PHYSICS

The following question given below consist of an "Assertion" (A) and "Reason" (R) Type questions. Use the following Key to choose the appropriate answer.

(A) If both (A) and (R) are true, and (R) is the correct explanation of (A).

(B) If both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) If (A) is true but (R) is false.

(D) If (A) is false but (R) is true.

Q.1 **Assertion** : Critical angle of the light passing from glass to air is minimum for violet colour.

Reason : The wavelength of violet light is greater than the light of other colours **[C]**

Q.2 **Assertion** : The frequencies of incident, reflected and refracted beam of monochromatic light incident from one medium to another are same.

Reason : The incident, reflected and refracted rays are coplanar. **B]**

Q.3 **Assertion** : If refractive index of one medium is equal to refractive index of second medium then beam does not bend at all.

Reason : The bending of light does not depend on refractive indices of media. **[C]**

Q.4 **Assertion** : In going from a denser to a rarer medium a ray of light bends away from normal.

Reason : This occurs because light travels faster in a rarer medium than in a denser medium.

[A]

Q. 5 **Assertion :** If a plane glass slab is placed on the letters of different colours all the letters appear to be raised up to the same height.

Reason : Different colours have different wavelengths. **[D]**

Q.6 **Assertion :** The frequencies of incident, reflected and refracted beam of monochromatic light incident from one medium to another one same.

Reason : incident, reflected ray and refracted rays are coplanar. **[C]**

Q.7 **Assertion :** A fish inside a pond will see a person standing outside, taller than be is actually.

Reason : Light bends away from the normal as it enters water from air. **[C]**

Q. 8 **Assertion :** When a ray of light enters glass from air, its frequency decreases.

Reason : The velocity of light in glass is less than that in air. **[A]**

Sol. [A] When light goes from one medium to another , its frequency remains unchanged.

Q. 9 **Assertion :** Even in absolutely clear water, a diver cannot see very clearly.

Reason : Velocity of light is reduced in water.

Sol. **[B]**

A – True

R – True. Not correct explanation

Q.10 **Assertion :** There is no dispersion of light refracted through a rectangular glass slab.

Reason : Dispersion of light is the phenomenon of splitting of a beam of white light into its constituent colours.

Sol. **[B]**

After refraction at two parallel faces of a glass slab, a ray of light emerges in a direction parallel to the direction of incidence of white light on the slab. As rays of all colours emerge in the same direction (of incidence of white light), hence there is no dispersion, but only lateral displacement.

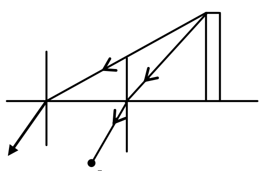
Q.11 **Assertion :** The frequencies of incident, reflected and refracted beam of monochromatic light incident form one medium to another are same.

Reason : The incident, reflected and refracted rays are coplanar. **[C]**

Q.12 **Assertion :** A fish inside a pond will see a person standing outside taller than he is actually.

Reason : Light rays from person converges into eyes of fish on entering water from air. **[C]**

Sol.



Fish

Q.13 **Assertion :** Optical fibre has thin glass core coated by glass of small refractive index and is used to send light signals.

Reason : All the rays of light entering the fibre are totally reflected even at very small angles of incidence. **[C]**

Sol. Angle of incidence at any location should be greater than critical angle.

Q.14 **Assertion :** A parallel beam of light traveling in air can be displaced laterally by a parallel transparent slab by distance more than the thickness of the plate.

Reason : The lateral displacement of light traveling in air increases with rise in value of refractive index of slab. **[D]**

Sol. $t \sin i \left(1 - \frac{1}{\mu}\right) < t$

Q.15 **Statement-I :** The sun is visible to us before actual sun-rise and after actual sun-set.

Statement-II : The density of air is small near the surface of earth as compared to higher altitudes.

