Physicsaholics

DPP – 7 (Geometrical Optics)

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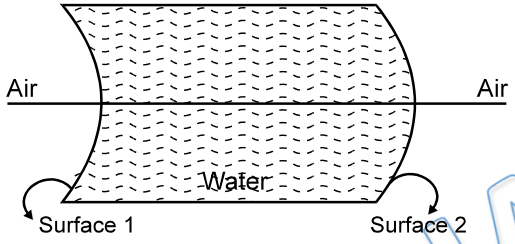
Q 1. Select correct Statement for an object on principal axis of given arrangement



(a) If light is incident on surface 1 from left, the image formed after the first refraction is definitely virtual for a real object

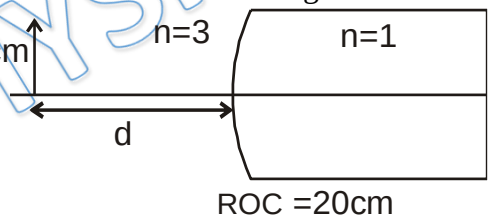
(b) If object is real and placed at left of surface 1, then the final image formed after two refractions may be real

(c) If object is real and placed at left of surface 1, then the final image formed after two refractions may be virtual

(d) If light is incident on surface 1 from left, the image formed after the first refraction is definitely real for a real object.

COMPREHENSION (Q2 to Q3)

An extended object of size 2 cm is placed at a distance of d (cm) in medium (refractive index n = 3) from pole, on the principal axis of a spherical curved surface. The medium on the other side of refracting surface is air (refractive index n = 1).



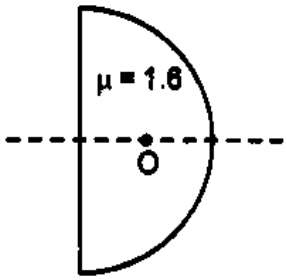
Q 2. For d = 20 cm, the distance of the image from the pole is

(a) 2 cm (b) 3 cm (c) 4 cm (d) 5 cm

Q 3. For d = 20 cm, the size of image is

(a) $\frac{1}{6}$ cm (b) $\frac{2}{15}$ cm (c) $\frac{6}{5}$ cm (d) $\frac{3}{2}$cm

Q 4. A plastic hemisphere has a radius of curvature of 8 cm and an index of refraction of 1.6. On the axis halfway between the plane surface and the spherical one (4 cm from each) is a small object O. The distance between the two images when viewed along the axis from the two sides of the hemisphere is approximately:

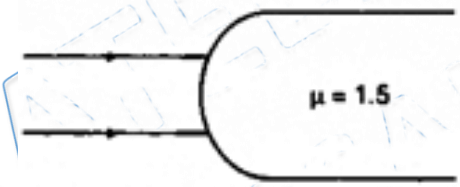


(a) 1.0 cm (b) 1.5 cm (c) 3.75 cm (d) 2.5 cm

Q 5. A spherical surface of radius of curvature R, separates air (refractive index 1.0) from glass (refractive index 1.5). The center of curvature is in the glass. A point object P placed in air is found to have a real image Q in the glass. The line PQ cuts the surface at a point O and PO = OQ. The distance PO is equal to:
(a) 5 R (b) 3 R (c) 2 R (d) 1.5 R

Q 6. A point object is placed at the center of a glass sphere of radius 6 cm and refractive index 1.5. The distance of the virtual image from the surface of the sphere is:
(a) 2 cm (b) 4 cm (c) 6 cm (d) 12 cm

Q 7. Parallel rays of light are falling on convex spherical surface of radius of curvature R = 20 cm as shown. Refractive index of the medium is μ = 1.5. After refraction from the spherical surface parallel rays:



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

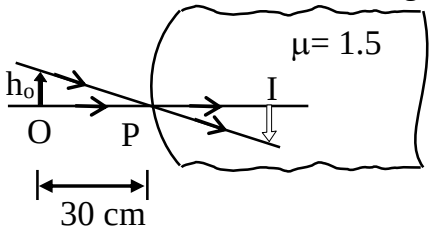
Q 8. For a spherical surface of radius of curvature R, separating two media of refractive indices μ_1 and μ_2 , the two principal focal lengths are f_1 and f_2 respectively. Which one of the following relations is correct?
(a) $f_1 = f_2$ (b) $f_2 / \mu_2 = f_1 / \mu_1$
(c) $f_2 / \mu_2 = - f_1 / \mu_1$ (d) $f_2 / \mu_1 = f_1 / \mu_2$

Q 9. A small object is enclosed in a sphere of solid glass 8 cm in radius. It is situated 2 cm from centre and is viewed from the side to which it is nearest. How far will it appear from the surface? ($\mu_g = 3/2$)
(a) 6 cm (b) 4 cm (c) $5\frac{1}{3}$ cm (d) $3\frac{2}{3}$ cm

Q 10. A hollow glass sphere has outer diameter 4R and inner diameter 2R. A point object on the inner surface is viewed along the diameter from the opposite side. Find the distance between the object and its image.

(a) $\frac{R(2\mu-1)}{3\mu-2}$ (b) $\frac{R(\mu-1)}{3\mu-2}$ (c) $\frac{R(2\mu-1)}{3\mu-1}$ (d) $\frac{R(\mu-1)}{3\mu-1}$

Q 11. A small object of height 0.5 cm is placed in front of a convex surface of glass (μ = 1.5) of radius of curvature 10 cm. Find the height of the image formed in glass.



