PRAYAS

JEE 2025

(JEE Adv. PYQ)

Lecture – 14

Physics

Ray oph'cs

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Topics *to be covered*

1. # JEE Advanced PYQs

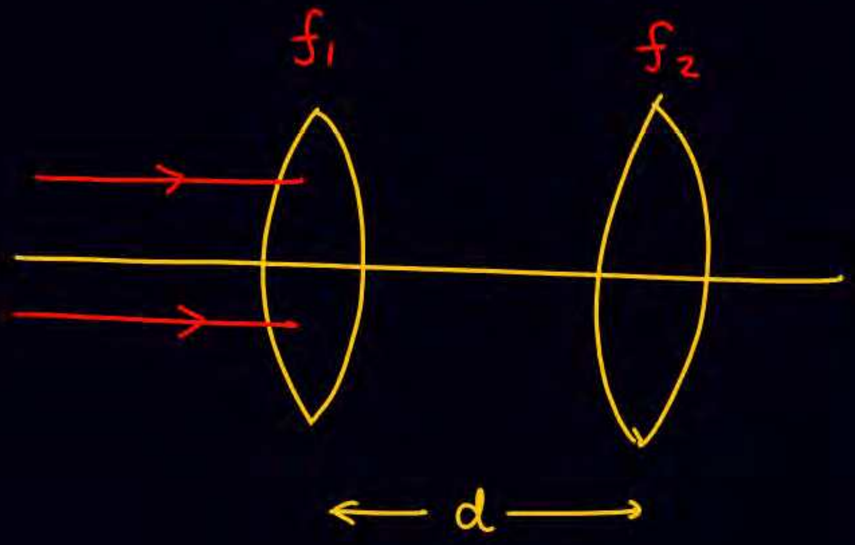
ATDB.uno

2. #

3. #

4. #

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



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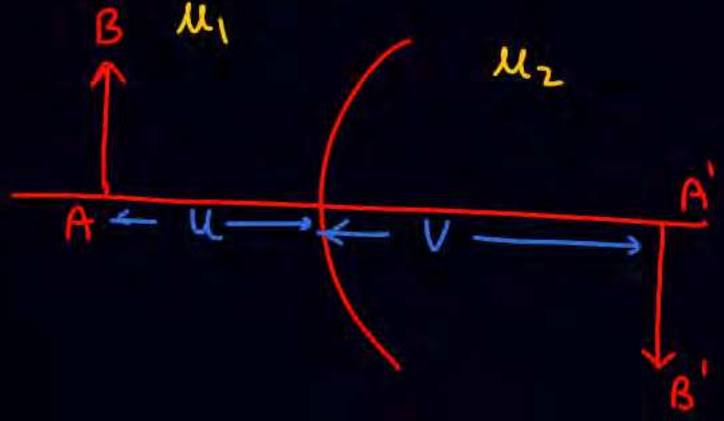
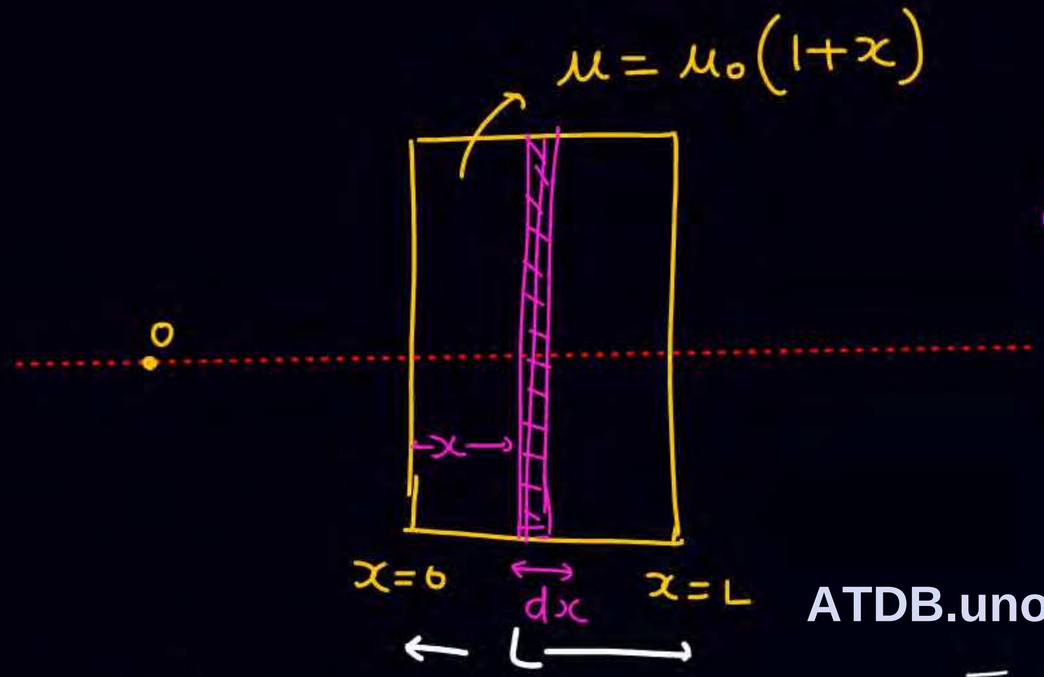


$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$$\text{magnification} = \frac{\text{height of image}}{\text{height of obj}} = \frac{A'B'}{AB} = \frac{V/\mu_2}{u/\mu_1}$$

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

Q



$$d(\text{shift}) = dx\left[1 - \frac{1}{\mu_0(1+x)}\right]$$

$$\text{shift} = \int_0^L dx\left(1 - \frac{1}{(1+x)\mu_0}\right)$$

$$= L - \frac{1}{\mu_0}\ln\left(\frac{1+L}{1}\right)$$

Net shift.

Que. (1)

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

(JEE Adv. 2013)

(a) 30° (b) 45° (c) 60° (d) 75°

angle b/w vectors

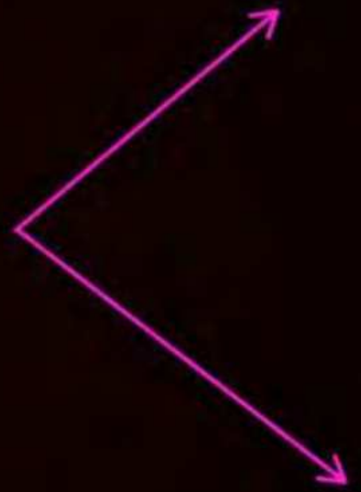
$\delta = 180 - 2i$

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

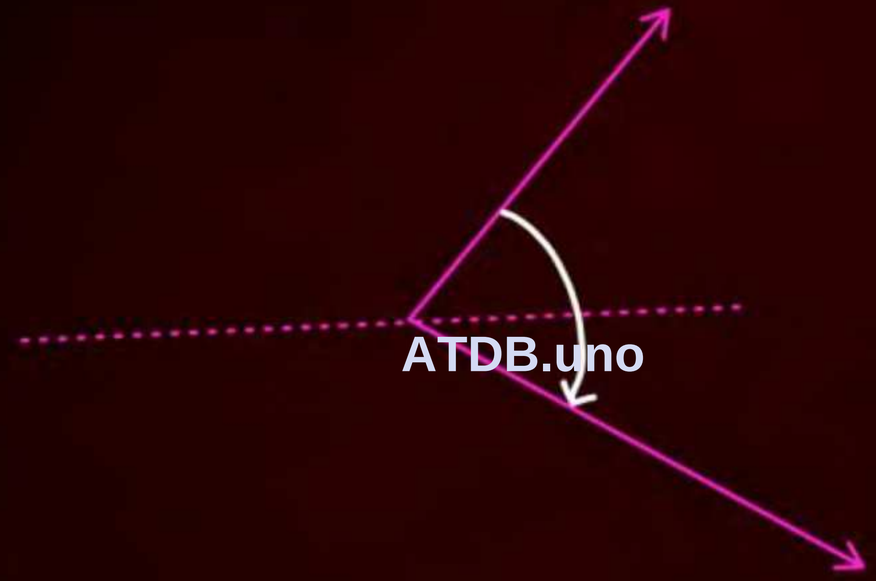
$= \frac{\frac{1}{4}\times(1-3)}{1\times 1}$

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

$\theta = 120°$



Ans : (a)

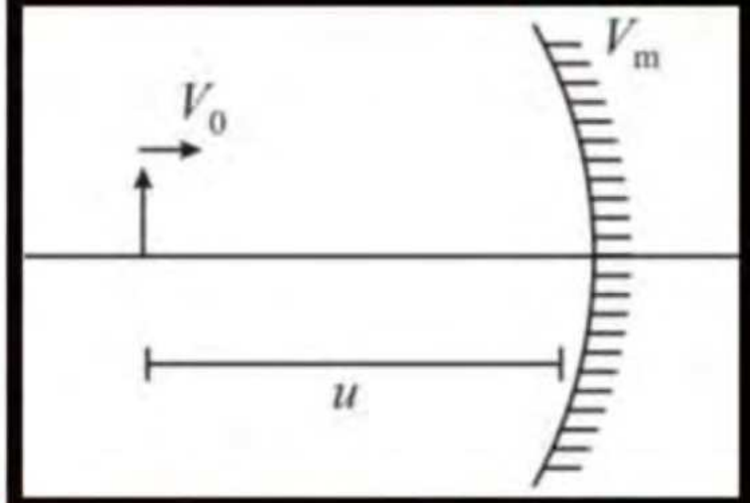


Que. 2

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 ___3___ cms^{-1}.

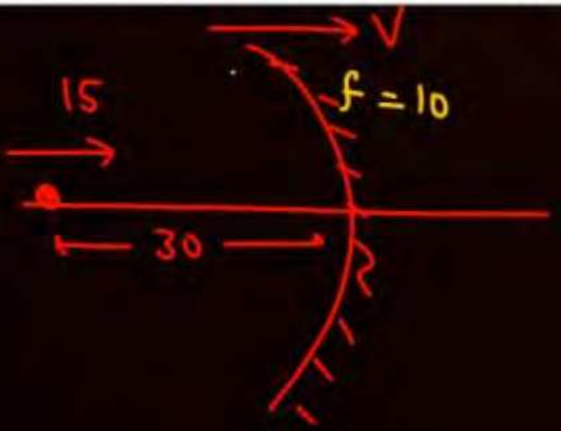
[JEE Adv 2022]

f = 10



$$v = \frac{uf}{u-f} = \frac{300}{-30+10} = -15$$

$$m = -\frac{v}{u} = -\frac{-15}{-30} = -\frac{1}{2}$$



$$V_{I/m} = -m^2 V_{O/m}$$

$$V_I - V_m = -m^2 (V_O - V_m)$$

$$0 - V = -\frac{1}{4}(15 - V)$$

$$V = 3$$

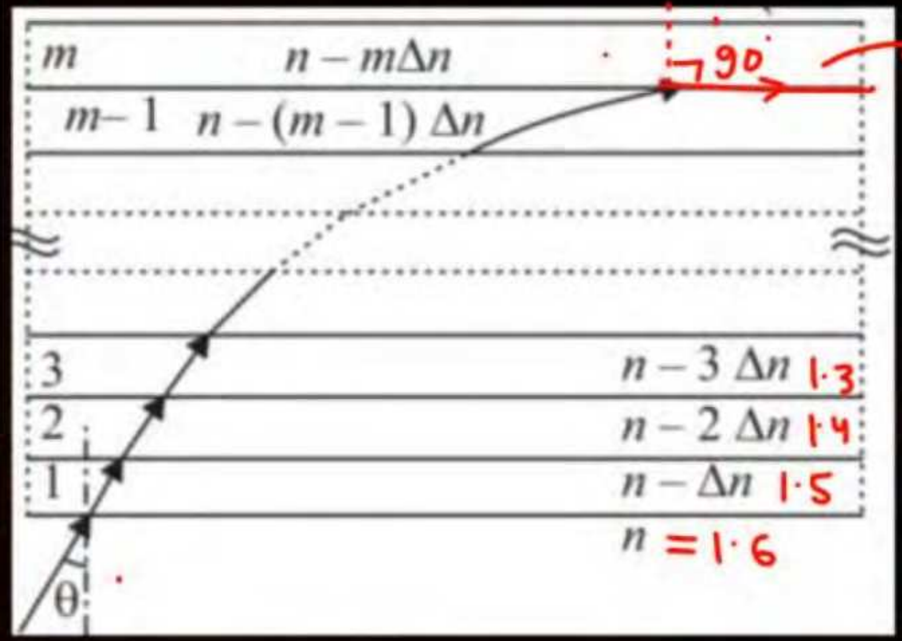
Ans : (3)

Que.

A monochromatic light is travelling in a medium of refractive index $n = 1.6$. It enters a stack of glass layers from the bottom side at an angle $\theta = 30°$. The interfaces of the glass layers are parallel to each other. The refractive indices of different glass layers are monotonically decreasing as $nm = n - m\Delta n$, where $n - m$ is the refractive index of the m^{th} slab and $\Delta n = 0.1$ (see the figure). The ray is refracted out parallel to the interface between the $(m-1)^{th}$ and m^{th} slabs from the right side of the stack. What is the value of m?

(JEE Adv. 2017)

(a) 8 (b) 9 (c) 10 (d) 11



$1.6 \sin 30 = \mu \sin 90$

$\mu = .8$

Ans : (a)

Que.

A point source S is placed at the bottom of a transparent block of height 10mm and refractive index 2.72.

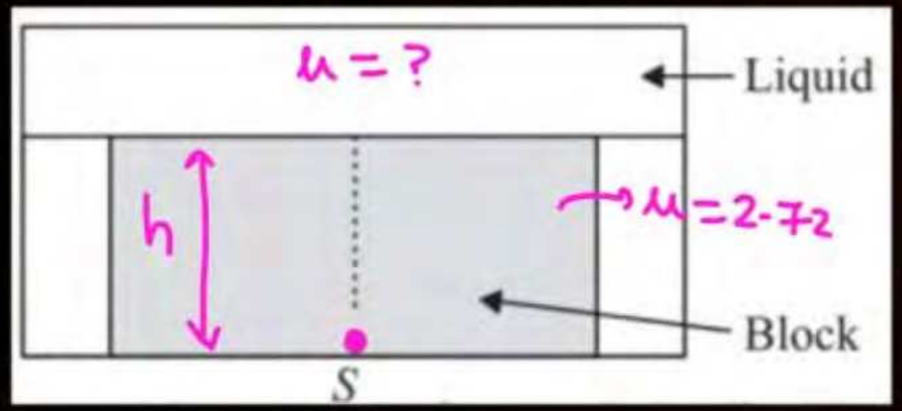
It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54mm on the top of the block. The refractive index of the liquid is

$\mu = 5.77$

(JEE Adv. 2014)

(a) 1.21 (b) 1.30 (c) 1.36 (d) 1.42

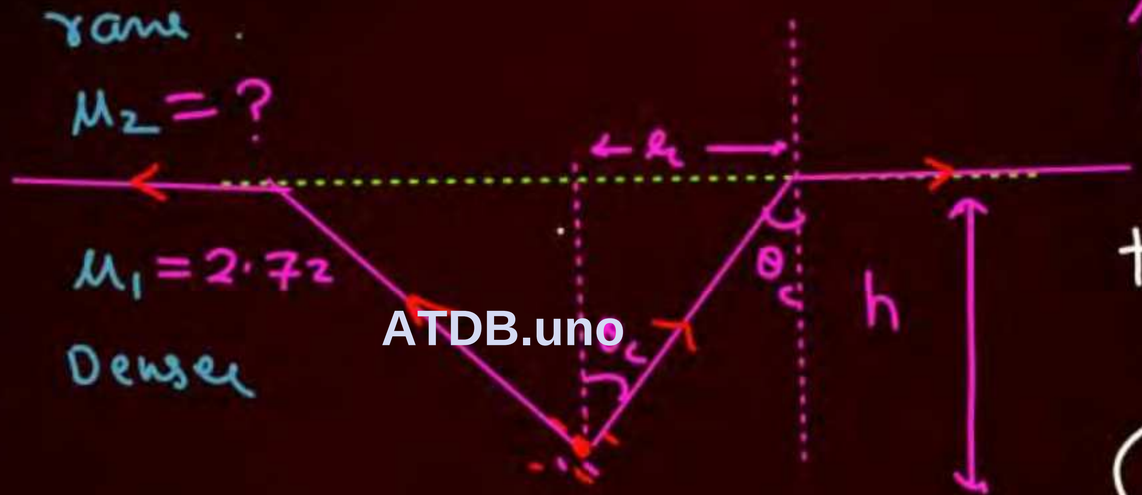
$\sin 30^\circ = \frac{\mu_{oil}}{\mu_{block}}$



Ans : (c)

$$\sin\theta_c = \frac{\mu_2}{\mu_1}$$

$$\tan\theta_c = \frac{R}{h}$$



rare

$\mu_2 = ?$

$\mu_1 = 2.72$

Denser

$R = 5.77$

$h = 10$

$$\tan\theta = \frac{R}{h} = .577$$

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

$\theta = 30^\circ$

Sol.

Correct Answer - C

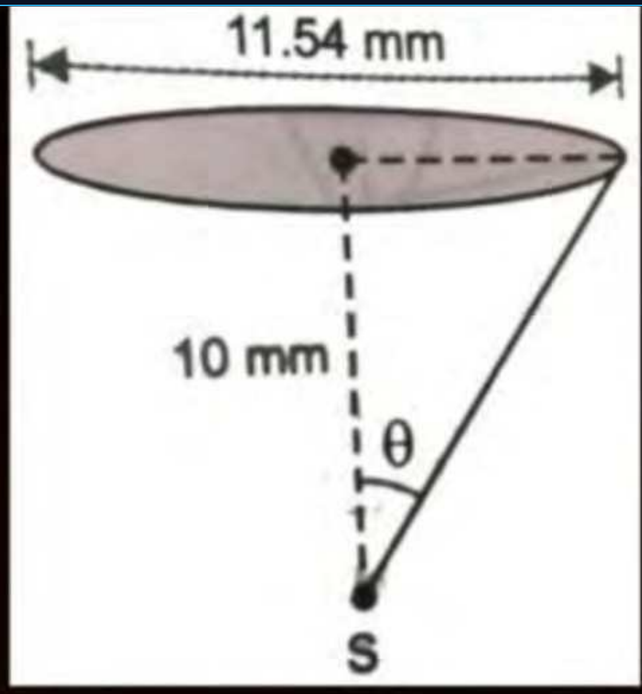
If θ critical angle between the pair of media in contact, then from Fig.

$$\tan\theta = \frac{11.54/2}{10} = \frac{5.77}{10} = 0.577$$

$$\therefore \theta = 30^\circ$$

$$\text{Now } {}^{.1}\mu_2 = \frac{1}{\sin\theta} = \frac{2.72}{\mu} = \frac{1}{\sin 30^\circ} = 2$$

$$2\mu = 2.72, \mu = 1.36$$



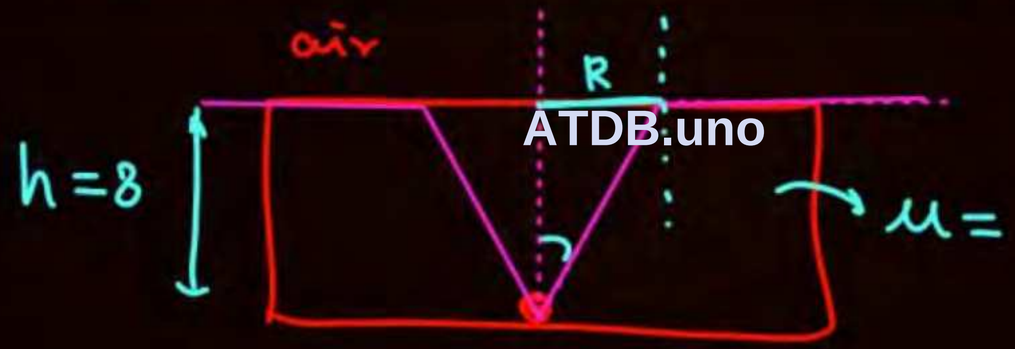
Que.

