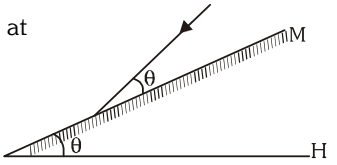
EXERCISE–01 CHECK YOUR GRASP

1. Two plane mirrors M_1 and M_2 are inclined to each other at 70 . A ray incident on the mirror M_1 at an angle θ falls on M_2 and is then reflected parallel to M_1 for

(A) $\theta=45$ (B) $\theta=50$ (C) $\theta=55$ (D) $\theta=60$

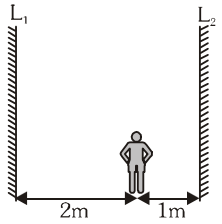
2. A mirror is inclined at an angle of θ with the horizontal. If a ray of light is incident at an angle θ as shown, then the angle made by reflected ray with the horizontal is



(A) θ (B) 2θ

(C) $\frac{\theta}{2}$ (D) zero

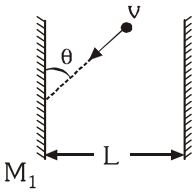
3. Two mirrors labelled L_1 for left mirror and L_2 for right mirror in the figure are parallel to each other and 3.0 m apart . A person standing 1.0 m from the right mirror (L_2) looks into this mirror and sees a series of images. The second nearest image seen in the right mirror is situated at a distance :



(A) 2.0 m from the person (B) 4.0 m from the person

(C) 6.0 m from the person (D) 8.0 m from the person

4. A bird is flying with a velocity v between two long vertical plane mirrors making an angle θ with mirror M_1 as shown. Then what will be the relative velocity of approach between the images formed by the mirrors due to the 1st reflection in each of them



(A) $v\sin\theta$ (B) $2v\sin\theta$

(C) $2(v\sin\theta+L)$ (D) zero

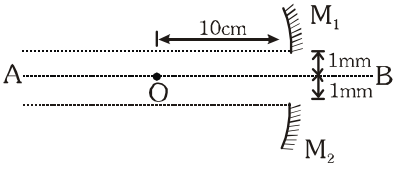
5. A plane mirror is moving with velocity $4\tilde{i}+5\tilde{j}+8\tilde{k}$ .The point object in front of the mirror moves with a velocity $3\tilde{i}+4\tilde{j}+5\tilde{k}$ .Here $\tilde{k}$ is along the normal to the plane mirror and facing towards the object. The velocity of the images is :

(A) $-3\tilde{i}-4\tilde{j}+5\tilde{k}$ (B) $3\tilde{i}+4\tilde{j}+11\tilde{k}$ (C) $-3\tilde{i}-4\tilde{j}+11\tilde{k}$ (D) $7\tilde{i}+4\tilde{j}+11\tilde{k}$

6. The distance of an object from a spherical mirror is equal to the focal length of the mirror. Then the image:

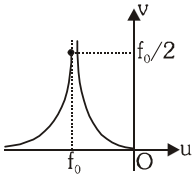
(A) must be at infinity (B) may be at infinity (C) may be at the focus (D) none

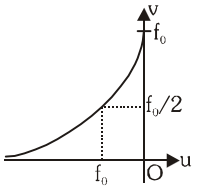
7. A concave mirror of focal length 20 cm is cut into two parts from the middle and the two parts are moved perpendicularly by a distance 1 mm from the previous principal axis AB. The distance between the images formed by the two parts is :

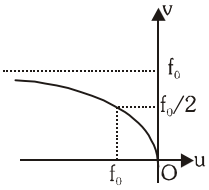


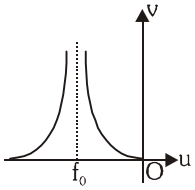
(A) 2 mm (B) 6 mm (C) 3 mm (D) 4 mm

8. A convex mirror of focal length 'f' is placed at the origin with its reflecting surface towards the negative x–axis. Choose the correct graphs between 'v' and 'u' for u < 0.

(A) 

(B) 

(C) 

(D) 

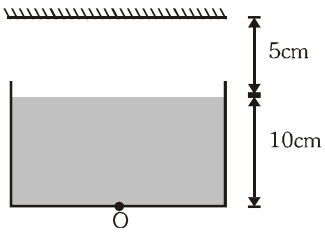
9. The x–z plane separates two media A and B of refractive indices μ_1 = 1.5 and μ_2 = 2. A ray of light travels from A to B. Its directions in the two media are given by unit vectors $\vec{u}_1=a\tilde{i}+b\tilde{j}$ and $\vec{u}_2=c\tilde{i}+d\tilde{j}$. Then–

(A) $\frac{a}{c}=\frac{4}{3}$ (B) $\frac{a}{c}=\frac{3}{4}$ (C) $\frac{b}{d}=\frac{4}{3}$ (D) $\frac{b}{d}=\frac{3}{4}$

10. A ray of light travelling in a medium of refractive index μ is incident at an angle θ on a composite transparent plate consisting of 50 plates of R.I. $1.01\,\mu$, $1.02\,\mu$, $1.03\,\mu$, ... , $1.50\,\mu$. The ray emerges from the composite plate into a medium of refractive index $1.6\,\mu$ at angle 'x' . Then :

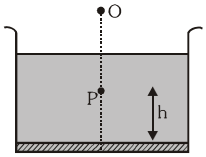
(A) $\sin x = \left(\frac{1.01}{1.5}\right)^{50} \sin\theta$ (B) $\sin x = \frac{5}{8}\sin\theta$ (C) $\sin x = \frac{8}{5}\sin\theta$ (D) $\sin x = \left(\frac{1.5}{1.01}\right)^{50} \sin\theta$

11. Consider the situation shown in figure. Water $\left(\mu_w = \frac{4}{3}\right)$ is filled in a beaker upto a height of 10 cm. A plane mirror is fixed at a height of 5 cm from the surface of water. Distance of image from the mirror after reflection from it of an object O at the bottom of the beaker is–



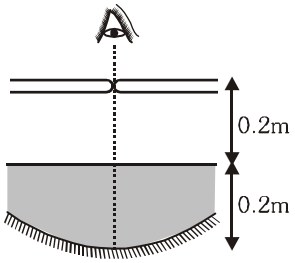
(A) 15 cm (B) 12.5 cm (C) 7.5 cm (D) 10 cm

12. A plane mirror is placed at the bottom of a tank containing a liquid of refractive index μ. P is a small object at a height h above the mirror. An observer O–vertically above P, outside the liquid–sees P and its image in the mirror. The apparent distance between these two will be :–



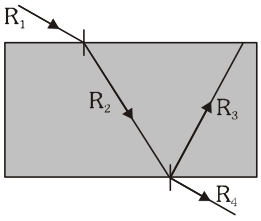
(A) $2\mu h$ (B) $\frac{2h}{\mu}$ (C) $\frac{2h}{\mu - 1}$ (D) $h\left(1 + \frac{1}{\mu}\right)$

13. When a pin is moved along the principal axis of a small concave mirror, the image position coincides with the object at a point 0.5 m from the mirror, refer figure. If the mirror is placed at a depth of 0.2 m in a transparent liquid, the same phenomenon occurs when the pin is placed 0.4 m from the mirror. The refractive index of the liquid is :–



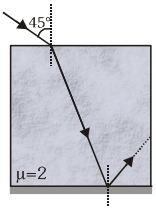
(A) 6/5 (B) 5/4 (C) 4/3 (D) 3/2

14. A ray R_1 is incident on the plane surface of the glass slab (kept in air) of refractive index $\sqrt{2}$ at an angle of incidence equal to the critical angle for this air glass system. The refracted ray R_2 undergoes partial reflection and refraction at the other surface. The angle between reflected ray R_3 and the refracted ray R_4 at that surface is :–



(A) 45 (B) 135 (C) 105 (D) 75

15. Bottom face of the glass cube is silvered as shown . A ray of light is incident on top face of the cube as shown. Find the deviation of the ray when it comes out of the glass cube.



(A) 0 (B) 90
(C) 180 (D) 270

16. A ray of light travels from an optical denser medium to rarer medium . The critical angle for the two media is C. The maximum possible deviation of the refracted light ray can be :–

(A) $\pi - C$ (B) $2C$ (C) $\pi - 2C$ (D) $\frac{\pi}{2} - C$

17. A ray of light from a denser medium strike a rarer medium. The angle of reflection is r and that of refraction is r′. The reflected and refracted rays make an angle of 90 with each other. The critical angle will be:

(A) $\sin^{-1}(\tan r)$ (B) $\tan^{-1}(\sin r)$ (C) $\sin^{-1}(\tan r')$ (D) $\tan^{-1}(\sin r')$

18. An object is immersed in a fluid. In order that the object becomes invisible, it should :

(A) behave as a perfect reflection (B) absorb all light falling on it (C) have refractive index one

(D) have refractive index exactly matching with that of the surrounding fluid

19. A ray of light is incident upon an air/water interface (it passes from air into water) at an angle of 45 . Which of the following quantities change as the light enters the water?

(I) wavelength (II) frequency (III) speed of propagation (IV) direction of propagation

(A) I, III only (B) III, IV only (C) I, II, IV only (D) I, III, IV only

20. A light ray is incident on a transparent sphere of index= $\sqrt{2}$, at an angle of incidence = 45 . What is the deviation of a tiny fraction of the ray , which enters the sphere , undergoes two internal reflections and then refracts out into air ?

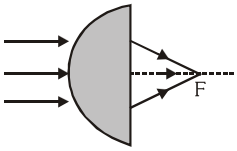
(A) 270 (B) 240 (C) 120 (D) 180

21. An air bubble is inside water. The refractive index of water is 4/3. At what distance from the air bubble should a point object be placed so as to form a real image at the same distance from the bubble :–

(A) 2R (B) 3R

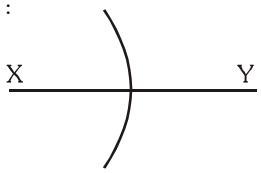
(C) 4R (D) The air bubble cannot form a real image

22. A paraxial beam is incident on a glass (n = 1.5) hemisphere of radius R=6 cm in air as shown. The distance of point of convergence F from the plane surface of hemisphere is :–



(A) 12 cm (B) 5.4 cm (C) 18 cm (D) 8 cm

23. A concave spherical surface of radius of curvature 10 cm, separates two medium X and Y of R.I. 4/3 and 3/2 respectively. If the object is placed along principal axis in medium X , then :



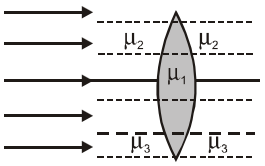
(A) image is always real

(B) image is real if the object distance is greater than 90 cm

(C) image is always virtual

(D) image is virtual if the object distance is less than 90 cm

24. A double convex lens, made of a material of refractive index μ_1, is placed inside two liquids of refractive indices μ_2 and μ_3, as shown. $\mu_2 > \mu_1 > \mu_3$. A wide, parallel beam of light is incident on the lens from the left. The lens will give rise to :–



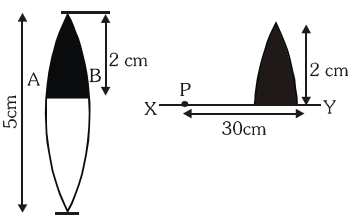
(A) a single convergent beam (B) two different convergent beams

(C) two different divergent beams (D) a convergent and a divergent beam

25. Optic axis of a thin equiconvex lens is the x–axis. The coordinates of a point object and its image are (–40 cm, 1 cm) and (50 cm, –2 cm) respectively. Lens is located at–

(A) x = + 20 cm (B) x = – 30 cm (C) x = –10 cm (D) origin

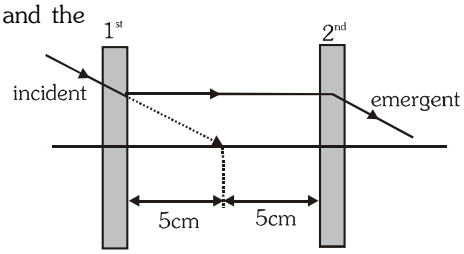
26. A converging lens of focal length 20 cm and diameter 5 cm is cut along the line AB. The part of the lens shown shaded in the diagram is now used to form an image of a point P placed 30 cm away from it on the line XY which is perpendicular to the plane of the lens. The image of P will be formed.



(A) 0.5 cm above XY (B) 1 cm below XY

(C) on XY (D) 1.5 cm below XY

27. Look at the ray diagram shown, what will be the focal length of the 1st and the 2nd lens, if the incident light ray passes without any deviation ?



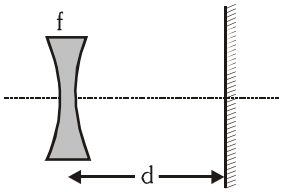
(A) –5 cm and +10 cm

(B) +5cm and +10cm

(C) –5cm and +5cm

(D) +5cm and – 5cm

28. A diverging lens of focal length 10 cm is placed 10 cm in front of a plane mirror as shown in the figure. Light from a very far away source falls on the lens. The final image is at a distance :–



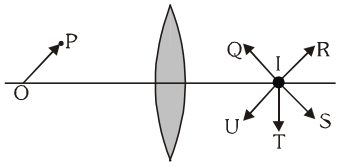
(A) 20 cm behind the mirror

(B) 7.5 cm in front of the mirror

(C) 7.5 cm behind the mirror

(D) 2.5 cm in front of the mirror

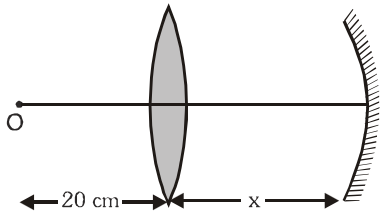
29. A point object O moves from the principal axis of a converging lens in a direction OP. I the image of O, will move initially in the direction :



(A) IQ (B) IR

(C) IS (D) IU

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



(A) 10 cm

(B) 15 cm

(C) 20 cm

(D) final image can never coincide with the object in the given conditions

31. A point source of light is placed on the principle axis between F and 2F of a concave lens. On the other side very far, a screen is placed perpendicular to principal axis. As the screen is brought close towards lens

(A) the light intensity on screen continuously decreases

(B) the light intensity on screen continuously increases

(C) the light intensity on screen first increases, then decreases

(D) the light intensity on screen first decreases, then increases

32. A man wishing to get a picture of a Zebra photographed a white donkey after fitting a glass with black streaks onto the objective of his camera.

