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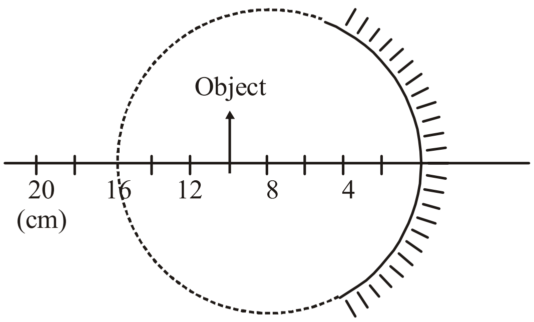
Ray Optics and Optical Instruments

TOPIC 1 Plane Mirror, Spherical Mirror and Reflection of Light

1. 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 from the mirror. If the object is moved with a speed of 9 cms^{-1}, the speed (in cms^{-1}) with which image moves at that instant is ________. **[NA Sep. 03, 2020 (II)]**

2.



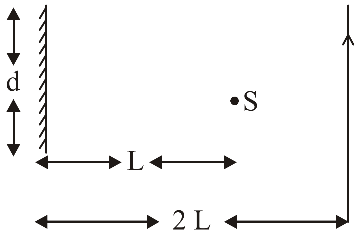
A spherical mirror is obtained as shown in the figure from a hollow glass sphere. If an object is positioned in front of the mirror, what will be the nature and magnification of the image of the object? (Figure drawn as schematic and not to scale) **[Sep. 02, 2020 (I)]**

(a) Inverted, real and magnified
(b) Erect, virtual and magnified
(c) Erect, virtual and unmagnified
(d) Inverted, real and unmagnified

3. A concave mirror for face viewing has focal length of 0.4 m. The distance at which you hold the mirror from your face in order to see your image upright with a magnification of 5 is: **[9 April 2019 I]**

(a) 0.24m (b) 1.60m (c) 0.32m (d) 0.16m

4. A point source of light, S is placed at a distance L in front of the centre of plane mirror of width d which is hanging vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror, at a distance 2L as shown below. The distance over which the man can see the image of the light source in the mirror is: **[12 Jan. 2019 I]**



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

5. Two plane mirrors are inclined to each other such that a ray of light incident on the first mirror (M_1) and parallel to the second mirror (M_2) is finally reflected from the second mirror (M_2) parallel to the first mirror (M_1). The angle between the two mirrors will be: **[9 Jan. 2019 II]**

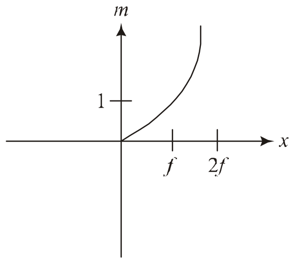
(a) 45° (b) 60°
(c) 75° (d) 90°

6. An object is gradually moving away from the focal point of a concave mirror along the axis of the mirror. The graphical representation of the magnitude of linear magnification (m) versus distance of the object from the mirror (x) is correctly given by

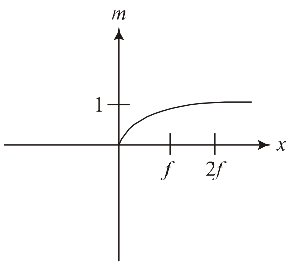
(Graphs are drawn schematically and are not to scale)

[8 Jan. 2020 II]

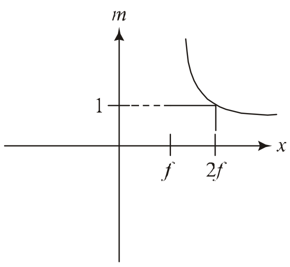
(a)



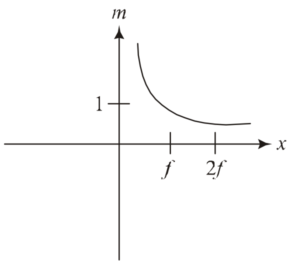
(b)



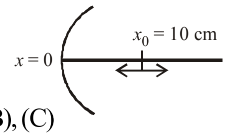
(c)



(d)



7. A particle is oscillating on the X-axis with an amplitude 2 cm about the point $x_0 = 10$ cm with a frequency ω. A concave mirror of focal length 5 cm is placed at the origin (see figure) Identify the correct statements: **[Online April 15, 2018]**
(A) The image executes periodic motion
(B) The image executes non-periodic motion
(C) The turning points of the image are asymmetric w.r.t the image of the point at $x = 10$ cm
(D) The distance between the turning points of the oscillation of the image is $\frac{100}{21}$



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

8. You are asked to design a shaving mirror assuming that a person keeps it 10 cm from his face and views the magnified image of the face at the closest comfortable distance of 25 cm. The radius of curvature of the mirror would then be : **[Online April 10, 2015]**
(a) 60 cm (b) –24 cm
(c) – 60 cm (d) 24 cm

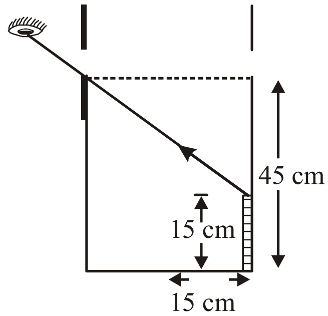
9. A car is fitted with a convex side-view mirror of focal length 20 cm. A second car 2.8 m behind the first car is overtaking the first car at a relative speed of 15 m/s. The speed of the image of the second car as seen in the mirror of the first one is : **[2011]**
(a) $\frac{1}{15}$ m/s (b) 10 m/s (c) 15 m/s (d) $\frac{1}{10}$ m/s

10. To get three images of a single object, one should have two plane mirrors at an angle of **[2003]**
(a) 60º (b) 90º (c) 120º (d) 30º

11. If two plane mirrors are kept at 60° to each other, then the number of images formed by them is **[2002]**
(a) 5 (b) 6 (c) 7 (d) 8

TOPIC 2 Refraction of Light at Plane Surface and Total Internal Reflection

12. An observer can see through a small hole on the side of a jar (radius 15 cm) at a point at height of 15 cm from the bottom (see figure). The hole is at a height of 45 cm. When the jar is filled with a liquid up to a height of 30 cm the same observer can see the edge at the bottom of the jar. If the refractive index of the liquid is $N/100$, where N is an integer, the value of N is __________. **[NA Sep. 03, 2020 (I)]**



13. A light ray enters a solid glass sphere of refractive index $\mu = \sqrt{3}$ at an angle of incidence 60°. The ray is both reflected and refracted at the farther surface of the sphere. The angle (in degrees) between the reflected and refracted rays at this surface is __________. **[NA Sep. 02, 2020 (II)]**

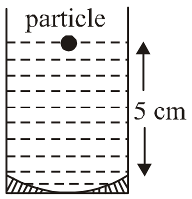
14. A vessel of depth 2h is half filled with a liquid of refractive index $2\sqrt{2}$ and the upper half with another liquid of refractive index $\sqrt{2}$. The liquids are immiscible. The apparent depth of the inner surface of the bottom of vessel will be: **[9 Jan. 2020 I]**
(a) $\frac{h}{\sqrt{2}}$ (b) $\frac{h}{2(\sqrt{2}+1)}$
(c) $\frac{h}{3\sqrt{2}}$ (d) $\frac{3}{4}h\sqrt{2}$

15. There is a small source of light at some depth below the surface of water (refractive index = $\frac{4}{3}$) in a tank of large cross sectional surface area. Neglecting any reflection from the bottom and absorption by water, percentage of light that emerges out of surface is (nearly):
[Use the fact that surface area of a spherical cap of height h and radius of curvature r is $2\pi rh$] **[9 Jan. 2020 II]**
(a) 21% (b) 34% (c) 17% (d) 50%

16. The critical angle of a medium for a specific wavelength, if the medium has relative permittivity 3 and relative permeability $\frac{4}{3}$ for this wavelength, will be: **[8 Jan. 2020 I]**

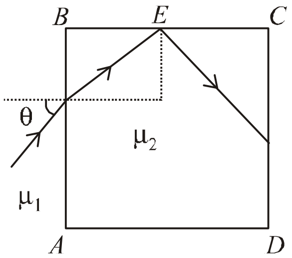
(a) 15° (b) 30°
(c) 45° (d) 60°

17. A concave mirror has radius of curvature of 40 cm. It is at the bottom of a glass that has water filled up to 5 cm (see figure). If a small partricle is floating on the surface of water, its image as seen, from directly above the glass, is at a distance d from the surface of water. The value of d is close to : **[12 Apr. 2019 I]**
(Refractive index of water = 1.33)



(a) 6.7 cm (b) 13.4 cm (c) 8.8 cm (d) 11.7 cm

18. A transparent cube of side d, made of a material of refractive index μ_2, is immersed in a liquid of refractive index $\mu_1 (\mu_1 < \mu_2)$. A ray is incident on the face AB at an angle θ (shown in the figure). Total internal reflection takes place at point E on the face BC.

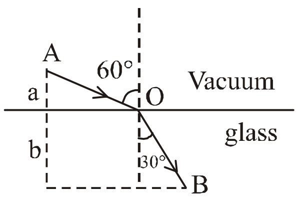


Then θ must satisfy : **[12 Apr. 2019 II]**

(a) $\theta < \sin^{-1}\frac{\mu_1}{\mu_2}$ (b) $\theta > \sin^{-1}\sqrt{\frac{\mu_2^2}{\mu_1^2}-1}$

(c) $\theta < \sin^{-1}\sqrt{\frac{\mu_2^2}{\mu_1^2}-1}$ (d) $\theta > \sin^{-1}\frac{\mu_1}{\mu_2}$

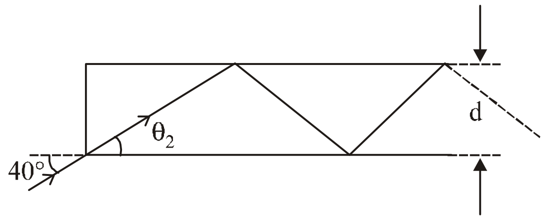
19. A ray of light AO in vacuum is incident on a glass slab at angle 60° and refracted at angle 30° along OB as shown in the figure. The optical path length of light ray from A to B is : **[10 Apr. 2019 I]**



(a) $\frac{2\sqrt{3}}{a} + 2b$ (b) $2a + \frac{2b}{3}$

(c) $2a + \frac{2b}{\sqrt{3}}$ (d) $2a + 2b$

20. In figure, the optical fiber is $l = 2$ m long and has a diameter of $d = 20$ μm. If a ray of light is incident on one end of the fiber at angle $\theta_1 = 40°$, the number of reflections it makes before emerging from the other end is close to :
(refractive index of fiber is 1.31 and sin 40° = 0.64)
[8 April 2019 I]



(a) 55000 (b) 66000 (c) 45000 (d) 57000

21. A light wave is incident normally on a glass slab of refractive index 1.5. If 4% of light gets reflected and the amplitude of the electric field of the incident light is 30 V/m, then the amplitude of the electric field for the wave propogating in the glass medium will be: **[12 Jan. 2019 I]**

(a) 30 V/m (b) 10 V/m
(c) 24 V/m (d) 6 V/m

22. Let the refractive index of a denser medium with respect to a rarer medium be n_{12} and its critical angle be θ_C. At an angle of incidence A when light is travelling from denser medium to rarer medium, a part of the light is reflected and the rest is refracted and the angle between reflected and refracted rays is 90°. Angle A is given by : **[Online April 8, 2017]**

(a) $\frac{1}{\cos^{-1}(\sin\theta_C)}$ (b) $\frac{1}{\tan^{-1}(\sin\theta_C)}$

(c) $\cos^{-1}(\sin\theta_C)$ (d) $\tan^{-1}(\sin\theta_C)$

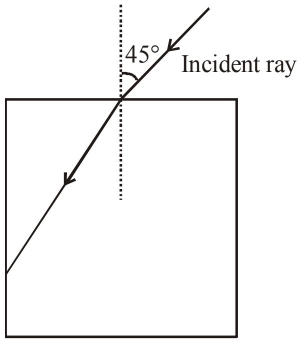
23. A diver looking up through the water sees the outside world contained in a circular horizon. The refractive index of water is $\frac{4}{3}$, and the diver's eyes are 15 cm below the surface of water. Then the radius of the circle is: **[Online April 9, 2014]**

(a) $15 \times 3 \times \sqrt{5}$ cm (b) $15 \times 3\sqrt{7}$ cm

(c) $\frac{15 \times \sqrt{7}}{3}$ cm (d) $\frac{15 \times 3}{\sqrt{7}}$ cm

24. A printed page is pressed by a glass of water. The refractive index of the glass and water is 1.5 and 1.33, respectively. If the thickness of the bottom of glass is 1 cm and depth of water is 5 cm, how much the page will appear to be shifted if viewed from the top ? **[Online April 25, 2013]**
(a) 1.033 cm (b) 3.581 cm
(c) 1.3533 cm (d) 1.90 cm

25. A light ray falls on a square glass slab as shown in the diagram. The index of refraction of the glass, if total internal reflection is to occur at the vertical face, is equal to : **[Online April 23, 2013]**



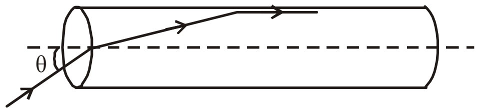
(a) $\frac{(\sqrt{2}+1)}{2}$ (b) $\sqrt{\frac{5}{2}}$ (c) $\frac{3}{2}$ (d) $\sqrt{\frac{3}{2}}$

26. Light is incident from a medium into air at two possible angles of incidence (A) 20° and (B) 40°. In the medium light travels 3.0 cm in 0.2 ns. The ray will : **[Online April 9, 2013]**
(a) suffer total internal reflection in both cases (A) and (B)
(b) suffer total internal reflection in case (B) only
(c) have partial reflection and partial transmission in case (B)
(d) have 100% transmission in case (A)

27. Let the x-z plane be the boundary between two transparent media. Medium 1 in $z \geq 0$ has a refractive index of $\sqrt{2}$ and medium 2 with $z < 0$ has a refractive index of $\sqrt{3}$. A ray of light in medium 1 given by the vector $\vec{A} = 6\sqrt{3}\hat{i} + 8\sqrt{3}\hat{j} - 10\hat{k}$ is incident on the plane of separation. The angle of refraction in medium 2 is: **[2011]**
(a) 45° (b) 60° (c) 75° (d) 30°

28. A beaker contains water up to a height h_1 and kerosene of height h_2 above water so that the total height of (water + kerosene) is $(h_1 + h_2)$. Refractive index of water is μ_1 and that of kerosene is μ_2. The apparent shift in the position of the bottom of the beaker when viewed from above is **[2011 RS]**
(a) $\left(1+\frac{1}{\mu_1}\right)h_1 - \left(1+\frac{1}{\mu_2}\right)h_2$
(b) $\left(1-\frac{1}{\mu_1}\right)h_1 + \left(1-\frac{1}{\mu_2}\right)h_2$
(c) $\left(1+\frac{1}{\mu_1}\right)h_2 - \left(1+\frac{1}{\mu_2}\right)h_1$
(d) $\left(1-\frac{1}{\mu_1}\right)h_2 + \left(1-\frac{1}{\mu_2}\right)h_1$

29. A transparent solid cylindrical rod has a refractive index of $\frac{2}{\sqrt{3}}$. It is surrounded by air. A light ray is incident at the mid-point of one end of the rod as shown in the figure.