H/W E

A large glass slab ($\mu = 5/3$) of thickness 8 cm is placed over a point source of light on a plane surface. It is seen that light emerges out of the top surface of the slab from a circular area of radius R cm. What is the value of R? **(IIIT-JEE 2010)**

(a) 6 cm (b) 7 cm (c) 8 cm (d) 9 cm

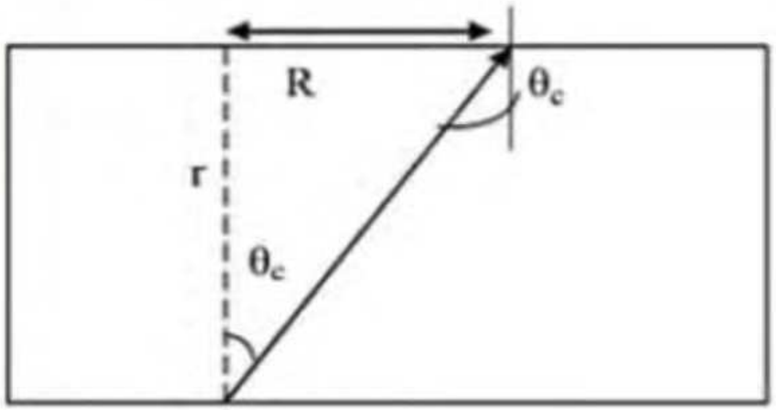
$\frac{R}{h} = \frac{3}{4}$



Ans : (a)

Sol.

$(R/t) = \tan \theta c$ or $R = t(\tan \theta c)$



But $\sin \theta_c = 1/\mu = 3/5$

$\tan \theta c = 3/4$ so $R = 3/4\ t = 3/4\ (8cm) = 6\ cm$

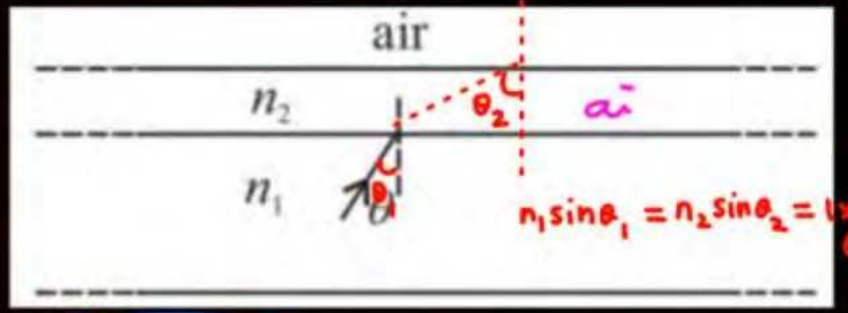
Hence the answer is 6.

Que.

$n_1 \sin\theta_1 = n_2 \sin\theta_2 = 1 \times \sin\theta_{air}$

A wide slab consisting of two media of refractive indices n_1 and n_2 is placed in air as shown in the figure. A ray of light is incident from medium n_1 to n_2 at an angle θ, where $\sin\theta$ is slightly larger than $\frac{1}{n_1}$. Take refractive index of air as 1 . Which of the following statement(s) is/are correct? **(JEE Adv. 2021)**

$n_1 \sin\theta_1 = 1 \times \sin\theta_{air} \Rightarrow \sin\theta_{air} > 1$



(a) The light ray enters air if $n_2 = n_1$ (TIR)

(b) The light ray is finally reflected back into the medium of refractive index n_1 if $n_2 < n_1$

(c) The light ray is finally reflected back into the medium of refractive index n_1; if $n_2 > n_1$

(d) The light ray is reflected back into the medium of refractive index n_1 if $n_2 = 1$

$\sin\theta > \frac{1}{n_1}$

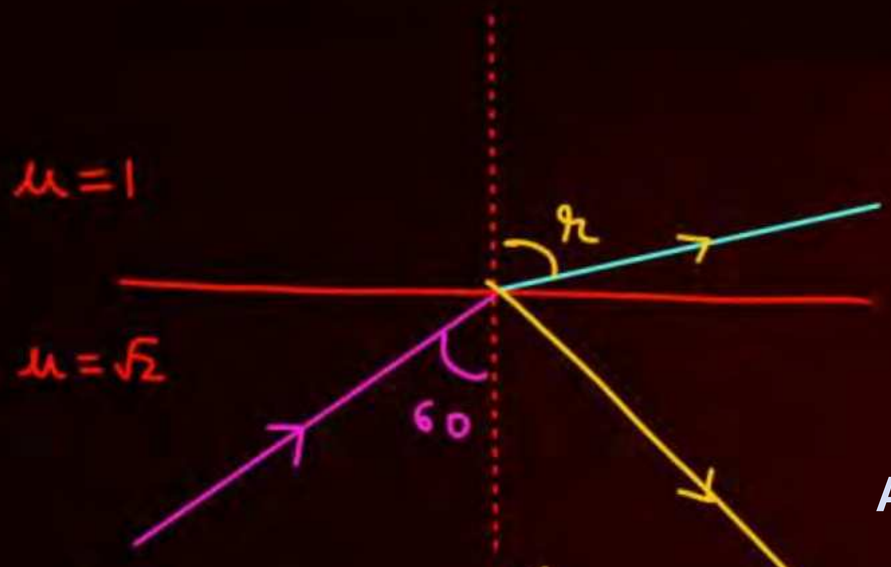
① $n_1 = n_2 = n$, $\theta_1 = \theta_2 = \theta$ $\quad n \sin\theta = \sin\theta_{air}$

$\sin\theta_1 > \frac{1}{n_1}$

$n_1 \sin\theta_1 = 1 \times \sin\theta_{air}$

Ans : (b, c, d)

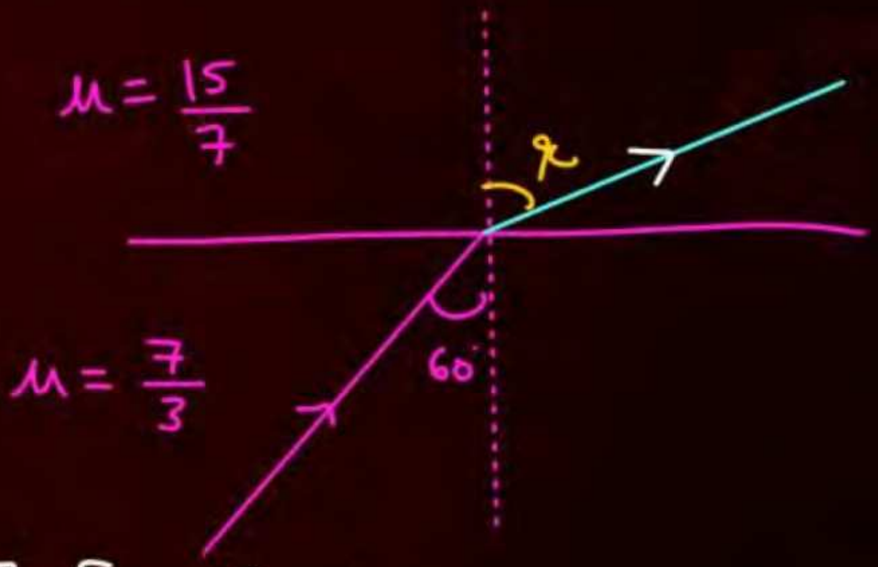
$$\frac{86 \times 1.73}{100 \times 2} = 8.65$$



$$\sqrt{2}\sin 60 = 1 \times \sin r$$

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

$$\sin r = \frac{\sqrt{3}}{\sqrt{2}} = \frac{1.73}{1.41} > 1$$



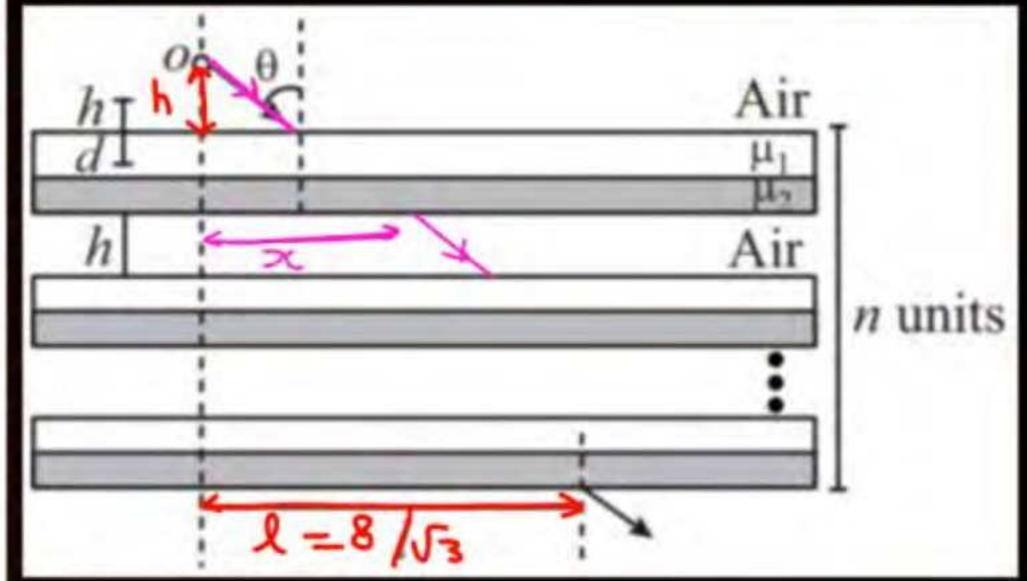
$$\frac{7}{3} \cdot \frac{\sqrt{3}}{2} = \frac{15}{7} \sin r$$

$$\frac{49\sqrt{3}}{90} = \frac{86.2}{90} = \sin r$$

Que.

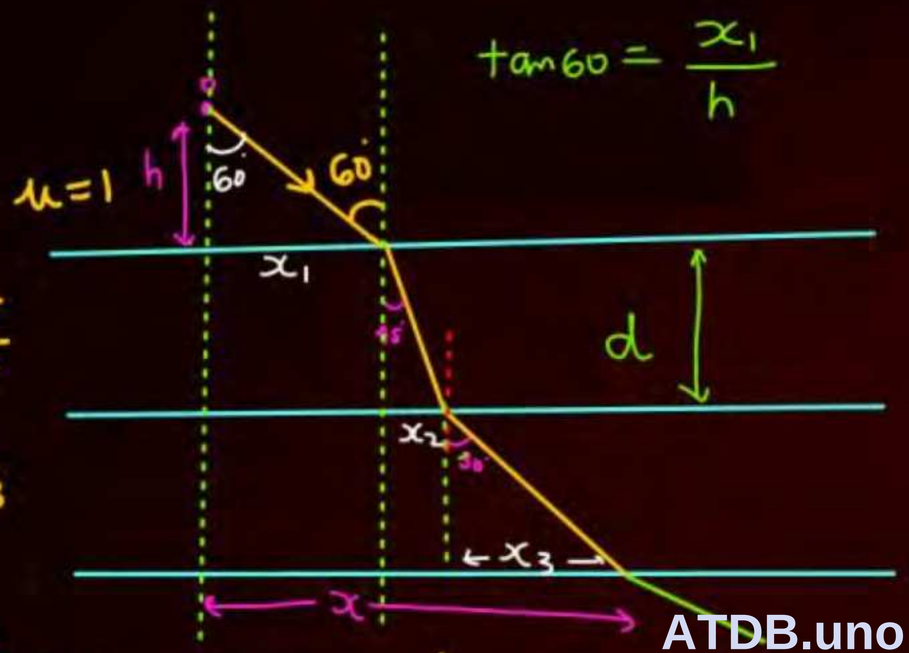
Consider a configuration of n identical units, each consisting of three layers. The first layer is a column of air of height $h = \frac{1}{3}$ cm, and the second and third layers are of equal thickness $d = \frac{\sqrt{3}-1}{2}$ cm, and refractive indices $\mu_1 = \sqrt{\frac{3}{2}}$ and $\mu_2 = \sqrt{3}$, respectively. A light source O is placed on the top of the first unit, as shown in the figure. A ray of light from O is incident on the second layer of the first unit at an angle of $\theta = 60°$ to the normal. For a specific value of n, the ray of light emerges from the bottom of the configuration at a distance $l = \frac{8}{\sqrt{3}}$ cm, as shown in the figure. The value of n is _____.

(JEE Adv. 2022)



$nx = \frac{8}{\sqrt{3}}$

Ans : (4)



$$\tan 60 = \frac{x_1}{h}$$

$$1 \times \frac{\sqrt{3}}{2} = \sqrt{\frac{3}{2}} \sin\theta_1 = \sqrt{3} \sin\theta_2$$

$$\theta_1 = 45$$

$$\theta_2 = 30$$

$$\tan 30 = \frac{x_3}{d}$$

$$x = x_1 + x_2 + x_3$$

$$= h\sqrt{3} + d + \frac{d}{\sqrt{3}}$$

Sol.

$$1\sin 60^\circ = \frac{\sqrt{3}}{2} r$$

$$r = 45^\circ$$

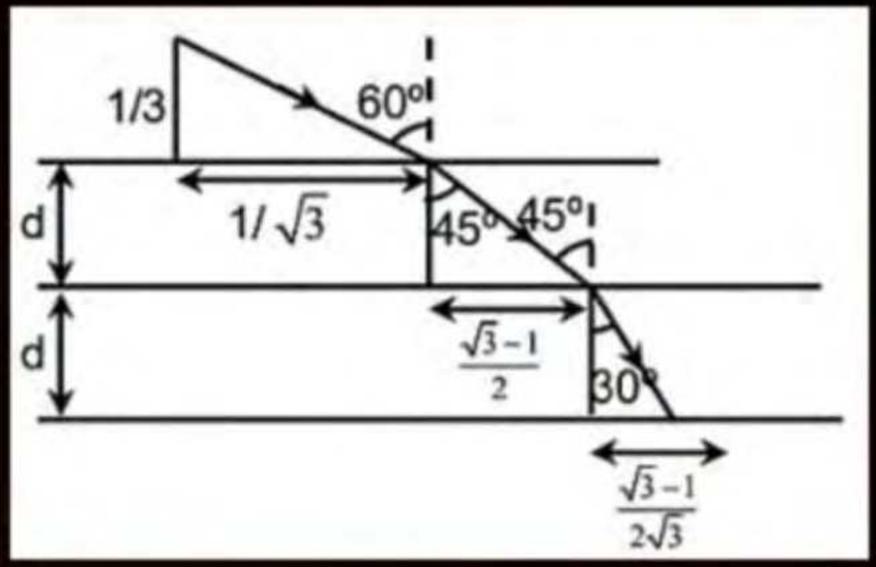
$$\frac{\sqrt{3}}{2}\sin 45^\circ = \sqrt{3}\sin r_2$$

$$r_2 = 30^\circ$$

$$\left(\frac{1}{\sqrt{3}} + \frac{(\sqrt{3}-1)}{2} + \frac{(\sqrt{3}-1)}{2\sqrt{3}}\right) \times n$$

$$= \frac{8}{\sqrt{3}}$$

$$n = 4.$$



ATDB.uno

Passage from next two Question

Passage Most materials have the refractive index, $n > 1$. So, when a light ray from air enters a naturally occurring material, then by Snell's law, $(\sin\theta_1)/(\sin\theta_2) = n_2/n_1$, it is understood that the refracted ray bends towards the normal. But it never emerges on the same side of the normal as the incident ray. According to electromagnetism, the refractive index of the medium is given by the relation, $n = (c/v) = \pm\sqrt{(\varepsilon r \mu r)}$, where c is the speed of electromagnetic waves in vacuum, v its speed in the medium, ε_r and μ_r are the relative In normal materials, both ε_r and μ_r are positive, implying positive n for the medium. When both ε_r and μ_r are negative, one must choose the negative root of n. Such negative refractive index materials can now be artificially prepared and are called meta-materials. They exhibit significantly different optical behaviour, without violating any physical laws. Since n is negative, it results in a change in the direction of propagation of the refracted light. However, similar to normal materials, the frequency of light remains unchanged upon refraction even in meta-materials.

(IIT-JEE 2012)

Que.

Choose the correct statement.

(*a*) The speed of light in the meta-material is $v = c|n|$

(*b*) The speed of light in the meta-material is $v = c/|n|$

(*c*) The speed of light in the meta-material is $v = c$

(*d*) The wavelength of the light in the meta-material (λ_m) is given by $\lambda_m = \lambda_{air}|n|$, where λ_{air} is the wavelength of the light in air. Incorrect

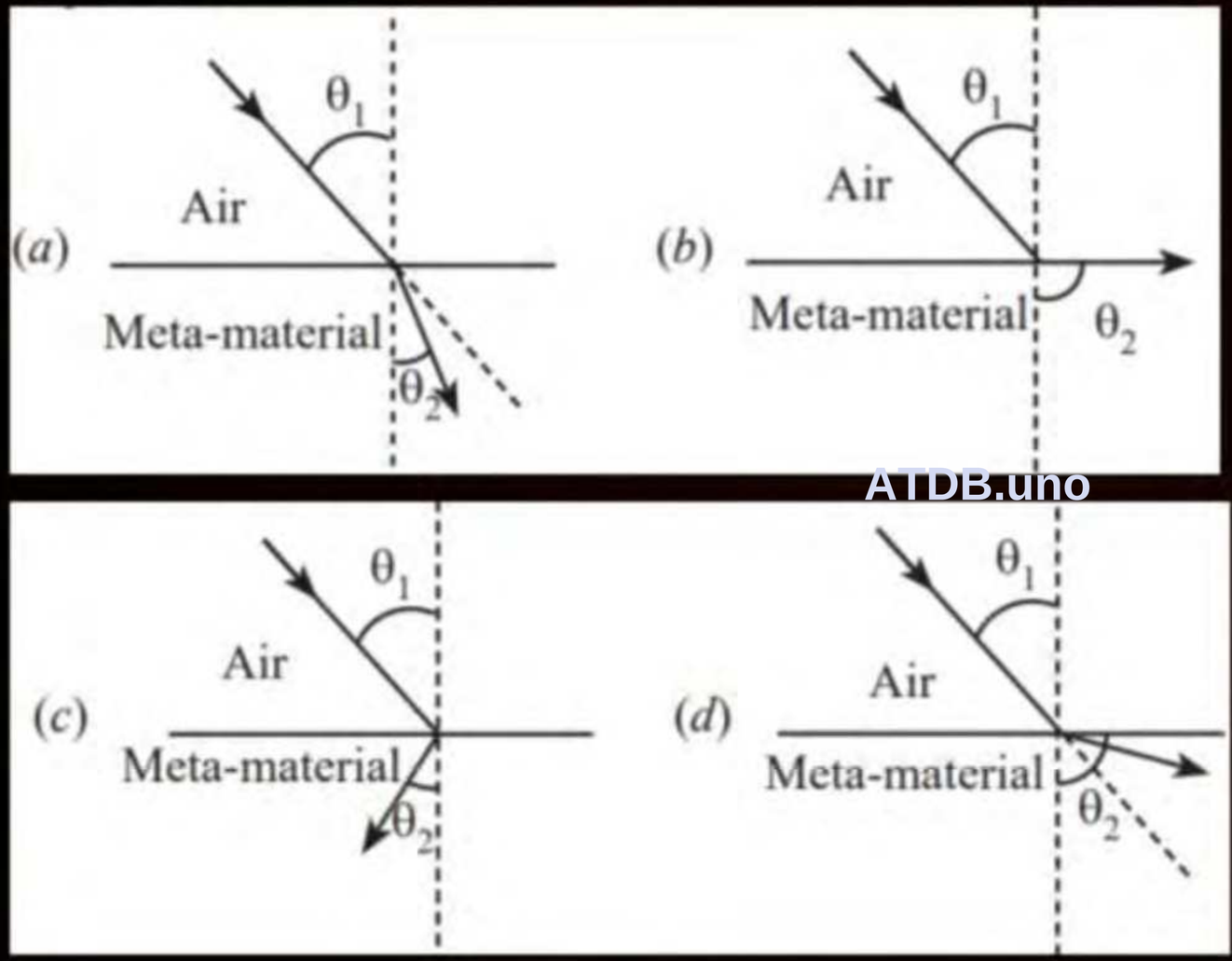
Ans : (b)

Sol.

Speed of light in mata-material is given by the same formula $v = c/n$. As n for meta material negative, we write $v = c/|n|$.

Que.

For light incident from air on a meta-material, the appropriate ray diagram is



Ans : (c)

Sol.

For meta-material, the refractive index is negative. Let n_1 is refractive index of air and n_2 is refractive index of meta-material.