(A) the image will look like a white donkey on the photograph

(B) the image will look like a Zebra on the photograph

(C) the image will be more intense compared to the case in which no such glass is used

(D) the image will be less intense compared to the case in which no such glass is used

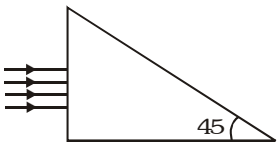
33. A lens is placed between a source of light and a wall. It forms images of area A_1 and A_2 on the wall, for its two different positions. The area of the source of light is :

(A) $\sqrt{A_1A_2}$ (B) $\frac{A_1+A_2}{2}$ (C) $\left(\frac{\sqrt{A_1}+\sqrt{A_2}}{2}\right)^2$ (D) None

34. In the displacement method , a convex lens is placed in between an object and a screen . If one of the magnification is 3 and the displacement of the lens between the two positions is 24 cm, then the focal length of the lens is :–

(A) 10 cm (B) 9 cm (C) 6 cm (D) 16/3 cm

35. A beam of light consisting of red, green and blue and is incident on a right angled prism. The refractive index of the material of the prism for the above red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. The prism will–



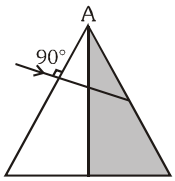
(A) separate part of the red color from the green and blue colors

(B) separate part of the blue color from the red and green colors

(C) separate all the three colors from the other two colors

(D) not separate even partially, any colors from the other two colors

36. A ray of light is incident normally on the first refracting face of the prism of refracting angle A. The ray of light comes out at grazing emergence. If one half of the prism (shaded position) is knocked off, the same ray will :–



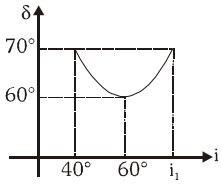
(A) Emerge at an angle of emergence $\sin^{-1}\left(\frac{1}{2}\sec A/2\right)$

(B) Not emerge out of the prism

(C) Emerge at an angle of emergence $\sin^{-1}\left(\frac{1}{2}\sec A/4\right)$

(D) None of these

37. The curve of angle of incidence versus angle of deviation shown has been plotted for prism. The value of refractive index of the prism used is :



(A) $\sqrt{3}$ (B) $\sqrt{2}$ (C) $\frac{\sqrt{3}}{\sqrt{2}}$ (D) $\frac{2}{\sqrt{3}}$

38. A beam of monochromatic light is incident at i = 50 on one face of an equilateral prism, the angle of emergence is 40 , then the angle of minimum deviation is :

(A) 30 (B) < 30 (C) ≤ 30 (D) ≥ 30

39. A parallel beam of white light falls on a convex lens . Images of blue , red and green light are formed on other side of the lens at distances x , y and z respectively from the pole of the lens . Then :

(A) x > y > z (B) x > z > y (C) y > z > x (D) None of these

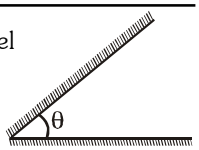
40. Which of the following quantities related to a lens does not depend on the wavelength of the incident light ?

(A) Refractive index (B) Focal length (C) Power (D) Radii of curvature

CHECK YOUR GRASP **ANSWER KEY** EXERCISE -1

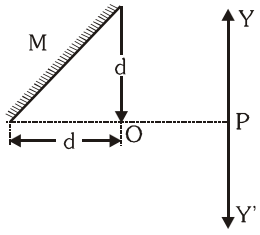
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	B	D	C	D	B	B	A	C	A	B	B	B	D	C	C	D	A	D	D	A
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	D	D	C	D	C	D	C	D	C	C	B	AD	A	B	A	A	A	B	C	D

1. Two mirrors are inclined at an angle θ as shown in the figure. Light ray is incident parallel to one of the mirrors. The ray will start retracting its path after third reflection if



(A) θ = 45 (B) θ = 30
(C) θ = 60 (D) all three

2. As shown in the figure a particle is placed at O in front of a plane mirror M.A man at P can move along path PY and PY' then which of the following is true?

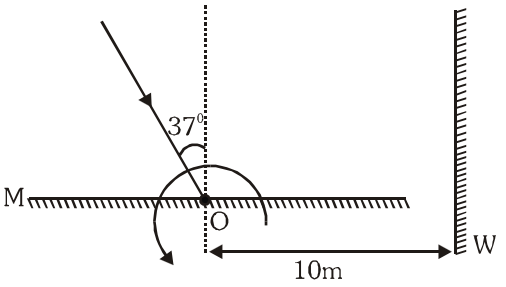


(A) For all points on PY man can see the image of O
(B) For all points on PY' man can see the image, but for no point on PY he can see the image of O
(C) For all points on PY' he can see the image but on PY he can see the image only upto distance d.
(D) He can see the image only upto a distance d on either side of P.

3. Two plane mirrors are placed parallel to each other at a distance L apart. A point object O is placed between them, at a distance L/3 from one mirror. Both mirrors form multiple images. The distance between any two images cannot be

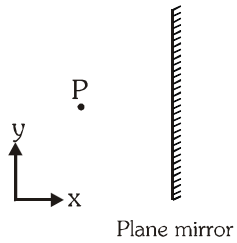
(A) 3L/2 (B) 2L/3 (C) 2L (D) None of these

4. A light ray I is incident on a plane mirror M. The mirror is rotated in the direction as shown in the figure by an arrow at frequency $9/\pi$ rev/s. The light reflected by the mirror is received on the wall W at a distance 10 m from the axis of rotation. When the angle of incidence becomes 37 the speed of the spot (a point) on the wall is :



(A) 10 m/s (B) 1000 m/s
(C) 360 m/s (D) none of these

5. Shown plane mirror is lying in y–z plane. A particle P has velocity $\vec{u} = 5\tilde{i} + 6\tilde{j}$ at t = 0 & acceleration $\vec{a} = 2t\tilde{j}$. Velocity of its image at t = 2s relative to it is

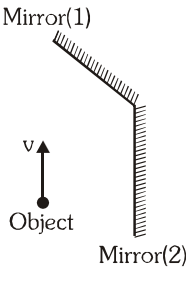


(A) $10\tilde{i}$ (B) $-10\tilde{i}$
(C) $20\tilde{j}$ (D) $-20\tilde{j}$

6. There are two plane mirror with reflecting surfaces facing each other. Both the mirrors are moving with speed v away from reach other. A point is placed between the mirrors. The velocity of the image from due to n–th reflection will be–

(A) nv (B) 2nv (C) 3nv (D) 4nv

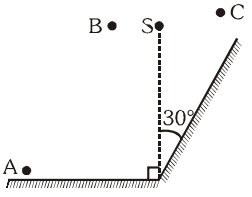
7. In the diagram shown, all the velocities are given with respect to earth. What is the relative velocity of the image in mirror (1) with respect to the image in the mirror (2) ? The mirror (1) forms an angle β with the vertical.



(A) 2v sin2β (B) 2vsinβ
(C) 2v/sin2β (D) None of these

8. A point source of light S is placed in front of two large mirrors as shown.

Which of the following observers will see only one image of S ?

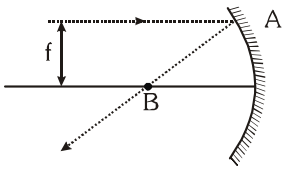


(A) only A (B) only C
(C) Both A and C (D) Both B and C

9. A ray reflected successively from two plane mirrors inclined at a certain angle (< 90) undergoes a deviation of 300 . The number of images observable are :

(A) 10 (B) 11 (C) 12 (D) 14

10. A ray of light is incident on a concave mirror. It is parallel to the principal axis and its height from principal axis is equal to the focal length of the mirror. The ratio of the distance of point B to the distance of the focus from the centre of curvature is (AB is the reflected ray)



(A) $\frac{2}{\sqrt{3}}$ (B) $\frac{\sqrt{3}}{2}$ (C) $\frac{2}{3}$ (D) $\frac{1}{2}$

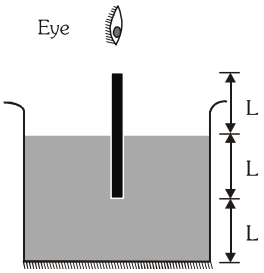
11. An infinitely long rod lies along the axis of a concave mirror of focal length f. The near end of the rod is at distance u > f from the mirror. Its image will have a length–

(A) $\frac{uf}{u-f}$ (B) $\frac{uf}{u+f}$ (C) $\frac{f^2}{u+f}$ (D) $\frac{f^2}{u-f}$

12. A short linear object of length b lies along the axis of a concave mirror of focal length f, at a distance u from the mirror. The size of the image is approximately–

(A) $b\left(\frac{u-f}{f}\right)^{1/2}$ (B) $b\left(\frac{f}{u-f}\right)$ (C) $b\left(\frac{u-f}{f}\right)$ (D) $b\left(\frac{f}{u-f}\right)^2$

13. What is the length of the image of the rod in mirror, according to the observer in air? (refractive index of the liquid is μ)



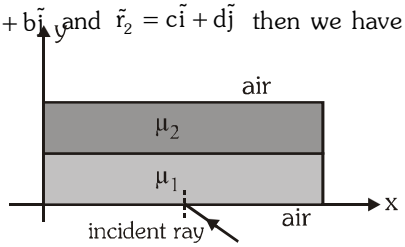
(A) μL + L

(B) $L + \frac{L}{\mu}$

(C) $L\mu + \frac{L}{\mu}$

(D) None of these

14. Two thin slabs of refractive indices μ_1 and μ_2 are placed parallel to each other in the x–y plane. If the direction of propagation of a ray in the two media are along the unit vectors $\tilde{r}_1 = a\tilde{i} + b\tilde{j}$ and $\tilde{r}_2 = c\tilde{i} + d\tilde{j}$ then we have



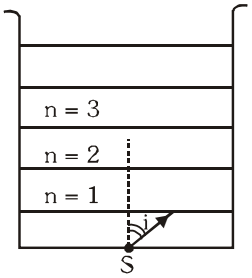
(A) $\mu_1 a = \mu_2 c$

(B) $\mu_1(a^2 + b^2) = \mu_2(c^2 + d^2)$

(C) $\mu_1 a / \sqrt{a^2 + b^2} = \mu_2 a / \sqrt{c^2 + d^2}$

(D) None of these

15. A point source S is placed at the bottom of different layers as shown in the figure. The refractive index of bottommost layer is μ_0. The refractive index of any other upper layer is $\mu(n) = \mu_0 + \frac{\mu_0}{4n-18}$ A ray of light with angle i = 30 starts from the source S. Total internal reflection takes place at the upper surface of layer having n equal to

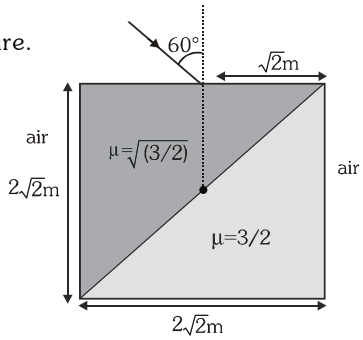


(A) 3 (B) 5 (C) 4 (D) 6

16. A ray of light in a liquid of refractive index 1.4 approaches the boundary surface between the liquid and air at an angle of incidence whose sine is 0.8 . Which of the following statement is correct about the behaviors of the light ?

(A) It is impossible to predict the behavior of the light ray on the basis of the information supplied.
(B) The sine of the angle of refraction of the emergent ray will be less than 0.8
(C) The ray will be internally reflected
(D) The sine of the angle of refraction of the emergent ray will be greater than 0.8

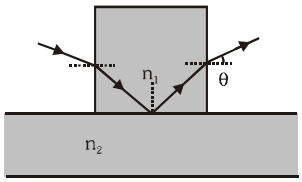
17. A ray of light strikes a cubical slab surrounded by air as shown in the figure. Then the geometrical path length traversed by the light in the slab will be :



(A) $2\sqrt{3}$ m (B) 2m

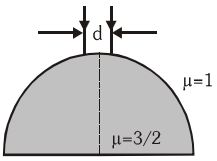
(C) 6m (D) $\left(\frac{\sqrt{3}}{2}+\frac{3}{2}\right)$ m

18. A cubical block of glass of refractive index n_1 is in contact with the surface of water of refractive index n_2. A beam of light is incident on vertical face of the block (see figure). After refraction, a total internal reflection at the base and refraction at the opposite vertical face, the ray emerges out at an angle θ. The value of θ is given by–



(A) $\sin\theta < \sqrt{n_1^2 - n_2^2}$ (B) $\tan\theta < \sqrt{n_1^2 - n_2^2}$ (C) $\sin\theta < \frac{1}{\sqrt{n_1^2 - n_2^2}}$ (D) $\tan\theta < \frac{1}{\sqrt{n_1^2 - n_2^2}}$

19. A beam of diameter 'd' is incident on a glass hemisphere as shown. If the radius of curvature of the hemisphere is very large in comparison to d, then the diameter of the beam at the base of the hemisphere will be :

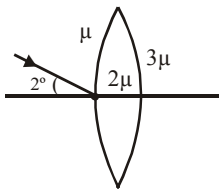


(A) $\frac{3}{4}$d (B) d (C) $\frac{d}{3}$ (D) $\frac{2}{3}$d

20. When the object is at distances u_1 and u_2 the images formed by the same lens are real and virtual respectively and of the same size. Then focal length of the lens is :

(A) $\frac{1}{2}\sqrt{u_1 u_2}$ (B) $\frac{u_1 + u_2}{2}$ (C) $\sqrt{u_1 u_2}$ (D) $\sqrt{(u_1 + u_2)}$

21. A light ray hits the pole of a thin biconvex lens as shown in figure. The angle made by the emergent ray with the optic axis will be nearly



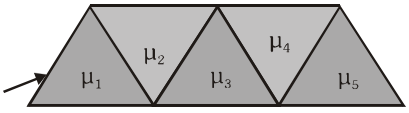
(A) 0 (B) (1/3)

(C) (2/3) (D) 2

22. A ray of light passes through a prism in a principle plane the deviation being equal to angle of incidence which is equal to 2α. It is given that α is the angle of prism and μ is the refractive index of the material of prism, then

(A) $\cos\alpha = \sqrt{\frac{\mu^2 - 1}{2}}$ (B) $\cos\alpha = \sqrt{\frac{\mu^2 - 1}{8}}$ (C) $\sin\alpha = \sqrt{\mu^2 - 1}$ (D) $\sin\alpha = \sqrt{\frac{\mu^2 - 1}{8}}$

23. The diagram shows five isosceles right angled prisms. A light ray incident at 90 at the first face emerges at same angle with the normal from the last face. Which of the following relations will hold regarding the refractive indices ?



