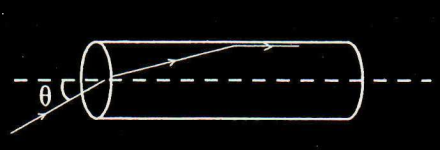
Chapter 22

Ray Optics

1. 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 **[AIEEE-2009]**

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

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

2. 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 **[AIEEE-2009]**

(1) $\left(\frac{f}{2}, \frac{f}{2}\right)$ (2) (f, f)

(3) $(4f, 4f)$ (4) $(2f, 2f)$

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

(1) Remain same

(2) Does not depend on colour of light

(3) Increase

(4) Decrease

4. 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 **[AIEEE-2011]**

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

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

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

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

5. An object 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 be shifted to be in sharp focus on film? **[AIEEE-2012]**

(1) 2.4 m (2) 3.2 m

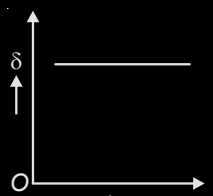
(3) 5.6 m (4) 7.2 m

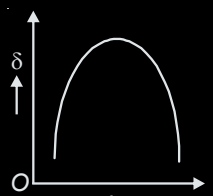
6. Diameter of a plano-convex lens is 6 cm and thickness at the centre is 3 mm. If speed of light in material of lens is 2×10^8 m/s, the focal length of the lens is **[JEE (Main)-2013]**

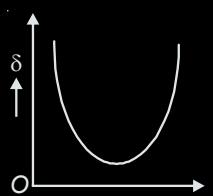
(1) 15 cm (2) 20 cm

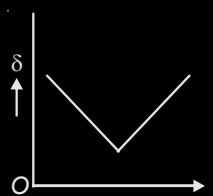
(3) 30 cm (4) 10 cm

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

(1) 

(2) 

(3) 

(4) 

8. 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 **[JEE (Main)-2014]**

(1) $f_1 = f_2 < f$

(2) $f_1 > f$ and f_2 becomes negative

(3) $f_2 > f$ and f_1 becomes negative

(4) f_1 and f_2 both become negative

9. A green light is incident from the water to the air - water interface at the critical angle(θ). Select the correct statement **[JEE (Main)-2014]**

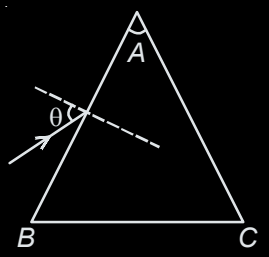
(1) The entire spectrum of visible light will come out of the water at an angle of 90° to the normal

(2) The spectrum of visible light whose frequency is less than that of green light will come out to the air medium

(3) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium

(4) The entire spectrum of visible light will come out of the water at various angles to the normal

10. 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. **[JEE (Main)-2015]**



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

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

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

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

11. 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 **[JEE (Main)-2016]**

(1) 10 times nearer (2) 20 times taller

(3) 20 times nearer (4) 10 times taller

12. In an experiment for determination of refractive index of glass of a prism by $i - \delta$, plot, it was found that a 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? **[JEE (Main)-2016]**

(1) 1.6 (2) 1.7

(3) 1.8 (4) 1.5

13. A diverging lens with magnitude of focal length 25 cm is placed at a distance of 15 cm from a converging lens of magnitude of focal length 20 cm. A beam of parallel light falls on the diverging lens. The final image formed is **[JEE (Main)-2017]**

(1) Real and at a distance of 40 cm from convergent lens

(2) Virtual and at a distance of 40 cm from convergent lens

(3) Real and at a distance of 40 cm from the divergent lens

(4) Real and at a distance of 6 cm from the convergent lens

14. 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 screen is shifted by a distance d. Then d is **[JEE (Main)-2019]**

(1) 1.1 cm away from the lens

(2) 0.55 cm towards the lens

(3) 0

(4) 0.55 cm away from the lens

15. 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 willl be **[JEE (Main)-2019]**

(1) 75° (2) 45°

(3) 90° (4) 60°

16. 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 **[JEE (Main)-2019]**

(1) $2\mu_1 - \mu_2 = 1$ (2) $3\mu_2 - 2\mu_1 = 1$

(3) $2\mu_2 - \mu_1 = 1$ (4) $\mu_1 + \mu_2 = 3$

17. 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. **[JEE (Main)-2019]**

(1) 4.0 cm (2) 1 cm

(3) 3.1 cm (4) 2 cm

18. 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 5 m/s, the speed and direction of the image will be **[JEE (Main)-2019]**

(1) 0.92×10^{-3} m/s away from the lens

(2) 2.26×10^{-3} m/s away from the lens

(3) 1.16×10^{-3} m/s towards the lens

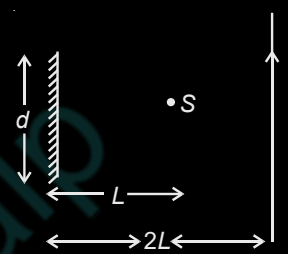
(4) 3.22×10^{-3} m/s towards the lens

19. 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 **[JEE (Main)-2019]**

(1) 90° (2) 30°

(3) 45° (4) 60°

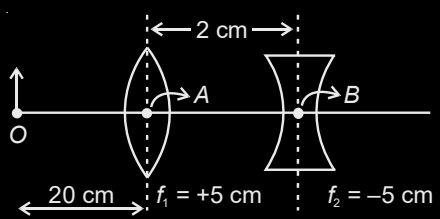
20. A point source of light, S is placed at a distance L in front of the centre of plane mirror of width d which is hanging vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror, at a distance $2L$ as shown below. The distance over which the man can see the image of the light source in the mirror is **[JEE (Main)-2019]**



(1) $\frac{d}{2}$ (2) $3d$

(3) $2d$ (4) d

21. What is the position and nature of image formed by lens combination shown in figure? (f_1, f_2 are focal lengths) **[JEE (Main)-2019]**



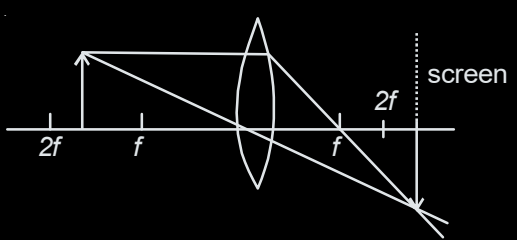
(1) $\frac{20}{3}$ cm from point B at right; real

(2) 70 cm from point B at right; real

(3) 40 cm from point B at right; real

(4) 70 cm from point B at left; virtual

22. Formation of real image using a biconvex lens is shown below: **[JEE (Main)-2019]**



If the whole set up is immersed in water without disturbing the object and the screen positions, what will one observe on the screen?

[JEE (Main)-2019]

(1) Erect real image (2) No change

(3) Image disappears (4) Magnified image

23. 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 **[JEE (Main)-2019]**

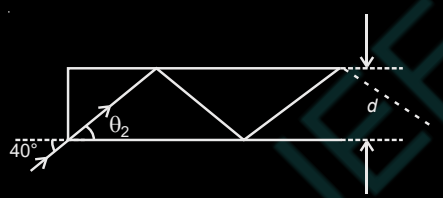
(1) $f_1 - f_2$ (2) $\frac{R}{\mu_2 - \mu_1}$

(3) $\frac{2f_1 f_2}{f_1 + f_2}$ (4) $f_1 + f_2$

24. 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)

[JEE (Main)-2019]



(1) 66000 (2) 55000

(3) 45000 (4) 57000

25. 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 image formed due to mirror will be **[JEE (Main)-2019]**

(1) 20 cm from the convergent mirror, twice the size of the object

(2) 20 cm from the convergent mirror, same size as the object

(3) 40 cm from the convergent lens, twice the size of the object

(4) 40 cm from the convergent mirror, same size as the object

26. Calculate the limit of resolution of a telescope objective having a diameter of 200 cm, if it has to detect light of wavelength 500 nm coming from a star. **[JEE (Main)-2019]**

(1) 457.5×10^{-9} radian (2) 305×10^{-9} radian

(3) 152.5×10^{-9} radian (4) 610×10^{-9} radian

27. 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 :

[JEE (Main)-2019]

(1) 30 cm (2) 25 cm

(3) 20 cm (4) 10 cm

28. 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

[JEE (Main)-2019]

(1) 0.32 m (2) 0.24 m

(3) 1.60 m (4) 0.16 m

29. 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

[JEE (Main)-2019]

(1) 3 : 1 (2) 2 : 1

(3) 4 : 3 (4) 5 : 3

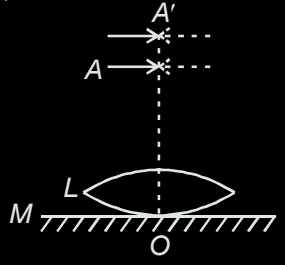
30. Diameter of the objective lens of a telescope is 250 cm. For light of wavelength 600 nm coming from a distant object, the limit of resolution of the telescope is close to **[JEE (Main)-2019]**

(1) 1.5×10^{-7} rad (2) 3.0×10^{-7} rad

(3) 2.0×10^{-7} rad (4) 4.5×10^{-7} rad

31. 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

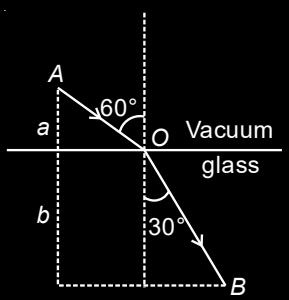
[JEE (Main)-2019]



(1) $\sqrt{2}$ (2) $\frac{4}{3}$

(3) $\sqrt{3}$ (4) $\frac{3}{2}$

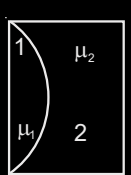
32. A ray of light *AO* in vacuum is incident on a glass slab at angle 60° and refracted at angle 30° along *OB* as shown in the figure. The optical path length of light ray from *A* to *B* is : **[JEE (Main)-2019]**



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

(3) $2a + \frac{2b}{3}$ (4) $2a + 2b$

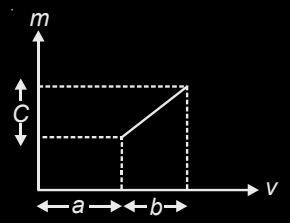
33. One plano-convex and one plano-concave lens of same radius of curvature '*R*' but of different materials are joined side by side as shown in the figure. If the refractive index of the material of 1 is μ_1 and that of 2 is μ_2, then the focal length of the combination is : **[JEE (Main)-2019]**



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

(3) $\frac{R}{\mu_1 - \mu_2}$ (4) $\frac{2R}{\mu_1 - \mu_2}$

34. 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? **[JEE (Main)-2019]**



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

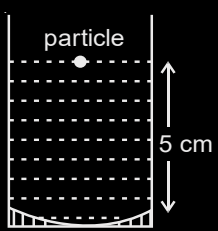
(3) $\frac{a}{c}$ (4) $\frac{b}{c}$

35. The value of numerical aperture of the objective lens of a microscope is 1.25. If light of wavelength 5000 Å is used, the minimum separation between two points, to be seen as distinct, will be : **[JEE (Main)-2019]**

(1) 0.24 μm (2) 0.38 μm

(3) 0.48 μm (4) 0.12 μm

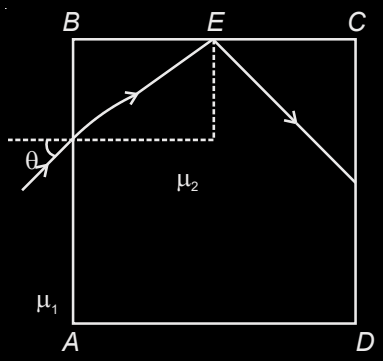
36. A concave mirror has radius of curvature of 40 cm. It is at the bottom of a glass that has water filled up to 5 cm (see figure). If a small particle is floating on the surface of water, its image as seen, from directly above the glass, is at a distance d from the surface of water. The value of d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