$\therefore$ From Snell's law, $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$

Since, n_2 is negative, therefore θ_2 is also negative. Hence, appropriate diagram (c) is correct.

Que.

Passage The figure shows a surface XY separating two transparent media, medium-1 and medium-2. The lines ab and cd represent wavefronts of a light wave travelling in medium-1 and incident on XY. The lines ef and gh represent wavefronts of the light wave in medium-2 after refraction.

(IIT-JEE 2007)

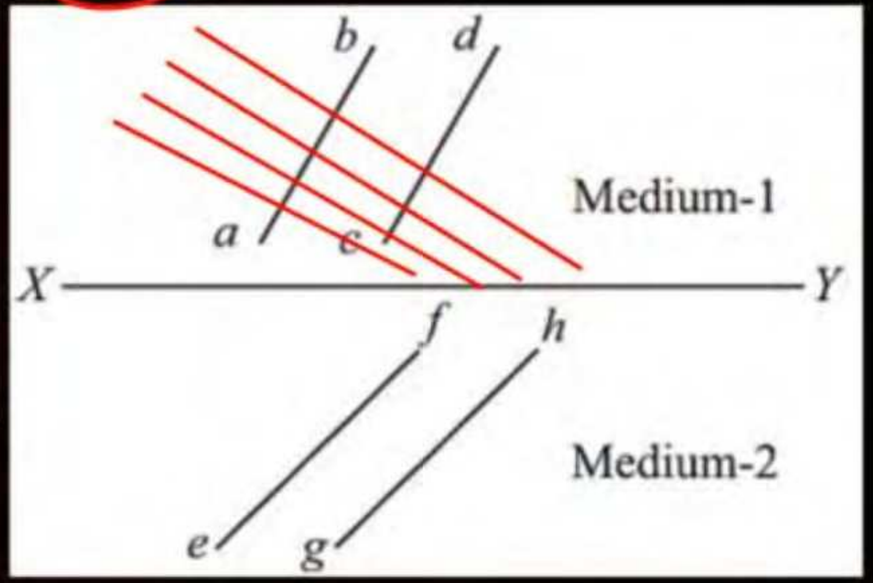
Light travels as a

(a) parallel beam in each medium

(b) convergent beam in each medium

(c) divergent beam in each medium

(d) divergent beam in one medium and convergent beam in the other medium



Ans : (a)

Que.

Passage The figure shows a surface XY separating two transparent media, medium-1 and medium-2. The lines ab and cd represent wavefronts of a light wave travelling in medium-1 and incident on XY. The lines ef and gh represent wavefronts of the light wave in medium-2 after refraction.

(IIT-JEE 2007)

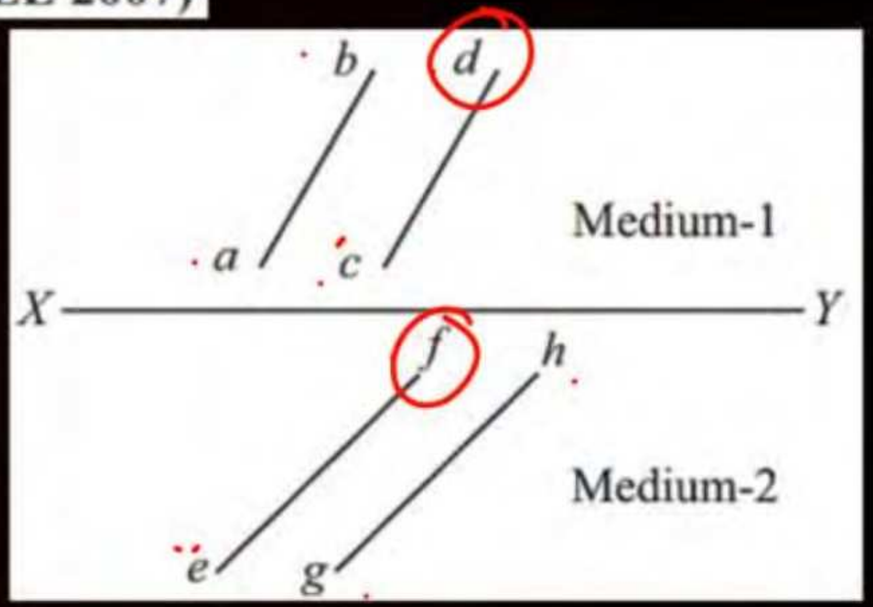
The phases of the light wave at c, d ,e and f are ϕ_c, ϕ_d, ϕ_e, and ϕ_f respectively. It is given that $\phi_c \neq \phi_f$

(a) ϕ_c cannot be equal to ϕ_d

(b) ϕ_d can be equal to ϕ_e

(c) $(\phi_d - \phi_f)$ is equal to $(\phi_c - \phi_e)$

(d) $(\phi_d - \phi_c)$ is not equal to $(\phi_f - \phi_e)$



Ans : (c)

Que.

Passage The figure shows a surface XY separating two transparent media, medium-1 and medium-2. The lines ab and cd represent wavefronts of a light wave travelling in medium-1 and incident on XY. The lines ef and gh represent wavefronts of the light wave in medium-2 after refraction.

(IIT-JEE 2007)

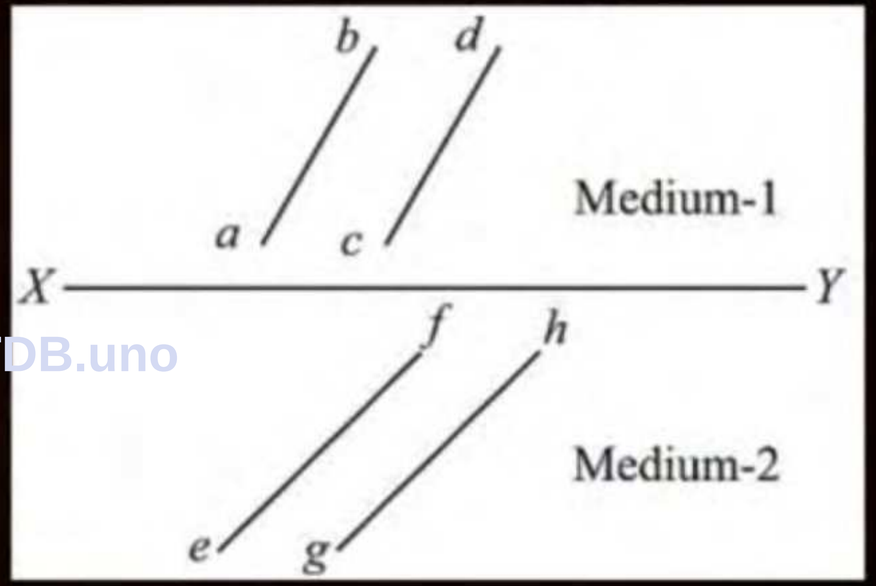
Speed of light is

(a) the same in medium-1 and medium-2

(b) larger in medium-1 than in medium-2

(c) larger in medium-2 than in medium-1

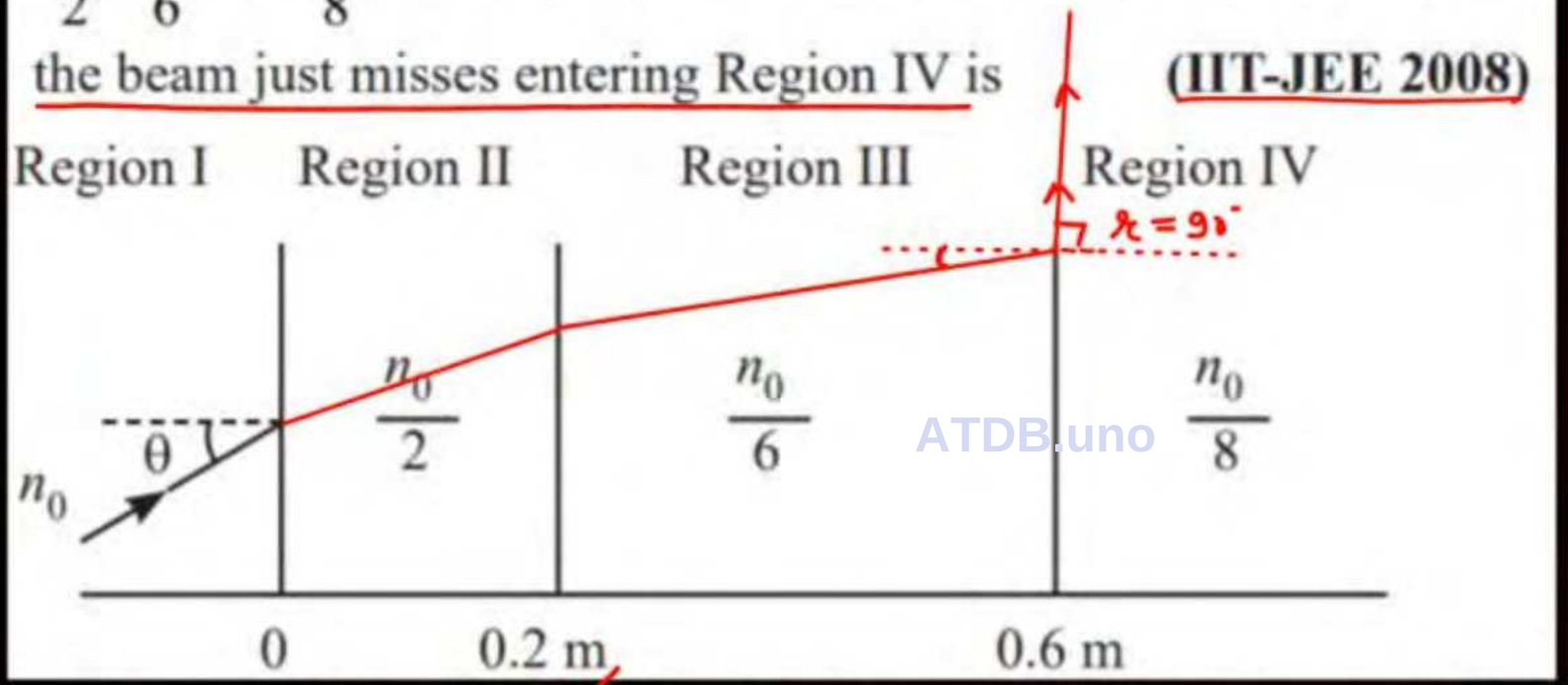
(d) different at b and d



Ans : (b)

Que.

A light beam is travelling from Region I to Region IV (Refer Figure). The refractive index in Regions I, II, III and IV are n_0, $\frac{n_0}{2}$, $\frac{n_0}{6}$ and $\frac{n_0}{8}$ respectively. The angle of incidence θ for which the beam just misses entering Region IV is **(IIT-JEE 2008)**



$n_0 \sin\theta = \frac{n_0}{8} \sin 90^\circ$

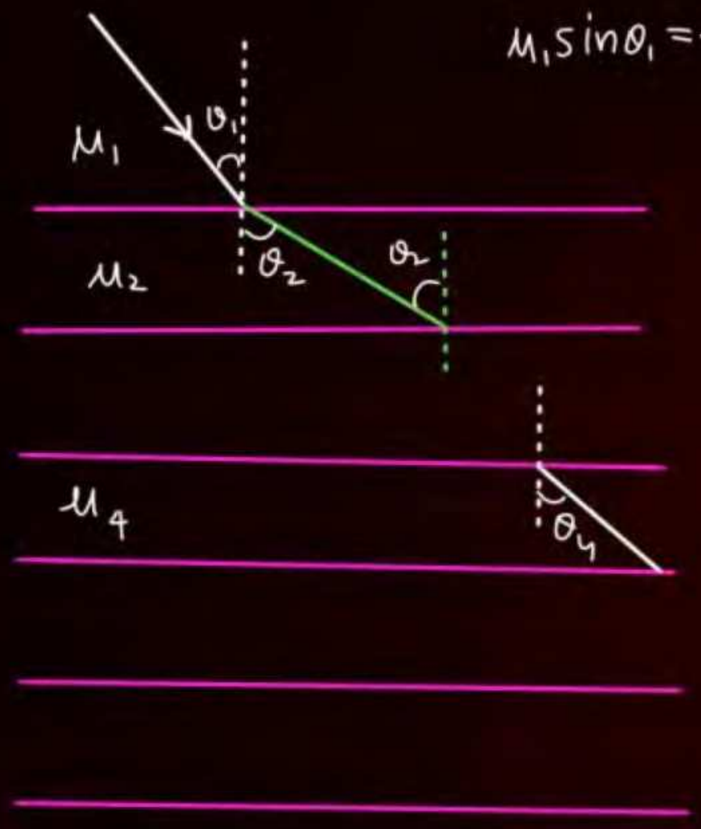
$r = 90^\circ$

(a) $\sin^{-1}(3/4)$ (b) $\sin^{-1}(1/8)$ (c) $\sin^{-1}(1/4)$ (d) $\sin^{-1}(1/3)$

Ans : (b)

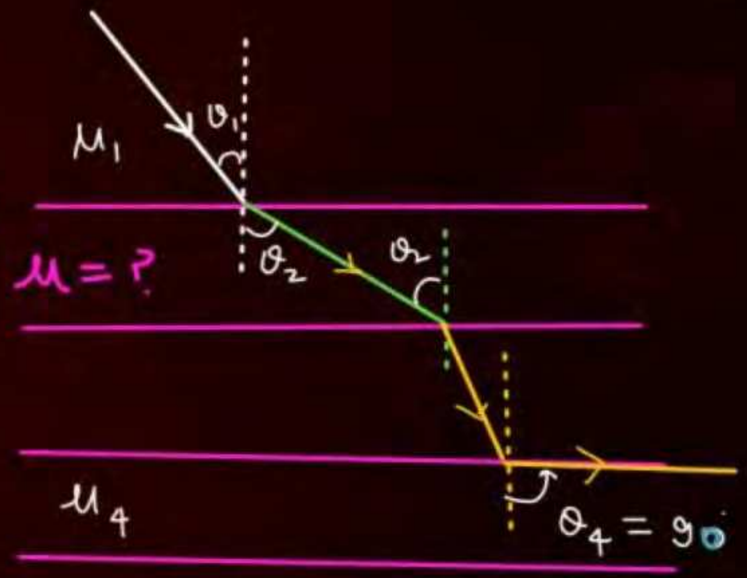
Copy

$\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2 = \cdots$



$\mu_1 \sin\theta = \mu_4 \sin 90^\circ$

ATDB.uno



Que.

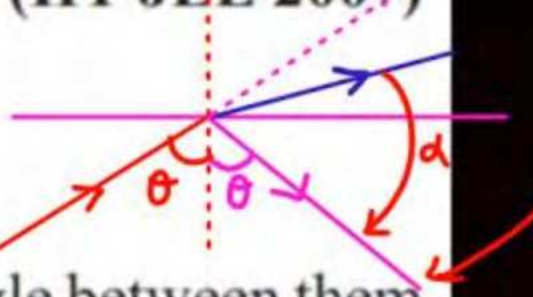
A ray of light travelling in water is incident on its surface open to air. The angle of incidence is θ, which is less than the critical angle. Then there will be **(IIT-JEE 2007)**

(a) only a reflected ray and no refracted ray

(b) only a refracted ray and no reflected ray

(c) a reflected ray and a refracted ray and the angle between them would be less than $180°-2\theta$

(d) a reflected ray and a refracted ray and the angle between them would be greater than $180° - 2\theta°$ Incorrect



$180-2\theta$

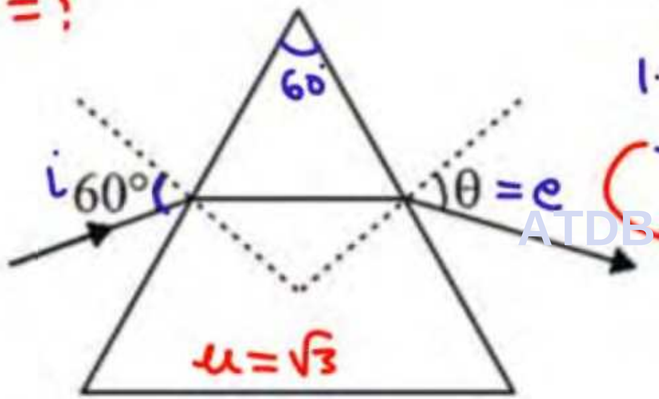
$180-2\theta > \alpha$

Ans : (c)

Que.

A monochromatic beam of light is incident at 60° on one face of an equilateral prism of refractive index n and emerges from the opposite face making an angle $\theta(n)$ with the normal (see figure). For $n = \sqrt{3}$ the value of $\theta(n)$ is 60° and $\frac{d\theta}{dn} = m$. The value of m is

(JEE Adv. 2015)



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

$e = \theta, \quad \mu = n$

e और μ के बीच Relation

$$\frac{de}{d\mu} = \frac{d\theta}{dn} \Big|_{\text{at } \theta = 60^\circ,\ \mu = \sqrt{3}}$$

$\theta \longrightarrow y \qquad \frac{dy}{dx} = ?$

$n \longrightarrow x$

$1 \cdot \sin i = \mu \sin r_1$

$\mu \sin(60 - r_1) = 1 \times \sin e$

$\mu\left(\frac{\sqrt{3}}{2}\cos r_1 - \frac{1}{2}\sin r_1\right) = \sin e$

$\frac{\sqrt{3}}{2}\mu\cos r_1 - \frac{\mu}{2}\sin r_1 = \sin e$

$\frac{\sqrt{3}}{2}\mu\cos r - \frac{1}{2}\sin i = \sin e$

↳ diff wrt μ

Ans : (a)

Que.

For an isosceles prism of angle A and refractive index μ, it is found that the angle of minimum deviation $\delta_m = A$. Which of the following options is/are correct?

(JEE Adv. 2017)

(*a*) For the angle of incidence $i_1 = A$, the ray inside the prism is parallel to the base of the prism

(*b*) For this prism, the refractive index μ and the angle prism A are related as $A = \frac{1}{2}\cos^{-1}\left(\frac{\mu}{2}\right)$

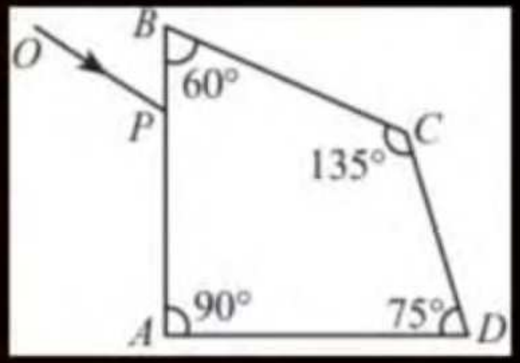
(*c*) For this prism, the emergent ray at the second surface will be tangential to the surface when the angle of incidence at the first surface is $\sin^{-1}\left[\sin A\sqrt{4\cos^2\frac{A}{2}-1}-\cos A\right]$

(*d*) At minimum deviation, the incident angle i_1 and the refracting angle r_1 at the first refracting surface are related by $r_i = (i_1/2)$

Ans : (a, c, d)

Que.

A ray OP of monochromatic light is incident on the face AB of prism $ABCD$ near vertex B at an incident angle of $60°$ (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is/are correct? **(IIT-JEE 2010)**



(a) The ray gets totally internally reflected at face CD

(b) The ray comes out through face AD

(c) The angle between the incident ray and the emergent ray is $90°$

(d) The angle between the incident ray and the emergent ray is $120°$

Ans : (a, b, c)

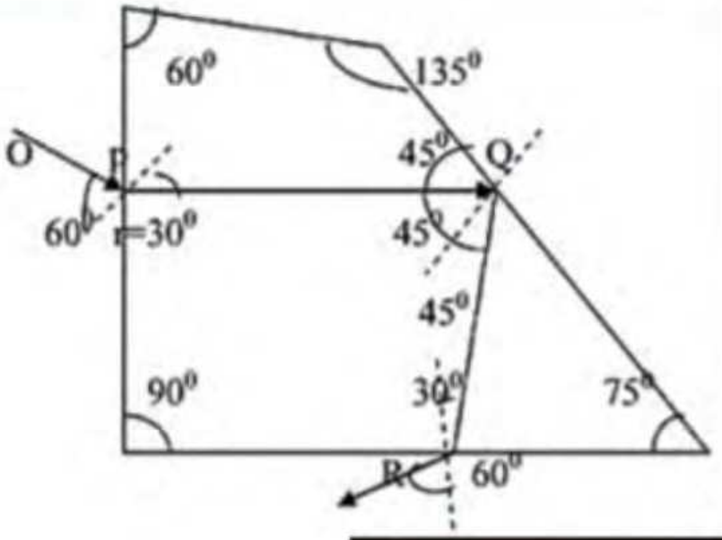
Sol.