Sol. **[D]**

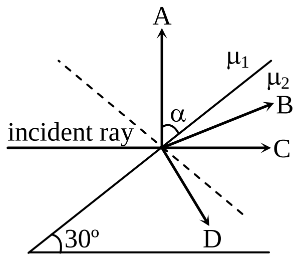
Q.16 **Statement-I :** If a plane glass slab is placed on the letters of different colours all the letters appear to be raised up to the same height.

Statement-II : Different colours have different wavelengths.

Sol. **[D]**

PHYSICS

Q.1



Column I	**Column II**
(A) Which ray is not possible	(P) A
(B) $\frac{\mu_1}{\mu_2} > \frac{2}{\sqrt{3}}$	(Q) B
(C) $\frac{\mu_1}{\mu_2} \le 1$	(R) C
(D) $\frac{\mu_1}{\mu_2} \ge 1$	(S) D

[(A) → S, (B) → P, (C) → R, (D) → P,Q,R]

Q.2 If (μ_1, λ_1, v_1) and (μ_2, λ_2, v_2) are the refractive indices, wavelengths and speeds of two light waves respectively, then match the entries of column I with the entries of column II.

Column I	**Column II**
(A) $\mu_1 > \mu_2$	(P) $v_1 < v_2$
(B) $\mu_1 < \mu_2$	(Q) $v_1 > v_2$
(C) $\mu_1 \neq \mu_2$	(R) $\lambda_1 = \lambda_2$
(D) $\mu_1 = \mu_2$	(S) $\lambda_1 < \lambda_2$

[(A) → P,S, (B) → Q, (C) → P, S (D) → R]

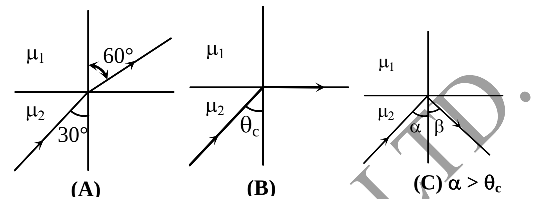
Q.3

Column I	**Column II**
(A) In refraction	(P) Speed of wave does not change.
(B) In reflection	(Q) wavelength must be decreased
(C) In refraction form a rarer to a denser medium	(R) frequency does not change
(D) In reflection from denser medium	(S) Phase change of π must takes place.

Sol. **A → R, B → P, R C → Q, R D → P, R, S**

conecptual

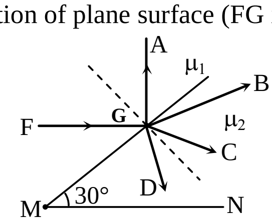
Q.4



Column I	**Column II**
(A) θ_c	(P) 45°
(B) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$	(Q)Critical angle
(C) Refractive index of 1 with respect to 2	(R) $\left(\frac{1}{\sqrt{3}}\right)$
(D) Total internal reflection	(S) $\alpha = \beta$

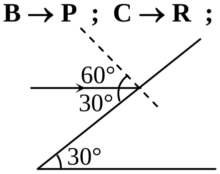
Ans. **A → Q; B → Q; C → R ; D → Q,S**

Q.5 Refraction of plane surface (FG is parallel to MN)



Column I	**Column II**
(A) Which ray is not possible	(P) A
(B) $\frac{\mu_1}{\mu_2} > \frac{2}{\sqrt{3}}$	(Q) B
(C) $\frac{\mu_1}{\mu_2} \le 1$	(R) C
(D) $\frac{\mu_1}{\mu_2} \ge 1$	(S) D

Sol. **A → S ; B → P ; C → R ; D → P,Q**



If $\frac{\mu_1}{\mu_2} < 1$ i.e. ray is going from Rarer to denser medium

$\therefore$ Ray will come closer to normal.

$60° > \theta_c$

$\sin 60° > \sin \theta_c$

$$\frac{\sqrt{3}}{2} > \frac{\mu_2}{\mu_1} \Rightarrow \frac{\mu_1}{\mu_2} > \frac{2}{\sqrt{3}}$$

Q.6 Light rays are incident on devices which may cause either reflection or refraction both. The natures of the incident light and the devices are described in column I. Some possible results of this on the rays are given in column II.

