Physicsaholics

DPP – 5 (Geometrical Optics)

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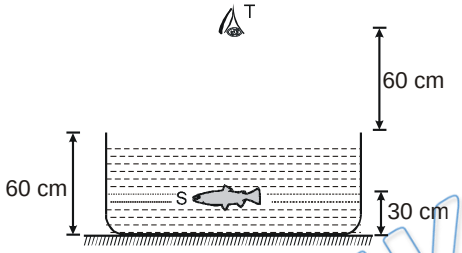
Comprehension (Q1 to Q2)

Consider the situation in figure. The bottom of the pot is a reflecting plane mirror, S is a small fish and T is a human eye. Refractive index of water is 4/3.

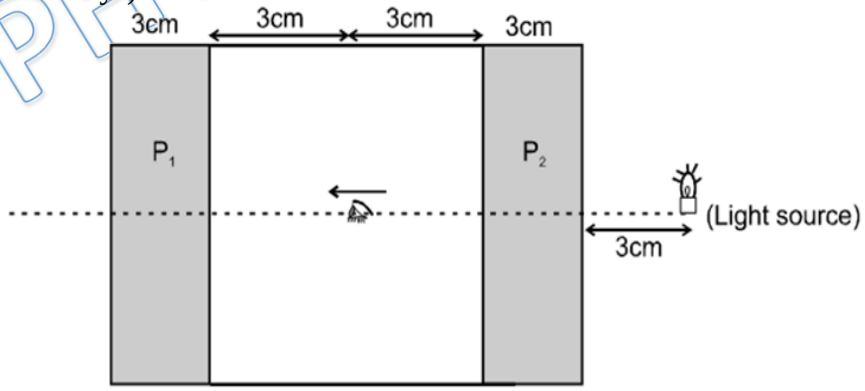


Q 1. At what distance from itself will the fish see the image of the eye in upward direction?
(a) 35 cm (b) 45 cm (c) 55 cm (d) 110 cm

Q 2. At what distance from itself will the fish see the image of the eye in downward direction?
(a) 90 cm (b) 110 cm (c) 170 cm (d) 180 cm

Comprehension (Q3 to Q5)

There is an insect inside a cabin eying towards a thick glass plate P_1. Insect sees the images of light source across the glass plate P_1 outside the cabin. Cabin is made of thick glass plates of refractive index $\mu = 3/2$ and thickness 3 cm. Insect is eying from the middle of the cabin as shown in figure. (Glass plates are partially reflective and consider only paraxial rays)



Q 3. At what distance (from eye of insect) will the eye see first image?
(a) 5 cm (b) 7 cm (c) 11 cm (d) 14 cm

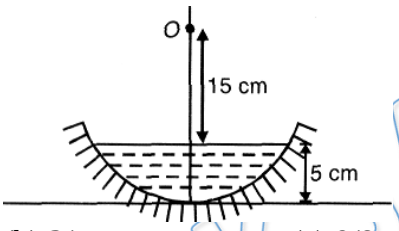
Q 4. At what distance (from eye of insect) will the eye see second image?

(a) 11 cm (b) 13 cm (c) 16.5 cm (d) 18 cm

Q 5. Number of images seen by insect?
(a) 2 (b) 4 (c) 8 (d) ∞

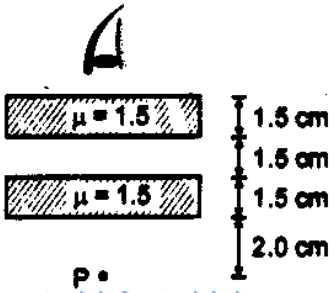
Q 6. A 3 cm thick glass slab is polished on back surface. A point object is placed at 10 cm in front of unsilvered face of slab. What will be the position of final image from unsilvered face (tan η_{glass} = 1.5)?
(a) 12 cm (b)14 cm (c)10 cm (d)16 cm

Q 7. In the diagram, an object is placed at distance 20 cm from pole. In this condition object and image coincide. Radius of curvature of mirror is 25 cm, refractive index of liquid is



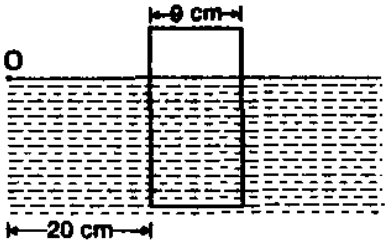
(a) 4/3 (b) 3/2 (c) 9/8 (d) 6/5

Q 8. The image of point P when viewed from top of the slabs will be:



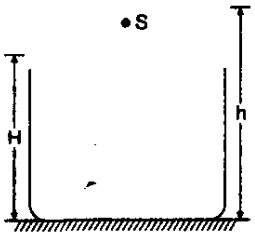
(a) 2.0 cm above P (b) 1.5 cm above P
(c) 2.0 cm below P (d) 1 cm above P

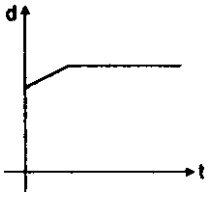
Q 9. A point object is placed at a distance of 20 cm from a glass slab, half immersed in water as shown in figure. The distance between two images when seen from the other side of the slab is :$\left(\mu_g = \frac{3}{2} and \mu_w = \frac{4}{3}\right)$ is

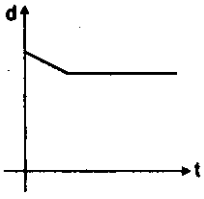


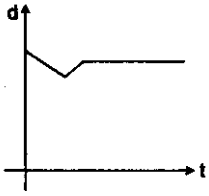
(a) 4 cm (b) 2 cm
(c) 6 cm (d) only one image is formed

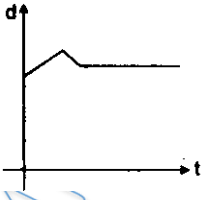
Q 10. A point source S is placed at a height h from the bottom of a vessel of height H(< h). The vessel is polished at the base. Water is gradually filled in the vessel at a constant rate α m^3/s. The distance d of image of the source from the bottom of the vessel varies with time t as:



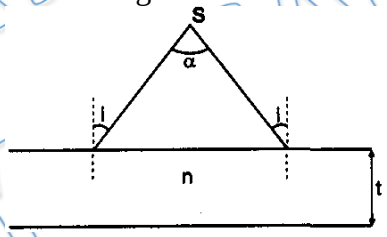
(a) 

(b) 

(c) 

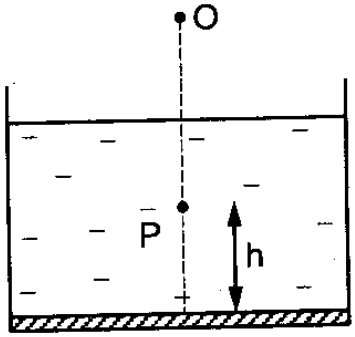
(d) 

Q 11. A diverging beam of light from a point source S having divergence angle a 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 r and its refractive Index is it, then the divergence angle of the emergent beam is :



(a) zero (b) α (c) $\sin^{-1}(1/n)$ (d) $2\sin^{-1}(1/n)$

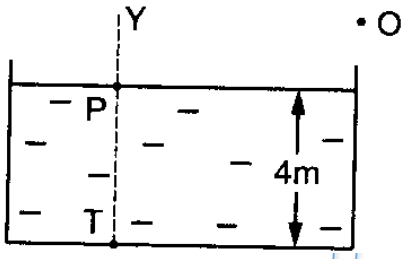
Q 12. A plane mirror is placed at the bottom of a tank containing a liquid of refractive index μ. P is a small object at a height h above the mirror. An observer O-vertically above P, outside the liquid-sees P and its image in the mirror. The apparent distance between these two will be



(a) 2μh (b) $\frac{2h}{\mu}$ (c) $\frac{2h}{\mu-1}$ (d) $h\left(1+\frac{1}{\mu}\right)$

