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PHYSICS

NEET and JEE Main 2020 : 45 Days Crash Course

Problem Solving Class
(Wave and Ray Optics, Optical Instruments)

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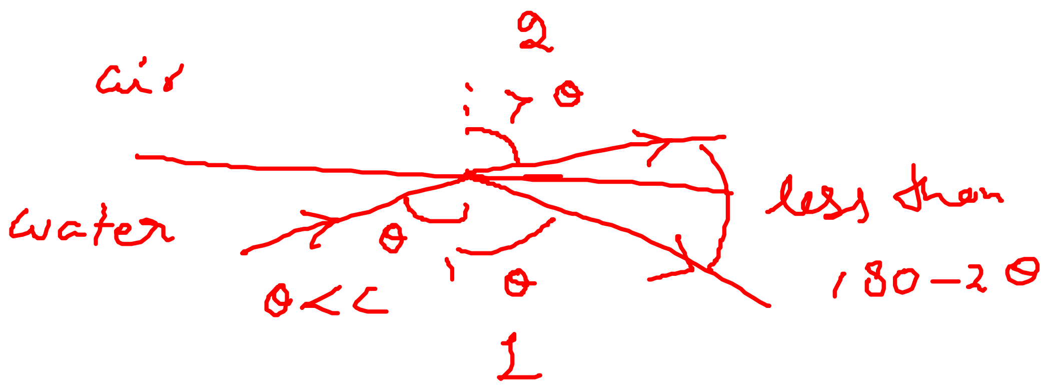
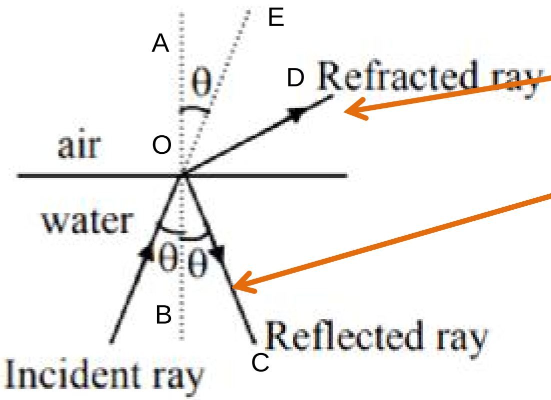
PQ27Q1

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

(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° − 2θ
(D) a reflected ray and a refracted ray and the angle between them would be greater than 180° − 2θ



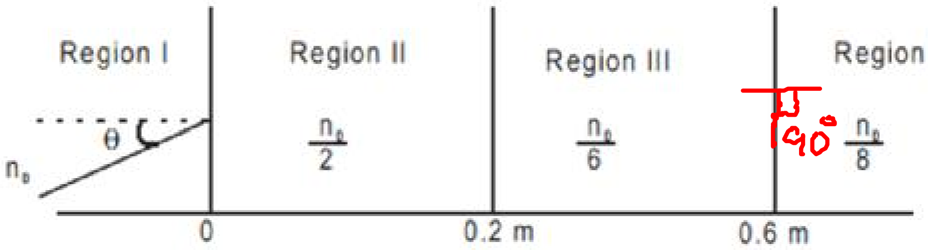
Ans [C]

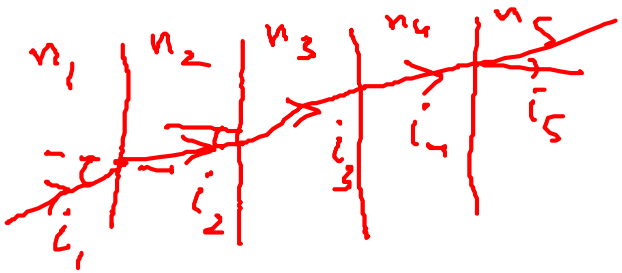


Whenever a ray travels from a denser to rarer medium a part of is reflected and some part is refracted as shown.

Looking at the figure
Sum of different angles on line AOB=180
AOE+EOD+DOC+COB=180
θ +EOD+DOC+θ=180
DOC=180-2θ-EOD
Hence,required angle is less than 180-2θ

A light beam is traveling from Region I to Region IV (Refer Figure). The refractive index in Regions I, II, III and IV are n_0, $n_0/2$, $n_0/6$ and $n_0/8$ respectively. The angle of incidence θ for which the beam just misses entering Region IV is