Column-I	**Column-II**
(A) A ray of white light is incident on one face of an equilateral prism.	(P) Divergent beam
(B) A ray of white light is incident at an angle on a thick glass sheet.	(Q) Total internal reflection
(C) A ray of white light passes from optically denser medium to rarer medium.	(R) Lateral shift
(D) A parallel beam of monochromatic light passes symmetrically through a glass lens.	(S) Dispersion

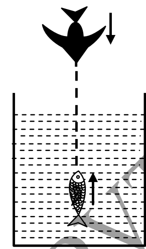
Sol. A→ P, R B→ S C→P, S D→ Q,R

Q.7 Light rays are incident on devices which may cause either reflection or refraction or both. The natures of the incident light and the devices are described in column –I. Some possible results of this on the rays are given in column-II.

Column - I	**Column - II**
(A) A ray of white light is incident on one face of an equivalent glass prism	(P) Divergent beam
(B) A ray of white light is incident at an angle on a thick glass sheet.	(Q) Total internal reflection
(C) A ray of white light passes from an optically denser medium to an optically rarer medium	(R) Lateral shift
(D) A parallel beam of monochromatic light passes symmetrically through a glass lens	(S) Dispersion

Sol. **A → P,Q,S** **B → R**
C → P,Q,S **D → P, Q**

Q.8 A bird in air is diving vertically over a tank with speed 6cm/sec. Base of tank is silvered. A fish in the tank is rising upward along the same line with 4cm/sec.



Column I	**Column II**
(A) Speed of image of fish as seen by the bird directly	(P) 12
(B) Speed of image of fish after reflection	(Q) 4
(C) Speed of image of bird relative to the fish looking upwards	(R) 9
(D) Speed of image of bird relative to the fish looking downwards in the mirror	(S) 3

Sol. [A → R ; B → S ; C → P ; D → Q]

Q.1 A ray of white light passes through a rectangular glass slab, entering and emerging at parallel faces. The angle of incidence, measured from the normal to the glass surface is large -

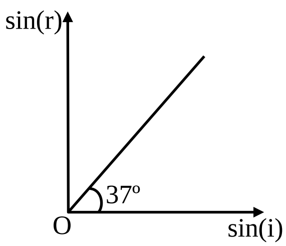
(A) White light will emerge from the slab

(B) The light emerging from the slab will have a number of parallel, coloured rays

(C) The emergent rays will not form a spectrum on a screen

(D) Colours will be seen if the emergent rays enter the eye directly **[A,C]**

Q.2 A ray of light, travelling in medium A, is incident on plane interface of two media A and B and gets refracted into medium B. The angle of incidence is i and that of refraction is r. Graph between sin(i) and sin(r) is as shown in figure. Which of the following statements is/are correct ?



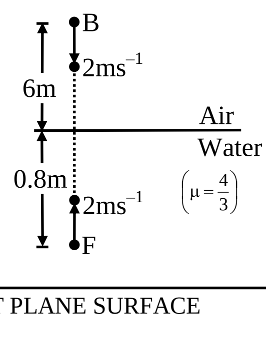
(A) Speed of light in medium B is three fourth of that in medium A

(B) Total internal reflection cannot take place

(C) Refraction index of medium A is greater than that of medium B

(D) None of these **[A,B]**

Q.3 A fish, F in the pond is at a depth of 0.8m from water surface and is moving vertically upwards with velocity 2 ms^{-1}. At the same instant a bird B is at a height of 6m from water surface and is moving downwards with velocity 3ms^{-1}. At this instant both are on the same vertical line as shown in figure. Which of the following statements is/are correct -



