PRAYAS

JEE 2025

Lecture – 05

Physics

Ray optics

By- Saleem Ahmed Sir

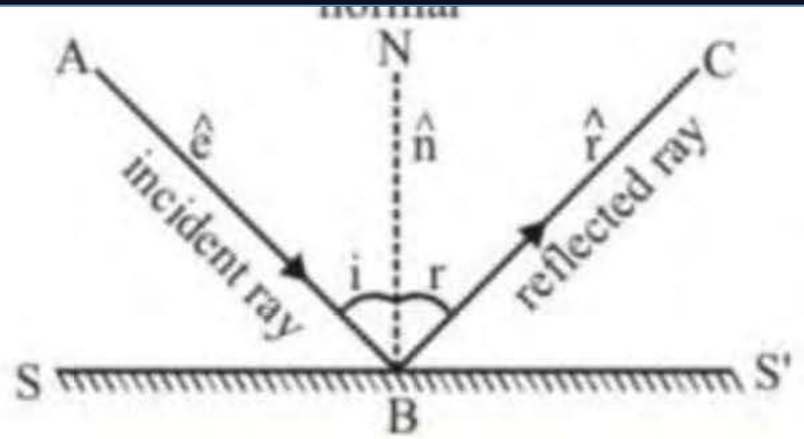
Topics *to be covered*

1 # Ques Practise

2 # Reflection from plane surface

3 # Snell's Law.

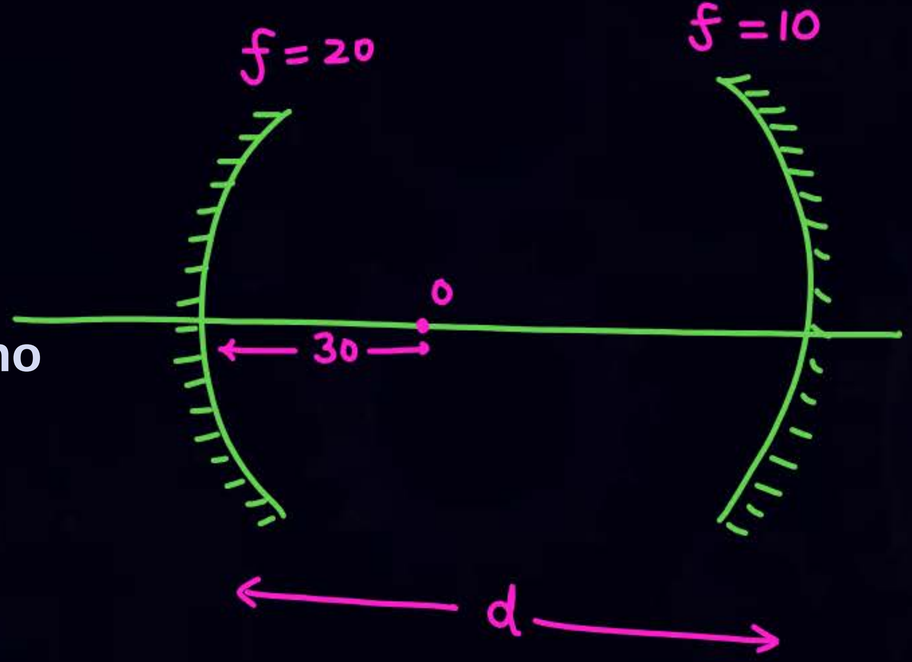
4 #



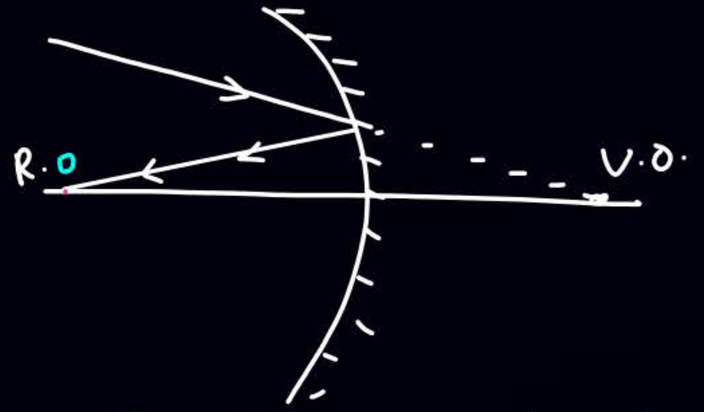
In vector form $\boxed{\hat{\mathbf{r}} = \hat{\mathbf{e}} - 2(\hat{\mathbf{e}}.\hat{\mathbf{n}})\hat{\mathbf{n}}}$

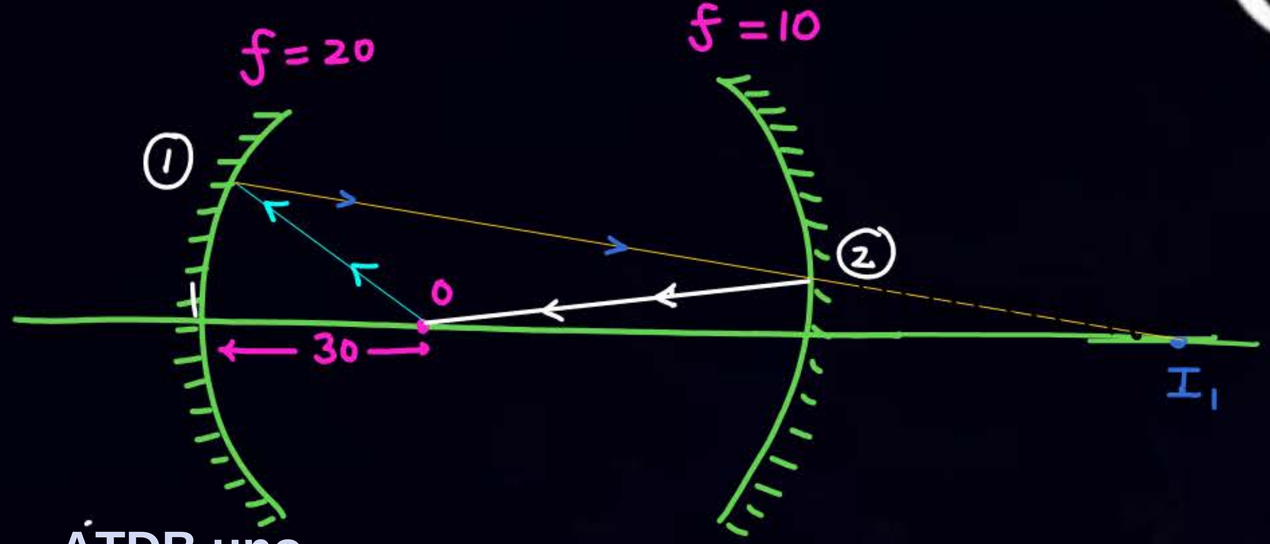
ATDB.uno

Q If image of the object formed at object after two sucessive reflection. find value of d' Consider 1st reflection at lift mirror. (All Data in cm)



for 2nd reflection





$u = +(60 - d)$

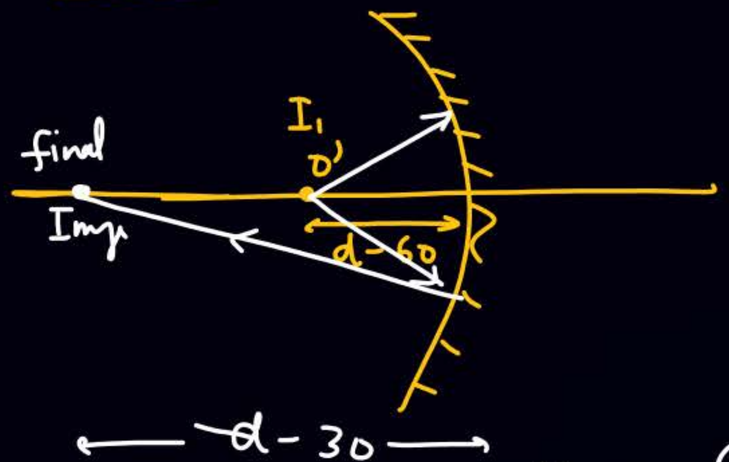
$v = -(d - 30)$

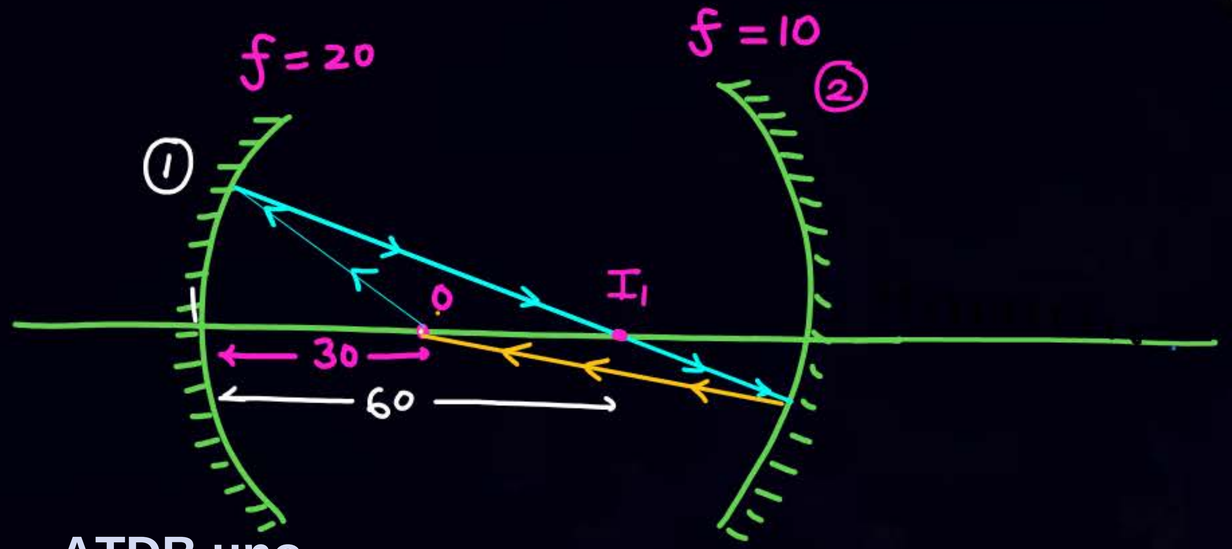
$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{-(d-30)} + \frac{1}{60-d} = \frac{1}{-10}$$

Solve & get

for 2nd ref



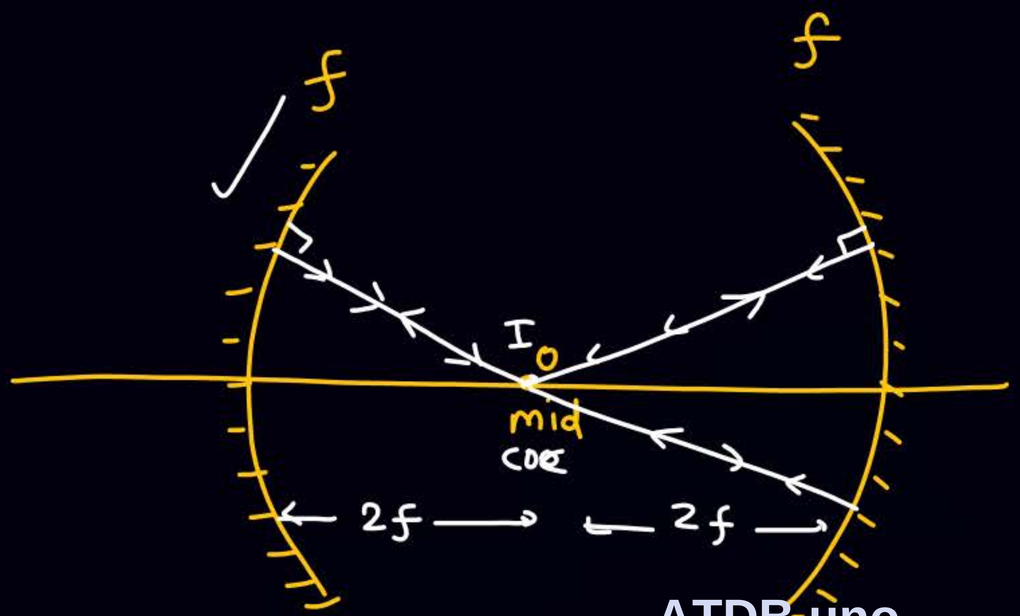


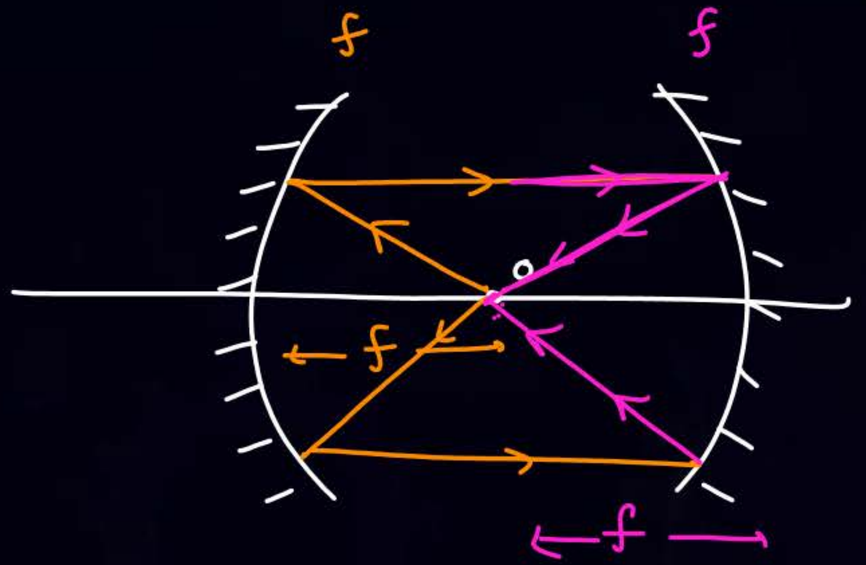
$$u = -(d-60) = 60-d$$

$$v = -(d-30)$$

$$\frac{1}{-(d-30)} + \frac{1}{-(d-60)} = \frac{1}{-10}$$

Q





d

$d = 4f$

$d = 2f$

2f

12. A point source S is placed midway between two converging mirrors having equal focal length f as shown in figure (18-E3). Find the values of d for which only one image is formed.