$\sqrt{3} = \sin 60°/ \sin r$

so $r=30°$

$\theta_C = \sin^{-1}(1/\sqrt{3})$

$\sin \theta_C = 1/\sqrt{3} = 0.577$



At point Q, angle of incidence inside the prism is $i = 45°$

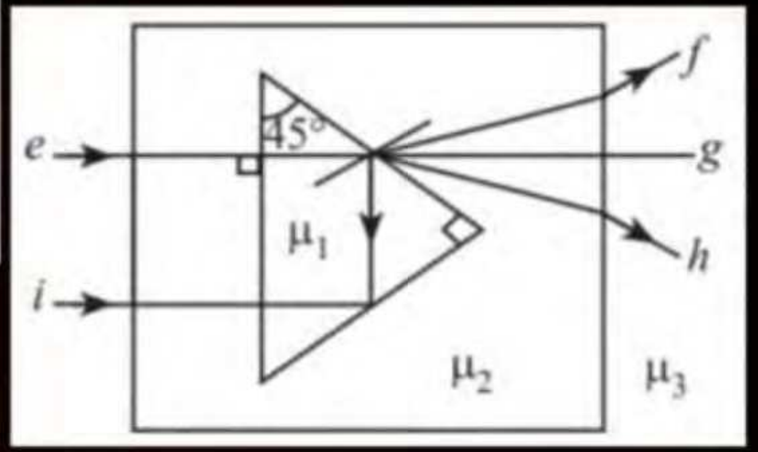
Since $\sin i = 1/\sqrt{2}$ is greater than $\sin \theta_C = 1/\sqrt{2}$, Ray gets totally internally reflected at face CD. Path of ray of light after point Q is shown in figure

From the figure, we can see that angle between incident ray OP and emergent ray RS is 90° therefore, correct options are (a), (b) and (c).

Que.

A right angled prism of refractive index μ_1 is placed in a rectangular block of refractive index μ_2, which is surrounded by a medium of refractive index μ_3, as shown in the figure, A ray of light 'e' enters the rectangular block at normal incidence. Depending upon the relationships between μ_1, μ_2 and μ_3, it takes one of the four possible paths 'e_f', 'e_g', 'e_h' or 'e_i'.

(JEE Adv. 2013)



Match the paths in Column-I with conditions of refractive indices in Column-II and select the correct answer using the codes given below the lists.

Column-I	Column-II
P. e to f	1. $\mu_1 > \sqrt{2}\,\mu_2$
Q. e to g	2. $\mu_2 > \mu_1$ and $\mu_2 > \mu_3$
R. e to h	3. $\mu_1 = \mu_2$
S. e to i	4. $\mu_2 < \mu_1 < \sqrt{2}\,\mu_2$ and $\mu_2 > \mu_3$

Codes:

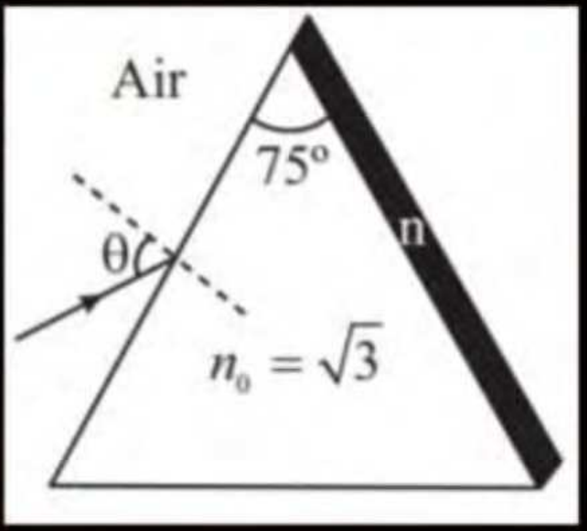
	P	Q	R	S
(a)	2	3	1	4
(b)	1	2	4	3
(c)	4	1	2	3
(d)	2	3	4	1

Ans : (d)

Que. A monochromatic light is incident from air on a refracting surface of a prism of angle 75° and refractive index $n_0 = \sqrt{3}$. The other refracting surface of a prism is coated by a thin film of material of refractive index n as shown in figure. The light suffers total internal reflection at the coated prism surface for an incidence angle of $\theta \leq 60^\circ$.

The value of n^2 is_____.

(JEE Adv. 2019)

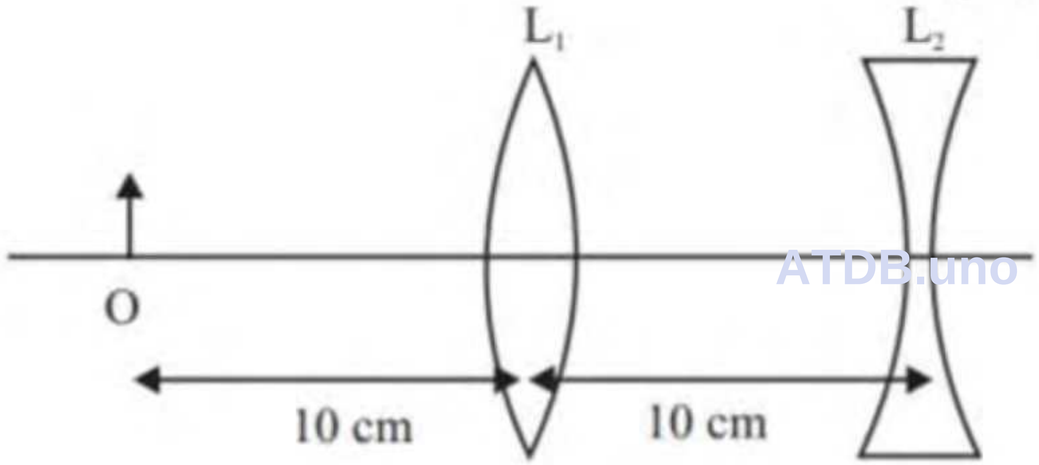


Ans : (1.50)

Que.

An extended object is placed at point O, 10 cm in front of a convex lens L_1 and a concave lens L_2 is placed 10 cm behind it, as shown in the figure. The radii of curvature of all the curved surfaces in both the lenses are 20 cm. The refractive index of both the lenses is 1.5. The total magnification of this lens system is

(JEE Adv. 2022)



(a) 0.4 (b) 0.8 (c) 1.3 (d) 1.6

Ans : (b)

Sol.

$$\frac{1}{f_1} = (1.5 - 1)\left(\frac{1}{20} + \frac{1}{20}\right) = \frac{1}{20}$$

$$\frac{1}{f_2} = (1.5 - 1)\left(-\frac{1}{20} - \frac{1}{20}\right) = -\frac{1}{20}$$

So, $\frac{1}{v} - \frac{1}{-10} = \frac{1}{20}$

So, $v = -20\,cm$

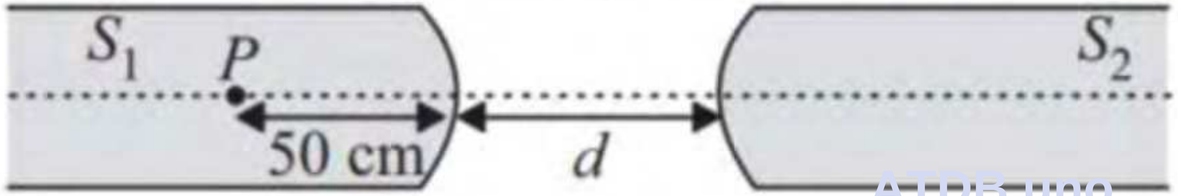
and $\frac{1}{v'} - \frac{1}{-30} = \frac{1}{-20}$

So, $v' = -12\,cm$

So total magnification $= \left(\frac{-20}{-10}\right)\left(\frac{-12}{-30}\right) = 0.8$

Que.

Two identical glass rods S_1 and S_2 (refractive index = 1.5) have one convex end of radius of curvature 10 cm. They are placed with the curved surfaces at a distance d as shown in the figure, with their axes (shown by the dashed line) aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emanating from it are found to be parallel to the axis inside S_2. The distance d is **(JEE Adv. 2015)**

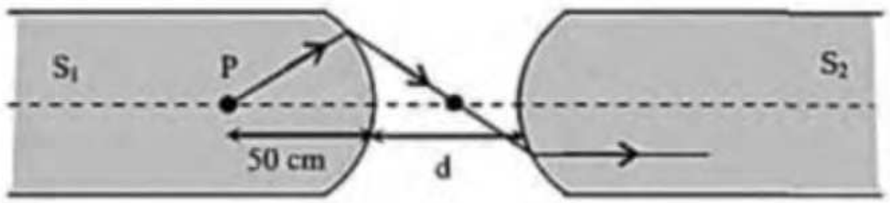


(a) 60 cm (b) 70cm (c) 80 cm (d) 90 cm

Ans : (b)

Sol.

(B) 70 cm



For Ist refraction

$$\frac{1}{v} - \frac{1.5}{-50} = \frac{1-1.5}{-10}$$

$$\Rightarrow v = 50 \text{ cm}$$

For IInd refraction

$$\frac{1.5}{\infty} - \frac{1}{-x} = \frac{1.5-1}{+10}$$

$$\Rightarrow x = 20 \text{ cm}$$

$$\Rightarrow d = 70 \text{ cm}$$

Que.

Sunlight of intensity $1.3 kWm^{-2}$ is incident normally on a thin convex lens of focal length 20 cm. Ignore the energy loss of light due to the lens and assume that the lens aperture size is much smaller than its focal length. The average intensity of light, in kWm^{-2}, at a distance 22 cm from the lens on the other side is

(JEE Adv. 2018)

(*a*) 130 kW/m^2

(*b*) 131 kW/m^2

(*c*) 132 kW/m^2

(*d*) 133 kW/m^2

Ans : (a)

Que.

The image of an object, formed by a plano-convex lens at a distance of 8 m behind the lens, is real and is one-third the size of the object. The wavelength of light inside the lens is 2/3 times the wavelength in free space. The radius of the curved surface of the lens is

(JEE Adv. 2013)

(*a*) 1 m (*b*) 2 m (*c*) 3 m (*d*) 6 m

Ans : (c)

Que.

A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is **(IIT-JEE 2010)**

(*a*) virtual and at a distance of 16 cm from the mirror

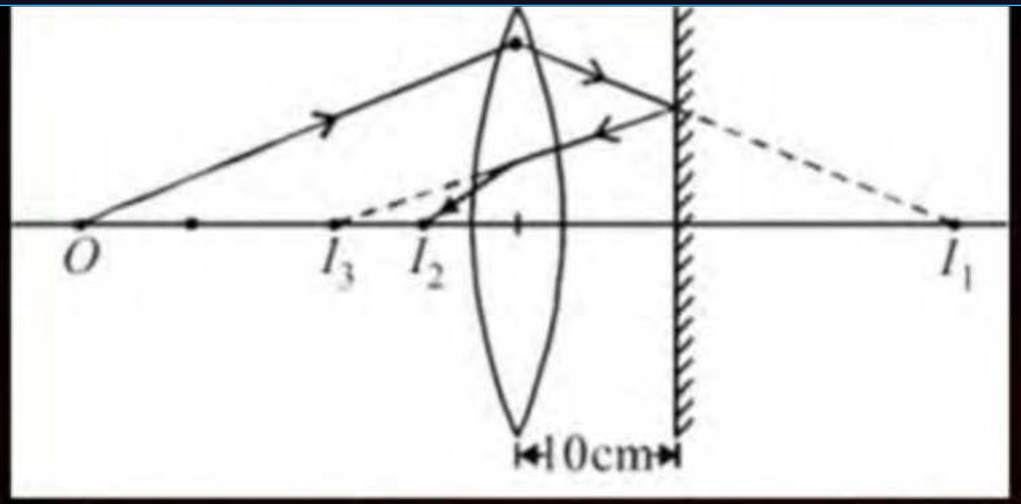
(*b*) real and at a distance of 16 cm from the mirror

(*c*) virtual and at a distance of 20 cm from the mirror

(*d*) real and at a distance of 20 cm from the mirror

Ans : (b)

Sol.



Focal length of the biconvex lens is 15 cm. A small object is placed at a distance of 30cm from the lens i.e. at a distance of 2f. Therefore the image should form at But since the ray strike the plane mirror before reaching I_1, the image I_(1) acts as the virtual object for reflection on plane mirror kept at a distance of 20 cm from it. It should produce an image I_(2) but as the ray encounters the lens, it gets refracted and the final image is formed at I_(3). For the last refraction from the biconvex lens, $u = 10cm$.

Applying lens formuls $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\Rightarrow \frac{1}{v} = \frac{1}{10} = \frac{1}{15} \Rightarrow \frac{1}{v} = \frac{1}{15} + \frac{1}{10} = \frac{25}{150}$$

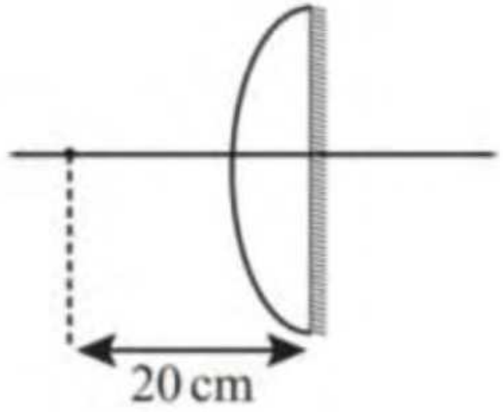
$$\Rightarrow v = 6cm$$

Therefore a real image is formed at a distance of 16cm from the plane mirror.

Que.

A point object is placed at a distance of 20 cm from a thin plano-convex lens of focal length 15 cm. The plane surface of the lens is now silvered. The image created by the system is at

(IIT-JEE 2006)



(*a*) 60 cm to the left of the system

(*b*) 60 cm to the right of the system

(*c*) 12 cm to the left of the system

(*d*) 12 cm to the right of the system

Ans : (c)

Sol.

Refraction from lens :

$(1/v)-(1/u) = 1/f$

$(1/v_1)-(1/-20) = 1/15$

v_1 = 60 cm +ive direction

i.e. first image is formed at 60 cm to the right of lens system.

Reflection from mirror:

After reflection from the mirror, the second image will be formed at a distance of

v_2 =60 cm to the left of lens system.

Refraction from lens:

$(1/v)-(1/u) = 1/f$ $(1/v_3) - (1/60) = (1/15)$ +ive direction

v_3 = 12 cm

Therefore, the final image is formed at 12 cm to the left of the lens system.

Que. A plano-convex lens is made of material of refractive index n. When a small object is placed 30 cm away in front of the curved surface of the lens, an image of double the size of the object is produced. Due to reflection from the convex surface of the lens, another faint image is observed at a distance of 10 cm away from the lens. Which of the following statement(s) is/are true?

(JEE Adv. 2016)

(a) The refractive index of the lens is 2.5

(b) The radius of curvature of the convex surface is 45 cm

(c) The faint image is erect and real

(d) The focal length of the lens is 20 cm

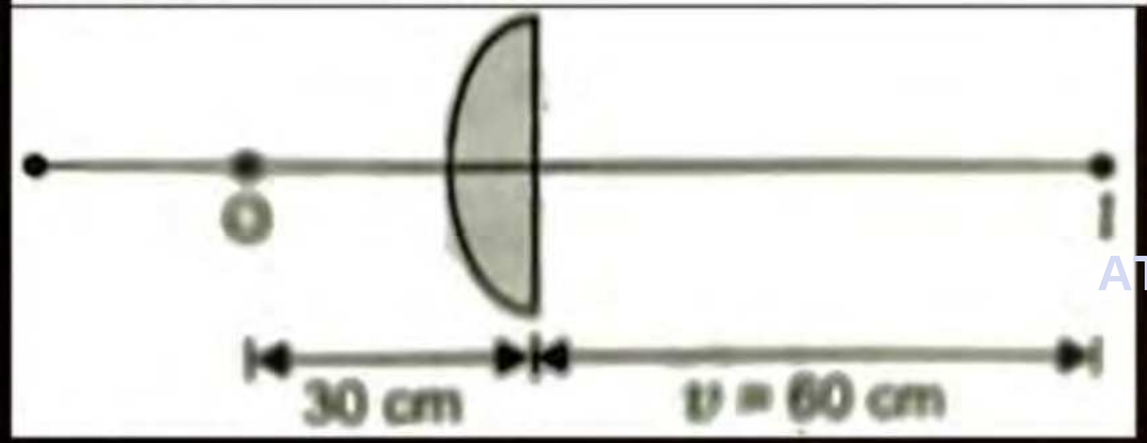
Ans : (a, d)

Sol.

As image is of double the size of object,

$v = 2u = -60cm.$

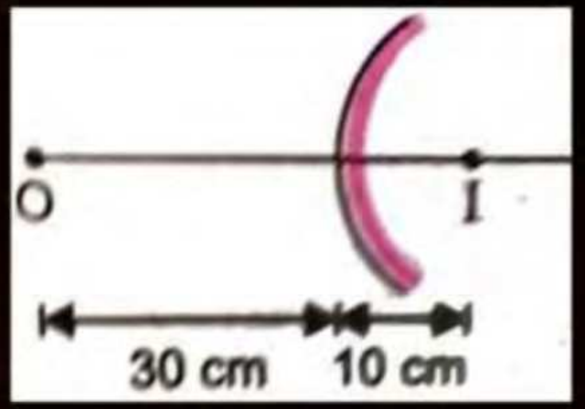
Here, $u = -30cm$



As $\frac{1}{f_1} = \frac{1}{v} - \frac{1}{u} = \frac{1}{60} + \frac{1}{30} = \frac{1}{20} \therefore f_1 = 20cm.$

In 2nd case, convex surface of lens acts as a convex mirror forming a faint image at a distance of $10cm$.

$u = -30cm, v = 10cm$



using mirror formula

$$\frac{1}{f_2} = \frac{1}{v} + \frac{1}{u} = \frac{1}{-30} + \frac{1}{10} = \frac{2}{30} = \frac{1}{15}$$

$f_2 = 15cm, R = 2f_2 = 30cm$

From $\frac{1}{f_1} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{\mu - 1}{R}$

$(\because R_2 = 00 \text{ and } R_1 = R)$

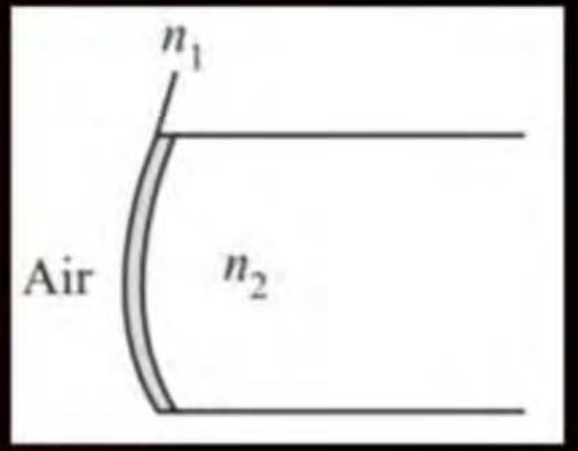
$$\mu = 1 = \frac{R}{f_1} = \frac{30cm}{20cm} = 1.5$$

$\mu = 1.5 + 1 = 2.5$

Choice (a) and (b) are correct.

Que. A transparent thin film of uniform thickness and refractive index $n_1 = 1.4$ is coated on the convex spherical surface of radius R at one end of a long solid glass cylinder of refractive index $n_2 = 1.5$, as shown in the figure. Rays of light parallel to the axis of the cylinder traversing through the film from air to glass get focused at distance f_1 from the film, while rays of light traversing from glass to air get focused at distance f_2 from the film. Then

(JEE Adv. 2014)



(a) $|f_1| = 3R$ (b) $|f_1| = 2.8R$ (c) $|f_2| = 2R$ (d) $|f_2| = 1.4R$

Ans : (a, c)

Sol.

As thickness of film is uniform, the effective power of the film is zero. Therefore, we can consider refraction at glass air interface.