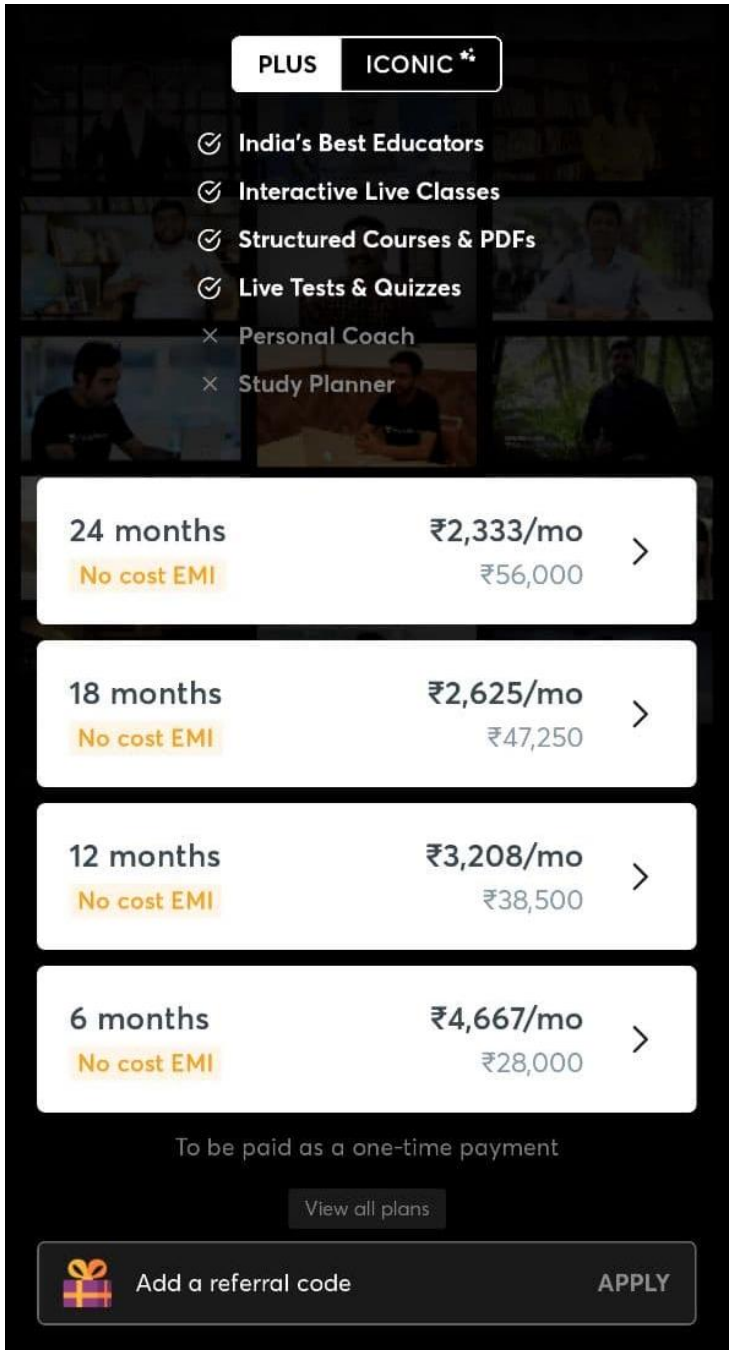
(a) 2 cm (b) 1 cm (c) 3 cm (d) 4 cm

Q 12. A parallel beam of light travelling in water (refractive index = 4/3) is refracted by a spherical air bubble of radius 2cm situated in water. Assuming the light rays to be paraxial, the position of the image due to refraction at the first surface is -

(a) 6cm from the first surface
(b) 12 cm from the first surface
(c) 3cm from the first surface
(d) 10 cm from the first surface

Answer Key

Q.1 a, b, c	**Q.2 c**	**Q.3 c**	**Q.4 d**	**Q.5 a**
Q.6 c	**Q.7 a, d**	**Q.8 c**	**Q.9 c**	**Q.10 d**
Q.11 b	**Q.12 a**			



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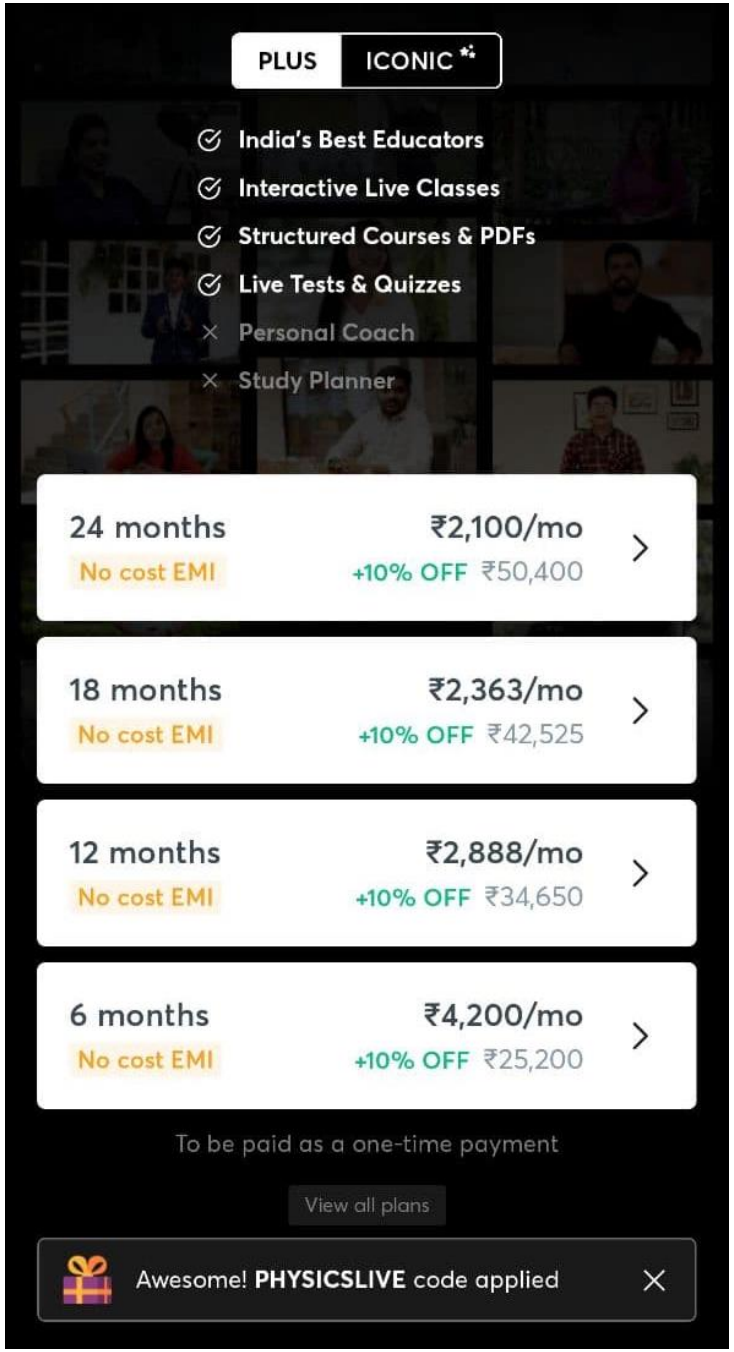