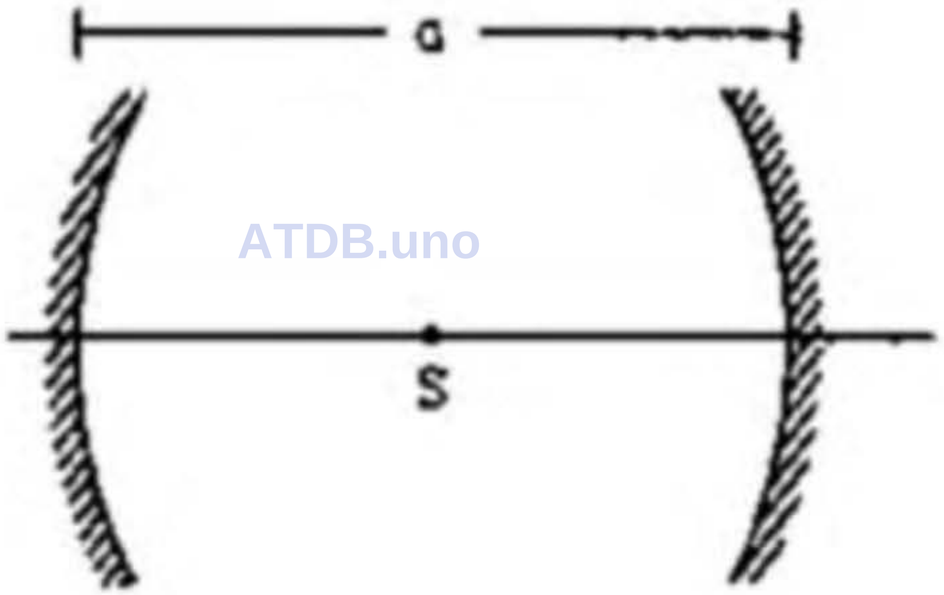
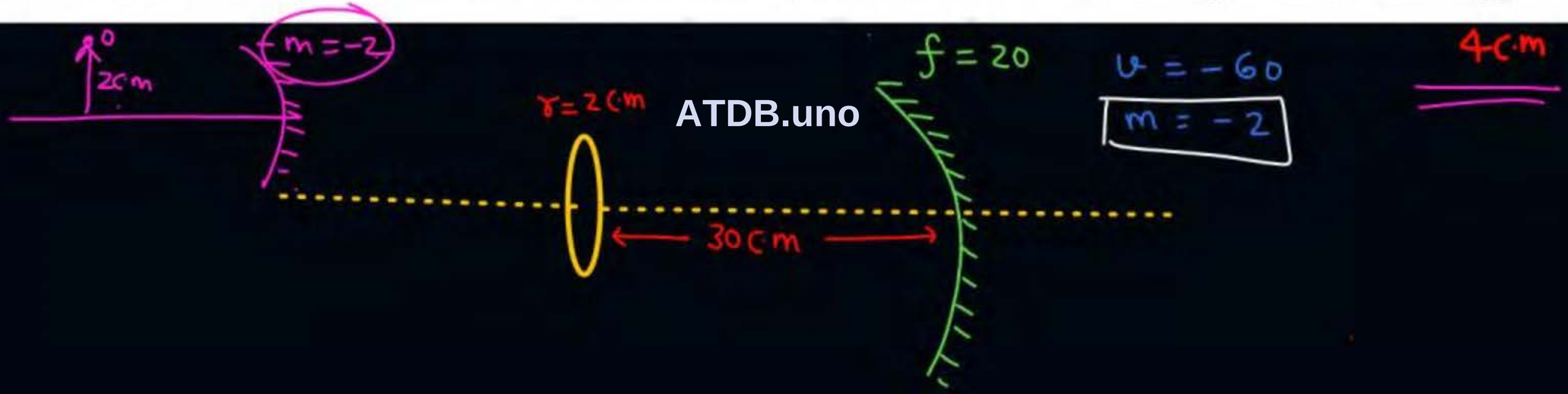


Figure 18-E3

10. A particle goes in a circle of radius 2·0 cm. A concave mirror of focal length 20 cm is placed with its principal axis passing through the centre of the circle and perpendicular to its plane. The distance between the pole of the mirror and the centre of the circle is 30 cm. Calculate the radius of the circle formed by the image.

16

17



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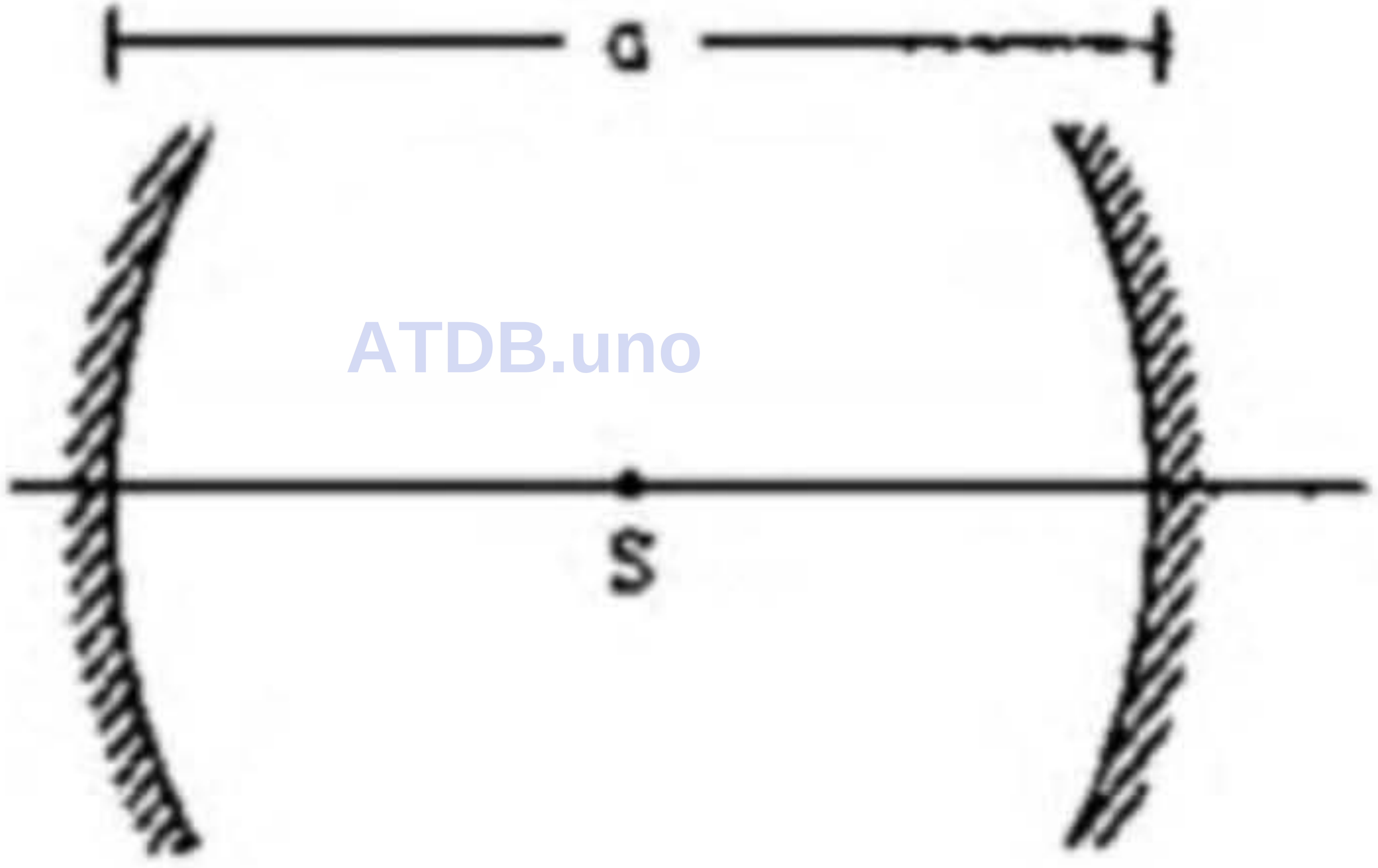


Figure 18-E3

Ans 2f, 4f

13. A converging mirror M_1, a point source S and a diverging mirror M_2 are arranged as shown in figure (18-E4). The source is placed at a distance of 30 cm from M_1. The focal length of each of the mirrors is 20 cm. Consider only the images formed by a maximum of two reflections. It is found that one image is formed on the source itself. (a) Find the distance between the two mirrors. (b) Find the location of the image formed by the single reflection from M_2.

Ans
(a) 50 cm
(b) 10 cm from M_2

(b) $v = \frac{-x \times 20}{-x-20} = \frac{20x}{20+x}$

(b) $x = 20$

Ans $\frac{20x}{20+x} = \frac{400}{40}$

$= 10$

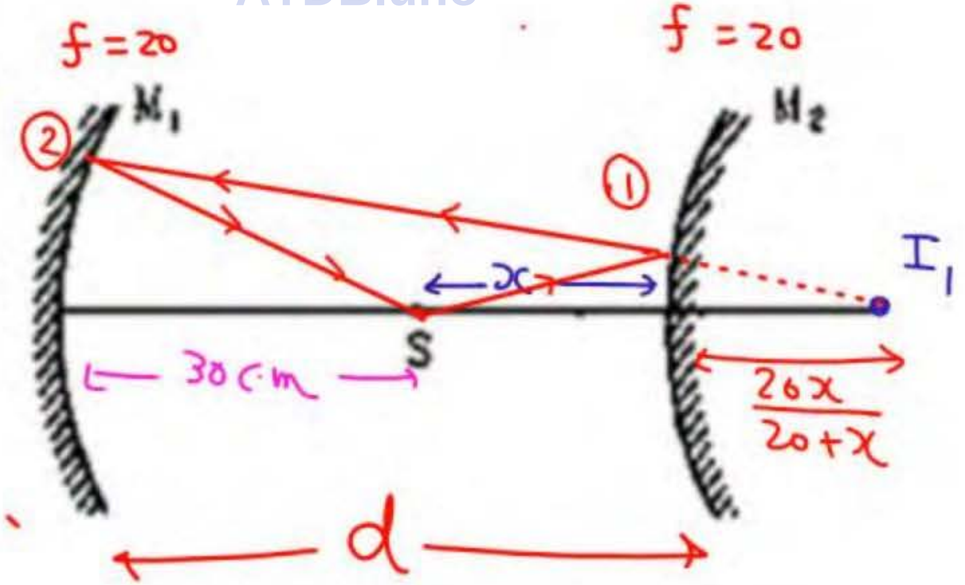
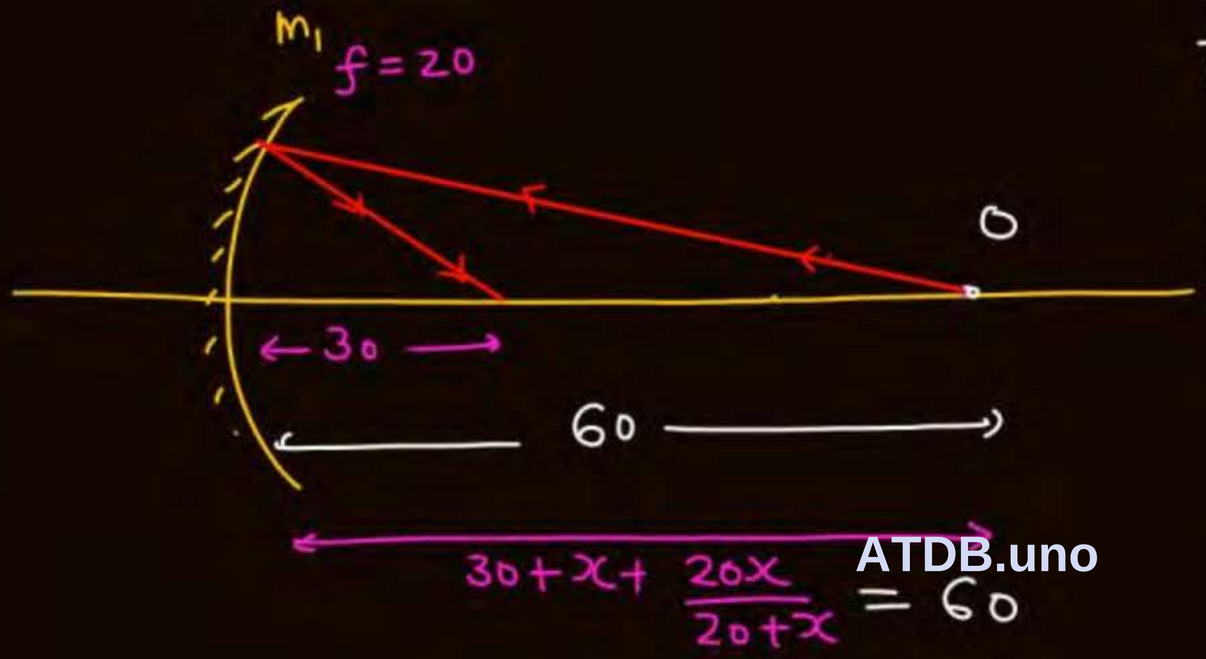