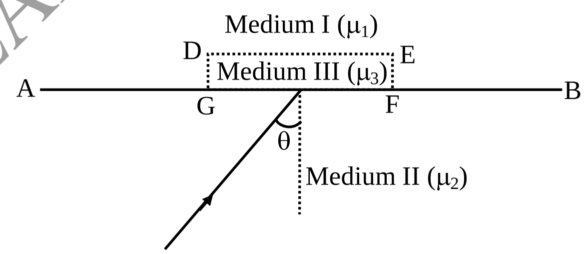
(A) Height of B, observed by F(from itself) is equal to 5.30 m

(B) Depth of F, observed by B(from itself) is equal to 6.60m

(C) Height of B, observed by F (from itself) is equal to 8.80 m

(D) None of these **[B,C]**

Q.4 Monochromatic light is incident on plane interface AB between two media of refractive indices μ_1 and μ_2 ($\mu_2 > \mu_1$) at angle θ shown in figure. The angle θ is infinitesimally greater than the critical angle for two media so that total internal reflection takes place. Now, if a transparent slab DEFG of uniform thickness and having refractive index μ_3 is introduced on the interface as shown in the figure, which of the following statements is/are correct ?



(A) If $\mu_3 < \mu_1$, total internal reflection will take place at face GF

(B) If $\mu_3 > \mu_1$, light will refract into the slab

(C) If $\mu_3 > \mu_1$, total internal reflection will take place at face DE

(D) Light can not be transmitted to medium I

[A,B,C,D]

Q.5 A ray of light travelling in a transparent medium falls on a surface separating the medium from air, at an angle of incidence of 45º. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible value(s) of n from the following -

(A) 1.3 (B) 1.4

(C) 1.5 (D) 1.6 **[C,D]**

Q.6 A ray of light passes from a denser to a rarer medium. At the surface of separation the angle of incidence is i and the angle between reflected and refracted rays is of 90º. If the angles of reflection and refraction are r and r' respectively, then the value of the critical angle is -

(A) $\sin^{-1}(\tan r')$ (B) $\sin^{-1}(\tan r)$
(C) $\sin^{-1}(\tan i)$ (D) $\tan^{-1}(\sin i)$ **[B,C]**

Q.7 When a beam of light with wavelength λ = 6000 Å, travelling in air, enters a glass medium whose refractive index is 1.5, then -

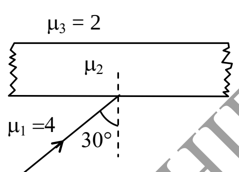
(A) frequency of light remains constant
(B) velocity of light increases to 1.5 times
(C) frequency of light increases to 1.5 times
(D) wavelength (λ) of light decreases to 1.5 times

[A,D]

Q.8 A ray of light travelling in a transparent medium falls on a surface separating the medium from air at an angle of incidence of 45°. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible value(s) of n from the following : **[IIT-JEE 1992]**

(A) 1.3 (B) 1.4
(C) 1.5 (D) 1.6 **[C,D]**

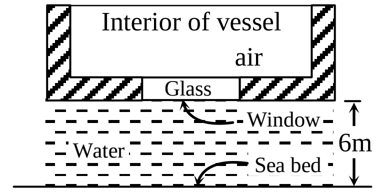
Q.9 A ray of light is incident in situation as shown in figure which of the following statement is/are true?



I If $\mu_2 > 2$ then angle of deviation is 60°
II If $\mu_2 < 2$ then angle of deviation is 60°
III If $\mu_2 < 2$ then angle of deviation is 120°
IV If $\mu_2 > 2$ the angle of deviation is zero

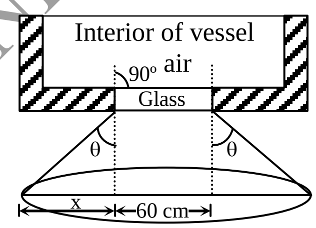
(A) I (B) II
(C) III (D) IV **[A,C]**

Q.10 A research vessel has a round glass window in bottom for observing the seabed. The diameter of the glass window is 60 cm, the thickness of the glass is 20 mm and the index of refraction of water is 1.33 and that of the glass is 1.55. The seabed is 6.0 m beneath the window. A man in interior of vessel can see seabed through window.



