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PHYSICS

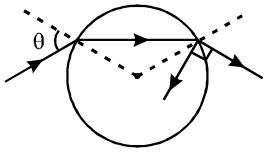
TARGET : JEE- Advanced 2023

CAPS-3

GEOMETRICAL OPTICS

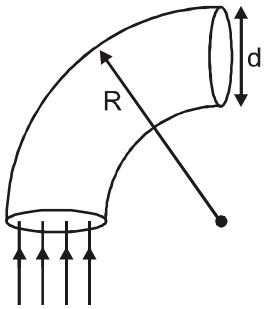
SCQ (Single Correct Type) :

1. A ray incident at a point at an angle of incidence θ enters into a glass sphere placed in air which is reflected and refracted at the farther surface of the sphere as shown in the figure. The angle between reflected and refracted rays at this surface is 90°. If refractive index of the sphere is $\sqrt{3}$, the angle θ is :



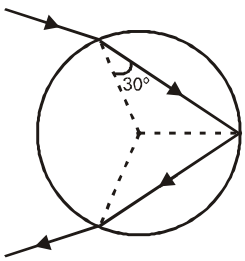
(A) $\frac{\pi}{3}$ (B) $\frac{\pi}{4}$ (C) $\frac{\pi}{6}$ (D) $\frac{2\pi}{3}$

2. A cylinderical optical fibre (quarter circular shape) of refractive index n = 2 and diameter d = 4mm is surrounded by air. A light beam is sent into the fibre along its axis as shown in figure. Then the smallest outer radius R (as shown in figure) for which no light escapes during first refraction from curved surface of fibre is :



(A) 2mm (B) 4mm (C) 8 mm (D) 6 mm

3. A ray is incident from air on a sphere of refractive index $\sqrt{2}$ as shown in figure. Angle of refraction of the ray inside sphere is 30º. The total deviation suffered by the ray is

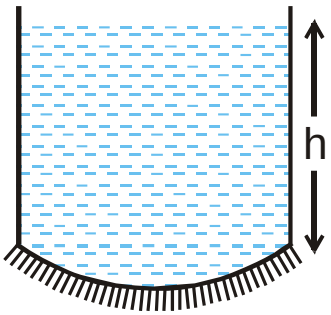


(A) 150° (B) 120° (C) 90° (D) 45°

4. The xz plane separates two media A and B with refractive indices μ_1 & μ_2 respectively. A ray of light travels from A to B. Its directions in the two media are given by the unit vectors, $\vec{r}_A = a\hat{i} + b\hat{j}$ & $\vec{r}_B = \alpha\hat{i} + \beta\hat{j}$ respectively where $\hat{i}$ & $\hat{j}$ are unit vectors in the x & y directions. Then:

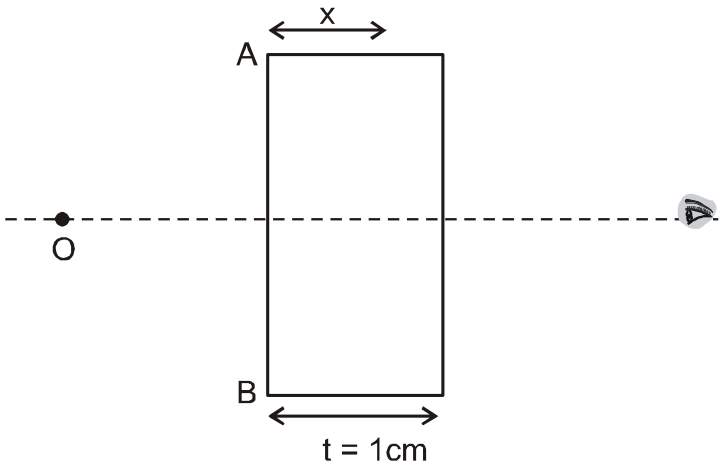
(A) $\mu_1 a = \mu_2 \alpha$ (B) $\mu_1 \alpha = \mu_2 a$ (C) $\mu_1 b = \mu_2 \beta$ (D) $\mu_1 \beta = \mu_2 b$