Q 13. A bird flies down vertically towards a water surface. To a fish inside the water, vertically below the bird, the bird will appear to
(a) be farther away than its actual distance
(b) be closer than its actual distance
(c) move faster than its actual speed
(d) move slower than its actual speed

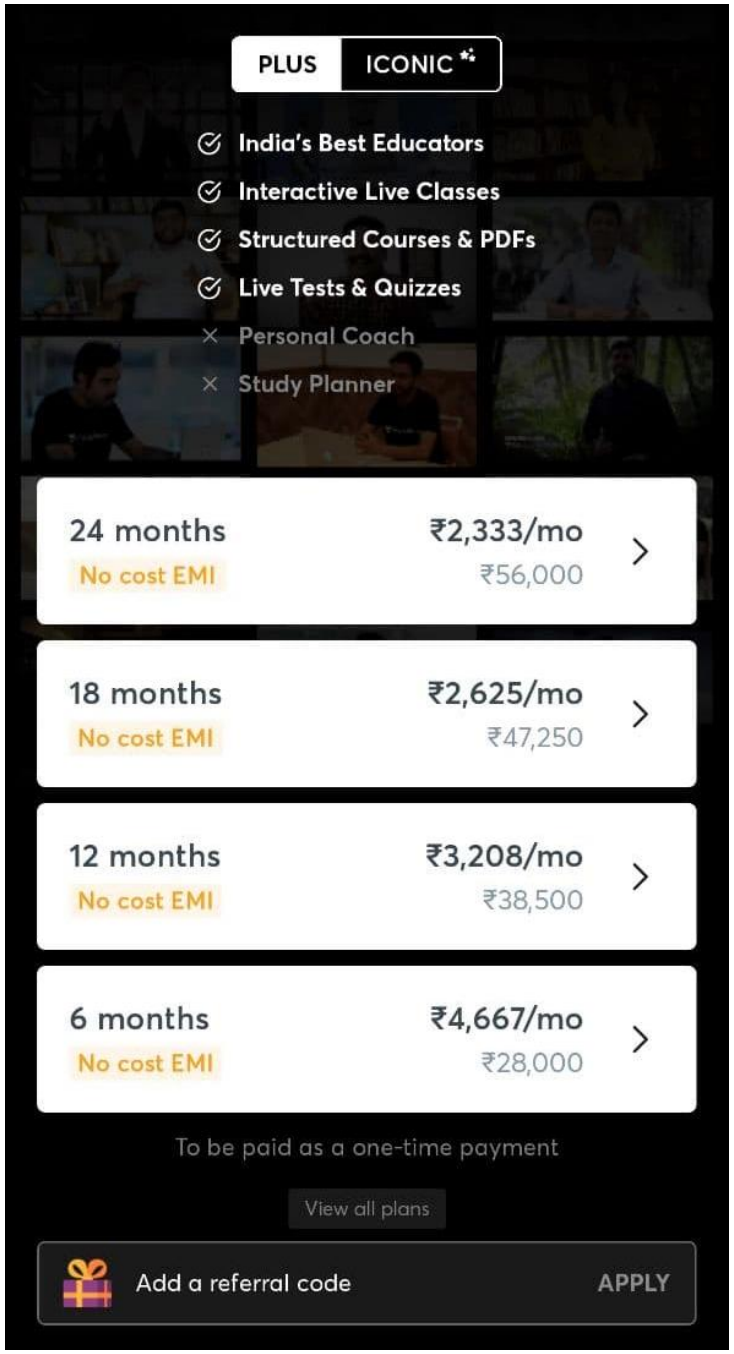
Q 14. T is a point at the bottom of a tank filled with water, as shown. The refractive index of water is 4/3. YPT is the vertical line through T. To an observer at the position O, T will appear to be



(a) to the left of YT (b) somewhere on YT
(c) at a depth 3 m below T (d) at a depth < 3m below P

Answer Key

Q.1 d	**Q.2 c**	**Q.3 d**	**Q.4 d**	**Q.5 d**
Q.6 b	**Q.7 a**	**Q.8 d**	**Q.9 b**	**Q.10 b**
Q.11 b	**Q.12 b**	**Q.13 a, c**	**Q.14 a, d**	



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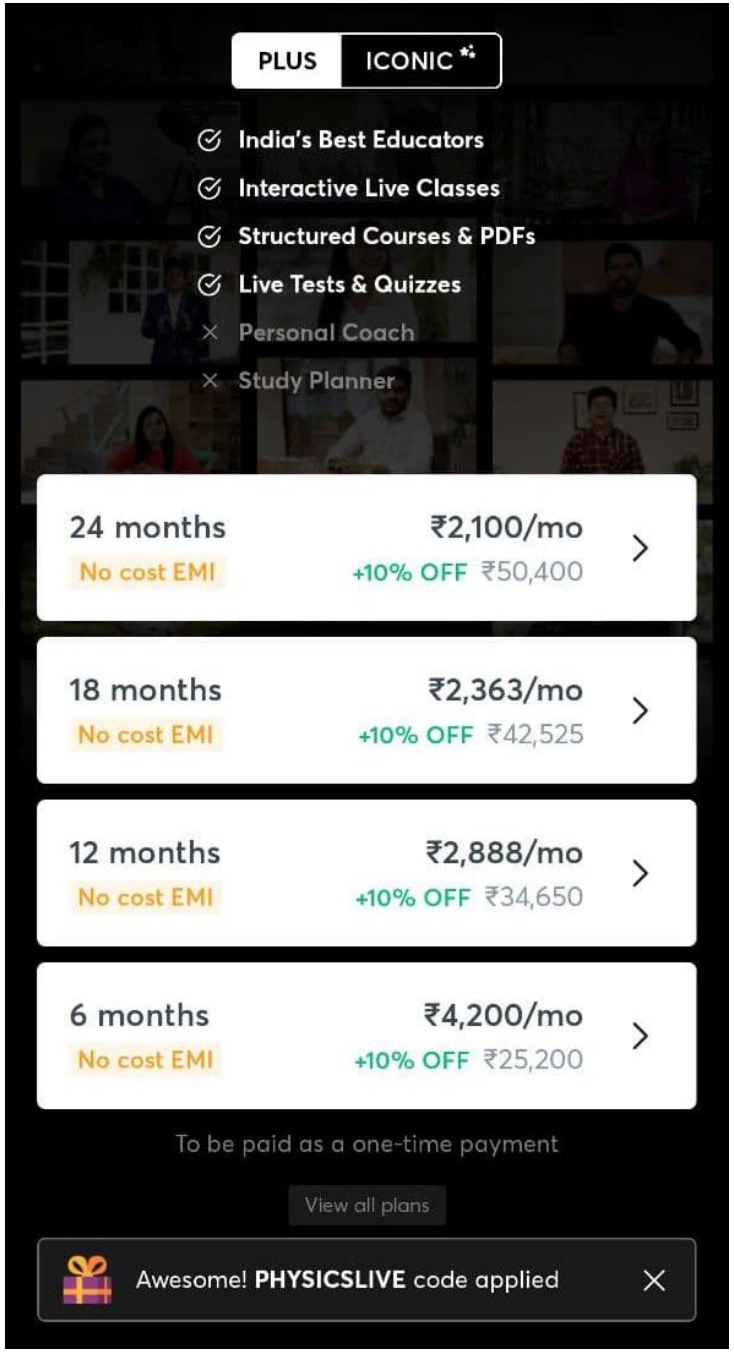