(A) Area of seabed that can be seen through the window is 40 m^2 (Approx)
(B) Viewable area of seabed from interior of vessel will increases as thickness of glass of window increases
(C) Viewable area of seabed from interior of vessel is independent of thickness of glass of window
(D) Area of seabed that can be seen through window is 160 m^2 (Approx)

Sol. **[C,D]**



Snell law

$1.33 \sin\theta = 1 \times \sin 90º$

$\sin\theta = \dfrac{1}{1.33} = \dfrac{3}{4}$

$x = 6 \tan\theta$

$x = 6 \times \dfrac{3}{\sqrt{7}} = 6.8$

Radius of viewable area = $\pi[6.8 + 0.3]^2$

$= 160 m^2$ approx

Q.11 In passing through a boundary refraction will not take place if -

(A) light is incident normally on the boundary
(B) the indices of refraction of the two media are same
(C) the boundary is not visible
(D) angle of incidence is lesser than angle of refraction but greater then $\sin^{-1}\left(\dfrac{\mu_R}{\mu_D}\right)$

[A,B,C,D]

Q.12 Monochromatic light is incident on a plane interface AB between two media of refractive indices μ_1 and μ_2 ($\mu_2 > \mu_1$) at an angle θ as shown in figure. The angle θ is infinitesimally greater than the critical angle for two media so that total internal reflection takes place. Now, if a transparent slab DEFG of uniform thickness and having refractive index μ_3 is introduced on the interface as shown in the figure (a). Which of the following statements are correct ?

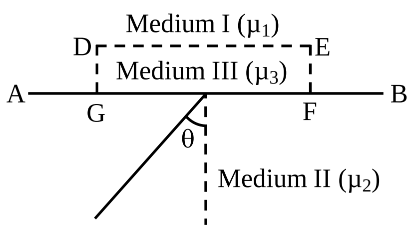


Fig. (a)

(A) If $\mu_3 < \mu_1$, total internal reflection will take place at face GF

(B) If $\mu_3 > \mu_1$, light will refract into the slab

(C) If $\mu_3 > \mu_1$, total internal reflection will take place at face DE

(D) Light cannot be transmitted to medium

[A,B]

Sol. $\sin C_1 = \dfrac{\mu_1}{\mu_2}$ (interface AB)

$\sin C_2 = \dfrac{\mu_3}{\mu_2}$ (interface GF)

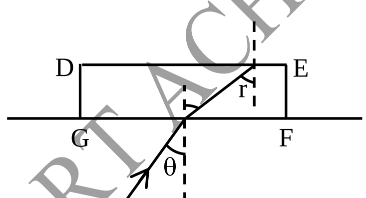


Fig. (b)

If $\mu_3 < \mu_1$, $\dfrac{\mu_3}{\mu_2} < \dfrac{\mu_1}{\mu_2}$, hence, $C_2 < C_1$ and total internal reflection will take place at interface G.F.

If $\mu_3 > \mu_1$, $\dfrac{\mu_3}{\mu_2} > \dfrac{\mu_1}{\mu_2}$, hence, $C_2 > C_1$

Therefore, $C_2 > \theta$, hence, light ray will get refracted into the slab.

Q.13 In passing through a boundary refraction will not take place if –

(A) light is incident normally on the boundary

(B) the indices of refraction of the two media are same

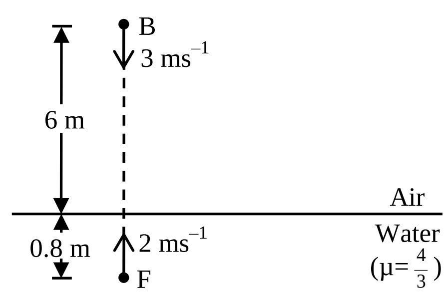
(C) the boundary is not visible if $\mu_1 = \mu_2$

(D) angle of incidence is lesser than the angle of refraction but greater than $\sin^{-1} (\mu_R/\mu_D)$ **[C,D]**

Sol. When light is incident normally on the boundary, then i = 0. So, according to Snell's law $\mu_1 \sin i = \mu_2 \sin r$, r is also zero, i.e., there is not refraction.