5. A beaker is filled with water as shown. The bottom surface of the beaker is a concave mirror of large radius of curvature and small aperture. The height of water is h = 40 cm. It is found that when an object is placed 4 cm above the water surface, the image coincides with the object. Now the water level h is reduced to zero (there will still be water left in the concave part of the mirror). The new height of the object above the new water surface so that the image again coincides with the object, will be (refractive index of water = 4/3)



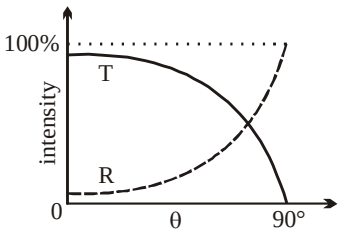
(A) 34 cm (B) 10 cm (C) 74 cm (D) zero

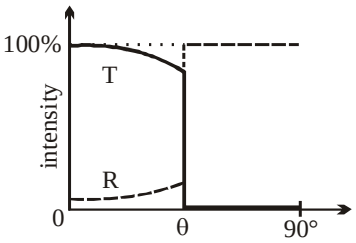
6. Refractive index of a glass slab is n = 1 + ax. where a = 1 cm^{-1} and x is perpendicular distance from AB face of the slab(as shown), then the shift in position of object will be :

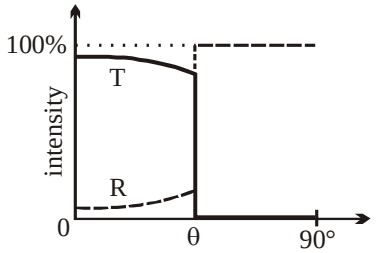


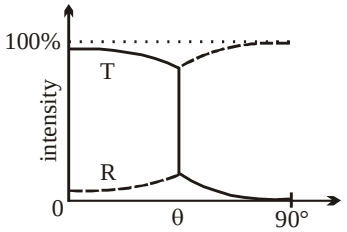
(A) ℓn2 cm (B) (1 – ℓn2) cm (C) (1 + ℓn2) cm (D) (1 + log2) cm

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

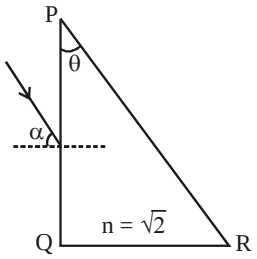
(A) 

(B) 

(C) 

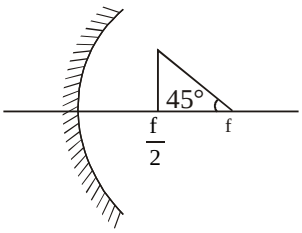
(D) 

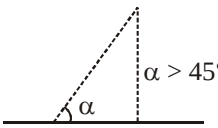
8. A parallel beam of light is incident from air at an angle α on the side PQ of a right angled triangular prism of refractive index $n = \sqrt{2}$. Light undergoes total internal reflection in the prism at the face PR when α has a minimum value of 45°. The angle θ of the prism is

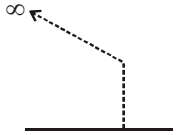


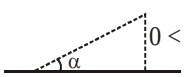
(A) 15° (B) 22.5° (C) 30° (D) 45°

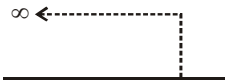
9. A wire is bent in the shape of a right angled triangle and is placed in front of a concave mirror of focal length f, as shown in the figure. Which of the figures shown in the four options qualitatively represent(s) the shape of the image of the bent wire? (These figures are not to scale)



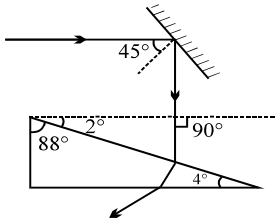
(A) 

(B) 

(C) 

(D) 

10. A ray of light strikes a plane mirror at an angle of incidence 45º as shown in the figure. After reflection, the ray passes through a prism of refractive index 1.5, whose apex angle is 4º. The angle through which the mirror should be rotated if the total deviation of the ray is to be 90º is