Written Solution

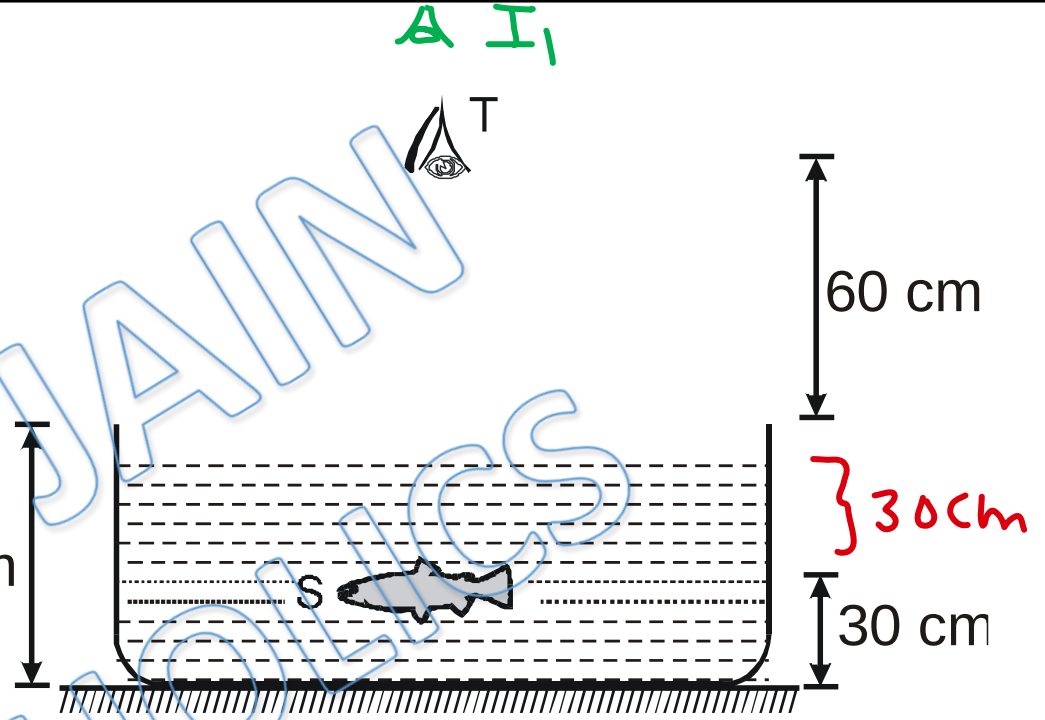
DPP-5 Lateral Shift, Normal Shift and Apparent Depth

By Physicsaholics Team

Solution: 1

Distance of image of eye from surface $= + \frac{\mu_2}{\mu_1}$

$= \frac{60 \times 4/3}{1} = 80$

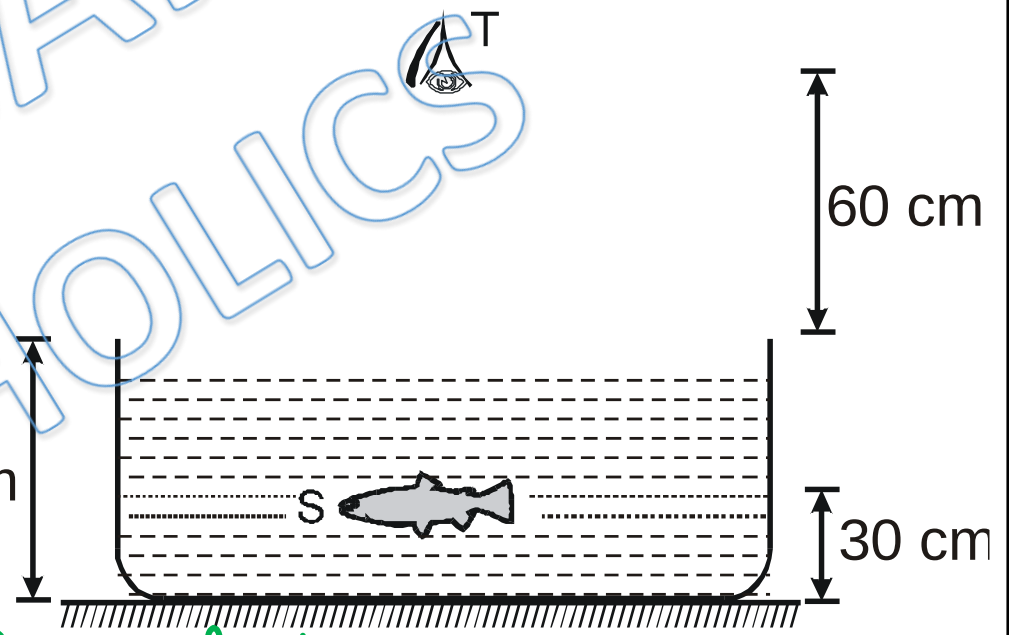


Distance of image of eye from fish $= 30 + 80 = 110$ cm

Ans(d)

Solution: 2 ANS(C)

Ray is refracted by surface of water then reflected by mirror & image formed by this reflection appears to fish in downward direction.



Distance of I_1 from surface = 80cm (Solved in last part)

" " " " mirror = 80+60 = 140cm

" " I_2 " " = 140cm

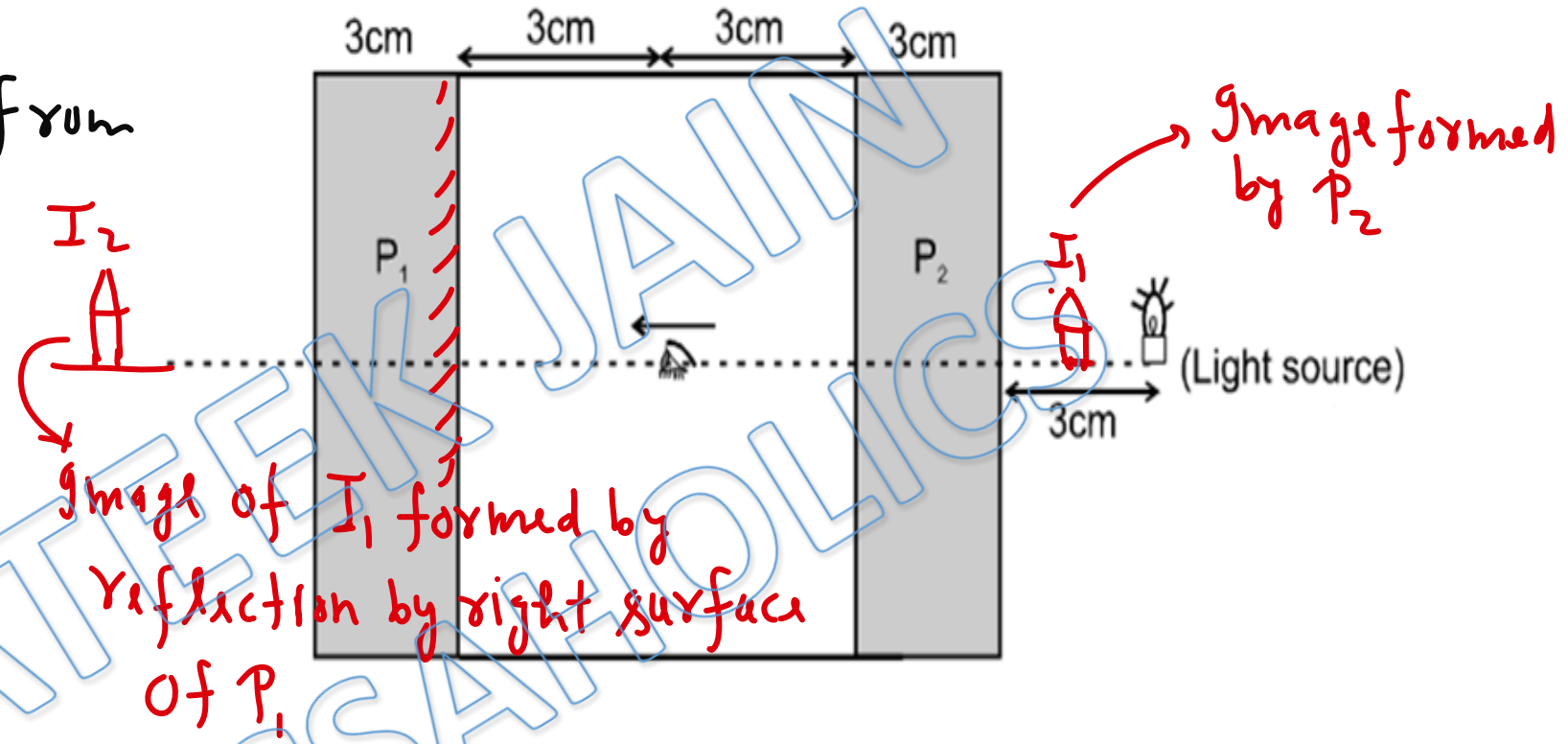
" " " " fish = 140+30 = 170cm

I_1 (image formed by refraction)

I_2 (image of I_1 formed by reflection)

Solution: 3

in this problem Ray from Light source will cross P_2 then it will reflect by right surface of P_1 & reach to eye.