If $\mu_1 = \mu_2$, then boundary will not be visible and r = i, i.e., there will be no refraction. If i < r and $i > \sin^{-1} (\mu_R/\mu_D)$ or $i > i_c$ (critical angle), then also there will be no refraction of light and light will be totally internally reflected.

Q.14 A fish F, in the pond is at a depth of 0.8 m from the water surface and is moving vertically upwards with velocity 2 ms^{-1}. At the same instant a bird B is at a height of 6 m from the water surface and is moving downwards with velocity 3 ms^{-1}. At this instant both are on the same vertical line as shown in the figure. Which of the following statements are correct ?



(A) Height of B, observed by F (from itself) is equal to 5.30 m

(B) Depth of F, observed by B (from itself) is equal to 6.60 m

(C) Height of B, observed by F (from itself) is equal to 8.80 m

(D) None of the above **[B,C]**

Sol. If an object is at a distance x from a plane refracting surface and is viewed normally then it appears at a distance x/μ from the surface where μ is refractive index of that medium (in which it is situated) with respect to the medium in which observer is situated.

Suppose height of bird from water surface is x and depth of fish from the surface is y then depth of fish, observed by the bird, will be equal to

$$r_1 = x + \frac{y}{\mu} \qquad \ldots (1)$$

where μ is refractive index of water with respect to air.

$\therefore \qquad r_1 = 6.60$ m

Hence, option (B) is correct.

Height of bird, observed by fish, will be equal to

$$r_2 = \frac{x}{\mu'} + y \qquad \ldots (2)$$

where μ′ is refractive index of air with respect to water.

Now, $\qquad \mu' = \frac{1}{\mu} = \frac{3}{4}$

Hence, $\qquad r_2 = 8.80$ m

Hence, option (A) is wrong while (C) is correct.

Q.15 A bird flies down vertically towards a water surface. To a fish inside the water, vertically below the bird, the bird will appear to –

(A) be farther away than its actual distance

(B) be closer than its actual distance

(C) move faster than its actual speed

(D) move slower than its actual speed **[A, C]**

Sol. For refraction at plane surface,

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

Let x = height of the bird above the water surface

For light travelling from the bird to fish,

$\mu_1 = 1$, $\mu_2 = \mu$ (refractive index of water) and $u = -x$,

hence, $\frac{\mu}{v} = \frac{1}{-x}$ or $\qquad v = -\mu x$

or, $|v| = \mu x$, $\qquad$ i.e., $\qquad |v| > x$

Speed of the bird = x

$\therefore$ Apparent speed of the bird = $|v| = \mu x$

Q.16 In passing through a boundary refraction will not take place if –

(A) light is incident normally on the boundary

(B) the indices of refraction of the two media are same

(C) the boundary is not visible

(D) angle of incidence is lesser than the angle of refraction but greater than $\sin^{-1}(\mu_R/\mu_D)$

[A, B, C, D]

Sol. When light is incident normally on the boundary, then i = 0. So, according to Snell's law $\mu_1 \sin i = \mu_2 \sin r$, r is also zero, i.e., there is no refraction.

If $\mu_1 = \mu_2$, then boundary will not be visible and r = i, i.e., there will be no refraction.

If i < r and i > $\sin^{-1}(\mu_R/\mu_D)$ or i > i_c (critical angle), then also there will be no refraction of light and light will be totally internally reflected.