(1) 11.7 cm (2) 6.7 cm

(3) 13.4 cm (4) 8.8 cm

37. A transparent cube of side *d*, made of a material of refractive index μ_2, is immersed in a liquid of refractive index μ_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: **[JEE (Main)-2019]**

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

(3) $\theta > \sin^{-1}\sqrt{\frac{\mu_2^2}{\mu_1^2}-1}$ (4) $\theta < \sin^{-1}\sqrt{\frac{\mu_2^2}{\mu_1^2}-1}$

38. 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 **[JEE (Main)-2020]**

(1) 2 mm (2) 33 mm

(3) 22 mm (4) 12 mm

39. 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 $\frac{f_l}{f}$ is closest to the integer **[JEE (Main)-2020]**

(1) 17 (2) 1

(3) 5 (4) 9

40. The critical angle of medium for a specific wavelength, if the medium has relative permittivity 3 and relative permeability $\frac{4}{3}$ for this wavelength, will be **[JEE (Main)-2020]**

(1) 60° (2) 45°

(3) 15° (4) 30°

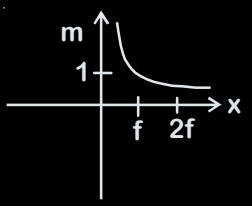
41. The magnifying power of a telescope with tube length 60 cm is 5. What is the focal length of its eye piece? **[JEE (Main)-2020]**

(1) 30 cm (2) 10 cm

(3) 20 cm (4) 40 cm

42. 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) **[JEE (Main)-2020]**

(1)


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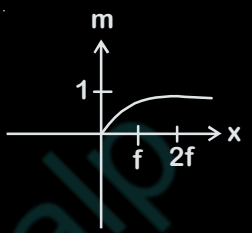

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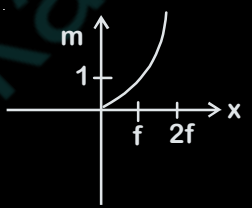
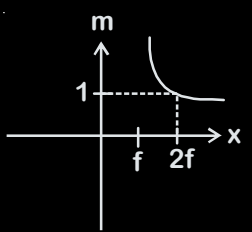


(4)


43. The aperture diameter of a telescope is 5 m. The separation between the moon and the earth is 4×10^5 km. With light of wavelength of 5500 Å, the minimum separation between objects on the surface of moon, so that they are just resolved, is close to **[JEE (Main)-2020]**

(1) 20 m (2) 200 m

(3) 600 m (4) 60 m

44. 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 **[JEE (Main)-2020]**

(1) $\frac{h}{\sqrt{2}}$ (2) $\frac{h}{2\left(\sqrt{2}+1\right)}$

(3) $\frac{h}{3\sqrt{2}}$ (4) $\frac{3}{4}h\sqrt{2}$

45. 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)

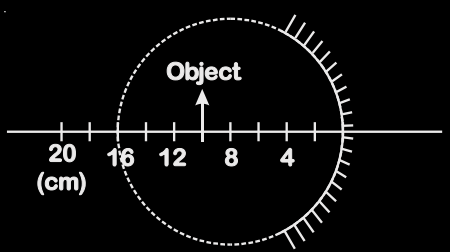
[Use the fact that surface area of a spherical cap of height h and radius of curvature r is $2\pi rh$]

[JEE (Main)-2020]

(1) 34% (2) 21%

(3) 50% (4) 17%

46.



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) **[JEE (Main)-2020]**

(1) Inverted, real and unmagnified

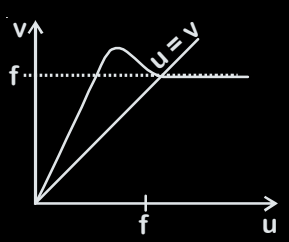
(2) Inverted, real and magnified

(3) Erect, virtual and magnified

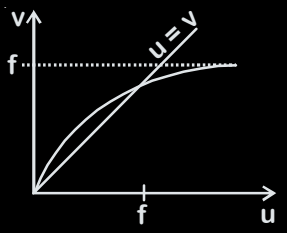
(4) Erect, virtual and unmagnified

47. 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) **[JEE (Main)-2020]**

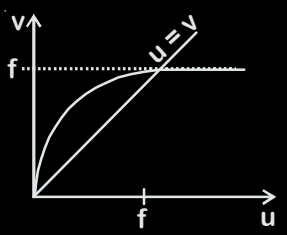
(1)



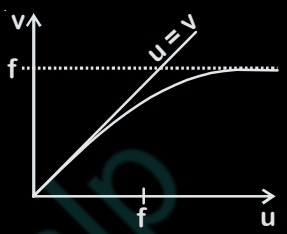
(2)



(3)



(4)



48. 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 **[JEE (Main)-2020]**

(1) 2.6 m from the mirror, real

(2) 1 m from the mirror, real

(3) 2.6 m from the mirror, virtual

(4) 1 m from the mirror, virtual

49. 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

[JEE (Main)-2020]

(1) $\frac{3R}{2}$ (2) $2R$

(3) $\frac{R}{3}$ (4) $\frac{R}{2}$

50. 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 _____.

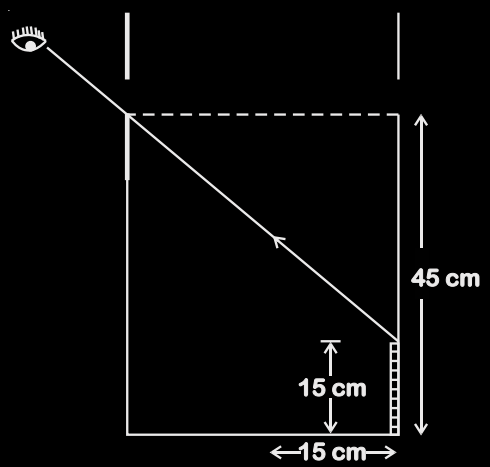
[JEE (Main)-2020]

51. 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 _____.

[JEE (Main)-2020]

52. 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 _____.

[JEE (Main)-2020]



53. 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 _____. **[JEE (Main)-2020]**

54. 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 _____. **[JEE (Main)-2020]**

55. 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 _____. **[JEE (Main)-2020]**

56. A compound microscope consists of an objective lens of focal length 1 cm and an eyepiece 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 _____.

[JEE (Main)-2020]

57. A prism of angle $A = 1°$ has a refractive index $\mu = 1.5$. A good estimate for the minimum angle of deviation (in degrees) is close to $\frac{N}{10}$. Value of N is ____ . **[JEE (Main)-2020]**

58. The focal length f is related to the radius of curvature r of the spherical convex mirror by

[JEE (Main)-2021]

(1) $f = r$ (2) $f = -\frac{1}{2}r$

(3) $f = +\frac{1}{2}r$ (4) $f = -r$

59. The same size images are formed by a convex lens when the object is placed at 20 cm or at 10 cm from the lens. The focal length of convex lens is _____ cm. **[JEE (Main)-2021]**

60. A short straight object of height 100 cm lies before the central axis of a spherical mirror whose focal length has absolute value $|f| = 40$ cm. The image of object produced by the mirror is of height 25 cm and has the same orientation of the object. One may conclude from the information :

[JEE (Main)-2021]

(1) Image is virtual, opposite side of convex mirror

(2) Image is virtual, opposite side of concave mirror

(3) Image is real, same side of convex mirror

(4) Image is real, same side of concave mirror

61. Given below are two statements: one is labeled as Assertion A and the other is labeled as Reason R.

Assertion A : For a simple microscope, the angular size of the object equals the angular size of the image.

Reason R : Magnification is achieved as the small object can be kept much closer to the eye than 25 cm and hence it subtends a large angle.

In the light of the above statements, choose the most appropriate answer from the options given below : **[JEE (Main)-2021]**

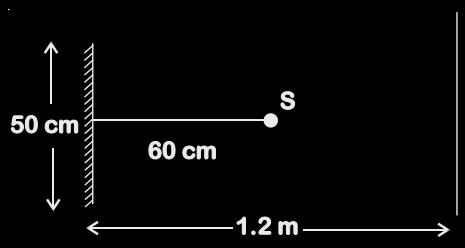
(1) A is false but R is true

(2) A is true but R is false

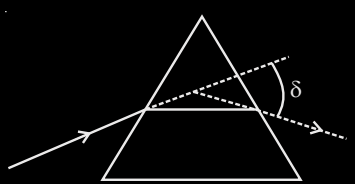
(3) Both A and R are true but R is NOT the correct explanation of A

(4) Both A and R are true and R is the correct explanation of A

62. A point source of light S, placed at a distance 60 cm in front of the centre of a plane mirror of width 50 cm, hangs vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance 1.2 m from it (see in the figure). The distance between the extreme points where he can see the image of the light source in the mirror is _____ cm. **[JEE (Main)-2021]**



63. The angle of deviation through a prism is minimum when **[JEE (Main)-2021]**



(A) Incident ray and emergent ray are symmetric to the prism

(B) The refracted ray inside the prism becomes parallel to its base

(C) Angle of incidence is equal to that of the angle of emergence

(D) When angle of emergence is double the angle of incidence

Choose the correct answer from the options given below:

(1) Only statement (D) is true

(2) Statements (B) and (C) are true

(3) Only statements (A) and (B) are true

(4) Statements (A), (B) and (C) are true

64. The refractive index of a converging lens is 1.4. What will be the focal length of this lens if it is placed in a medium of same refractive index? Assume the radii of curvature of the faces of lens are R_1 and R_2 respectively. **[JEE (Main)-2021]**

(1) $\frac{R_1R_2}{R_1-R_2}$ (2) Zero

(3) 1 (4) Infinite

65. The thickness at the centre of a plano convex lens is 3 mm and the diameter is 6 cm. If the speed of light in the material of the lens is 2×10^8 ms^{-1}, the focal length of the lens is _____. **[JEE (Main)-2021]**

(1) 1.5 cm (2) 0.30 cm

(3) 15 cm (4) 30 cm

66. The image of an object placed in air formed by a convex refracting surface is at a distance of 10 m behind the surface. The image is real and is at $\frac{2}{3}^{rd}$ of the distance of the object from the surface. The wavelength of light inside the surface is $\frac{2}{3}$ times the wavelength in air. The radius of the curved surface is $\frac{x}{13}$m. The value of 'x' is _____. **[JEE (Main)-2021]**

67. Your friend is having eye sight problem. She is not able to see clearly a distant uniform window mesh and it appears to her as non-uniform and distorted. The doctor diagnosed the problem as: **[JEE (Main)-2021]**

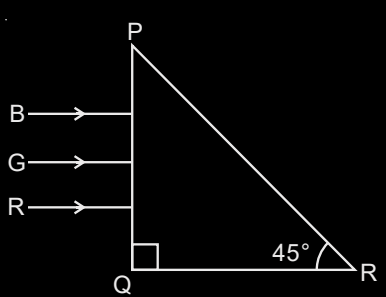
(1) Myopia and hypermetropia

(2) Presbyopia with Astigmatism

(3) Myopia with Astigmatism

(4) Astigmatism

68. Three rays of light, namely red (R), green (G) and blue (B) are incident on the face PQ of a right angled prism PQR as shown in the figure. **[JEE (Main)-2021]**



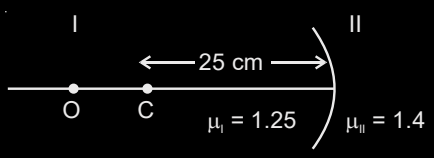
The refractive indices of the material of the prism for red, green and blue wavelength are 1.27, 1.42 and 1.49 respectively. The colour of the ray(s) emerging out of the face PR is:

(1) Blue (2) Green

(3) Red (4) Blue and Green

69. Region I and II are separated by a spherical surface of radius 25 cm. An object is kept in region I at a distance of 40 cm from the surface. The distance of the image from the surface is

[JEE (Main)-2021]