(A) $\sin^{-}(3/4)$

(B) $\sin^{-}(1/8)$ ✓

(C) $\sin^{-}(1/4)$

(D) $\sin^{-}(1/3)$

$n_1 \sin i_1 = n_2 \sin i_2$

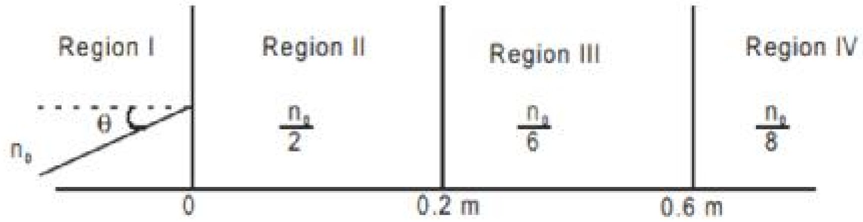
$= n_3 \sin i_3 =$

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

$\sin\theta = \frac{1}{8}$

Ans [B]

In the case of just missing to enter region IV,the angle of refraction would be 90^o when the ray crosses region III to enter IV



If the angle of incidence between Regions III and IV be ϕ ,

then $n_0/6 \sin\phi = ° \, n_0/8 \sin 90$

⇒ ϕ= Let the angle of incidence between Regions II and III be α .

$n_0/6 \sin \alpha = ° \, n_0/2 \sin \phi$

$(\sin \alpha)/3 = ° \sin \phi$

Also,

$n_o \sin\theta = n_o/2 \sin\alpha$

Hence,

$\sin\theta = (\sin\alpha)/2 = (\sin\phi)/6 = 1/8$

∴ $\theta = \sin^{-1} 1/8$

PQ27Q5

A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is 4/3. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, when the ball is 12.8 m above the water surface, the fish sees the speed of ball as

(A)9 m/s (B)12 m/s

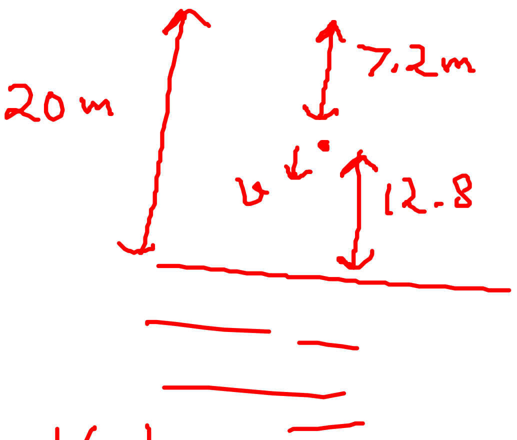
(C)16 m/s (D)21.33 m/s

12 m/s ↓

$\mu_i = 1$

$\mu_r = \frac{4}{3}$

fish



$v = \sqrt{2gh}$

$= \sqrt{2 \times 10 \times 7.2}$

$= 12$ m/s

$v' = \frac{v}{n_{rel}} = \frac{12}{1} \times \frac{4}{3} = 16$ m/s

PQ27S5

Ans [C]

For fish the ball appears to be at a greater height than its original height from surface of water.Hence,it covers more distance in same interval of time as seen by fish,so its velocity will appear to be more than original.

$v^{2=}$ 2x10x7.2 =12 ,m/s

⇒ x_{image} of ball = 4/3 x of ball

⇒ $v_{image\ of}$ ball=4/3 v of ball

Hence velocity of ball as seen by fish=4/3 x 12=16 m/s

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 m_{25}/m_{50} is

(A) 6 (B) 8

(C) 2 (D) 4

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

$m_{25} = \frac{20}{20-25} = \frac{20}{-5} = -4$

$m_{50} = \frac{20}{20-50} = \frac{20}{-30} = -\frac{2}{3}$

$\frac{m_{25}}{m_{50}} = \frac{4}{2} \times 3 = 6$

Mirror

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

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

Lens

Replace u by −u

PQ27S7

Ans [A]

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

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

$\frac{1}{v}$= $(f + u)/fu$

Magnification=v/u=$f/(f + u)$

m_{25} = 20/20-25=-4
m_{50} = 20/20-50=-2/3
Putting values of u and f in the two cases we get m_{25} /m_{50}=6

PQ27Q8

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 [illegible]