Apparent shift by $P_2 = t\left(1-\frac{1}{\mu}\right) = 3\left(1-\frac{2}{3}\right) = 1\text{cm}$

Distance of I_1 from right surface of $P_1 = 12-1 = 11\text{cm}$

" " I_2 " " " " " " " $= 11\text{cm}$

Distance of I_2 from insect $= 11+3 = 14\text{cm}$

Ans(d)

In this problem Ray is crossing P_2 then refracted by right surface of P_1 then reflected by left surface of P_1 again refracted by right surface of P_1 to reach insect.

Distance of I_1 from right surface of P_1 = 11 cm (Solved in last part)

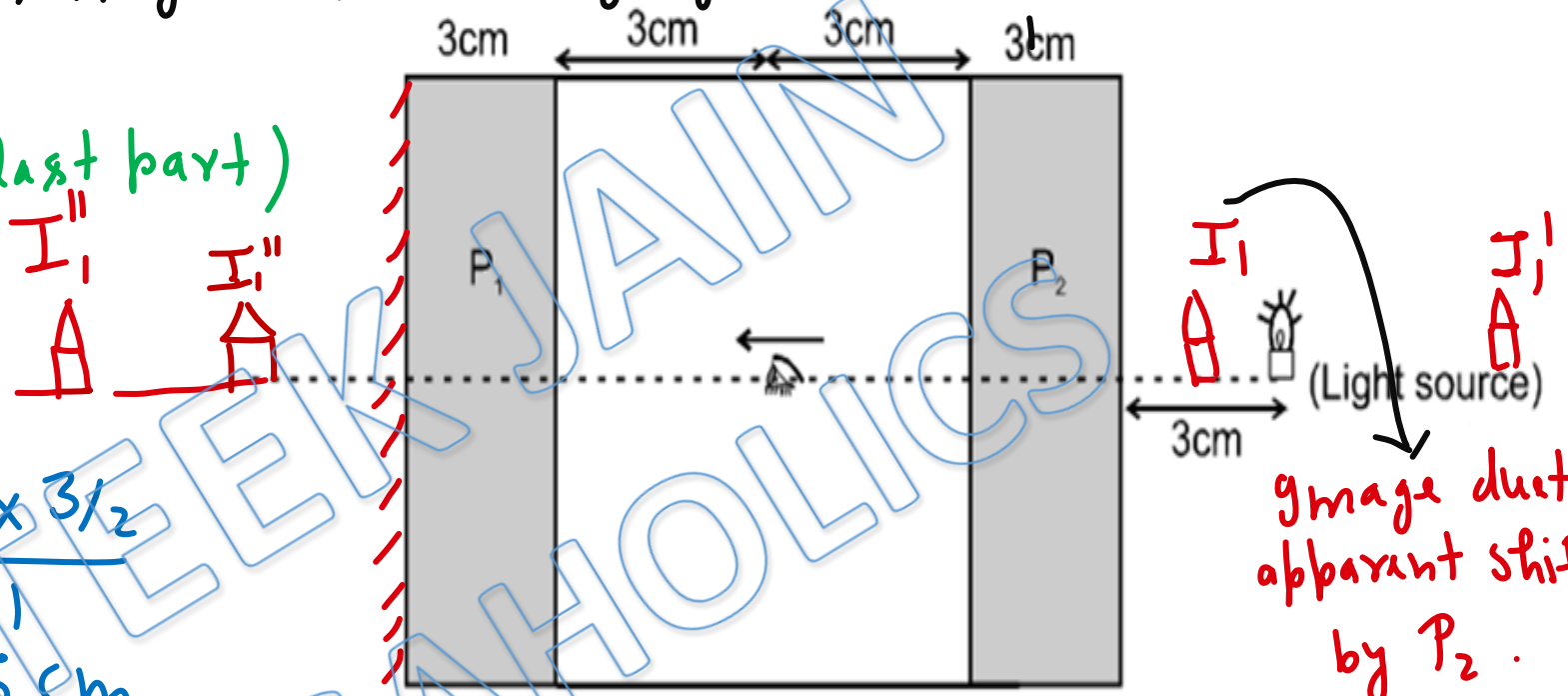
Distance of I_1' from right surface of $P_1 = t\frac{\mu_2}{\mu_1} = \frac{11 \times 3/2}{1}$

$= \frac{33}{2} = 16.5$ cm

Solution: 4

Distance of I_1' from left surface of $P_1 = 3 + 16.5 = 19.5$ cm

Distance of I_1'' from left surface of $P_1 = 19.5$ cm



I_1'' I_1'

Image due to apparent shift by P_2.

$I_1' \rightarrow$ Image of I_1 formed by refraction by right surface of P_1

$I_1'' \rightarrow$ Image of I_1' formed by reflection by left surface of P_1.

Distance of I_1'' from right surface of P_1

$= 19.5 + 3 = 22.5$ cm

Distance of I_1''' from right surface of P_1

$= t\frac{\mu_2}{\mu_1} = \frac{22.5 \times 1}{3/2} = \frac{45}{3} = 15$ cm

Distance of I_1''' from insect

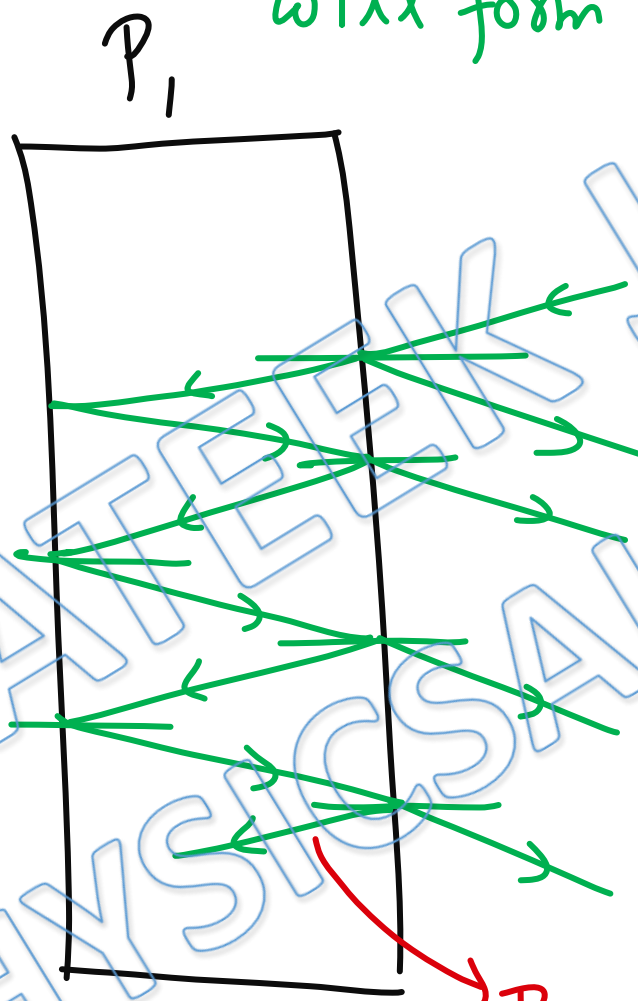
$= 15 + 3 = 18$ cm

(I_1''' is image of I_1'' formed by refraction by right surface of P_1)