In case I : Refraction from air to glass

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

$$-\frac{1}{\infty}+\frac{1.5}{f_1}=\frac{1.5-1}{R} \text{ or } f_1=3R$$

In case II : Refraction from denser to rarer

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

$$-\frac{1.5}{\infty}+\frac{1}{f_2}=\frac{1-1.5}{R} \text{ or } f_2=2R$$

Choice (a) and (c) are correct.

Que.

List-I contains four combinations of two lenses (1 and 2) whose focal lengths (in cm) are indicated in the figures. In all cases, the object is placed 20 cm from the first lens on the left, and the distance between the two lenses is 5 cm. List-II contains the positions of the final images. **(JEE Adv. 2022)**

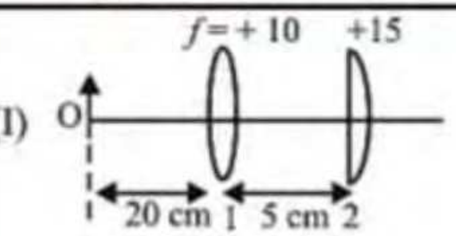
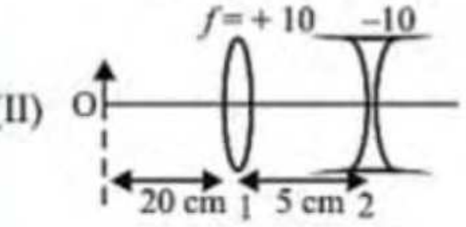
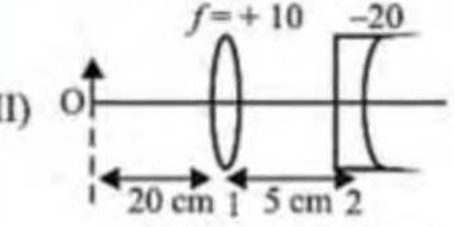
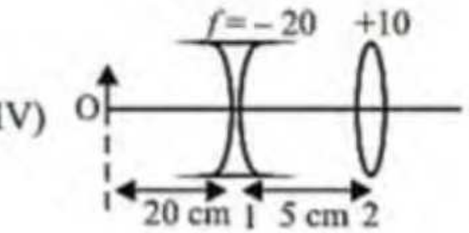
Which one of the following options is correct?

(*a*) (I) → P; (II) → R; (III) → Q; (IV) → T

(*b*) (I) → Q; (II) → P; (III) → T; (IV) → S

(*c*) (I) →; ; (II) → T; (III) → R; (IV) → Q

(*d*) (I) → T; (II) → S; (III) → Q; (IV) → R

List-I	List-II
(I) 	(P) Final image is formed at 7.5 cm on the right side of lens 2 .
(II) 	(Q) Final image is formed at 60.0 cm on the right side of lens 2.
(III) 	(R) Final image is formed at 30.0 cm on the left side of lens 2 .
(IV) 	(S) Final image is formed at 6.0 cm on the right side of lens 2 . (T) Final image is formed at 30.0 cm on the right side of lens 2 .

Ans : (a)

Sol.

(A) (I) → P; (II) → R; (III) → Q; (IV) → T

$$\frac{1}{v}=\frac{1}{f}+\frac{1}{u} \quad (concave\ lens)$$

$$\Rightarrow \quad v = -10$$

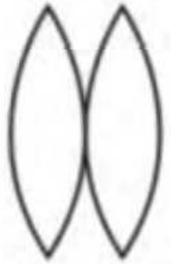
$$\frac{1}{v}=\frac{1}{f}+\frac{1}{u} \quad (convex\ lens)$$

$$\frac{1}{v}=\frac{1}{10}+\frac{1}{-15}$$

$$\Rightarrow \quad v = +30$$

Que.

Four combinations of two thin lenses are given in Column-I. The radius of curvature of all curved surfaces is r and the refractive index of all the lenses is 1.5. Match lens combinations in Column-I with their focal length in Column-II and select the correct answer using the codes given below the lists. **(JEE Adv. 2014)**

Column-I		Column-II
(P)		1. 2r
(Q)		2. $\frac{r}{2}$
(R)		3. –r
(S)		4. r

(a) P-1,Q-2, R-3,S-4 (b) P-2, Q-4, R-3, S-1

(b) P-4,Q-1,R-2,S-3 (c) P-2, Q-1, R-3, S-4

Ans : (b)

Sol.

The correct option is **B** P – 2, Q – 4, R – 3, S – 1

Given that,

Radius of curvature of each lens, R = r

Refractive index of each lens, $\mu = 1.5$

Focal length of a lens is given by

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

Focal length of single biconvex lens

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\Rightarrow \frac{1}{f} = (1.5 - 1)\left[\frac{1}{r} - \frac{1}{-r}\right]$$

$$\Rightarrow \frac{1}{f} = (0.5)\left[\frac{2}{r}\right]$$

$$\Rightarrow \frac{1}{f} = \frac{1}{r} \ldots (i)$$

$$\Rightarrow f = r$$

Similarly,

Focal length of plano-convex lens = 2r

& Focal length of plano-concave lens = −2r

For the combination P:

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{r} + \frac{1}{r} = \frac{2}{r}$$

$$\therefore F = \frac{r}{2}$$

For combination Q: Combination of two plano-convex lenses.

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{2r} + \frac{1}{2r} = \frac{2}{2r} = \frac{1}{r}$$

$$\therefore F = r$$

For combination R: Combination of two plano-concave lenses.

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = -\frac{1}{2r} - \frac{1}{2r} = -\frac{2}{2r} = -\frac{1}{r}$$

$$\therefore F = -r$$

For combination S: One is a convex lens and another is a plano-concave lens.

$$\frac{1}{F} = \frac{1}{r} + \frac{1}{-2r}$$

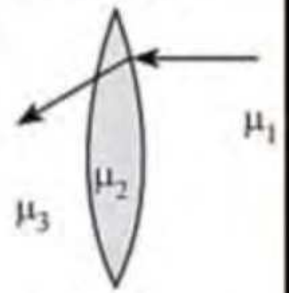
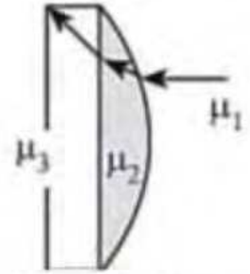
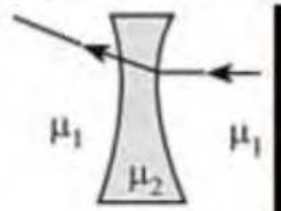
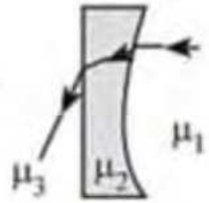
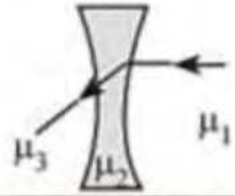
$$\Rightarrow \frac{1}{F} = \frac{1}{2r}$$

$$\Rightarrow F = 2r$$

Hence, option (b) is correct.

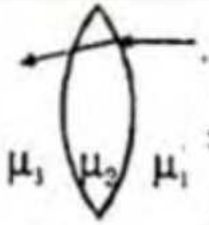
Que.

Two transparent media of refractive indices μ_1 and μ_3 have a solid lens shaped transparent material of refractive index μ_2 between them as shown in figures in Column-II. A ray traversing these media is also shown in the figures. In Column-I different relationships between μ_1,μ_2 and μ_3 are given. Match them to the ray diagram shown in Column-II. **(IIT JEE 2010)**

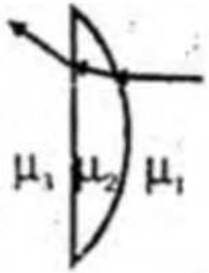
Column-I	Column-II
A. $\mu_1 < \mu_2$	(p) 
B. $\mu_1 > \mu_2$	(q) 
C. $\mu_3 = \mu_2$	(r) 
D. $\mu_2 > \mu_3$	(s) 
	(t) 

Ans : (A) → *p*, *r* (B) → q, s, t (C) → p, r, t (D) → q, s

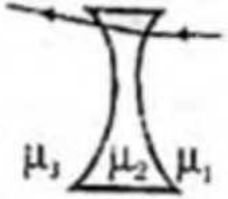
Sol.

For (p) : 

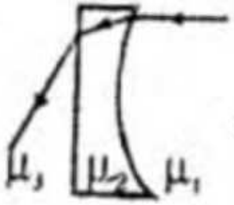
$\Rightarrow \mu_2 > \mu_1$ and $\mu_2 = \mu_3 \Rightarrow \mu_3 > \mu$

For (q) : 

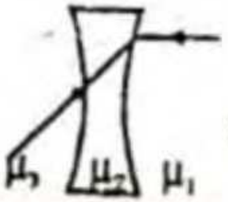
$\Rightarrow \mu_1 > \mu_2 > \mu_3$

For (r) : 

$\Rightarrow \mu_3 = \mu_2 > \mu_1$

For (s) : 

$\Rightarrow \mu_3 < \mu_2 < \mu_1$

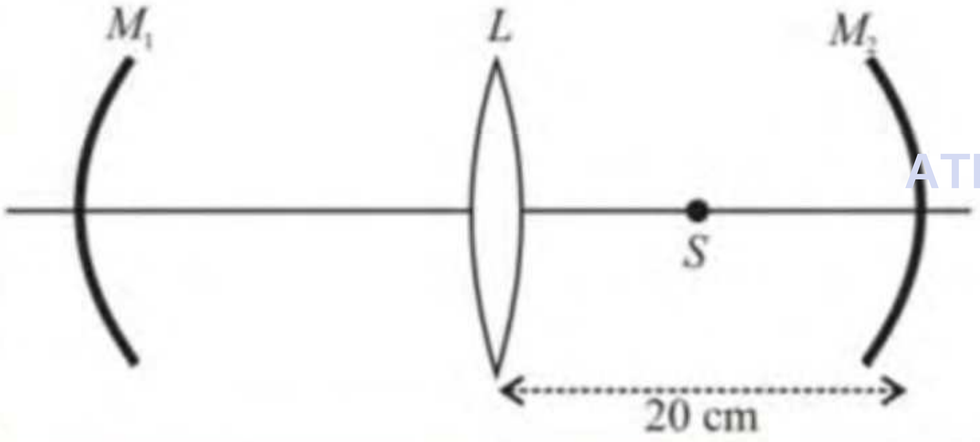
For (t) : 

$\Rightarrow \mu_2 = \mu_3 < \mu_1$

Que.

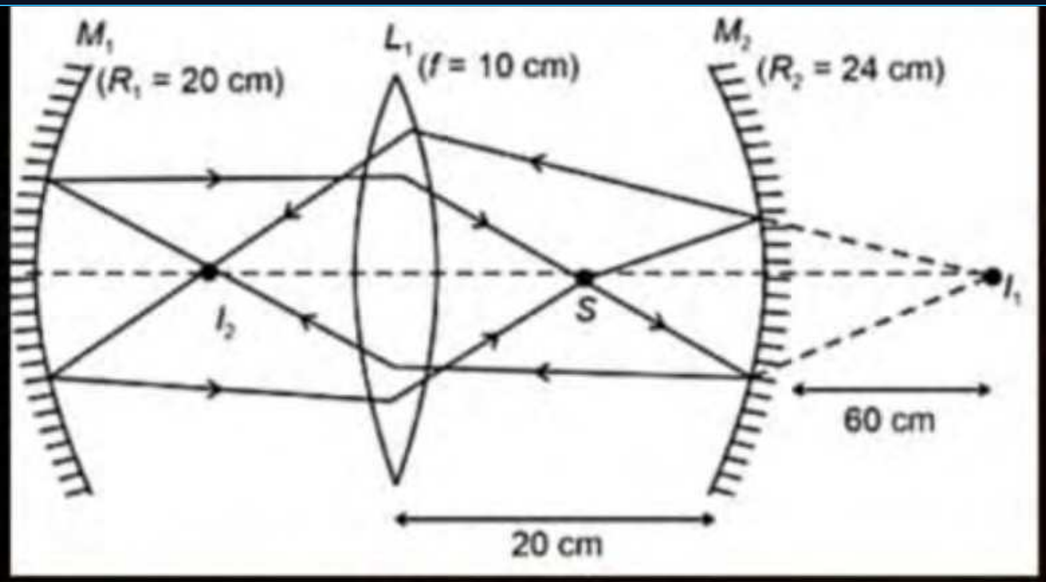
An optical arrangement consists of two concave mirrors M_1 and M_2, and a convex lens L with a common principal axis, as shown in the figure. The focal length of L is 10 cm. The radii of curvature of M_1 and M_2 are 20 cm and 24 cm, respectively. The distance between L and M_2 is 20 cm. A point object S is placed at the mid-point between L and M_2 on the axis. When the distance between L and M_1 is n/7cm, one of the images coincides with S. The value of n is

(JEEE Adv. 2023)



Ans : (220)

Sol.



For reflection from M_2

$$\frac{1}{v}+\frac{1}{(-10)}=\frac{1}{(-12)}$$

$$\frac{1}{v}=\frac{1}{10}-\frac{1}{12}$$

$v = +60$ cm (for I_1)

For refraction from L

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

$$\frac{1}{v}-\frac{1}{(-80)}=\frac{1}{10}$$

$$v = +\frac{80}{7}\ (\text{For } I_2)$$

This image should be at focus of M_1

$$\therefore \frac{20}{2}+\frac{80}{7}=\frac{n}{7}$$

$$\boxed{n = 150}$$

Also,

If I_2 is formed at pole of M_1

then $\frac{n}{7}=\frac{80}{7}$

$$\boxed{n = 80}$$

And further if I_2 is formed at centre of curvature of M_1 then

$$\frac{n}{7}=\frac{80}{7}+20$$

$$\therefore \boxed{n = 220}$$

Que. In an experiment for determination of the focal length of a thin convex lens, the distance of the object from the lens is 10 ± 0.1 cm and the distance of its real image from the lens is 20 ± 0.2 cm. The error in the determination of focal length of the lens is $n\%$. The value of n is _____ :

(JEE Adv. 2023)

Ans : (1)

Sol.

Object distance = 10 ± 0.1 cm

Image distance = 20 ± 0.2 cm

Applying lens formula

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \qquad \ldots(i)$$

$$\Rightarrow \quad \frac{1}{20} - \frac{1}{(-10)} = \frac{1}{f}$$

$$\Rightarrow \quad f = \frac{20}{3} \text{ cm}$$

Differentiate equation (i)

$$-\frac{1}{v^2}dv + \frac{1}{u^2}du = \frac{-1}{f^2}df$$

For calculating error

$$\frac{1}{f^2}df = +\frac{1}{v^2}dv + \frac{1}{u^2}du$$

$$\left(\frac{df}{f}\right) \times 100 = \left(\frac{0.2}{20^2} + \frac{0.1}{10^2}\right)\frac{20}{3} \times 100$$

$$= \left(\frac{0.2}{4} + \frac{0.1}{1}\right)\frac{20}{3} = 1$$

$$\therefore \quad \frac{df}{f} \times 100 = 1\%$$

Que. An optical bench has 1.5 m long scale having four equal divisions in each cm. While measuring the focal length of a convex lens, the lens is kept at 75 cm mark of the scale and the object pin is kept at 45 cm mark. The image of the object pin on the other side of the lens overlaps with image pin that is kept at 135 cm mark. In this experiment, the percentage error in the measurement of the focal length of the lens is _____.

(JEE Adv. 2019)

Ans : (1.39)

Sol.

$$u = (x_2 - x_1) = 75 - 45 = 30cm$$

$$\Delta u = \Delta x_2 + \Delta x_1 = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}cm$$

$$v = (x_3 - x_2) = 135 - 75 = 60cm$$

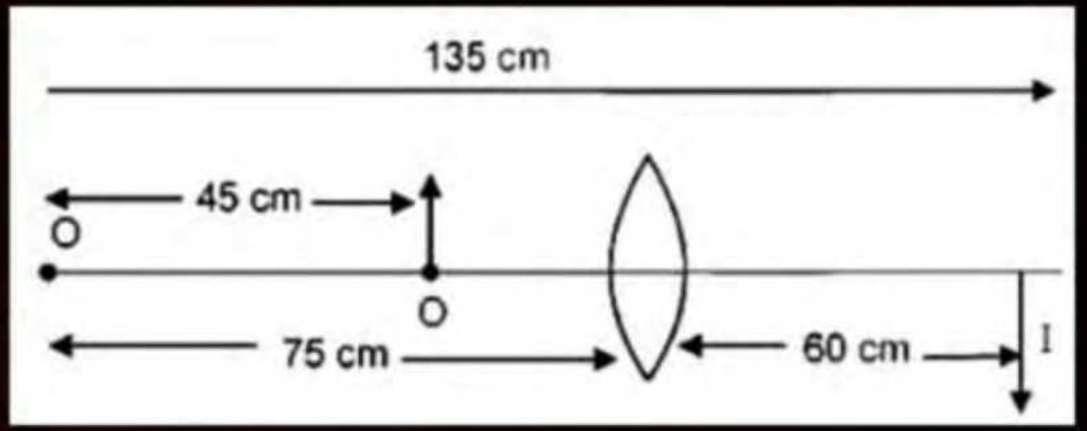
$$\Delta v = \Delta x_3 + \Delta x_2 = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}cm$$

$$\therefore \frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{60} + \frac{1}{30} = \frac{1}{f}$$

$$\therefore f = 20cm \quad \text{Also,} \ \frac{-dv}{v^2} + \frac{-du}{u^2} = \frac{-df}{f^2}$$

$$\Rightarrow \frac{df}{f} = f\left[(dv)(v^2) + \frac{du}{u^2}\right] = 20\left[\frac{1}{60^2} + \frac{1}{30^2}\right]\frac{1}{2}$$

$$\therefore \frac{df}{f} \times 100 = 10\left[\frac{1}{36} + \frac{1}{9}\right] = \frac{50}{36} = 1.38\&1.39 \text{ (both)}$$



H/W

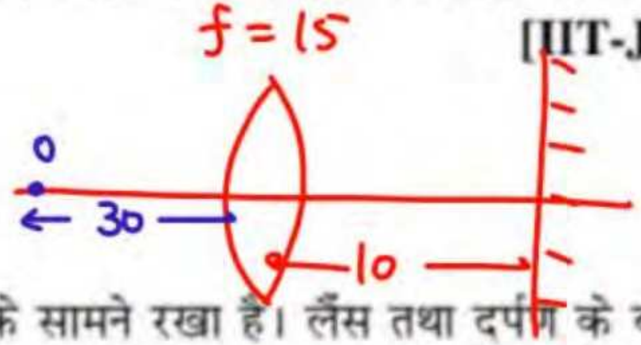
1. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is

(A) virtual and at a distance of 16 cm from the mirror **[IIT-JEE 2010]**

(B) real and at a distance of 16 cm from the mirror

(C) virtual and at a distance of 20 cm from the mirror

(D) real and at a distance of 20 cm from the mirror



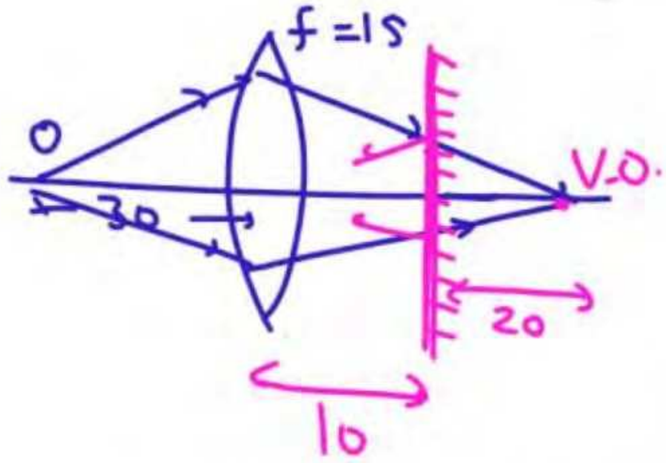
15 cm फोकस दूरी वाला एक उभयोत्तल लैंस एक समतल दर्पण के सामने रखा है। लैंस तथा दर्पण के बीच की दूरी 10 cm है। एक छोटा बिंब लैंस से 30 cm की दूरी पर रखा गया है। इसका अंतिम प्रतिबिंब **[IIT-JEE 2010]**