(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

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

$u = -30$

$f = -15$

$v = 30$

For 2nd refraction at lens

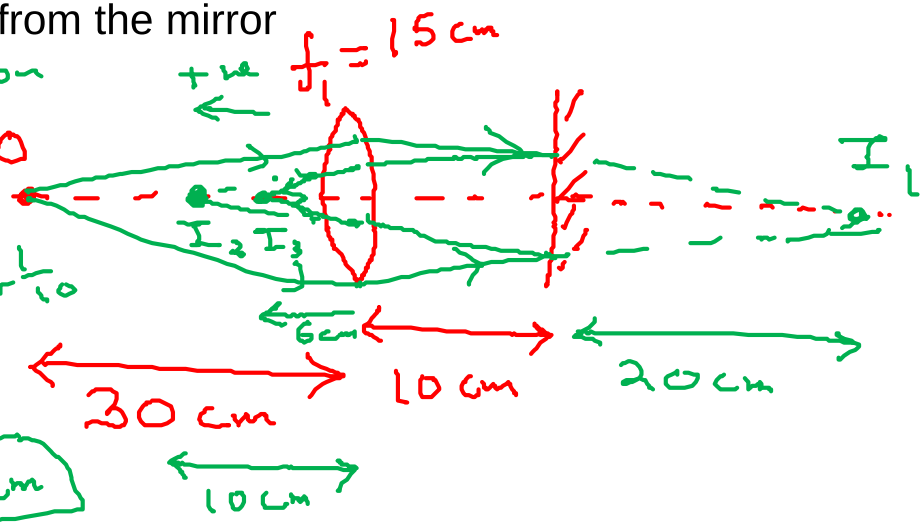
$u = 10$

$f = 15$

$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{15} + \frac{1}{10}$

$= \frac{2+3}{30}$

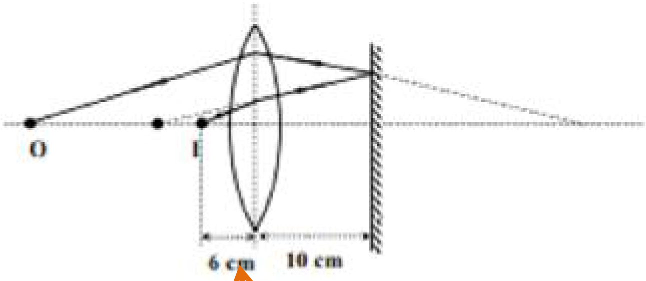
$v = 6$ cm



PQ27S8

Ans [B]

For lens : $\frac{1}{v} - \frac{1}{u} = 1/f$



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

$$\frac{1}{v} - \frac{1}{-30} = \frac{1}{15}$$

For mirror u = + 20 cm
v = – 20 cm

For lens: u=+10 cm(from right side of the lens

Again using lens formula and viewing from right side of the lens

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

v=6 cm to the left of lens

PQ27Q9

A large glass slab (μ = 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 in cm ?

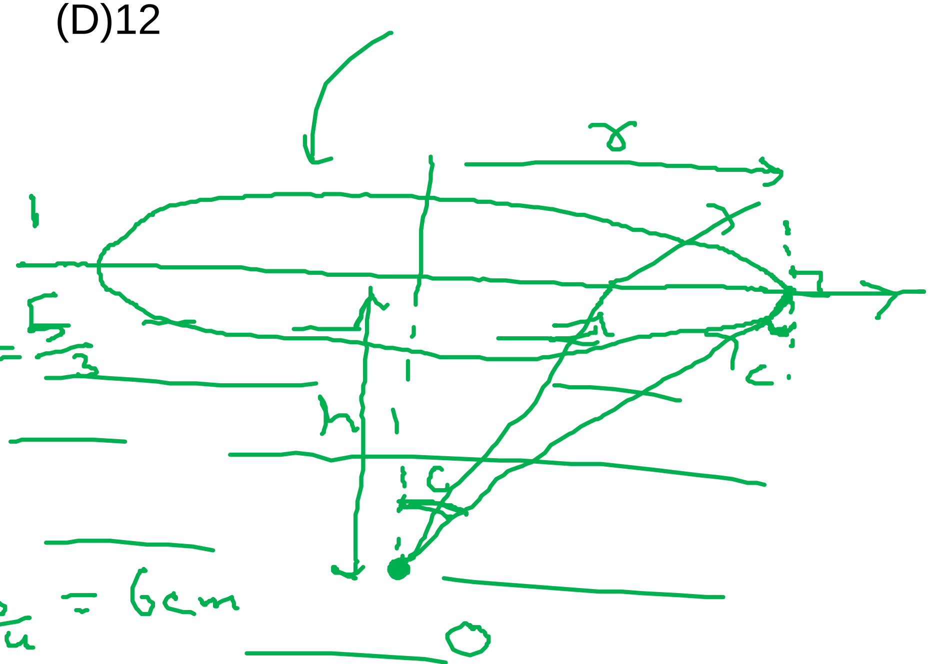
(A)6 ✓

(B)5

(C)8

(D)12

circle of illuminance



$\tan C = \frac{r}{h}$

$r = h \tan C$

$\sin C = \frac{1}{\mu} = \frac{3}{5}$

$C = 37^\circ$

$r = h \tan 37^\circ$

$= 8\,cm \times \frac{3}{4} = 6\,cm$

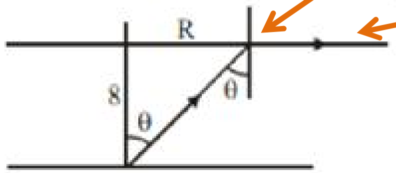
$\sin C = \frac{3}{5}$ $\tan C = \frac{3}{4}$