Figure 18-E4



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

$$\frac{1}{u} - \frac{1}{30} = -\frac{1}{20}$$

$$\frac{1}{u} = -\frac{1}{20} + \frac{1}{30} = -\frac{1}{60}$$

$$u = -60$$

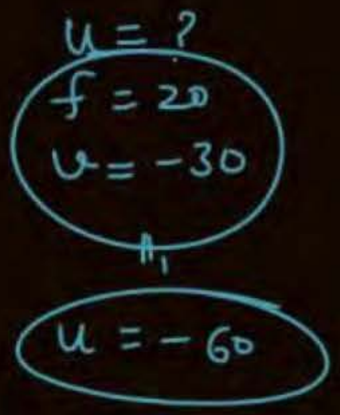
$$x + \frac{20x}{20+x} = 30$$

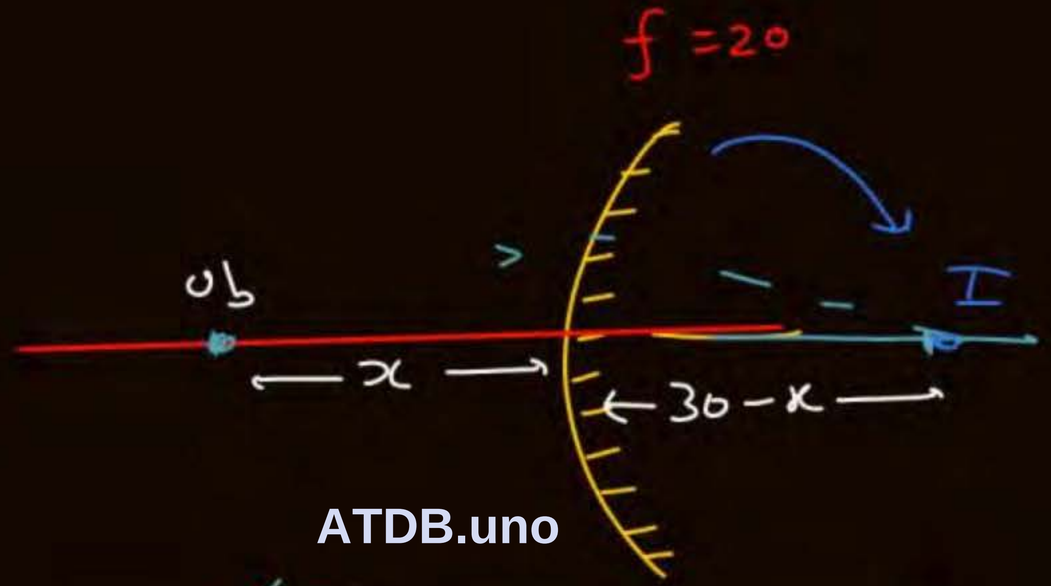
$$\frac{20x + x^2 + 20x}{20+x} = 30$$

$$x^2 + 40x = 600 + 30x$$

$$x^2 + 10x - 600 = 0$$

$$(x+30)(x-20) = 0$$

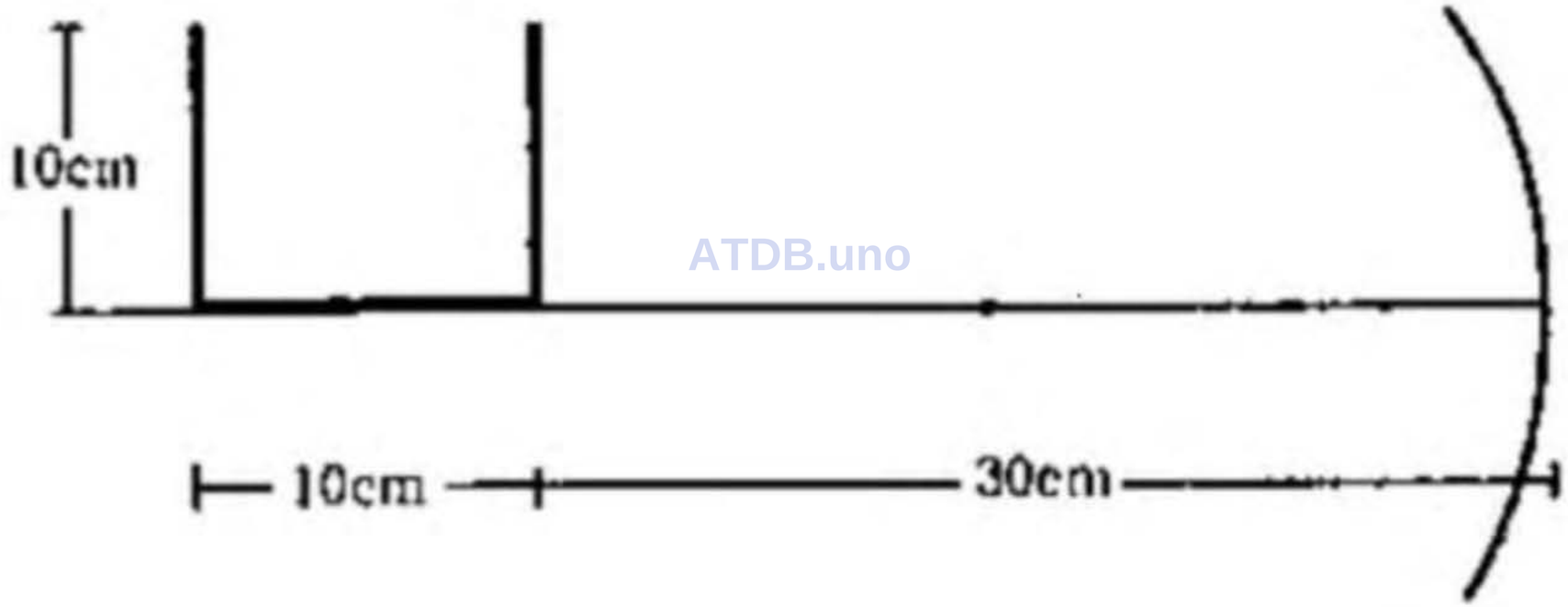




$$\frac{1}{30-x} + \frac{1}{-x} = \frac{1}{20}$$

$$\frac{1}{10} - \frac{1}{20} = \frac{1}{20}$$

7. A U-shaped wire is placed before a concave mirror having radius of curvature 20 cm as shown in figure (18-E1). Find the total length of the image.

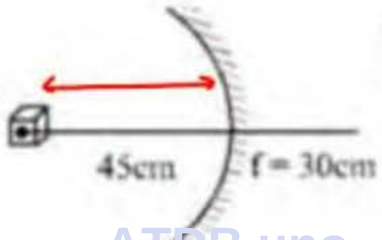


Ans 10 cm

Figure 18-E1

A cube of side length 1mm is placed on the axis of a concave mirror at a distance of 45 cm from the pole as shown in the figure. One edge of the cube is parallel to the axis. The focal length of the mirror is 30 cm. Find approximate volume of the image.

1mm भुजा लम्बाई वाला एक घन चित्रानुसार किसी अवतल दर्पण की अक्ष पर ध्रुव से 45 cm दूरी पर रखा है। घन की एक भुजा अक्ष के समान्तर है। यदि दर्पण की फोकस दूरी 30 cm हो तो प्रतिबिम्ब का लगभग आयतन ज्ञात कीजिए।



$m^4(V_0)$

$(16) \times (1mm)^3 = 16mm^3$

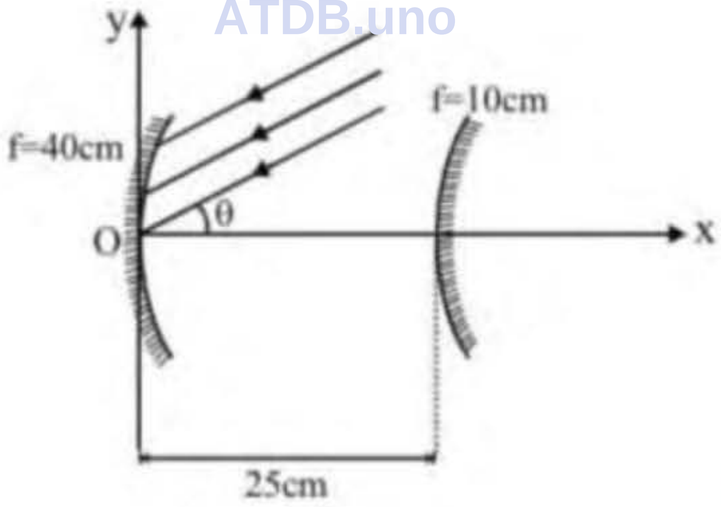
$v = \frac{45 \times 30}{-45 + 30} = \frac{45 \times 30}{-15} = -90$