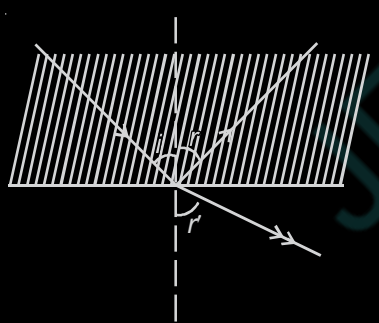


(1) 18.23 cm (2) 9.52 cm

(3) 37.58 cm (4) 55.44 cm

70. An object viewed from a near point distance of 25 cm, using a microscopic lens with magnification '6', gives an unresolved image. A resolved image is observed at infinite distance with a total magnification double the earlier using an eyepiece along with the given lens and a tube of length 0.6 m, if the focal length of the eyepiece is equal to ____ cm. **[JEE (Main)-2021]**

71. A ray of light passes from a denser medium to a rarer medium at an angle of incidence *i*. The reflected and refracted rays make an angle of 90° with each other. The angle of reflection and refraction are respectively *r* and *r'*. The critical angle is given by **[JEE (Main)-2021]**



(1) $\sin^{-1}(\tan r)$ (2) $\sin^{-1}(\cot r)$

(3) $\sin^{-1}(\tan r')$ (4) $\tan^{-1}(\sin i)$

72. A ray of light passing through a prism $(\mu = \sqrt{3})$ suffers minimum deviation. It is found that the angle of incidence is double the angle of refraction within the prism. Then, the angle of prism is _____ (in degrees). **[JEE (Main)-2021]**

73. A ray of laser of wavelength 630 nm is incident at an angle of 30° at the diamond-air interface. It is going from diamond to air. The refractive index of diamond is 2.42 and that of air is 1. Choose the correct option. **[JEE (Main)-2021]**

(1) refraction is not possible

(2) angle of refraction is 30°

(3) angle of refraction is 24.41°

(4) angle of refraction is 53.4°

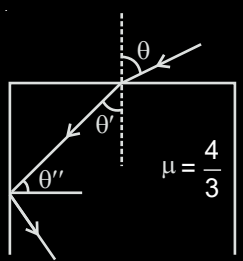
74. A prism of refractive index μ and angle of prism A is placed in the position of minimum angle of deviation. If minimum angle of deviation is also A, then in terms of refractive index value of A is

[JEE (Main)-2021]

(1) $2\cos^{-1}\left(\frac{\mu}{2}\right)$ (2) $\cos^{-1}\left(\frac{\mu}{2}\right)$

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

75. A ray of light entering from air into a denser medium of refractive index $\frac{4}{3}$, as shown in figure. The light ray suffers total internal reflection at the adjacent surface as shown. The maximum value of angle θ should be equal to **[JEE (Main)-2021]**



(1) $\sin^{-1}\frac{\sqrt{5}}{4}$ (2) $\sin^{-1}\frac{\sqrt{7}}{3}$

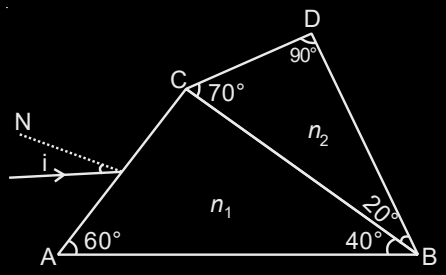
(3) $\sin^{-1}\frac{\sqrt{5}}{3}$ (4) $\sin^{-1}\frac{\sqrt{7}}{4}$

76. A prism of refractive index n_1 and another prism of refractive index n_2 are stuck together (as shown in the figure). n_1 and n_2 depend on λ, the wavelength of light, according to the relation

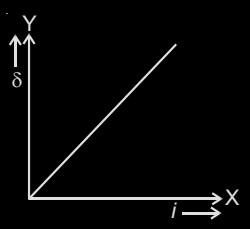
$$n_1 = 1.2 + \frac{10.8 \times 10^{-14}}{\lambda^2} \text{ and } n_2 = 1.45 + \frac{1.8 \times 10^{-14}}{\lambda^2}$$

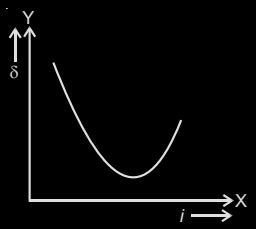
The wavelength for which rays incident at any angle on the interface BC pass through without bending at that interface will be _____ nm.

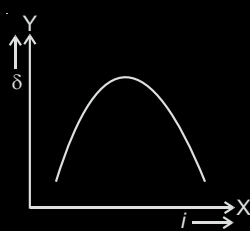
[JEE (Main)-2021]

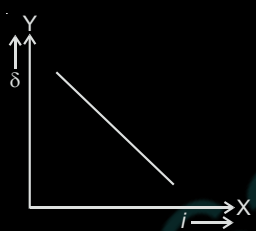


77. The expected graphical representation of the variation of angle of deviation 'δ' with angle of incidence 'i' in a prism is : **[JEE (Main)-2021]**

(1) 

(2) 

(3) 

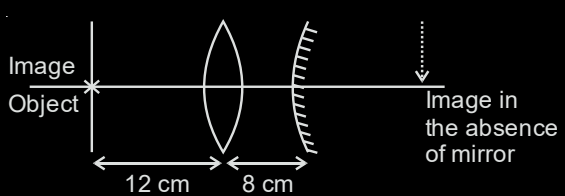
(4) 

78. Car B overtakes another car A at a relative speed of 40 ms^{-1}. How fast will the image of car B appear to move in the mirror of focal length 10 cm fitted in car A, when the car B is 1.9 m away from the car A? **[JEE (Main)-2021]**

(1) 0.2 ms^{-1} (2) 0.1 ms^{-1}

(3) 4 ms^{-1} (4) 40 ms^{-1}

79. An object is placed at a distance of 12 cm from a convex lens. A convex mirror of focal length 15 cm is placed on other side of lens at 8 cm as shown in the figure. Image of object coincides with the object.



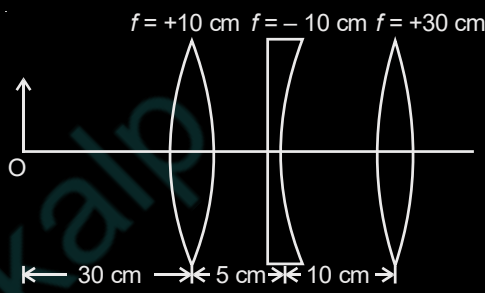
When the convex mirror is removed, a real and inverted image is formed at a position. The distance of the image from the object will be _____ (cm). **[JEE (Main)-2021]**

80. An object is placed beyond the centre of curvature C of the given concave mirror. If the distance of the object is d_1 from C and the distance of the image formed is d_2 from C, the radius of curvature of this mirror is: **[JEE (Main)-2021]**

(1) $\frac{d_1d_2}{d_1-d_2}$ (2) $\frac{d_1d_2}{d_1+d_2}$

(3) $\frac{2d_1d_2}{d_1+d_2}$ (4) $\frac{2d_1d_2}{d_1-d_2}$

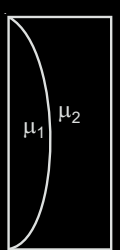
81. Find the distance of the image from object O, formed by the combination of lenses in the figure: **[JEE (Main)-2021]**



(1) 75 cm (2) 10 cm

(3) Infinity (4) 20 cm

82. Curved surfaces of a plano-convex lens of refractive index μ_1 and a plano-concave lens of refractive index μ_2 have equal radius of curvature as shown in figure. Find the ratio of radius of curvature to the focal length of the combined lenses. **[JEE (Main)-2021]**



(1) $\mu_2 - \mu_1$ (2) $\mu_1 - \mu_2$

(3) $\frac{1}{\mu_2-\mu_1}$ (4) $\frac{1}{\mu_1-\mu_2}$

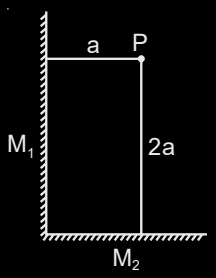
83. An object is placed at the focus of concave lens having focal length f. What is the magnification and distance of the image from the optical centre of the lens? **[JEE (Main)-2021]**

(1) 1, ∞ (2) $\frac{1}{2}, \frac{f}{2}$

(3) $\frac{1}{4}, \frac{f}{4}$ (4) Very high, ∞

84. Two plane mirrors M_1 and M_2 are at right angle to each other shown. A point source 'P' is placed at 'a' and '2a' meter away from M_1 and M_2 respectively. The shortest distance between the images thus formed is: (Take $\sqrt{5} = 2.3$)

[JEE (Main)-2021]

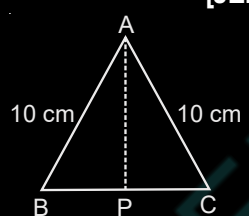


(1) $2\sqrt{10}a$ (2) 2.3a

(3) 4.6a (4) 3a

85. Cross-section view of a prism is the equilateral triangle ABC shown in the figure. The minimum deviation is observed using this prism when the angle of incidence is equal to the prism angle. The time taken by light to travel from P (midpoint of BC) to A is _____ $\times 10^{-10}$ s. (Given, speed of light in vacuum = 3×10^8 m/s and $\cos 30° = \frac{\sqrt{3}}{2}$)

[JEE (Main)-2021]



86. A glass tumbler having inner depth of 17.5 cm is kept on a table. A student starts pouring water $\left(\mu = \frac{4}{3}\right)$ into it while looking at the surface of water from the above. When he feels that the tumbler is half filled, he stops pouring water. Up to what height, the tumbler is actually filled?

[JEE (Main)-2021]

(1) 11.7 cm

(2) 7.5 cm

(3) 10 cm

(4) 8.75 cm

87. Two identical thin biconvex lenses of focal length 15 cm and refractive index 1.5 are in contact with each other. The space between the lenses is filled with a liquid of refractive index 1.25. The focal length of the combination is ___ cm. **[JEE (Main)-2022]**

88. A light wave travelling linearly in a medium of dielectric constant 4, incidents on the horizontal interface separating medium with air. The angle of incidence for which the total intensity of incident wave will be reflected back into the same medium will be :

(Given : relative permeability of medium $\mu_r = 1$)

[JEE (Main)-2022]

(1) 10° (2) 20°

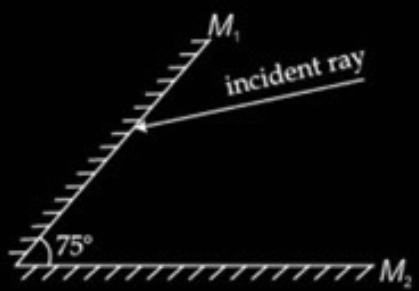
(3) 30° (4) 60°

89. The difference of speed of light in the two media *A* and *B* ($\upsilon_A - \upsilon_B$) is 2.6×10^7 m/s. If the refractive index of medium *B* is 1.47, then the ratio of refractive index of medium *B* to medium *A* is: (Given: speed of light in vacuum $C = 3 \times 10^8$ ms^{-1}) **[JEE (Main)-2022]**

(1) 1.303 (2) 1.318

(3) 1.13 (4) 0.12

90. A light ray is incident, at an incident angle θ_1, on the system of two plane mirrors M_1 and M_2 having an inclination angle 75° between them (as shown in figure). After reflecting from mirror M_1 it gets reflected back by the mirror M_2 with an angle of reflection 30°. The total deviation of the ray will be _____ degree. **[JEE (Main)-2022]**



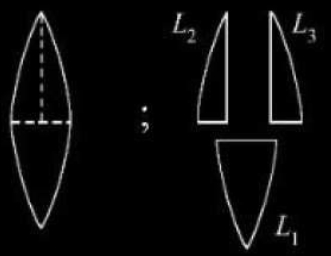
91. Consider a light ray travelling in air is incident into a medium of refractive index $\sqrt{2n}$. The incident angle is twice that of refracting angle. Then, the angle of incidence will be: **[JEE (Main)-2022]**

(1) $\sin^{-1}\left(\sqrt{n}\right)$ (2) $\cos^{-1}\left(\sqrt{\frac{n}{2}}\right)$

(3) $\sin^{-1}\left(\sqrt{2n}\right)$ (4) $2\cos^{-1}\left(\sqrt{\frac{n}{2}}\right)$

92. A convex lens has power *P*. It is cut into two halves along its principal axis. Further one piece (out of the two halves) is cut into two halves perpendicular to the principal axis (as shown in figures). Choose the incorrect option for the reported pieces.