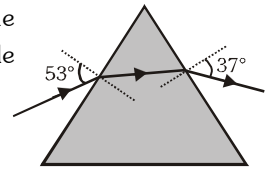
(A) $\mu_1^2 + \mu_3^2 + \mu_5^2 = \mu_2^2 + \mu_4^2$ (B) $\mu_1^2 + \mu_3^2 + \mu_5^2 = 1 + \mu_2^2 + \mu_4^2$

(C) $\mu_1^2 + \mu_3^2 + \mu_5^2 = 2 + \mu_2^2 + \mu_4^2$ (D) none of these

24. A certain prism is found to produce a minimum deviation of 38 . It produces a deviation of 44 when the angle of incidence is either 42 or 62 . What is the angle of incidence when it is undergoing minimum deviation ?

(A) 45 (B) 49 (C) 40 (D) 55

25. A ray incident at an angle 53 on a prism emerges at an angle 37 as shown. If the angle of incidence is made 50 , which of the following is a possible value of the angle of emergence?

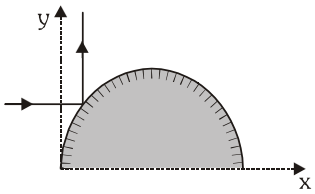


(A) 35 (B) 42
(C) 40 (D) 38

26. A man of height 170 cm wants to see his complete image in a plane mirror (while standing) . His eyes are at a height of 160 cm from the ground .
(A) Minimum length of the mirror = 80 cm
(B) Minimum length of the mirror = 85 cm
(C) Bottom of the mirror should be at a height 80 cm
(D) Bottom of the mirror should be at a height 85 cm

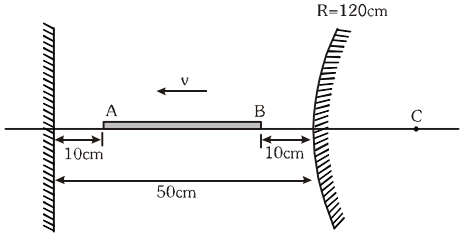
27. Two plane mirrors at an angle such that a ray incident on a mirror undergoes a total deviation of 240 after two reflections :
(A) the angle between the mirrors is 60
(B) the number of images formed by this system will be 5 , if an object is placed symmetrically between the mirrors
(C) the number of images will be 5 if an object is kept unsymmetrical between the mirrors
(D) a ray will retrace its path after 2 successive reflections, if the angle of incidence on one mirror is 60^{o}

28. If the equation of mirror is given by $y = 2/\pi \sin\pi x$ $(y > 0,\ 0 \le x \le 1)$ then find the point on which horizontal ray should be incident so that the reflected ray become perpendicular to the incident ray



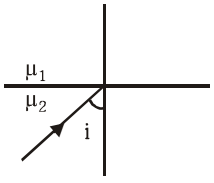
(A) $\left(\frac{1}{3}, \frac{\sqrt{3}}{\pi}\right)$ (B) $\left(\frac{\sqrt{3}}{\pi}, \frac{1}{3}\right)$ (C) $\left(\frac{2}{3}, \frac{\sqrt{3}}{\pi}\right)$ (D) (1,0)

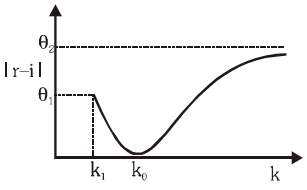
29. In the fig. shown consider the first reflection at the plane mirror and second at the convex mirror. AB is object.



(A) the second image is real and inverted with magnification 1/5
(B) the second image is virtual and erect with magnification 1/5
(C) the second image moves towards the convex mirror
(D) the second image moves away from the convex mirror

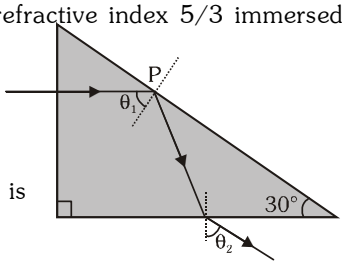
30. The figure shows a ray incident on a plane boundary at an angle $i = \pi/3$. The plot drawn shows the variation of $|r - i|$ versus $\frac{\mu_1}{\mu_2} = k$ (r = angle of refraction). Choose the correct alternative.





(A) The value of k_1 is $\frac{2}{\sqrt{3}}$
(B) The value of θ_1 is $\pi/6$
(C) The value of θ_2 is $\pi/3$
(D) The value of k_0 is 1

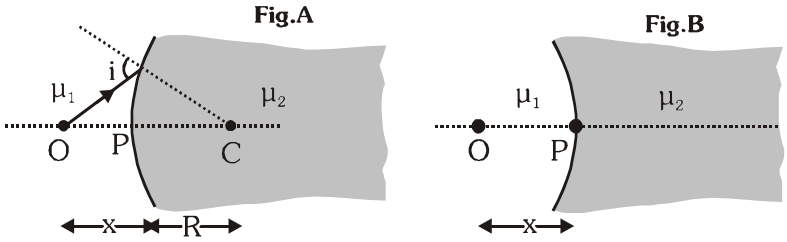
31. A ray of light is incident normally on one face of 30 – 60 – 90 prism of refractive index 5/3 immersed in water of refractive index 4/3 as shown in figure .



(A) The exit angle θ_2 of the ray is $\sin^{-1}(5/8)$
(B) The exit angle θ_2 of the ray is $\sin^{-1}\left(\frac{5}{4\sqrt{3}}\right)$
(C) Total internal reflection at point P ceases if the refractive index of water is increased to $\frac{5}{2\sqrt{3}}$ by dissolving some substance
(D) Total internal reflection at point P ceases if the refractive index of water is increased to 5/6 by dissolving some substance

Question No.32 to 34

A curved surface of radius R separates two medium of refractive indices μ_1 and μ_2 as shown in figures A and B.

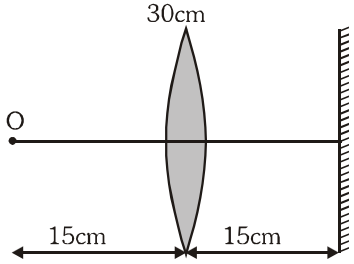


32. Choose the correct statement(s) related to the real image formed by the object O placed at a distance x, as shown in figure A.
(A) Real image is always formed irrespective of the position of object if $\mu_2 > \mu_1$
(B) Real image is formed only when x>R
(C) Real image is formed due to the convex nature of the interface irrespective of μ_1 and μ_2
(D) None of these

33. Choose the correct statement(s) related to the virtual image formed by object O placed at a distance x, as shown in figure A
(A) Virtual image is formed for any position of O if $\mu_2 < \mu_1$
(B) Virtual image can be formed if $x > R$ and $\mu_2 < \mu_1$
(C) Virtual image is formed if $x < R$ and $\mu_2 > \mu_1$
(D) None of these

34. Identify the correct statement(s) related to the formation of images of a real object O placed at x from the pole of the concave surface, as shown in figure B
(A) If $\mu_2 > \mu_1$, then virtual image is formed for any value of x
(B) If $\mu_2 < \mu_1$, then virtual image is formed if $x < \dfrac{\mu_1 R}{\mu_1 - \mu_2}$
(C) If $\mu_2 < \mu_1$, then real image is formed for any value of x
(D) None of these

35. An object O is kept infront of a converging lens of focal length 30 cm behind which there is a plane mirror at 15 cm from the lens.
(A) The final image is formed at 60 cm from the lens towards right of it
(B) The final image is at 60 cm from lens towards left of it
(C) The final image is real
(D) The final image is virtual



36. A converging lens of focal length f_1 is placed in front of and coaxial with a convex mirror of focal length f_2. Their separation is d. A parallel beam of light incident on the lens returns as a parallel beam from the arrangement–
(A) The beam diameters of the incident and reflected beams must be the same
(B) $d = |f_1| - 2|f_2|$
(C) $d = |f_1| - |f_2|$
(D) If the entire arrangement is immersed in water, the conditions will remain unaltered

37. Choose the correct alternative corresponding to the object distance 'u', image distance 'v' and the focal length 'F' of a converging lens from the following.
(i) The average speed of the image as the object moves with uniform speed from distance $\dfrac{3F}{4}$ to $\dfrac{F}{2}$ is greater than the average speed of the image as the object moves with same speed from distance $\dfrac{F}{2}$ to $\dfrac{F}{4}$
(ii) The minimum distance between a real object and its real image in case of a converging lens is 4F where F is its focal length.
(A) both are correct
(B) both are incorrect
(C) (i) is correct, (ii) is incorrect
(D) (i) is incorrect, (ii) is correct

38. An object and a screen are fixed at a distance d apart. When a lens of focal length f is moved between the object and the screen, sharp images of the object are formed on the screen for two positions of the lens. The magnifications produced at these two positions are M_1 and M_2–

(A) $d > 2f$ (B) $d > 4f$ (C) $M_1M_2 = 1$ (D) $|M_1| - |M_2| = 1$

39. A diminished image of an object is to be obtained on a large screen 1 m from it. This can be achieved by

(A) using a convex mirror of focal length less than 0.25 m

(B) using a concave mirror of focal length less than 0.25 m

(C) using a convex lens of focal length less than 0.25 m

(D) using a concave lens of focal length than 0.25 m

40. A convex lens forms an image of an object on a screen. The height of the image is 9 cm. The lens is now displaced until an image is again obtained on the screen. Then height of this image is 4 cm . The distance between the object and the screen is 90 cm.

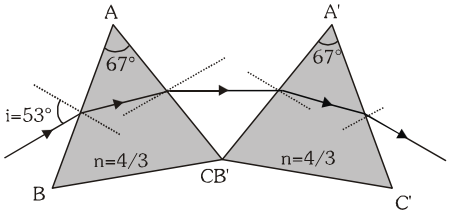
(A) The distance between the two positions of the lens is 30 cm

(B) The distance of the object from the lens in its first position is 36 cm

(C) The height of the object is 6 cm

(D) The focal length of the lens is 21.6 cm

41. A ray is incident on the first prism at an angle of incidence 53 as shown in the figure. The angle between side CA and B′A′ for the net deviation by both the prisms to be double of the deviation produced by the first prism, will be



(A) $\sin^{-1}\frac{2}{3} + 53$ (B) $\sin^{-1}\frac{2}{3} + 37$ (C) $\cos^{-1}\frac{2}{3} + 53$ (D) $2\sin^{-1}\frac{2}{3}$

42. For the refraction of light through a prism

(A) For every angle of deviation there are two angles of incidence

(B) The light travelling inside an equilateral prism is necessarily parallel to the base when prism is set for minimum deviation

(C) There are two angles of incidence for maximum deviation

(D) Angle of minimum deviation will increase if refractive index of prism (μ_P) is increased keeping the refractive index of the outside medium (μ_S) unchanged if $\mu_P > \mu_S$.

43. Two lenses in contact made of materials with dispersive powers in the ratio 2 : 1, behaves as an achromatic diverging lens of focal length 10 cm. The individual focal length of the lenses are :

(A) 5 cm, –10cm (B) –5 cm, 10 cm (C) 10 cm, –20 cm (D) –20 cm, 10 cm

BRAIN TEASERS — ANSWER KEY — EXERCISE -2

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ans.	B	C	A	B	B	B	B	B	B	A	D	D	B	A	A	C
Que.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Ans.	C	A	D	B	C	B	B	B	D	B,C	A,B,C,D	A,C	B,C	B,C,D	A,C	D
Que.	33	34	35	36	37	38	39	40	41	42	43					
Ans.	A,B	A,B	B,C	A,B	A	B,C	C	B,C,D	A,D	B,C,D	B					

EXERCISE–03

MISCELLANEOUS TYPE QUESTIONS

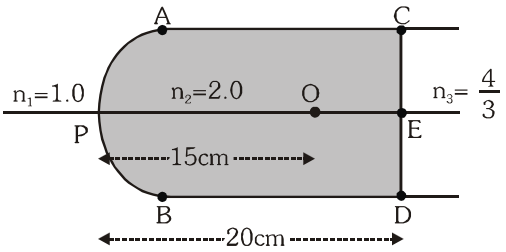
TRUE /FALSE TYPE QUESTIONS:

1. The image and object are never on either side of focus in a spherical mirror.
2. A virtual image must be erect.
3. An image formed in a plane mirror must have same speed as the object has.
4. Laws of reflection are same for all wavelengths.
5. Plane mirror changes right handed coordinate system to left handed coordinate system and vice versa.

FILL IN THE BLANK TYPE QUESTIONS

1. A thin lens of refractive index 1.5 has a focal length of 15 cm in air. When the lens is placed in a medium of refractive index 4/3, its focal length will become_____cm.

2. A slab of material of refractive index 2 shown in figure has a curved surface APB of radius of curvature 10cm and a plane surface CD. On the left of APB is air and on the right of CD is water with refractive indices as given in the figure. An object O is placed at a distance of 15cm from the pole P as shown. The distance of the final image of O from P, as viewed from the left is _____.



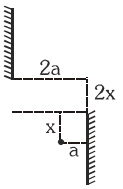
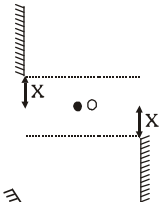
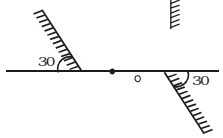
3. A ray of light is incident normally on one of the faces of a prism of apex angle 30 and refractive index $\sqrt{2}$. The angle of deviation of the ray is _____ degrees.

4. A plano–convex lens is silvered on its plane–side and then it acts like a concave mirror of focal length 20 cm, when the convex side is silvered it acts like a concave mirror of 7 cm focal length. The refractive index of the lens is _____.