$m = -\left(\frac{-90}{-45}\right) = -2$

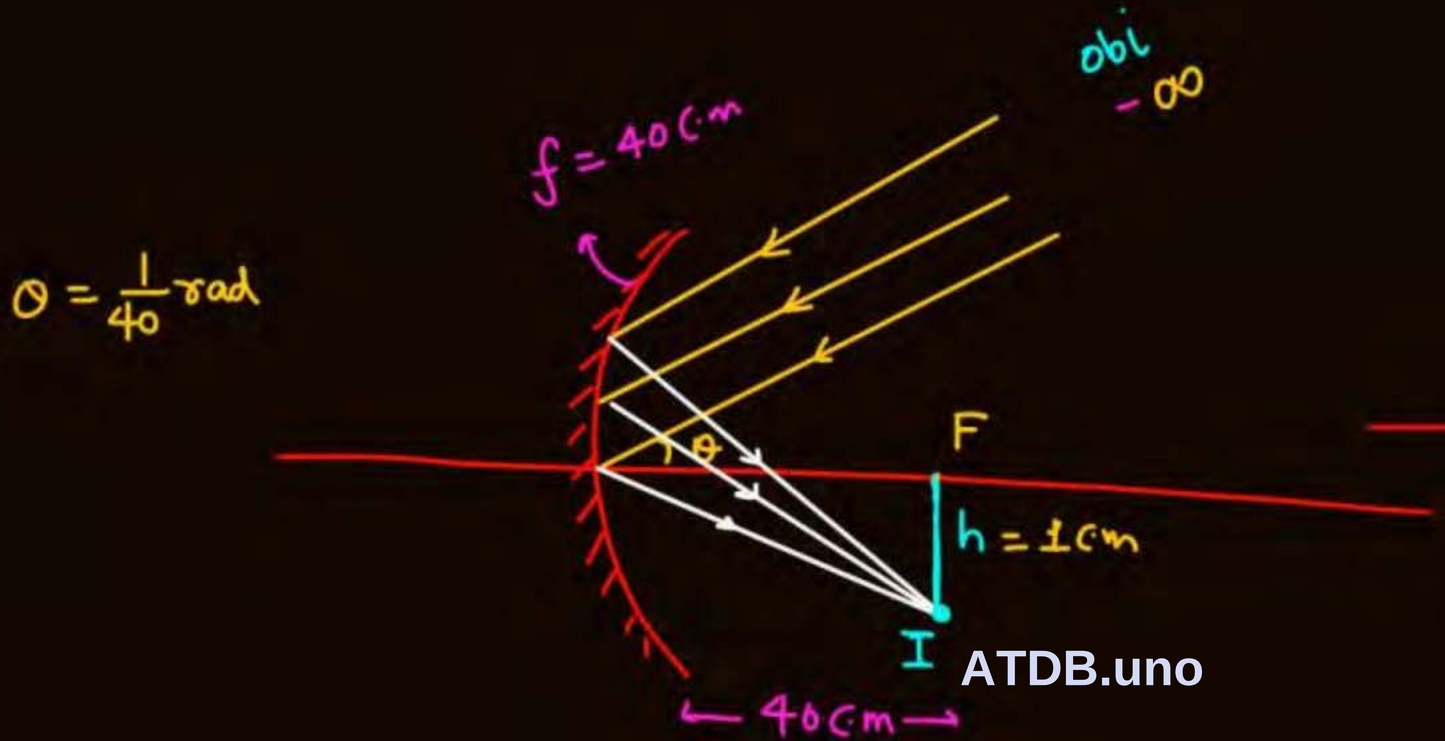
Ans. 16 mm^3

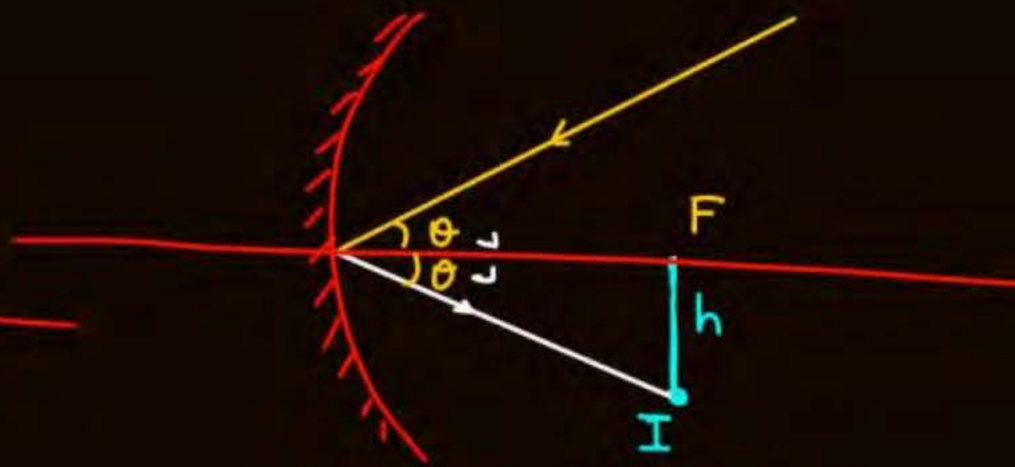
angle $\theta = \frac{1}{40}$ radian are incident on it. A convex mirror is kept at a distance 25 cm from the first mirror as shown. Find the y-coordinate of the image (in cm) formed by the system of mirrors after two reflections.

एक 40 cm फोकस दूरी वाला अवतल दर्पण मूलबिन्दु पर रखा हुआ है। समान्तर किरणें, इस पर $\theta = \frac{1}{40}$ rad कोण बनाते हुए आपतित होती है। एक अन्य उत्तल दर्पण को प्रथम दर्पण से 25 cm दूरी पर रखा जाता है। दर्पणों के इस निकाय द्वारा दो परावर्तनों के पश्चात् बनने वाले प्रतिबिम्ब का y-निर्देशांक (सेमी में) ज्ञात कीजिए।



Ans. 2

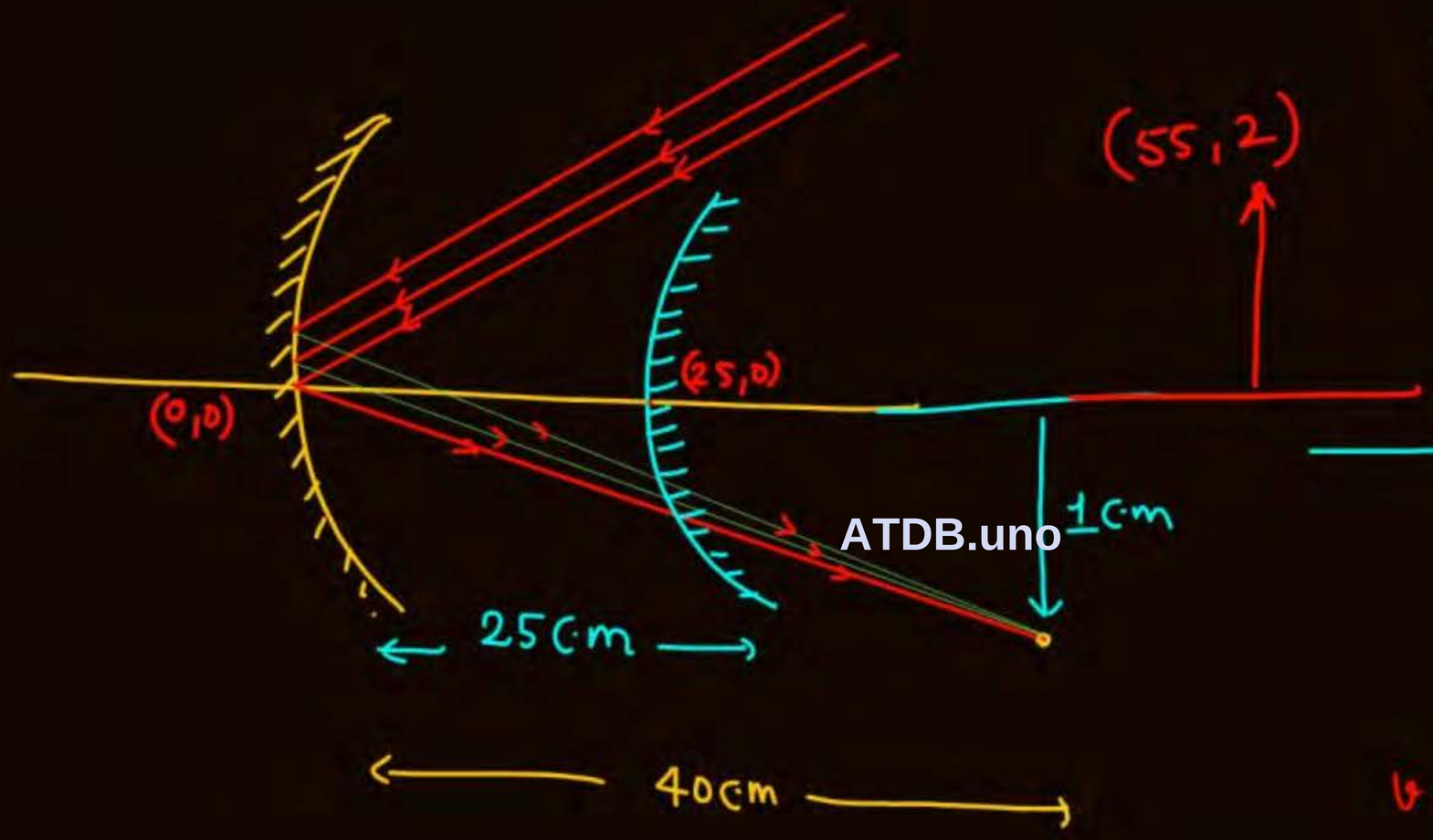




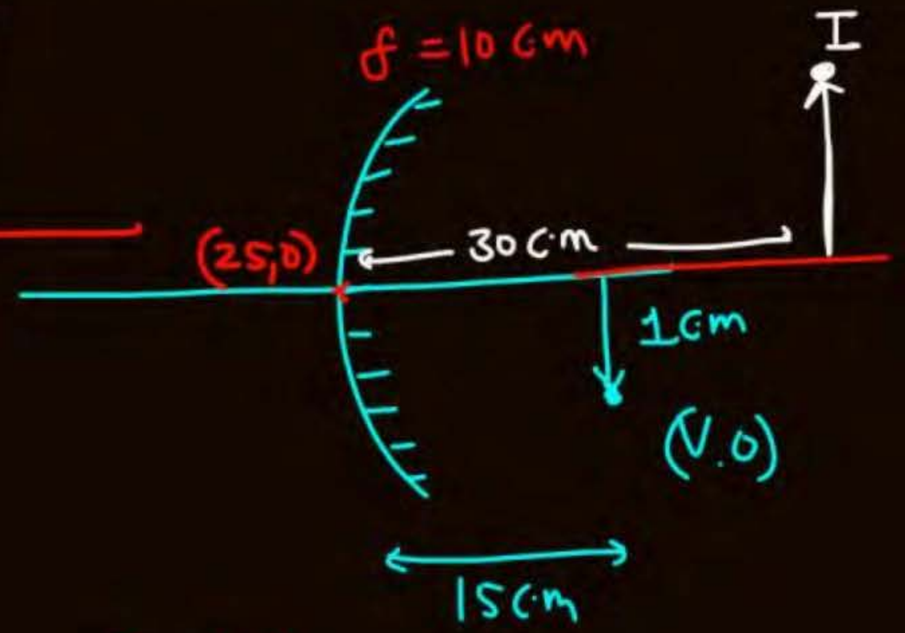
$$\tan\theta = \frac{h}{f} = \theta$$

$$\frac{1}{40} = \frac{h}{40\ \text{cm}}$$

$$\boxed{h = 1\ \text{cm}}$$



2nd reflection

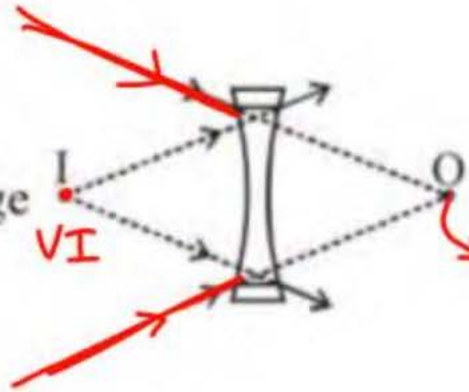


$$v = \frac{uf}{u-f} = \frac{15 \times 10}{15-10} = 30$$

$$m = -\frac{v}{u} = -\frac{30}{+15} = -2$$

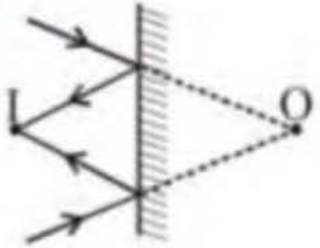
The nature of object and image given with each of the optical condition is shown. Choose the **correct** option(s) :-

(A) Virtual image



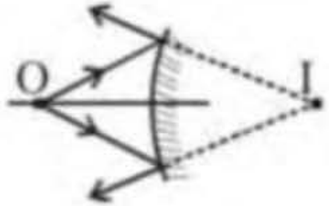
Virtual object

(B) Virtual image



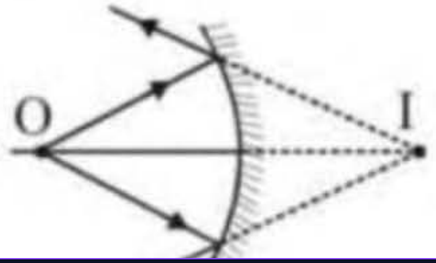
Real object

(C) Real object



Virtual image

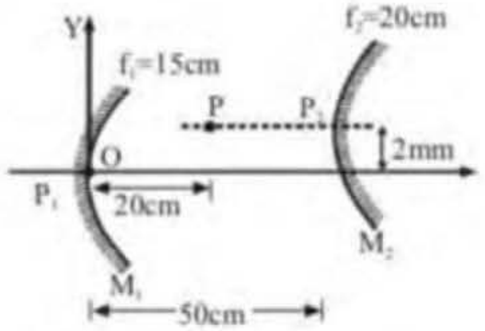
(D) Real object



Virtual image

Find co-ordinates of image of point object P formed after two successive reflection in situation as show n figure considering first reflection at concave mirror and then at convex.