[JEE (Main)-2022]



(1) Power of $L_1 = \frac{P}{2}$ (2) Power of $L_2 = \frac{P}{2}$

(3) Power of $L_3 = \frac{P}{2}$ (4) Power of $L_1 = P$

93. If a wave gets refracted into a denser medium, then which of the following is true? **[JEE (Main)-2022]**

(1) Wavelength, speed and frequency decreases

(2) Wavelength increases, speed decreases and frequency remains constant

(3) Wavelength and speed decreases but frequency remains constant

(4) Wavelength, speed and frequency increases

94. The refracting angle of a prism is *A* and refractive index of the material of the prism is cot (*A*/2). Then the angle of minimum deviation will be :

[JEE (Main)-2022]

(1) 180 – 2A

(2) 90 – A

(3) 180 + 2A

(4) 180 – 3A

95. A parallel beam of light is allowed to fall on a transparent spherical globe of diameter 30 cm and refractive index 1.5. The distance from the centre of the globe at which the beam of light can converge is_____ mm. **[JEE (Main)-2022]**

96. The speed of light in media '*A*' and '*B*' are 2.0×10^{10} cm/s and 1.5×10^{10} cm/s respectively. A ray of light enters from the medium *B* to *A* at an incident angle 'θ'. If the ray suffers total internal reflection, then **[JEE (Main)-2022]**

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

(2) $\theta > \sin^{-1}\left(\frac{2}{3}\right)$

(3) $\theta < \sin^{-1}\left(\frac{3}{4}\right)$

(4) $\theta > \sin^{-1}\left(\frac{3}{4}\right)$

97. Which of the following statement is correct?

[JEE (Main)-2022]

(1) In primary rainbow, observer sees red colour on the top and violet on the bottom

(2) In primary rainbow, observer sees violet colour on the top and red on the bottom

(3) In primary rainbow, light wave suffers total internal reflection twice before coming out of water drops

(4) Primary rainbow is less bright than secondary rainbow

98. For an object placed at a distance 2.4 m from a lens, a sharp focused image is observed on a screen placed at a distance 12 cm form the lens. A glass plate of refractive index 1.5 and thickness 1 cm is introduced between lens and screen such that the glass plate plane faces parallel to the screen. By what distance should the object be shifted so that a sharp focused image is observed again on the screen? **[JEE (Main)-2022]**

(1) 0.8 m

(3) 3.2 m

(3) 1.2 m

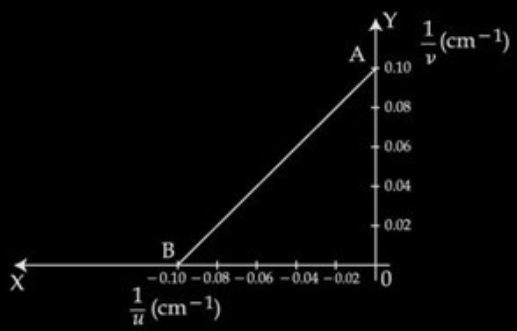
(4) 5.6 m

99. A convex lens of focal length 20 cm is placed in front of a convex mirror with principal axis coinciding each other. The distance between the lens and mirror is 10 cm. A point object is placed on principal axis at a distance of 60 cm from the convex lens. The image formed by combination coincides the object itself. The focal length of the convex mirror is_____cm.

[JEE (Main)-2022]

100. The graph between $\frac{1}{u}$ and $\frac{1}{v}$ for a thin convex lens in order to determine its focal length is plotted as shown in the figure. The refractive index of lens is 1.5 and its both the surfaces have same radius of curvature *R*. The value of *R* will be _____ cm.

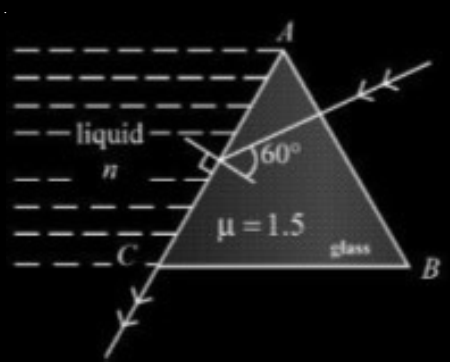
(where *u* = object distance, *v* = image distance)



101. In the given figure, the face *AC* of the equilateral prism is immersed in a liquid of refractive index '*n*'. For incident angle 60° at the side *AC* the refracted light beam just grazes along face *AC*. The refractive index of the liquid $n = \frac{\sqrt{x}}{4}$. The value of *x* is_____.

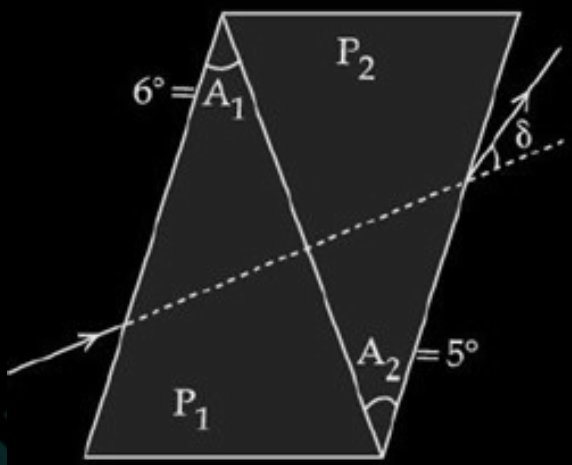
(Given refractive index of glass = 1.5)

[JEE (Main)-2022]



102. A thin prism of angle 6° and refractive index for yellow light (n_Y)1.5 is combined with another prism of angle 5° and n_Y = 1.55. The combination produces no dispersion. The net average deviation (δ) produced by the combination is $\left(\frac{1}{x}\right)^\circ$. The value of *x* is_____.

[JEE (Main)-2022]



103. In normal adjustment, for a refracting telescope, the distance between objective and eye piece is 30 cm. The focal length of the objective, when the angular magnification of the telescope is 2, will be:

[JEE (Main)-2022]

(1) 20 cm (2) 30 cm

(3) 10 cm (4) 15 cm

104. The power of a lens (biconvex) is 1.25 m^{-1} in particular medium. Refractive index of the lens is 1.5 and radii of curvature are 20 cm and 40 cm respectively. The refractive index of surrounding medium

[JEE (Main)-2022]

(1) 1.0 (2) $\frac{9}{7}$

(3) $\frac{3}{2}$ (4) $\frac{4}{3}$

105. An object O is placed at a distance of 100 cm in front of a concave mirror of radius of curvature 200 cm as shown in the figure. The object starts moving towards the mirror at a speed 2 cm/s. The position of the image from the mirror after 10 s will be at ____ cm.

[JEE (Main)-2022]

106. In an experiment with a convex lens, the plot of the image distance (ν') against the object distance (μ') measured from the focus gives a curve $\nu'\mu' = 225$. If all the distances are measured in cm. The magnitude of the focal length of the lens is _____ cm.

[JEE (Main)-2022]

107. The X-Y plane be taken as the boundary between two transparent media M_1 and M_2. M_1 in $Z \geq 0$ has a refractive index of $\sqrt{2}$ and M_2 with $Z < 0$ has a refractive index of $\sqrt{3}$. A ray of light travelling in M_1 along the direction given by the vector $\vec{P} = 4\sqrt{3}\hat{i} - 3\sqrt{3}\hat{j} - 5\hat{k}$, is incident on the plane of separation. The value of difference between the angle of incident in M_1 and the angle of refraction in M_2 will be _____ degree. **[JEE (Main)-2022]**

108. Light enters from air into a given medium at an angle of 45° with interface of the air-medium surface. After refraction, the light ray is deviated through an angle of 15° from its original direction. The refractive index of the medium is **[JEE (Main)-2022]**

(1) 1.732 (2) 1.333

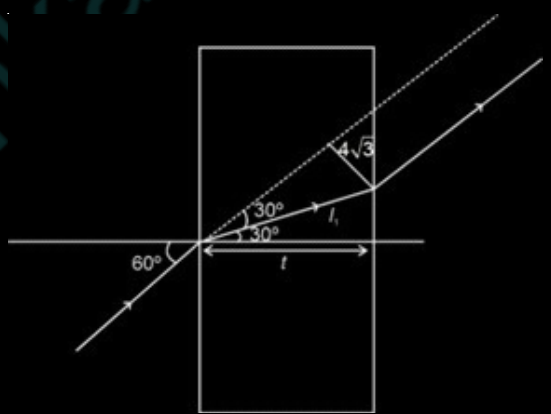
(3) 1.414 (4) 2.732

109. Light travels in two media M_1 and M_2 with speeds $1.5 \times 10^8\ ms^{-1}$ and $2.0 \times 10^8\ ms^{-1}$ respectively. The critical angle between them is: **[JEE (Main)-2022]**

(1) $\tan^{-1}\left(\frac{3}{\sqrt{7}}\right)$ (2) $\tan^{-1}\left(\frac{2}{3}\right)$

(3) $\cos^{-1}\left(\frac{3}{4}\right)$ (4) $\sin^{-1}\left(\frac{2}{3}\right)$

110. A ray of light is incident at an angle of incidence 60º on the glass slab of refractive index $\sqrt{3}$. After refraction, the light ray emerges out from other parallel faces and lateral shift between incident ray and emergent ray is $4\sqrt{3}$ cm. The thickness of the glass slab is _____ cm. **[JEE (Main)-2022]**



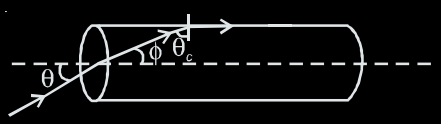
111. A small bulb is placed at the bottom of a tank containing water to a depth of $\sqrt{7}$ m. The refractive index of water is $\frac{4}{3}$. The area of the surface of water through which light from the bulb can emerge out is $x\pi$ m^2. The value of x is _____. **[JEE (Main)-2022]**

❑ ❑ ❑

Chapter 22

Ray Optics

1. Answer (3)



$f + \theta_C = 90°$ $\qquad \theta_C = \sin^{-}\left(\frac{1}{\mu}\right)$

Using Snell's law

$\frac{\sin\theta}{\sin\phi} = \mu$

$\Rightarrow \sin\theta = \mu\cos\theta_C$

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

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

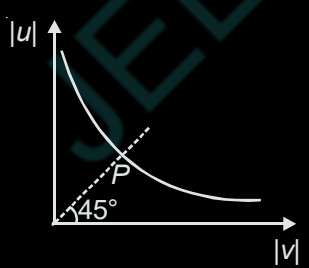
2. Answer (4)

At point P

$|u| = |v| = x$

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

$\Rightarrow u = 2f$



3. Answer (3)

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

Now, $\mu_{blue} > \mu_{red}$

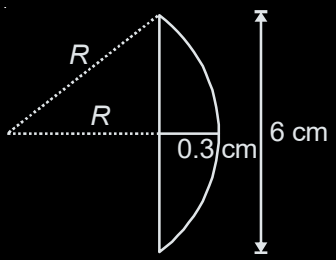
$\Rightarrow f_{blue} < f_{red}$

4. Answer (4)

Apparent shift = $t\left[1-\frac{1}{\mu}\right]$

5. Answer (3)

6. Answer (3)



$\mu=\frac{c}{v}=1.5$

$R^2 = 3^2 + (R-0.3)^2$

$\Rightarrow R^2 = 9 + R^2 + 0.09 - 0.6R$

$\Rightarrow 0.6R = 9.09$

$\Rightarrow R = \frac{9.09}{0.6} \approx 15$ cm.

Now, $f=\frac{R}{\mu-1}=\frac{15}{0.5}$ = 30 cm.

