Physicsaholics

DPP – 8 (Geometrical Optics)

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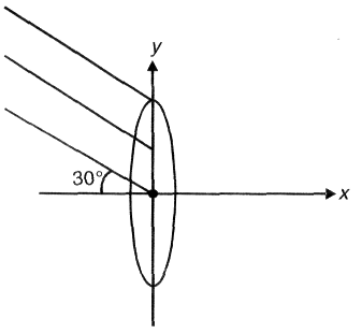
Q 1. A thin lens of refractive index 1.5 has a focal length of 15 cm in air. When lens is placed in a medium of refractive index (4/3), focal length will be now
(a) 30 cm (b) 60 cm (c) – 60 cm (d) – 30 cm

Q 2. A thin convergent glass lens ($\mu_g = 1.5$) has focal length 20 cm. When this lens is immersed in a liquid of refractive index μ_1 it acts as a divergent lens of focal length 100 cm. The value of μ_1 must be
(a) 4/3 (b) 5/3 (c) 2 (d) 7/3

Q 3. An object is placed at 15 cm from convex lens of focal length 20 cm, which of the following is correct?
(a) Virtual image is formed
(b) Real image at 60 cm from lens is formed
(c) Virtual image at 40 cm from lens is formed
(d) Real image at 40 cm from lens is formed

Q 4. Parallel rays are focused by a convex lens of focal length of 20 cm. Lens is placed along y-axis. Rays are focused at point:



(a) (20, 0) (b) (20, -20) (c) (20, -10) (d) (20, $-\frac{20}{\sqrt{3}}$)

Q 5. A thin lens of focal length f produces an upright image of the same size as the object. What is the distance of the object from the optical center of the lens?
(a) 2 f (b) zero (c) 3f /2 (d) infinity

Q 6. A concave lens of glass of 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 a
(a) convergent lens of focal length 3.5 R
(b) convergent lens of focal length 3.0 R

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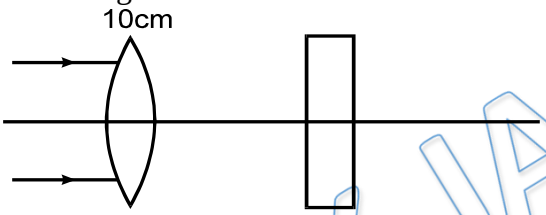
(c) divergent lens of focal length 3.5 R
(d) divergent lens of focal length 3.0 R

Q 7. A converging lens of focal length f_1 is placed in front of and coaxially with the 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 incident and reflected beams must be same
(b) $d = |f_1| - 2|f_2|$
(c) $d = |f_2| - |f_1|$
(d) If entire arrangement immersed in water, the conditions will remain unaltered

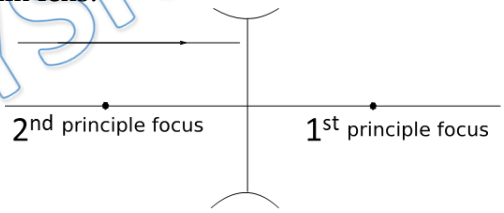
Q 8. A parallel beam of light is incident on a lens of focal length 10 cm. A parallel slab of refractive index 1.5 and thickness 3 cm is placed on the other side of the lens. Find the distance of the final image from the lens.



(a) 11 cm (b) 9 cm (c) 4 cm (d) 15 cm

Q 9. In displacement method, the distance between object and screen is 96 cm. The ratio of length of two images formed by a convex lens placed between them is 4.84.
(a) Ratio of the length of object to the length of shorter image is 11/5.
(b) Distance between the two positions of the lens is 36 cm.
(c) Focal length of the lens is 22.5 cm.
(d) Distance of the lens from the shorter image is 30 cm.

Q 10. Match the column:
For diverging thin lens:



(A) Object lies between first principle focus and optic center.	(P) Image real
(B) Object lies between second principle focus and optic center.	(Q) Image is virtual
(C) Object is real	(R) Image is erect
(D) A real object is at a point whose distance from optic center is twice the magnitude of focal length	(S) Image is inverted
	(T) Image is magnified

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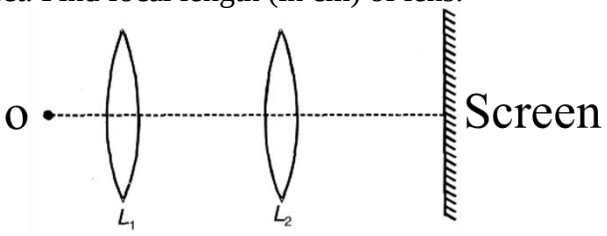
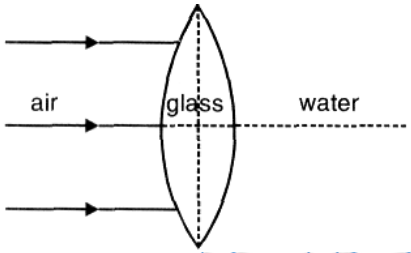
Q 11. Position of object and screen is fixed and lens is moved. At two positions of lens we get clear image. First position is at 30 cm from object and second position is at 50 cm from object. Find focal length (in cm) of lens.



(a) 25/4 (b) 75/4 (c) 45/4 (d) 65/4

Q 12. An equiconvex lens made of glass ($\mu = 3/2$) is placed in such a way, one surface is in contact with water ($\mu = 4/3$) and another surface is in contact with air. Find focal length of setup. Radius of curvature R = 30 cm.



(a) 60 cm (b)120 cm (c) 30 cm (d)100 cm

Q 13. A converging lens of focal length f is placed at a distance 0.3 m from an object to produce an image on a screen 0.9 m from the lens. With the object and the screen in the same positions, an image of the object could also be produced on the screen by placing a converging lens of focal length
(a) f at a distance 0.1 m from the screen
(b) f at a distance 0.3 m from the screen
(c) 3f at a distance 0.3 m from the screen
(d) 3f at a distance 0.1 m from the screen

Q 14. A screen is placed a distance 40 cm away from an illuminated object. A converging lens is placed between the source and the screen and it is attempted to form the image of the source on the screen. If no position could be found, the focal length of the lens –
(a) must be less than 10 cm
(b) must be greater than 10 cm
(c) must not be greater than 20 cm
(d) must not be less than 10 cm

Q 15. Figure shows variation of magnification m (produced by a thin convex lens) and distance v of image from pole of lens. Which of the following statements is/are correct–

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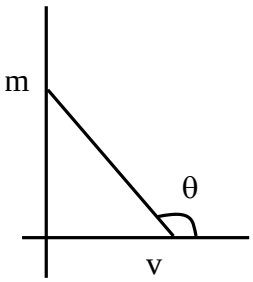
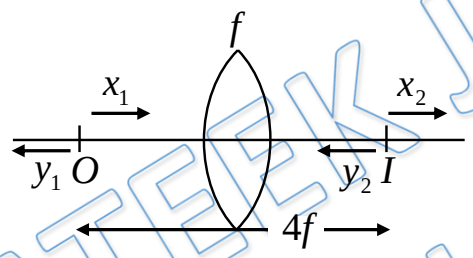


(a) Focal length of the lens is equal to intercept on v-axis
(b) Focal length of thin lens is equal to negative of inverse of slope of the line
(c) Magnitude of intercept on m-axis is equal to unity
(d) None of these