The incident angle θ for which the light ray grazes along the wall of the rod is : **[2009]**
(a) $\sin^{-1}(\sqrt{3}/2)$ (b) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$
(c) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (d) $\sin^{-1}(1/2)$

30. A fish looking up through the water sees the outside world contained in a circular horizon. If the refractive index of water is $\frac{4}{3}$ and the fish is 12 cm below the surface, the radius of this circle in cm is **[2005]**
(a) $\frac{36}{\sqrt{7}}$ (b) $36\sqrt{7}$ (c) $4\sqrt{5}$ (d) $36\sqrt{5}$

31. Consider telecommunication through optical fibres. Which of the following statements is **not** true? **[2003]**
(a) Optical fibres can be of graded refractive index
(b) Optical fibres are subject to electromagnetic interference from outside
(c) Optical fibres have extremely low transmission loss
(d) Optical fibres may have homogeneous core with a suitable cladding.

32. Which of the following is used in optical fibres? **[2002]**
(a) total internal reflection (b) scattering
(c) diffraction (d) refraction.

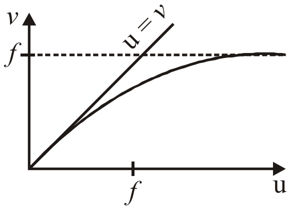
TOPIC 3 Refraction at Curved Surface Lenses and Power of Lens

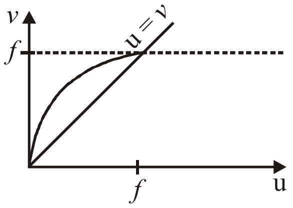
33. A point like object is placed at a distance of 1 m in front of a convex lens of focal length 0.5 m. A plane mirror is placed at a distance of 2 m behind the lens. The position and nature of the final image formed by the system is : **[Sep. 06, 2020 (I)]**
(a) 2.6 m from the mirror, real
(b) 1 m from the mirror, virtual
(c) 1 m from the mirror, real
(d) 2.6 m from the mirror, virtual

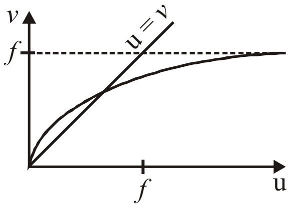
34. A double convex lens has power P and same radii of curvature R of both the surfaces. The radius of curvature of a surface of a plano-convex lens made of the same material with power 1.5 P is : **[Sep. 06, 2020 (II)]**

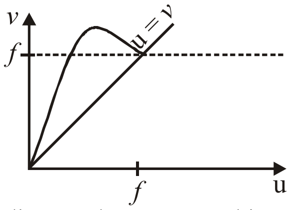
(a) $2R$ (b) $\frac{R}{2}$ (c) $\frac{3R}{2}$ (d) $\frac{R}{3}$

35. For a concave lens of focal length f, the relation between object and image distances u and v, respectively, from its pole can best be represented by ($u = v$ is the reference line) : **[Sep. 05, 2020 (I)]**

(a)


(b)


(c)


(d)


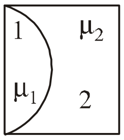
36. The distance between an object and a screen is 100 cm. A lens can produce real image of the object on the screen for two different positions between the screen and the object. The distance between these two positions is 40 cm. If the power of the lens is close to $\left(\frac{N}{100}\right)D$ where N is an integer, the value of N is __________. **[NA Sep. 04, 2020 (II)]**

37. A point object in air is in front of the curved surface of a *plano-convex* lens. The radius of curvature of the curved surface is 30 cm and the refractive index of the lens material is 1.5, then the focal length of the lens (in cm) is__________. **[NA 8 Jan. 2020 I]**

38. A thin lens made of glass (refractive index = 1.5) of focal length f = 16 cm is immersed in a liquid of refractive index 1.42. If its focal length in liquid is f_l, then the ratio f_l/f is closest to the integer: **[7 Jan. 2020 II]**

(a) 1 (b) 9 (c) 5 (d) 17

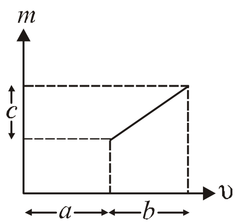
39. One plano-convex and one plano-concave lens of same radius of curvature 'R' but of different materials are joined side by side as shown in the figure. If the refractive index of the material of 1 is μ_1 and that of 2 is μ_2, then the focal length of the combination is : **[10 Apr. 2019 I]**



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

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

40. The graph shows how the magnification m produced by a thin lens varies with image distance v. What is the focal length of the lens used ? **[10 Apr. 2019 II]**

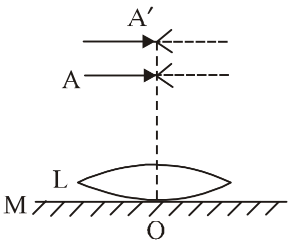


(a) $\frac{b^2}{ac}$ (b) $\frac{b^2c}{a}$ (c) $\frac{a}{c}$ (d) $\frac{b}{c}$

41. A convex lens of focal length 20 cm produces images of the same magnification 2 when an object is kept at two distances x_1 and x_2 ($x_1 > x_2$) from the lens. The ratio of x_1 and x_2 is: **[9 Apr. 2019 II]**

(a) 2 : 1 (b) 3 : 1 (c) 5 : 3 (d) 4 : 3

42. A thin convex lens L (refractive index = 1.5) is placed on a plane mirror M. When a pin is placed at A, such that OA = 18 cm, its real inverted image is formed at A itself, as shown in figure. When a liquid of refractive index μ_l is put between the lens and the mirror, the pin has to be moved to A', such that OA' = 27 cm, to get its inverted real image at A' itself. The value of μ_l will be: **[9 Apr. 2019 II]**

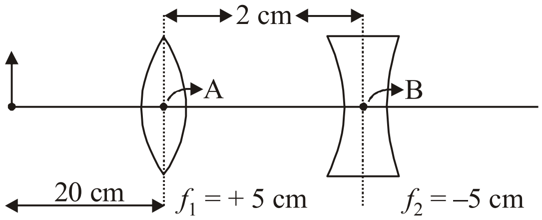


(a) $\frac{4}{3}$ (b) $\frac{3}{2}$ (c) $\sqrt{3}$ (d) $\sqrt{2}$

43. An upright object is placed at a distance of 40 cm in front of a convergent lens of focal length 20 cm. A convergent mirror of focal length 10 cm is placed at a distance of 60 cm on the other side of the lens. The position and size of the final image will be : **[8 April 2019 I]**
(a) 20 cm from the convergent mirror, same size as the object
(b) 40 cm from the convergent mirror, same size as the object
(c) 40 cm from the convergent lens, twice the size of the object
(d) 20 cm from the convergent mirror, twice the size of the object

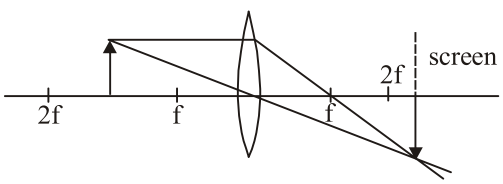
44. A convex lens (of focal length 20 cm) and a concave mirror, having their principal axes along the same lines, are kept 80 cm apart from each other. The concave mirror is to the right of the convex lens. When an object is kept at a distance of 30 cm to the left of the convex lens, its image remains at the same position even if the concave mirror is removed. The maximum distance of the object for which this concave mirror, by itself would produce a virtual image would be : **[8 Apr. 2019 II]**
(a) 30 cm (b) 25 cm (c) 10 cm (d) 20 cm

45. What is the position and nature of image formed by lens combination shown in figure? (f_1, f_2 are focal lengths) **[12 Jan. 2019 I]**



(a) 70 cm from point B at left; virtual
(b) 40 cm from point B at right; real
(c) $\frac{20}{3}$ cm from point B at right, real
(d) 70 cm from point B at right; real

46. Formation of real image using a biconvex lens is shown below : **[12 Jan. 2019 II]**



If the whole set up is immersed in water without disturbing the object and the screen positions, what will one observe on the screen ?
(a) Image disappears (b) Magnified image
(c) Erect real image (d) No change

47. A plano-convex lens (focal length f_2, refractive index μ_2, radius of curvature R) fits exactly into a plano-concave lens (focal length f_1, refractive index μ_1, radius of curvature R). Their plane surfaces are parallel to each other. Then, the focal length of the combination will be : **[12 Jan. 2019 II]**
(a) $f_1 - f_2$ (b) $\frac{R}{\mu_2 - \mu_1}$
(c) $\frac{2f_1 f_2}{f_1 + f_2}$ (d) $f_1 + f_2$

48. An object is at a distance of 20 m from a convex lens of focal length 0.3 m. The lens forms an image of the object. If the object moves away from the lens at a speed of 5m/s, the speed and direction of the image will be : **[11 Jan. 2019 I]**
(a) 2.26×10^{-3} m/s away from the lens
(b) 0.92×10^{-3} m/s away from the lens
(c) 3.22×10^{-3} m/s towards the lens
(d) 1.16×10^{-3} m/s towards the lens

49. A plano convex lens of refractive index μ_1 and focal length f_1 is kept in contact with another plano concave lens of refractive index μ_2 and focal length f_2 If the radius of curvature of their spherical faces is R each and $f_1 = 2f_2$, then μ_1 and μ_2 are related as: **[10 Jan. 2019 I]**
(a) $\mu_1 + \mu_2 = 3$ (b) $2\mu_1 - \mu_2 = 1$
(c) $3\mu_2 - 2\mu_1 = 1$ (d) $2\mu_2 - \mu_1 = 1$

50. The eye can be regarded as a single refracting surface. The radius of curvature of this surface is equal to that of cornea (7.8 mm). This surface separates two media of refractive indices 1 and 1.34. Calculate the distance from the refracting surface at which a parallel beam of light will come to focus. **[10 Jan. 2019 II]**
(a) 1 cm (b) 2 cm
(c) 4.0 cm (d) 3.1 cm

51. A convex lens is put 10 cm from a light source and it makes a sharp image on a screen, kept 10 cm from the lens. Now a glass block (refractive index 1.5) of 1.5 cm thickness is placed in contact with the light source. To get the sharp image again, the screem is shifted by a distance d. Then d is: **[9 Jan. 2019 I]**
(a) 1.1 cm away from the lens
(b) 0
(c) 0.55 cm towards the lens
(d) 0.55 cm away from the lens

52. A planoconvex lens becomes an optical system of 28 cm focal length when its plane surface is silvered and illuminated from left to right as shown in Fig-A. If the same lens is instead silvered on the curved surface and illuminated from other side as in Fig. B, it acts like an optical system of focal length 10 cm. The refractive index of the material of lens if: **[Online April 15, 2018]**

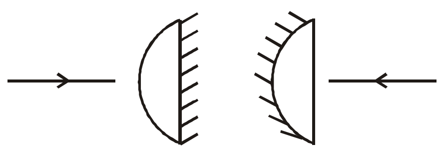


Fig. A Fig. B

(a) 1.50 (b) 1.55 (c) 1.75 (d) 1.51

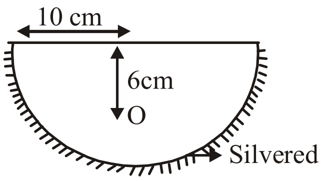
53. A convergent doublet of separated lenses, corrected for spherical aberration, has resultant focal length of 10cm. The separation between the two lenses is 2cm. The focal lengths of the component lenses **[Online April 15, 2018]**

(a) 18cm, 20cm (b) 10cm, 12cm
(c) 12cm, 14cm (d) 16cm, 18cm

54. In an experiment a convex lens of focal length 15 cm is placed coaxially on an optical bench in front of a convex mirror at a distance of 5 cm from it. It is found that an object and its image coincide, if the object is placed at a distance of 20 cm from the lens. The focal length of the convex mirror is : **[Online April 9, 2017]**

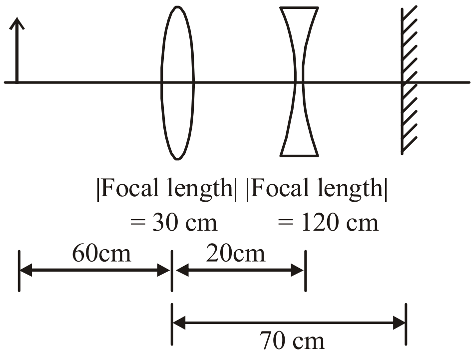
(a) 27.5 cm (b) 20.0 cm (c) 25.0 cm (d) 30.5 cm