7. Answer (3)

8. Answer (2)

By Lens maker's formula

$\frac{1}{f_1}=\left(\frac{3/2}{4/3}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

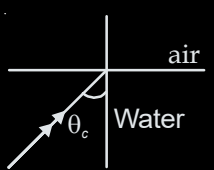
$\frac{1}{f_2}=\left(\frac{3/2}{5/3}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$\frac{1}{f}=\left(\frac{3}{2}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$\Rightarrow f_1 = 4f$ & $f_2 = -5f$

9. Answer (2)

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

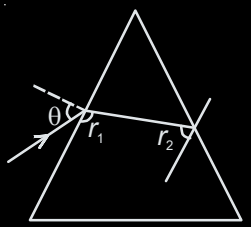


For greater wavelength (i.e. lesser frequency) μ is less

So, θ_c would be more. So, they will not suffer reflection and come out at angles less then 90°.

10. Answer (1)

$\sin\theta = \mu \sin r_1$



$$\Rightarrow \sin r_1 = \frac{\sin\theta}{\mu}$$

$$\Rightarrow r_1 = \sin^{-1}\left(\frac{\sin\theta}{\mu}\right)$$

$$r_2 = A - \sin^{-1}\left(\frac{\sin\theta}{\mu}\right)$$

$$\Rightarrow r_2 < \sin^{-1}\left(\frac{1}{\mu}\right)$$

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

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

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

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

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

11. Answer (3)

By defination of magnification in telescope object will appear 20 times nearer to the observer.

12. Answer (4)

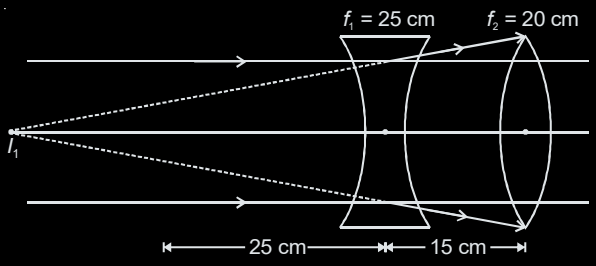
From the given data, $A = i + e - \delta = 74°$, $\delta = 40°$

Now, $\mu = \dfrac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} < \dfrac{\sin\left(\frac{A+\delta}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$$\Rightarrow \mu < \frac{\sin 57°}{\sin 37°} \Rightarrow \mu < 1.39°$$

Nearest value is 1.5

13. Answer (1)



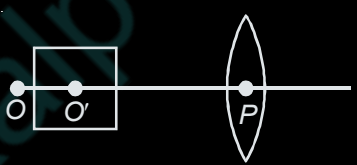
For converging lens

$u = -40$ cm which is equal to $2f$

$\therefore$ Image will be real and at a distance of 40 cm from convergent lens.

14. Answer (4)

$2f = 10$ cm $\Rightarrow f = 5$ cm



$$\text{Shift} = OO' = 1.5\left(1 - \frac{2}{3}\right)$$

$= 0.5$ cm

$\Rightarrow O'P = 9.5$ cm

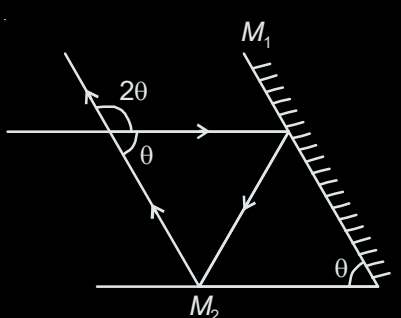
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} + \frac{1}{9.5} = \frac{1}{5}$$

$\Rightarrow v = 10.55$ cm

Shift = 0.55 cm away

15. Answer (4)



$3\theta = 180°$

$\Rightarrow \theta = 60°$

16. Answer (1)

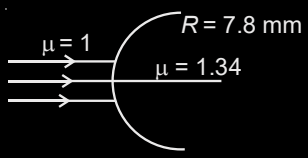
$$\frac{1}{f_1} = (\mu_1 - 1)\frac{1}{R}$$

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

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

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

17. Answer (3)



$$\frac{1.34}{v} - \frac{1}{u} = \frac{1.34 - 1}{(7.8\text{ mm})}$$

As $u = -\infty$ $\therefore$ $v = f$

$$\therefore \quad \frac{1.34}{f} = \frac{0.34}{7.8\text{ mm}}$$

$$\Rightarrow f = \left(\frac{1.34 \times 7.8}{0.34}\right)\text{mm}$$

$$\Rightarrow \quad f = 3.07 \approx 3.1\text{ cm}$$

18. Answer (3)

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

$u = -20$ m, $f = 0.3$

$$\frac{1}{v} = \frac{1}{0.3} - \frac{1}{20}$$

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

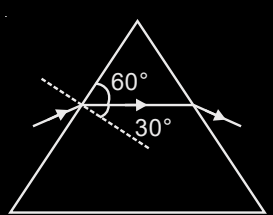
$$v = \frac{60}{197}\text{ m}$$

$$v_{\text{image}} = \left(\frac{3}{197}\right)^3 \times 5$$

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

19. Answer (4)

For minimum deviation the ray passes symmetrically

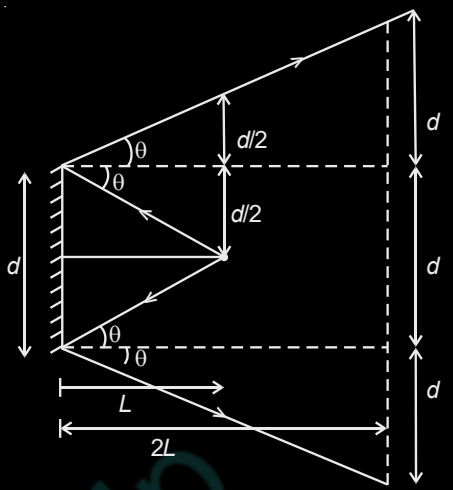


$$\Rightarrow \quad r = 30°$$

$$\sin i = \sqrt{3}\sin 30° = \frac{\sqrt{3}}{2}$$

$$\Rightarrow \quad i = 60°$$

20. Answer (2)



$$\frac{d}{d/2} = \frac{y}{2L}$$

$$\Rightarrow \quad y = d$$

Hence, the distance over which the image can be seen is $d + d + d = 3d$.

21. Answer (2)

For lens A

$$\frac{1}{v} - \frac{1}{(-20)} = \frac{1}{5}$$

$$\Rightarrow \quad v = \frac{20}{3}\text{ cm}$$

For lens B

$$u = \frac{20}{3} - 2$$

$$u = \frac{14}{3}\text{ cm}$$

$$\therefore \quad \frac{1}{v} - \frac{1}{\frac{14}{3}} = -\frac{1}{5}$$

$$\Rightarrow \quad v = 70\text{ cm}$$

Image is real and right of B.

22. Answer (3)

Initially, $\frac{1}{f}=\left(\frac{3}{2}-1\right)\frac{2}{R}$ $\left[\mu \text{ for glass}=\frac{3}{2}\right]$

$\therefore$ $f = R$

Now for water $\mu_w = 4/3$

$\therefore$ $\frac{4}{3f'}=\frac{2}{6R}\Rightarrow f'=\frac{6\times4\times R}{3\times2}$

$\Rightarrow$ $f' = 4R = 4f$

Now object in placed is between focus and lense, so there will not be any real image on screen.

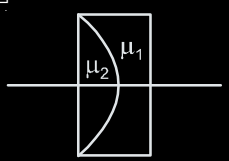
23. Answer (2)

For plano-convex lens

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

For plano – concave lens

$\frac{1}{f_1}=-\left[\frac{\mu_1-1}{R}\right]$ ...(ii)



Now for combination

$$\frac{\mu_2}{v_1}-\frac{1}{\infty}=\frac{\mu_2-1}{\infty}$$

$$\frac{\mu_1}{v'_1}-\frac{\mu_2}{v_1}=\frac{\mu_2-\mu_1}{R}$$

$$\frac{\frac{1}{f}-\frac{\mu_1}{v'_1}=\frac{1-\mu_1}{\infty}}{\frac{1}{f}=\frac{(\mu_2-\mu_1)}{R}=\frac{1}{f_1}+\frac{1}{f_2}}$$

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

24. Answer (4)

$1 \times \sin 40° = 1.31 \sin\theta$

$\Rightarrow$ $\sin\theta=\frac{0.64}{1.31}\Rightarrow \theta\simeq 30°$

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

$\therefore$ $N=\frac{2}{20\times10^{-6}\times\cot\theta}$

$=\frac{2\times10^6}{20\times\sqrt{3}}=57735$

$N \approx 57000$

25. Answer (2)

$v_1=\frac{40\times20}{(40-20)}=40\text{ cm}$

$u_2 = 60 - 40 = 20$ cm

$\therefore$ $v_2=\frac{20\times10}{(20-10)}=20\text{ cm}$

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

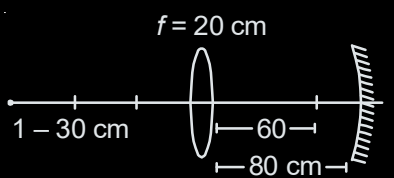
26. Answer (2)

$\theta=\frac{1.22\lambda}{D}$

$\theta=\frac{1.22\times500\times10^{-9}}{200\times10^{-2}}=\frac{1.22\times500\times10^{-9}}{2}$

$\theta = 305 \times 10^{-9}$ radian

27. Answer (4)



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

$\therefore$ $\frac{1}{v}+\frac{1}{30}=\frac{1}{20}$

$\frac{1}{v}=\frac{30-20}{20\times30}=\frac{10}{20\times30}$

$v = 60$ cm

So clearly radius of curvature of mirror is 20 cm. Now if the object is placed within focal plane i.e. 10 cm then image formed by mirror is virtual.

28. Answer (1)

$$\frac{1}{V}+\frac{1}{U}=-\frac{1}{40}$$

$$\frac{V}{U}=-5$$

$$-\frac{1}{5U}+\frac{1}{U}=-\frac{1}{40}$$

$U = -32$ cm

29. Answer (1)

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

$$\therefore \quad v = (\pm 2u)$$

$$\therefore \quad \frac{1}{2u}+\frac{1}{u}=\frac{1}{20} \quad \Rightarrow \quad \frac{3}{2u}=\frac{1}{20}$$

$$\therefore \quad u_1 = 30 \text{ cm}$$

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

$$\therefore \quad \frac{1}{2u}=\frac{1}{20} \qquad \therefore \quad u_2 = 10$$

$$\therefore \quad \frac{30}{10}=3$$

30. Answer (2)

$$\theta=\frac{1.22\,\lambda}{D}$$

$$\Rightarrow \quad \theta=\frac{1.22\times 600\times 10^{-9}}{250}\times 100 = 2.92\times 10^{-7}$$

$\Rightarrow \quad \theta = 3 \times 10^{-7}$ rad

31. Answer (2)

$f_L = 18$ cm

$$\frac{1}{18}=0.5\times\frac{2}{R} \quad \Rightarrow \quad R = 18 \text{ cm}$$

$$\frac{1}{f_2}=(\mu_l-1)\left(-\frac{1}{18}\right)$$

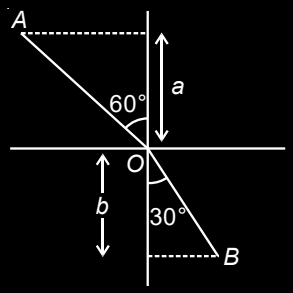
$$\frac{1}{27}=\frac{1}{18}-\frac{(\mu_l-1)}{18}=\frac{1-\mu_l+1}{18}$$