5 3

PQ27S9

Ans [A]

Circular area at the top will be due to total internal reflection after the angle of incidence crosses $\theta_{critical}$.



Ray grazing the surface at $\theta_{critical}$

Applying snell's law

$\sin\theta_{crirtical} / \sin 90 = 1/(5/3) = 3/5$

$\therefore \tan\theta_{critical} = 3/4$

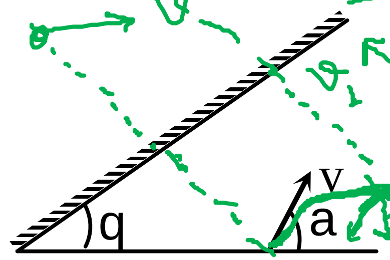
Hence,looking at the figure above,

R/8=3/4

R=6 cm

PQ27Q15

A plane mirror is inclined at an angle θ with the horizontal surface. A particle is projected with velocity v at angle α. Image of the particle is observed from the frame of the particle projected path of the image as seen by the particle is



(A) parabolic path

(B) straight line

(C) circular path

(D) helical path

PQ27S15

Ans [C]

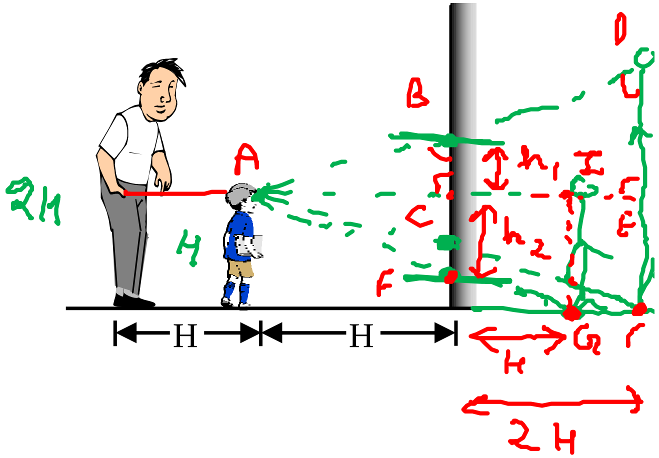
At any instant velocity of particle can be resolved in two components, one parallel and other perpendicular to it. Parallel components of particle velocity and image velocity are identical and hence the path of light is straight line perpendicular to mirror.

PQ27Q16

A child is standing in front of a straight plane mirror. His father is standing behind him, as shown in the fig. The height of the father is double the height of the child. What is the minimum length of the mirror required so that the child can completely see his own image and his father's image in the mirror? Given that height of the father is 2H.

(A) H/2 (B) 5H/6

(C) 3H/2 (D) None



$\Delta ABC \sim \Delta ADE$

$\frac{h_1}{H} = \frac{H}{3H} \Rightarrow h_1 = \frac{H}{3}$

$\Delta ACF \sim \Delta AIG$

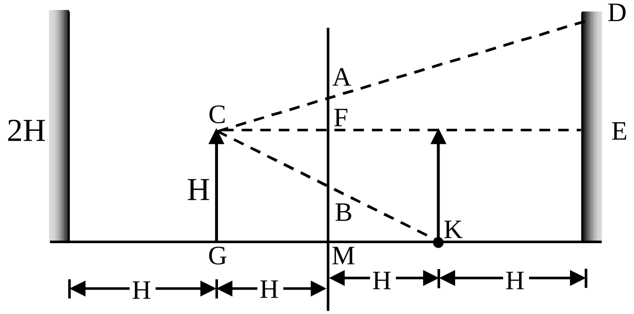
$\frac{h_2}{H} = \frac{H}{2H} \Rightarrow h_2 = \frac{H}{2}$

$h_1 + h_2 = \frac{H}{3} + \frac{H}{2}$

$= 5H/6$

Ans [B]