Q 16. In a converging lens of focal length f and the distance between real object and its real image is 4f. If the object moves x_1 distance towards lens its image moves distance x_2 away from the lens and when object moves distance y_1 away from the lens its image moves distance y_2 towards the lens, then choose the correct option



(a) $x_1 > x_2$ and $y_1 > y_2$
(b) $x_1 < x_2$ and $y_1 < y_2$
(c) $x_1 < x_2$ and $y_1 > y_2$
(d) $x_1 > x_2$ and $y_2 > y_1$

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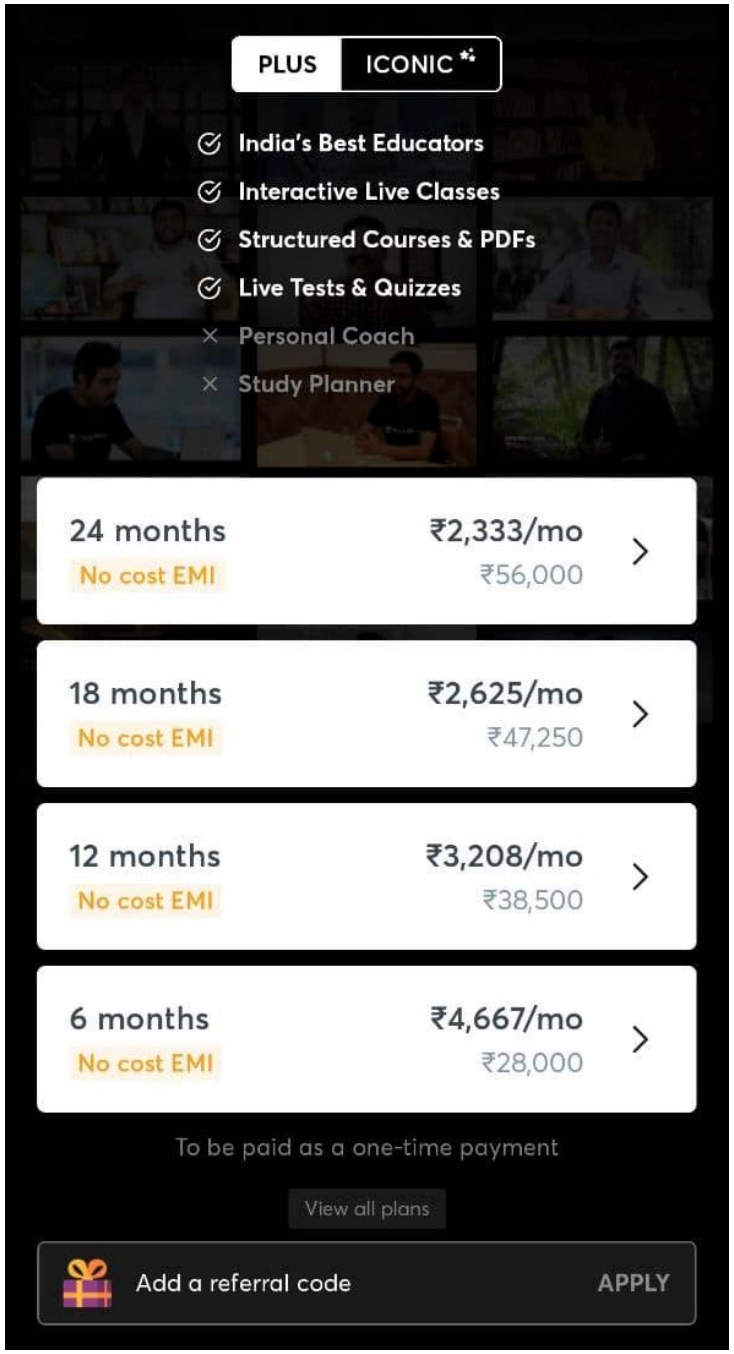
Answer Key

Q.1 b	**Q.2 b**	**Q.3 a**	**Q.4 d**	**Q.5 b**
Q.6 a	**Q.7 a, b**	**Q.8 a**	**Q.9 a, b, d**	**Q.10 A– P, R, T; B – Q, R; C – Q, R; D – Q, R**
Q.11 b	**Q.12 a**	**Q.13 b**	**Q.14 b**	**Q.15 a, b, c**
Q.16 c				



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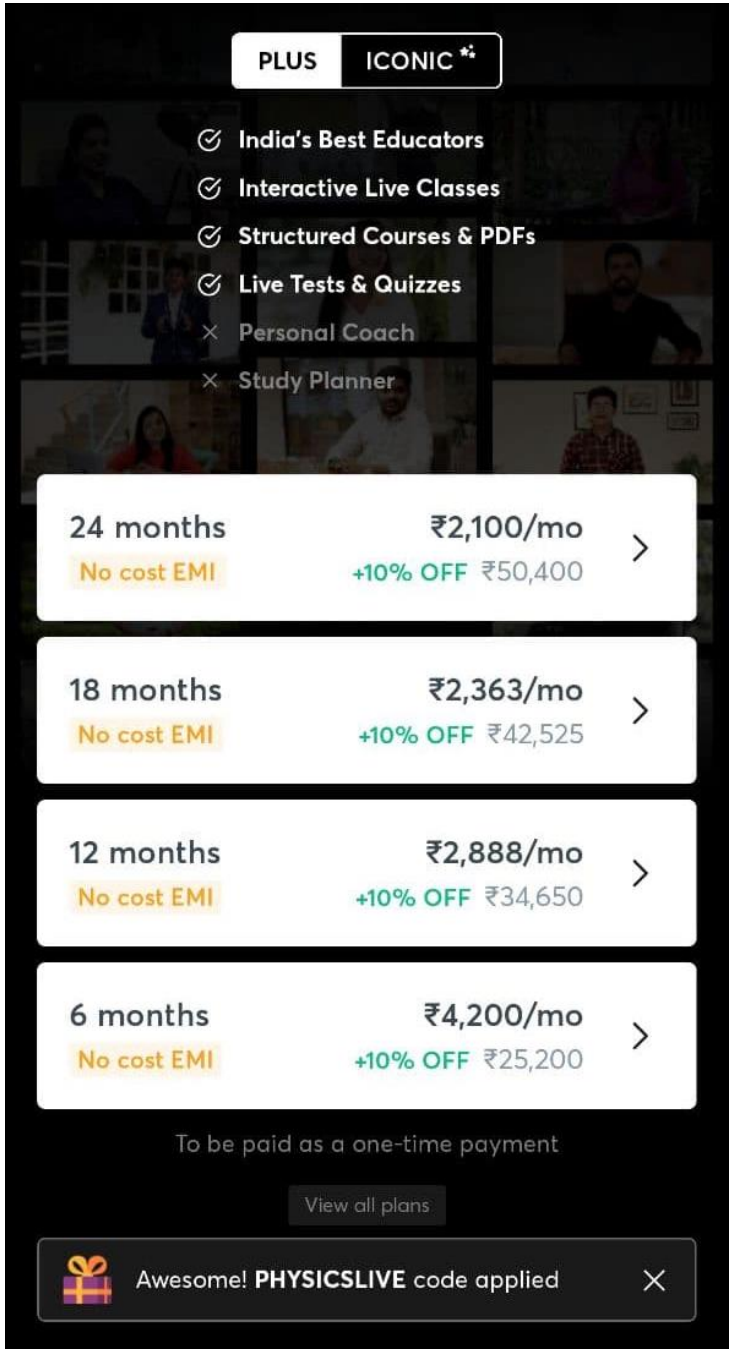
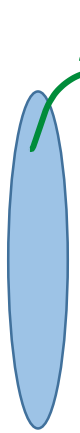