5. The flat bottom of cylinder tank is silvered and water (μ=4/3) is filled in the tank upto a height h. A small bird is hovering at a height 3h from the bottom of the tank. When a small hole is opened near the bottom of the tank, the water level falls at the rate of 1 cm/s. The bird will perceive that its image's velocity is _____.

MATCH THE COLUMN TYPE QUESTIONS

1. Plane mirrors are arranged parallel to each other as shown in column–I and the number of images formed by the combination is in column–II.

Column I		Column II	
(A)		(p)	2
(B)		(q)	3
(C)		(r)	4
(D)		(s) (t)	∞ 0

2.

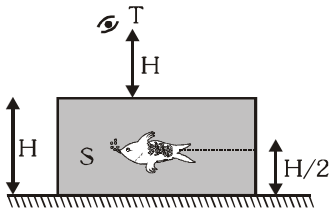
	Column–I		Column–II
(A)	An object is placed at a distance equal to focal length from pole before convex mirror	(p)	Magnification is (∞)
(B)	An object is placed at focus before a concave mirror	(q)	Magnification is (0.5)
(C)	An object is placed at the centre of curvature before a concave mirror.	(r)	Magnification is (1/3)
(D)	An object is placed at a distance equal to radius of curvature before a convex mirror.	(s)	Magnification is (–1)

3. An object is placed at a distance x from a mirror on its optic axis. The object begins to move towards the pole of the mirror. Let R be the radius of curvature of the mirror.

	Column–I		Column–II
(A)	As object approaches from $x = \infty$ to $x = R$, the image approaches the pole. The mirror must be	(p)	convex
(B)	As object approaches from $x = R/2$ to $x = 0$, then the image approaches the pole. The mirror may be	(q)	concave
(C)	The speed of the object is u, then if mirror is concave the speed of the image is	(r)	$\left(\frac{R}{R+2x}\right)^2 u$
(D)	The speed of the object is u, then if mirror is convex then speed of the image is	(s)	$\left(\frac{R}{R-2x}\right)^2 u$

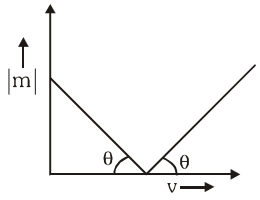
4. Consider the situation in figure. The bottom of the pot is reflecting plane mirror, S is a small fish and T is a human eye. Refractive index of water is μ. Fish can see two images of human eye, first due to refraction only and other due to refraction and than reflection. Distance of these images from fish are S_1 and S_2 respectively. Human eye can also see the two images of fish, first due to refraction only and other due to, reflection and then refraction. Distance of these images from human eye are S_3 and S_4 respectively. Match the quantities of column–I (with their values in column–II)

	Column I		Column II
(A)	S_1	(p)	$H\left[1+\frac{1}{2\mu}\right]$
(B)	S_2	(q)	$H\left[\mu+\frac{1}{2}\right]$
(C)	S_3	(r)	$H\left[1+\frac{3}{2\mu}\right]$
(D)	S_4	(s)	$H\left[\mu+\frac{3}{2}\right]$

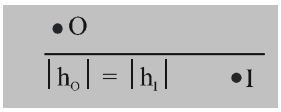


5. Consider the following diagram representing magnitude of magnification against image distance for a convex lens:

	Column – I		Column – II
(A)	Focal length of the lens	(p)	Inverse of slope of line.
(B)	Intercept on x–axis	(q)	Unity
(C)	Intercept on y–axis	(r)	Focal length
(D)	Magnitude of slope of the line(s)	(s)	Inverse of the focal length.



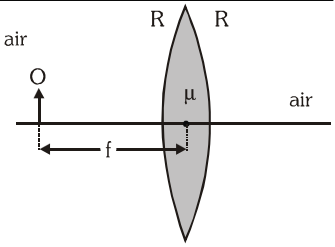
6. In **Column I** are shown four diagrams of real object point O, image point I and principal axis (optical axis). Select the proper optical system from **Column II** which can produce the required image. (Image may be real or virtual)

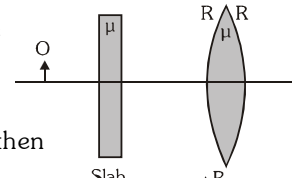
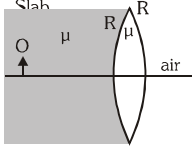
Column – I		Column – II	
(A)		(p)	Diverging lens
(B)		(q)	Converging lens
(C)		(r)	Concave mirror
(D)		(s)	Convex mirror

7. Four rays of light above the optic axis (parallel to it) and their path after striking an optical system are shown in column–I. Match the corresponding optical instrument from column–II :

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

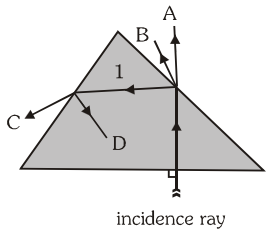
8. An object O (real) is placed at focus of an equi–biconvex lens as shown in . figure I. The refractive index of lens is μ=1.5 and the radius of curvature of either surface of lens is R. The lens is surrounded by air. In each statement of column–I some changes are made to situation given above and information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



Column–I		Column–II	
(A)	If the refractive index of the lens is doubled (that is, made 2μ) then	(p)	final image is real
(B)	If the radius of curvature is doubled (that is, made 2R) then	(q)	final image is virtual
(C)	If a glass slab of refractive index μ = 1.5 is size in introduced between the object and lens as shown then 	(r)	final image becomes smaller in comparison to size of image before the change was made
(D)	If the left side of lens is filled with a medium of refractive index μ= 1.5 as shown, then 	(s)	final image is of same size of object.

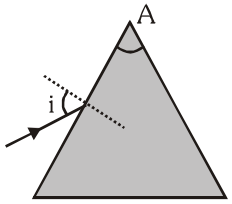
9. A white light ray is incident on a glass prism, and it creates four refracted rays A, B, C and D. Match the refracted rays with the colours given (1 & D are rays due to total internal reflection):

Column–I (Ray)		Column–II (Colour)	
(A)	A	(p)	red
(B)	B	(q)	green
(C)	C	(r)	yellow
(D)	D	(s)	blue



10. For a prism of refracting angle A and refractive index 2. Assume rays are incident at all angles of incidence $0 \le i \le 90$. Ignore partial reflection.

Column–I		Column–II	
(A)	A = 15	(p)	All rays are reflected back from the second surface.
(B)	A = 45	(q)	All rays are refracted into air from the second surface
(C)	A = 70	(r)	Some rays are reflected back from second surface
(D)	A = 50	(s)	Some rays are refracted into air from the second surface



11. Column–II shows the optical phenomenon that can be associated with optical components given in column–I. Note that column–I may have more than one matching options in column–II.

Column–I		Column–II	
(A)	Convex mirror	(p)	Dispersion
(B)	Converging lens	(q)	Deviation
(C)	Thin prism	(r)	Real image of real object
(D)	Glass slab	(s)	Virtual images of real object

ASSERTION & REASON

1. **Statement –I** : For observing traffic at our back, we prefer to use a convex mirror.

and

Statement –II : A convex mirror has a larger field of view than a plane mirror or concave mirror.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

2. **Statement –I** : A convex lens must be converging.

and

Statement –II: The nature of a lens depends upon the refractive indices of the material of lens and surrounding medium besides geometry.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

3. **Statement –I** : Uniform hollow prism forms no spectra as a solid equilateral prism of glass.

and

Statement –II : Neglecting the thickness of the hollow glass surface, the medium is same. So dispersion does not take place.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

4. **Statement – I** : Sun glasses have zero power even though their surfaces are curved.

and

Statement – II : Both the surfaces of the sun glasses are curved in the same direction with same radii.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

5. **Statement–I** : 11 English alphabets do not show lateral inversion.

and

Statement–II : If some portion of a mirror is covered, the intensity of image will increase.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

6. **Statement–I** : The images formed by total internal reflections are much brighter than those formed by mirrors or lenses.

and

Statement–II : There is no loss of intensity in total internal reflection.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

7. **Statement–I** : Image formed by concave lens is not always virtual.

and

Statement–II : Image formed by a lens is real if the image is formed in the direction of ray of light with respect to the lens.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

COMPREHENSION BASED QUESTIONS

Comprehension # 1

When two plane mirrors subtend an angle θ between them, then a ray of light incident parallel to one of them retraces its path after n reflections such that $n\theta=c$ (where c is a constant)

1. What is the value of c?

(A) π (B) $\frac{\pi}{2}$ (C) $\frac{3\pi}{2}$ (D) None of these

2. If the angle between mirrors is 60 . Then light ray retraces its path after n reflections where n is

(A) 3 (B) 4 (C) 2 (D) None of these

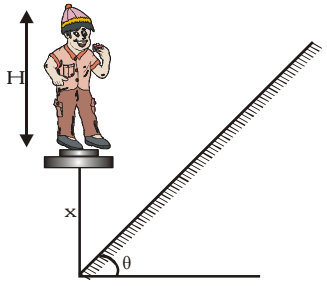
3. The graph between θ and n will

(A) be continuous but not differentiable (B) be continuous & differentiable

(C) Not be continuous (D) Can't say

Comprehension # 2

A man of height H is standing in front of an inclined plane mirror at an angle θ from horizontal. The vertical separation between man and inclined plane is x.



Man can see its complete image in length $\frac{H(H+x)\sin\theta}{H+2x}$ of mirror.

(Given : x = H=1m and $\theta = 45^0$)

1. If man starts moving with velocity $\sqrt{2}$ ms^{-1} along inclined plane, find out length of mirror at t = 1s in which he can see his complete image.

(A) $\frac{\sqrt{2}}{3}$m (B) $\frac{2}{3}$m (C) $\frac{1}{3}$m (D) $\frac{1}{3\sqrt{2}}$m

2. If man starts moving with velocity 1 ms^{-1} along vertical, find out length of mirror at t = 1s in which he can see his complete image.

(A) $\frac{3}{10}$m (B) $\frac{3\sqrt{2}}{5}$m (C) $\frac{3}{5\sqrt{2}}$ (D) $\frac{3}{5}$m

3. If man starts moving with velocity 1 ms^{-1} horizontally, find out length of mirror at t = 1s in which he can see his complete image.

(A) $\sqrt{2}$ m (B) $\frac{1}{\sqrt{2}}$m (C) $\frac{1}{2\sqrt{2}}$m (D) $2\sqrt{2}$ m

Comprehension # 3

A turnip sits before a thin converging lens, outside the focal point of the lens. The lens is filled with a transparent gel so that it is flexible ; by squeezing its ends towards its centre as indicated in figure, you can change the curvature of its front and rear sides.

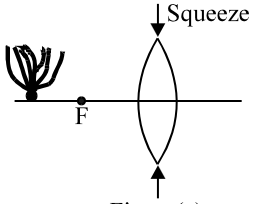
1. When you squeeze the lens, the image :

(A) moves towards the lens

(B) moves away from the lens

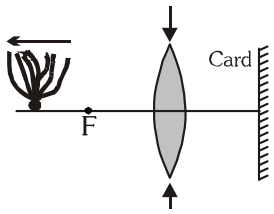
(C) shifts up

(D) remains as it is

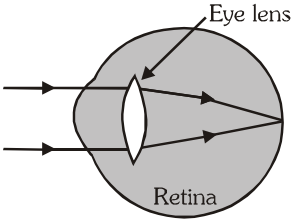


2. In above questions the lateral height of image :
(A) increases (B) decreases (C) remains same (D) data insufficient

3. Suppose that the image must be formed on a card which is at a certain distance behind the lens as shown in the figure, while you move the turnip away from the lens, then you should :
(A) decrease the squeeze of the lens
(B) increase the squeeze of the lens
(C) keep the card and lens as it is
(D) move the card away from the lens



Comprehension # 4 : Human Eye



The ciliary muscles of eye control the curvature of the lens in the eye and hence can alter the effective focal length of the system. When the muscles are fully relaxed, the focal length is maximum. When the muscles are strained the curvature of lens increases (that means radius of curvature decreases) and focal length decreases. For a clear vision the image must be on retina. The image distance is therefore fixed for a clear vision and it equals the distance of retina from eye–lens. It is about 2.5 cm for a grown–up person.
A person can theoretically have clear vision of objects situated at any large distance from the eye. The smallest distance at which a person can clearly see is related to minimum possible focal length. The ciliary muscles are most strained in this position. For an average grown up person minimum distance of object should be around 25 cm.
A person suffering from eye defects uses spectacles (Eye glass). The function of lens of spectacles is to form the image of the objects within the range in which person can see clearly. The image of the spectacle–lens becomes object for eye–lens and whose image is formed on retina.
The number of spectacle–lens used for the remedy of eye defect is decided by the power of the lens required and the number of spectacle–lens is equal to the numerical value of the power of lens with sign. For example power of lens required is +3D (converging lens of focal length $\frac{100}{3}$ cm) then number of lens will be +3).
For all the calculations required you can use the lens formula and lens maker's formula. Assume that the eye lens is equiconvex lens. Neglect the distance between eye lens and the spectacle lens.