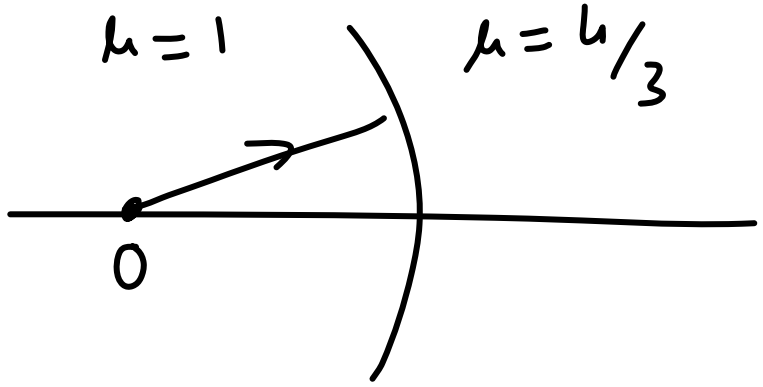
Written Solution

DPP -7 , Geometrical Optics – Refraction By Spherical Surface

By Physicsaholics Team

Solution: 1

(a)



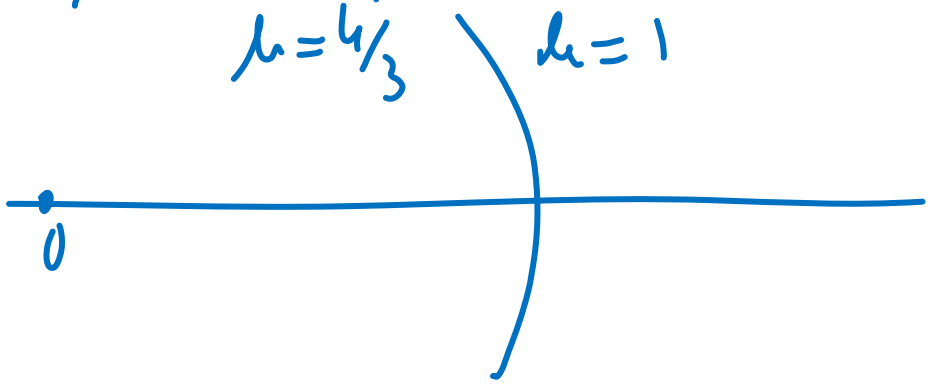
$$\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{(\mu_2 - \mu_1)}{R}$$

$\frac{\mu_1}{u} \to -ve$, $\frac{(\mu_2-\mu_1)}{R} \to +ve$, $R \to -ve$

$$\frac{\mu_2}{V} = \frac{\mu_1}{u} + \frac{(\mu_2 - \mu_1)}{R} = -ve$$

$$\Rightarrow V = -ve \Rightarrow \text{Virtual image}$$

(b & c) for second refraction



$$\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{(\mu_2 - \mu_1)}{R}$$

$\frac{\mu_1}{u} \to -ve$, $\frac{(\mu_2-\mu_1)}{R} \to -ve$

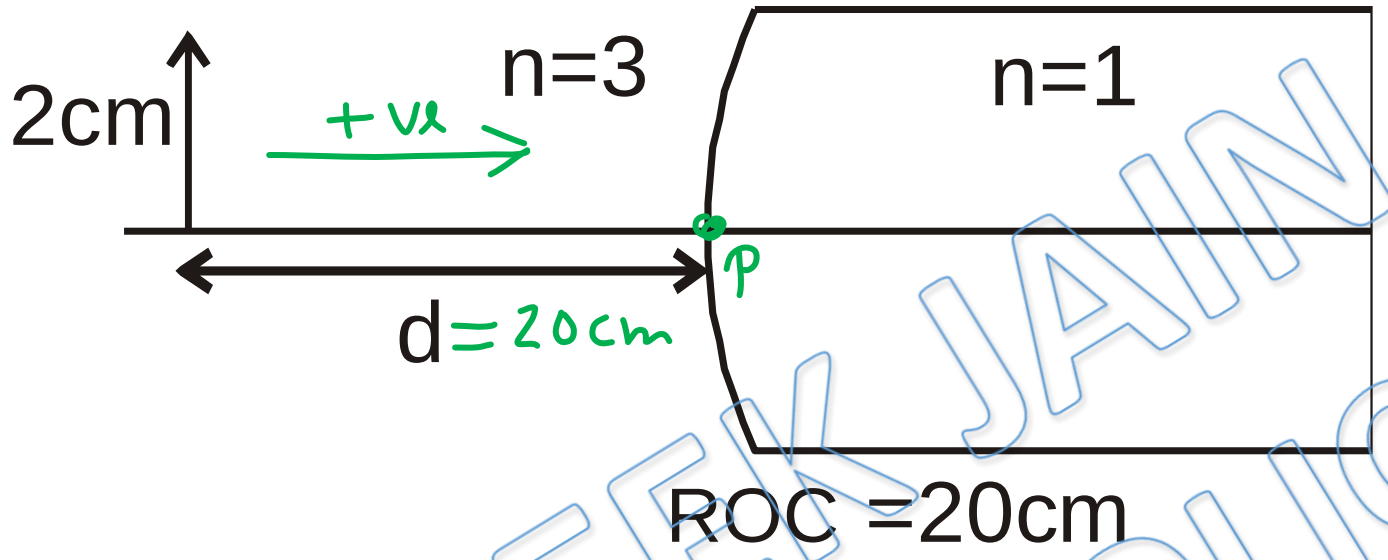
$$\frac{\mu_2}{V} = \left(\frac{\mu_1}{u}\right) + \left(\frac{(\mu_2 - \mu_1)}{R}\right)$$

$\frac{\mu_1}{u} \to -ve$, $\left(\frac{(\mu_2-\mu_1)}{R}\right) \to +ve$.

v may be +ve $\Rightarrow$ Image may be real, may be virtual

Ans(a, b, c)