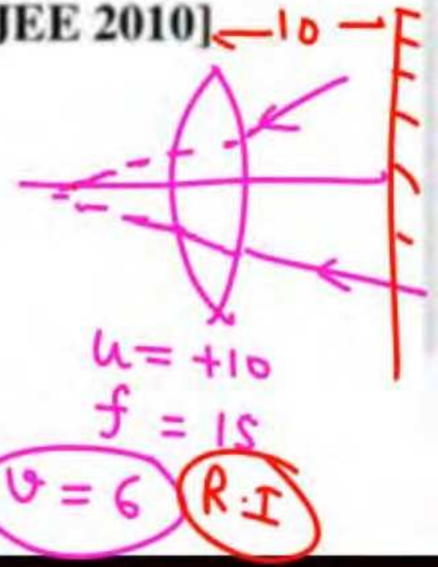
(A) आभासी तथा दर्पण से 16 cm की दूरी पर है।

(B) वास्तविक तथा दर्पण से 16 cm की दूरी पर है।

(C) आभासी तथा दर्पण से 20 cm की दूरी पर है।

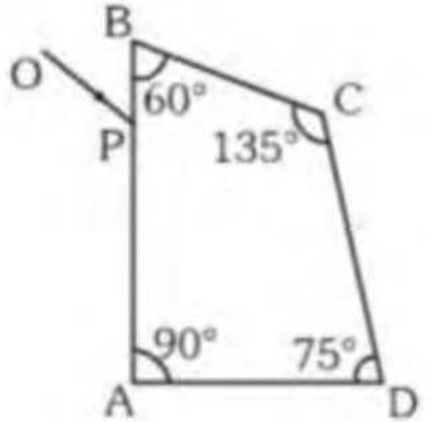
(D) वास्तविक तथा दर्पण से 20 cm की दूरी पर है।





Ans. (B)

ABCD near vertex B at an incident angle of 60° (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) correct? **[IIT-JEE 2010]**



(A) The ray gets totally internally reflected at face CD

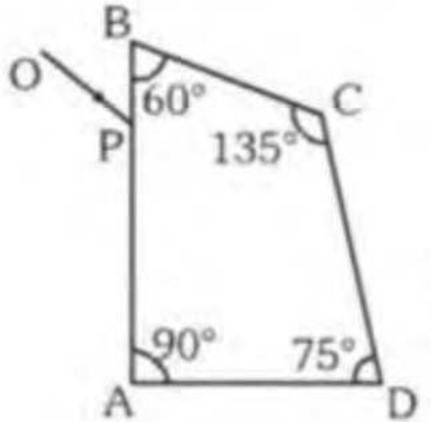
(B) The ray comes out through face AD

(C) The angle between the incident ray and the emergent ray is 90°

(D) The angle between the incident ray and the emergent ray is 120°

चित्रानुसार एक प्रिज्म ABCD के AB तल पर शीर्ष B के पास प्रकाश की एक एकवर्णीय किरण OP, 60° आपतन कोण पर आपतित है। यदि प्रिज्म के पदार्थ का अपवर्तनांक $\sqrt{3}$ है, तो निम्नलिखित में से कौन सा (कौन से) कथन सही है?

[IIT-JEE 2010]



(A) किरण का CD तल से पूर्ण आन्तरिक परावर्तन हो जाता है।

(B) किरण AD तल से बाहर आ जाती है।

(C) निर्गत किरण और आपतित किरण के बीच के कोण का मान 90° है।

(D) निर्गत किरण और आपतित किरण के बीच के कोण का मान 120° है।

Ans. (A,B,C)

$\delta =$

$-30 + (180 - 2 \times 45) + 30$

$1 \times \frac{\sqrt{3}}{2} = \sqrt{3} \times \sin r$

$r = 30$

$\sqrt{3} \sin 45 = 1 \times \sin r$

$\frac{\sqrt{3} \times}{\sqrt{2}} = \sin r = \frac{1.73}{1.41} > 1$

$\sqrt{3} \sin 30 = 1 \times \sin r$

$r = 60^\circ$

refractive index μ_2 between them as shown in figures in **Column II**. A ray traversing these media is also shown in the figures. In **Column I** different relationships between μ_1, μ_2 and μ_3 are given. Match them to the ray diagrams shown in **Column II**.

स्तम्भ II में दिये गये चित्रों में दर्शाये अनुसार μ_2 अपवर्तनांक वाले पदार्थ से बना पारदर्शी ठोस लेंस, μ_1 व μ_3 अपवर्तनांक वाले दो पारदर्शी माध्यमों के मध्य रखा हुआ है। इन माध्यमों से गुजरने वाली एक किरण भी चित्रों में दर्शाई गई है। स्तम्भ I में μ_1, μ_2 तथा μ_3 के मध्य विभिन्न संबंध दर्शाये गये हैं। इन्हें स्तम्भ II में दिये गये किरण चित्रों से सुमेलित कीजिए।

[IIT-JEE 2010]

E

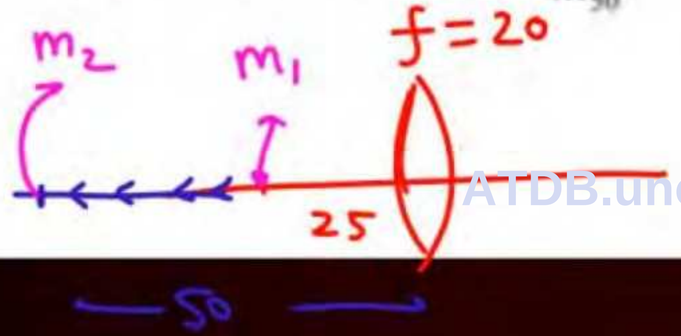
Column I	**Column II**
(A) $\mu_1 < \mu_2$	(p) 
(B) $\mu_1 > \mu_2$	(q) 
(C) $\mu_2 = \mu_3$	(r) 
(D) $\mu_2 > \mu_3$	(s) 
	(t) 

4. The focal length of a thin biconvex lens is 20 cm. When an object is moved from a distance of 25 cm in front of it to 50 cm, the magnification of its image changes from m_{25} to m_{50}. The ratio $\frac{m_{25}}{m_{50}}$ is

एक पतले उभयोत्तल लैंस की फोकस दूरी 20 cm है। जब लैंस के सामने बिंब को 25 cm से 50 cm दूर ले जाया जाता है तो इसके प्रतिबिंब का आवर्धन m_{25} से m_{50} हो जाता है। $\frac{m_{25}}{m_{50}}$ अनुपात का मान क्या होगा? **[IIT-JEE 2010]**

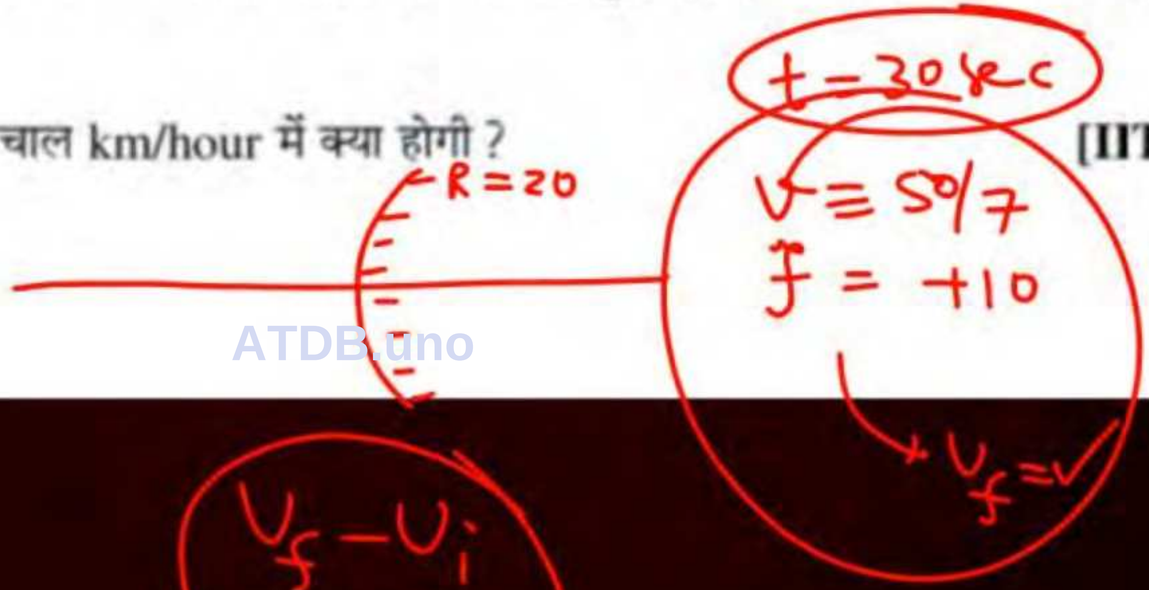
Ans. 6

HW

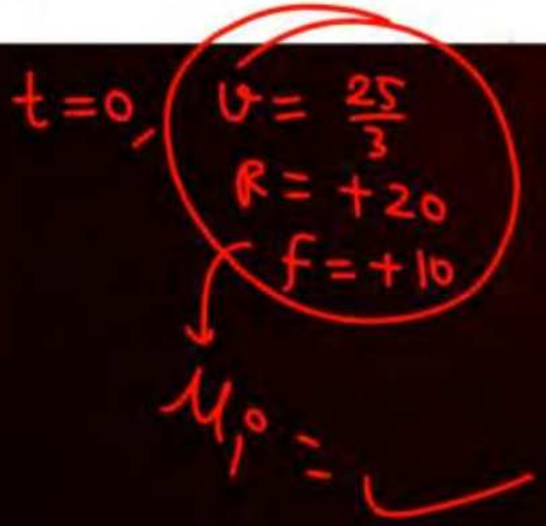


5. Image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from $\frac{25}{3}$ m to $\frac{50}{7}$ m in 30 seconds. What is the speed of the object in km per hour?

20m वक्रता त्रिज्या के एक उत्तल दर्पण की ओर प्रकाश अक्ष पर जाते हुए एक बिंब का प्रतिबिंब 30 sec में $\frac{25}{3}$ m से $\frac{50}{7}$ m पर खिसकता है। बिंब की चाल km/hour में क्या होगी ? **[IIT-JEE 2010]**



Ans. 3



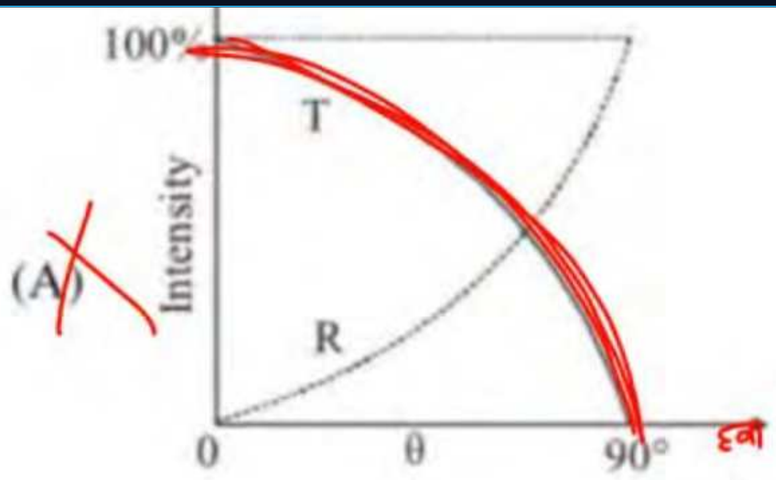
6. A large glass slab $\left(\mu = \frac{5}{3}\right)$ of thickness 8 cm is placed over a point source of light on a plane surface. It is seen that light emerges out of the top surface of the slab from a circular area of radius R cm. What is the value of R?

एक समतल सतह पर काँच $\left(\mu = \frac{5}{3}\right)$ का 8 cm मोटाई का एक बड़ा गुटका प्रकाश के एक बिन्दु स्रोत पर रखा है। यह देखा जाता है कि इसके ऊपरी पृष्ठ से प्रकाश R cm त्रिज्या के वृत्ताकार क्षेत्र से बाहर निकलता है। R का मान ज्ञात कीजिए।

[IIT-JEE 2010]

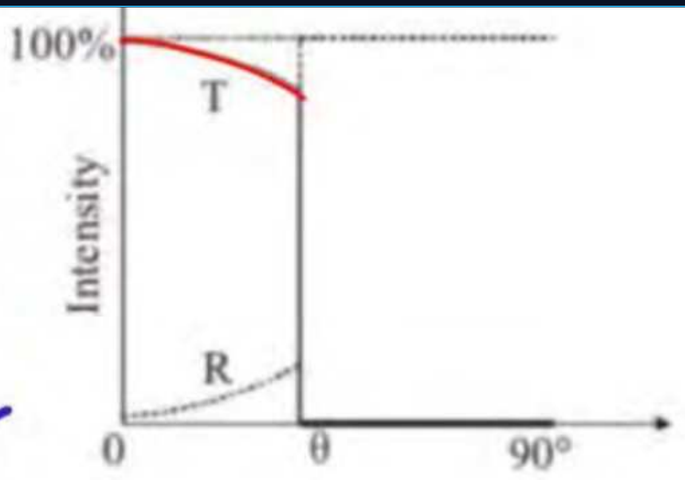
GO0201

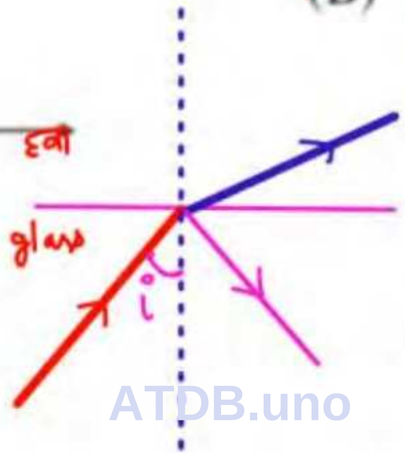
Ans. 6

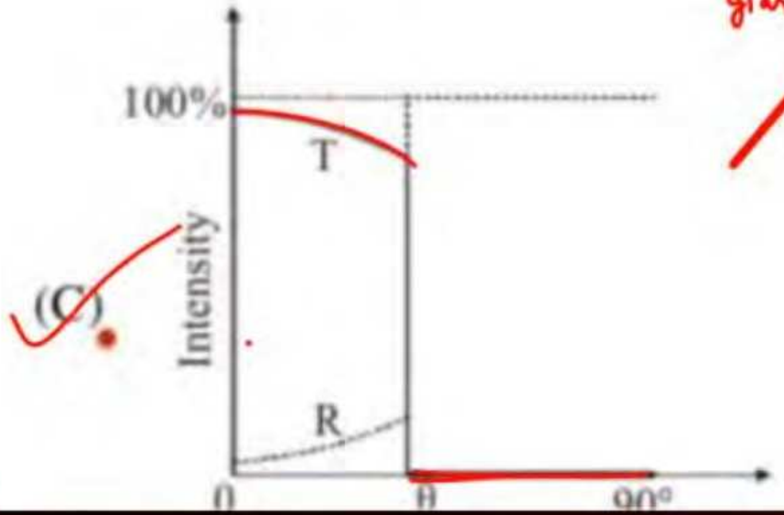


(A)

(B)

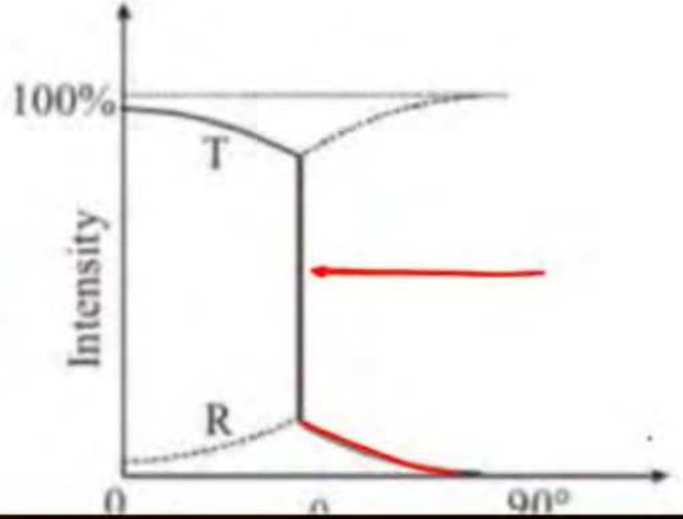






(C)

(D)



12. 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 :-

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)

is one-third the size of the object. The wavelength of light inside the lens is $\frac{2}{3}$ times the wavelength in free space. The radius of the curved surface of the lens is :-

एक समतल उत्तल लेंस एक वास्तविक प्रतिबिम्ब लेंस के 8 m पीछे बनाता है जो कि वस्तु के आकार का एक-तिहाई है। लेंस के अन्दर प्रकाश की तरंगदैर्ध्य निर्वात की तरंगदैर्ध्य से $\frac{2}{3}$ गुना है। लेंस के गोलीय वक्रित पृष्ठ की वक्रता त्रिज्या है:-

[JEE-Advance-2013]

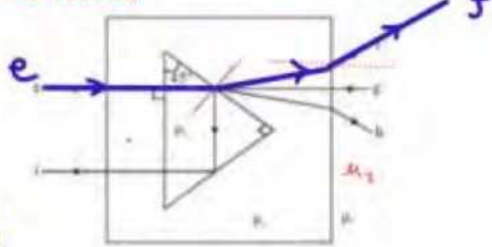
(A) 1 m (B) 2 m (C) 3 m (D) 6 m

Ans. (C)

which is surrounded by a medium of refractive index μ_3, as shown in the figure. A ray of light 'e' enters the rectangular block at normal incidence. Depending upon the relationships between μ_1, μ_2, and μ_3, it takes one of the four possible paths 'ef', 'eg', 'eh' or 'ei'.