1. Minimum focal length of eye lens of a normal person is :
(A) 25 cm (B) 2.5 cm (C) $\frac{25}{9}$ cm (D) $\frac{25}{11}$ cm

2. Maximum focal length of eye lens of normal person is:
(A) 25 cm (B) 2.5 cm (C) $\frac{25}{9}$ cm (D) $\frac{25}{11}$ cm

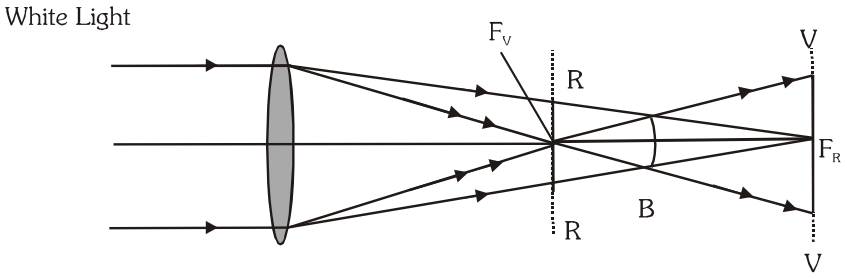
3. A near–sighted man can clearly see object only upto a distance of 100 cm and not beyond this. The number of the spectacles lens necessary for the remedy of this defect will be:
(A) + 1 (B) –1 (C) + 3 (D) –3

4. A farsighted man cannot see object clearly unless they are at least 100 cm from his eyes. The number of the spectacles lens that will make his range of clear vision equal to an average grown up person
(A) + 1 (B) –1 (C) + 3 (D) –3

5. A person who can see object clearly from distance 10 cm to ∞, then we can say that the person is:
(A) Normal sighted person (B) Near–sighted person
(C) Far–sighted person (D) A person with exceptional eye having no eye defect

Comprehension # 5 : Chromatic Abserration

The image of a white object in white light formed by a lens is usually coloured and blurred. This defect of image is called chromatic abserration and arises due to the fact that focal length of a lens is different for different colours. As μ of lens is maximum for violet while minimum for red, violet is focused nearest to the lens while red farthest from it as shown in figure. As a result of this, in case of convergent lens if a screen is placed at F_v centre of the image will be violet and focused while sides are red and blurred. White at F_R, reverse is the case, i.e., centre will be red and focused while sides violet and blurred. The difference between f_v and f_R is a measure of the longitudinal chromatic aberration (L.C.A), i.e.,



L.C.A. = $f_R - f_V$ = $-df$ with $df = f_v - f_R$

However, as for a single lens,

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \Rightarrow -\frac{df}{f^2} = d\mu\left[\frac{1}{R_1} - \frac{1}{R_2}\right] - \frac{df}{f} = \frac{d\mu}{(\mu - 1)} = \omega$$ = dispersive power.

Therefore, L. C. A. = – df = ωf

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

Condition of Achromatism (achromatic doublet) :

In case of two thin lenses in contact $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow -\frac{dF}{F^2} = \frac{-df_1}{f_1^2} - \frac{df_2}{f_2^2}$

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

So $\frac{df_1}{f_1^2} + \frac{df_2}{f_2^2} = 0 \Rightarrow \frac{\omega_1 f_1}{f_1^2} + \frac{\omega_2 f_2}{f_2^2} = 0 \Rightarrow \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$

This condition is called condition of achromatism (for two thin lenses in contact) and the lens combination which satisfies this condition is called achromatic lens, From above discussions it is clear that

(i) The two lenses must be a different materials. $\because$ If $\omega_1 = \omega_2, \frac{1}{f_1} + \frac{1}{f_2} = 0 \Rightarrow \frac{1}{F} = 0$ or $F = \infty$

(ii) As ω_1 and ω_2 are positive quantities for Eqn. (5) to hold, f_1 and f_2 must be of opposite nature, i.e., if one of the lenses is converging the other must be diverging.

(iii) If the achromatic combination is convergent, $f_C < f_D$ and as $-\frac{f_C}{f_D} = \frac{\omega_C}{\omega_D}$, $\omega_C < \omega_D$ i.e., in a convergent achromatic doublet, convex lens has lesser focal length and dispersive power than the divergent one.

1. Chromatic aberration in the formation of images by a lens arises because :

(A) of non–paraxial rays

(B) the radii of curvature of the two sides are not same

(C) of the defect in grinding

(D) the focal length varies with wavelength

2. Chromatic aberration of a lens can be corrected by :

(A) providing different suitable curvatures of its two surfaces

(B) proper polishing of its two surfaces

(C) suitably combining it with another lens

(D) reducing its aperture

3. A combination is made of two lenses of focal lengths f and f' in contact ; the dispersive powers of the materials of the lenses are ω and ω'. The combination is achromatic when :

(A) $\omega = \omega_0$, $\omega' = 2\omega_0$,f' = 2f (B) $\omega = \omega_0$, $\omega' = 2\omega_0$,f' = f/2

(C) $\omega = \omega_0$, $\omega' = 2\omega_0$,f' = –f/2 (D) $\omega = \omega_0$, $\omega' = 2\omega_0$,f' = –2f

4. The dispersive power of crown and flint glasses are 0.02 and 0.04 respectively. An achromatic converging lens of focal length 40 cm is made by keeping two lenses, one of crown glass and the other of flint glass, in contact with each other. The focal lengths of the two lenses are:

(A) 20 cm and 40 cm (B) 20 cm and –40 cm (C) –20 cm and 40 cm (D) 10 cm and –20cm

5. Chromatic aberration in a spherical concave mirror is proportional to :

(A) f (B) f^2 (C) 1/f (D) None of these

MISCELLANEOUS TYPE QUESTION — ANSWER KEY — EXERCISE –3

- ***True / False***

1. T **2.** F **3.** F **4.** T **5.** T

- ***Fill in the Blanks***

1. 60 cm, **2.** 30 cm to the right P (Virtual Image) **3.** 15 **4.** 20/13 **5.** 0.5 cm/s downwards

- ***Match the Column***

1. (A)–s (B)–q (C)–p (D)–p **2.** (A)–q (B)–p (C)–s (D)–r

3. (A)–p (B)–p,q (C)–s (D)–r **4.** (A)–q (B)–s (C)–p (d)–r

5. (A)–p (B)–r (C)–q (D)–s **6.** (A)–p, s (B)–q,r (C) q, (D)–q,r

7. (A)–r (B) –q (C) –p (D) –s **8.** (A)–p, r(B)–q,r (C) q, r (D)–q,r

9. (A)–p (B) r (C)–q (d)–s **10.** (A)–q, (B)–r,s (C)–p (D)–r, s

11. (A)–q, s (B)–p,q,r,s (C)–p,q,s (d)–s

- ***Assertion – Reason Questions***

1. A **2.** D **3.** A **4.** A **5.** C **6.** A **7.** B

- ***Comprehension Based Quesions***

Comprehension #1 : 1. B 2. D 3. C

Comprehension #2: 1. A 2. C 3. B

Comprehension #3 : 1. A 2. B 3. A

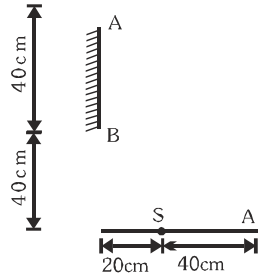
Comprehension #4 : 1. D 2. B 3. B 4. C 5. D

Comprehension #5: 1. D 2. C 3. D 4. B 5. D

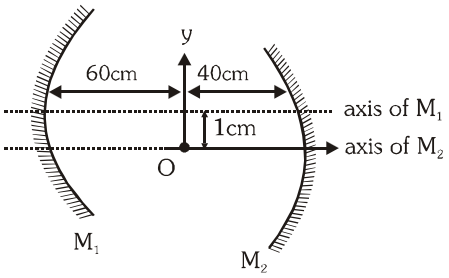
EXERCISE–04 [A] CONCEPTUAL SUBJECTIVE EXERCISE

1. A plane mirror of circular shape with radius r= 20 cm is fixed to the ceiling. A bulb is to be placed on the axis of the mirror. A circular area of radius R = 1m on the floor is to be illuminated after reflection of light from the mirror. The height of the room is 3 m. What is the maximum distance from the centre of the mirror and the bulb so that the required area is illuminated?

2. In figure shown AB is a plane mirror of length 40cm placed at a height 40 cm from the ground. There is a light source S at a point on the ground. Find the minimum and maximum height of a man (eye height) required to see the image of the source if he is standing at a point A on the ground as shown in figure .

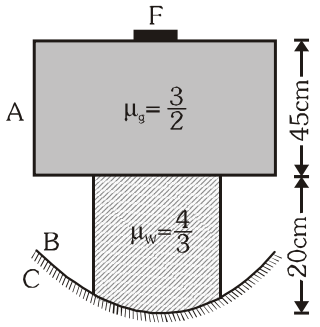


3. Two concave mirrors each of radius of curvature 40 cm are placed such that their principal axes are parallel to each other & at a distance of 1 cm to each other. Both the mirrors are at a distance of 100 cm to each other. Consider first reflection at M_1 and then at M_2, find the coordinates of the image thus formed. Take location of object as the origin.



4. A balloon is rising up along the axis of a concave mirror of radius of curvature 20m. A ball is dropped from the balloon at a height 15m from the mirror when the balloon has velocity 20 m/s. Find the speed of the image of the ball formed by concave mirror after 4 seconds ? [Take : g = 10 m/s^2]

5. A fly F is sitting on a glass slab A, 45 cm thick and of refractive index 3/2. The slab covers the top of a container B containing water (Refractive index 4/3) upto a height of 20 cm. The bottom of container is closed by a concave mirror C of radius of curvature 40 cm. Locate the final image formed by all refractions and reflection assuming paraxial rays.

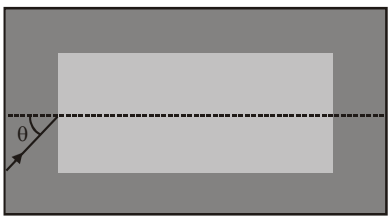


6. A tiny air bubble inside a glass slab appears to be 6 cm deep when viewed from one side and 4 cm deep when viewed from the other side. Assuming μ_{glass} = 3/2. Find the thickness of slab.

7. A slab of glass of thickness 6 cm and index 1.5 is place somewhere in between a concave mirror and a point object, perpendicular to the mirror's optical axis. The radius of curvature of the mirror is 40 cm. If the reflected final image coincides with the object, then find the distance of the object from the mirror.

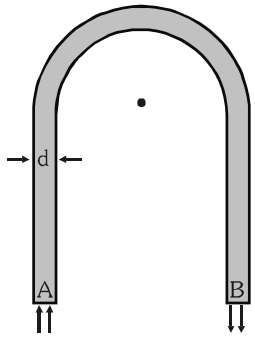
8. A point object is placed 33 cm from a convex mirror of curvature radius = 40 cm. A glass plate of thickness 6 cm and index 2.0 is placed between the object and mirror, close to the mirror. Find the distance of final image from the object.

9. A long solid cylindrical glass rod of refractive index 3/2 is immersed in a liquid of refractive index $\frac{3\sqrt{3}}{4}$. The ends of the rod are perpendicular to the central axis of the rod. A light enters one end of the rod at the central axis as shown in the figure. Find the maximum value of angle θ for which total internal reflection occurs inside the rod?



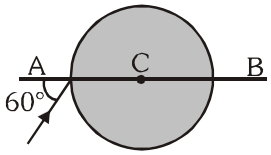
10. Light from a luminous point on the lower face of a rectangular glass slab, 2 cm thick, strikes the upper face and the totally reflected rays outline a circle of 3.2 cm radius on the lower face. Find the refractive index of the glass.

11. A rod made of glass (μ=1.5) and of square cross–section is bent into the shape shown in figure. A parallel beam of light falls perpendicularly on the plane flat surface A. Referring to the diagram, d is the width of a side & R is the radius of inner semicircle. Find the maximum value of ratio $\frac{d}{R}$ so that all light entering the glass through surface A emerge from the glass through surface B.



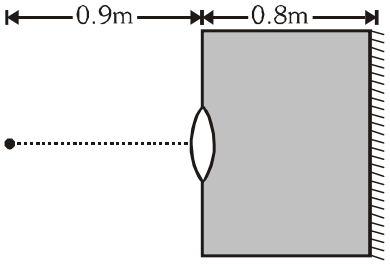
12. A fish is rising up vertically inside a pond with velocity 4 cm/s and notices a bird, which is diving vertically downward and its velocity appears to be 16 cm/s (to the fish). What is the real velocity of the diving bird, if refractive index of water is 4/3.

13. A ray of light falls on a transparent sphere with centre at C as shown in figure. The ray emerges from the sphere parallel to line AB. Find the refractive index of the sphere.

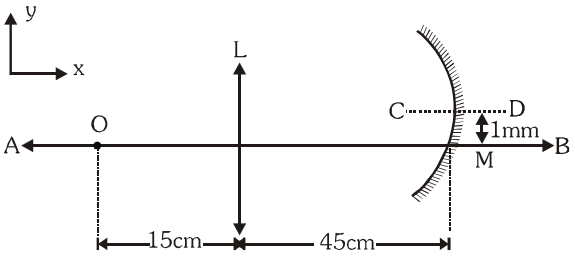


14. A parallel beam of light is incident on a transparent sphere of refractive index 'n'. If the beam finally gets focussed at a point situated at a distance = 2 (radius of sphere) from the centre of the sphere, then find n.

15. A thin equiconvex lens of glass of refractive index μ = 3/2 and of focal length 0.3 m in air is sealed into an opening at one end of a tank filled with water μ = 4/3. On the opposite side of the lens, a mirror is placed inside the tank on the tank wall perpendicular to the lens axis, as shown in figure. The separation between the lens and the mirror is 0.8 m.A small object is placed outside the tank in front of the lens at a distance of 0.9 m from the lens on its axis. Find the position (relative to the lens) of the image of the object formed by the system.



16. In the figure shown L is converging lens of focal length 10 cm and M is a concave mirror of radius of curvature 20 cm. A point object O is placed in front of the lens at a distance 15 cm. AB and CD are optical axes of the lens and mirror respectively. Find the coordinates of the final image formed by this system taking O as origin. The distance between CD & AB is 1mm.

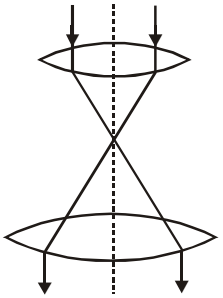


17. An object is kept at a distance of 16 cm from a thin lens and the image formed is real. If the object is kept at a distance of 6 cm from the same lens the image formed is virtual. If the size of the image formed are equal, then find the focal length of the lens ?

18. A point source of light is kept at a distance of 15 cm from a converging lens, on its optical axis. The focal length of the lens is 10 cm and its diameter is 3 cm. A screen is placed on the other side of the lens, perpendicular to the axis of lens, at a distance 20 cm from it. Then find the area of the illuminated part of the screen.

19. A lens placed between a candle and a screen forms a real triply magnified image of the candle on the screen. When the lens is moved away from the candle by 0.8 m without changing the position of the candle, a real image one–third the size of the candle is formed on the screen . Determine the focal length of the lens.