Solution: 2



$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{1}{v} - \frac{3}{-20} = \frac{1-3}{+20}$$

$$\Rightarrow \frac{1}{v} + \frac{3}{20} = -\frac{1}{10} \Rightarrow \frac{1}{v} = -\left(\frac{3}{20} + \frac{1}{10}\right) = -\left(\frac{3+2}{20}\right)$$

$$\Rightarrow v = -4\,cm$$

Ans(c)

Solution: 3

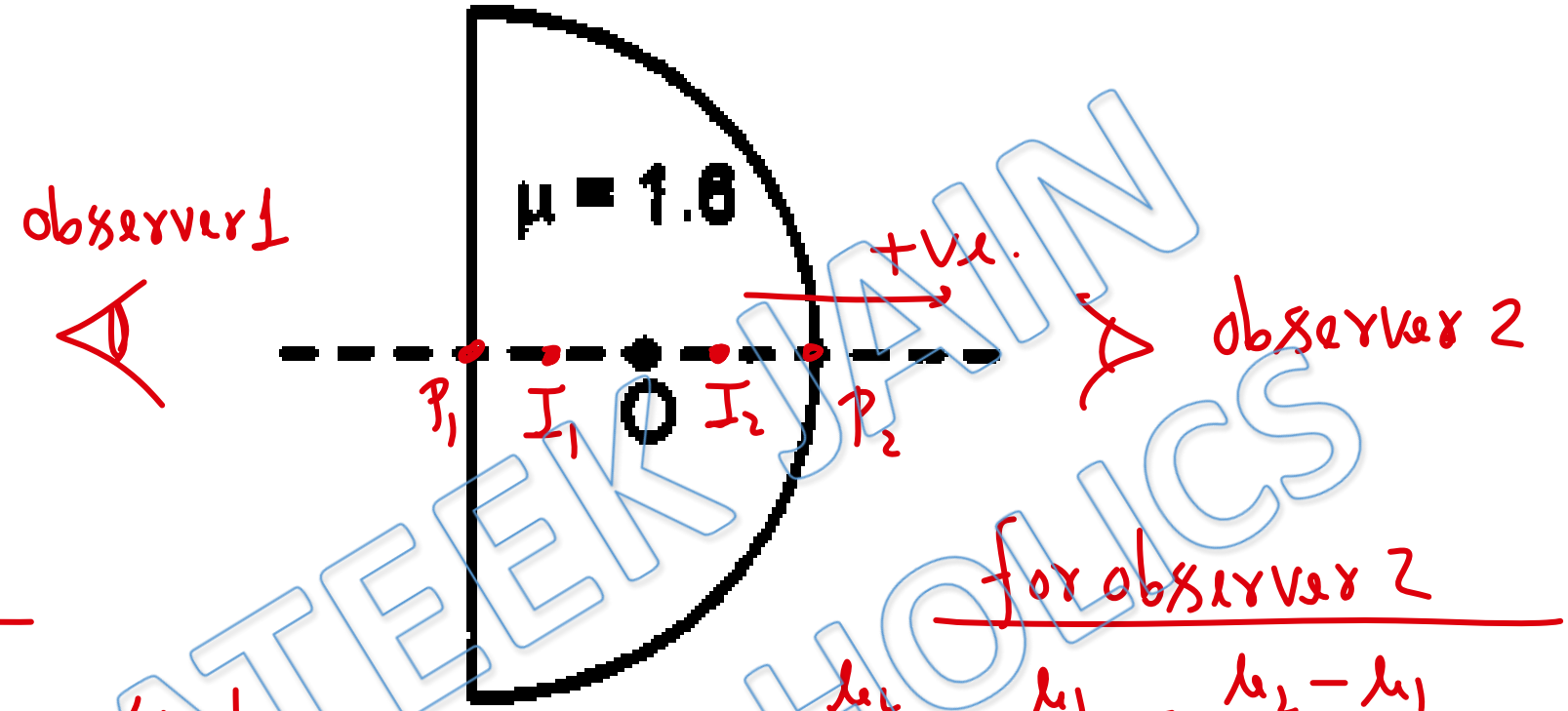
$$m = \frac{I}{O} = \frac{\mu_1 V}{\mu_2 U}$$

$$\Rightarrow \frac{I}{+2} = \frac{3}{1} \times \left(\frac{-4}{-20}\right)$$

$$\Rightarrow I = \frac{6}{5}\ cm$$

Ans (c)

Solution: 4



for observer 1

$$P_1I_1 = t\frac{\mu_2}{\mu_1} = \frac{4\times 1}{1.6} = \frac{40}{16} = 2.5\ cm$$