किसी दु बिम्ब P के पहले अवतल दर्पण तथा फिर उत्तल दर्पण से चित्रानुसार दो क्रमागत परावर्तनों के पश्चात् बनने वाले प्रतिबि के निर्देशांक ज्ञात कीजिए।



Ans. (30 cm, – 14 mm)

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

$\vec{A}\cdot\vec{B} = AB\cos\theta$

$\frac{1}{4}(1-3) = 1\times1\times\cos\theta$

$\cos\theta = -\frac{1}{2}$

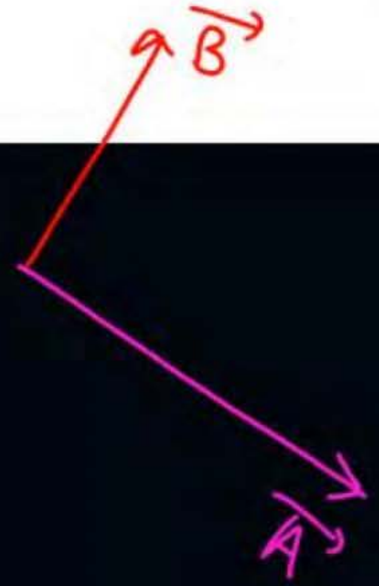
$\theta = 120^\circ$

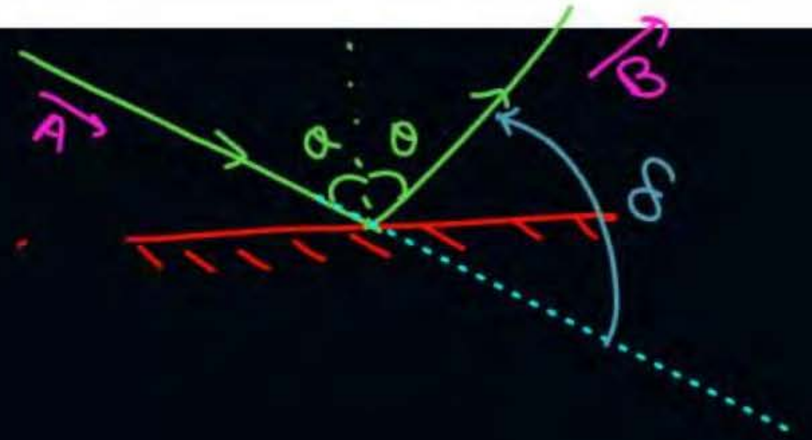
एक समतल दर्पण पर आपतित प्रकाश किरण की प्रगामी दिशा $\frac{1}{2}\left(\hat{i}+\sqrt{3}\hat{j}\right)$ है। परावर्तन के बाद प्रगामी दिशा $\frac{1}{2}\left(\hat{i}-\sqrt{3}\hat{j}\right)$ हो जाती है। किरण का आपतन कोण है :-

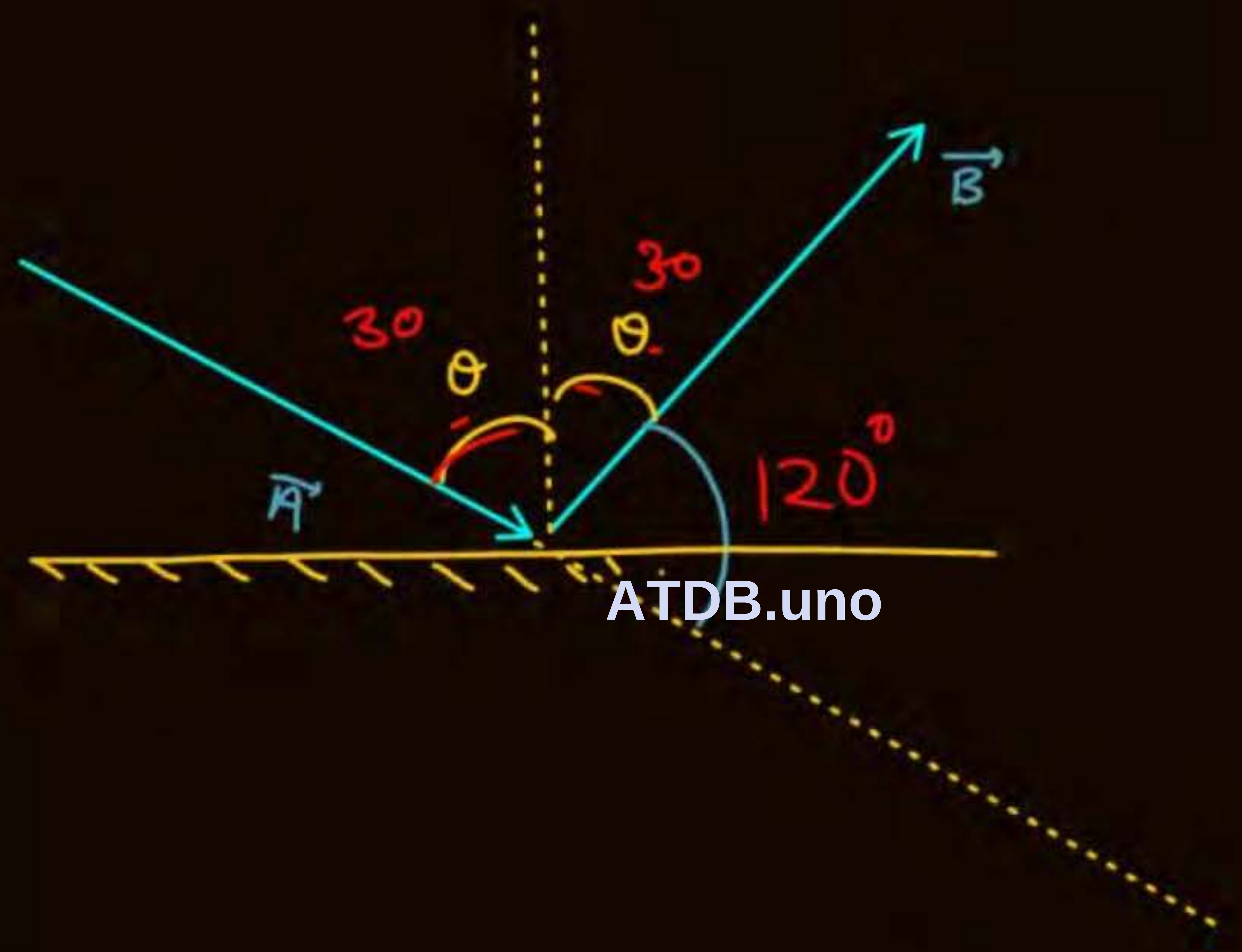
[JEE-Advance-2013]

(A) 30° (B) 45° (C) 60° (D) 75°

Ans. (A)

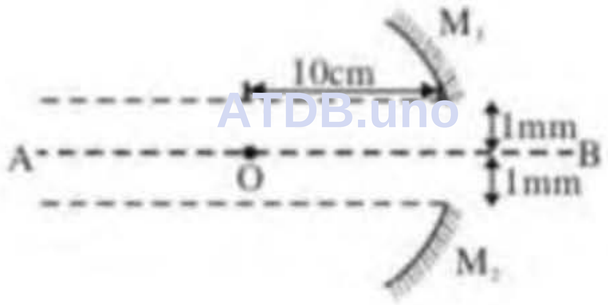






A concave mirror of focal length 20 cm is cut into two parts from the middle and the two parts are moved perpendicularly by a distance 1 mm from the previous principal axis AB. If an object is placed of a distance of 10 cm from the mirror on the line AB then, find the distance between the images formed by the two parts?

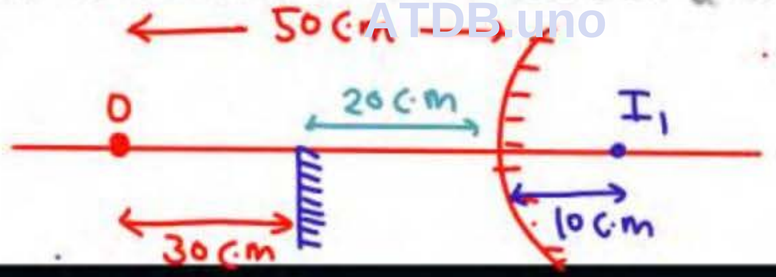
20 cm फोकस दूरी के अवतल दर्पण को बीच में से दो भागों में काटा गया है तथा दोनों भागों को पूर्व मुख्य अक्ष AB से 1mm लम्बवत् खिसकाकर रखा गया है तथा यदि रेखा AB पर एक बिम्ब को दर्पण से 10 cm की दूरी पर रखा जाये तो दोनों भागों द्वारा बनाये गये प्रतिबिम्बों के मध्य की दूरी ज्ञात कीजिए।



Ans. 2 mm

An experimentalist devises a method for finding the radius of curvature of a convex mirror. He uses a plane mirror strip between the object and the convex mirror and adjusts it till the two virtual images formed by reflection at both the mirrors coincide without parallax. In his observations, the object distance from the convex mirror is 0.5 m while it is 0.30 m in front of the plane mirror. Find the radius of curvature (in cm) of the convex mirror.

एक प्रयोगकर्ता ने उत्तल दर्पण की वक्रता त्रिज्या ज्ञात करने के लिये एक विधि बताई। उसने बिम्ब तथा उत्तल दर्पण के मध्य एक समतल दर्पण पट्टिका का उपयोग किया तथा इसे तब तक व्यवस्थित किया जब तक कि दोनों दर्पणों पर परावर्तन द्वारा बनने वाले दो आभासी प्रतिबिम्ब बिना विस्थापनाभास (parallax) के सम्पाती ना हो जाये। उसके प्रेक्षणों में उत्तल दर्पण से बिम्ब की दूरी 0.5 m है, जब कि यह समतल दर्पण के सामने 0.30 m दूरी है। उत्तल दर्पण की वक्रता त्रिज्या (cm में) ज्ञात कीजिए।



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

$$\frac{1}{-50}+\frac{1}{10}=\frac{1}{f}$$

Ans. 25

$$\frac{4}{50}=\frac{1}{f}$$

$$f = 12.5$$

$$R = 2f = 25$$

8. A man uses a concave mirror for shaving. He keeps his face at a distance of 25 cm from the mirror and gets an image which is 1·4 times enlarged. Find the focal length of the mirror.

The focal length of a concave mirror is 12 cm. Where should an object of height 4 cm be placed, so that a real image of 1 cm height is formed–

एक अवतल दर्पण की फोकस दूरी 12 cm है। एक 4 cm ऊंचाई की वस्तु कहाँ रखी जानी चाहिए ताकि एक 1 cm ऊँचाई का वास्तविक प्रतिबिम्ब बनता है–

(A) 48 cm (B) 3 cm (C) 60 cm (D) 15 cm

Ans. (C)

$f = -12$

$u < 0$
$u < 0$

$m = -\frac{v}{u}$

$m < 0$

$|m| = \left|\frac{v}{u}\right| = \left|\frac{h_I}{h_o}\right|$

$\frac{1}{4} = \left|\frac{v}{u}\right|$

$m = -\frac{1}{4} = -\frac{v}{u}$

$\frac{v}{u} = \frac{1}{4}$

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

$\frac{u}{v} + \frac{u}{u} = \frac{u}{f}$

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

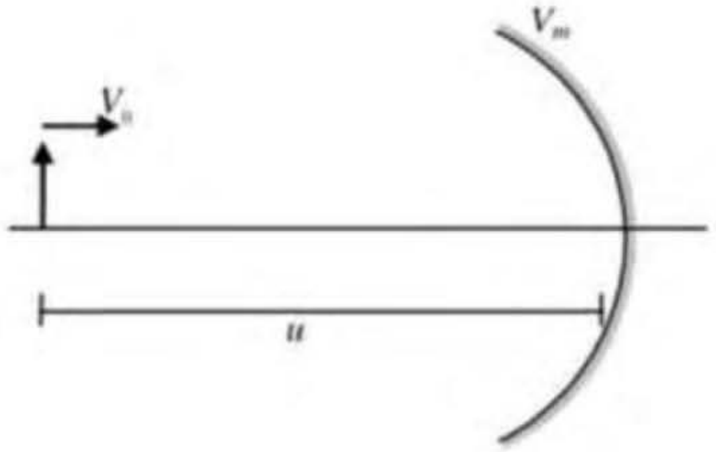
$u = -60$

$4 + 1 = \frac{u}{-12}$

An object and a concave mirror of focal length f = 10 cm both move along the principal axis of the mirror with constant speeds. The object moves with speed $V_0 = 15$ cm s^{-1} towards the mirror with respect to a laboratory frame. The distance between the object and the mirror at a given moment is denoted by u. When u = 30 cm, the speed of the mirror V_m is such that the image is instantaneously at rest with respect to the laboratory frame, and the object forms a real image. The magnitude of V_m is _____ cm s^{-1}.