55. A hemispherical glass body of radius 10 cm and refractive index 1.5 is silvered on its curved surface. A small air bubble is 6 cm below the flat surface inside it along the axis. The position of the iamge of the air bubble made by the mirror is seen : **[Online April 10, 2016]**



(a) 14 cm below flat surface
(b) 20 cm below flat surface
(c) 16 cm below flat surface
(d) 30 cm below flat surface

56. A convex lens, of focal length 30 cm, a concave lens of focal length 120 cm, and a plane mirror are arranged as shown. For an object kept at a distance of 60 cm from the convex lens, the final image, formed by the combination, is a real image, at a distance of : **[Online April 9, 2016]**



(a) 60 cm from the convex lens
(b) 60 cm from the concave lens
(c) 70 cm from the convex lens
(d) 70 cm from the concave lens

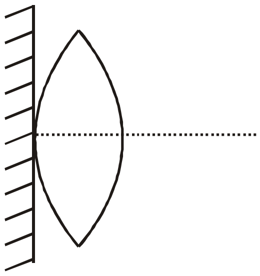
57. To find the focal length of a convex mirror, a student records the following data : **[Online April 9, 2016]**

Object Pin	Convex Lens	Convex Mirror	Image Pin
22.2cm	32.2cm	45.8cm	71.2cm

The focal length of the convex lens is f_1 and that of mirror is f_2. Then taking index correction to be negligibly small, f_1 and f_2 are close to :

(a) $f_1 = 7.8$ cm $f_2 = 12.7$ cm
(b) $f_1 = 12.7$ cm $f_2 = 7.8$ cm
(c) $f_1 = 15.6$ cm $f_2 = 25.4$ cm
(d) $f_1 = 7.8$ cm $f_2 = 25.4$ cm

58. A thin convex lens of focal length 'f' is put on a plane mirror as shown in the figure. When an object is kept at a distance 'a' from the lens - mirror combination, its image is formed at a distance $\frac{a}{3}$ in front of the combination. The value of 'a' is : **[Online April 11, 2015]**

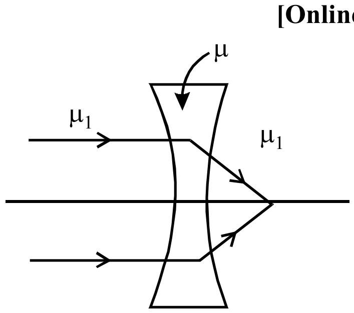


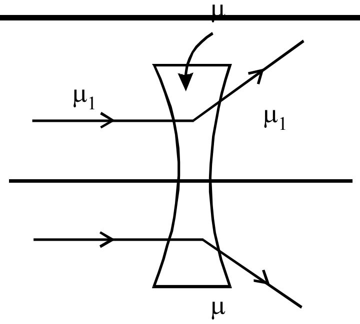
(a) 3f (b) $\frac{3}{2}$f (c) f (d) 2f

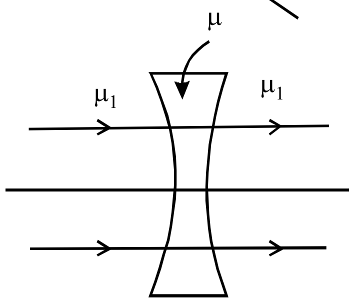
59. A thin convex lens made from crown glass $\left(\mu = \frac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\frac{4}{3}$ and $\frac{5}{3}$, it has the focal lengths f_1 and f_2 respectively. The correct relation between the focal lengths is: **[2014]**

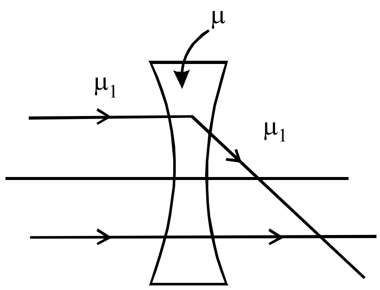
(a) $f_1 = f_2 < f$
(b) $f_1 > f$ and f_2 becomes negative
(c) $f_2 > f$ and f_1 becomes negative
(d) f_1 and f_2 both become negative

60. The refractive index of the material of a concave lens is μ. It is immersed in a medium of refractive index μ_1. A parallel beam of light is incident on the lens. The path of the emergent rays when $\mu_1 > \mu$ is: **[Online April 12, 2014]**

(a)


(b)


(c)


(d)


61. An object is located in a fixed position in front of a screen. Sharp image is obtained on the screen for two positions of a thin lens separated by 10 cm. The size of the images in two situations are in the ratio 3 : 3. What is the distance between the screen and the object? **[Online April 11, 2014]**

(a) 124.5 cm (b) 144.5 cm
(c) 65.0 cm (d) 99.0 cm

62. Diameter of a plano-convex lens is 6 cm and thickness at the centre is 3 mm. If speed of light in material of lens is 2×10^8 m/s, the focal length of the lens is **[2013]**

(a) 15 cm (b) 20 cm (c) 30 cm (d) 10 cm

63. The image of an illuminated square is obtained on a screen with the help of a converging lens. The distance of the square from the lens is 40 cm. The area of the image is 9 times that of the square. The focal length of the lens is : **[Online April 22, 2013]**

(a) 36 cm (b) 27 cm (c) 60 cm (d) 30 cm

64. An object at 2.4 m in front of a lens forms a sharp image on a film 12 cm behind the lens. A glass plate 1 cm thick, of refractive index 1.50 is interposed between lens and film with its plane faces parallel to film. At what distance (from lens) should object shifted to be in sharp focus of film? **[2012]**

(a) 7.2 m (b) 2.4 m (c) 3.2 m (d) 5.6 m

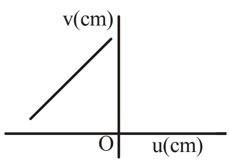
65. When monochromatic red light is used instead of blue light in a convex lens, its focal length will **[2011 RS]**

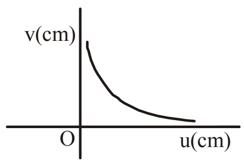
(a) increase
(b) decrease
(c) remain same
(d) does not depend on colour of light

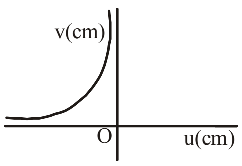
66. In an optics experiment, with the position of the object fixed, a student varies the position of a convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be **[2009]**

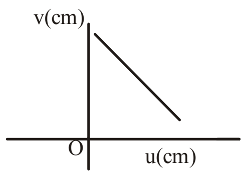
(a) $\left(\frac{f}{2}, \frac{f}{2}\right)$ (b) (f, f)
(c) $(4f, 4f)$ (d) $(2f, 2f)$

67. A student measures the focal length of a convex lens by putting an object pin at a distance 'u' from the lens and measuring the distance 'v' of the image pin. The graph between 'u' and 'v' plotted by the student should look like **[2008]**

(a)


(b)


(c)


(d)


68. Two lenses of power –15 D and +5 D are in contact with each other. The focal length of the combination is **[2007]**

(a) + 10 cm (b) – 20 cm
(c) – 10 cm (d) + 20 cm

69. A thin glass (refractive index 1.5) lens has optical power of – 5 D in air. Its optical power in a liquid medium with refractive index 1.6 will be **[2005]**

(a) – 1D (b) 1D (c) – 25D (d) 25D

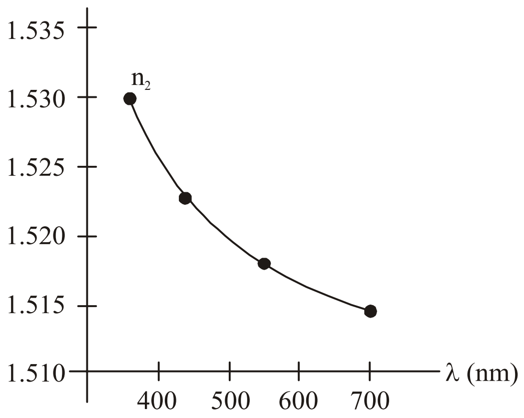
70. A plano convex lens of refractive index 1.5 and radius of curvature 30 cm. Is silvered at the curved surface. Now this lens has been used to form the image of an object. At what distance from this lens an object be placed in order to have a real image of size of the object **[2004]**

(a) 60 cm (b) 30 cm (c) 20 cm (d) 80 cm

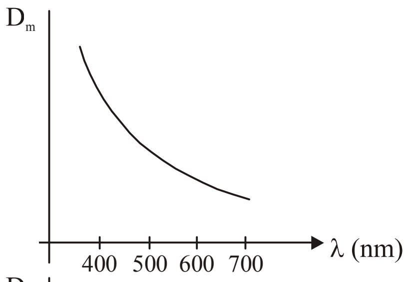
TOPIC 4 Prism and Dispersion of Light

71. The surface of a metal is illuminated alternately with photons of energies $E_1 = 4$ eV and $E_2 = 2.5$ eV respectively. The ratio of maximum speeds of the photoelectrons emitted in the two cases is 2. The work function of the metal in (eV) is ________________. **[NA Sep. 05, 2020 (II)]**

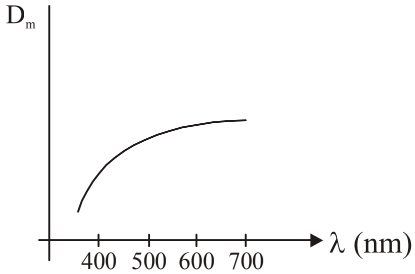
72. The variation of refractive index of a crown glass thin prism with wavelength of the incident light is shown. Which of the following graphs is the correct one, if D_m is the angle of minimum deviation ? **[11 Jan. 2019, I]**



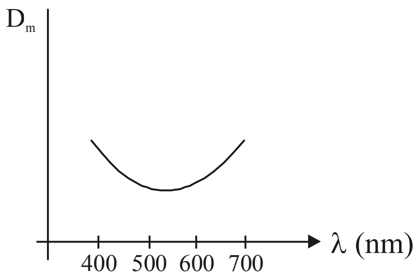
(a)



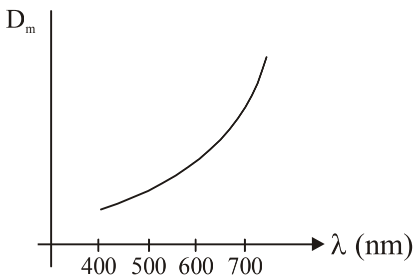
(b)



(c)



(d)



73. A monochromatic light is incident at a certain angle on an equilateral triangular prism and suffers minimum deviation. If the refractive index of the material of the prism is $\sqrt{3}$, then the angle of incidence is : **[11 Jan. 2019 II]**

(a) 90° (b) 30°
(c) 60° (d) 45°

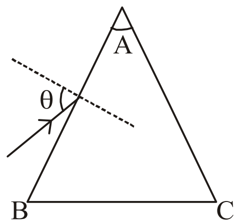
74. A ray of light is incident at an angle of 60° on one face of a prism of angle 30°. The emergent ray of light makes an angle of 30° with incident ray. The angle made by the emergent ray with second face of prism will be: **[Online April 16, 2018]**

(a) 30° (b) 90° (c) 0° (d) 45°

75. In an experiment for determination of refractive index of glass of a prism by $i - \delta$, plot it was found thata ray incident at angle 35°, suffers a deviation of 40° and that it emerges at angle 79°. In that case which of the following is closest to the maximum possible value of the refractive index? **[2016]**

(a) 1.7 (b) 1.8 (c) 1.5 (d) 1.6

76. Monochromatic light is incident on a glass prism of angle A. If the refractive index of the material of the prism is μ, a ray, incident at an angle θ, on the face AB would get transmitted through the face AC of the prism provided : **[2015]**



(a) $\theta > \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

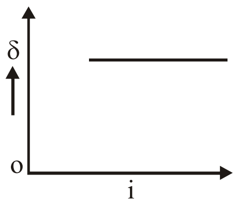
(b) $\theta < \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

(c) $\theta > \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

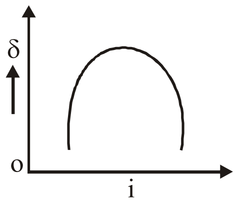
(d) $\theta < \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

77. The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by **[2013]**

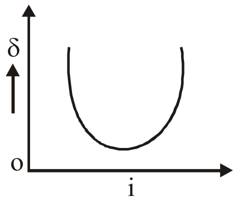
(a)



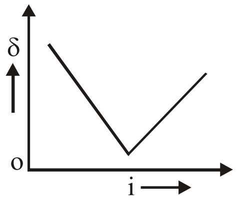
(b)



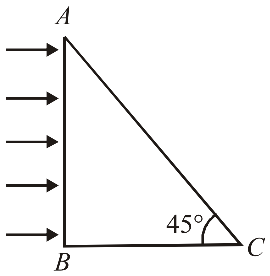
(c)



(d)

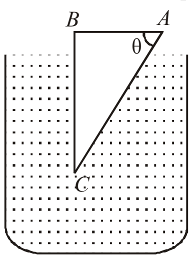


78. A beam of light consisting of red, green and blue colours is incident on a right-angled prism on face AB. The refractive indices of the material for the above red, green and blue colours are 1.39, 1.44 and 1.47 respectively. A person looking on surface AC of the prism will see **[Online May 26, 2012]**



(a) no light
(b) green and blue colours
(c) red and green colours
(d) red colour only

79. A glass prism of refractive index 1.5 is immersed in water (refractive index $\frac{4}{3}$) as shown in figure. A light beam incident normally on the face AB is totally reflected to reach the face BC, if **[Online May 19, 2012]**



(a) $\sin\theta > \frac{5}{9}$ (b) $\sin\theta > \frac{2}{3}$
(c) $\sin\theta > \frac{8}{9}$ (d) $\sin\theta > \frac{1}{3}$

80. Which of the following processes play a part in the formation of a rainbow? **[Online May 7, 2012]**

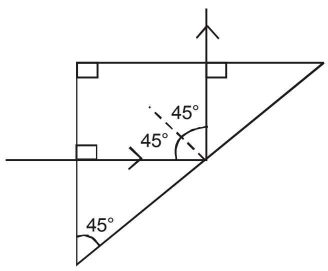
(i) Refraction (ii) Total internal reflection
(iii) Dispersion (iv) Interference

(a) (i), (ii) and (iii) (b) (i) and (ii)
(c) (i), (ii) and (iv) (d) (iii) and (iv)

81. The refractive index of a glass is 1.520 for red light and 1.525 for blue light. Let D_1 and D_2 be angles of minimum deviation for red and blue light respectively in a prism of this glass. Then, **[2006]**

(a) $D_1 < D_2$
(b) $D_1 = D_2$
(c) D_1 can be less than or greater than D_2 depending upon the angle of prism
(d) $D_1 > D_2$

82. A light ray is incident perpendicularly to one face of a 90° prism and is totally internally reflected at the glass-air interface. If the angle of reflection is 45°, we conclude that the refractive index n **[2004]**



(a) $n > \frac{1}{\sqrt{2}}$ (b) $n > \sqrt{2}$
(c) $n < \frac{1}{\sqrt{2}}$ (d) $n < \sqrt{2}$

TOPIC 5 Optical Instruments

83. A compound microscope consists of an objective lens of focal length 1 cm and an eye piece of focal length 5 cm with a separation of 10 cm.