for observer 2

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

$$\frac{1}{V} - \frac{1.6}{-4} = \frac{1-1.6}{-8}$$

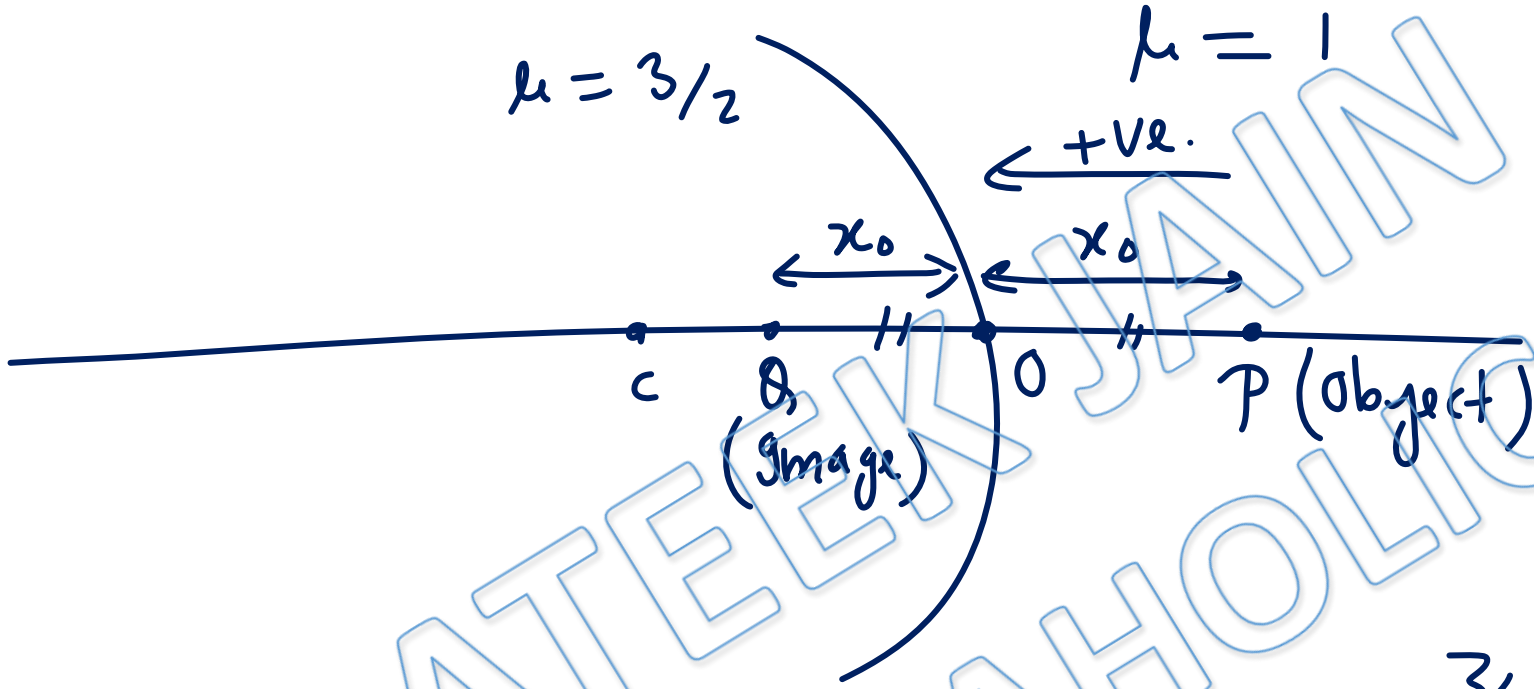
$$\Rightarrow \frac{1}{V} + \frac{16}{40} = \frac{3}{40} \Rightarrow \frac{1}{V} = -\frac{13}{40}$$

$$\Rightarrow V = -3\ cm$$

Distance between images $= 8 - 3 - 2.5 = 2.5\ cm$

Ans (d)

Solution: 5

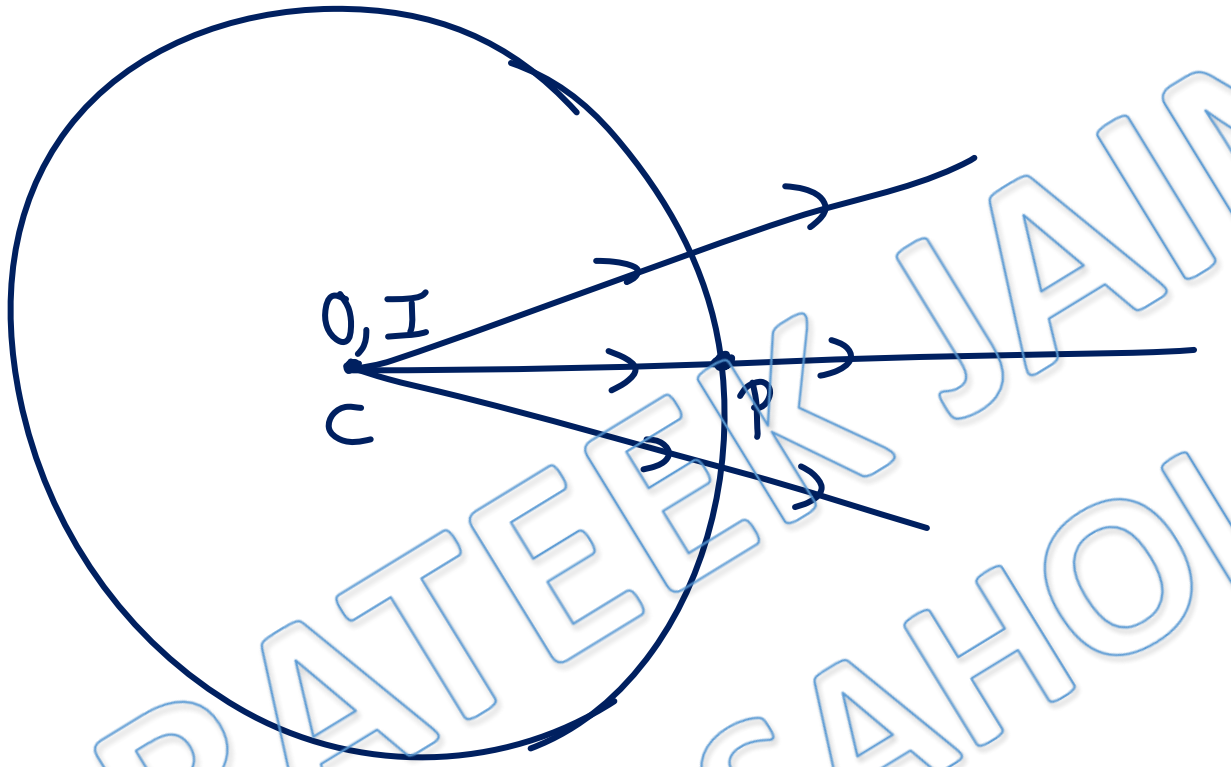


$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{3}{2(+x_0)} - \frac{1}{(-x_0)} = \frac{3/2 - 1}{+R}$$

$$\Rightarrow \frac{5}{2x_0} = \frac{1}{2R} \Rightarrow x_0 = 5R$$

Ans(a)

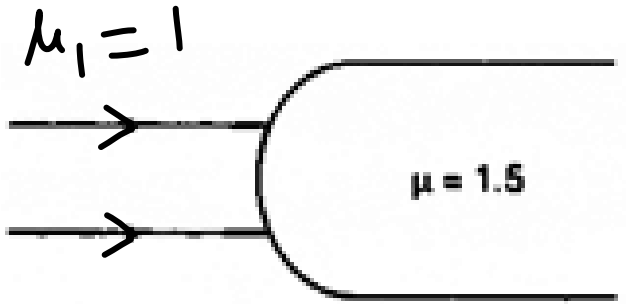
Solution: 6



Refracted Rays are intersecting at C. ⇒ Image is at C.