एक बिम्ब तथा फोकस दूरी f = 10 cm वाला एक अवतल दर्पण नियत चालों के साथ दर्पण की मुख्य अक्ष के अनुदिश गति करते हैं। बिम्ब, प्रयोगशाला तंत्र के सापेक्ष दर्पण की ओर $V_0 = 15$ cm s^{-1} चाल से गति करता है। बिम्ब व दर्पण के मध्य दिये गये क्षण पर दूरी u है। u = 30 cm होने पर दर्पण की चाल V_m इस प्रकार होती है प्रतिबिम्ब, प्रयोगशाला तंत्र के सापेक्ष तात्क्षणिक रूप से विराम में रहता है तथा बिम्ब एक वास्तविक प्रतिबिम्ब बनाता है। V_m का परिमाण cm s^{-1} में ज्ञात कीजिये।

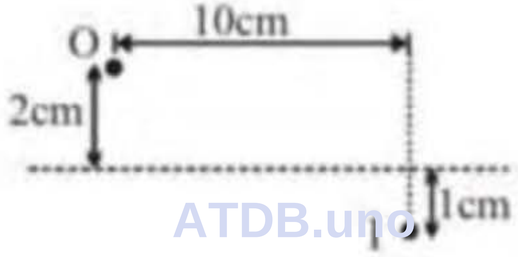
[JEE-Advance-2022]



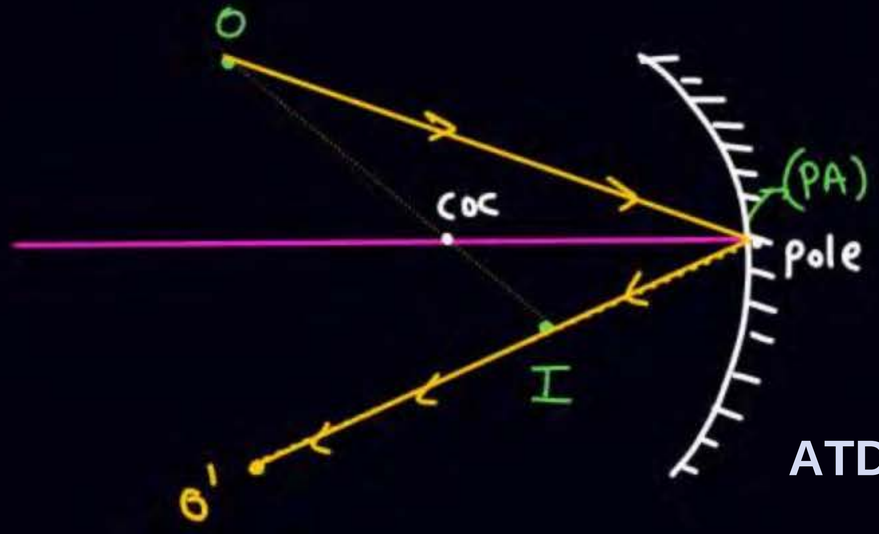
Ans. (3)

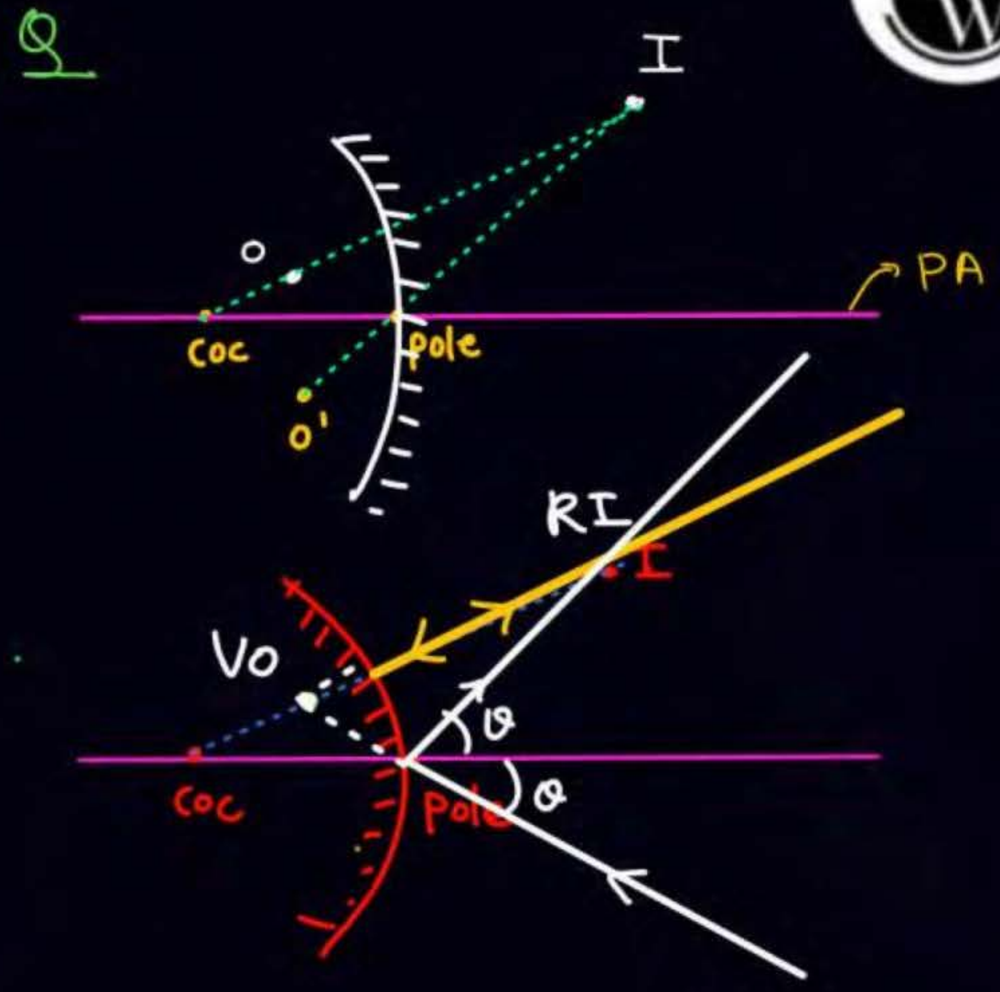
The principal axis of a spherical mirror is shown by dotted line. O is the point object whose real image is I. Find the distance of the pole and centre of curvature of the mirror from object measured along principal axis by drawing ray diagram.

गोलाकार दर्पण की मुख्य अक्ष को बिन्दुकित् रेखा द्वारा प्रदर्शित किया गया है। O एक बिन्दु बिम्ब है जिसका वास्तविक प्रतिबिम्ब I है। किरण आरेख द्वारा मुख्य अक्ष के अनुदिश मापी गई बिम्ब से ध्रुव की दूरी तथा दर्पण के वक्रता केन्द्र की दूरी ज्ञात कीजिए।



Ans. 20 cm from object, 20/3 cm from object





Q At what distance from pole an object must be placed so that image formed has size four times of object, ($f = 10\ cm$)

Sol^n (Case 1) If image is real

$u = -x$

$v = -4x$

$f = -10$

$$\frac{1}{-x} + \frac{1}{-4x} = \frac{1}{-10}$$

$$\frac{5}{4x} = \frac{1}{10}$$

$$x = 12.5$$

Case 2 image ⟶ virtual

$u = -x$

$v = +4x$

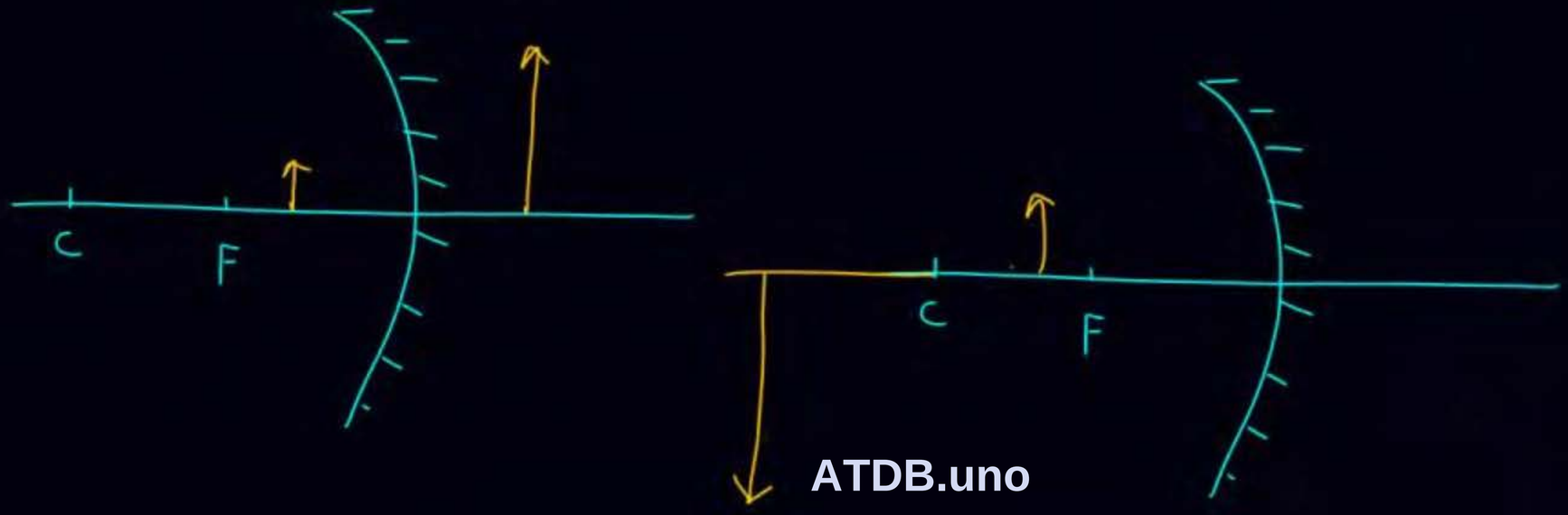
$f = -10$

$$\frac{1}{-x} + \frac{1}{4x} = \frac{1}{-10}$$

$$\frac{1}{x} - \frac{1}{4x} = \frac{1}{10}$$

$$\frac{3}{4x} = \frac{1}{10}$$

$x = 7.5$



An object is placed 10 cm in front of a convex mirror of focal length 20 cm. The distance of the image from the mirror is

एक बिम्ब को 20 cm फोकस दूरी वाले उत्तल दर्पण से 10 cm पर रखा गया है। दर्पण से प्रतिबिम्ब की दूरी है :-

(A) 10/3 cm (B) 20/3 cm (C) 10 cm (D) 40/3 cm

Ans. (B)

An object is placed at 20 cm from a convex mirror of focal length 20 cm. The distance of the image from the pole of the mirror is

एक बिम्ब को 20 cm फोकस दूरी वाले उत्तल दर्पण से 20 cm पर रखा गया है। दर्पण के ध्रुव से प्रतिबिम्ब की दूरी है :-

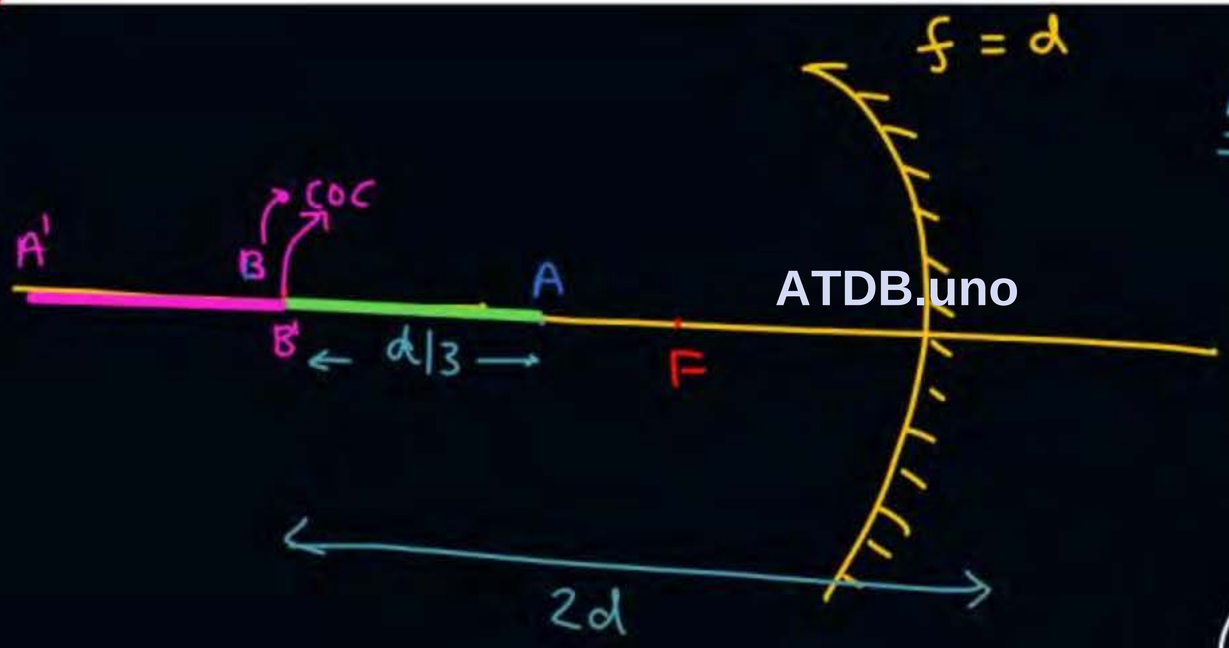
(A) infinity/अनन्त (B) 10 cm (C) 15 cm (D) 40 cm

Ans. (B)

A thin rod of length d/3 is placed along the principal axis of a concave mirror of focal length = d such that its image, which is real and elongated, just touches the rod. Find the length of the image?