AB is the required size of mirror



ΔAFC & CDE similar triangle

$$\frac{DE}{AF} = \frac{CE}{CF} \qquad AF = \frac{CF \times DE}{CE} = \frac{H \times H}{3H} = \frac{H}{3}$$

ΔCKG & BMK similar Δ

$$\therefore \frac{CG}{GK} = \frac{BM}{MK} \Rightarrow BM = \frac{CG \times GM}{MK} = \frac{H \times H}{2H} = \frac{H}{2}$$

size of mirror = AB= AF + FB= $\frac{H}{3}$+ (FM – BM)

$$= \frac{H}{3} + H - \frac{H}{2} = H\left[\frac{1}{2} + \frac{1}{3}\right] = \frac{5H}{6}$$

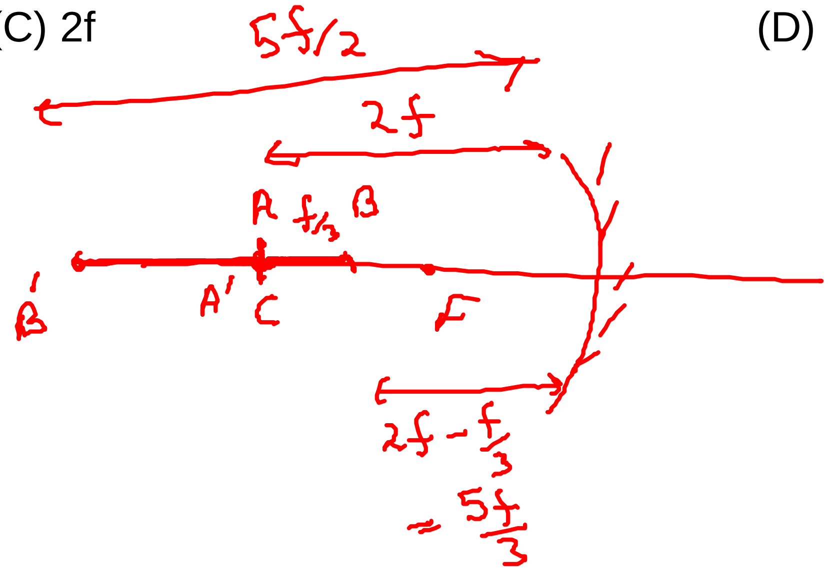
A thin rod of length $\frac{f}{3}$ lies along the axis of a concave mirror of focal length f. One end of its magnified image touches an end of the rod, the length of the image is

(A) f

(B) f/2

(C) 2f

(D) f/4



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

$$\frac{1}{v} - \frac{3}{5f} = -\frac{1}{f}$$

$$\frac{1}{v} = \frac{3}{5f} - \frac{1}{f}$$

$$= \frac{3-5}{5f}$$

$$v = -\frac{5f}{2}$$

$$\text{Size} = \frac{5f}{2} - 2f = f/2$$

PQ27S21

Ans [B]

Find image distance of both ends of the rod and their difference would give size of the image

$u_1 = v_1 = 2f \quad -\text{(i)}$

$$u_2 = -\left(2f - \frac{f}{3}\right) = -\frac{5f}{3}$$

$v_2 = ?\ f = -f$

by mirror formula

$$\frac{1}{v_2} = \frac{1}{f} - \frac{1}{u_2} = \frac{1}{-f} + \frac{3}{5f} = -\frac{2}{5f}$$

$$v_2 = -\frac{5f}{2}$$

Size of image = $|v_2| - |v_1|$

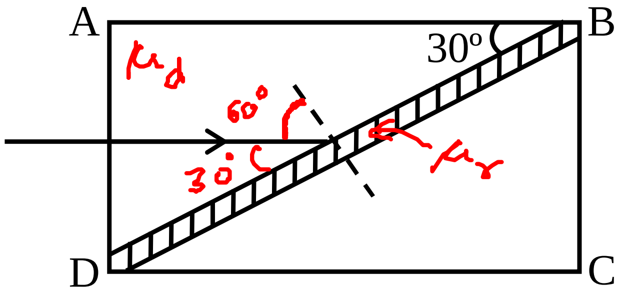
$$= \frac{5f}{2} - 2f = \frac{f}{2}$$

PQ27Q24

Two right–angled 30º–60º–90º glass prisms are cemented along the hypotenuse by Canada balsam, where μ = 1.632. What should be the minimum refractive index of the material of the prisms so that the ray passing through one end may be totally reflected?

