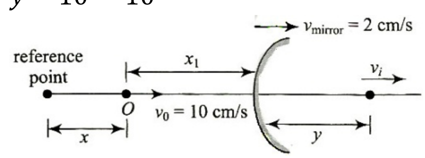
For TIR, $i>\theta_C \Rightarrow \frac{2}{3}\mu$

$\mu<\frac{3\sqrt{3}}{4}=\frac{I\sqrt{3}}{4}$ (given) So, $I=3$

382 **(0)**

$\frac{1}{y}+\frac{1}{-x_1}=\frac{1}{10}$ (i)

$$\frac{1}{y}-\frac{1}{10}=\frac{1}{10} \Rightarrow y=5 \text{ cm}$$



$$\frac{dx}{dt}=10 \text{ cm/s}, \frac{d(x+x_1)}{dt}=2 \text{ cm/s}$$

$$\frac{dx_1}{dt}=-8 \text{ cm/s}$$

$$\frac{dy}{dt}=v_i=2$$

From (i): $\frac{dy}{dt}=\left(\frac{y}{x_2}\right)^2\frac{dx_1}{dt}$

$$\Rightarrow v_i-2=\left(\frac{5}{10}\right)^2(-8) \Rightarrow v_i=0$$

383 **(8)**

When object is placed perpendicular to the principal axis, image size $=m\times$(object size)

Or $4=m\times 2 \Rightarrow m=2$

When object is placed along principal axis,

Image size $=m^2$(object size)$=4\times 2=8$ mm