एक पतली छड़ की लम्बाई d/3 है। इसे फोकस दूरी d वाले अवतल दर्पण की मुख्य अक्ष के अनुदिश इस प्रकार से रखा गया है कि इसका प्रतिबिम्ब जो कि वास्तविक तथा बड़ा है, छड़ को ठीक स्पर्श करता है। प्रतिबिम्ब की लम्बाई ज्ञात करें।

Ans. d/2



$A \equiv A''$ $\quad u = 2d - \frac{d}{3} = \frac{5d}{3}$

$$\frac{1}{v} + \frac{1}{-\frac{5d}{3}} = \frac{1}{-d}$$

$$\frac{1}{V} = \frac{3}{5d} - \frac{1}{d} = \frac{-2}{5d}$$

$$v_A = \frac{-5d}{2} \qquad V_B = -2d$$

$A' \equiv$

$B' \equiv$

$f\lambda = v$

$v = \frac{c}{\mu}$

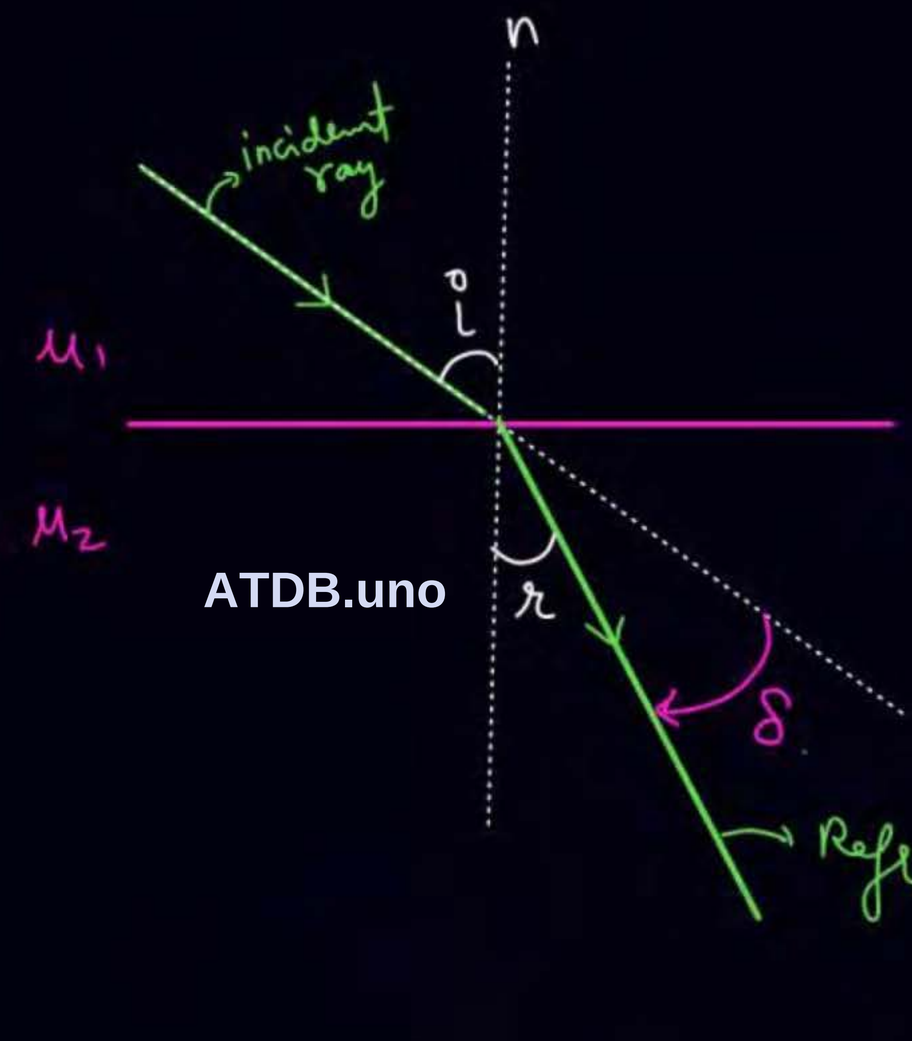
Refraction

$\angle i \longrightarrow$ angle of incidence

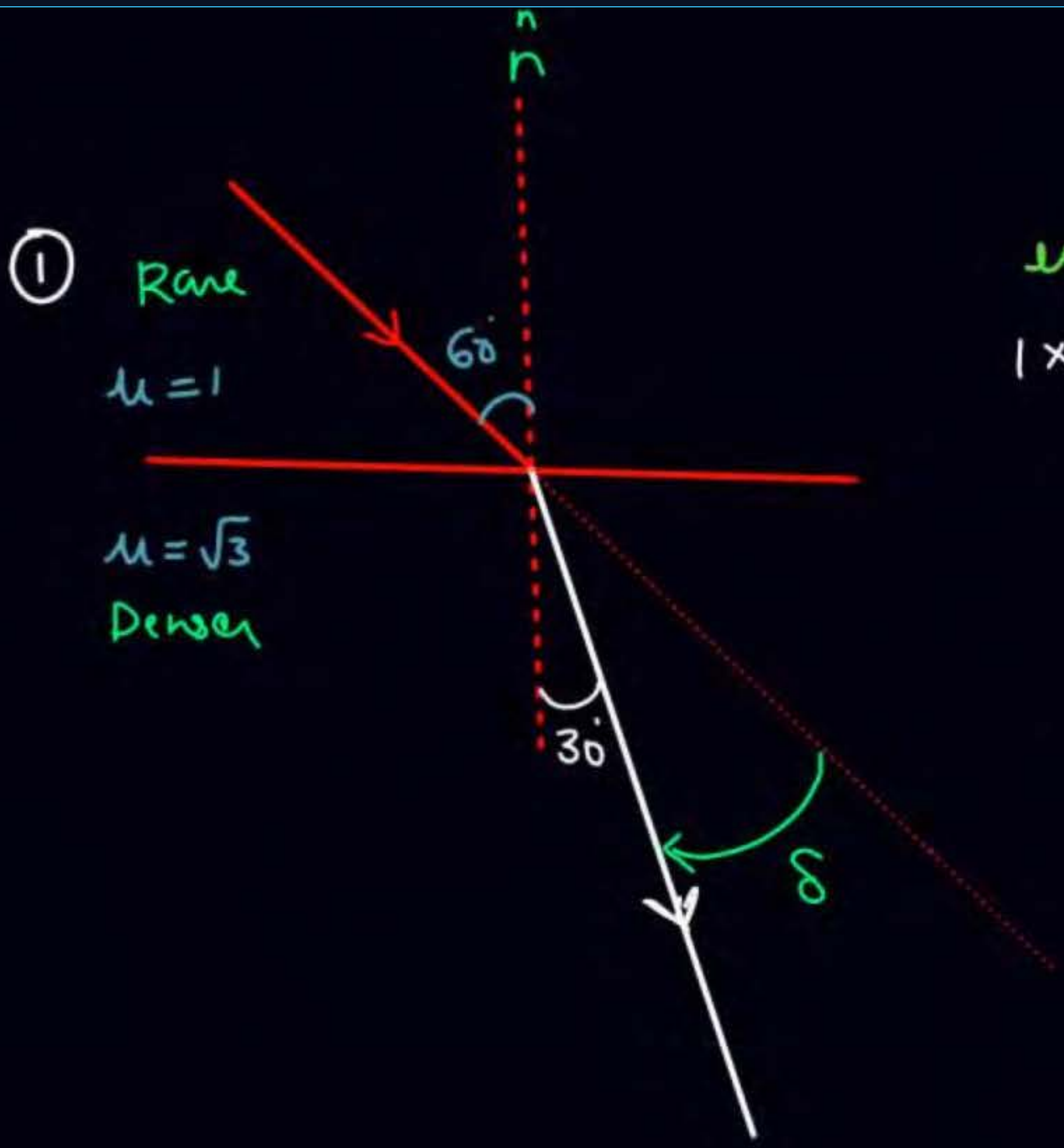
$\angle r \longrightarrow$ " " refraction

Snell's Law

- $\mu_1 \sin i = \mu_2 \sin r$
- $\delta = |i - r|$



speed	change
f	same
λ	change



$\mu_1 \sin i = \mu_2 \sin r$

$1 \times \sin 60 = \sqrt{3} \cdot \sin r$

$\frac{\sqrt{3}}{2} = \sqrt{3} \sin r$

$\sin r = \frac{1}{2}$

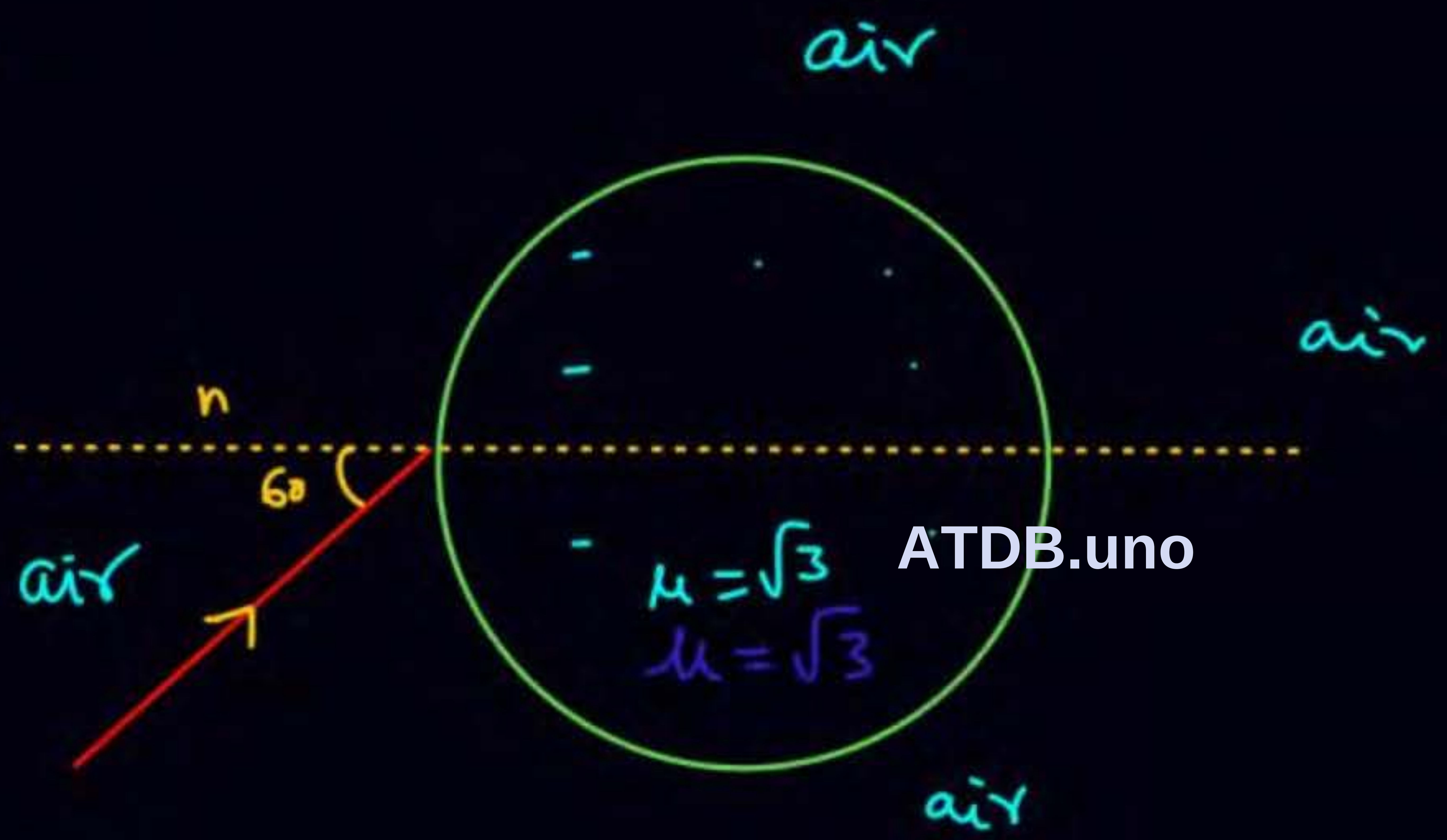
$r = 30°$

$\delta = 60 - 30 = 30\,(cw)$

- Rare to Denser: Bend towards normal
- Denser to rare ≡ Away from normal

DRA

Q



Q2

$$\delta_{net} = (60-30)_{cw} + (60-30)_{cw}$$

$$= 60$$

① $\mu_1 \sin i = \mu_2 \sin r$

$1 \times \sin 60 = \sqrt{3} \sin r$

$r = 30°$

② $\sqrt{3} \sin 30 = 1 \times \sin r_f$

$r_f = 60$

QUESTION

When an object is kept at a distance of 30 cm from a concave mirror, the image is formed at a distance of 10 cm from the mirror. If the object is moved with a speed of 9 cms^{-1}, the speed (in cms^{-1}) with which image moves at that instant is _____.