(A) 1.88 (B) 1.5

(C) 1.66 (D) 1.33



Ans [A]

The angle of incidence on the layer is 60º, So the ray is totally reflected if $60^\circ\ ^{3}\ C$, where C is the critical angle for glass balsam surface.

$$\sin 60^\circ\ ^{3}\ \sin C \text{ or } \frac{\sqrt{3}}{2}\ ^{3}\ \sin C$$

$$\frac{\sqrt{3}}{2}\ ^{3}\ \frac{1.632}{m}$$

$$\mu\ ^{3}\ 1.88$$

$$\mu_{min} = 1.88$$

At critical angle of incidence, θ_c angle of refraction is 90º and $\sin\theta_c = 1/\mu$

PQ27Q29

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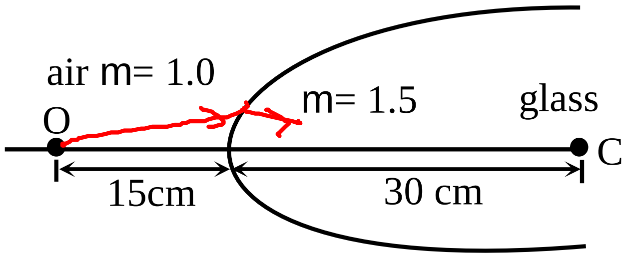
The point C denotes the centre of curvature of the curved surface of refractive index 1.5. An object O is placed in air at a distance of 15 cm. Location of the image will be



(A) – 30cm (B)+30cm

(C) – 20cm (D)+20cm

$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

$n_1 = 1$, $n_2 = 3/2$, $u = -15$, $v = ?$, $R = 30$

$\frac{3}{2v} + \frac{1}{15} = \frac{1/2}{30}$

$\frac{3}{2v} = \frac{1}{60} - \frac{1}{15} = \frac{1-4}{60}$

$\frac{3}{2v} = -\frac{1}{20}$

$v = -30\text{ cm}$

PQ27S29

Ans [A]

Using the formula,

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

Here $u = -15$ cm, $R = +30$ cm, $\mu_1 = 1$

and $\mu_2 = 1.5$

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{1.5}{v} - \frac{1}{-15} = \frac{1.5-1}{R}$$

$$\Rightarrow \frac{1.5}{v} + \frac{1}{15} = \frac{0.5}{30} = \frac{1}{60}$$

$$\Rightarrow \frac{1.5}{v} = \frac{1}{60} - \frac{1}{15}$$

$$\Rightarrow v = -20 \times 1.5 = -30 \text{ cm}$$

So image is formed 30 cm left to the spherical surface and is virtual erect.

PQ27Q34

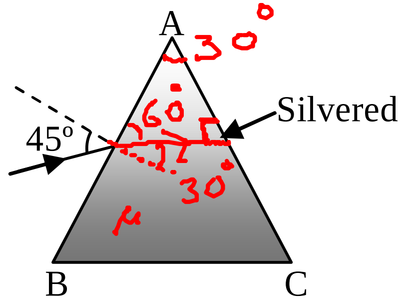
A prism ABC of angle 30º has its face AC silvered. A ray of light incident at an angle of 45º at the face AB retraces its path after refraction at face AB and reflection at face AC. The refractive index of the material of the prism is

(A) 1.5

(B) $\frac{3}{\sqrt{2}}$

(C) $\sqrt{2}$

(D) $\frac{4}{3}$



$1 \sin 45^\circ = \mu \sin 30^\circ$

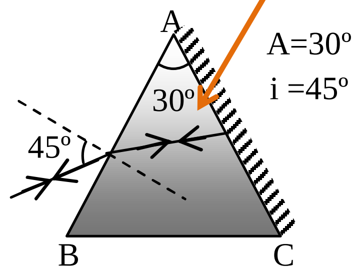
$\frac{1}{\sqrt{2}} = \mu \times \frac{1}{2}$

$\mu = \frac{2}{\sqrt{2}} = \sqrt{2}$

Ans [C]

$r_1+r_2=A$
$A=30^o$

Since,ray retraces its path angle of incidence on the polished surface=0
$r_2=0$
$r_1=30^o$



For 2nd surface

$C=0 \Rightarrow r_2=0$

$r_1+r_2=A$

$r_1=30^o$

$$\mu=\frac{\sin i}{\sin r_1}=\frac{\sin 45^\circ}{\sin 30^\circ}$$

$$\boxed{\mu=\sqrt{2}}$$

Finally using snell's law

PQ27Q51

A girl stands at a distance 30 cm from the mirror. She is able to see her erect image but of 1/5 height of actual height. The mirror will be :

(A) Plane mirror

(B) Concave mirror

(C) Convex mirror

(D) Plane convex mirror

PQ27S51

Ans [C]

Small and erect image is formed only by convex mirror. Plane mirror from images equal to object and concave mirror form images bigger than object.