$\Rightarrow \quad 2 = 3(2 - \mu_l) = 6 - 3\,\mu_l$

$$\Rightarrow \quad \mu_l=\frac{4}{3}$$

32. Answer (4)

From the given figure



$$\frac{a}{AO}=\cos 60°$$

$AO = 2a$

$$\frac{b}{BO}=\cos 30°$$

$$BO=\frac{2b}{\sqrt{3}}$$

$\therefore$ Length of optical path $= AO + BO \times \sqrt{3}$

$= 2a + 2b$

33. Answer (3)

Focal length of plano-convex lens-

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

Focal length of plano concave lens-

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

For the combination of two lens-

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

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

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

34. Answer (4)

As the graph between magnification (m) and image distance (v) varies linearly, then

$$m = k_1 v + k_2$$

$$\Rightarrow \quad \frac{v}{u}=k_1 v+k_2$$

$$\Rightarrow \quad \frac{1}{u}=k_1+\frac{k_2}{v}$$

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

Clearly, $k_1=\frac{1}{f}$ and $k_2=1$ here

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

35. Answer (1)

$$\theta_{min} = \frac{1.22\lambda}{D}$$

$$\frac{D}{2f} = 1.25$$

$$d_{min} = \frac{1.22\lambda f}{D} = \frac{1.22 \times 5000 \times 10^{-10}}{2.50}$$

$$= 0.24\ \mu m$$

36. Answer (4)

$$\frac{1}{V} + \frac{1}{U} = \frac{-1}{20}$$

$$\frac{1}{V} - \frac{1}{5} = \frac{-1}{20}$$

$$\frac{1}{V} = \frac{-1}{20} + \frac{1}{5}$$

$$\frac{1}{V} = \frac{3}{20}$$

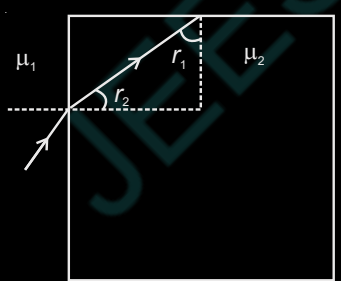
$$d = \left(\frac{20}{3} + 5\right) \times 3/4$$

$$= \frac{35}{4}$$

d = 8.8 cm

37. Answer (4)

$\mu_2 \sin r_1 > \mu_1$



$$\Rightarrow \sin r_1 > \frac{\mu_1}{\mu_2}$$

$$r_1 > \sin^{-1}\left[\frac{\mu_1}{\mu_2}\right]$$

$\mu_1 \sin\theta = \mu_2 \sin r_2 = \mu_2 \sin(90° - r_1)$

$$\sin\theta = \frac{\mu_2}{\mu_1}\sin(90° - r_1) = \frac{\mu_2}{\mu_1}\cos r_1$$

$$\Rightarrow \theta < \sin^{-1}\left[\frac{\mu_2}{\mu_1}\frac{\sqrt{\mu_2^2 - \mu_1^2}}{\mu_2}\right]$$

$$\Rightarrow \theta < \sin^{-1}\left[\sqrt{\frac{\mu_2^2}{\mu_1^2} - 1}\right]$$

38. Answer (3)

$$m \simeq \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

$$\Rightarrow 375 = \frac{150}{5}\left(1 + \frac{250}{f_e}\right)$$

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

$$\Rightarrow f_e = \frac{250}{11.5} = 21.7$$

$$\Rightarrow \boxed{f_e \approx 22\ \text{mm}}$$

39. Answer (4)

$$\frac{1}{f_a} = (1.5 - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$ Lens Maker's formula

$$\frac{1}{f_e} = \left(\frac{1.5}{1.42} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

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

40. Answer (4)

For relative permittivity = 3, $\varepsilon = 3\varepsilon_0$

For relative permeability $= \frac{4}{3}$, $\mu = \frac{4}{3}\mu_0$

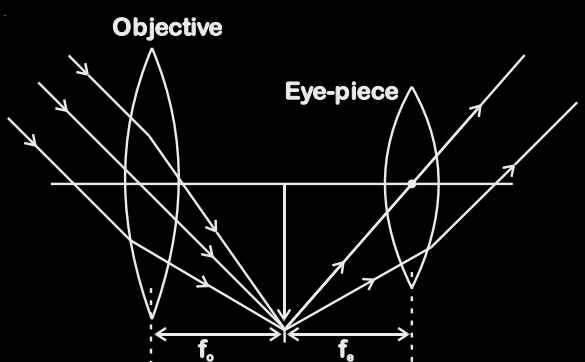
$\therefore \quad \mu\varepsilon = 4\mu_0\varepsilon_0$

$$\sqrt{\frac{\mu_0\varepsilon_0}{\mu\varepsilon}} = \frac{v}{c} = \frac{1}{2}$$

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

$\therefore \quad \theta_c = 30°$

41. Answer (2)



For telescope

Tube length (L) = $f_o + f_e$

and magnification (m) $= \frac{f_e}{f_o}$

where f_o and f_e are focal length of objective and eyepiece

$\therefore \quad f_o + f_e = 60$

and $f_e = 5f_o$

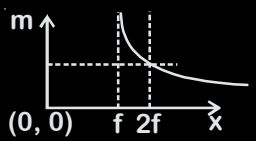
$\therefore \quad f_o = 50$ cm

$f_e = 10$ cm

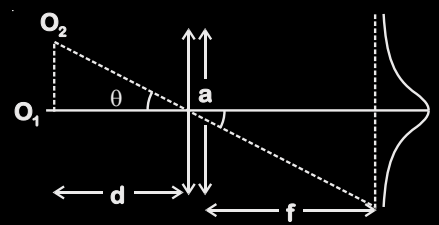
42. Answer (4)

At focus magnification is ∞

And at x = 2f, magnification is 1.



43. Answer (4)



$\theta = 1.22\dfrac{\lambda}{a}$

Distance $O_1O_2 = (\theta)d$

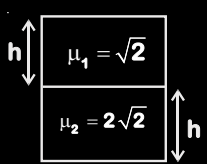
$= \left(1.22\dfrac{\lambda}{a}\right)d$

$= \dfrac{(1.22)(5500\times10^{-10})\times4\times10^5\times10^3}{5}$

$= 5368 \times 10^{-2}$ m

$= 53.68$ m

44. Answer (4)

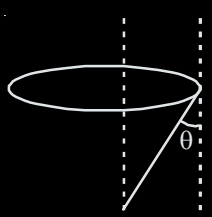


$D = \dfrac{t_1}{\mu_1} + \dfrac{t_2}{\mu_2} = \dfrac{h}{\sqrt{2}} + \dfrac{h}{2\sqrt{2}} = \dfrac{3h}{2\sqrt{2}}$

45. Answer (4)

$\sin\theta = \dfrac{3}{4}$

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



$\Omega = 2\pi(1 - \cos\theta)$

$= 2\pi(1 - \sqrt{7}/4)$

Fraction of energy transmitted = $\dfrac{1-\sqrt{7}/4}{2}$

= 17%

46. Answer (1)

$f = \dfrac{R}{2} = 4$ cm

$u = 10$ cm

Using mirror formula

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

$\dfrac{1}{v} + \dfrac{1}{-10} = \dfrac{1}{-4}$

$v = -\dfrac{20}{3}$ cm.

So image would be real, inverted and smaller than object.

47. Answer (4)

Theoretical

48. Answer (1)

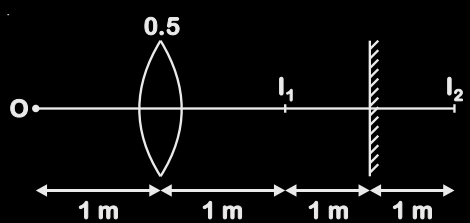


Image formed by one will be object for other.

$\dfrac{1}{v_1} + \dfrac{1}{1} = \dfrac{1}{0.5} \quad \Rightarrow \quad v_1 = 1\,\text{m}$

I_2 will be formed in behind the mirror.

$\dfrac{1}{v_3} + \dfrac{1}{3} = \dfrac{1}{0.5} \quad \Rightarrow \quad v_3 = 0.6\,\text{m}$

So, final image will be formed at 2.6 m from the mirror, real.

49. Answer (3)

$$P = \frac{1}{f} = \frac{2(\mu - 1)}{R}$$

$$1.5P = \frac{(\mu - 1)}{R'}$$

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

50. Answer (60)

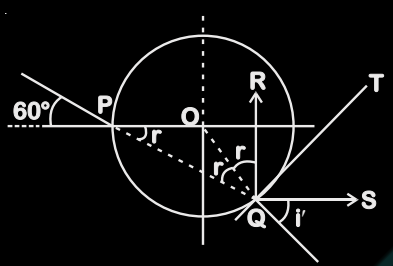
Lens-maker formula $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

for plano-convex lens.

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

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

51. Answer (90)



QR is reflected ray and QS is refracted ray. QT is tangent and OQ is normal.

Now, $\mu.\sin 60° = \sqrt{3}\sin r$

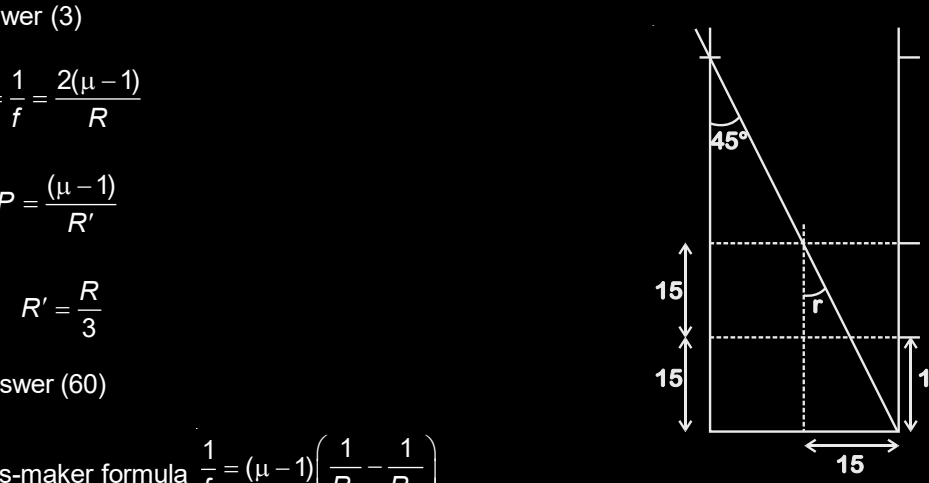
$$\Rightarrow \quad \frac{\sqrt{3}}{2} = \sqrt{2}\sin r \;\Rightarrow\; \sin r = \frac{1}{2} \;\therefore\; r = 30°$$

Yet again $\sqrt{3}\sin r = \sin i'$ $\therefore$ $i' = 60°$

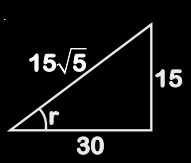
$\therefore$ Angle between QR and QS $\Rightarrow$ ($\angle$RQS) = 90°

52. Answer (158)

See the figure



For r



$\mu_1 \sin 45° = \mu_2 \sin r$

$$\Rightarrow \quad \frac{1}{\sqrt{2}} = \frac{\mu}{\sqrt{5}} \quad \therefore \quad \mu = \sqrt{\frac{5}{2}} \simeq 1.58 \approx \frac{158}{100}$$

53. Answer (1)

For concave mirror

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

$$|m| = \left|-\frac{v}{u}\right| = \frac{10}{30} = \frac{1}{3}$$

$v_{image} = v_{object}\ (m^2)$

$$\Rightarrow v_{image} = 9 \times \frac{1}{9} = 1 \text{ cm/s}$$

54. Answer (06.25)

For compound microscope the magnification when final image by eye-piece is formed at D = 25 cm (least distance for clear vision)