Ans(c)

Solution: 7



$$R = 20\,cm$$

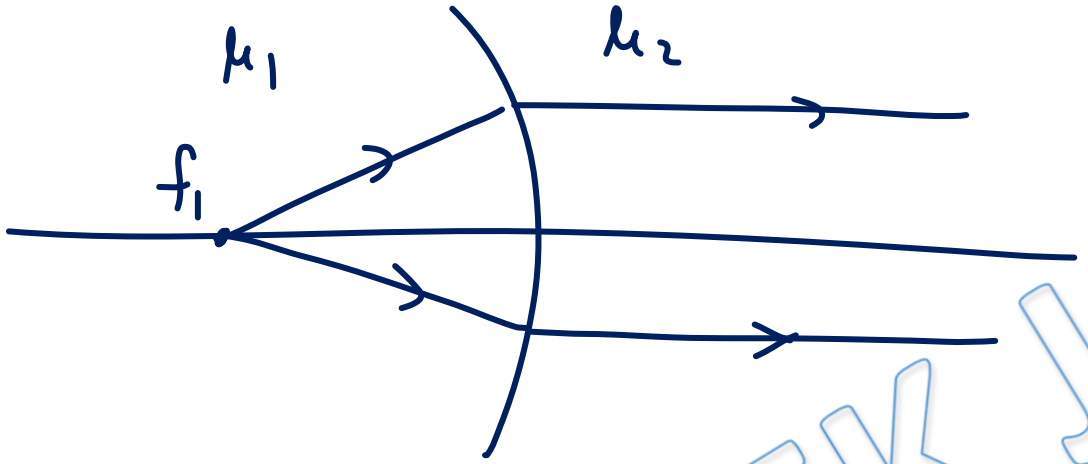
$$\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\Rightarrow \frac{1.5}{V} - \frac{\mu_1}{\infty} = \frac{1.5-1}{R} = \frac{.5}{R}$$

$$\Rightarrow V = 3R = 60\,cm$$

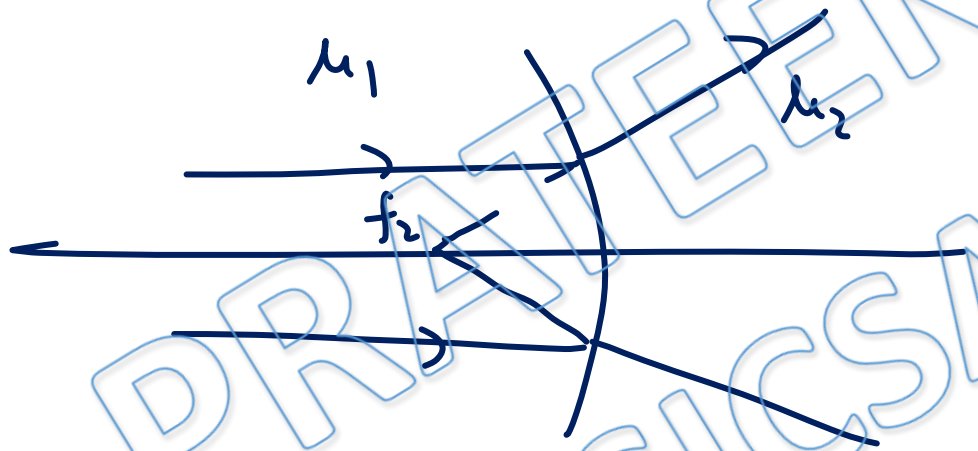
Ans (a,d)

Solution: 8



If object is at f_1, image will be at ∞.

$$\frac{\mu_2}{\infty} - \frac{\mu_1}{f_1} = \frac{\mu_2 - \mu_1}{R} \quad --(1)$$



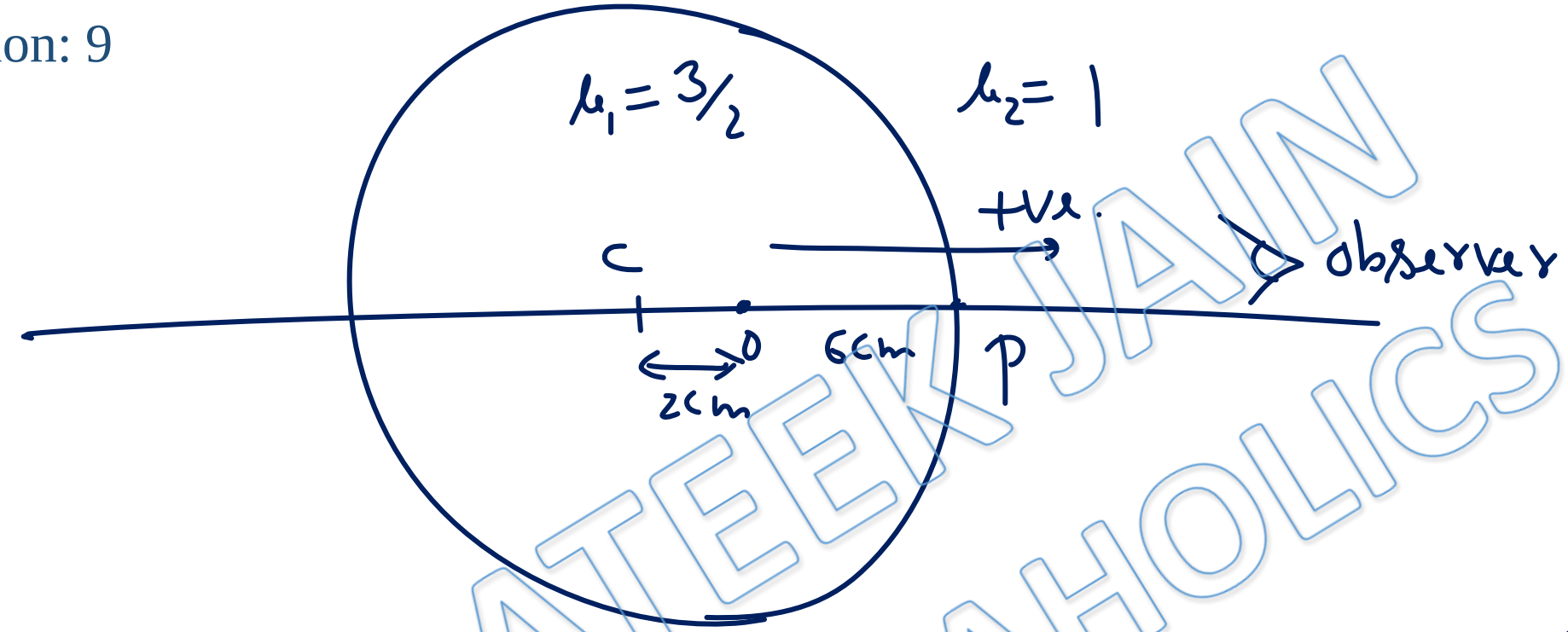
If object is at ∞, image will be at f_2.