Ans(d)

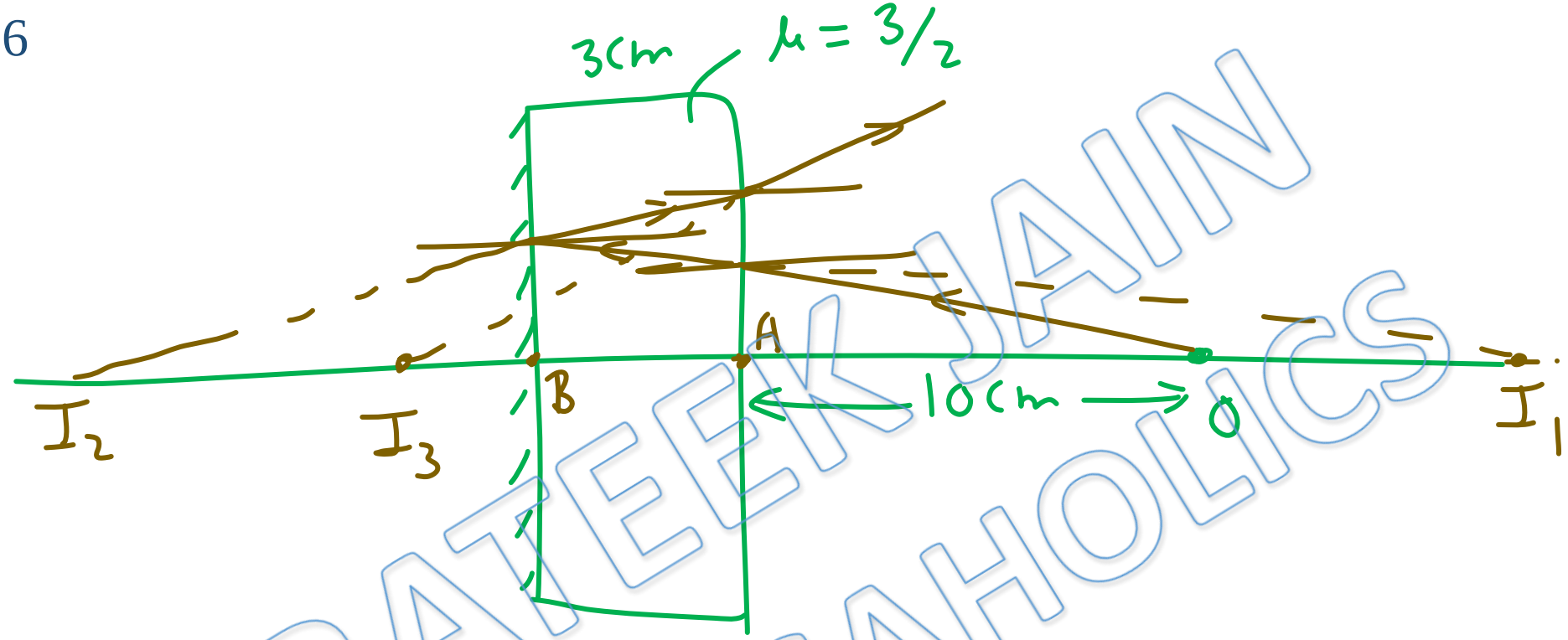
Solution: 5

Each Ray Comming out in rightward direction from P_1 will form an image. So total no of images $= \infty$



Ans(d)

Solution: 6



$$AI_1 = \frac{10 \times 3/2}{1} = 15\text{cm} \Rightarrow BI_1 = 15+3 = 18\text{cm}$$

$$\Rightarrow BI_2 = 18\text{cm} \Rightarrow AI_2 = 18+3 = 21\text{cm}$$

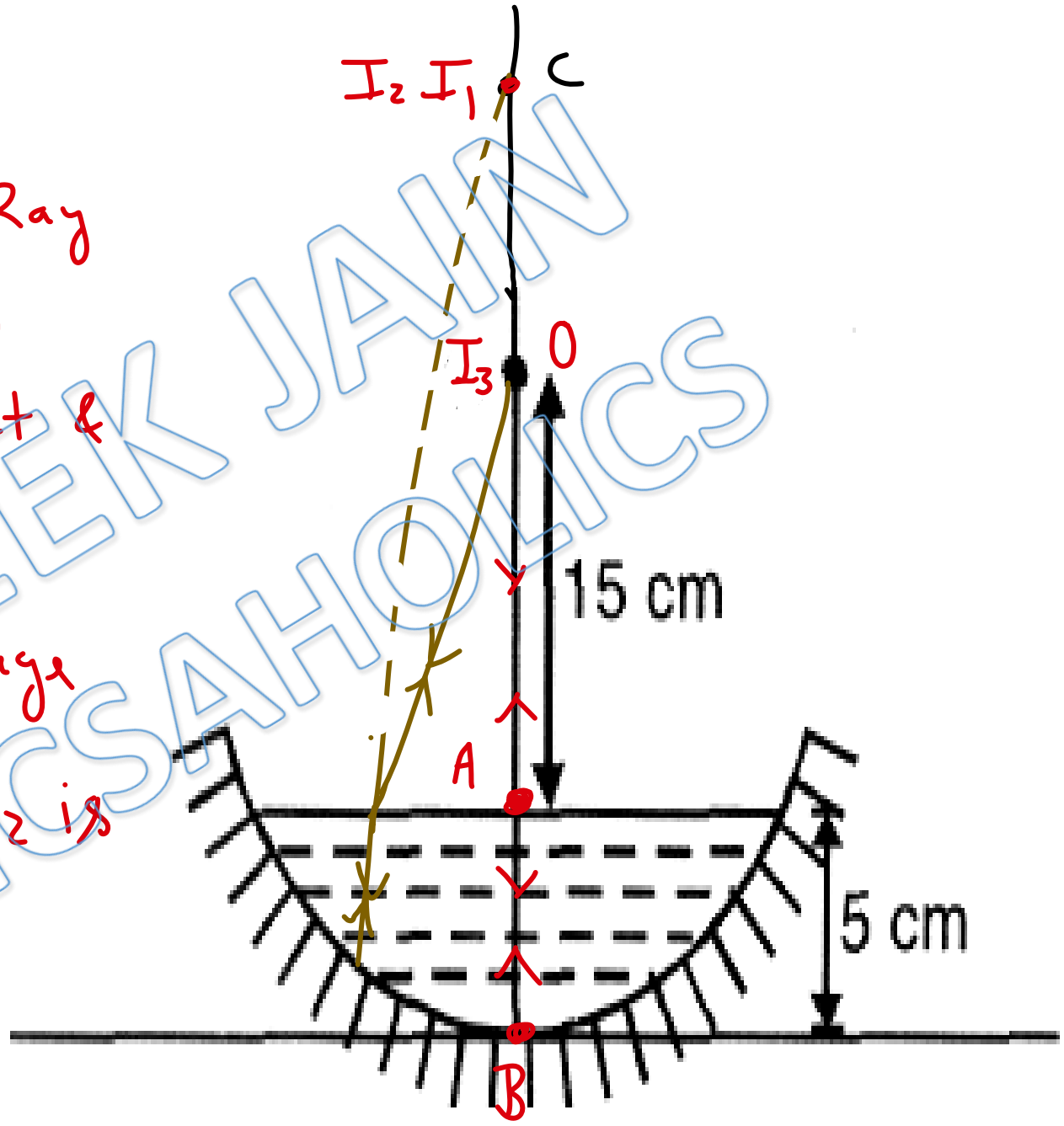
$$\Rightarrow AI_3 = \frac{21 \times 1}{3/2} = 14\text{cm}$$