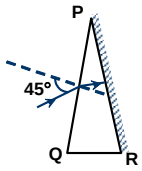


(A) 1° clockwise (B) 1° anticlockwise (C) 2° clockwise (D) 2° anticlockwise

11. A convex lens forms inverted image of a real object on a fixed screen. The size of image is 12 cm. When lens is displaced 20 cm along principle axis it again forms a real image of size 3 cm on the screen. Focal length of the lens is. (Assume image formation only by paraxial rays)

(A) $\frac{40}{3}$cm (B) $\frac{80}{3}$cm (C) 20 cm (D) $\frac{50}{3}$cm

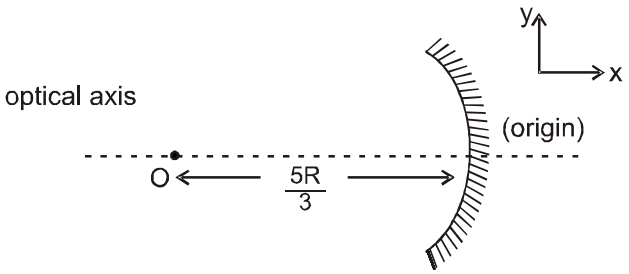
12. The face PR of a prism QPR of angle 30° is silvered. A ray is incident on face PQ at an angle of 45° as shown in figure. The refracted ray undergoes reflection on face PR and retraces its path. The refractive index of the prism is



(A) √2 (B) 3/√2 (C) 1.5 (D) 1.33

MCQ (One or more than one correct) :

13. A point object is placed at a distance of $\frac{5R}{3}$ from the pole of concave mirror of small aperature and radius of curvature R. Point object oscillates with amplitude 1mm perpendicular to the optical axis. Then



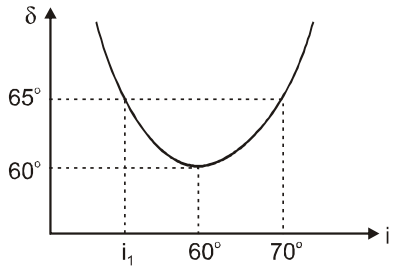
(A) amplitude of image is $\frac{3}{7}$mm.

(B) phase difference between motion of object and its image when object crosses optical axis is π.

(C) position of image of object from pole is $\left(-\frac{5R}{7},0\right)$, when object at 'O'.

(D) Image of object is real.

14. The angle of deviation (δ) vs angle of incidence (i) is plotted for a prism. Pick up the correct statements.



(A) The angle of prism is 60°

(B) The refractive index of the prism is n = $\sqrt{3}$

(C) For deviation to be 65° the angle of incidence i_1 = 55°

(D) The curve of 'δ' vs 'i' is parabolic

15. A small air bubble is trapped inside a transparent cube of size 12 cm. When viewed from one of the vertical faces, the bubble appears to be at 5 cm from it. When viewed from opposite face, it appears at 3 cm from it.

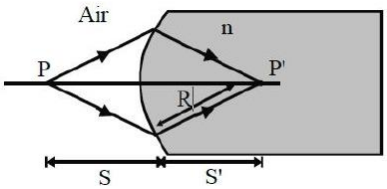
(A) The distance of the air bubble from the first face is 7.5 cm.

(B) The distance of the air bubble from the first face is 9 cm.

(C) Refractive index of the material of the cube is 2.0.

(D) Refractive index of the material of the cube is 1.5.

16. Which of these actions will move the real image point P' farther from the boundary?



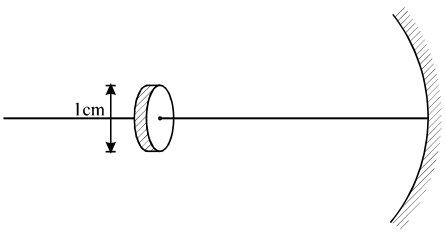
(A) Decrease the index of refraction n. (B) Decrease the distance S.

(C) Increase the radius of curvature R. (D) Increase the index of refraction n.

Comprehension Type Question:

A concave mirror of radius of curvature 20 cm is shown in the figure. A circular disc of diameter 1 cm is placed on the principle axis of mirror with its plane perpendicular to the principal axis at a distance 15 cm from the pole of the mirror. The radius of disc starts increasing according to the law r = (0.5 + 0.1 t) cm/sec where t is time is second.