Written Solution

DPP 8 – Geometrical Optics : lens formula, lens maker’s formula,Displacement Method

By Physicsaholics Team

Solution: 1



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

if dipped in medium of refractive index of $\mu_2 = 4/3$

$$\frac{1}{f'} = \left(\frac{\mu_1}{\mu_2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad -②$$

$$\frac{f'}{f} = \frac{(\mu_1 - 1)}{\left(\frac{\mu_1}{\mu_2} - 1\right)}$$

$$\frac{f'}{15\text{cm}} = \frac{(1.5 - 1)}{\left(\frac{1.5}{4/3} - 1\right)}$$

$$\frac{f'}{15\text{cm}} = \frac{0.5}{\left(\frac{9}{8} - 1\right)} = \frac{0.5}{1/8}$$

$$\frac{f'}{15\text{cm}} = 0.5 \times 8 = 4$$

$$f' = 15\text{cm} \times 4$$

$$\boxed{f' = 60 \text{ cm}}$$

Ans: b

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Solution: 2

for lens in air

$$\frac{1}{f} = \frac{1}{20} = (1.5-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{R_1} - \frac{1}{R_2} = \frac{1}{10} \quad \text{--- (1)}$$

for lens in liquid ($f = -100\,cm$)

$$-\frac{1}{100} = \left(\frac{1.5}{\mu_2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1.5}{\mu_2} - 1 = -\frac{1}{10} \Rightarrow \frac{1.5}{\mu_2} = -\frac{9}{10}$$

$$\Rightarrow \mu_2 = \frac{15}{9} = 5/3$$

Ans(b)

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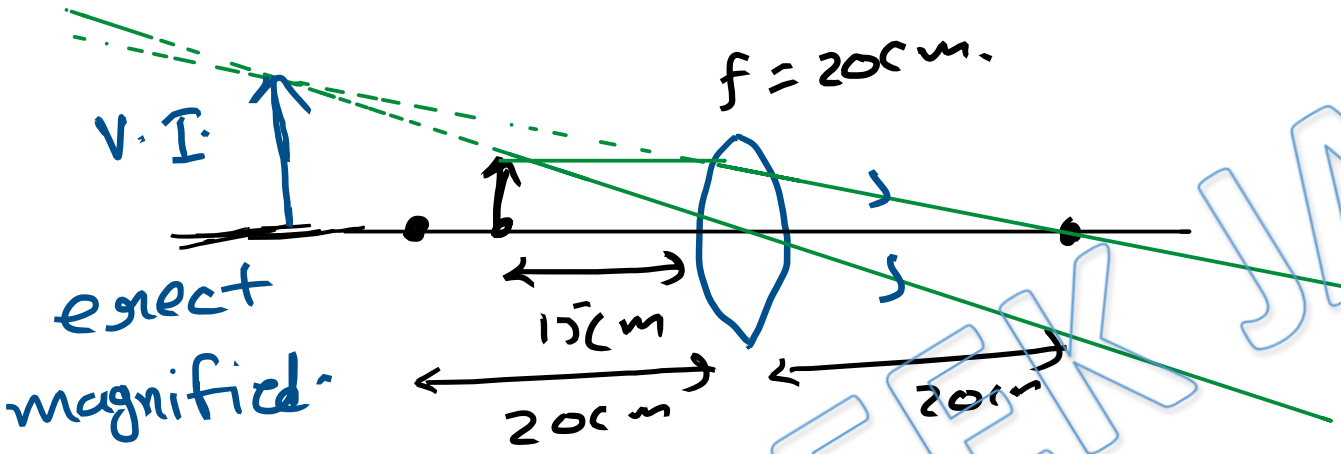
Solution: 3



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

$$\frac{1}{v} + \frac{1}{15} = \frac{1}{20}$$

$$\frac{1}{v} = \frac{1}{20} - \frac{1}{15} = \frac{15-20}{15\times 20}$$

$$\frac{1}{v} = \frac{-5}{15\times 20} \Rightarrow \boxed{v = -60\,cm}$$ (V.I)

Ans: (a)

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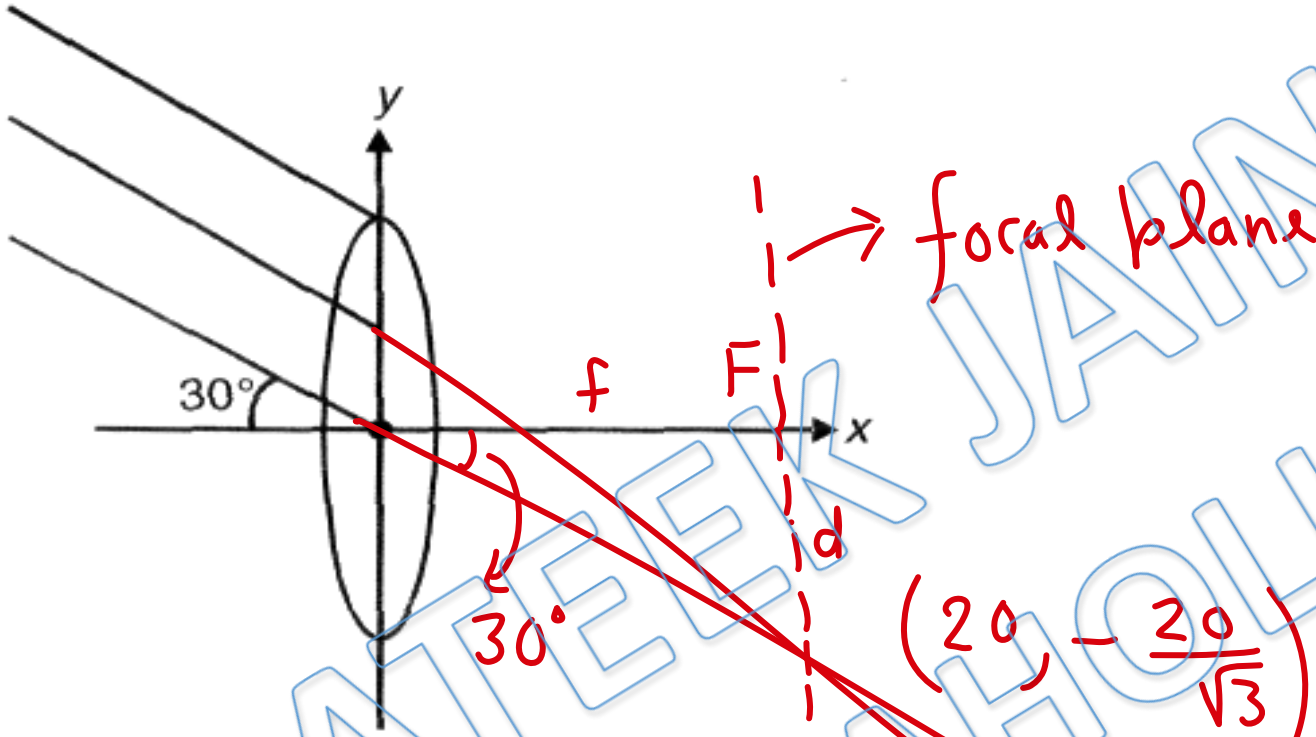
Solution: 4