Ans(b)

Solution: 7

To form image on object, Ray Should be normal to mirror.

for first refraction O is object & I_1 is image. for reflection I_1 is object & I_2 is image and for second refraction I_2 is object & I_3 is image.



for first refraction

$$AI_1 = +\frac{\mu_2}{\mu_1}$$

$$25 - 5 = 15\,\frac{\mu}{1}$$

$$\mu = \frac{20}{15} = 4/3$$

Ans(a)

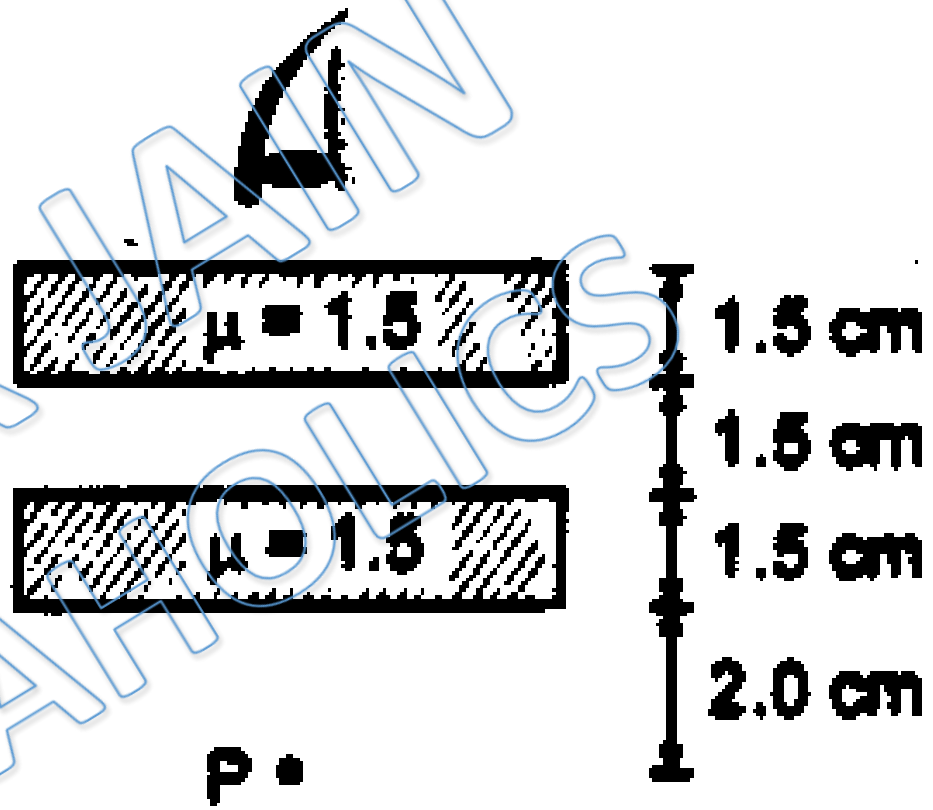
Solution: 8

Apparent Shift

$$= t_1\left(1-\frac{1}{\mu_1}\right)+t_2\left(1-\frac{1}{\mu_2}\right)$$

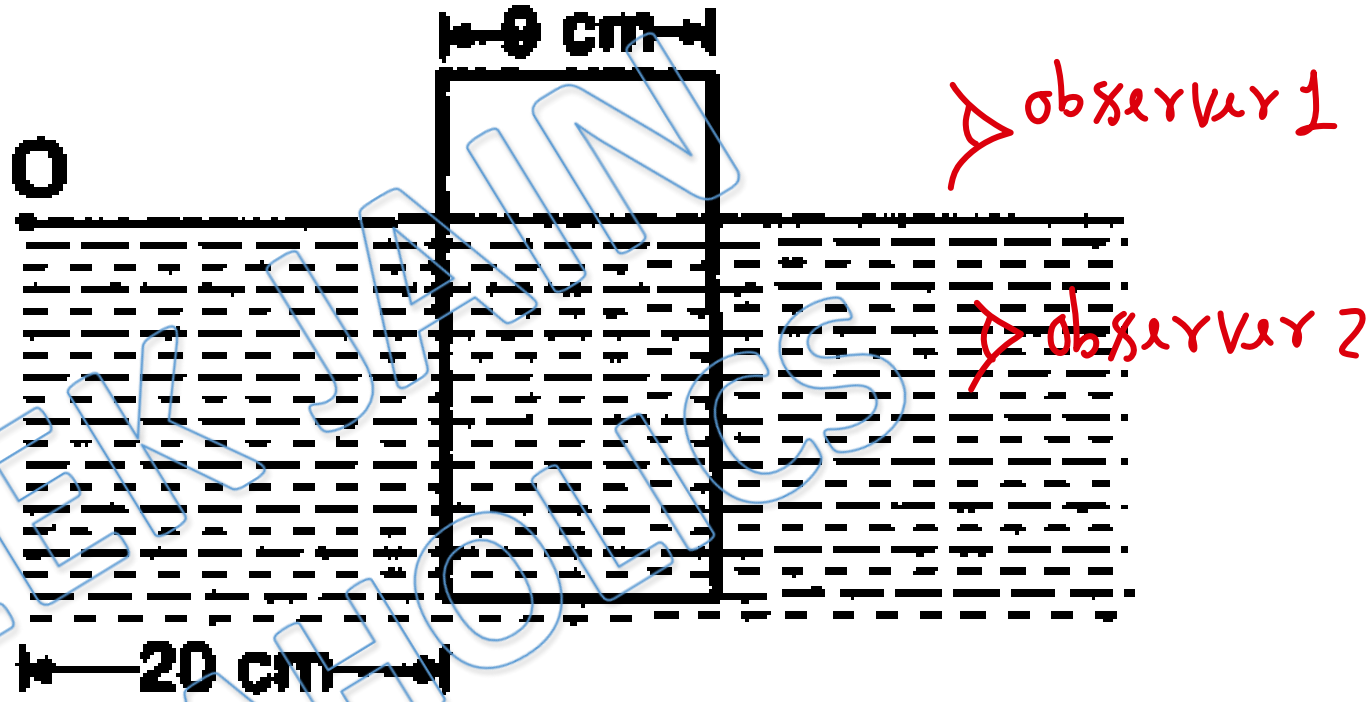
$$= 1.5\left(1-\frac{1}{1.5}\right)+1.5\left(1-\frac{1}{1.5}\right)$$

$$= 3\left(1-\frac{2}{3}\right) = 1\text{ cm above P}$$



Ans (d)

Solution: 9



for observer 1 →

apparent Shift

$= 9\left(1 - \frac{1}{3/2}\right) = 3\,cm$

for observer 2 →

apparent Shift $= 9\left(1 - \frac{4/3}{3/2}\right) = 9\left(1 - \frac{8}{9}\right) = 1\,cm$

Distance between Images $= 3 - 1 = 2\,cm$

Ans (b)