The distance between an object and the objective lens, at which the strain on the eye is minimum is $\frac{n}{40}$ cm.

The value of n is ______. **[NA Sep. 05, 2020 (I)]**

84. In a compound microscope, the magnified virtual image is formed at a distance of 25 cm from the eye-piece. The focal length of its objective lens is 1 cm. If the magnification is 100 and the tube length of the microscope is 20 cm, then the focal length of the eye-piece lens (in cm) is ______. **[NA Sep. 04, 2020 (I)]**

85. The magnifying power of a telescope with tube length 60 cm is 5. What is the focal length of its eye piece? **[8 Jan. 2020 I]**

(a) 20 cm (b) 40 cm
(c) 30 cm (d) 10 cm

86. If we need a magnification of 375 from a compound microscope of tube length 150 mm and an objective of focal length 5 mm, the focal length of the eye-piece, should be close to: **[7 Jan. 2020 I]**

(a) 22mm (b) 12mm
(c) 2mm (d) 33mm

87. An observer looks at a distant tree of height 10 m with a telescope of magnifying power of 20. To the observer the tree appears : **[2016]**

(a) 20 times taller (b) 20 times nearer
(c) 10 times taller (d) 10 times nearer

88. To determine refractive index of glass slab using a travelling microscope, minimum number of readings required are : **[Online April 10, 2016]**

(a) Two (b) Four (c) Three (d) Five

89. A telescope has an objective lens of focal length 150 cm and an eyepiece of focal length 5 cm. If a 50 m tall tower at a distance of 1 km is observed through this telescope in normal setting, the angle formed by the image of the tower is θ, then θ is close to : **[Online April 10, 2015]**

(a) 30° (b) 15° (c) 60° (d) 1°

90. In a compound microscope, the focal length of objective lens is 1.2 cm and focal length of eye piece is 3.0 cm. When object is kept at 1.25 cm in front of objective, final image is formed at infinity. Magnifying power of the compound microscope should be: **[Online April 11, 2014]**

(a) 200 (b) 100
(c) 400 (d) 150

91. The focal lengths of objective lens and eye lens of a Galilean telescope are respectively 30 cm and 3.0 cm. telescope produces virtual, erect image of an object situated far away from it at least distance of distinct vision from the eye lens. In this condition, the magnifying power of the Galilean telescope should be: **[Online April 9, 2014]**

(a) +11.2 (b) –11.2 (c) –8.8 (d) +8.8

92. This question has Statement-1 and Statement-2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement 1: Very large size telescopes are reflecting telescopes instead of refracting telescopes.

Statement 2: It is easier to provide mechanical support to large size mirrors than large size lenses. **[Online April 23, 2013]**

(a) Statement-1 is true and Statement-2 is false.
(b) Statement-1 is false and Statement-2 is true.
(c) Statement-1 and statement-2 are true and Statement-2 is correct explanation for statement-1.
(d) Statements-1 and statement-2 are true and Statement-2 is not the correct explanation for statement-1.

93. The focal length of the objective and the eyepiece of a telescope are 50 cm and 5 cm respectively. If the telescope is focussed for distinct vision on a scale distant 2 m from its objective, then its magnifying power will be: **[Online April 22, 2013]**

(a) –4 (b) –8 (c) +8 (d) –2

94. A telescope of aperture 3×10^{-2} m diameter is focused on a window at 80 m distance fitted with a wire mesh of spacing 2×10^{-3} m. Given: $\lambda = 5.5 \times 10^{-7}$ m, which of the following is true for observing the mesh through the telescope? **[Online May 26, 2012]**

(a) Yes, it is possible with the same aperture size.
(b) Possible also with an aperture half the present diameter.
(c) No, it is not possible.
(d) Given data is not sufficient.

95. We wish to make a microscope with the help of two positive lenses both with a focal length of 20 mm each and the object is positioned 25 mm from the objective lens. How far apart the lenses should be so that the final image is formed at infinity? **[Online May 12, 2012]**

(a) 20mm (b) 100mm
(c) 120mm (d) 80mm

96. An experment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by **[2008]**

(a) a vernier scale provided on the microscope
(b) a standard laboratory scale
(c) a meter scale provided on the microscope
(d) a screw gauge provided on the microscope

97. The image formed by an objective of a compound microscope is **[2003]**

(a) virtual and diminished
(b) real and diminished
(c) real and enlarged
(d) virtual and enlarged

98. An astronomical telescope has a large aperture to **[2002]**

(a) reduce spherical aberration
(b) have high resolution
(c) increase span of observation
(d) have low dispersion

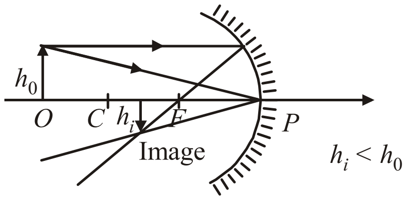
Hints & Solutions

1. **(1)**
Distance of object, $u = -30$ cm
Distance of image, $v = 10$ cm

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

Speed of image $= m^2 \times$ speed of object $= \frac{1}{9} \times 9 = 1 \text{ cm s}^{-1}$

2. **(d)** Object is placed beyond radius of curvature (R) of concave mirror hence image formed is real, inverted and diminished or unmagnified.



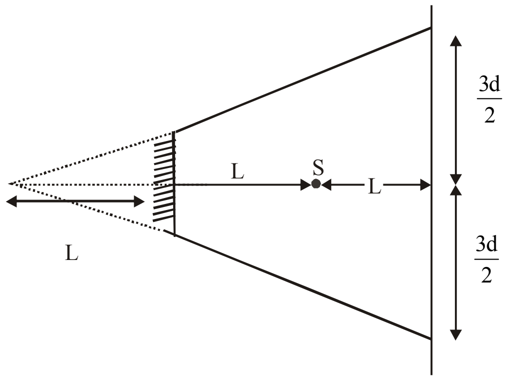
3. **(c)** $+5 = -\frac{v}{u} \Rightarrow v = -5u$

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

or $\frac{1}{-5u} + \frac{1}{u} = \frac{1}{0.4}$

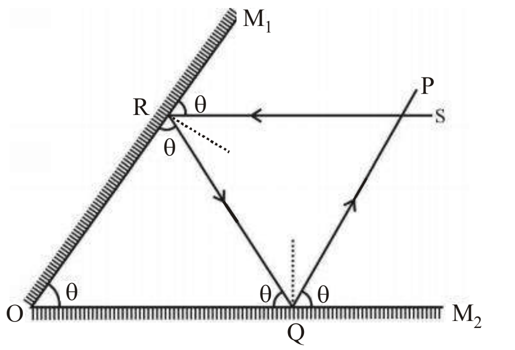
$\therefore$ u = 0.32 m

4. **(c)**



Total distance $= \frac{3d}{2} + \frac{3d}{2} = 3d$

5. **(b)**



Let angle between the two mirrors be θ.

Ray PQ || mirror M_1 and Rs || mirror M_2

$\therefore$ $M_1Rs = \angle ORQ = \angle M_1OM_2 = \theta$

Similarly, $\angle M_2QP = \angle OQR = \angle M_2OM_1 = \theta$

$\therefore$ In ΔORQ, $3\theta = 180° \Rightarrow \theta = \frac{180°}{3} = 60°$

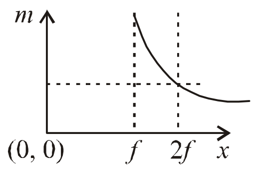
6. **(c)** Using mirror formula, magnification is given by

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

At focus magnification is ∞

And at $u = 2f$, magnification is 1.

Hence graph (d) correctly depicts 'm' versus distance of object 'x' graph.



7. **(c)** When object is at 8 cm

Image $V_1 = \frac{f \times u}{u - f} = \frac{5 \times 8}{8-5} = -\frac{40}{3}$ cm

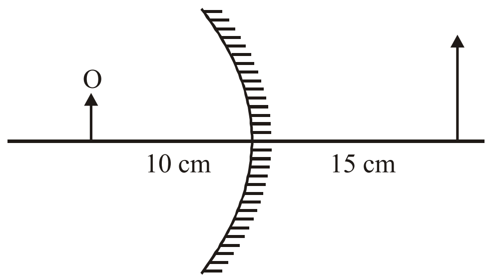
When object is at 12 cm

Image $V_2 = \frac{f \times u}{u - f} = \frac{5 \times 12}{12-5} = -\frac{60}{7}$ cm

Separation $= |V_1 - V_2| = \frac{40}{3} - \frac{60}{7} = \frac{100}{21}$ cm

So A, C and D are correct statements.

8. **(c)** Convex morror is used as a shaving mirror.



From question : $v = 15$ cm, $u = -10$ cm

Radius of curvature, $R = 2f = ?$

Using mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{15} + \frac{1}{(-10)} = \frac{1}{f} \Rightarrow f = -30$ cm

Therefore radius of curvature,

$R = 2f = -60$ cm

9. (a) From mirror formula

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

Differentiating the above equation, we get

$$\frac{dv}{dt}=-\frac{v^2}{u^2}\left(\frac{du}{dt}\right)$$

Also,

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

$$\Rightarrow \frac{dv}{dt}=-\left(\frac{f}{u-f}\right)^2\frac{du}{dt}$$

$$\Rightarrow \frac{dv}{dt}=\left(\frac{0.2}{2.8-0.2}\right)^2\times 15$$

$$\Rightarrow \frac{dv}{dt}=\frac{1}{15}\text{ m/s}$$

10. (b) The number of images formed is given by

$$n=\frac{360}{\theta}-1$$

$$\Rightarrow \frac{360}{\theta}-1=3$$

$$\Rightarrow \theta=\frac{360°}{4}=90°$$

11. (a) When two plane mirrors are inclined at each other at an angle θ then the number of the images (n) of a point object kept between the plane mirrors is

$$n=\frac{360°}{\theta}-1,$$

(if $\frac{360°}{\theta}$ is even integer)

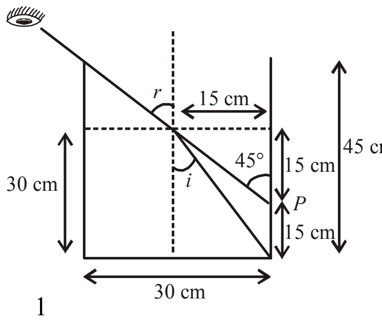
$\therefore$ Number of images formed $=\frac{360°}{60°}-1=5$

12. (158)

From figure, $\sin i=\frac{15}{\sqrt{15^2+30^2}}$ and $\sin r=\sin 45°$

From Snell's law, $\mu\times\sin i=1\times\sin r$

$$\Rightarrow \mu\times\frac{15}{\sqrt{15^2+30^2}}=1\times\sin 45°=\frac{1}{\sqrt{2}}$$

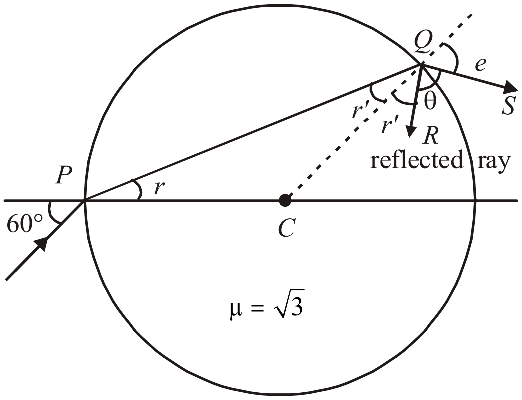


$$\therefore \mu=\frac{\frac{1}{\sqrt{2}}}{\frac{15}{\sqrt{1125}}}=158\times10^{-2}=\frac{N}{100}$$

Hence, value of $N\simeq 158$.

13. (90.00)

In the figure, QR is the reflected ray and QS is refracted ray. CQ is normal.