$\tan 30° = \frac{d}{f} = \frac{1}{\sqrt{3}}$

$\Rightarrow d = f/\sqrt{3} = \frac{2f}{\sqrt{3}}$

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Ans(d)

Solution: 5

Exact same size image $\Rightarrow m = 1 = \frac{v}{u} \Rightarrow v = u$

$$\underbrace{\frac{1}{f}}_{\text{L.H.S.} \neq 0} = \underbrace{\frac{1}{v} - \frac{1}{u}}_{\text{R.H.S} = 0} \Rightarrow$$

It means this formula is not valid for $m = 1$

We know that this formula is not valid for only one value of u,

$u = 0$

ANS(b)

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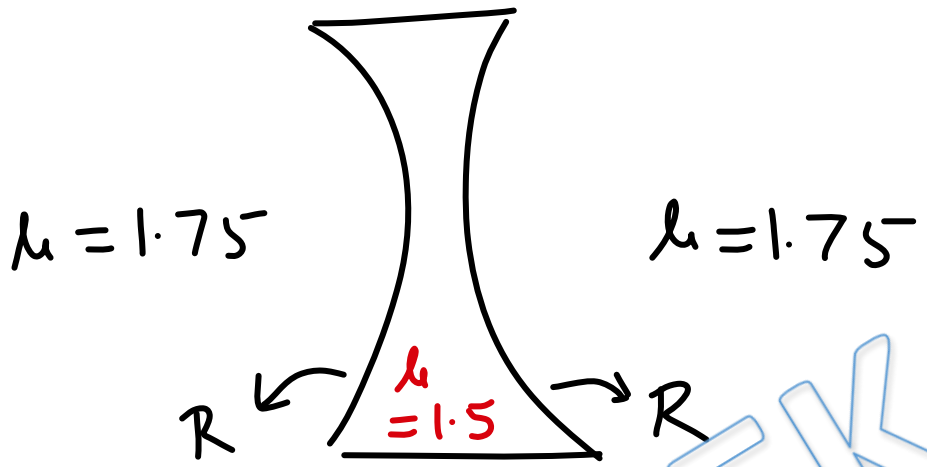
Solution: 6



$$\frac{1}{f} = \left(\frac{1.5}{1.75} - 1\right)\left(\frac{1}{-R} - \frac{1}{+R}\right) = \left(\frac{6}{7} - 1\right)\left(-\frac{2}{R}\right)$$

$$\Rightarrow \quad f = +3.5R$$

ANS(a)

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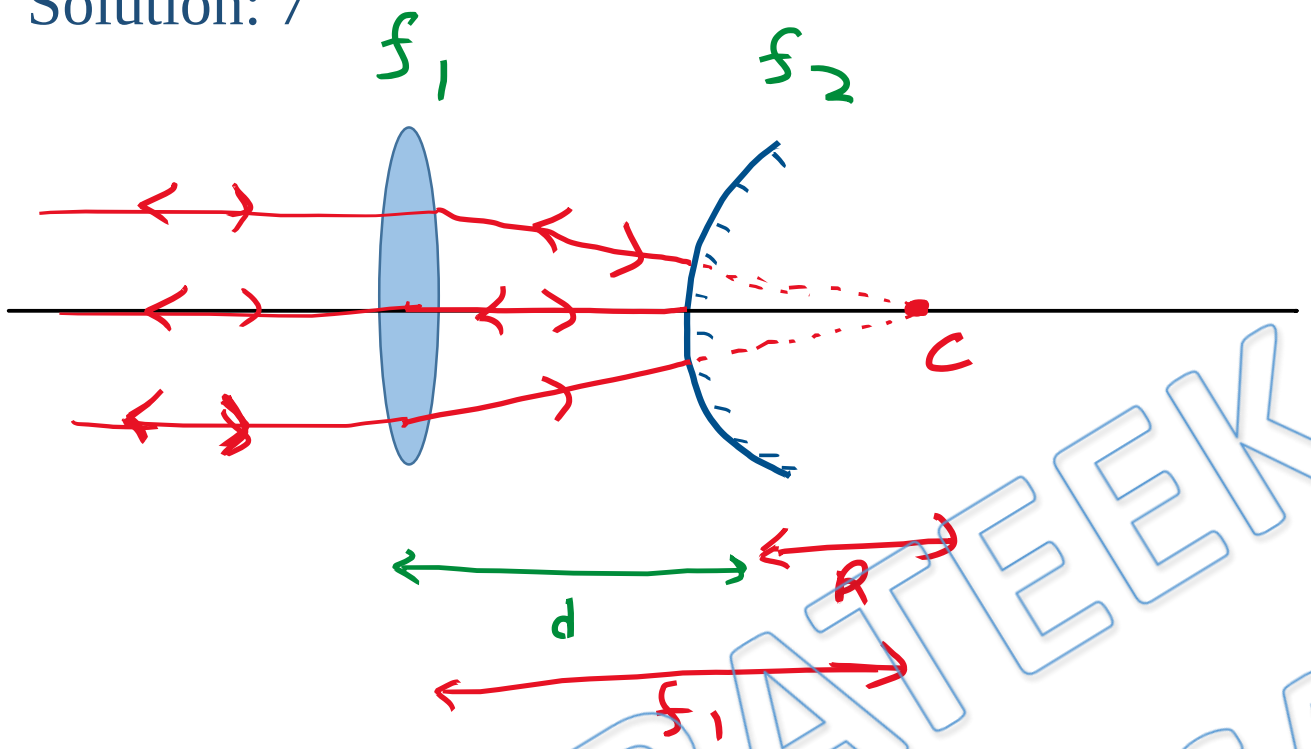
Solution: 7



If rays are returning Parallel after refraction- reflection & again refraction.

So; lens should converge Parallel beam at centre of curvature of mirror. And this will be focal length of lens also.

So; $|f_1| = d + |R|$

& $|R| = 2|f_2|$

$|f_1| = d + 2|f_2|$

$$\boxed{d = |f_1| - 2|f_2|}$$

Diameter of incident & final returning beam will also be same as each ray will retrace its path after reflection.