एक μ_3 अपवर्तनांक के समकोण प्रिज्म को μ_2 अपवर्तनांक के आयताकार ब्लॉक में रखा गया है। पूर्ण व्यवस्था μ_3 अपवर्तनांक के माध्यम से चित्र में दर्शाए अनुसार घिरी हुई है। प्रकाश की किरण 'e' आयताकार ब्लॉक पर अभिलंबवत आपतित होती है। μ_1, μ_2 और μ_3 के मानों पर निर्भर होती हुई प्रकाश की किरण चार संभव पथों 'ef', 'eg', 'eh' या 'ei' में से एक लेती है।

[JEE-Advance-2013]



Match the paths in List I with conditions of refractive indices in List II and select the correct answer using the codes given below the lists :

सूची I में दिये गये पथों को सूची II की अपवर्तनांक की शर्तों से सुमेलित कीजिए और सूचियों के नीचे दिये गये कोड का प्रयोग करके सही उत्तर चुनिये :-

List I		List II	
P.	$e \to f$	1.	$\mu_1 > \sqrt{2}\mu_2$
Q.	$e \to g$	2.	$\mu_2 > \mu_1$ and $\mu_2 > \mu_3$
R.	$e \to h$	3.	$\mu_1 = \mu_2$
S.	$e \to i$	4.	$\mu_2 < \mu_1 < \sqrt{2}\mu_2$ and $\mu_2 > \mu_3$

Codes :

	P	Q	R	S
(A)	2	3	1	4
(B)	1	2	4	3
(C)	4	1	2	3
(D)	2	3	4	1

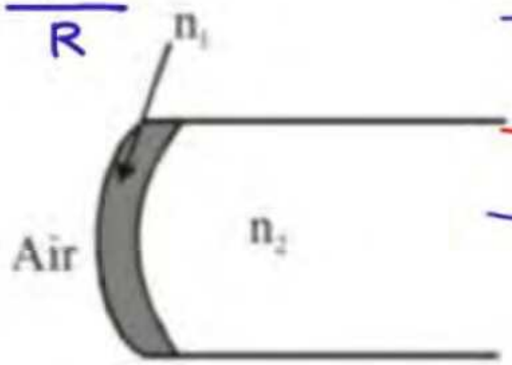
15. A transparent thin film of uniform thickness and refractive index $n_1 = 1.4$ is coated on the convex spherical surface of radius R at one end of a long solid glass cylinder of refractive index $n_2 = 1.5$, as shown in the figure. Rays of light parallel to the axis of the cylinder traversing through the film from air to glass get focused at distance f_1 from the film, while rays of light traversing from glass to air get focused at distance f_2 from the film. Then

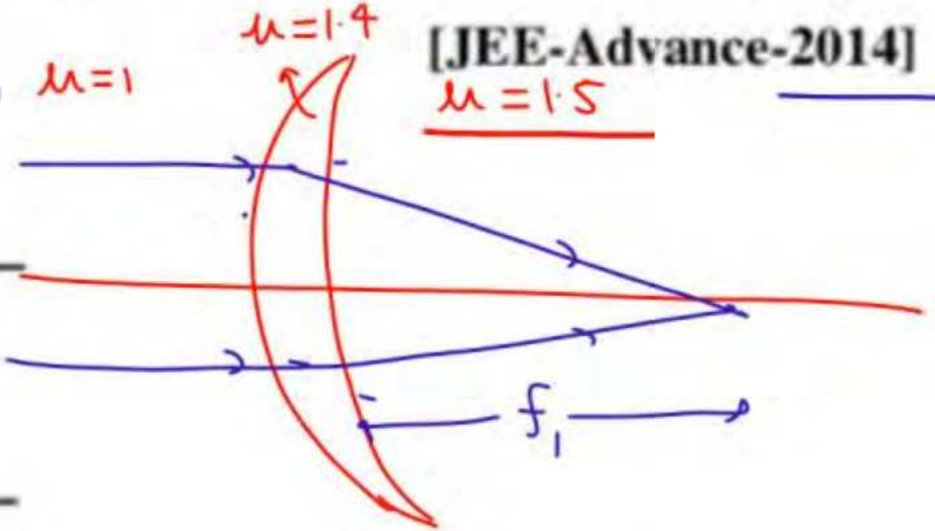
$$\frac{1}{f_2} - \frac{1.5}{-\infty} = \frac{1-1.4}{-R} + \frac{1.4-1.5}{-R}$$

काँच के एक लम्बे व ठोस बेलन, जिसका अपवर्तनांक $n_2 = 1.5$ है, का एक छोर गोलीय है जैसा कि चित्र में दर्शाया गया है। इस गोलीय पृष्ठ की त्रिज्या R है और इस पर $n_1 = 1.4$ अपवर्तनांक की एकसमान मोटाई वाली एक पारदर्शी पतली फिल्म लगी है। वायु से फिल्म में होकर काँच में जाने वाली प्रकाश की किरणें जो कि बेलन के अक्ष के समांतर हैं, फिल्म से f_2 दूरी पर फोकस होती हैं। तब :-

[JEE-Advance-2014]

$$\frac{1.5}{f_1} - \frac{1}{\infty} = \frac{1.5-1.4}{R} + \frac{1.4-1}{R}$$





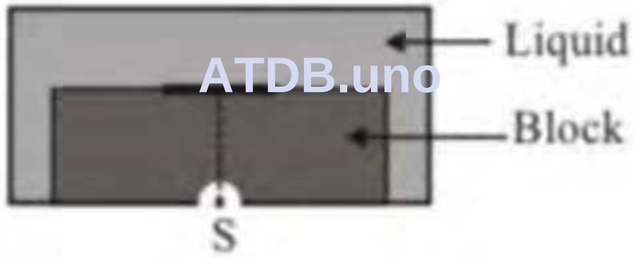
(A) $|f_1| = 3R$ (B) $|f_1| = 2.8\,R$ (C) $|f_2| = 2R$ (D) $|f_2| = 1.4\,R$

Ans. (A,C)

16. A point source S is placed at the bottom of a transparent block of height 10 mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is :-

एक बिन्दु प्रकाश स्त्रोत (S) एक 10 mm ऊँचाई वाले पारदर्शी गुटके की निचली सतह पर रखा है। गुटके का अपवर्तनांक 2.72 है। गुटके को एक कम अपवर्तनांक वाले द्रव में डुबोया गया है, जैसा चित्र में दर्शाया गया है। गुटके से निकल कर द्रव में जाने वाला प्रकाश, गुटके की ऊपरी सतह पर 11.54 mm व्यास का एक दीप्त वृत्त (Spot) बनाता है। द्रव का अपवर्तनांक है:-

[JEE-Advance-2014]



(A) 1.21 (B) 1.30 (C) 1.36 (D) 1.42

Ans. (C)

is r and the refractive index of all the lenses is 1.5. Match lens combinations in List-I with their focal length in List-II and select the correct answer using the code given below the lists.

दो पतले लेन्सों के चार संयोजन सूची-I में दिए हैं। प्रत्येक लेन्स के वक्रीय पृष्ठ की वक्रता त्रिज्या r तथा अपवर्तनांक 1.5 है। सूची-I में विभिन्न लेन्स संयोजन दिए हैं तथा सूची-II में उनकी फोकस दूरी दी हुई है। सूची-I को सूची-II से सुमेलित कीजिए तथा सूचियों के नीचे दिए गए कोड का प्रयोग करके सही उत्तर चुनिए :- **[JEE-Advance 2014]**

List–I		List–II	
(P)		(1)	2r
(Q)		(2)	$\frac{r}{2}$
(R)		(3)	–r
(S)		(4)	r

Code :

(A) P-1, Q-2, R-3, S-4

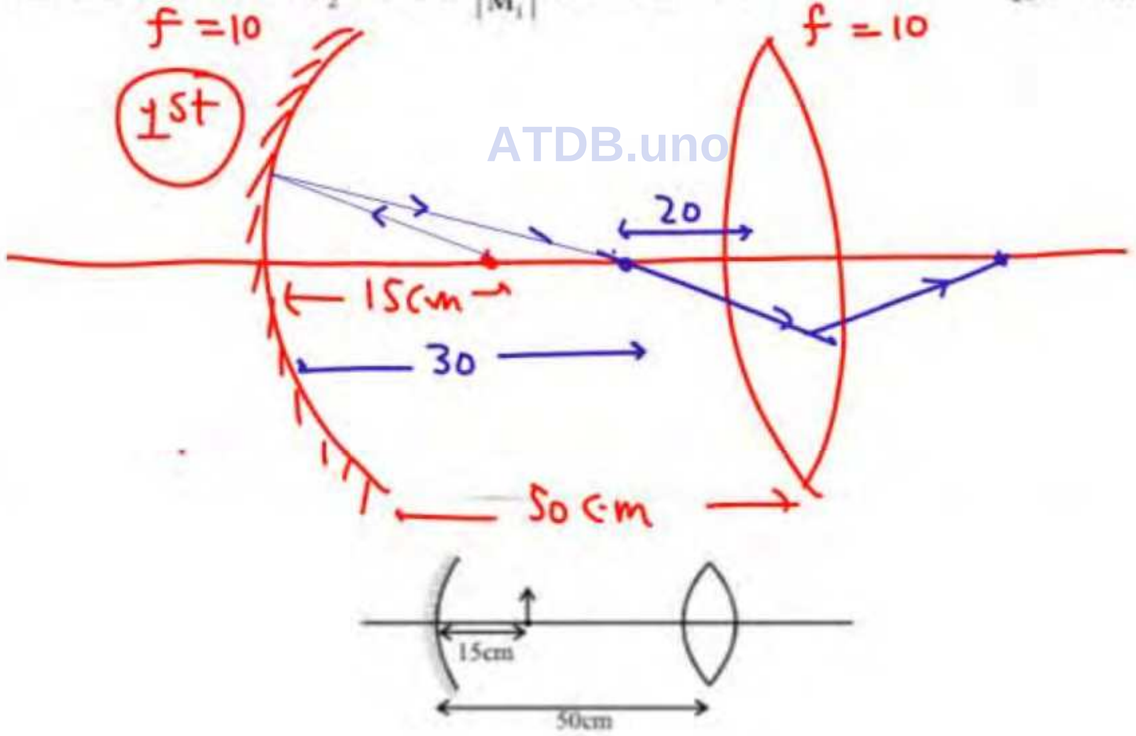
(B) P-2, Q-4, R-3, S-1

(C) P-4, Q-1, R-2, S-3

(D) P-2, Q-1, R-3, S-4

18. Consider a concave mirror and a convex lens (refractive index = 1.5) of focal length 10 cm each, separated by a distance of 50 cm in air (refractive index = 1) as shown in the figure. An object is placed at a distance of 15 cm from the mirror. Its erect image formed by this combination has magnification M_1. When the set-up is kept in a medium of refractive index 7/6 the magnification becomes M_2. The magnitude $\left|\frac{M_2}{M_1}\right|$ is.

एक अक्तल दर्पण तथा उत्तल लेंस (अपवर्तनांक = 1.5) जिनमें प्रत्येक की फोकस दूरी 10 cm है, दर्शाये चित्रानुसार एक-दूसरे से 50 cm की दूरी पर वायु (अपवर्तनांक = 1) में स्थित है। एक वस्तु को दर्पण से 15 cm की दूरी पर रखा गया है। इस संयोजन द्वारा वस्तु के सीधे बनने वाले प्रतिबिंब का आवर्धन M_1 है। जब यह सेट-अप 7/6 अपवर्तनांक के माध्यम में रखा जाता है तब आवर्धन M_2 हो जाता है। $\left|\frac{M_2}{M_1}\right|$ के परिमाण का मान है। **[JEE-Advance-2015]**

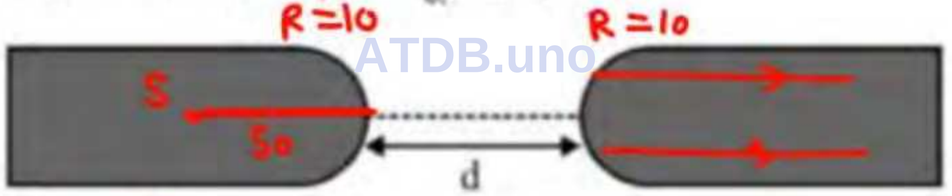


$$\frac{1}{f_{\text{पानी}}} = \left(\frac{\mu_L}{\mu_W} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Ans. 7

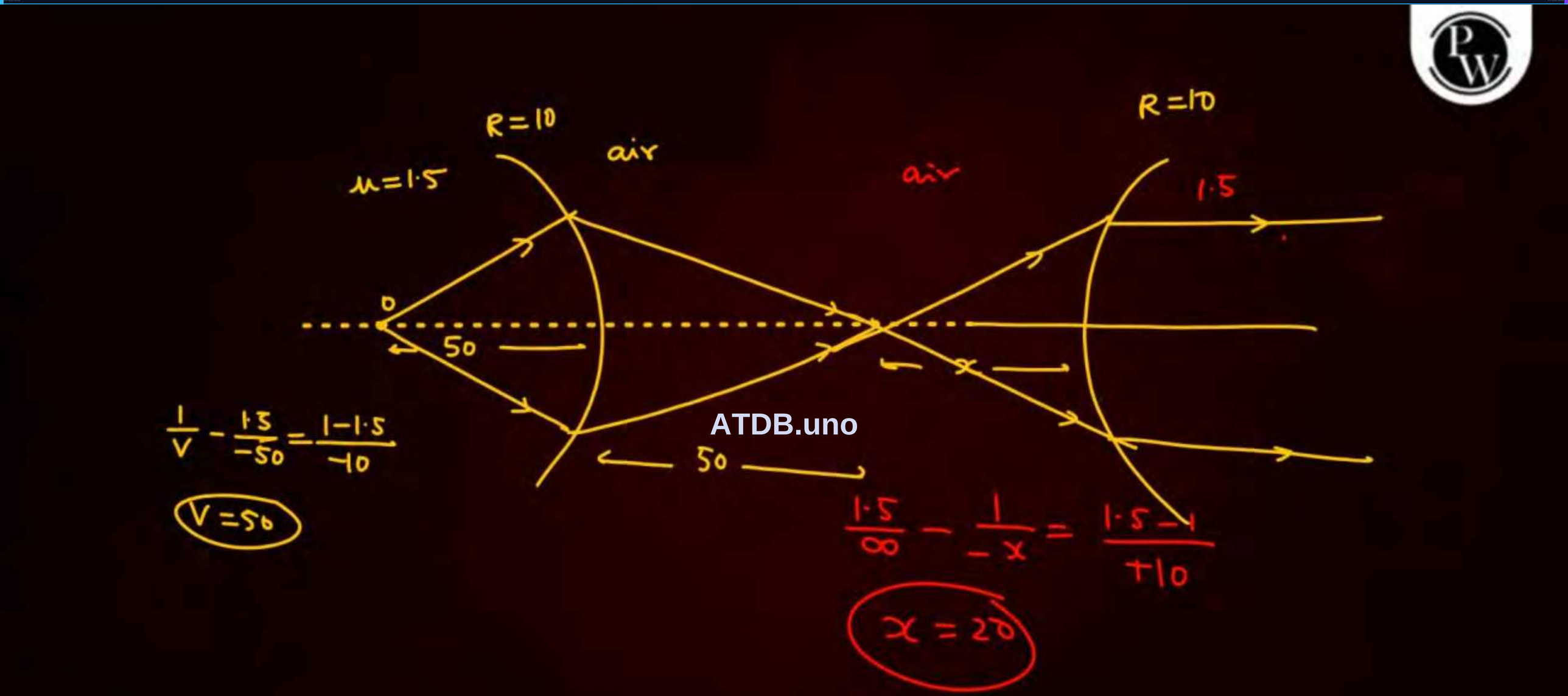
19. Two identical glass rods S_1 and S_2 (refractive index = 1.5) have one convex end of radius of curvature 10 cm. They are placed with the curved surfaces at a distance d as shown in the figure, with their axes (shown by the dashded line) aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emanating from it are found to be parallel to the axis inside S_2. The distance d is :

दो काँच (अपवर्तनांक = 1.5) की एकरूप छड़ों S_1 तथा S_2 का एक छोर 10 cm वक्रता त्रिज्या की उत्तल सतह है। उनकी वक्र सतह एक-दूसरे से d दूरी पर दर्शाये चित्रानुसार रखी हैं तथा उनके अक्ष एक रेखा (चित्र में असतत रेखा) पर हैं। यदि प्रकाश के एक बिंदु स्त्रोत P को छड़ S_1 के अंदर वक्र सतह से 50 cm की दूरी पर रखने पर इससे निकलने वाली प्रकाश की किरणें छड़ S_2 के अन्दर अक्ष के समांतर हों, तब दूरी d होगी : **[JEE-Advance-2015]**



(A) 60 cm (B) 70 cm (C) 80 cm (D) 90 cm

Ans. (B)



$$\frac{1}{V} - \frac{1.5}{-50} = \frac{1-1.5}{-10}$$

$V = 50$

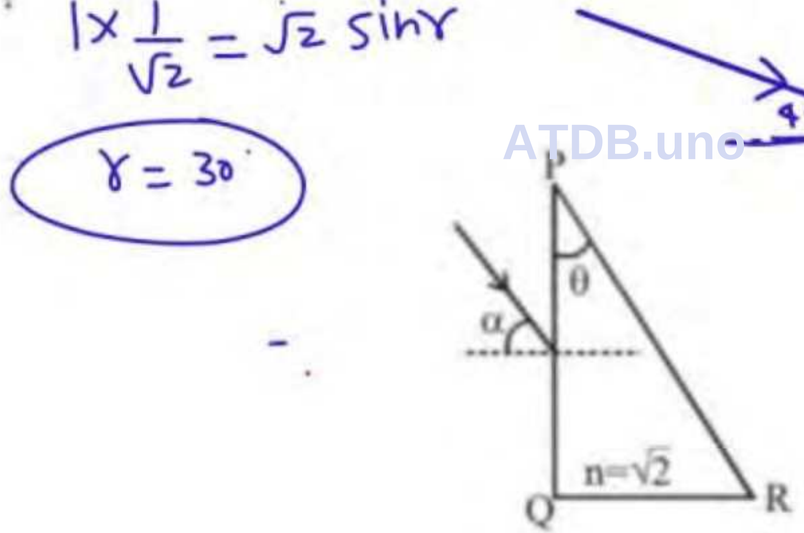
$$\frac{1.5}{\infty} - \frac{1}{-x} = \frac{1.5-1}{+10}$$

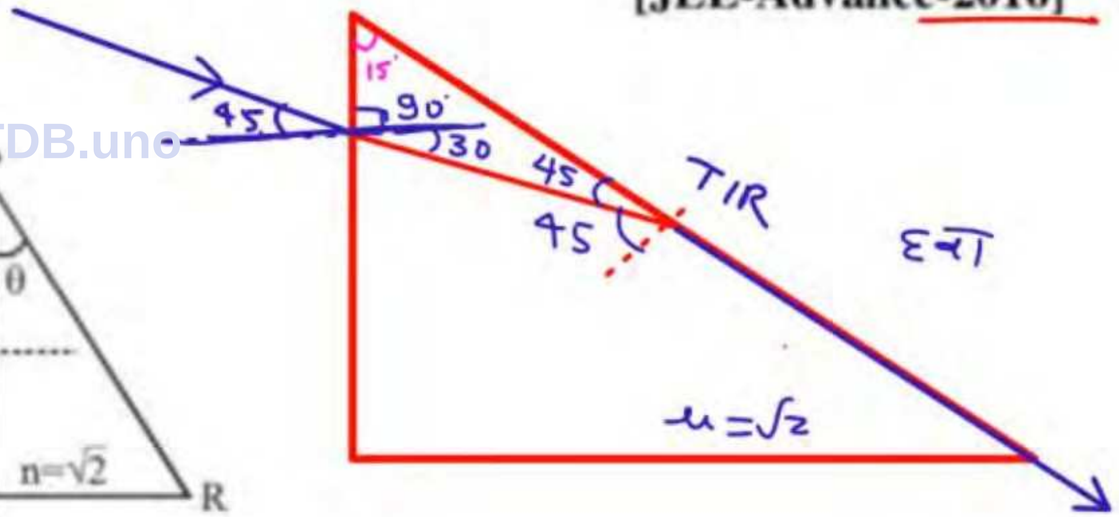
$x = 20$

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 :

वायु से आती प्रकाश की एक समानान्तर किरण-पुंज (parallel beam) एक समकोण त्रिभुजीय प्रिज्म (right angled triangular prism), जिसका अपवर्तनांक $n = \sqrt{2}$ है, के PQ तल पर α कोण से आपतित होती है। जब α का न्यूनतम मान 45° है तो प्रकाश का प्रिज्म की PR सतह पर पूर्ण आंतरिक परावर्तन (total internal reflection) होता है। प्रिज्म का कोण θ क्या होगा ?

[JEE-Advance-2016]





(A) 15° (B) 22.5° (C) 30° (D) 45°

Ans. (A)

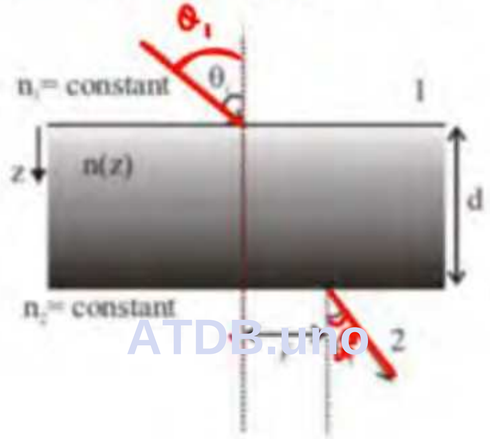
24. A transparent slab of thickness d has a refractive index n(z) that increases with z. Here z is the vertical distance inside the slab, measured from the top. The slab is placed between two media with uniform refractive indices n_1 and n_2 ($> n_1$), as shown in the figure. A ray of light is incident with angle θ_i from medium 1 and emerges in medium 2 with refraction angle θ_f with a lateral displacement ℓ. Which of the following statement(s) is(are) true ? **[JEE-Advance-2016]**

(A) ℓ is independent of n_2

(B) ℓ is dependent on n(z)

(C) $n_1 \sin\theta_i = (n_2 - n_1)\sin\theta_f$

(D) $n_1 \sin\theta_i = n_2 \sin\theta_f$



d मोटाई के एक पारदर्शी पट्ट का अपवर्तनांक n(z) का मान z बढ़ाने से बढ़ता है। यहाँ z पट्ट के अंदर ऊपरी सतह से मापी गयी ऊर्ध्वाधर दूरी है। पट्ट को दो माध्यमों के बीच रखा गया है जिनके एकसमान (uniform) अपवर्तनांक n_1 एवं n_2 ($> n_1$) है, जैसा की चित्र में दर्शाया गया है। यहाँ n_1 और n_2 स्थिर (constant) है। प्रकाश की एक किरण माध्यम 1 से पट्ट पर θ_i कोण से आपतित है तथा माध्यम 2 में पार्श्विक विस्थापन (lateral displacement) ℓ से अपवर्तन कोण θ_f पर निकसित होती है। निम्नलिखित में से कौनसा/कौनसे कथन सत्य है/हैं?