17. The image formed by the mirror will be in the shape of a :



(A) circular disc (B) elliptical disc with major axis horizontal

(C) elliptical disc with major axis vertical (D) distorted disc

18. In the above question, the area of image of the disc at t = 1 second is :

(A) 1.2 π cm^2 (B) 1.44 π cm^2 (C) 1.52 π cm^2 (D) none of these

19. What will be the rate at which the radius of image will be changing

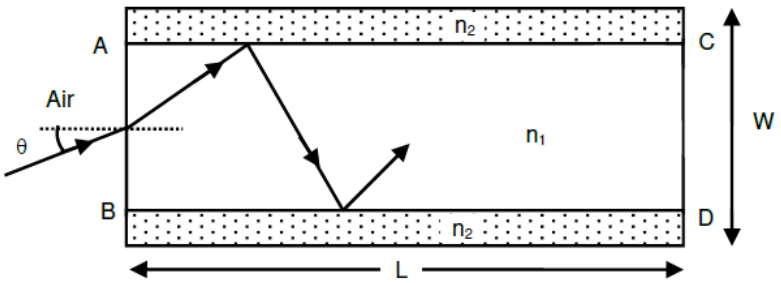
(A) 0.2 cm/sec increasing (B) 0.2 cm/sec decreasing

(C) 0.4 cm/sec increasing (D) 0.4 cm/sec decreasing

Numerical based Questions :

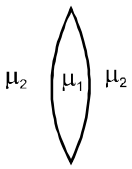
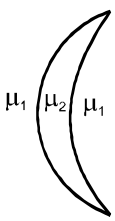
20. An object lies in front of a thick parallel glass slab, the bottom of which is polished. If the distance between first two images formed by bottom surface is 4cm then find the thickness of the slab. [Assume n_{glass} = 3/2 and paraxial rays]

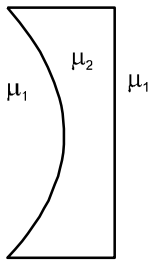
21. A planar structure of length L and width W is made of two different optical media of refractive indices n_1 = 1.5 and n_2 = 1.44 as shown in figure. If L >> W, a ray entering from end AB will emerge from end CD only if the total internal reflection condition is met inside the structure. For L = 9.6 m, if the incident angle θ is varied, the maximum time taken by a ray to exit the plane CD is t × 10^{-9} s, where t is _____ . [Speed of light c = 3 × 10^8 m/s]



Matrix Match Type :

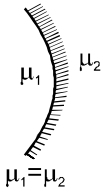
22. **Match the column :**

	Column–I	**Column–II**
(A)	 If $\mu_2 > \mu_1$	(p) Optical power will be positive
(B)	 If $\mu_2 > \mu_1$	(q) Optical power will be negative

(C) 

If $\mu_2 < \mu_1$

(r) System will converge a parallel beam of light incident on it

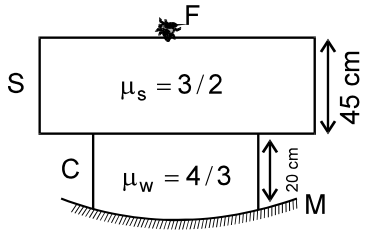
(D) 

(s) Focal length will be positive

(t) Focal length will be negative

Subjective Type Questions :

23. A fly F is sitting on a glass slab S 45cm thick & of refractive index 3/2. The slab covers the top of a container C containing water (R.I. 4/3) upto a height of 20 cm. Bottom of container is closed by a concave mirror M of radius of curvature 40 cm. Locate the final image formed by all refractions & reflection assuming paraxial rays.



24. (i) A paper weight of refractive index n = 3/2 in the form of a hemisphere of radius 3.0 cm is used to hold down a printed page. An observer looks at the page vertically through the paperweight. At what height above the page will the printed letters near the centre appear to the observer?

(ii) Solve the previous problem if the paperweight is inverted at its place so that the spherical surface touches the paper.

25. A ray of light strikes a glass slab of thickness t, at angle of incidence θ. Prove that for a small angle of incident the lateral shift y is given by y= $t\theta\left(1-\frac{1}{n}\right)$, where n is the refractive index of glass with respect to air.