Ans : a, b

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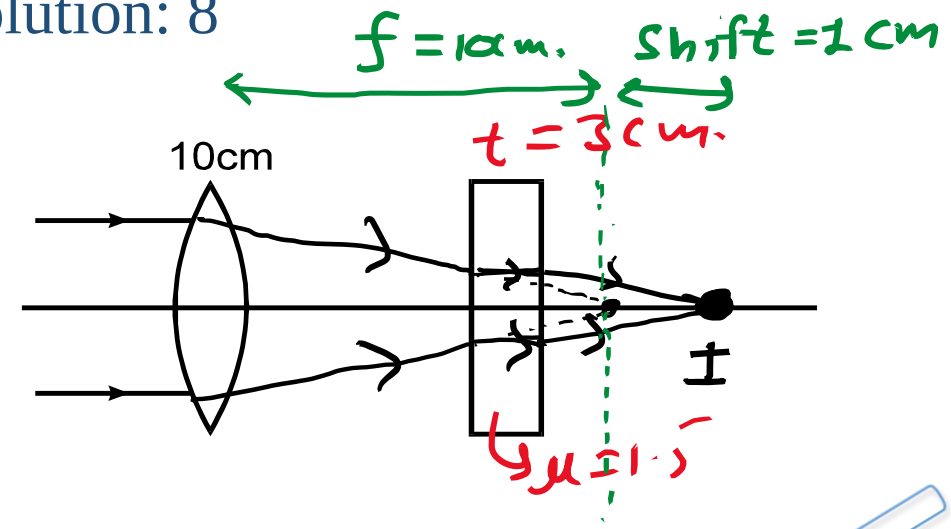
Solution: 8



Shift produced by slab $= \left(\frac{1}{\mu} - 1\right) t$

$= \left(\frac{1}{1.5} - 1\right) \times 3$

$= \frac{1}{3} \times 3$

Shift = 1 cm

in the direction of Propagation of ray.

final Image will form at = 10 + 1 cm

= 11 cm

Ans : (a)

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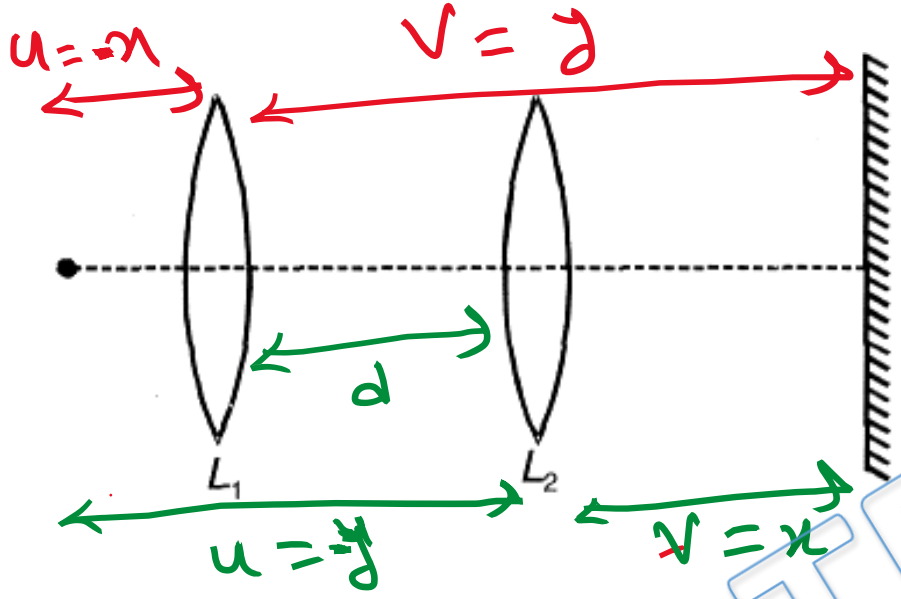
Solution: 9



$m_1 = \frac{y}{-x}$, $m_2 = \frac{x}{-y}$

Ratio of Images = Ratio of magnification

$= \frac{m_1}{m_2} = \frac{-y/x}{-x/y}$

So, $\frac{h_{I_1}}{h_{I_2}} = 4.84 = \frac{y^2}{x^2}$

$\frac{484}{100} = \left(\frac{y}{x}\right)^2$

$\left(\frac{y}{x}\right) = \frac{22}{10} = \frac{11}{5}$

given D = 96 cm.

$y = \frac{11}{11+5} \times 96 = 66$ cm.

$x = 30$ cm

$x + d + x = 96$

$\boxed{d = 36 \text{ cm}}$ ✓

Shorter Image will form when lens is at L_2

So, $V = x = 30$ cm ✓

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and $\dfrac{\text{length/size of Shorten Image}}{\text{length/size of it's object}} = |m_2| = \left|-\dfrac{x}{y}\right| = \dfrac{x}{y}$

So, $\dfrac{\text{length of object}}{\text{length of Shorten Image}} = \dfrac{y}{x} = \dfrac{11}{5}$ ~ ✓

for focal length:

when $u = -x = -30\text{cm}$, $\Rightarrow v = y = 66\text{cm}$.

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{66} - \frac{1}{-30} = \frac{1}{f} \Rightarrow \frac{1}{66} + \frac{1}{30} = \frac{1}{f}$$

$$\frac{30+66}{66\times 30} = \frac{1}{f} \Rightarrow f = \frac{66\times 30}{96} = \frac{660}{32}$$

$$f = \frac{330}{16} = 20.6\text{ cm}$$

Ans: a, b, d

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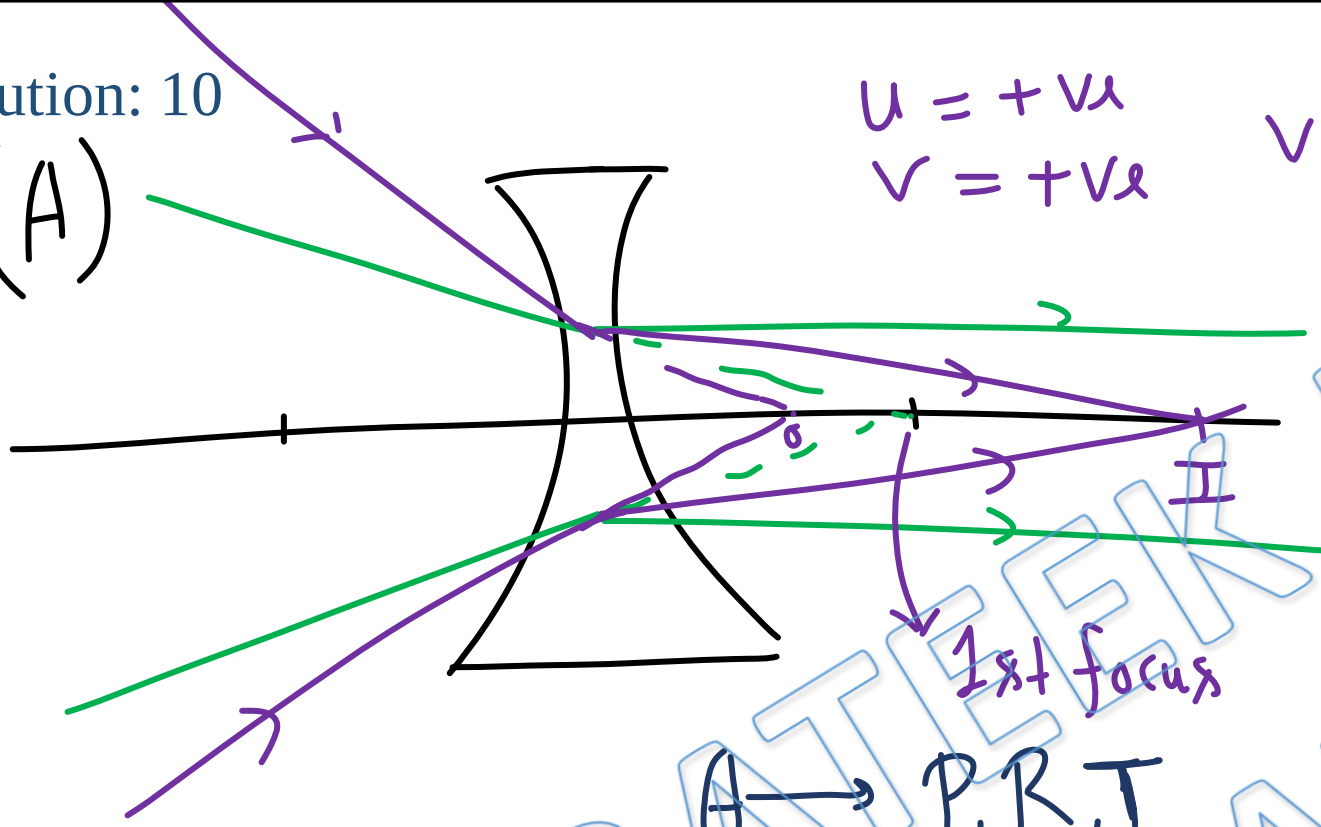
Solution: 10