Concave mirror forms erect virtual image if the object is placed between focus and the pole
This image is larger in size than the object

P-Q2901

Maximum intensity in $YDSE$ is $\boldsymbol{I_0}$. Find the intensity at a point on the screen where the path difference between them is $\frac{\lambda}{4}$

$A)\ I_0$

B) $\frac{I_0}{2}$

C) $2I_0$

D) $\frac{I_0}{4}$

$\Delta\phi = K\Delta x = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{4} = \pi/2$

$I = 4I_0 \cos^2\frac{\Delta\phi}{2}$

$I = I_0 \cos^2\frac{\Delta\phi}{2}$

$= I_0 \cos^2\frac{\pi}{4} \Rightarrow I_0\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I_0}{2}$

P-Q2901-Solution

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Ans [B]

Phase difference corresponding to the given path difference $\Delta x = \frac{\lambda}{4}$

$$\phi = \frac{2\pi}{\lambda}\Delta x$$

Phase difference from path difference

$$\phi = \left(\frac{2\pi}{\lambda}\right)\left(\frac{\lambda}{4}\right)$$

$$= \frac{\pi}{2}$$

Or $\frac{\phi}{2} = \frac{\pi}{4}$

Maximum intensity at phase difference / 2

$$I = I_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$$

P-Q2902

Bichromatic light is used in $YDSE$ having wavelengths $\boldsymbol{\lambda_1} = \mathbf{400}\boldsymbol{nm}\ and\ \boldsymbol{\lambda_2} = \mathbf{700}\boldsymbol{nm}$.

Find minimum order of λ_1 which will overlaps with $\boldsymbol{\lambda_2}$

A) 5 B) 7

C) 6 D) 14

$\beta = \frac{\lambda D}{d}$

$\beta \propto \lambda$

×7 ×4

2800 nm

7^{th} max. of λ_1 coincides with 4^{th} max. of λ_2

P-Q2902-Solution

Ans [B]

Let $\boldsymbol{n_1}$ bright fringe of $\boldsymbol{\lambda_1}$ overlaps with $\boldsymbol{n_2}$ bright fringe of $\boldsymbol{\lambda_2}$

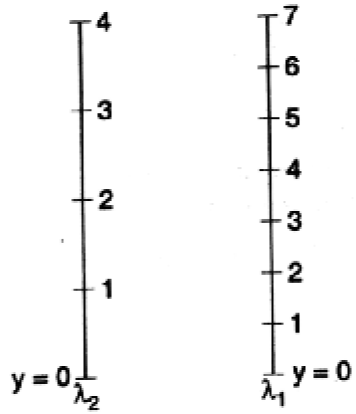
$$\frac{n_1\lambda_1 D}{d} = \frac{n_2\lambda_2 D}{d}$$

Both will overlap when bright fringes have equal distance

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{700}{400} = \frac{7}{4}$$

$\boldsymbol{\lambda_1 < \lambda_2}$

$\boldsymbol{\omega_1 < \omega_2}$



The ratio $\frac{n_1}{n_2} = \frac{7}{4}$ implies that 7^{th} bright fringe of λ_1 will overlap with 4^{th} bright fringe of λ_2. Similarly 14^{th} of λ_1 will overlap with 8^{th} of λ_2 and so on.

So the minimum order of λ_1 which overlaps with λ_2 is 7.

P-Q2921

Two coherent monochromatic light beams of intensities I and $4I$ are superposed.

The **maximum** and **minimum** possible intensities in the resulting beam are

(A) $5I$ and I (B) $5I$ and $3I$

(C) $9I$ and I (D) $9I$ and $3I$

$$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2} = \frac{(1+2)^2}{(1-2)^2} = \left(\frac{3}{1}\right)^2$$

$= 9 : 1$

P-Q2921-Solution

Ans [C]

$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2 = (\sqrt{I} + \sqrt{4I})^2 = 9I$$

$$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2 = (\sqrt{I} - \sqrt{4I})^2 = I$$

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\varphi$$

I *will be maximum if* $\varphi = 0$ *and minimum if* $\varphi = 180°$

Wavelength of light of frequency 100*Hz*

(A) $2 \times 10^{6} m$

(B) $3 \times 10^{6} m$

(C) $4 \times 10^{6} m$

(D) $5 \times 10^{6} m$

$v = f\lambda$

$\lambda = \frac{3 \times 10^{8}}{100}$

$= 3 \times 10^{6} m$

P-Q2925-Solution

Ans [B]

$$\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{100} = 3 \times 10^6 m$$