(A) ℓ का मान n_2 पर निर्भर करता है।

(B) ℓ का मान n(z) पर निर्भर करता है।

(C) $n_1 \sin\theta_i = (n_2 - n_1)\sin\theta_f$

(D) $n_1 \sin\theta_i = n_2 \sin\theta_f$

Ans. (A,B,D)

$$\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2 = \mu_3 \sin\theta_3$$

27. For an isosceles prism of angle A and refractive index μ, it is found that the angle of minimum deviation $\delta_m = A$. Which of the following options is/are correct ? **[JEE-Advance-2017]**

(A) At minimum deviation, the incident angle i_1 and the refracting angle r_1 at the first refracting surface are related by $r_1 = (i_1/2)$

(B) For this prism, the refractive index μ and the angle of prism A are related as $A = \frac{1}{2}\cos^{-1}\left(\frac{\mu}{2}\right)$

(C) For this prism, the emergent ray at the second surface will be tangential to the surface when the angle of incidence at the first surface is $i_1 = \sin^{-1}\left[\sin A\sqrt{4\cos^2\frac{A}{2} - 1} - \cos A\right]$

(D) For the angle of incidence $i_1 = A$, the ray inside the prism is parallel to the base of the prism.

एक समद्विबाहु प्रिज्म का प्रिज्म कोण A है (isosceles prism of angle A) इस प्रिज्म का अपवर्तनांक μ है। इस प्रिज्म का न्यूनतम विचलन कोण (angle of minimum deviation) $\delta_m = A$ है। निम्न मे से कौन सा (से) कथन सही है/हैं?

[JEE-Advance-2017]

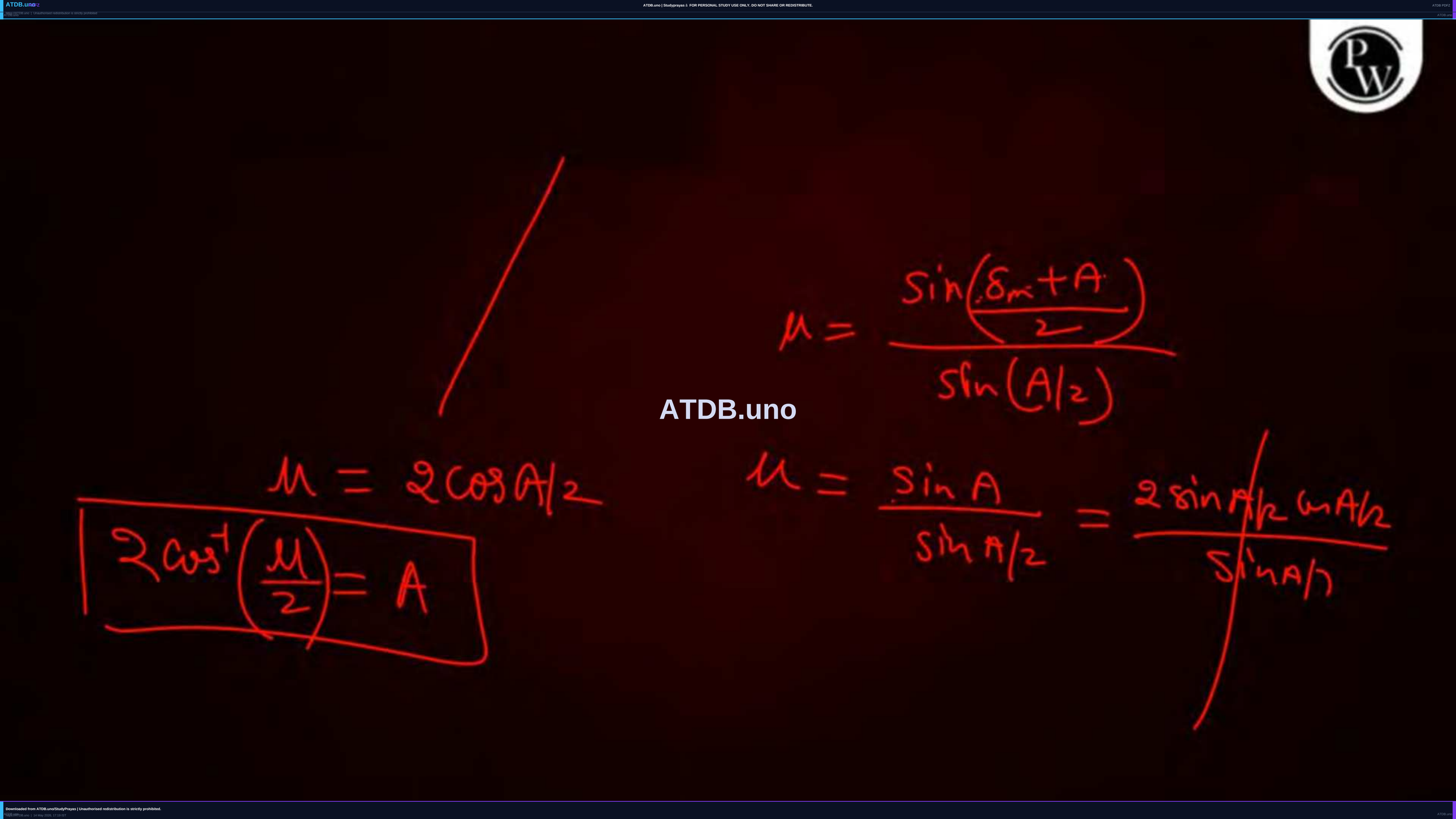
(A) न्यूनतम विचलन में आपतित कोण i_1 एवं प्रथम अपवर्तक तल के अपवर्तक कोण $r_1 = (i_1/2)$ द्वारा संबन्धित है।

(B) प्रिज्म का अपवर्तनांक μ एवं प्रिज्म कोण (A) $A = \frac{1}{2}\cos^{-1}\left(\frac{\mu}{2}\right)$ द्वारा संबंधित है।

(C) जब पहले तल पर आपतन कोण $i_1 = \sin^{-1}\left[\sin A\sqrt{4\cos^2\frac{A}{2} - 1} - \cos A\right]$ है, तब इस प्रिज्म के लिए द्वितीय तल से निर्गत किरण प्रिज्म के पृष्ठ से स्पर्शीय होगी (tangential to the emergent surface)

(D) जब प्रिज्म का आपतन कोण $i_1 = A$ है तब प्रिज्म के भीतर प्रकाश किरण प्रिज्म के आधार के समानान्तर होगी।

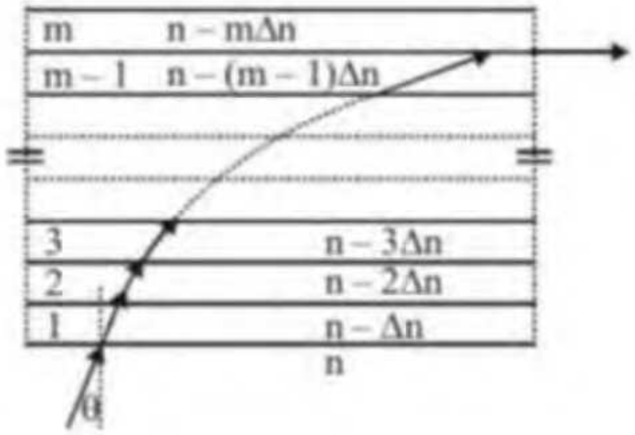
Ans. (A,C,D)



28. A monochromatic light is travelling in a medium of refractive index $n = 1.6$. It enters a stack of glass layers from the bottom side at an angle $\theta = 30°$. The interfaces of the glass layers are parallel to each other. The refractive indices of different glass layers are monotonically decreasing as $n_m = n - m\Delta n$, where n_m is the refractive index of the m^{th} slab and $\Delta n = 0.1$ (see the figure). The ray is refracted out parallel to the interface between the $(m-1)^{th}$ and m^{th} slabs from the right side of the stack. What is the value of m ?

एकवर्णी प्रकाश (monochromatic light) अपवर्तनांक $n = 1.6$ वाले माध्यम में प्रगामी है। यह प्रकाश काँच की चीती (stack of glass layers) पर निचले सतह से $\theta = 30°$ कोण पर आपतित होता है। (जैसा कि चित्र में दर्शाया गया है)। काँचों के स्तर परस्पर समांतर है। काँच के चीती के अपवर्तनांक एकदिष्ट $n_m = n - m\Delta n$ क्रम से घट रहे है। यहाँ m स्तर का अपवर्तनांक n_m है और $\Delta n = 0.1$ है। प्रकाश किरण $(m-1)^{th}$ एवं m^{th} स्तर के पृष्ठतल से समांतर दिशा में दाई ओर से बाहर निकलता है। तब m का मान होगा ?

[JEE-Advance-2017]



Ans. 8

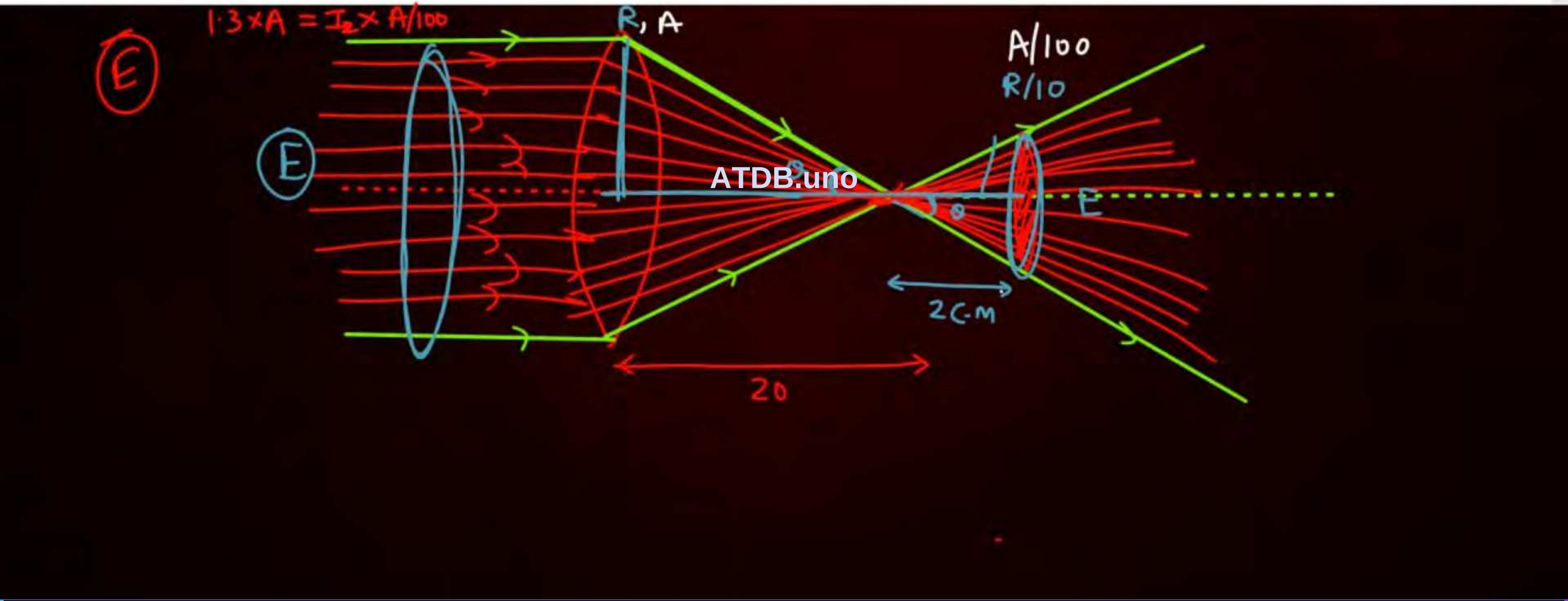
29. Sunlight of intensity 1.3 kW m^{-2} is incident normally on a thin convex lens of focal length 20 cm. Ignore the energy loss of light due to the lens and assume that the lens aperture size is much smaller than its focal length. The average intensity of light, in kW m^{-2}, at a distance 22 cm from the lens on the other side is 130.

$I_1 A_1 = I_2 A_2$

100×1.3

$I = \frac{E}{At}$

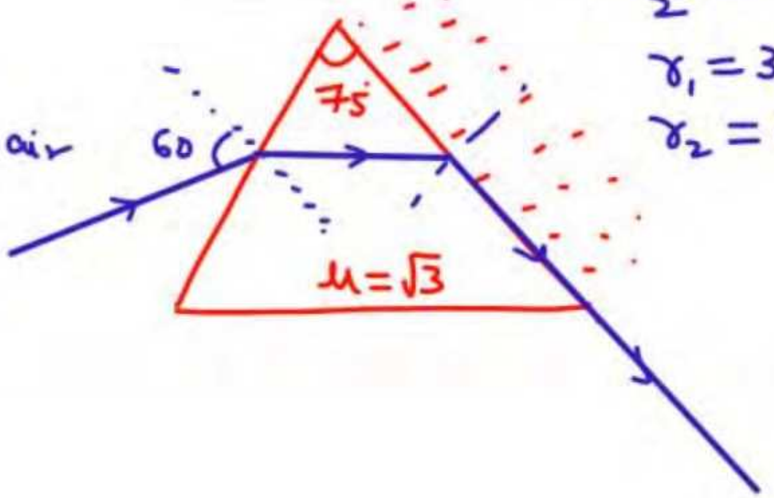
$E = IAt$



54. A monochromatic light is incident from air on a refracting surface of a prism of angle 75° and refractive index $n_0 = \sqrt{3}$. The other refracting surface of a prism is coated by a thin film of material of refractive index n as shown in figure. The light suffers total internal reflection at the coated prism surface for an incidence angle of $\theta \leq 60°$. The value of n^2 is _____.

एक प्रिज्म जिसका प्रिज्म कोण 75° तथा अपवर्तनांक $n_0 = \sqrt{3}$ है के अपवर्ती पृष्ठ पर वायु से एकवर्णी (monochromatic) प्रकाश आपतित होता है। चित्रानुसार प्रिज्म का दूसरे अपवर्ती पृष्ठ पर किसी एक पदार्थ की कलई (coating) की गयी है, जिसका अपवर्तनांक n है। आपतित कोण $\theta \leq 60°$ के लिए प्रकाश की किरण का कलई किए गए पृष्ठ पर पूर्ण आंतरिक परावर्तन होता है। n^2 का मान _____ है।

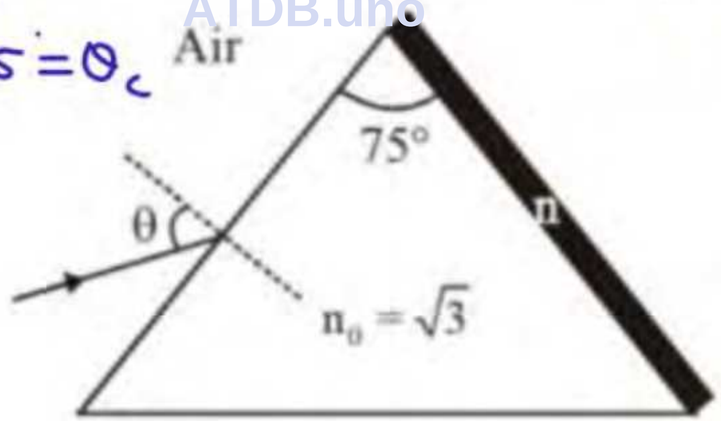
[JEE-Advance-2019]



$1 \times \frac{\sqrt{3}}{2} = \sqrt{3} \sin r_1$

$r_1 = 30$

$r_2 = 45 = \theta_c$



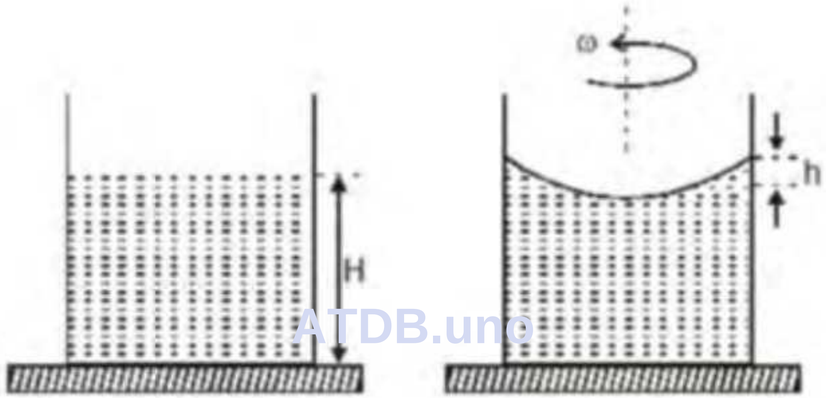
$\sin\theta_c = \sin 45 = \frac{1}{\sqrt{2}} = \frac{n}{\sqrt{3}}$

$n = \frac{\sqrt{3}}{\sqrt{2}}$

$n^2 = 3/2 = 1.5$

Ans. (1.50)

36. A beaker of radius r is filled with water (refractive index $\frac{4}{3}$) up to a height H as shown in the figure on the left. The beaker is kept on a horizontal table rotating with angular speed ω. This makes the water surface curved so that the difference in the height of water level at the center and at the circumference of the beaker is h ($h \ll H$, $h \ll r$), as shown in the figure on the right. Take this surface to be approximately spherical with a radius of curvature R. Which of the following is/are correct? (g is the acceleration due to gravity) **[JEE-Advance-2020]**



(A) $R = \frac{h^2 + r^2}{2h}$

(B) $R = \frac{3r^2}{2h}$

(C) Apparent depth of the bottom of the beaker is close to $\frac{3H}{2}\left(1+\frac{\omega^2 H}{2g}\right)^{-1}$

(D) Apparent depth of the bottom of the beaker is close to $\frac{3H}{4}\left(1+\frac{\omega^2 H}{4g}\right)^{-1}$

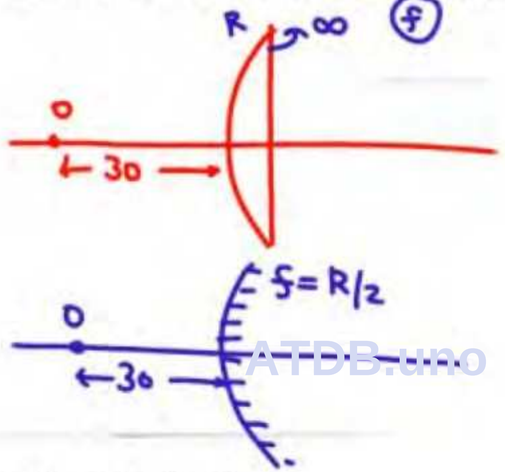
Ans. (A,D)

25. A plano-convex lens is made of a material of refractive index n. When a small object is placed 30 cm away in front of the curved surface of the lens, an image of double the size of the object is produced. Due to reflection from the convex surface of the lens, another faint image is observed at a distance of 10 cm away from the lens. Which of the following statement(s) is(are) true?

[JEE-Advance-2016]

(A) The refractive index of the lens is 2.5

(B) The radius of curvature of the convex surface is 45 cm



(C) The faint image is erect and real

(D) The focal length of the lens is 20 cm.

एक समतल-उत्तल लेंस के पदार्थ का अपवर्तनांक n है। जब एक छोटी वस्तु को लेंस के वक्रपृष्ट के सामने 30 cm की दूरी पर रखते है तो उस वस्तु की दुगुनी साइज का प्रतिबिम्ब बनता है। उत्तल पृष्ट से परावर्तन के कारण लेंस से 10 cm की दूरी पर एक क्षीण प्रतिबिम्ब भी बनता है। निम्नलिखित में से कौनसा/कौनसे कथन सत्य है/हैं?

(A) लेंस का आवर्तनांक 2.5 है।

(B) उत्तल पृष्ठ की वक्रता त्रिज्या 45 cm है।

(C) क्षीण प्रतिबिम्ब वास्तविक एवं सीधा है।

(D) लेंस की फोकस दूरी 20 cm है।