(JEE Main-2020)

$$V_I = -m^2 V_0$$

$$= -m^2 \times 9$$

$$= -\left(\frac{1}{3}\right)^2 \times 9$$

$$= -1$$

$$m = -\frac{v}{u}$$

$$|m| = \left|\frac{-v}{u}\right| = \frac{10}{30} = \frac{1}{3}$$

Ans : (1)

QUESTION

A spherical mirror is obtained as shown in the figure from a hollow glass sphere. If an object is positioned in front of the mirror, what will be the nature and magnification of the image of the object? (Figure drawn as schematic and not to scale)

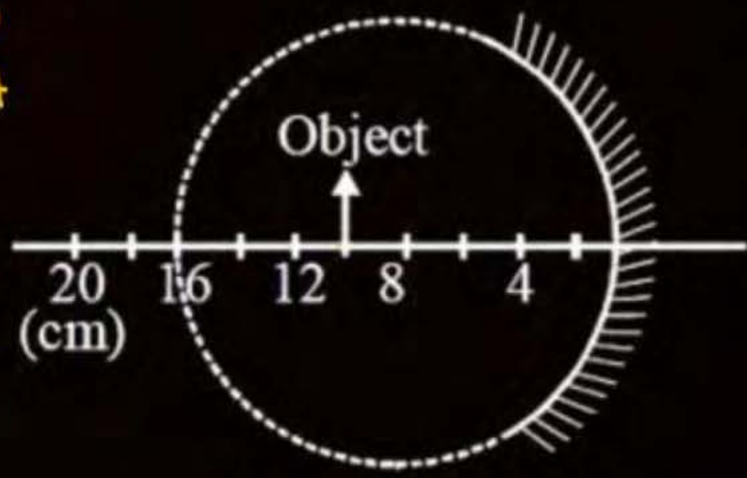
(JEE Main-2020)

$R = 8$

$f = 4$

$u = -10$

$f = -4$



1. Inverted, real and magnified
2. Erect, virtual and magnified
3. Erect, virtual and unmagnified
4. Inverted, real and unmagnified

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

$$= \frac{40}{-10-(-4)} = \frac{-40}{6}$$

$$m = -\frac{v}{u} = -\frac{-40}{6 \times (-10)} = \frac{-2}{3}$$

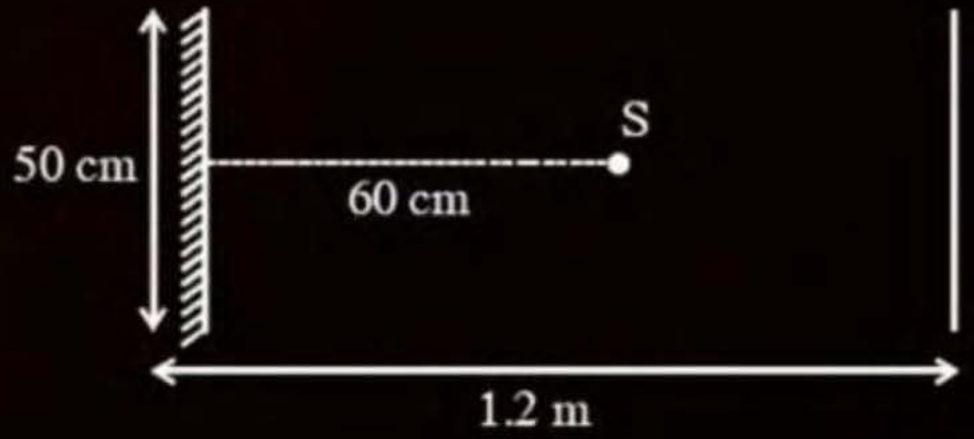
Ans : (4)

QUESTION

Class

A point source of light S, placed at a distance 60 cm in front of the centre of a plane mirror of width 50 cm, hangs vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance 1.2 m from it (see in the figure). The distance between the extreme points where he can see the image of the light source in the mirror is _____ cm.

(JEE Main-2021)



Ans : (150)

QUESTION

The focal length f is related to the radius of curvature r of the spherical convex mirror by:

(JEE Main-2021)

$f = +R/2$

1. $f = +\frac{1}{2}r$
2. $f = -r$
3. $f = -\frac{1}{2}r$
4. $f = r$

Ans : (1)

QUESTION

A short straight object of height 100 cm lies before the central axis of a spherical mirror whose focal length has absolute value $|f| = 40$cm. The image of object produced by the mirror is of height 25 cm and has the same orientation of the object. One may conclude rom the information: **(JEE Main-2021)**

1. Image is real, same side of concave mirror.

2. Image is virtual, opposite side of concave mirror.

3. Image is real, same side of convex mirror.

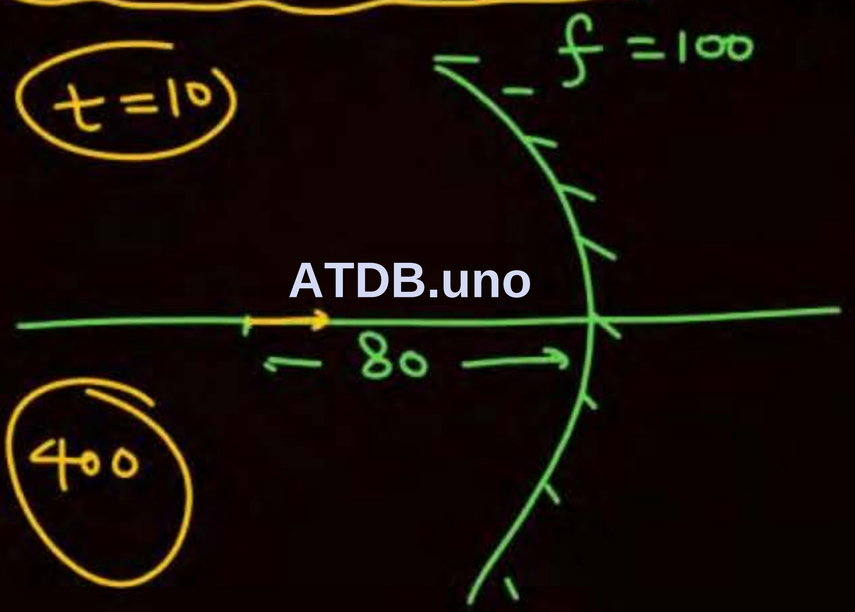
4. Image is virtual, opposite side of convex mirror.

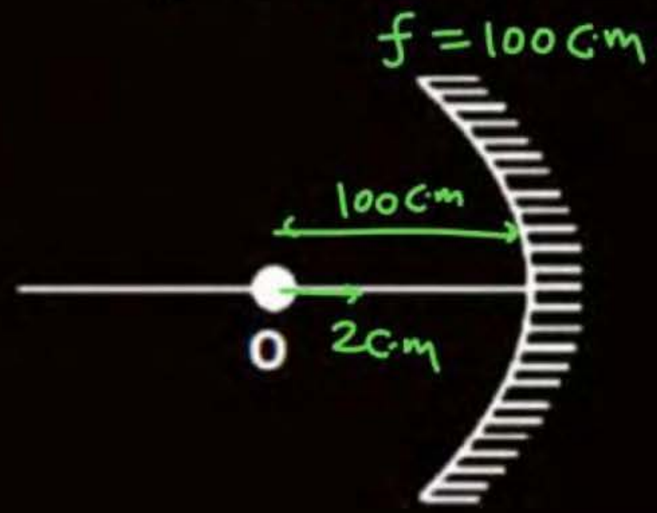
Ans : (4)

QUESTION

An object 'o' is placed at a distance of 100 cm in front of a concave mirror of radius of curvature 200 cm as shown in the figure. The object starts moving towards the mirror at a speed 2 cm/s. The position of the image from the mirror after 10 s is will be at _____ cm.

(JEE Main-2022)



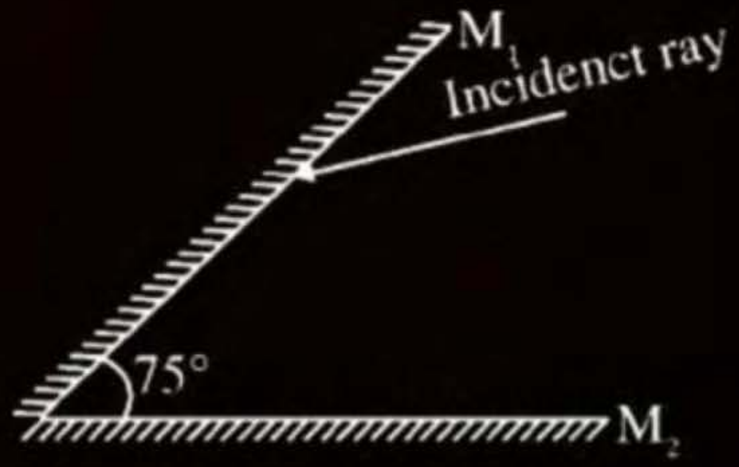


Ans : (400)

QUESTION

A light ray is incident, at an incident angle θ_1, on the system of two plane mirrors M_1 and M_2 having an inclination angle 75° between them (as shown in figure). After reflecting from mirror M_1 it gets reflected back by the mirror M_2 with an angle of reflection 30°. The total deviation of the ray will be _____ degree.

(JEE Main-2022)



Ans : (210)

QUESTION

Two objects A and B are placed at 15 cm and 25 cm from the pole in front of a concave mirror having radius of curvature 40 cm. The distance between images formed by the mirror is:

(01 February 2023 - Shift 2)

1. 40 cm
2. 60 cm
3. 160 cm
4. 100 cm

Ans : (3)

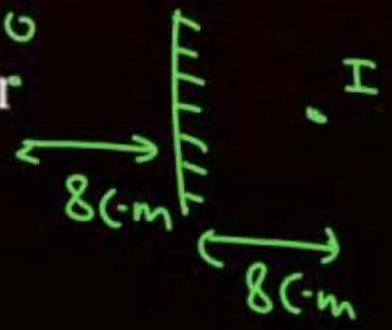
QUESTION

An object is placed at a distance of 12cm in front of a plane mirror. The virtual and erect image is formed by the mirror. Now the mirror is moved by 4 cm towards the stationary object. The distance by which the position of ~~image would be~~ shifted, ~~will be.~~

(10 April 2023 - Shift 1)

1. 4 cm towards mirror
2. 8 cm towards mirror
3. 8 cm away from mirror
4. 2 cm towards mirror

24 - 16



Ans :

QUESTION

When one light ray is reflected from a plane mirror with 30° angle of reflection, the angle of deviation of the ray after reflection is:

(11 April 2023 - Shift 2)

1. 120°
2. 110°
3. 140°
4. 130°

Ans : (1)

(R) An image of a candle on a screen is found to be double its size. When the candle is shifted by a distance of 5 cm, then the image becomes triple its size. Find the nature and radius of curvature of the mirror.

RI, $u<0$

RO $u<0$

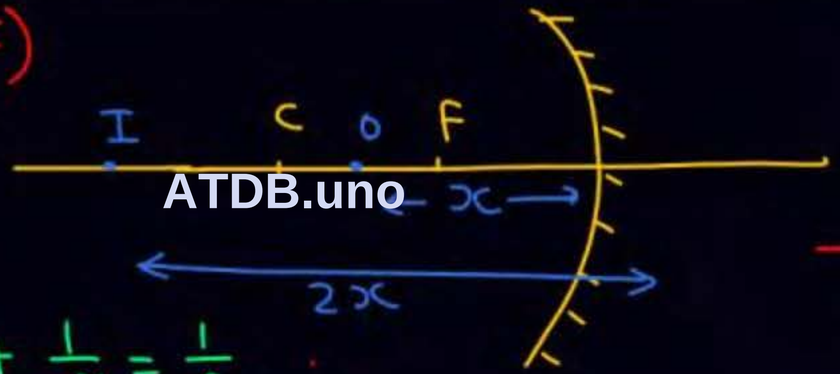
(RO ⟶ RI)

∥

Concave.

$m = -\frac{v}{u} \Rightarrow m<0$

$m = -2$



$u = -(x-5)$

$v = -3(x-5)$

$-\frac{1}{(x-5)} + \frac{1}{-3(x-5)} = \frac{-3}{2x}$

$\frac{4}{3(x-5)} = \frac{3}{2x}$

$8x = 9x - 45$

$x = 45$

$\frac{1}{-2x} + \frac{1}{-x} = \frac{1}{f}$

$\boxed{\frac{-3}{2x} = \frac{1}{f}}$

$x \longrightarrow$ the Dista

$\frac{-3}{2\times 45} = \frac{1}{f}$

$f = -30$

$R = 60$