Apply Snell's law at P

$$1\sin 60°=\sqrt{3}\sin r$$

$$\Rightarrow \sin r=\frac{1}{2}\Rightarrow r=30°$$

From geometry, $CP=CQ$

$\therefore r'=30°$

Again apply snell's law at Q,

$$\sqrt{3}\sin r'=1\sin e$$

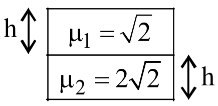
$$\Rightarrow \frac{\sqrt{3}}{2}=\sin e\Rightarrow e=60°$$

From geometry

$r'+\theta+e=180°$ (As angles lies on a straight line)

$$\Rightarrow 30°+\theta+60°=180°\Rightarrow\theta=90°.$$

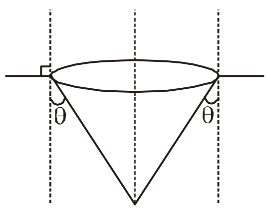
14. (d) Apparent depth,



$$D=\frac{t_1}{\mu_1}+\frac{t_2}{\mu_2}=\frac{h}{\sqrt{2}}+\frac{h}{2\sqrt{2}}=\frac{3h}{2\sqrt{2}}=\frac{3h\sqrt{2}}{4}$$

15. (c) Given,

Refractive index, $\mu=\frac{4}{3}$



$$\frac{4}{3}\sin\theta=1\sin 90°$$

$$\Rightarrow \sin\theta=\frac{3}{4}$$

$$\cos\theta=\frac{\sqrt{7}}{4}$$

Solid angle, $\Omega=2\pi(1-\cos\theta)=2\pi(1-\sqrt{7}/4)$

Fraction of energy transmitted

$= \frac{2\pi(1-\cos\theta)}{4\pi} = \frac{1-\sqrt{7}/4}{2} = 0.17$

Percentage of light emerges out of surface
$= 0.17 \times 100 = 17\%$

16. **(b)** Here, from question, relative permittivity

$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} = 3 \Rightarrow \varepsilon = 3\varepsilon_0$

Relative permeability $\mu_r = \frac{\mu}{\mu_0} = \frac{4}{3} \Rightarrow \mu = \frac{4}{3}\mu_0$

$\therefore \mu\varepsilon = 4\mu_0\varepsilon_0$

$\sqrt{\frac{\mu_0\varepsilon_0}{\mu\varepsilon}} = \frac{v}{c} = \frac{1}{2} \left(\because c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}\right)$

$n = \sqrt{\mu_r\varepsilon_r} = \sqrt{\frac{4}{3}\times 3} = 2$

And $n = \frac{1}{\sin\theta_c}$

$\Rightarrow \sin\theta_c = \frac{1}{n} = \frac{1}{2}$

$\therefore$ Critical angle, $\theta_c = 30°$

17. **(c)** If v is the distance of image formed by mirror, then

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

or $\frac{1}{v} + \frac{1}{-5} = \frac{1}{-20}$

$\therefore v = \frac{20}{3}$ cm

Distance of this image from water surface

$= \frac{20}{3} + 5 = \frac{35}{3}$ cm

Using, $\frac{RD}{AD} = \mu$

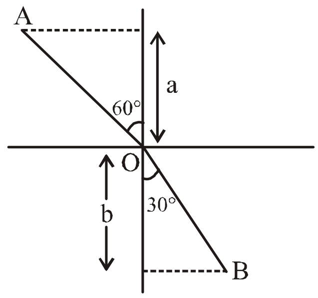
$\therefore AD = d = \frac{RD}{\mu} = \frac{(35/3)}{1.33} = 8.8$ cm

18. **(c)** Using, $\sin\theta_{max} = \mu_1\sqrt{\mu_2^2 - \mu_1^2} = \sqrt{\frac{\mu_2^2}{\mu_1^2} - 1}$

or $\theta_{max} = \sin^{-1}\left(\sqrt{\frac{\mu_2^2}{\mu_1^2} - 1}\right)$

For $T_1 R, \theta < \sin^{-1}\left(\sqrt{\frac{\mu_2^2}{\mu_1^2} - 1}\right)$

19. **(d)** From the given figure
As $\sin 60° = \mu \sin 30°$



$\Rightarrow \mu = \frac{\sin 60°}{\sin 30°} = \sqrt{3}$

$\frac{a}{AO} = \cos 60° \Rightarrow AO = 2a$

$\frac{b}{BO} = \cos 30° \Rightarrow BO = \frac{2b}{\sqrt{3}}$

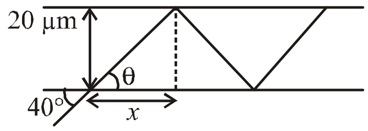
Optical path length = AO + μBO

$= 2a + (\sqrt{3})\frac{2b}{\sqrt{3}} = 2a + 2b$

20. **(d)** Using Snell's law of refraction,
$1 \times \sin 40° = 1.31 \sin\theta$

$\Rightarrow \sin\theta = \frac{0.64}{1.31} = 0.49 \approx 0.5$

$\Rightarrow \theta = 30°$



$x = 20\ \mu m \times \cot\theta$

$\therefore$ Number of reflections $= \frac{2}{20\times 10^{-6} \times \cot\theta}$

$= \frac{2\times 10^6}{20\times\sqrt{3}} = 57735 \approx 57000$

21. **(c)** As 4% of light gets reflected, so only (100 – 4 = 96%) of light comes after refraction so,

$P_{refracted} = \frac{96}{100}P_I$

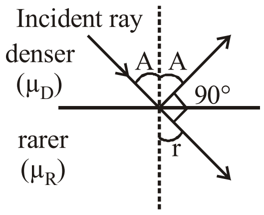
$\Rightarrow K_2A_t^2 = \frac{96}{100}K_1A_i^2$

$\Rightarrow r_2A_t^2 = \frac{96}{100}r_1A_i^2$

$\Rightarrow A_t^2 = \frac{96}{100} \times \frac{1}{\frac{3}{2}} \times (30)^2$

$A_t \sqrt{\frac{64}{100} \times (30)^2} = 24$

22. (d)



From Snell's law, $\dfrac{\mu_R}{\mu_D} = \dfrac{\sin i}{\sin r}$ ..... (i)

$\because \angle i = A$ and $\angle r = (90° - A)$

We also know that, $\sin\theta_C = \dfrac{\mu_R}{\mu_D}$

From eq^n (i), $\sin\theta_C = \dfrac{\sin A}{\sin(90° - A)}$

$$\sin\theta_C = \frac{\sin A}{\cos A}$$

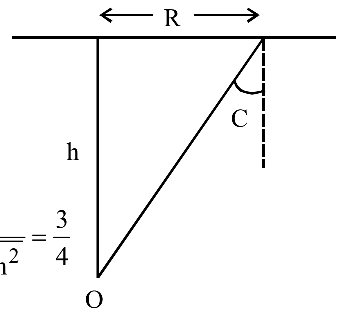
$$\sin\theta_C = \tan A$$

or $\quad A = \tan^{-1}(\sin\theta_C)$

23. (d) Given, $\mu = \dfrac{4}{3}$

$h = 15$ cm

$R = ?$



$$\frac{\sin 90°}{\sin C} = \mu$$

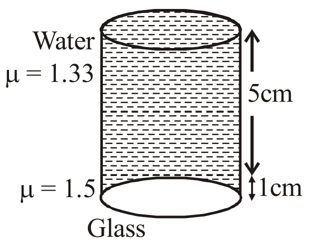
$\Rightarrow \quad \sin C = \dfrac{1}{\mu} = \dfrac{R}{\sqrt{R^2 + h^2}} = \dfrac{3}{4}$

$\Rightarrow \quad 16R^2 = 9R^2 + 9h^2$

or, $\quad 7R^2 = 9h^2$

or, $\quad R = \dfrac{3}{\sqrt{7}} h = \dfrac{3}{\sqrt{7}} \times 15\,\text{cm}$

24. (c) Real depth = 5 cm + 1cm = 6 cm



Apparent depth $= \dfrac{d_1}{\mu_1} + \dfrac{d_2}{\mu_2} + ...$

$= \dfrac{5}{1.33} + \dfrac{1}{1.5}$

$\simeq 3.8 + 0.7 \simeq 4.5$ cm

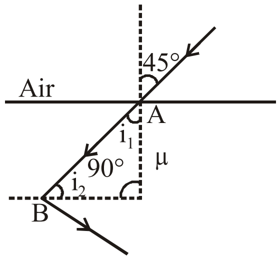
$\therefore$ Shift = 6 cm – 4.5 cm $\cong$ 1.5 cm

25. (d) At point A by Snell's law

$\mu = \dfrac{\sin 45°}{\sin r} \Rightarrow \sin r = \dfrac{1}{\mu\sqrt{2}}$ ...(i)

At point B, for total internal reflection,

$\sin i_1 = \dfrac{1}{\mu}$



From figure, $i_1 = 90° - r$

$\therefore \quad (\sin 90° - r) = \dfrac{1}{\mu}$

$\Rightarrow \cos r = \dfrac{1}{\mu}$ ...(ii)

Now $\cos r = \sqrt{1 - \sin^2 r} = \sqrt{1 - \dfrac{1}{2\mu^2}}$

$= \sqrt{\dfrac{2\mu^2 - 1}{2\mu^2}}$ ...(iii)

From eqs (ii) and (iii)

$$\frac{1}{\mu} = \sqrt{\frac{2\mu^2 - 1}{2\mu^2}}$$

Squaring both sides and then solving, we get

$$\mu = \sqrt{\frac{3}{2}}$$

26. (b) Velocity of light in medium

$$V_{med} = \frac{3\,\text{cm}}{0.2\,\text{ns}} = \frac{3 \times 10^{-2}\,\text{m}}{0.2 \times 10^{-9}\,\text{s}} = 1.5\,\text{m/s}$$

Refractive index of the medium

$$\mu = \frac{V_{air}}{V_{med}} = \frac{3 \times 10^8}{1.5} = 2\,\text{m/s}$$

As $\mu = \dfrac{1}{\sin C}$

$\therefore \sin C = \dfrac{1}{\mu} = \dfrac{1}{2} = 30°$

Condition of TIR is angle of incidence i must be greater than critical angle. Hence ray will suffer TIR in case of (B) $(i = 40° > 30°)$ only.

27. (a) As refractive index for $z > 0$ and $z \leq 0$ is different xy plane should be the boundry between two media.

Angle of incidence is given by

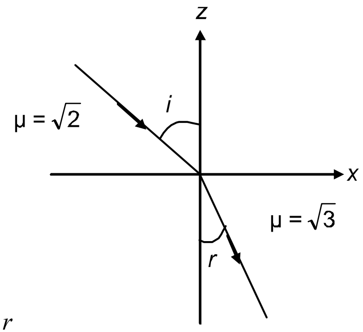
$$\cos(\pi - i) = \frac{\left(6\sqrt{3}\hat{i} + 8\sqrt{3}\hat{j} - 10\hat{k}\right).\hat{k}}{20}$$

$$-\cos i = -\frac{1}{2}$$

$$\Rightarrow \angle i = 60°$$

From Snell's law,

$$\frac{\sin i}{\sin r} = \frac{u_2}{u_1}$$



$$\Rightarrow \frac{\sin i}{\sin r} = \frac{\sqrt{3}}{\sqrt{2}}$$

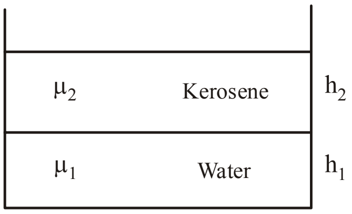
$$\Rightarrow \sqrt{2}\sin i = \sqrt{3}\sin r$$

$$\Rightarrow \sqrt{2}\ \sin 60° = \sqrt{3}$$

$$\Rightarrow \sqrt{2} \times \frac{\sqrt{3}}{2} = \sqrt{3}\sin r$$

$$\Rightarrow \angle r = 45°$$

28. (b)



Apparent shift of the bottom due to water,

$$\Delta h_1 = h_1\left[1 - \frac{1}{\mu_1}\right]$$

Apparent shift of the bottom due to kerosene, Δh_2

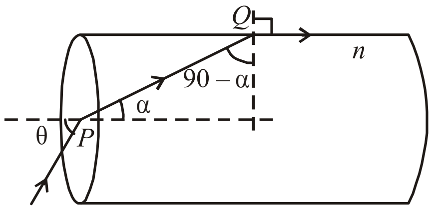
$$= h_2\left[1 - \frac{1}{\mu_2}\right]$$

Thus, total apparent shift :

$$= \Delta h_1 + \Delta h_2$$

$$= h_1\left(1 - \frac{1}{\mu_1}\right) + h_2\left(1 - \frac{1}{\mu_2}\right)$$

29. (c)



Applying Snell's law

for medium inside the cylinder and air at Q we get

$$n = \frac{\sin 90°}{\sin(90° - \alpha)} = \frac{1}{\cos\alpha}$$

$$\therefore\ \cos\alpha = \frac{1}{n}$$

$$\therefore\ \sin\alpha = \sqrt{1 - \cos^2\alpha} = \sqrt{1 - \frac{1}{n^2}} = \frac{\sqrt{n^2 - 1}}{n} \quad ...(i)$$

Applying Snell's Law for air and medium inside the cylinder at P we get

$$n = \frac{\sin\theta}{\sin\alpha}$$

$$\Rightarrow \sin\theta = n \times \sin\alpha = \sqrt{n^2 - 1};\ \text{[from (i)]}$$

$$\therefore\ \sin\theta = \sqrt{\left(\frac{2}{\sqrt{3}}\right)^2 - 1} = \sqrt{\frac{4}{3} - 1} = \frac{1}{\sqrt{3}}$$

or $\quad \theta = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

30. (a) From the figure it is clear that

$$\tan\theta_c = \frac{AB}{OA}$$

$$\Rightarrow R = OA\tan\theta_c$$

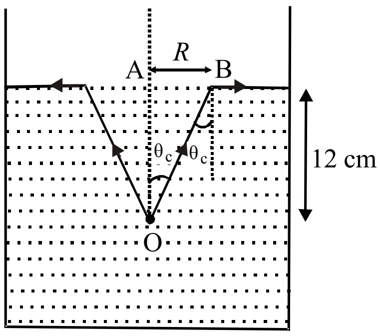
$$\Rightarrow R = \frac{OA\sin\theta_c}{\cos\theta_c}$$

$$\Rightarrow R = \frac{OA\sin\theta_c}{\sqrt{1 - \sin^2\theta_c}}$$

$$\Rightarrow \tan\theta_c = \frac{R}{12} = \frac{\sin\theta_c}{\sqrt{1 - \sin^2\theta_c}}$$

$$\because \sin\theta_c = \frac{1}{\mu} = \frac{3}{4}$$

$$\Rightarrow \tan\theta_c = \frac{3}{\sqrt{16 - 9}} = \frac{3}{\sqrt{7}} = \frac{R}{12}$$



$$\Rightarrow R = \frac{36}{\sqrt{7}}\ \text{cm}$$

31. (b) Optical fibres form a dielectric wave guide and are free from electromagnetic interference or radio frequency interference. There is extremely low transmission loss in optical fibre.