(A)



$u = +ve$

$v = +ve$

$v > u$

$v = +ve \Rightarrow$ real image

$m = \frac{v}{u} = +ve$

$\Rightarrow$ erect image

$|m| = \left|\frac{v}{u}\right| > 1 \Rightarrow$ magnified

$A \rightarrow P, R, T$

(II)

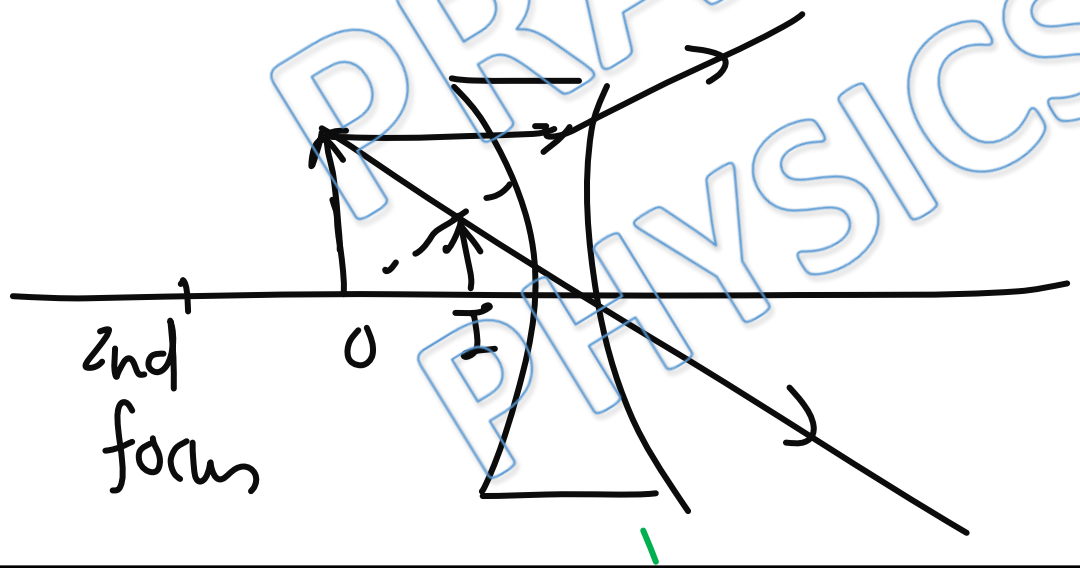


Image is virtual & erect

$B \rightarrow Q, R$

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(C)

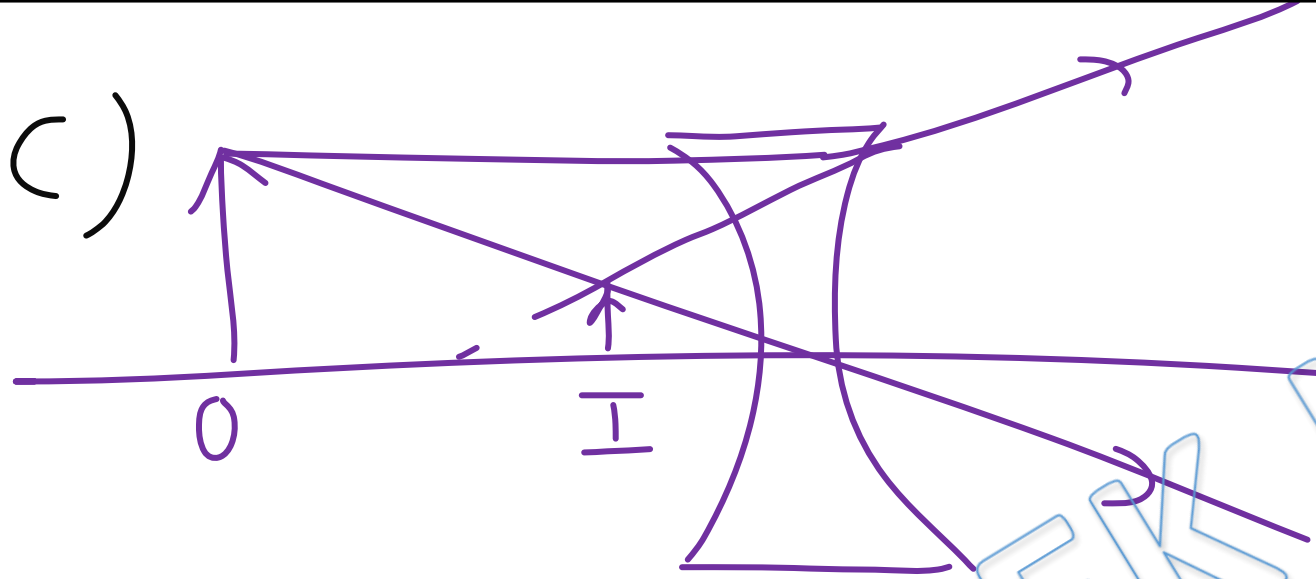

Image is Virtual & erect & Smaller than object.

C → Q, R.

(D)

object is real → Image is Virtual & erect & Smaller than object

D → Q, R.

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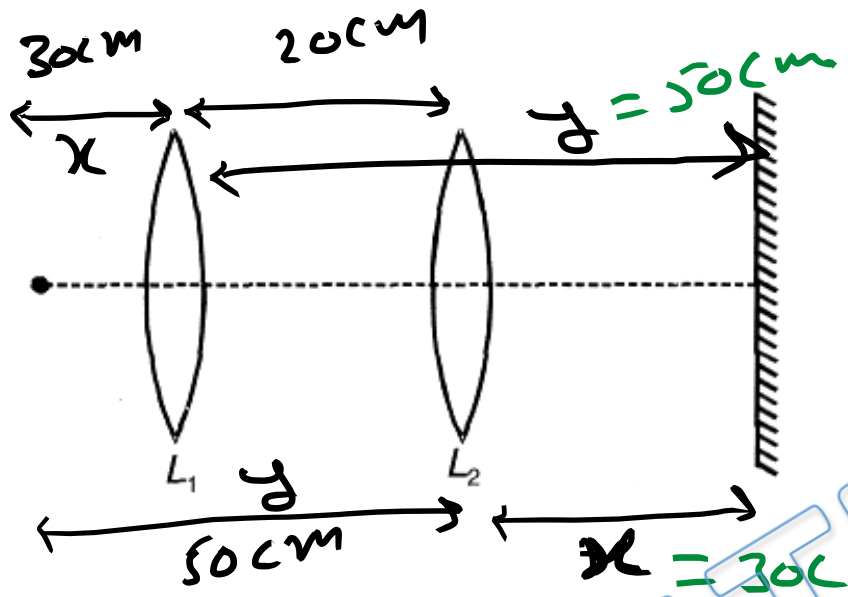
Solution: 11



In Displacement method, object & Image distances are interchanges at two positions of lens.