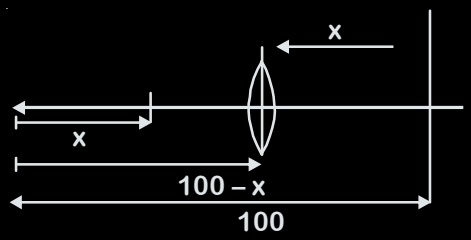
$$m = \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right) = 100$$

$$\Rightarrow \quad \frac{20}{1}\left(1 + \frac{25}{f_e}\right) = 100$$

$$\Rightarrow \quad 1 + \frac{25}{f_e} = 5 \;\Rightarrow\; \frac{25}{f_e} = 4$$

$$\Rightarrow \quad f_e = \frac{25}{4} = 6.25 \text{ cm}$$

55. Answer (476)



Clearly 100 – x – x = 40

$\Rightarrow$ 60 = 2x

$\therefore$ x = 30, And 100 – x = 70

$$\frac{1}{70}+\frac{1}{30}=\frac{1}{f}$$

$$\Rightarrow \frac{100}{21\times 100}=\frac{1}{f}=\frac{1}{21}$$

$$\therefore f=\left(\frac{21}{100}\right)$$

$$\therefore \text{Power} = \frac{1}{f}=\left(\frac{100}{21}\right)\approx 4.76$$

$$\frac{N}{100}=4.76$$

$\therefore$ N = 476

56. Answer (50.00)

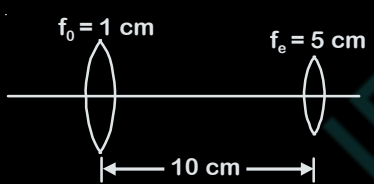


Image by objective is formed at the focus of eye-piece

$\therefore$ For objective, v = 5, u, f = 1 cm

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

$$\therefore |u|=\frac{5}{4}cm \Rightarrow |u|=\frac{50}{40}\text{cm}$$

$\therefore$ n = 50

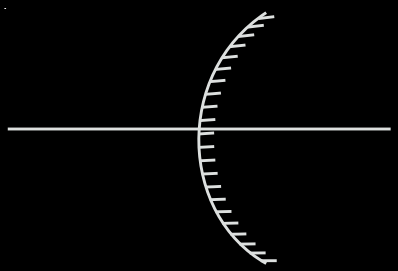
57. Answer (05)

$$\delta_{min}=(\mu-1)A$$

$$\Rightarrow \frac{N}{10}=(1.5-1)1$$

$\Rightarrow$ N = 5

58. Answer (3)



$$f=+\frac{r}{2}$$

as f is positive for convex mirror.

59. Answer (15)

Let magnification be m.

In case-I (Real Image)

$$\frac{1}{mu_1}-\frac{1}{-u_1}=\frac{1}{f}$$

In case-II (Virtual Image)

$$\frac{1}{-mu_2}-\frac{1}{-u_2}=\frac{1}{f}$$

$$\Rightarrow -\frac{f}{-20+f}=+\frac{f}{-10+f}$$

f = 15 cm

60. Answer (1)

Image is diminished and magnification is positive.

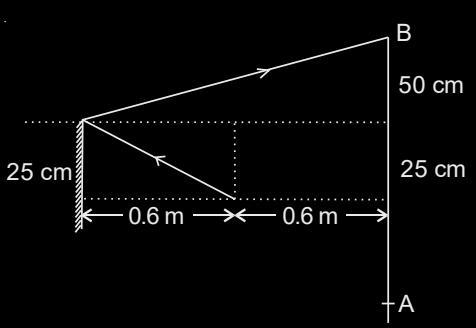
$\therefore$ It is possible if object is placed in front of convex mirror.

61. Answer (4)

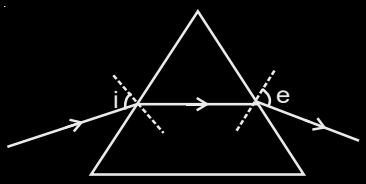
Though image size is bigger than object size, the angular size of the image is equal to the angular size of object

62. Answer (150.00)

AB = 2 × (50 + 25) cm = 150 cm



63. Answer (4)



For minimum deviation,

$i = e$

and refracted ray is parallel to the base.

64. Answer (4)

$$\because \quad \frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

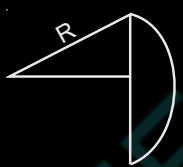
$$\Rightarrow \quad \frac{1}{f} = \left(\frac{1.4}{1.4} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$\Rightarrow \quad f = \infty$

65. Answer (4)

$\mu = 1.5$

$$R^2 = (R - t)^2 + \left(\frac{d}{2}\right)^2$$



$$2Rt = \frac{d^2}{4}$$

$$R = \frac{d^2}{8t} = \frac{36}{8 \times 0.3} = 15 \text{ cm}$$

$$\frac{1}{f} = \frac{(1.5 - 1)}{15}$$

f = 30 cm

66. Answer (30)

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

$\mu_1 = 1, \quad \mu_2 = 1.5$

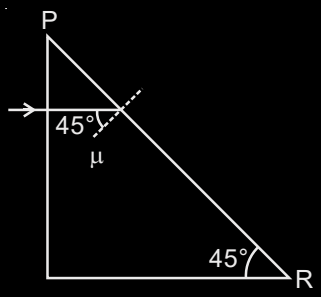
$$\frac{1.5}{+10} - \frac{1}{-15} = \frac{1.5 - 1}{+R}$$

$$R = \frac{30}{13} \text{m}$$

67. Answer (3)

Myopia with Astigmatism causes distant objects to be blurry and distorted.

68. Answer (3)



$$\sin\theta_C = \frac{1}{\mu} \Rightarrow \mu = \sqrt{2}$$

$\mu = 1.41$

$\mu_{Red} = 1.27 < 1.41$

$\Rightarrow$ Only red will emerge

69. Answer (3)

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

$$\frac{1.4}{v} + \frac{1.25}{40} = \frac{1.4 - 1.25}{-25}$$

$$\Rightarrow \quad \frac{1.4}{v} = \frac{0.15}{-25} - \frac{1.25}{40}$$

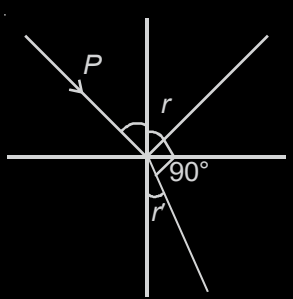
$v \simeq -37.58$ cm

70. Answer (25)

$$m_1 = 1 + \frac{D}{f} \Rightarrow f = 5 \text{ cm}$$

$$m_2 = \frac{LD}{f_o f_e} \Rightarrow f_e = \frac{LD}{f_o \times m_2} = 25 \text{ cm}$$

71. Answer (1)



$n \sin\theta_c = 1$

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

$i = r$

$r' + r + 90° = 180°$

$r' = 90° - r = 90° - i$

$\cos r' = \cos(90° - i)$

$\cos r' = \sin i$ ...(i)

$n\sin i = \sin r'$ ...(ii)

$n = \tan r'$

$\frac{1}{\sin\theta_c} = \tan r'$

$\sin\theta_c = \cot r'$

$\sin\theta_c = \tan r$

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

72. Answer (60)

For minimum deviation $r_1 = r_2 = A/2$

given $i = 2r$

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin 2r}{\sin r}$$

$$\Rightarrow \cos r = \frac{\mu}{2}$$

$\Rightarrow r = 30°$

$\Rightarrow A = 60°$

73. Answer (1)

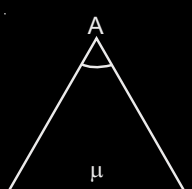
$$\theta_C = \sin^{-1}\left(\frac{1}{2.42}\right)$$

$\theta > \theta_C$

hence, refraction is not possible

74. Answer (1)

$\delta_m = A$



$$\therefore \mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\Rightarrow \mu = \frac{\sin A}{\sin\left(\frac{A}{2}\right)} = 2\cos\left(\frac{A}{2}\right)$$

$$\Rightarrow \frac{A}{2} = \cos^{-1}\left(\frac{\mu}{2}\right)$$

$$\Rightarrow A = 2\cos^{-1}\left(\frac{\mu}{2}\right)$$

75. Answer (2)

$$\frac{4}{3}\sin\theta'' = 1 \qquad \Rightarrow \sin\theta'' = \frac{3}{4}$$

$$\frac{4}{3}\sin\theta' = 1 \times \sin\theta$$

$$\Rightarrow \sin\theta = \frac{4}{3}\sqrt{1-\frac{9}{16}}$$

$$= \frac{4}{3}\sqrt{\frac{7}{16}} = \frac{\sqrt{7}}{3}$$

76. Answer (600)

For no deviation $n_1 = n_2$

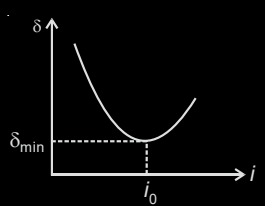
$$1.2 + \frac{10.8\times10^{-14}}{\lambda^2} = 1.45 + \frac{1.8\times10^{-14}}{\lambda^2}$$

$$0.25 = \frac{9\times10^{-14}}{\lambda^2}$$

$$\Rightarrow \lambda = \frac{3}{5}\times10^{-6} = 6\times10^{-7}\ \text{m}$$

= 600 nm

77. Answer (2)



78. Answer (2)

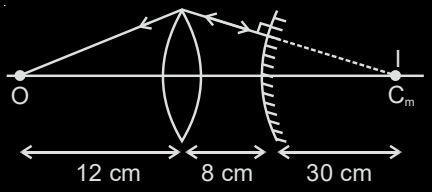
Here, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{-190} = \frac{1}{10} \Rightarrow v = \frac{19}{2}$

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

$$\Rightarrow \left(\frac{dv}{dt}\right) = -\left(\frac{\frac{19}{2}}{190}\right)^2 \times 40$$

$$= \frac{-1}{400}\times 40 = -0.1\ \text{m/s}$$

79. Answer (50)



Distance of image from object = 50 cm

80. Answer (4)

Here distance from focus

object distance, $x = \left(\frac{R}{2} + d_1\right)$

image distance, $y = \left(\frac{R}{2} - d_2\right)$

Now $xy = f^2$

$$\Rightarrow \left(\frac{R}{2} + d_1\right)\left(\frac{R}{2} - d_2\right) = \frac{R^2}{4}$$

$$\Rightarrow \frac{R^2}{4} + \frac{R}{2}(d_1 - d_2) - d_1 d_2 = \frac{R^2}{4}$$

$$\Rightarrow R = \frac{2d_1 d_2}{d_1 - d_2}$$

81. Answer (1)

1st refraction

$$\frac{1}{v_1} - \frac{1}{-30} = \frac{1}{10} \Rightarrow v_1 = 15$$

for 2nd refraction

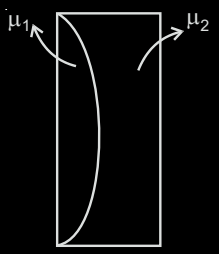
$$\frac{1}{v_2} - \frac{1}{10} = \frac{1}{-10} \Rightarrow v_2 = \infty$$

for 3rd refraction

Ray will converge at focus of L_3 at 30 cm right of it.