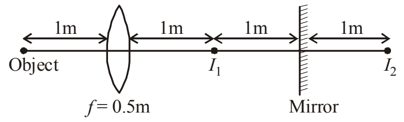
32. (a) In an optical fibre, light is sent through the fibre without any loss by the phenomenon of total internal reflection. Total internal reflection of light waves confine the light rays inside the optical fiber.

33. (d) Focal length of the convex lens, $f = 0.5$ m

Object is at $2f$ so, image (I_1) will also be at $2f$.

Image of I_1 i.e., I_2 will be 1 m behind mirror.

Now I_2 will be object for lens.



$\therefore u = (-1)+(-1)+(-1) = -3$ m

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

$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{+0.5} + \frac{1}{-3}$ or $v = \frac{3}{5} = 0.6$ m

Hence, distance of image from mirror $= 2 + 0.6 = 2.6$ m and real.

34. **(d)** Given, using lens maker's formula

$$\frac{1}{f} = (k-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Here, $R_1 = R_2 = R$ (For double convex lens)

$$\therefore \frac{1}{f} = (\mu - 1)\left(\frac{1}{R} - \frac{1}{-R}\right)$$

$$\Rightarrow P = \frac{1}{f} = (\mu - 1)\frac{2}{R} \quad ...(i)$$

For plano convex lens,

$R_1 = R'$, $R_2 = \infty$

Using lens maker's formula again, we have

$$1.5P = (\mu - 1)\left(\frac{1}{R'} - \frac{1}{\infty}\right) \quad ...(ii)$$

$$\Rightarrow \frac{3}{2}P = \frac{\mu - 1}{R'}$$

From (i) and (ii),

$$\frac{3}{2} = \frac{R'}{2R} \Rightarrow R' = \frac{R}{3}$$

35. **(d)** From lens formula,

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

Case-I : If $v = u \Rightarrow f + u = f \Rightarrow u = 0$

Case-II : If $u = \infty$ then $v = f$.

Hence, correct u versus v graph, that satisfies this condition is (a).

36. **(476.19)**

Given,

Distance between an object and screen, $D = 100$ cm

Distance between the two position of lens, $d = 40$ cm

Focal length of lens,

$$f = \frac{D^2 - d^2}{4D} = \frac{100^2 - 40^2}{4(100)} = \frac{(100+40)(100-40)}{4(100)} = 21 \text{ cm}$$

Power, $P = \frac{1}{f} = \frac{100}{21} = \frac{N}{100}$

$\therefore N = 476.19$.

37. **(60)** Given : $\mu = 1.5$; $R_{curved} = 30$ cm

Using, Lens-maker formula

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

For plano-convex lens

$R_1 \to \infty$ then $R_2 = -R$

$$\therefore f = \frac{R}{\mu - 1} = \frac{30}{1.5 - 1} = 60 \text{ cm}$$

38. **(b)** Using lens maker's formula

$$\frac{1}{f} = \left(\frac{\mu_g}{\mu_a} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

Here, μ_g and μ_a are the refractive index of glass and air respectively

$$\Rightarrow \frac{1}{f} = (1.5 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(i)$$

When immersed in liquid

$$\frac{1}{f_l} = \left(\frac{\mu_g}{\mu_l} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

[Here, μ_l = refractive index of liquid]

$$\Rightarrow \frac{1}{f_l} = \left(\frac{1.5}{1.42} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(ii)$$

Dividing (i) by (ii)

$$\Rightarrow \frac{f_l}{f} = \frac{(1.5-1)1.42}{0.08} = \frac{1.42}{0.16} = \frac{142}{16} \approx 9$$

39. **(a)** Focal length of plano-convex lens-

$$\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{-R}\right) = \frac{\mu_1 - 1}{R}$$

$$\Rightarrow f_1 = \frac{R}{(\mu_1 - 1)}$$

Focal length of plano-concave lens -

$$\frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{-R} - \frac{1}{\infty}\right) = \frac{\mu_2 - 1}{-R}$$

$$\Rightarrow f_2 = \frac{-R}{(\mu_2 - 1)}$$

For the combination of two lens-

$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{\mu_1 - 1}{R} - \frac{\mu_2 - 1}{R}$$

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

$\Rightarrow f_{eq} = \frac{R}{\mu_1 - \mu_2}$

40. (d) From the equation of line

$m = k_1 v + k_2 \quad (\because y = mx + c)$

$\Rightarrow \frac{v}{u} = k_1 v + k_2 \quad \left(\because m = \frac{v}{u}\right)$

$\Rightarrow \frac{1}{u} = k_1 + \frac{k_2}{v}$ (Dividing both sides by v)

$\Rightarrow \frac{k_2}{v} - \frac{1}{u} - k_1$

Comparing with lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, we get

$k_1 = \frac{1}{-f}$ and $k_2 = 1$

$\therefore f = \frac{1}{\text{slope of } m - v \text{ graph}} = -\frac{b}{c}$

41. (b) Using, $M = \frac{v}{u}$

or $-2 = \frac{v_1}{x_1} \Rightarrow v_1 = -2x_1$

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

or $\frac{1}{-2x_1} - \frac{1}{x_1} = \frac{1}{20}$

$x_1 = 30$ cm

And $\frac{1}{2x_2} - \frac{1}{x_2} = \frac{1}{20}$

or $x_2 = -10$ cm

So, $\frac{x_1}{x_2} = \frac{30}{10} = 3$

42. (a) $\frac{1}{f_1} = \frac{2}{f_\ell}$

Here $2f_1 = 18$ cm or $f_1 = 9$ cm

So, $\frac{1}{9} = \frac{2}{f_\ell}$ or $f_\ell = 18$ cm

Using, $\frac{1}{f_\ell} = (\mu - 1)\left(\frac{2}{R}\right)$

or $\frac{1}{18} = (1.5 - 1)\left(\frac{2}{R}\right)$

$\therefore R = 18$ cm

when liquid is put between, then

$\frac{1}{f_2} = \frac{2}{f_\ell} + \frac{2}{f}$

or $\frac{1}{(27/2)} = \frac{2}{18} + \frac{2}{f}$

or $f = -54$ cm

Now $-\frac{1}{54} = (\mu_1 - 1) \times \frac{1}{R}$

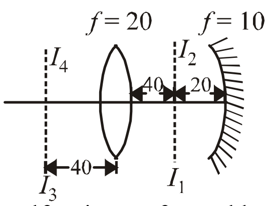
$= (\mu_1 - 1) \times \left(\frac{1}{-18}\right)$

$\therefore \mu_1 = \frac{1}{3} + 1 = \frac{4}{3}$

43. (Bouns) $v_1 = \frac{40 \times 20}{(40 - 20)} = 40\,cm$

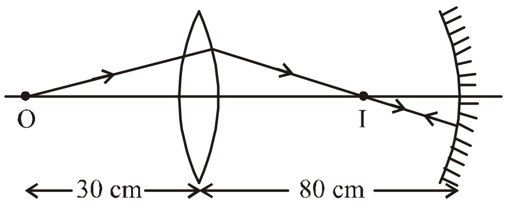
$u_2 = 60 - 40 = 20$ cm

$\therefore v_2 = \frac{20 \times 10}{(20 - 10)} = 20\,cm$



$\therefore$ Image traces back to object itself as image formed by lens is a centre of curvature of mirror.

44. (c) For lens



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

or $\frac{1}{v} - \frac{1}{-30} = \frac{1}{20}$

$\therefore \quad v = +60$ cm

According to the condition, image formed by lens should be the centre of curvature of the mirror, and so $2f' = 20$ or $f' = 10$ cm

45. (d) By lens's formula, $\frac{1}{V} - \frac{1}{u} = \frac{1}{f}$

For first lens, $[u_1 = -20]$

$\frac{1}{V_1} - \frac{1}{-20} = \frac{1}{5} \Rightarrow V_1 = \frac{20}{3}$

Image formed by first lense will behave as an object for second lens

so, $u_2 = \frac{20}{3} - 2 = \frac{14}{3}$

$\frac{1}{V_2} - \frac{1}{\frac{14}{3}} = \frac{1}{-5} \Rightarrow V_2 = 70\,\text{cm}$

46. **(a)** According to lens maker's formula,

$$\frac{1}{f}=(\mu_{rel}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Focal length of lens will change due to change in refrective index μ_{rel}. So, image will be formed at new position. Hence image disappears

47. **(b)** $\frac{1}{f_2}=(\mu_2-1)\left(\frac{+1}{R}\right)$

$$\frac{1}{f_1}=(\mu_1-1)\frac{(-1)}{R}$$

Now when combined the focal length is given by

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

$$=(\mu_1-1)\frac{(-1)}{R}+(\mu_2-1)\frac{+1}{R}$$

$$=\frac{1}{R}\left[\mu_2-\not{1}-\mu_1+\not{1}\right]$$

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

$$\Rightarrow\ f=\frac{R}{\mu_2-\mu_1}$$

48. **(d)** By lens formula

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

$$\frac{1}{v}-\frac{1}{(-20)}=\frac{10}{3}$$

$$\frac{1}{v}=\frac{10}{3}-\frac{1}{20}$$

$$\frac{1}{v}=\frac{197}{60};\ v=\frac{60}{197}$$

Magnification of lens (m) is given by

$$m=\left(\frac{v}{u}\right)=\frac{\left(\frac{60}{197}\right)}{20}$$

velocity of image wrt. to lens is given by

$v_{I/L}=m^2 v_{O/L}$

direction of velocity of image is same as that of object

$v_{O/L}=5$ m/s

$$v_{I/L}=\left(\frac{60\times 1}{197\times 20}\right)^2(5)$$

$=1.16\times 10^{-3}$ m/s towards the lens

49. **(b)** From lens maker's formula,

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

$$\frac{1}{f_1}=(\mu_1-1)\left(\frac{1}{\infty}-\frac{1}{-R}\right)=\frac{1}{2f_2}$$

Similarly, for plano-concave lens

$$\frac{1}{f_2}=(\mu_2-1)\left(\frac{1}{-R}-\frac{1}{\infty}\right)$$

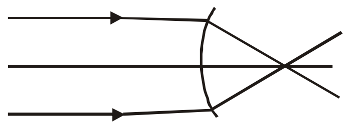
Dividing $\frac{1}{f_1}$ by $\frac{1}{f_2}$ we get,

$$\frac{(\mu_1-1)}{R}=\frac{(\mu_2-1)}{2R}$$

or, $2\mu_1-\mu_2=1$

50. **(d)** using, $\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$

R = 7.8 mm

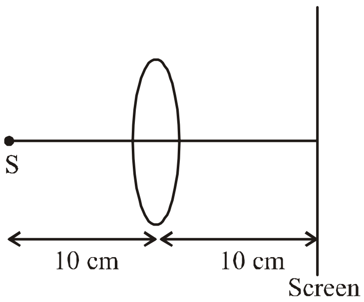


$\mu_1=1$ $\mu_2=1.34$

$$\Rightarrow\frac{1.34}{V}-\frac{1}{\infty}=\frac{1.34-1}{7.8}\ [\because u=\infty]$$

$\therefore$ V = 30.7 mm = 3.07 cm ≃ 3.1 cm

51. **(d)**



Using lens formula

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\Rightarrow\frac{1}{10}-\frac{1}{-10}=\frac{1}{f}\Rightarrow f=5\text{cm}$$

Shift due to slab, $=t\left(1-\frac{1}{\mu}\right)$ in the direction of incident ray

or, $d=1.5\left(1-\frac{2}{3}\right)=0.5$

Now, u = – 9.5

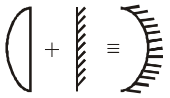
Again using lens formulas $\frac{1}{v}-\frac{1}{-9.5}=\frac{1}{5}$

$$\Rightarrow \frac{1}{v} = \frac{1}{5} - \frac{2}{19} = \frac{9}{95}$$

$$\text{or,} \quad v = \frac{95}{9} = 10.55 \text{cm}$$

Thus, screen is shifted by a distance
$d = 10.55 - 10 = 0.55$ cm away from the lens.