⇒ At L_1

$u = -30\,cm$

$v = 50\,cm$

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

$\frac{1}{50} - \frac{1}{-30} = \frac{1}{f}$

$\frac{1}{50} + \frac{1}{30} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{3+5}{150}$

$f = \frac{150}{8} = \frac{75}{4}\,cm$

$\boxed{f = \frac{75}{4}\,cm}$ Ans: (b)

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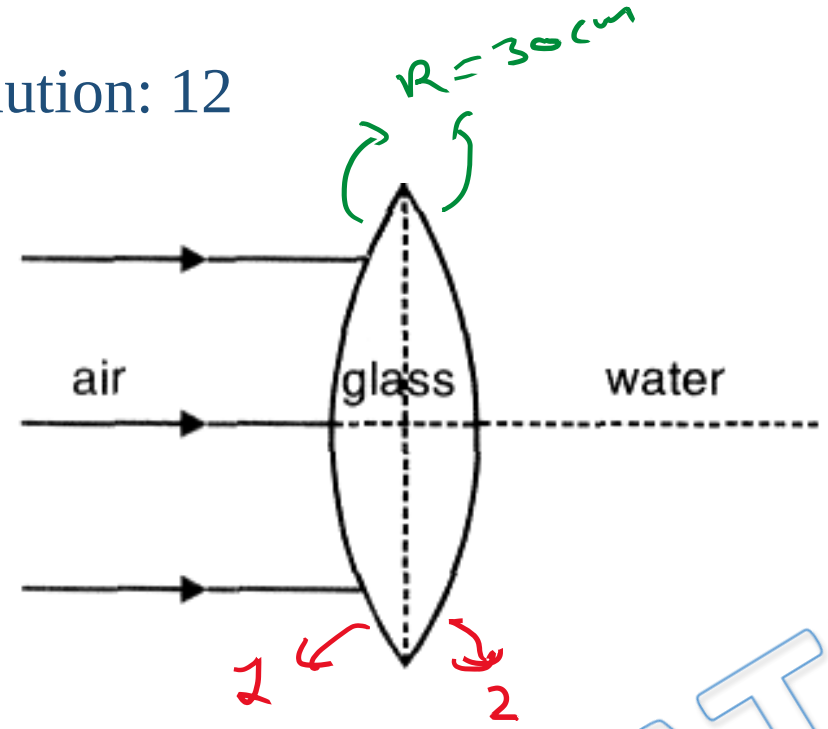
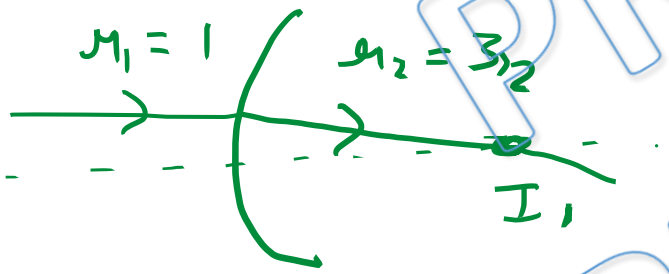
Solution: 12



Refraction at 1st surface



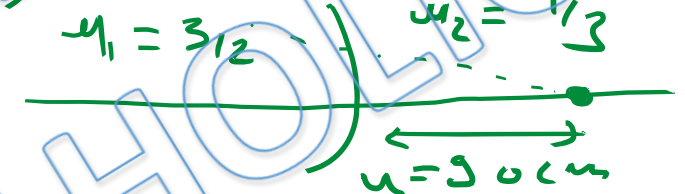
$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{3/2}{v} - \frac{1}{-\infty} = \frac{3/2 - 1}{30} = \frac{1/2}{30}$$

$$\frac{3}{2v} + 0 = \frac{1}{60} \Rightarrow \boxed{v = 90\,cm}$$

I_1 will be object for surface - 2

So; Now Refraction at 2nd surface



$$\frac{4/3}{v} - \frac{3/2}{30} = \frac{4/3 - 3/2}{-30}$$

$$\frac{4}{3v} - \frac{1}{60} = \frac{+1/6}{+30} = \frac{1}{180}$$

$$\frac{4}{3v} = \frac{1}{60} + \frac{1}{180} = \frac{4}{180}$$

$$\boxed{v = 60\,cm}$$

$\therefore$ focal length is when parallel rays are meeting after refraction.

So; $\boxed{f = 60\,cm}$ Ans: (a)

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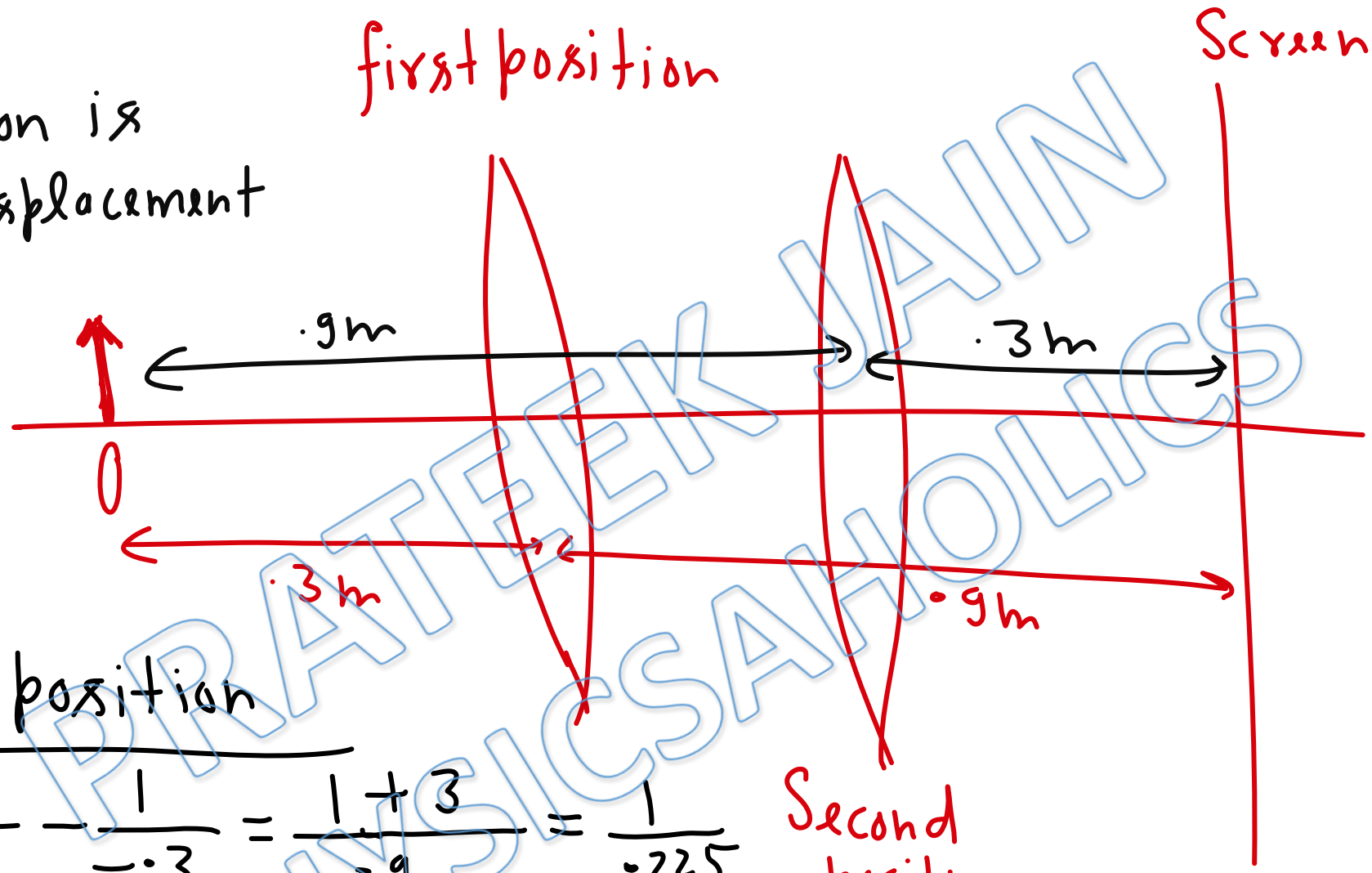
Solution: 13