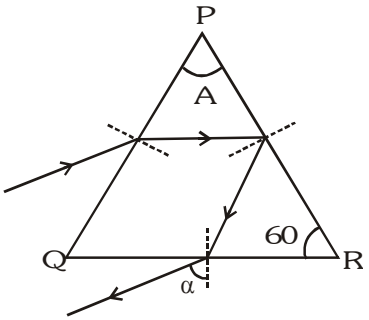
20. Consider a 'beam expander' which consists of two converging lenses of focal lengths 40 cm and 100 cm having a common optical axis. A laser beam of diameter 4 mm is incident on the 40 cm focal length lens. Then what is the diameter of the final beam (see figure)?



21. A prism of refractive index $\sqrt{2}$ has refracting angle 60 . Find the angle of incidence so that a ray suffers minimum deviation.

22. An equilateral prism deviates ray through 23 for two angles of incidence differing by 23 . Find μ of the prism .

23. The figure shows the path of a ray passing through an equiangular prism PQR. It is incident on face PR at an angle slightly greater than the critical angle for total internal reflection. If the angle α shown in the figure is 30 . Calculate the R.I. of the material of the prism.

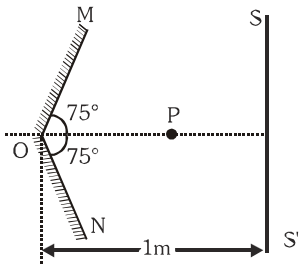


CONCEPTUAL SUBJECTIVE EXERCISE — ANSWER KEY — EXERCISE-4(A)

1. 75cm
2. 160 cm min, 320 cm max
3. 12cm, –0.6cm
4. 80 m/s
5. $\frac{45}{2}$ cm below F
6. 15 cm
7. 42 cm
8. 42 cm
9. $\sin^{-1}\frac{1}{\sqrt{3}}$
10. 1.17
11. 1/2
12. 9 cm/s
13. $\sqrt{3}$
14. $\frac{4}{3}$
15. 0.9m from the lens (rightwards) or 0.1 m behind the mirror
16. (–15cm, – 6mm)
17. 11 cm
18. $\frac{\pi}{4}$ cm^2
19. 30 cm
20. 1cm
21. 45
22. $\frac{\sqrt{43}}{5}$
23. $\left(\frac{7}{3}\right)^{1/2}$

EXERCISE–04 [B] BRAIN STORMING SUBJECTIVE EXERCISE

1. Two large plane mirrors OM and ON are arranged as shown. Findthe length of the part of large screen SS' in which two images of the object placed at P can be seen ?

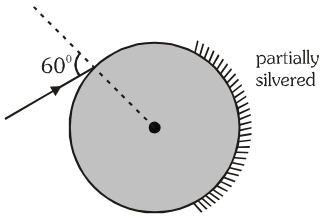


2. Two plane mirrors makes an angle of 120 with each other. The distance between the two images of a point source formed in them is 20 cm. Determine the distance from the light source of the point where the mirrors touch, the light source lies on the bisector of the angle formed by the mirrors.

3. A thief is running away in a car with velocity of 20 m/s. A police jeep is following him, which is sighted by thief in his rear view mirror which is a convex mirror of focal length 10 m. He observes that the image of jeep is moving towards him with a velocity of 1 cm/s. If the magnification of the mirror for the jeep at that time is 1/10. Find (a) actual speed of jeep (b) rate at which magnification is changing. Assume that police jeep is on axis of the mirror.

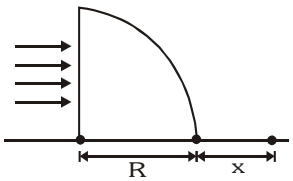
4. A surveyor on one bank of canal observed the image of the 4 inch and 17 ft marks on a vertical staff, which is partially immersed in the water and held against the bank directly opposite to him, coincides. If the 17ft mark and the surveyor's eye are both 6ft above the water level, estimate the width of the canal, assuming that the refractive index of the water is 4/3.

5. A ray is incident on a glass sphere as shown. The opposite surface of the sphere is partially silvered. If the net deviation of the ray transmitted at the partially silvered surface is 1/3 rd of the net deviation suffered by the ray reflected at the partially silvered surface (after emerging out of the sphere). Find the refractive index of the sphere.

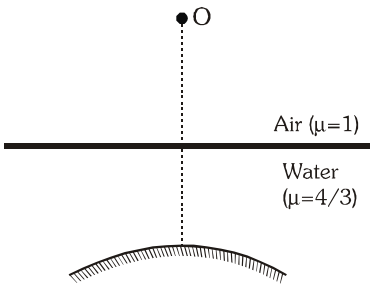


6. A concave mirror has the form of a hemisphere with a radius of R = 60 cm. A thin layer of an unknown transparent liquid is poured into the mirror. The mirror–liquid system forms one real image and another real image is formed by mirror alone, with the source in a certain position. One of them coincides with the source and the other is at a distance of ℓ = 30 cm from source. Find the possible value(s) refractive index μ of the liquid.

7. A uniform, horizontal beam of light is incident upon a quarter cylinderof radius R = 5 cm, and has a refractive index $2/\sqrt{3}$. A patch on the table for a distance 'x' from the cylinder is unilluminated. Find the value of 'x' ?



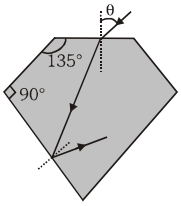
8. A point object lies 30 cm above water on the axis of a convex mirror of focal length 40 cm lying 20 cm below water surface. Consider two images.



(i) Image formed by partial reflection from water surface

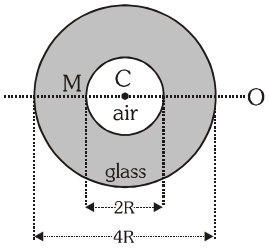
(ii) Image formed by refraction from water surface followed by reflection from mirror and again refraction out of the water surface. Find the distance between these two images.

9. A ray of light enters a diamond (n = 2) from air and is being internally reflected near the bottom as shown in the figure. Find maximum value of angle θ possible.

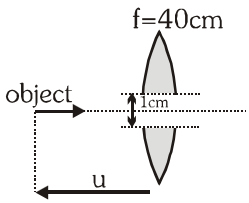


10. A spider and a fly are on the surface of a glass sphere . As the fly moves on the surface, find the maximum area on the glass sphere for the spider to be able to see it ? Assume that the radius of the sphere (R) is much larger than the sizes of the spider and the fly . Take the refractive index of glass μ_g to be equal to $\sqrt{2}$.

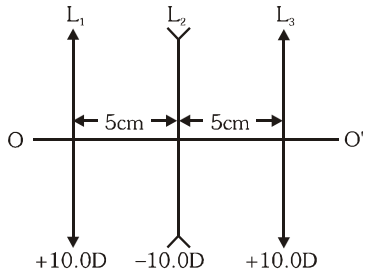
11. A hollow sphere of glass of R.I. n has a small mark M on its interior surface which is observed by an observer O from a point outside the sphere. .C is centre of the sphere. The inner cavity (air) is concentric with the external surface and thickness of the glass is every where equal to the radius of the inner surface. Find the distance by which the mark will appear nearer than it really is in terms of n and R assuming paraxial rays.



12. In the figure shown, find the relative speed of approach/separation of the two final images formed after the light rays pass through the lens, at the moment when u = 30 cm. The speed of object = 4 cm/s. The two lens halves are placed symmetrically w.r.t. the moving object.



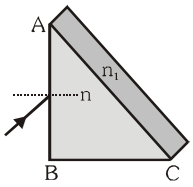
13. The figure illustrates an aligned system consisting of three thin lenses. The system is located in air. Determine (a) the position (relative to right most lens) of the point of convergence of a parallel ray incoming from the left after passing through the system (b) The distance between the first lens and a point lying on the axis to the left of the system, at which that point and its image are located symmetrically with respect to the lens system ?



14. Two thin similar watch glass pieces are joined together, front to front, with rear portion silvered and the combination of glass pieces is placed at a distance a = 60 cm from a screen. A point object is placed on optical axis of the combination such that its two times magnified image is formed on the screen. If air between the glass pieces is replaced by water (μ = 4/3), calculate the distance through which the object must be displaced so that a sharp image is again formed on the screen.

15. One side of radius of curvature r_1 =120 cm of a convex lens of material of refractive index μ = 3/2 and focal length f_1=20 cm is silvered. It is placed on a horizontal surface with silvered surface in contact with it. Another convex lens of focal length f_2=20 cm is fixed coaxially d = 10 cm above. A luminous point object O on the axis gives rise to an image coincident on it. Find its height above the upper lens.

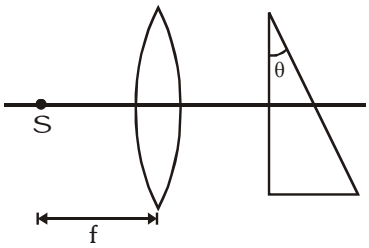
16. A right angle prism (45 –90 –45) of refractive index n has a plane of refractive index n_1 (n_1 < n) cemented to its diagonal face. The assembly is in air. The ray is incident on AB.



(i) Calculate the angle of incidence at AB for which the ray strikes the diagonal face at the critical angle.

(ii) Assuming n = 1.352, calculate the angle of incidence at AB for which the refracted ray passes through the diagonal face undeviated.

17. A glass wedge with a small angle of refraction θ is placed at a certaindistance from a converging lens with a focal length f, one surface of the wedge being perpendicular to the optical axis of the lens. A point sources S of light is on the other side of the lens at its focus. The rays reflected from the wedge (not from base) produce, after refraction in the lens, two images of the source displaced with respect to each other by d. Find the refractive index of the wedge glass. [Consider only paraxial rays].



BRAIN STORMING SUBJECTIVE EXERCISE — ANSWER KEY — EXERCISE-4(B)

1. $\frac{2}{\sqrt{3}}$ m **2.** $\frac{20}{\sqrt{3}}$ cm **3.** (a) 21 m/s (b) 10^{-3} m/s **4.** 16 feet

5. $\sqrt{3}$ **6.** 1.5 or $\sqrt{5}-1$ **7.** 5m **8.** (ii) 3 cm

9. $\sin^{-1}\left(\frac{\sqrt{3}-1}{\sqrt{2}}\right)$ **10.** $2\pi R^2$ **11.** $\frac{(n-1)R}{(3n-1)}$ **12.** $\left(\frac{8}{5}\right)$ cm/s

13. (a) 3.3 cm(b) 50 /3 cm **14.** 15cm towards the combination **15.** $\frac{100}{19}$ cm

16. (i) $e=\sin^{-1}\frac{1}{\sqrt{2}}\left[\left(\sqrt{n^2-n_1^2}\right)-n_1\right]$ (ii) $\sin^{-1}(0.956)$ **17.** $\frac{d}{2f\theta}$

EXERCISE–05(A) PREVIOUS YEARS QUESTIONS

1. If two mirrors are kept at 60 to each other, then the number of images formed by them is- **[AIEEE- 2002]**
(1) 5 (2) 6 (3) 7 (4) 8

2. Wavelength of light used in a optical instrument are λ_1 = 4000 Å and λ_2 = 5000 Å, then ratio of their respective resolving powers (corresponding to λ_1 and λ_2) is- **[AIEEE - 2002]**
(1) 16 : 25 (2) 9 : 1 (3) 4 : 5 (4) 5 : 4

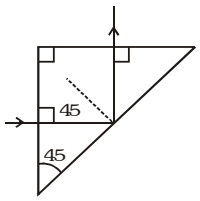
3. Which of the following is used in optical fibres? **[AIEEE - 2002]**
(1) Total internal reflection (2) Scattering (3) Diffraction (4) Refraction

4. An astronomical telescope has a large aperture to **[AIEEE - 2002]**
(1) reduced spherical aberration (2) have high resolution
(3) increase span of observation (4) have low dispersion

5. The image formed by an objective of a compound microscope is **[AIEEE - 2003]**
(1) virtual and diminished (2) real and diminished
(3) real and enlarged (4) virtual and enlarged

6. To get three images of a single object, one should have two plane mirrors at an angle of- **[AIEEE - 2003]**
(1) 60 (2) 90 (3) 120 (4) 30

7. A light ray is incident perpendicular 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 : **[AIEEE-2004]**



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

8. 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 the size of the object? **[AIEEE-2004]**
(1) 20 cm (2) 30 cm (3) 60 cm (4) 80 cm

9. 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 water surface, the radius of this circle in cm is **[AIEEE-2005]**

(1) $36\sqrt{7}$ (2) $\frac{36}{\sqrt{7}}$ (3) $36\sqrt{5}$ (4) $4\sqrt{5}$

10. Two point white dots are 1 mm apart on a black paper. They are viewed by eye of pupil diameter 3 mm. Approximately, what is the maximum distance at which these dots can be resolved by the eye ? [Take wavelength of light = 500 nm] **[AIEEE-2005]**
(1) 5 m (2) 1 m (3) 6 m (4) 3 m

11. A thin glass (refractive index 1.5) lens has optical power of – 5D in air. Its optical power in a liquid medium with refractive index 1.6 will be **[AIEEE-2005]**
(1) 1 D (2) – 1D (3) 25 D (4) – 25 D

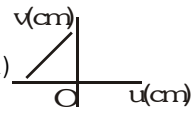
12. The refractive index of glass is 1.520 for red light and 1.525 for blue light. Let D_1 and D_2 be angles of minimum deviation for red and blue light respectively in a prism of this glass. Then- **[AIEEE-2006]**

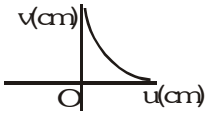
(1) $D_1 < D_2$
(2) $D_1 = D_2$
(3) D_1 can be less than or greater than D_2 depending upon the angle of prism
(4) $D_1 > D_2$

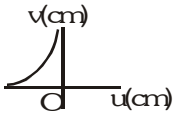
13. Two lenses of power – 15D and +5D are in contact with each other. The focal length of the combination is- **[AIEEE-2007]**

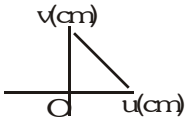
(1) – 20 cm (2) – 10 cm (3) + 20 cm (4) + 10 cm

14. A stuydent 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- **[AIEEE - 2008]**

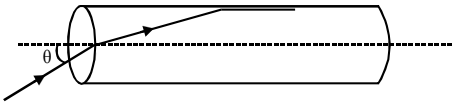
(1) 

(2) 

(3) 