Relation between wavelength, frequency and velocity

$$v = f\lambda$$

Monochromatic green light of wavelength $5 \times 10^{-7} m$ illuminates a pair of slits 1 mm apart. The separation of bright lines on the interference pattern formed on a screen 2 m away is

(A) 0.25 mm

(B) 0.1 mm

(C) 1.0 mm

(D) 0.01 mm

$$\beta = \frac{\lambda D}{d} = \frac{5 \times 10^{-7} \times 2}{10^{-3}}$$

$$= 10 \times 10^{-4}$$

$$= 10^{-3} m$$

$$= 1 mm$$

P-Q2936-Solution

Ans [C]

$$\beta = \frac{\lambda D}{d} = \frac{5 \times 10^{-7} \times 2}{10^{-3}} m = 10^{-3} m = 1.0\ mm$$

$$Separation\ of\ bright\ lines(\beta) = Y_2 - Y_1 = \frac{(n+1)\lambda D}{d} - \frac{n\lambda D}{d} = \frac{\lambda D}{d}$$

P-Q2938

In a certain double slit experimental arrangement interference fringes of width **1.0 mm** each are observed when light of wavelength **5000 Å** is used. Keeping the set up unaltered, if the source is replaced by another source of wavelength **6000 Å**, the fringe width will be

(A) 0.5 mm (B) 1.0 mm

(C) 1.2 mm (D) 1.5 mm

$$\beta = \frac{\lambda D}{d}$$

$$\beta \propto \lambda$$

$$\frac{\beta_2}{\beta_1} = \frac{\lambda_2}{\lambda_1}$$

$$\frac{\beta_2}{1\,mm} = \frac{6000}{5000}$$

$$\beta_2 = 1.2\,mm$$

P-Q2938-Solution

Ans [C]

$$\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$$

$$Fringe\ width = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda$$

Or $\frac{1.0}{\beta_2} = \frac{5000}{6000}$

Or $\beta_2 = \frac{6000}{5000} = 1.2\ mm$.

P-Question

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An unpolarised beam of intensity I_0 is incident on a pair of nicol prisms making an angle of 60º with each other. The intensity of light emerging from the pair is -

(A) I_0 (B) $I_0/2$

(C) $I_0/4$ ~~(D) $I_0/8$~~

$$\frac{I_0}{2}\cos 60^\circ \cdot \cos 60^\circ$$

$$\frac{I_0}{2} \times \frac{1}{4} = \frac{I_0}{8}$$

Ans [D]

$$\frac{I_0}{2}\cos^2 60° = \frac{I_0}{8}$$

P-Question

The angle of polarisation for any medium is 60º, what will be critical angle for this –

(A) $\sin^{-1}\sqrt{3}$

(B) $\tan^{-1}\sqrt{3}$

(C) $\cos^{-1}\sqrt{3}$

(D) $\sin^{-1}\dfrac{1}{\sqrt{3}}$

$$\mu = \tan\theta_p = \sqrt{3}$$

$$\sin C = \frac{1}{\mu} = \frac{1}{\sqrt{3}}$$

$$C = \sin^{-1}\left(1/\sqrt{3}\right)$$

Ans [D]

$$\mu = \tan\theta_p \Rightarrow \mu = \tan 60^\circ = \sqrt{3}$$

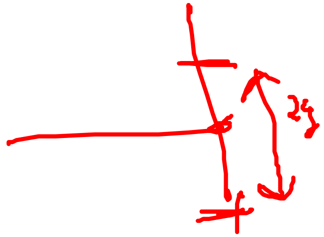
$$\Rightarrow \frac{1}{\sin c} = \sqrt{3} \; ; \; c = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

P-Question

A beam of light of wavelength 600 nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2m away. The distance between the first dark fringes on either side of the central bright fringe is -

(A) 1.2 cm (B) 1.2 mm

(C) 2.4 cm (D) 2.4 mm



$a \sin\theta = n\lambda$

$a \sin\theta = \lambda$

$a \cdot \frac{y}{D} = \lambda$

$y = \frac{\lambda D}{a}$

$= \frac{600 \times 10^{-9} \times 2}{10^{-3}}$

$= 12 \times 10^{-4}$ m

$= 1.2$ mm

2.4 mm Ans

P-Solution

Ans [D]

$$\frac{2D\lambda}{a} = \frac{2 \times 600 \times 10^{-9} \times 2}{10^{-3}}$$

$$= 2.4 \times 10^{-3}\ \text{m} = 2.4\text{mm}$$