This question is based on displacement Method.



for first position

$$\frac{1}{f} = \frac{1}{.9} - \frac{1}{-.3} = \frac{1+3}{.9} = \frac{1}{.225}$$

$$f = .225\,m$$

$$3f = .675\,m$$

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To form real image on screen by using lens of focal length 3f (i.e. .675m) distance between object & screen must be greater than or equal to 4 times focal length (i.e. 2.7m).

So lens of focal length 3f can not form image on screen.

Ans(b)

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Solution: 14

If distance between object and screen is less than $4f$, Converging lens can not form image on screen.

$$4f > 40\,cm$$

$$f > 10\,cm$$

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Ans(6)

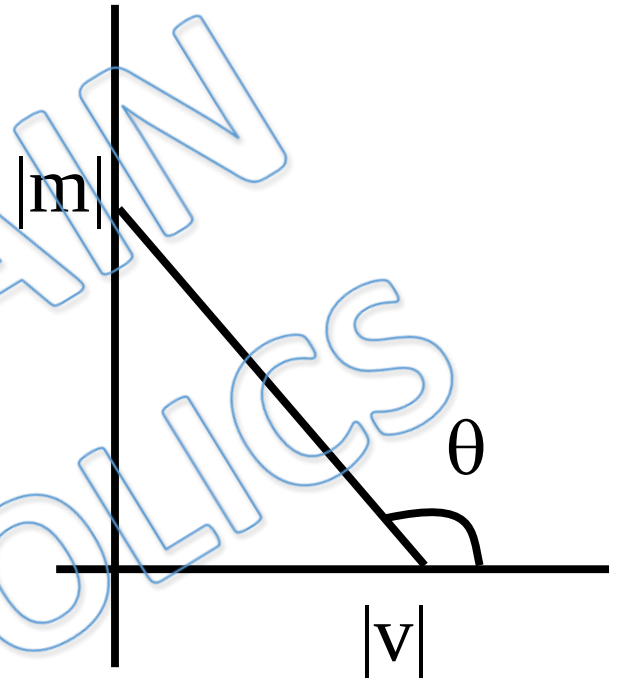
Solution: 15

At intercept on V axis →

$m = 0 \Rightarrow I = 0 \Rightarrow V = f$

At intercept on m axis

$V = 0 \Rightarrow u = 0 \Rightarrow m = 1$



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

$\Rightarrow \frac{dm}{dv} = -\frac{1}{f} \Rightarrow f = -\left(\frac{1}{\text{Slope}}\right)$

Ans(a,b,c)

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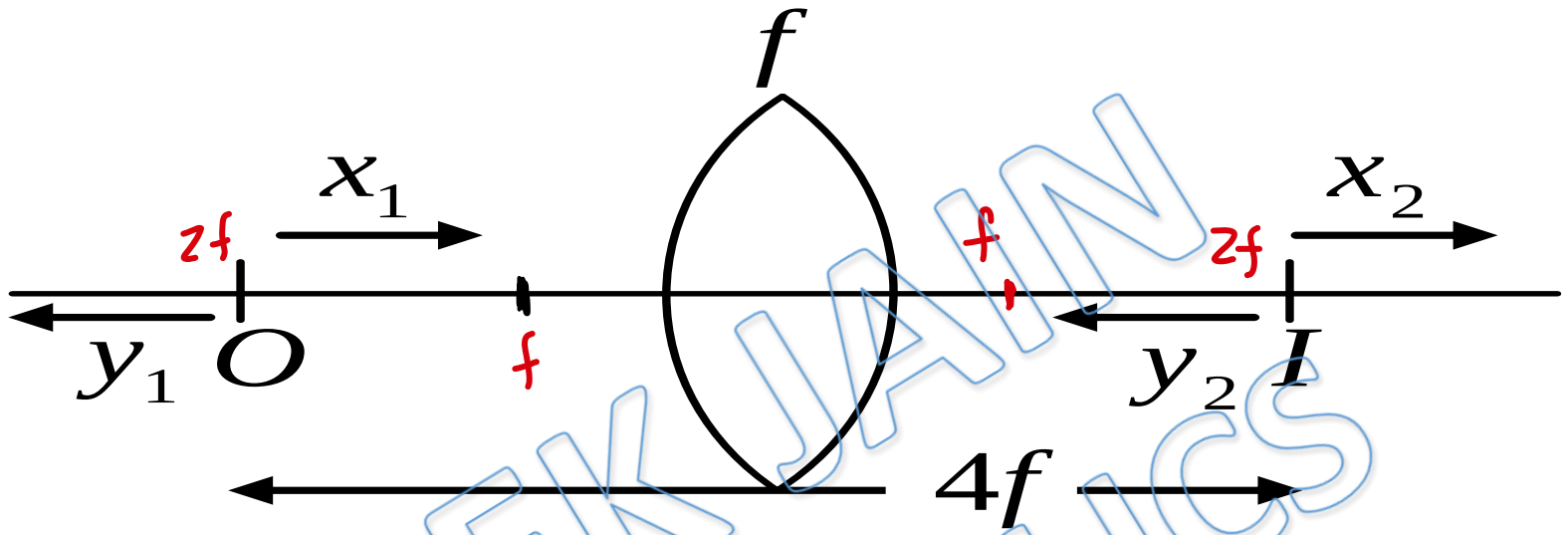
Solution: 16



Since distance b/w Real object & its real image is 4f, object & image both are at 2f.

When object moves 2f to f, image moves 2f to ∞ ⇒ image is moving faster

⇒ $x_2 > x_1$

When object moves 2f to ∞, image moves 2f to f ⇒ image is moving slower.

⇒ $y_1 > y_2$

Ans(c)

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