52. **(b)** **Case-1**

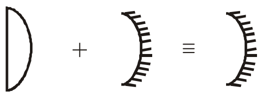


$$\frac{1}{f_1} = \left(\frac{\mu - 1}{R}\right) \quad f = -28$$

$$P = 2P_1 + P_2 \Rightarrow \frac{1}{28} = 2\left(\frac{\mu - 1}{R}\right)$$

$$\left(\because \text{ Power, } P = \frac{1}{f} \;\&\; f_{\text{plane mirror}} = \infty\right)$$

Case-2



$$\frac{1}{f_1} = \left(\frac{\mu - 1}{R}\right) \quad f_2 = -\frac{R}{2} \quad f = -10 \text{ cm}$$

$$P = 2P_1 + P_2 \Rightarrow \frac{1}{10} = 2\left(\frac{\mu - 1}{2}\right) + \frac{2}{R}$$

$$\text{or,} \quad \frac{1}{10} = \frac{1}{28} + \frac{2}{R} \Rightarrow \frac{2}{R} = \frac{1}{10} - \frac{2}{28} = \frac{18}{280}$$

$$\text{or,} \quad R = \frac{280}{9} \text{cm}$$

$$\text{or,} \quad \frac{1}{28} = 2\left(\frac{\mu - 1}{280}\right)9 \quad \Rightarrow \quad \mu - 1 = \frac{5}{9}$$

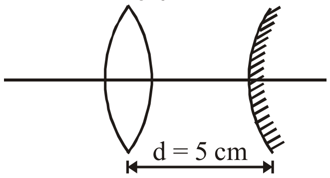
$$\therefore \quad \mu = 1 + \frac{5}{9} = \frac{14}{9} = 1.55$$

53. **(a)** For minimum spherical aberration separation,
$d = f_1 - f_2 = 2$ cm
Resultant focal length = F = 10 cm

Using $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$ and solving, we get f_1, f_2 18 cm and 20 cm respectively.

54. **(a)** Given, focal length of lens (f) = 15 cm
object is placed at a distance (u) = – 20 cm
By lens formula,

f = 15 cm



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

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

$$\frac{1}{v} = \frac{4 - 3}{60}$$

v = 60 cm

The image I gets formed at 60 cm to the right of the lens and it will be inverted.
The rays from the image (I) formed further falls on the convex mirror forms another image. This image should formed in such a way that it coincide with object at the same point due to reflection takes place by convex mirror.
Distance between lens and mirror will be
d = image distance (v) – radius of curvature of convex mirror.
$5 = 60 - 2f$
$2f = 60 - 5$

$$f = \frac{55}{2} = 27.5 \text{ cm (convex mirror)}$$

55. **(b)** Given, radius of hemispherical glass R = 10 cm

$$\therefore \text{ Focal length } f = \frac{10}{2} = -5 \text{ cm}$$

$u = (10 - 6) = -4$ cm.
By using mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{-4} = \frac{1}{-5} \Rightarrow v = 20 \text{ cm.}$$

Apparent height, $h_a = h_r \frac{\mu_1}{\mu_2} = 30 \times \frac{1}{1.5} = 20$ cm below flat surface.

56. **(a)** Len's formula is given by

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

For convex lens,

$$\frac{1}{30} = \frac{1}{v} + \frac{1}{60} \Rightarrow \frac{1}{60} = \frac{1}{v}$$

Similarly for concave lens

$$\frac{1}{-120} = \frac{1}{v} - \frac{1}{40} \Rightarrow \frac{1}{v} = \frac{1}{60}$$

Virtual object 10 cm behind plane mirror.
Hence real image 10 cm infront of mirror or, 60 cm from convex lens.

57. **(a)** Taking $f_2 = 12.07$
Using Mirror's formula

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

$$\Rightarrow \frac{1}{12.7} = \frac{1}{25.4} + \frac{1}{u} \Rightarrow \frac{1}{12.7} - \frac{1}{25.4} = \frac{1}{u}$$

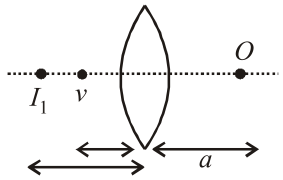
$u = 25.4 = v'$
Now using Len's formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{f_1} = \frac{1}{25.4 + 13.6} + \frac{1}{10}$$

$$\Rightarrow \frac{1}{f_1} = \frac{1}{39} + \frac{1}{10} \Rightarrow f_1 = \frac{390}{49} = 7.96$$

The closest answers is (a) as option (c) and (d) are not possible.

58. (d) When object is kept at a distance 'a' from thin covex lens

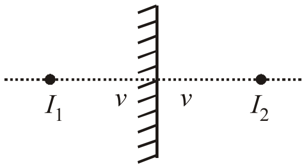


By lens formula : $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

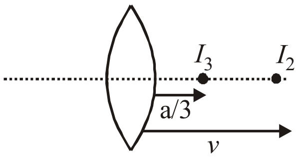
$$\frac{1}{V} - \frac{1}{(-a)} = \frac{1}{f}$$

or, $\frac{1}{v} = \frac{1}{f} - \frac{1}{a}$ ...(i)

Mirror forms image at equal distance from mirror



Now, again from lens formula



$$\frac{3}{a} - \frac{1}{V} = \frac{1}{f}$$

$$\frac{3}{a} - \frac{1}{f} + \frac{1}{a} = \frac{1}{f} \quad \text{[From eqn. (i)]}$$

Hence, $a = 2f$

59. **(b)** By Lens maker's formula for convex lens

$$\frac{1}{f} = \left(\frac{\mu}{\mu_L} - 1\right)\left(\frac{2}{R}\right)$$

for, $\mu_{L_1} = \frac{4}{3}, f_1 = 4R$

for $\mu_{L_2} = \frac{5}{3}, f_2 = -5R$

$\Rightarrow f_2 = (-)$ ve

60. **(a)** If a lens of refractive index μ is immersed in a medium of refractive index μ_1, then its focal length in medium is given by

$$\frac{1}{f_m} = ({}_m\mu_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

If f_a is the focal length of lens in air, then

$$\frac{1}{f_a} = ({}_a\mu_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{f_m}{f_a} = \frac{({}_a\mu_l - 1)}{({}_m\mu_l - 1)}$$

If $\mu_1 > \mu$, then f_m and f_a have opposite signs and the nature of lens changes i.e. a convex lens diverges the light rays and concave lens converges the light rays. Thus given option (a) is correct.

61. **(d)** **Given:** Separation of lens for two of its position, $d = 10$ cm

Ratio of size of the images in two positions

$$\frac{I_1}{I_2} = \frac{3}{2}$$

Distance of object from the screen, $D = ?$

Applying formula,

$$\frac{I_1}{I_2} = \frac{(D+d)^2}{(D-d)^2}$$

$$\Rightarrow \frac{3}{2} = \frac{(D+10)^2}{(D-10)^2}$$

$$\Rightarrow \frac{3}{2} = \frac{D^2 + 100 + 20D}{D^2 + 100 - 20D}$$

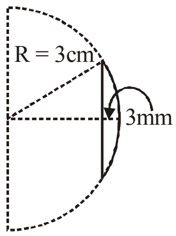
$\Rightarrow 3D^2 + 300 - 60D = 2D^2 + 200 + 40D$

$\Rightarrow D^2 - 100D + 100 = 0$

On solving, we get $D = 99$ cm

Hence the distance between the screen and the object is 99 cm.

62. **(c)** $\therefore$ n = $\frac{\text{Velocity of light in vacuum}}{\text{Velocity of light in medium}}$



$\therefore$ n = $\frac{3}{2}$

$3^2 + (R - 3mm)^2 = R^2$

$\Rightarrow 3^2 + R^2 - 2R(3mm) + (3mm)^2 = R^2$

$\Rightarrow R \approx 15$ cm

$$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{15}\right) \Rightarrow f = 30 \text{ cm}$$

63. **(d)** If side of object square = ℓ

and side of image square = ℓ'

From question, $\frac{\ell'^2}{\ell} = 9$

or $\frac{\ell'}{\ell} = 3$

i.e., magnification m = 3

u = – 40 cm

v = 3 × 40 = 120 cm

f = ?

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

$$\frac{1}{120}-\frac{1}{-40}=\frac{1}{f}$$

or, $\frac{1}{f}=\frac{1}{120}+\frac{1}{40}=\frac{1+3}{120}$ $\therefore$ f = 30 cm

64. **(d)** The focal length of the lens

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

$$=\frac{1}{12}+\frac{1}{240}$$

$$=\frac{20+1}{240}=\frac{21}{240}$$

$$f=\frac{240}{21}\text{cm}$$

When glass plate is interposed between lens and film, so shift produced will be

Shift $=t\left(1-\frac{1}{\mu}\right)$

$$1\left(1-\frac{1}{3/2}\right)=1\times\frac{1}{3}$$

Now image should be form at

$$v'=12-\frac{1}{3}=\frac{35}{3}\text{cm}$$

Now the object distance u.
Using lens formula again

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

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

$$\Rightarrow \frac{1}{u}=\frac{3}{35}-\frac{21}{240}=\frac{1}{5}\left[\frac{3}{7}-\frac{21}{48}\right]$$

$$\Rightarrow \frac{1}{u}=\frac{1}{5}\left[\frac{48-49}{7\times16}\right]$$

$\Rightarrow u=-7\times16\times5=-560$ cm $=-5.6$ m

65. **(a)** From the Cauchy

Formula, $\mu=A+\frac{B}{\lambda^2}+\frac{C}{\lambda^1}$

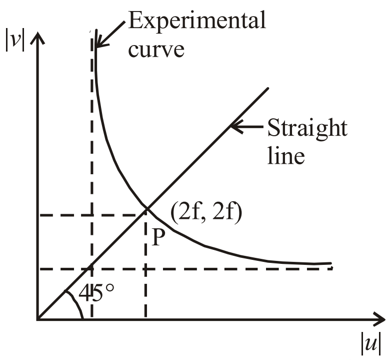
$$\therefore \mu\propto\frac{1}{\lambda}$$

As, $\lambda_{blue}<\lambda_{red}$
$\therefore \lambda_{blue}>\mu_{red}$
From lens maker's formula

and $\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$$\Rightarrow \frac{1}{f_B}>\frac{1}{f_R} \quad \Rightarrow f_R>f_B.$$

66. **(d)**



For the graph to intersect y = x line. The value of $|v|$ and $|u|$ must be equal.

From lens formula

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

When $u=-2f, v=2f$

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

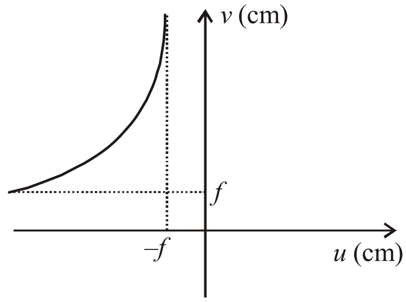
As $|u|$ increases, v decreases for $|u|>f$. The graph between $|v|$ and $|u|$ is shown in the figure. A straight line passing through the origin and making an angle of 45°with the x-axis meets the experimental curve at $P(2f, 2f)$.

67. **(c)** From the lens formula $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$

This graph suggest that when

$u=-f, v=+\infty$

When u is at $-\infty$, $v=f$.



When the object is moved further away from the lens, v decreases but remains positive.

68. **(c)** When two thin lenses are in contact coaxially, power of combination is given by

$P=P_1+P_2$

$=(-15+5)D$

$=-10D.$

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

$$\Rightarrow f=\frac{1}{P}=\frac{1}{-10}\text{ metre}$$

$$\therefore f=-\left(\frac{1}{10}\times100\right)\text{cm}=-10\text{ cm.}$$

69. **(b)** According to lens maker's formula in air

$$\frac{1}{f_a}=\left({}_a\mu_g-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{f_a}=\left(\frac{1.5}{1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad \text{.... (i)}$$

Using lens maker's formula in liquid medium,

$$\frac{1}{f_m}=\left(\frac{\mu_g}{\mu_m}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{f_m}=\left(\frac{1.5}{1.6}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad \text{.... (ii)}$$

Dividing (i) by (ii),

$$\frac{f_m}{f_a}=\left(\frac{1.5-1}{\frac{1.5}{1.6}-1}\right)=-8$$

$$P_a=-5=\frac{1}{f_a}$$

$$\Rightarrow f_a=-\frac{1}{5}$$

$$\Rightarrow f_m=-8\times f_a=-8\times-\frac{1}{5}=\frac{8}{5}$$

$$P_m=\frac{\mu}{f_m}=\frac{1.6}{8}\times 5=1\text{D}$$

70. **(c)** The focal length(F) of the final mirror is

$$\frac{1}{F}=\frac{2}{f_\ell}+\frac{1}{f_m}$$

Using lens maker's formula

Here $\frac{1}{f_\ell}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

Here, $R_1=\infty$

$R_2=30$ cm

$$=(1.5-1)\left[\frac{1}{\infty}-\frac{1}{-30}\right]=\frac{1}{60}$$

$$\therefore \frac{1}{F}=2\times\frac{1}{60}+\frac{1}{30/2}=\frac{1}{10}$$

$\therefore$ $F=10$ cm

Real image will be equal to the size of the object if the object distance

$u=2F=20$ cm

71. **2**

From the Einstein's photoelectric equation

Energy of photon

= Kinetic energy of photoelectrons + Work function

$\Rightarrow$ Kinetic energy = Energy of Photon – Work Function

Let ϕ_0 be the work function of metal and v_1 and v_2 be the velocity of photoelectrons. Using Einstein's photoelectric equation we have

$$\frac{1}{2}mv_1^2=4-\phi_0 \quad \text{...(i)}$$

$$\frac{1}{2}mv_2^2=2.5-\phi_0 \quad \text{...(ii)}$$

$$\Rightarrow \frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2}=\frac{4-\phi_0}{2.5-\phi_0}$$

$$\Rightarrow (2)^2=\frac{4-\phi_0}{2.5-\phi_0}\Rightarrow 10-4\phi_0=4-\phi_0$$

$$\phi_0=2eV$$

72. **(a)** When angle of prism is small, then angle of deviation is given by $D_m=(\mu-1)A$

So, if wavelength of incident light is increased, μ decreases and hence D_m decreases.