(4) 

15. A transparent solid cyclindrical 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. **[AIEEE - 2009]**



The incident angle θ for which the light ray grazes along the wall of the rod is :-

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

16. Let the x–y 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 $\vec{A} = 6\sqrt{3}\tilde{i} + 8\sqrt{3}\tilde{j} - 10\tilde{k}$ is incident on the plane of separation. The angle of refraction in medium 2 is :-

[AIEEE - 2011]

(1) 60 (2) 75 (3) 30 (4) 45

17. 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:- **[AIEEE- 2011]**

(1) 10 m/s (2) 15 m/s (3) $\frac{1}{10}$ m/s (4) $\frac{1}{15}$ m/s

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

(1) Does not depend on colour of light
(2) Increase
(3) Decrease
(4) Remain same

19. A beaker contains water up to a height h_1 and kerosene of height h_2 above watger 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) $\left(1+\frac{1}{\mu_1}\right)h_1 - \left(1+\frac{1}{\mu_2}\right)h_2$

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

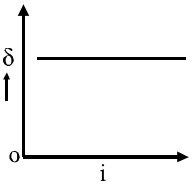
(4) $\left(1+\frac{1}{\mu_1}\right)h_2 - \left(1+\frac{1}{\mu_2}\right)h_1$

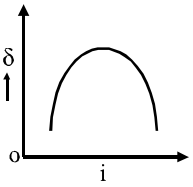
20. An object 2.4 m in front of a lens forms a sharp image on a film 12 cm behind the lens. A glass plate 1 cm thick, of refractive index 1.50 is interposed between lens and film with its plane faces parallel to film. At what distance (from lens) should object be shifted to be in sharp focus on film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

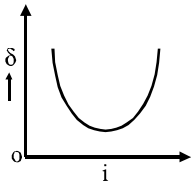
(1)5.6 m (2) 7.2 m (3) 2.4 m (4) 3.2 m

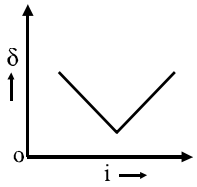
21. The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by

[JEE Mains- 2013]

(1) 

(2) 

(3) 

(4) 

22. Diameter of a plano-convex lens is 6cm 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 Mains–2013]**

(1) 15 cm (2) 20 cm (3) 30 cm (4) 10 cm

ANSWER-KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	4	1	2	3	2	2	1	2	1	1	1	2	3	2	4	4	2	3	1
Que.	21	22																		
Ans.	3	3																		

EXERCISE–05(B) PREVIOUS YEARS QUESTIONS

MCQS ONE CORRECT ANSWER

1. A concave mirror is placed on a horizontal table with its axis directed vertically upwards. Let O be the pole of the mirror and C its centre of curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be :– **[IIT-JEE 1998]**

(A) real and will remain at C
(B) real and located at a point between C and ∞
(C) virtual and located at a point between C and O
(D) real and located at a point between C and O

2. A spherical surface of radius of curvature R, separates air (refractive index 1.0) from glass (refractive index 1.5). The centre of curvature is in the glass. A point object P placed in air is found to have a real image Q in the glass. The line PQ cuts the surface at a point O and PO = OQ. The distance PO is equal to :– **[IIT-JEE 1998]**

(A) 5R (B) 3R (C) 2R (D) 1.5R

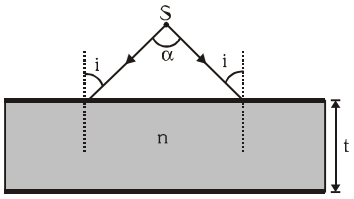
3. A concave lens of glass, refractive index 1.5 has both surfaces of same radius of curvature R. On immersion in a medium of refractive index 1.75, it will behave as a :– **[IIT-JEE 1999]**

(A) convergent lens of focal length 3.5 R
(B) convergent lens of focal length 3.0 R
(C) divergent lens of focal length 3.5 R
(D) divergent lens of focal length 3.0 R

4. A hollow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 or L_2 having refracting indices n_1 and n_2 respectively ($n_2 > n_1 > 1$). The lens will diverge a parallel beam of light if it is filled with :– **[IIT-JEE 2000]**

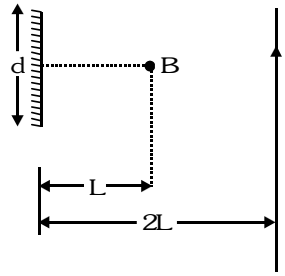
(A) air and placed in air
(B) air and immersed in L_1
(C) L_1 and immersed in L_2
(D) L_2 and immersed in L_1

5. A diverging beam of light from a point source S having divergence angle α falls symmetrically on a glass slab as shown. The angles of incidence of the two extreme rays are equal. If the thickness of the glass slab is t and its refractive index is n, then the divergence angle of the emergent between them is : **[IIT-JEE 2000]**



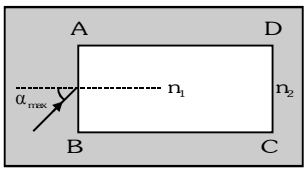
(A) zero (B) α (C) $\sin^{-1}(1/n)$ (D) $2\sin^{-1}(1/n)$

6. A point source of light B, placed at a distance L in front of the centre of plane mirror of width d, hangs vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance 2L from it as shown. The greatest distance over which he can see the image of the light source in the mirror is : **[IIT-JEE 2000]**



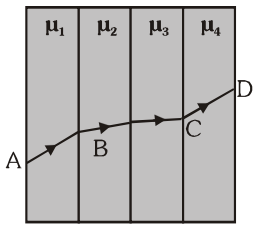
(A) d/2
(B) d
(C) 2d
(D) 3d

7. A rectangular glass slab ABCD of refractive index n_1 is immersed in water of refractive index n_2 ($n_1 > n_2$). A ray of light is incident at the surface AB of the slab as shown. The maximum value of the angle of incidence α_{max}, such that the ray comes out only from the other surface CD, is given by :– **[IIT-JEE 2000]**



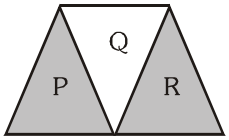
(A) $\sin^{-1}\left[\frac{n_1}{n_2}\cos\left(\sin^{-1}\frac{n_2}{n_1}\right)\right]$
(B) $\sin^{-1}\left[n_1\cos\left(\sin^{-1}\frac{1}{n_2}\right)\right]$
(C) $\sin^{-1}\left(\frac{n_1}{n_2}\right)$
(D) $\sin^{-1}\left(\frac{n_2}{n_1}\right)$

8. A ray of light passes through four transparent media with refractive indices μ_1, μ_2, μ_3 and μ_4 as shown in the figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have :– **[IIT-JEE 2000]**



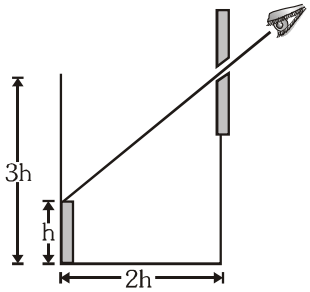
(A) $\mu_1 = \mu_2$ (B) $\mu_2 = \mu_3$ (C) $\mu_3 = \mu_4$ (D) $\mu_4 = \mu_1$

9. A given ray of light suffers minimum deviation in an equilateral prism P. Additional prism Q and R of identical shape and of the same material as P are now added as shown in the figure. The ray will suffer :– **[IIT-JEE 2001]**



(A) greater deviation (B) no deviation
(C) same deviation as before (D) total internal reflection

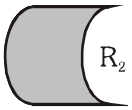
10. An observer can see through a pin–hole the top end of a thin rod of height h, placed as shown in the figure. The beaker height is 3h and its radius h. When the beaker is filled with a liquid up to a height 2h, he can see the lower end of the rod. Then the refractive index of the liquid is :– **[IIT-JEE 2002]**

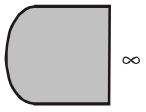


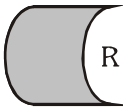
(A) $\frac{5}{2}$ (B) $\sqrt{\frac{5}{2}}$

(C) $\sqrt{\frac{3}{2}}$ (D) $\frac{3}{2}$

11. Which one of the following spherical lenses does not exhibit dispersion ? The radii of curvature of the surfaces of the lenses are as given in the diagrams :– **[IIT-JEE 2002]**

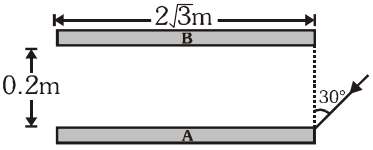
(A) 

(B) 

(C) 

(D) 

12. Two plane mirrors A and B are aligned parallel to each other, as shown in the figure. A light ray is incident at an angle 30 at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is :– **[IIT-JEE 2002]**



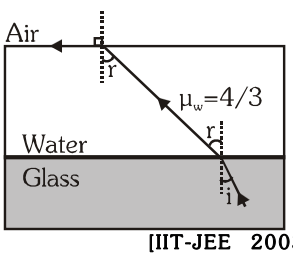
(A) 28 (B) 30 (C) 32 (D) 34

13. The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30cm is 2cm. If a concave lens of focal length 20cm is placed between the convex lens and the image at a distance of 26cm from the convex lens, calculate the new size of the image :– **[IIT-JEE 2003]**

(A) 1.25 cm (B) 2.5 cm (C) 1.05 cm (D) 2cm

14. A ray of light is incident at the glass–water interface at an angle i, it emerges finally parallel to the surface of water, then the value of μ_g would be :–

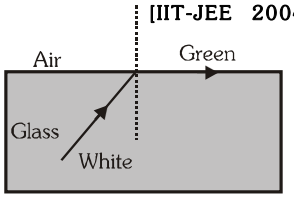
(A) (4/3) sin i
(B) 1/sin i
(C) 4/3
(D) 1



[IIT-JEE 2003]

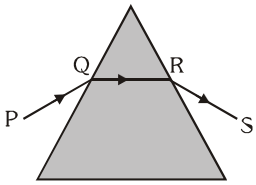
15. White light is incident on the interface of glass and air as shown in the figure. If green light is just totally internally reflected then the emerging ray in air contains. **[IIT-JEE 2004]**

(A) yellow, orange, red
(B) violet, indigo, blue
(C) all colours
(D) all colours except green



16. A ray of light is incident on an equilateral glass prism placed on a horizontal table. For minimum deviation which of the following is true ? **[IIT-JEE 2004]**

(A) PQ is horizontal
(B) QR is horizontal
(C) RS is horizontal
(D) Either PQ or RS is horizontal

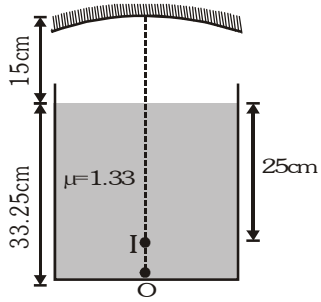


17. A point object is placed at the centre of a glass sphere of radius 6cm and refractive index 1.5. The distance of the virtual image from the surface of the sphere is :- **[IIT-JEE 2004]**

(A) 2cm (B) 4cm (C) 6cm (D) 12cm

18. A container is filled with water (μ = 1.33) upto a height of 33.25 cm. A concave mirror is placed 15cm above the water level and the image of an object placed at the bottom is formed 25cm below the water level. The focal length of the mirror is :- **[IIT-JEE 2004]**

(A) 10 cm (B) 15 cm
(C) 20 cm (D) 25 cm

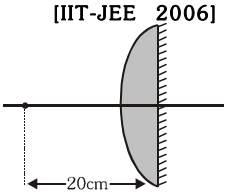


19. A convex lens is in contact with concave lens. The magnitude of the ratio of their focal length is 2/3. Their equivalent focal length is 30cm. What are their individual focal lengths ? **[IIT-JEE 2005]**

(A) –75, 50 (B) –10, 15 (C) 75, 50 (D) –15, 10

20. A point object is placed at distance of 20cm from a thin plano–convex lens of focal length 15cm. The plane surface of the lens is now silvered. The image created by the system is at :- **[IIT-JEE 2006]**

(A) 60cm to the left of the system
(B) 60cm to the right of the system
(C) 12cm to the left of the system
(D) 12cm to the right of the system



21. A biconvex lens of focal length f forms a circular image of radius r of sun in focal plane. Then which option is correct ? **[IIT-JEE 2006]**

(A) $\pi r^2 \propto f$
(B) $\pi r^2 \propto f^2$
(C) if lower half part is covered by black sheet, then area of the image is equal to $\pi r^2/2$
(D) if f is doubled, intensity will increase

22. A ray of light travelling in water is incident on its surface open to air. The angle of incidence is θ, which is less than the critical angle. Then there will be :- **[IIT-JEE 2007]**

(A) only a reflected ray and no refracted ray
(B) only a refracted ray and no reflected ray
(C) a reflected ray and a refracted ray and the angle between them would be less than $180 - 2\theta$
(D) a reflected ray and a refracted ray and the angle between them would be greater than $180 - 2\theta$

23. In an experiment to determine the focal length (f) of a concave mirror by the u–v method, a student placed the object pin A on the principal axis at a distance x from the pole P. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with PA. When the student shift his/her eye towards left, the image appears to the right of the object pin. Then– **[IIT-JEE 2007]**

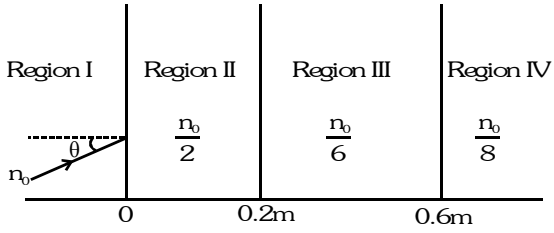
(A) $x < f$ (B) $f < x < 2f$ (C) $x = 2f$ (D) $x > 2f$

24. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is 60). In the position of minimum deviation, the angle of refraction will be :– **[IIT-JEE 2008]**

(A) 30 for both the colours (B) greater for the violet colour

(C) greater for the red colour (D) equal but not 30 for both the colours

25. A light beam is traveling from Region I to Region IV (Refer figure). The refractive index in Regions I,II,III and IV are n_0 , $\frac{n_0}{2}$, $\frac{n_0}{6}$ and $\frac{n_0}{8}$, respectively. The angle of incidence θ for which the beam just misses entering Region IV is **[IIT-JEE 2008]**