$$\frac{\mu_2}{f_2} - \frac{\mu_1}{\infty} = \frac{\mu_2 - \mu_1}{R} \quad --(11)$$

$$\Rightarrow \frac{\mu_1}{f_1} + \frac{\mu_2}{f_2} = 0$$

ANS (C)

Solution: 9

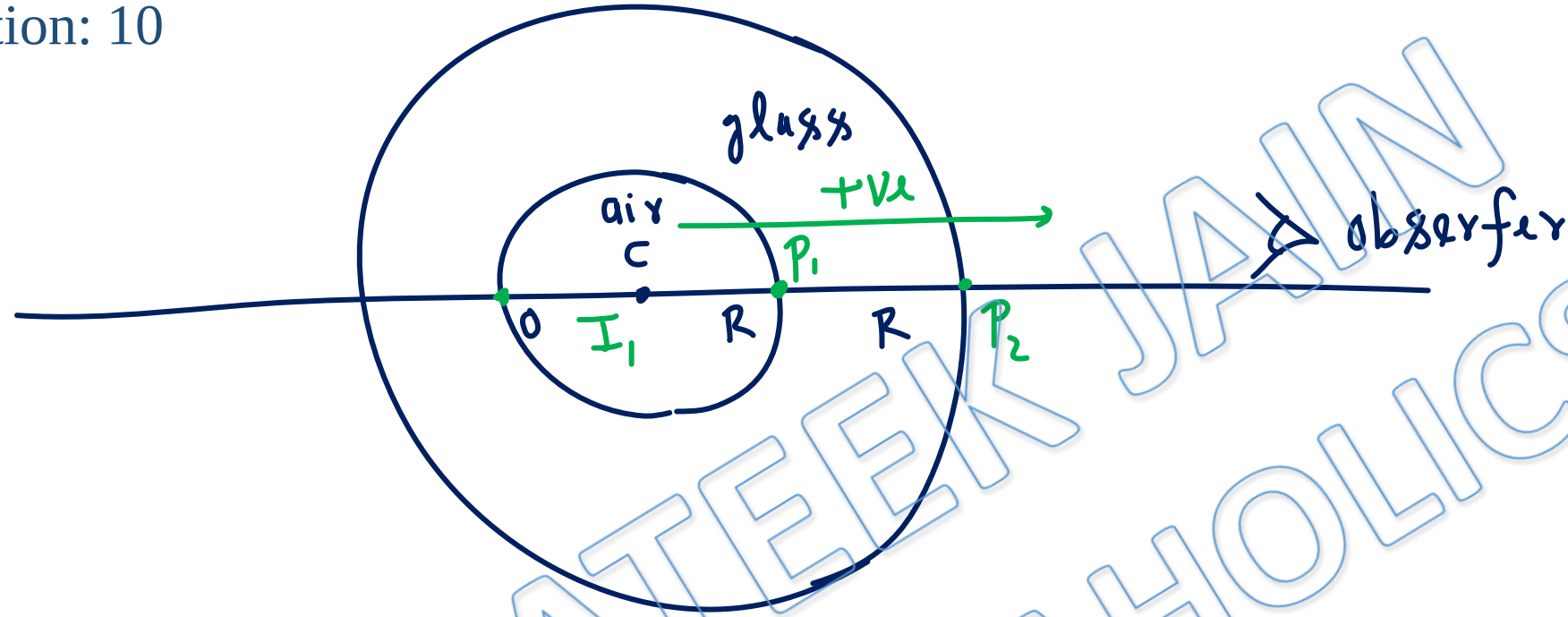


$$\frac{1}{V} - \frac{3}{2(-6)} = \frac{1-3/2}{-8} \Rightarrow \frac{1}{V} + \frac{1}{4} = \frac{1}{16}$$

$$\Rightarrow \frac{1}{V} = \frac{1}{16} - \frac{1}{4} = \frac{1-4}{16} \Rightarrow V = -\frac{16}{3} = -5\frac{1}{3}\,\text{cm}$$

ANS(C)

Solution: 10



first refraction is from air to glass

$$\frac{\mu}{V_1} - \frac{1}{-2R} = \frac{\mu - 1}{-R} \Rightarrow \frac{\mu}{V_1} = -\left[\frac{1}{2R} + \frac{\mu - 1}{R}\right]$$

$$\Rightarrow \frac{\mu}{V_1} = -\left[\frac{1 + 2\mu - 2}{2R}\right] \Rightarrow V_1 = \frac{-2\mu R}{2\mu - 1}$$

for Second refraction

$\mu_1 = \mu$, $\mu_2 = 1$, $R = -4R$

$$U = -\left[R + \frac{2\mu R}{2\mu - 1} \right] = -\left[\frac{2\mu R - R + 2\mu R}{2\mu - 1} \right] = -\left[\frac{4\mu R - R}{2\mu - 1} \right]$$

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

$$\Rightarrow \frac{1}{V} - \frac{\mu(2\mu - 1)}{-(4\mu R - R)} = \frac{1 - \mu}{-2R} = \frac{\mu - 1}{2R}$$

$$\Rightarrow \frac{1}{V} = \frac{\mu - 1}{2R} - \frac{2\mu^2 - \mu}{R(4\mu - 1)} = \frac{4\mu^2 - \mu - 4\mu + 1 - 4\mu^2 + 2\mu}{2R(4\mu - 1)}$$

$$\frac{1}{V} = \frac{1-3\mu}{2R(4\mu-1)} \Rightarrow V = -\frac{2R(4\mu-1)}{3\mu-1}$$