Solution: 10

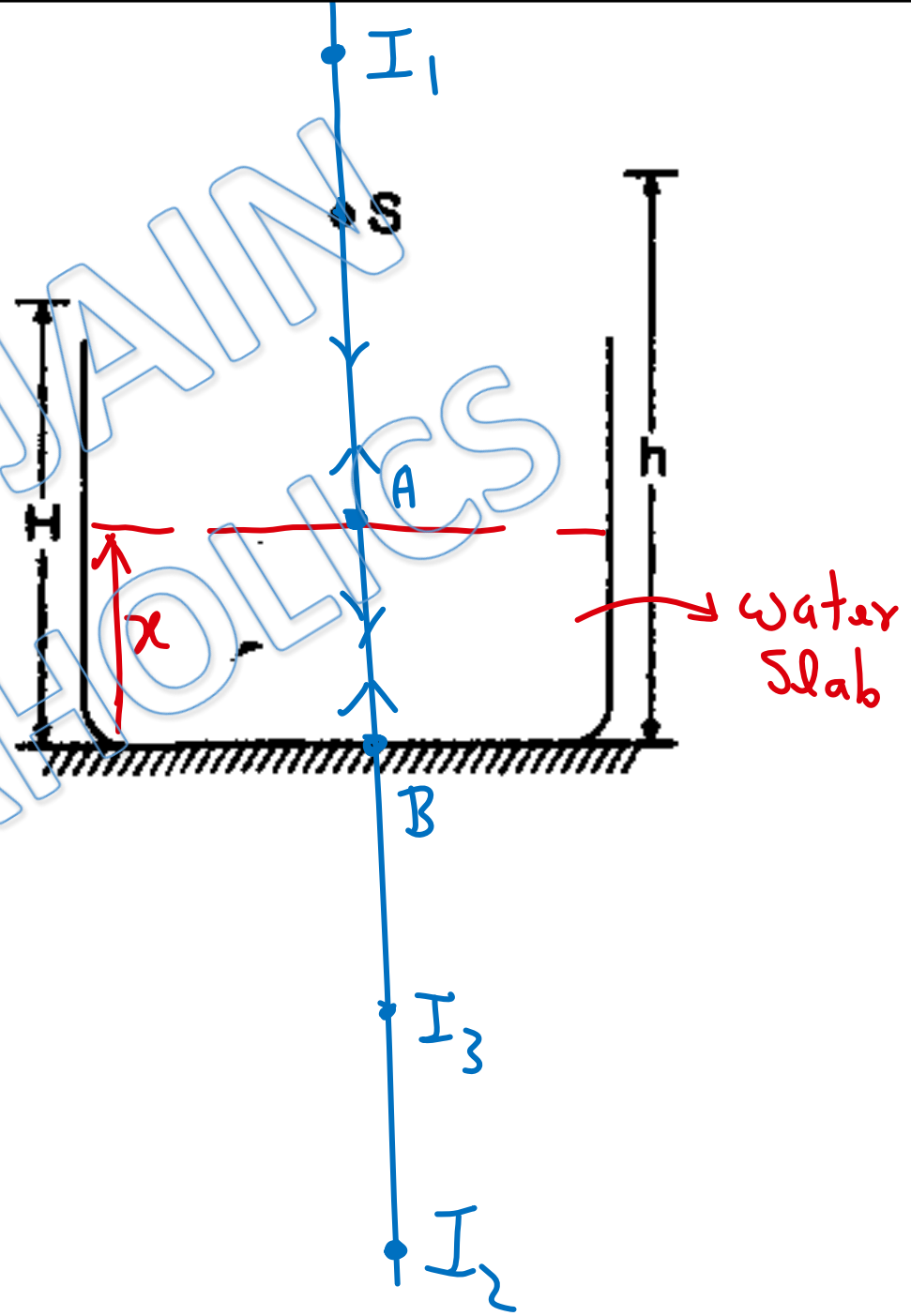
Ray from source first refracted (form image I_1), then reflected (form image I_2), then refracted to form final image I_3.

$$AI_1 = (h-x)\frac{\mu}{1} = \mu h - \mu x$$

$$\Rightarrow BI_1 = \mu h - \mu x + x$$

$$\Rightarrow BI_2 = \mu h - \mu x + x$$

$$\Rightarrow AI_2 = \mu h - \mu x + 2x$$

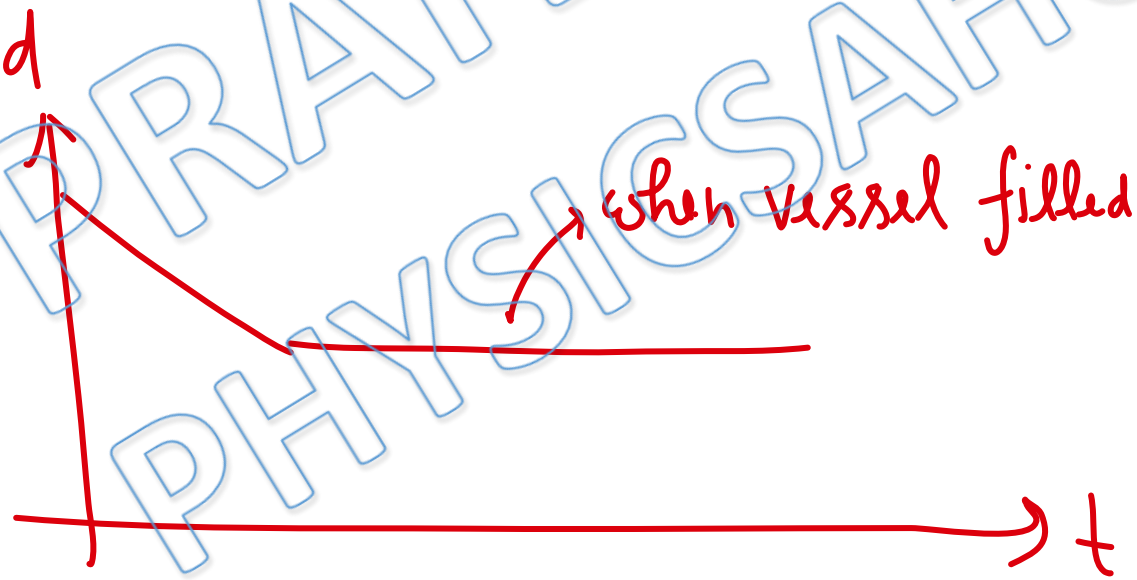


$$AI_3 = (\mu h - \mu x + 2x)\frac{1}{\mu}$$

$$= h - x + \frac{2x}{\mu}$$

$$\Rightarrow \quad BI_3 = h - 2x + \frac{2x}{\mu} = h + 2x\left(1 - \frac{1}{\mu}\right)$$

$$\Rightarrow \quad d = h - 2x\left(1 - \frac{1}{\mu}\right) = h - 2\left(\frac{\alpha}{A}\right)t\left(1 - \frac{1}{\mu}\right)$$



Ans (b)

Solution: 11

deviation produce by slab = δ

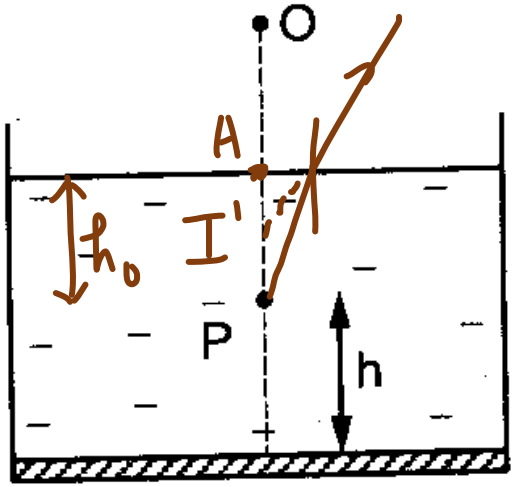
$\Rightarrow$ divergence angle of emergent beam