82. Answer (2)

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



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

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

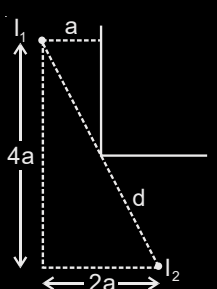
83. Answer (2)

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

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

$$m = \frac{v}{u} \Rightarrow m = \frac{1}{2}$$

84. Answer (3)



$$\therefore d = \sqrt{(2a)^2 + (4a)^2}$$

$$= 2\sqrt{5}a$$

$$= 4.6a$$

85. Answer (5)

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

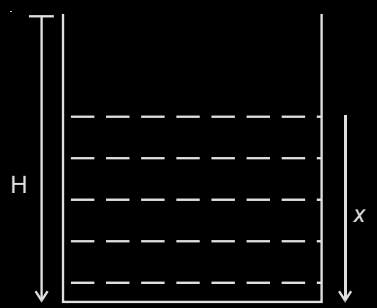
$$i = \frac{A+\delta_m}{2} = A \Rightarrow \delta_m = A$$

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

$$t = \frac{PA}{v} = \frac{0.10 \times \frac{\sqrt{3}}{2}}{3 \times \frac{10^8}{\sqrt{3}}}$$

$$= 5 \times 10^{-10} \text{ sec}$$

86. Answer (3)



$$\frac{x}{\mu} = H - x$$

$$x\left(1+\frac{1}{\mu}\right) = H$$

$$x = \frac{\mu H}{1+\mu}$$

x = 10 cm

87. Answer (10)

$$\frac{1}{f_l} = \left(\frac{\mu_e}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

here $|R_1| = |R_2| = R$

$$\Rightarrow \frac{1}{f_{l_1}} = (1.5-1)\left(\frac{2}{R}\right) = \frac{1}{15}$$

$$\Rightarrow \frac{1}{R} = \frac{1}{15} \text{ or } R = 15 \text{ cm}$$

for the concave lens made up of liquid

$$\frac{1}{f_{l_2}} = (1.25-1)\left(-\frac{2}{R}\right) = -\frac{1}{30} \text{ cm}$$

now for equivalent lens

$$\frac{1}{f_e} = \frac{2}{f_{l_1}} + \frac{1}{f_{l_2}}$$

$$= \frac{2}{15} - \frac{1}{30} = \frac{3}{30} = \frac{1}{10}$$

or f_e = 10 cm

88. Answer (4)

$n = \sqrt{K\mu} = 2$ (n $\Rightarrow$ refractive index)

So for TIR

$$\theta > \sin^{-1}\left(\frac{1}{n}\right)$$

$\theta > 30$

Only option is 60°

89. Answer (3)

Speed of light in a medium $= \frac{c}{n}$

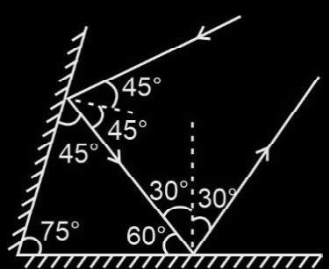
$\Rightarrow$ According to given information,

$$\frac{c}{n_A} - \frac{c}{n_B} = 2.6 \times 10^7$$

$$\Rightarrow \frac{n_B}{n_A} - 1 = \frac{2.6 \times 10^7}{3 \times 10^8} \times n_B$$

$$\Rightarrow \frac{n_B}{n_A} \simeq 1.13$$

90. Answer (210)



On first reflection angel of deviation is 90° and on second reflection angle of deviation is 120°

so total deviation is δ = 90° +120° = 210°

91. Answer (4)

According to the law,

$$1\times\sin\theta=\sqrt{2n}\times\sin\left(\frac{\theta}{2}\right)$$

$$\Rightarrow\quad \cos\frac{\theta}{2}=\sqrt{\frac{n}{2}}$$

$$\Rightarrow\quad \theta=2\cos^{-1}\left(\sqrt{\frac{n}{2}}\right)$$

92. Answer (1)

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

$$L_1:\frac{1}{f_1}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)=P_1=(\mu-1)\left(\frac{2}{R}\right)=P$$

$$L_2:\frac{1}{f_2}=(\mu-1)\left(\frac{1}{R_1}\right)=P_2=\frac{\mu-1}{R}$$

$$L_3:\frac{1}{f_3}=(\mu-1)\left(-\frac{1}{R_2}\right)=P_3=\frac{\mu-1}{R}$$

93. Answer (3)

Frequency is independent of medium. For denser medium, wavelength and speed both would decrease.

94. Answer (1)

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

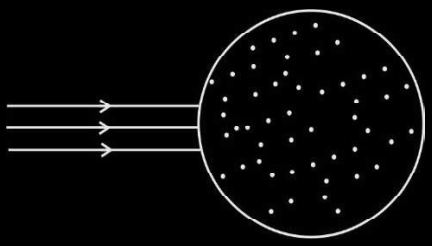
$$\Rightarrow\quad \cos A/2=\sin\left(\frac{\delta_m+A}{2}\right)$$

$$\Rightarrow\quad \frac{\pi}{2}-\frac{A}{2}=\frac{\delta_m+A}{2}$$

$\Rightarrow\quad \pi-2A=\delta_m$

Option (A) is correct

95. Answer (225)



1st refraction: $\frac{1.5}{v_1}-0=\frac{0.5}{15}$

$\Rightarrow\quad v_1 = 45$ cm

2nd refraction: $\frac{1}{v_2}-\frac{1.5}{15}=\frac{-0.5}{-15}$

$$\Rightarrow\quad \frac{1}{v_2}=\frac{1}{30}+\frac{1}{10}=\frac{4}{30}$$

$\Rightarrow\quad v_2 = +7.5$ cm

$\Rightarrow$ Distance from centre = 22.5 cm

96. Answer (4)

$$\mu_A=\frac{3\times10^8}{2\times10^8}=1.5$$

$$\mu_B=\frac{3\times10^8}{1.5\times10^8}=2$$

For TIR

$\theta > i_c$

$$\theta>\sin^{-1}\left(\frac{1.5}{2}\right)$$

$$\theta>\sin^{-1}\left(\frac{3}{4}\right)$$

97. Answer (1)

In primary rainbow, observer sees red colour on the top and violet on the bottom.

98. Answer (2)

The shift produced by the glass plate is

$$d=t\left(1-\frac{1}{\mu}\right)=1\times\left(1-\frac{1}{1.5}\right)=\frac{1}{3}\text{ cm}$$

So final image must be produced at $\left(12-\frac{1}{3}\right)\text{cm}=\frac{35}{3}$ cm from lens so that glass plate must shift it to produce image at screen. So

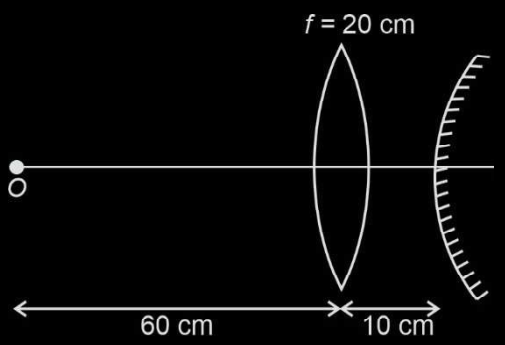
$$\frac{1}{12}-\frac{1}{-240}=\frac{1}{f}=\frac{1}{35/3}-\frac{1}{u}$$

$$\frac{1}{u}=\frac{3}{35}-\frac{1}{12}-\frac{1}{240}$$

or u = – 560 cm

so shift = 5.6 – 2.4 = 3.2 m

99. Answer (10)



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

$$\frac{1}{v}-\frac{1}{-60}=\frac{1}{20}$$

$$\frac{1}{v}=-\frac{1}{60}+\frac{1}{20}=\frac{-1+3}{60}=\frac{2}{60}$$

$\Rightarrow$ v = +30 cm

$\Rightarrow$ Radius of curvature of mirror = 30 – 10 = 20 cm

$$\Rightarrow \quad f_{mirror}=\frac{20}{2}=10 \text{ cm}$$

100. Answer (10)

f = 10 cm

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

$$\frac{1}{10}=\frac{1.5-1}{1}\times\frac{2}{R}$$

$$\frac{1}{10}=\frac{1}{R}$$

R = 10 cm

101. Answer (27)

1.5 sin60° = 4 sin90°

$$1.5\times\frac{\sqrt{3}}{2}=\frac{3\sqrt{3}}{4}=\frac{\sqrt{27}}{4}=\frac{\sqrt{x}}{4}$$

x = 27

102. Answer (4)

$$\delta_{net}=\delta_1+\delta_2$$

$$=|(\mu_1-1)A_1-(\mu_2-1)A_2|$$

$$=|3°-2.75°|$$

$$\delta_{net}=\frac{1°}{4}$$

$\Rightarrow$ x = 4

103. Answer (1)

$$\because \quad m=\frac{f_o}{f_e}$$

$$\Rightarrow \quad 2=\frac{f_o}{f_e} \qquad \text{...(i)}$$

and, $l = f_o + f_e$

$\Rightarrow$ $30 = f_o + f_e$ ...(ii)

$$\Rightarrow \quad 30=f_o+\frac{f_o}{2}$$

$$\Rightarrow \quad 30\times\frac{2}{3}=f_o$$

$\Rightarrow$ $f_o = 20$ cm

104. Answer (2)

$$\because \quad \frac{1}{f}=\left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1.25}{100}=\left(\frac{1.5}{\mu_1}-1\right)\left(\frac{1}{20}+\frac{1}{40}\right)$$

$$\Rightarrow \frac{1}{80}=\left(\frac{1.5}{\mu_1}-1\right)\times\frac{(4+2)}{80}$$

$$\Rightarrow \frac{1.5}{\mu_1}-1=\frac{1}{6}$$

$$\Rightarrow \frac{1.5}{\mu_1}=\frac{7}{6}$$

$$\Rightarrow \mu_1=\frac{1.5\times6}{7}=\frac{9}{7}$$

105. Answer (400)

The object after 10 second will be at u = –80 cm.

So $\frac{1}{v}-\frac{1}{80}=-\frac{1}{100}\Rightarrow v=\frac{8000}{+20}=400$ cm

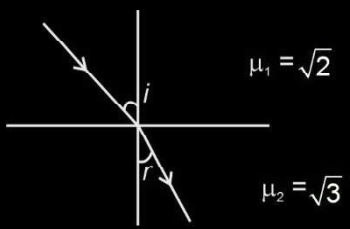
106. Answer (15)

Using Newton's formula for lenses,

$\nu'\mu' = f^2 = 225 \Rightarrow f = 15$

107. Answer (15)

Normal will be $-\hat{k}$ so



$\cos i=\frac{\vec{P}\cdot\hat{n}}{|\vec{P}|\cdot|\hat{n}|}$

$\frac{5}{10}=\frac{1}{2}$

$\Rightarrow$ i = 60°

and using snells law

$\sqrt{2}\sin 60°=\sqrt{3}\sin r$

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

$\Rightarrow$ r = 45°

So, i – r = 15°

108. Answer (3)

1 × sin45° = μ × sin30°

$\Rightarrow \mu=\frac{1}{\sqrt{2}}\times\frac{2}{1}$

$\mu=\sqrt{2}$

= 1.414

109. Answer (1)

Critical angle between them

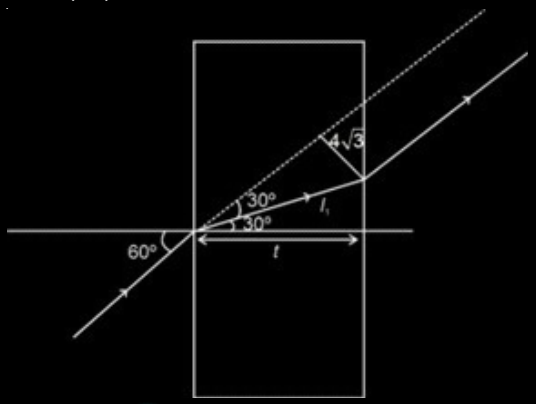
$\sin i_c=\frac{\mu_2}{\mu_1}=\frac{v_1}{v_2}$

$\sin i_c=\frac{3}{4}$

$\Rightarrow \tan i_c=\frac{3}{\sqrt{7}}$

$i_c=\tan^{-1}\frac{3}{\sqrt{7}}$

110. Answer (12)



$1\times\sin 60°=\sqrt{3}\times\sin r$

$\Rightarrow$ r = 30°

$\therefore$ $l_1=4\sqrt{3}\times 2$

$=8\sqrt{3}$ cm

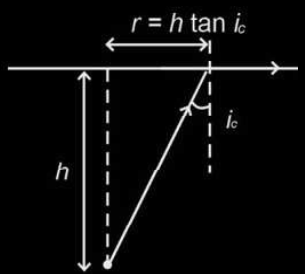
$\therefore$ Thickness, $t = l_1\cos 30°$

$=8\sqrt{3}\times\frac{\sqrt{3}}{2}$

= 4 × 3

= 12 cm

111. Answer (9)



So $r=h\frac{\sin i_c}{\sqrt{1-\sin^2 i_c}}$

So $A = \pi r^2$

$=\frac{\pi h^2\sin^2 i_c}{1-\sin^2 i_c}$

$=\frac{\pi 7\times\frac{9}{16}}{1-\frac{9}{16}}=\frac{\pi\times 7\times 9}{7}=9\pi$

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