Distance between object & image →

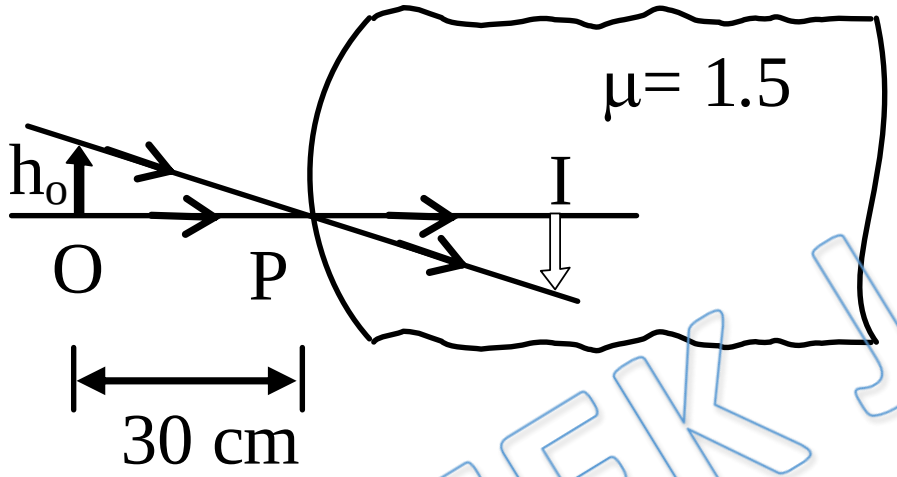
$$= 3R - \frac{2R(4\mu-1)}{3\mu-1}$$

$$= \frac{9\mu R - 3R - 8\mu R + 2R}{3\mu-1}$$

$$= \frac{\mu R - R}{3\mu-1} = \frac{R(\mu-1)}{3\mu-1}$$

Ans(d)

Solution: 11



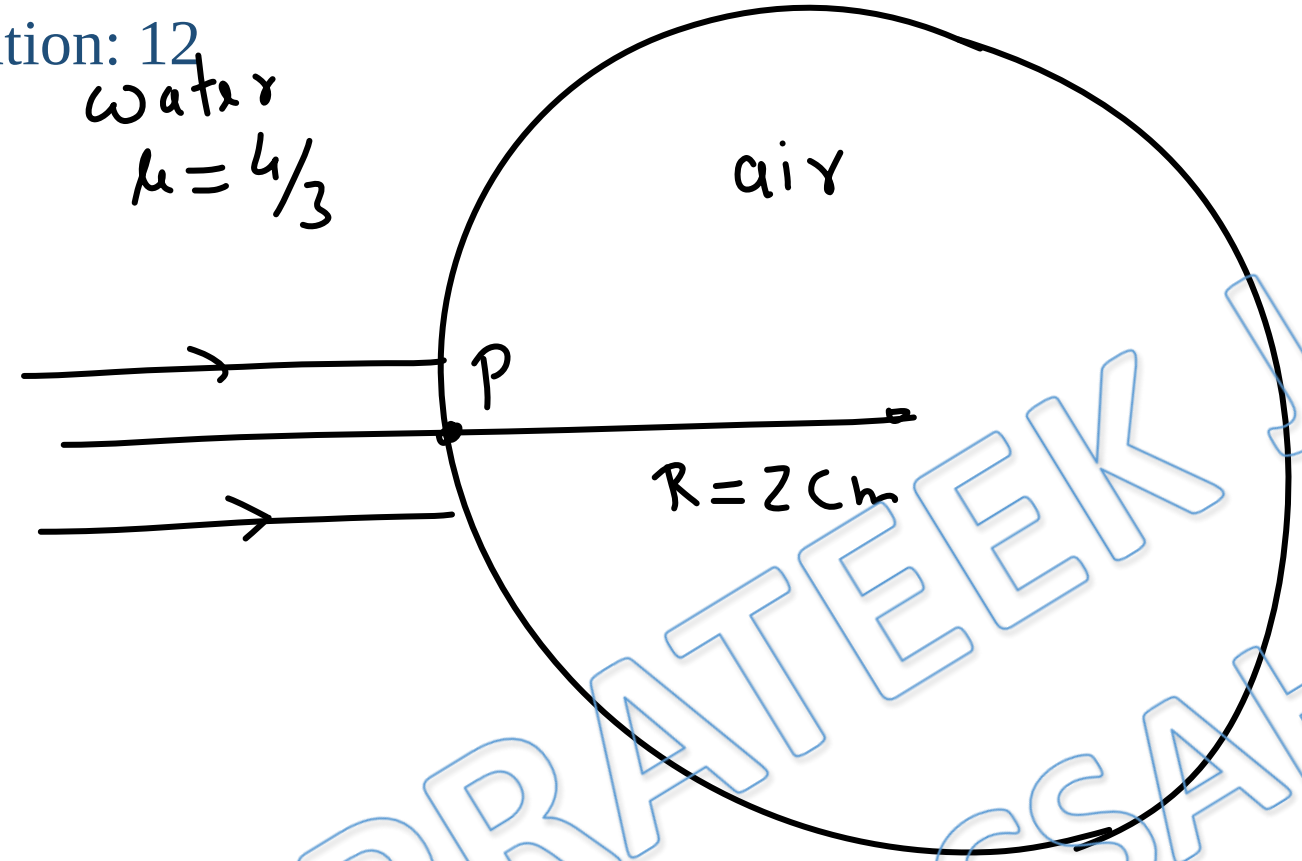
$$\frac{\mu_2}{V}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R} \Rightarrow \frac{1.5}{v}-\frac{1}{-30}=\frac{1.5-1}{+10} \Rightarrow \frac{1.5}{V}=\frac{1}{20}-\frac{1}{30}=\frac{1}{60}$$

$$\Rightarrow V=90\,cm$$

$$m=\frac{I}{5}=\frac{1}{1.5}\left(\frac{+90}{-30}\right)=-2cm \Rightarrow I=-1cm$$

ANS(b)

Solution: 12



$$\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{1}{V} - \frac{4/3}{\infty} = \frac{1 - 4/3}{+2}$$

$$\Rightarrow \frac{1}{V} = -\frac{1}{6} \Rightarrow V = -6\,\text{cm}$$

ANS(a)

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