$=$ " " incident beam

$= \alpha$

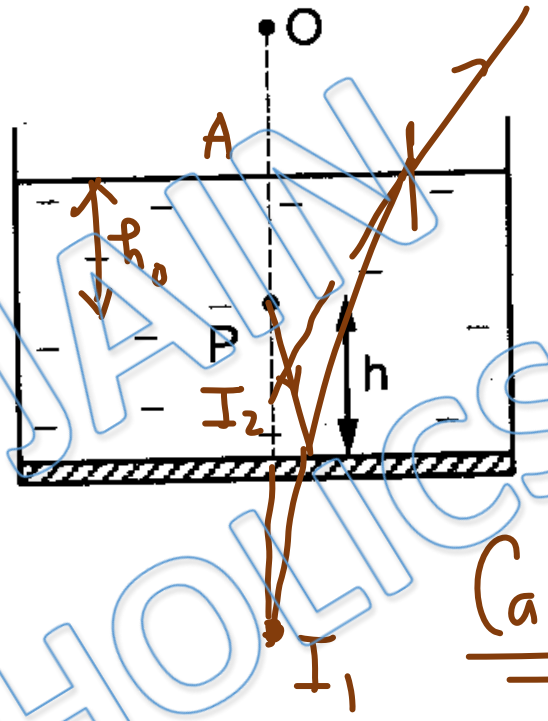
ANS(6)

Solution: 12



Case 1

$$AI' = h_0\left(\frac{1}{\mu}\right) = \frac{h_0}{\mu}$$



Case 2

$$AI_1 = h_0 + 2h$$

$$AI_2 = (h_0 + 2h)\frac{1}{\mu}$$

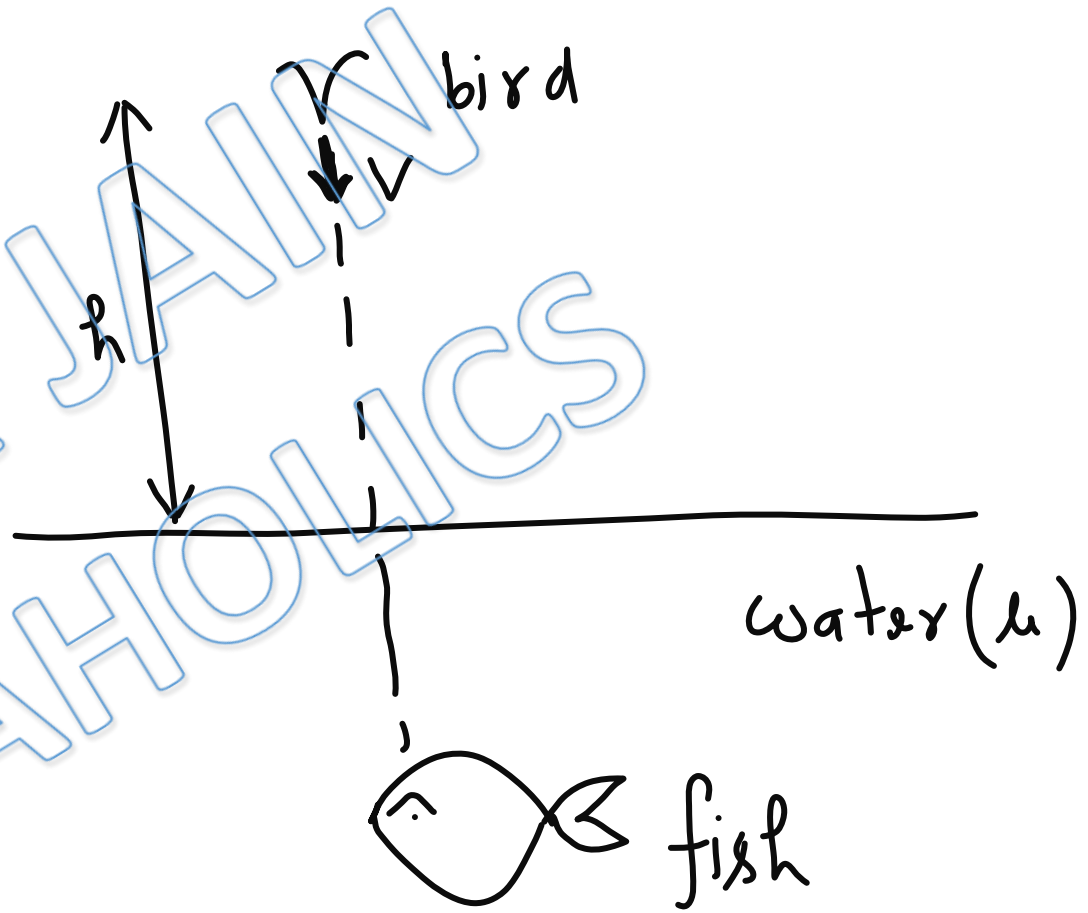
$$\text{distance between } I' \text{ \& } I_2 = \left(\frac{h_0}{\mu} + \frac{2h}{\mu}\right) - \frac{h_0}{\mu} = \frac{2h}{\mu}$$

Ans(b)

Solution: 13

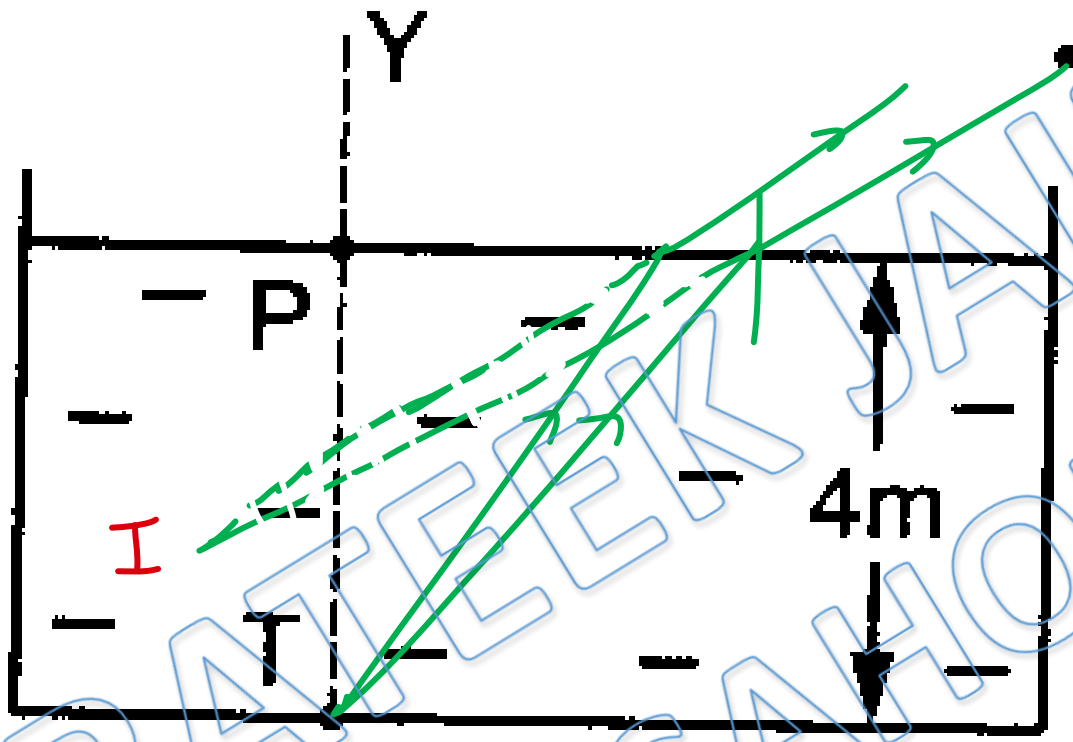
Distance of image of bird from water surface $= \frac{h \times \mu}{1} = \mu h > h$

Velocity of image of bird $= \frac{d}{dt}(\mu h) = \mu \frac{dh}{dt} = \mu v > v$



Ans (a, c)

Solution: 14



Apparent depth for near normal view $= t\frac{\mu_2}{\mu_1} = 4 \times \frac{3}{4} = 3m$

Apparent depth for far normal view $<$ Apparent depth for near normal view

$< 3m$

Ans (a, d)

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