(A) $\sin^{-1}\left(\frac{3}{4}\right)$ (B) $\sin^{-1}\left(\frac{1}{8}\right)$ (C) $\sin^{-1}\left(\frac{1}{4}\right)$ (D) $\sin^{-1}\left(\frac{1}{3}\right)$

26. A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is 4/3. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, when the ball is 12.8 m above the water surface, the fish sees the speed of ball as [Take $g = 10\ m/s^2$.] **[IIT-JEE 2009]**

(A) 9 m/s (B) 12 m/s (C) 16 m/s (D) 21.33 m/s

27. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is **[IIT-JEE 2010]**

(A) virtual and at a distance of 16 cm from the mirror

(B) real and at a distance of 16 cm from the mirror

(C) virtual and at a distance of 20 cm from the mirror

(D) real and at a distance of 20 cm from the mirror

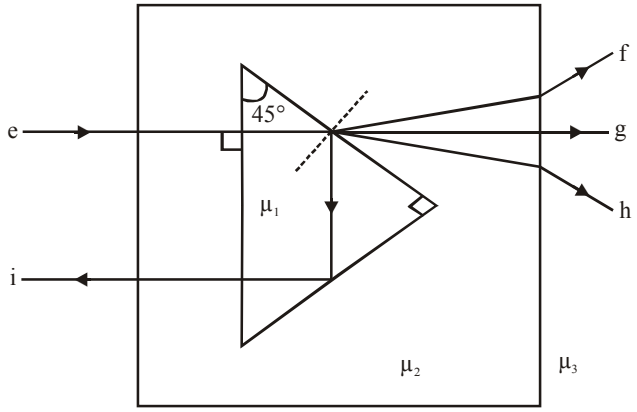
28. A ray of light travelling in the direction $\frac{1}{2}\left(\tilde{i}+\sqrt{3}\tilde{j}\right)$ is incident on a plane mirror. After reflection, it travels along the direction $\frac{1}{2}\left(\tilde{i}-\sqrt{3}\tilde{j}\right)$. The angle of incidence is :- **[JEE Advanced 2013]**

(A) 30 (B) 45 (C) 60 (D) 75

29. The image of an object, formed by a plano-convex lens at a distance of 8 m behind the lens, is real and is one-third the size of the object. The wavelength of light inside the lens is $\frac{2}{3}$ times the wavelength in free space. The radius of the curved surface of the lens is :- **[JEE Advanced 2013]**

(A) 1 m (B) 2 m (C) 3 m (D) 6 m

30. A right angled prism of refractive index μ_1 is placed in a rectangular block of refractive index μ_2, which is surrounded by a medium of refractive index μ_3, as shown in the figure. A ray of light 'e' enters the rectangular block at normal incidence. Depending upon the relationships between μ_1, μ_2, and μ_3, it takes one of the four possible paths 'ef', 'eg', 'eh' or 'ei'. **[JEE Advanced 2013]**



Match the paths in List I with conditions of refractive indices in List II and select the correct answer using the codes given below the lists :

	List I		List II
P.	e → f	1.	$\mu_1 > \sqrt{2}\mu_2$
Q.	e → g	2.	$\mu_2 > \mu_1$ and $\mu_2 > \mu_3$
R.	e → h	3.	$\mu_1 = \mu_2$
S.	e → i	4.	$\mu_2 < \mu_1 < \sqrt{2}\mu_2$ and $\mu_2 > \mu_3$

Codes :

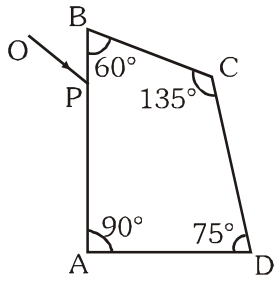
	P	Q	R	S
(A)	2	3	1	4
(B)	1	2	4	3
(C)	4	1	2	3
(D)	2	3	4	1

MCQ'S WITH ONE OR MORE THAN ONE CORRECT ANSWER

1. A ray of light traveling in a transparent medium falls on a surface separating the medium from air at an angle of incidence 45 . The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible value (s) of n from the following :– **[IIT-JEE 1998]**

(A) 1.3 (B) 1.4 (C) 1.5 (D) 1.6

2. A ray OP of monochromatic light is incident on the face AB of prism ABCD near vertex B at an incident angle of 60 (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) correct? **[IIT-JEE 2010]**



(A) The ray gets totally internally reflected at face CD

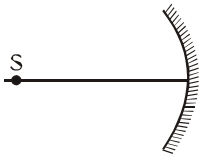
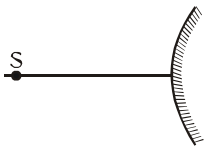
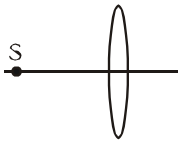
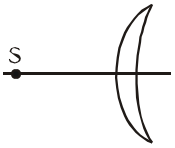
(B) The ray comes out through face AD

(C) The angle between the incident ray and the emergent ray is 90

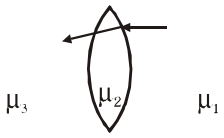
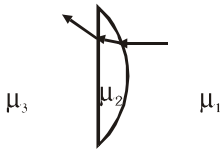
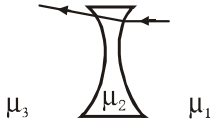
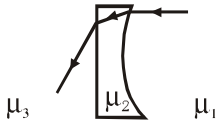
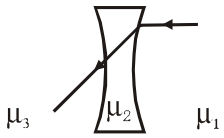
(D) The angle between the incident ray and the emergent ray is 120

MATCH THE COLUMNS

1. An optical component and an object S placed along its optic axis are given in **Column I**. The distance between the object and the component can be varied. The properties of images are given in **Column II**. Match all the properties of images from Column II with the appropriate components given in **Column I**. Indicate your answer by darkening the appropriate bubbles of the 4 4 matrix given in the ORS. **[IIT-JEE 2008]**

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

2. Two transparent media of refractive indices μ_1 and μ_3 have a solid lens shaped transparent material of refractive index μ_2 between them as shown in figures in **Column II**. A ray traversing these media is also shown in the figures. In **Column I** different relationships between μ_1, μ_2 and μ_3 are given. Match them to the ray diagrams shown in **Column II**. **[IIT-JEE 2010]**

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

ASSERTION & REASON

This question contains, statement I (assertion) and statement II (reason).

1. **Statement–I :** The formula connecting u, v and f for a spherical mirror is valid only for mirrors whose sizes are very small compared to their radii of curvature. **[IIT-JEE 2007]**

   Because :

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

   (A) statement–I is true, statement–II is true ; statement–II is a correct explanation for statement–I

   (B) statement–I is true, statement–II is true ; statement–II is NOT a correct explanation for statement–I

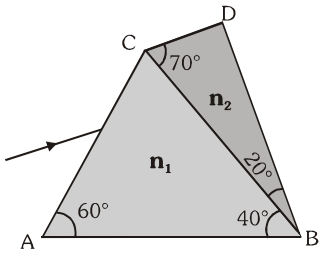
   (C) statement–I is true, statement–II is false

   (D) statement–I is false, statement–II is true

SUBJECTIVE QUESTIONS

1. A prism of refractive index n_1 and another prism of refractive index n_2 are stuck together with a out gap as shown in the figure. The angles of the prism are as shown. The refractive indices n_1 and n_2 depend on λ, the wavelength of light according to relations :

   $n_1 = 1.20 + \frac{10.8\times10^4}{\lambda^2}$ and $n_2 = 1.45 + \frac{1.80\times10^4}{\lambda^2}$ where λ is in nm.

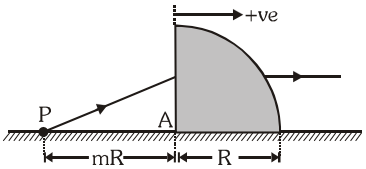


   (a) Calculate the wavelength λ_0 for which rays incident at any angle on the interface BC pass through without bending at that interface.

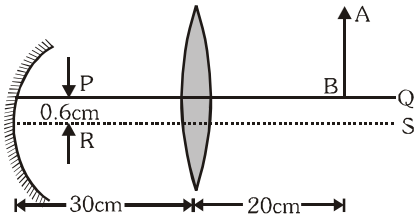
   (b) For light of wavelength λ_0, find the angle of incidence i on the face AC such that the deviation produced by the combination of prisms is minimum. **[IIT-JEE 1998]**

2. The x–y plane is the boundary between two transparent media. Medium–1 with $z \geq 0$ has a refractive index $\sqrt{2}$ and medium–2 with $z \leq 0$ has a refractive index $\sqrt{3}$. A ray of light in medium–1 given by vector $\vec{A} = 6\sqrt{3}\tilde{i} + 8\sqrt{3}\tilde{j} - 10\tilde{k}$ is incident on the plane of separation. Find the unit vector in the direction of the refracted ray in medium–2. **[IIT-JEE 1999]**

3. A quarter cylinder of radius R and refractive index 1.5 is placed on a table. A point object P is kept at a distance of mR from it. Find the value of m for which a ray from P will emerge parallel to the table as shown in figure. **[IIT-JEE 1999]**



4. A convex lens of focal length 15cm and a concave mirror of focal length 30 cm are kept with their optic axis PQ and RS parallel but separated in vertical direction by 0.6 cm as shown. The distance between the lens and mirror is 30cm. An upright object AB of height 1.2 cm is placed on the optic axis PQ of the lens at a distance of 20cm from the lens. If A'B' is the image after refraction from the lens and the reflection from the mirror, find the distance of A' B' from the pole of the mirror and obtain its magnification. Also locate positions of A' and B' with respect to the optic axis RS. **[IIT-JEE 2000]**

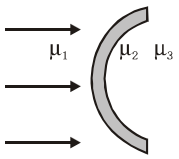


5. The refractive indices of the crown glass for blue and red light are 1.51 and 1.49 respectively and those of the flint glass are 1.77 and 1.73 respectively. An isosceles prism of angle 6 is made of crown glass. A beam of white light is incident at a small angle on this prism. The other flint glass isosceles prism is combined with the crown glass prism such that there is no deviation of the incident light. **[IIT-JEE 2001]**

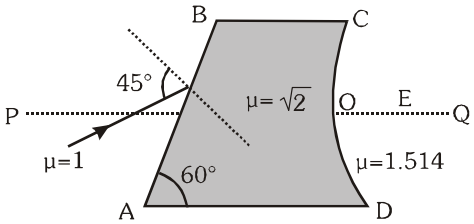
(a) Determine the angle of the flint glass prism.

(b) Calculate the net dispersion of the combined system.

6. In the figure, light is incident on the thin lens as shown. The radius of curvature for both the surface is R. Determine the focal length of this system. **[IIT-JEE 2003]**

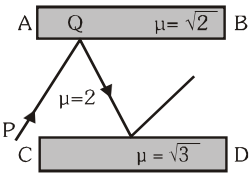


7. Figure shows an irregular block of material of refractive index $\sqrt{2}$. A ray of light strikes the face AB as shown in the figure. After refraction it is incident on a spherical surface CD of radius of curvature 0.4m and enters a medium of refractive index 1.514 to meet PQ at E. Find the distance OE upto two placed of decimal. **[IIT-JEE 2004]**

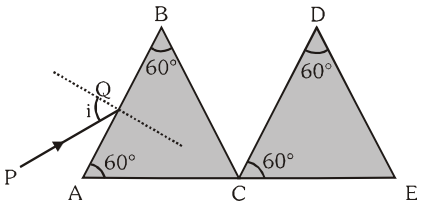


8. An object is approaching a thin convex lens of focal length 0.3m with a speed of 0.01 m/s. Find the magnitude of the rates of change of position and lateral magnification of image when the object is at a distance of 0.4 m from the lens. **[IIT-JEE 2004]**

9. AB and CD are two slabs. The medium between the slabs has refractive index 2. Find the minimum angle of incidence of Q, so that the ray is totally reflected by both the slabs. **[IIT-JEE 2005]**



10. A ray of light is incident on a prism ABC of refractive index $\sqrt{3}$ as shown in figure. **[IIT-JEE 2005]**



(a) Find the angle of incidence for which the deviation of light ray by the prism ABC is minimum.
(b) By what angle the second prism must be rotated, so that the final ray suffer net minimum deviation.

11. The focal length of a thin biconvex lens is 20 cm. When an object is moved from a distance of 25 cm in front of it to 50 cm, the magnification of its image changes from m_{25} to m_{50}. The ratio $\frac{m_{25}}{m_{50}}$ is **[IIT-JEE 2010]**

12. Image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from $\frac{25}{3}$ m to $\frac{50}{7}$ m in 30 seconds. What is the speed of the object in km per hour? **[IIT-JEE 2010]**

PREVIOUS YEARS QUESTIONS — ANSWER KEY — EXERCISE –5[B]

- **MCQ's One correct answers**

1. D	**2.** A	**3.** A	**4.** D	**5.** B	**6.** D	**7.** A	**8.** D	**9.** C
10. B	**11.** C	**12.** B	**13.** B	**14.** B	**15.** A	**16.** B	**17.** C	**18.** C
19. D	**20.** C	**21.** B	**22.** C	**23.** B	**24.** A	**25.** B	**26.** C	**27.** B
28. A	**29.** C	**30.** D						

- **MCQ's with one or more than one correct answer** **1.** C,D **2.** ABC
- ***Match the Column*** **1.** (A) p,q,r,s (B) q, (C) p,q,r,s (D) p,q,r,s
  2. (A)–pr, (B) –qst, (C) –prt, (D) –qs
- ***Assertion – Reason Questions*** **1.** C
- ***Subjective Questions***

1. (a) 600 nm (b) $\sin^{-1}(3/4)$ **2.** $\frac{1}{5\sqrt{2}}\left(3\tilde{i}+4\tilde{j}-5\tilde{k}\right)$ **3.** 4/3

4. 15 cm, $\frac{-3}{2}$ **5.**(i) 4 (ii) – 0.04 **6.** $\frac{\mu_3 R}{\mu_3-\mu_1}$ **7.** 6.06 m

8. 0.09 m/s, 0.3 /s **9.** 60 **10.** (a) 60 (b) 60

11. 6 **12.** 3