73. **(c)** For minimum deviation:

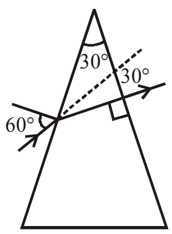
$$r_1=r_2=\frac{A}{2}=30^\circ$$

by Snell's law $\mu_1 \sin i=\mu_2 \sin r$

$$1\times\sin i=\sqrt{3}\times\frac{1}{2}=\frac{\sqrt{3}}{2}\Rightarrow i=60$$

74. **(c)** Angle of prism, $A=30°$, $i=60°$,

angle of deviation, $\delta=30°$



Using formula, $\delta=i+e-A$

$\Rightarrow e=\delta+A-i$

$=30°+30°-60°=0°$

$\therefore$ Emergent ray will be perpendicular to the face

So it will make angle 90° with the force through which it emerges.

75. **(c)** We know that $i+e-A=\delta$

$35°+79°-A=40°$ $\quad\therefore\quad A=74°$

$$\text{But } \mu=\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin A/2}=\frac{\sin\left(\frac{74+\delta_m}{2}\right)}{\sin\frac{74}{2}}$$

$$=\frac{5}{3}\sin\left(37°+\frac{\delta_m}{2}\right)$$

μ_{max} can be $\frac{5}{3}$. That is μ_{max} is less than $\frac{5}{3} = 1.67$

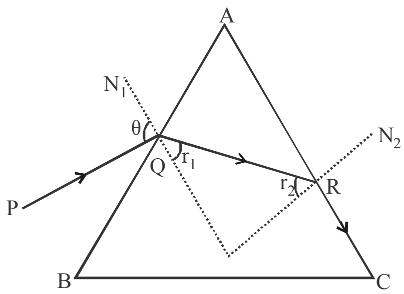
But δ_m will be less than 40° so

$$\mu < \frac{5}{3}\sin 57° < \frac{5}{3}\sin 60° \Rightarrow \mu = 1.5$$

76. **(c)** When $r_2 = C, \angle N_2RC = 90°$

Where C = critical angle

As $\sin C = \frac{1}{\mu} = \sin r_2$



Applying snell's law at 'R'

$\mu \sin r_2 = 1 \sin 90°$ ...(i)

Applying snell's law at 'Q'

$1 \times \sin\theta = \mu \sin r_1$ ...(ii)

But $r_1 = A - r_2$

So, $\sin\theta = \mu \sin(A - r_2)$

$\sin\theta = \mu \sin A \cos r_2 - \cos A$ ...(iii) [using (i)]

From (1)

$$\cos r_2 = \sqrt{1 - \sin^2 r_2} = \sqrt{1 - \frac{1}{\mu^2}} \quad ...(iv)$$

By eq. (iii) and (iv)

$$\sin\theta = \mu \sin A\sqrt{1 - \frac{1}{\mu^2}} - \cos A$$

on further solving we can show for ray not to transmitted through face AC

$$\theta = \sin^{-1}\left[\mu \sin(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right]$$

So, for transmission through face AC

$$\theta > \sin^{-1}\left[\mu \sin(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right]$$

77. **(c)** For the prism as the angle of incidence (i) increases, the angle of deviation (δ) first decreases goes to minimum value and then increases.

78. **(d)** For light to come out through face 'AC', total internal reflection must not take place.

i.e., $\theta < c \Rightarrow \sin\theta < \sin c$

$$\Rightarrow \sin\theta < \frac{1}{\mu}$$

or $\mu < \frac{1}{\sin\theta} \Rightarrow \mu < \frac{1}{\sin 45°}$

$\Rightarrow \mu < \sqrt{2} \Rightarrow \mu < 1.414$

79. **(c)** For total internal reflection on face AC

$\theta >$ critical angle (C)

and $\sin\theta \geq \sin C$

$$\sin\theta \geq \frac{1}{{}^w\mu_g}$$

$$\sin\theta \geq \frac{\mu_w}{\mu_g} \Rightarrow \sin\theta \geq \frac{\frac{4}{3}}{\frac{3}{2}}$$

$$\therefore \sin\theta \geq \frac{8}{9}.$$

80. **(a)** Rainbow is formed due to the dispersion of light suffering refraction and total internal reflection (TIR) in the droplets present in the atmosphere.

81. **(a)** When angle of prism is small,

Angle of deviation, $D = (\mu - 1)A$

Since $\lambda_b < \lambda_r$

$\Rightarrow \mu_r < \mu_b \qquad \Rightarrow D_1 < D_2$

82. **(b)** For total internal reflection

Incident angle (i) > critical angle (i_c),

$\therefore \sin i > \sin i_c$

$\Rightarrow \sin 45° > \sin i_c \quad \Rightarrow \sin i_c = \frac{1}{n}$

$\therefore \sin 45° > \frac{1}{n}$

$\Rightarrow \frac{1}{\sqrt{2}} > \frac{1}{n} \qquad \Rightarrow n > \sqrt{2}$

83. **(50)**

Given : Length of compound microscope, $L = 10$ cm

Focal length of objective $f_0 = 1$ cm and of eye-piece, $f_e = 5$ cm

$u_0 = f_e = 5$ cm

Final image formed at infinity (∞), $v_e = \infty$

$v_0 = 10 - 5 = 5$

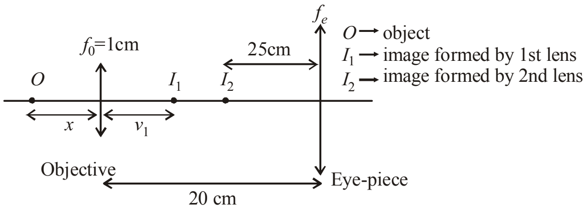
Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0} \Rightarrow \frac{1}{5} - \frac{1}{u_0} = \frac{1}{1} \Rightarrow u_0 = -\frac{5}{4} \text{ cm}$$

or, $\frac{5}{4} = \frac{N}{40}$

$$\therefore N = \frac{200}{4} = 50 \text{ cm.}$$

84. **(4.48)**
According to question, final image i.e., $v_2 = 25$ cm, $f_0 = 1$ cm, magnification, $m = m_1 m_2 = 100$



Using lens formula,

For first lens or objective $= \frac{1}{v_1} - \frac{1}{-x} = \frac{1}{1} \Rightarrow v_1 = \frac{x}{x-1}$

Also magnification $|m_1| = \left|\frac{v_1}{u_1}\right| = \frac{1}{x-1}$

For 2nd lens or eye-piece, this is acting as object

$\therefore u_2 = -(20 - v_1) = -\left(20 - \frac{x}{x-1}\right)$ and $v_2 = -25$ cm

Angular magnification $|m_A| = \left|\frac{D}{u_2}\right| = \frac{25}{|u_2|}$

Total magnification $m = m_1 m_A = 100$

$$\left(\frac{1}{x-1}\right)\left(\frac{25}{20 - \frac{x}{x-1}}\right) = 100$$

$$\Rightarrow \frac{25}{20(x-1) - x} = 100 \Rightarrow 1 = 80(x-1) - 4x$$

$$\Rightarrow 76x = 81 \Rightarrow x = \frac{81}{76}$$

$$\Rightarrow u_2 = -\left(20 - \frac{\frac{81}{76}}{\frac{81}{76} - 1}\right) = \frac{-19}{5}$$

Again using lens formula for eye-piece

$$\frac{1}{-25} - \frac{1}{-\frac{19}{5}} = \frac{1}{f_e} \Rightarrow f_e = \frac{25 \times 19}{106} \approx 4.48 \text{cm}$$

85. **(d)** For telescope
Tube length (L) $= f_o + f_e = 60$
and magnification $(m) = \frac{f_o}{f_e} = 5 \Rightarrow f_0 = 5 f_e$
$\therefore$ $f_0 = 50$ cm and $f_e = 10$ cm
Hence focal length of eye-piece, $f_e = 10$ cm

86. **(a)** According question, $M = 375$
$L = 150$ mm, $f_0 = 5$ mm and $f_e = ?$

Using, magnification, $M \simeq \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$

$$\Rightarrow 375 = \frac{150}{5}\left(1 + \frac{250}{f_e}\right) \quad (\because D = 25\text{ cm} = 250\text{ mm})$$

$$\Rightarrow 12.5 = 1 + \frac{250}{f_e}$$

$$\Rightarrow f_e = \frac{250}{11.5} = 21.7 \approx 22\,mm$$

87. **(b)** A telescope magnifies by making the object appearing closer.

88. **(c)** Reading one $\Rightarrow$ without slab
Reading two $\Rightarrow$ with slab
Reading three $\Rightarrow$ with saw dust
Minimum three readings are required to determine refractive index of glass slab using a travelling microscope.

89. **(c)** Magnifying power of telescope,

$$MP = \frac{\beta \text{ (angle subtended by image at eye piece)}}{\alpha \text{ (angle subtended by object on objective)}}$$

Also, $MP = \frac{f_o}{f_e} = \frac{150}{5} = 30$

$$\alpha = \frac{50}{1000} = \frac{1}{20}\text{rad}$$

$$\therefore \quad \beta = \theta = \text{MP} \times \alpha = 30 \times \frac{1}{20} = \frac{3}{2} = 1.5\text{ rad}$$

$$\text{or,} \quad \beta = 1.5 \times \frac{180°}{\pi} \simeq 84°$$

90. **(a)** **Given :** $f_0 = 1.2$ cm; $f_e = 3.0$ cm
$u_0 = 1.25$ cm; $M_\infty = ?$

From $\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0}$

$$\Rightarrow \frac{1}{1.2} = \frac{1}{v_0} - \frac{1}{(-1.25)}$$

$$\Rightarrow \frac{1}{v_0} = \frac{1}{1.2} - \frac{1}{1.25}$$

$\Rightarrow$ $v_0 = 30$ cm
Magnification at infinity,

$$M_\infty = -\frac{v_0}{u_0} \times \frac{D}{f_e}$$

$$= \frac{30}{1.25} \times \frac{25}{3}$$

($\because$ $D = 25$ cm least distance of distinct vision) = 200
Hence the magnifying power of the compound microscope is 200

91. **(d)** Given, Focal length of objective, $f_0 = 30$ cm
focal length of eye lens, $f_e = 3.0$ cm
Magnifying power, M = ?
Magnifying power of the Galilean telescope,

$$M_D = \frac{f_0}{f_e}\left(1 - \frac{f_e}{D}\right)$$

$$= \frac{30}{3}\left(1 - \frac{3}{25}\right) \quad [\because D = 25 \text{ cm}]$$

$$= 10 \times \frac{22}{25} = 8.8 \text{ cm}$$

92. **(c)** One side of mirror is opaque and another side is reflecting this is not in case of lens hence, it is easier to provide mechanical support to large size mirrors than large size lenses. Reflecting telescopes are based on the same principle except that the formation of images takes place by reflection instead of refraction.

93. **(d)** Given: $f_0 = 50$ cm, $f_e = 5$ cm
$d = 25$ cm, $u_0 = -200$ cm
Magnification M = ?

As $\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$

$$\Rightarrow \frac{1}{v_0} = \frac{1}{f_0} + \frac{1}{u_0} = \frac{1}{50} - \frac{1}{200} = \frac{4-1}{200} = \frac{3}{200}$$

or $v_0 = \frac{200}{3}$ cm

Now $v_e = d = -25$ cm

From, $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

$$-\frac{1}{u_e} = \frac{1}{f_e} - \frac{1}{v_e}$$

$$= \frac{1}{5} + \frac{1}{25} = \frac{6}{25}$$

or, $v_e = \frac{-25}{6}$ cm

Magnification $M = M_0 \times M_e$

$$= \frac{v_0}{u_0} \times \frac{v_e}{u_e} = \frac{-200/3}{200} \times \frac{-25}{-25/6}$$

$$= -\frac{1}{3} \times 6 = -2$$

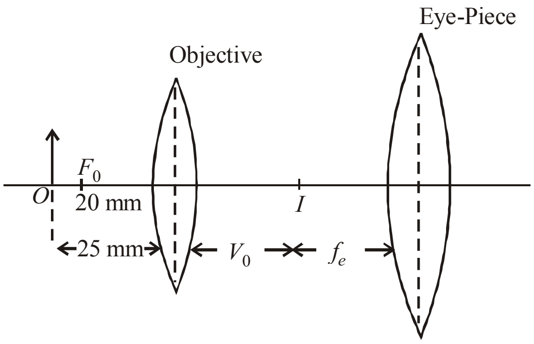
94. **(a)** Given : $d = 3 \times 10^{-2}$ m
$\lambda = 5.5 \times 10^{-7}$ m

Limit of resolution, $\Delta\theta = \frac{1.22\lambda}{d}$

$$= \frac{1.22 \times 5.5 \times 10^{-7}}{3 \times 10^{-2}} = 2.23 \times 10^{-5} \text{ rad.}$$

At a distance of 80 m , the telescope is able to resolve between two points which are separated by $2.23 \times 10^{-5} \times 80$ m
$= 1.78 \times 10^{-3}$ m

95. **(c)**



To obtain final image at infinity, object which is the image formed by objective should be at focal distance of eye-piece.
By lens formula (for objective)

$$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

or, $\frac{1}{v_0} - \frac{1}{-25} = \frac{1}{20}$

$$\Rightarrow \frac{1}{v_0} = \frac{1}{20} - \frac{1}{25} = \frac{5-4}{100} = \frac{1}{100} \text{mm}$$

$\therefore$ $v_0 = 100$ mm
Therefore the distance between the lenses
$= v_0 + f_e = 100 \text{ mm} + 20 \text{ mm} = 120 \text{ mm}$

96. **(a)** To find the refractive index of glass using a travelling microscope, a vernier scale is provided on the microscope

97. **(c)** A real, inverted and enlarged image of the object is formed by the objective lens of a compound microscope.

98. **(b)** The resolving power of a telescope is

$$R.P = \frac{D}{1.22\lambda}$$

where D = diameter of the objective lens
λ = wavelength of light.

Clearly, $R.P \propto \frac{D}{\lambda}$

Resolving power of telescope resolution will be high if its objective is of large aperture.