Q.17 Monochromatic light is incident on a plane interface AB between two media of refractive indices μ_1 and μ_2 ($\mu_2 > \mu_1$) at an angle θ as shown in figure. The angle θ is infinitesimally greater than the critical angle for two media so that total internal reflection takes place. Now, if a transparent slab DEFG of uniform thickness and having refractive index μ_3 is introduced on the interface as shown in the figure. Which of the following statements are correct ?

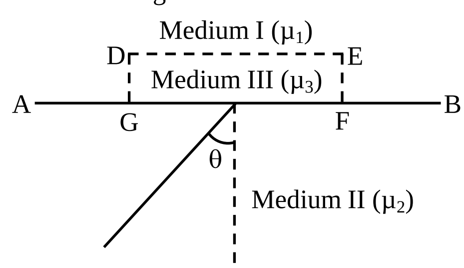


Fig.

(A) If $\mu_3 < \mu_1$, total internal reflection will take place at face GF

(B) If $\mu_3 > \mu_1$, light will refract into the slab

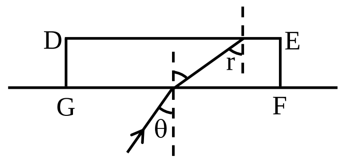
(C) If $\mu_3 > \mu_1$, total internal reflection will take place at face DE

(D) Light cannot be transmitted to medium

[A, B, C, D]

Sol. $\sin C_1 = \frac{\mu_1}{\mu_2}$ (interface AB)

$\sin C_2 = \frac{\mu_3}{\mu_2}$ (interface GF)



If $\mu_3 < \mu_1$, $\frac{\mu_3}{\mu_2} < \frac{\mu_1}{\mu_2}$, hence, $C_2 < C_1$ and total internal
reflection will take place at interface GF.

If $\mu_3 > \mu_1$, $\frac{\mu_3}{\mu_2} > \frac{\mu_1}{\mu_2}$, hence, $C_2 > C_1$

Therefore, $C_2 > \theta$, hence, light ray will get refracted into the slab.

Q.18 A ray of light from a denser medium strikes a rarer medium at an angle of incidence i as shown in figure. Refracted and reflected rays make an angle of 90º with each other. Angle of reflection and refraction are r and r′. Then critical angle is –

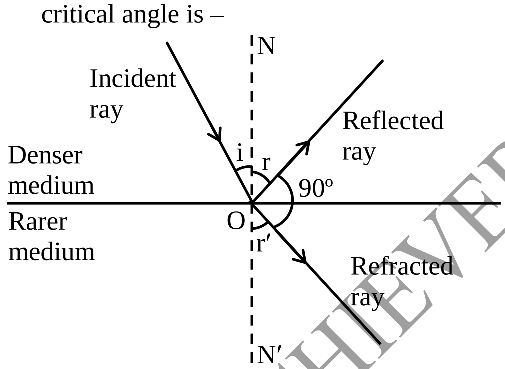


Fig.

(A) $\sin^{-1}(\sin i)$ (B) $\sin^{-1}(\sin r)$
(C) $\sin^{-1}(\tan i)$ (D) $\sin^{-1}(\tan r)$

[C, D]

Sol. From fig. in question, $r + r' = 90º$

$\therefore r' = 90º - r = 90º - i$

When light travels from denser medium to rarer medium,

$\frac{1}{\mu} = \frac{\sin i}{\sin r'} = \frac{\sin i}{\sin(90º - i)} = \frac{\sin i}{\cos i}$

$= \tan i$

Also, $\sin i_c = \frac{1}{\mu}$

(if angle of incidence = critical angle)

$\therefore \sin i_c = \tan i = \tan r$

$\therefore i_c = \sin^{-1}(\tan i)$

$= \sin^{-1}(\tan r)$

Q.19 Due to refraction of light in atmosphere -

(A) Stars appear to twinkle
(B) The sun appears to be oval in morning or evening
(C) The period of visibility of sun is increased
(D) The phenomenon of mirage and looming take place **[A,B,C]**

Sol. Option (D) is wrong because mirage is the effect of total internal reflection.

Q.20 Out of the following, which statements are correct–

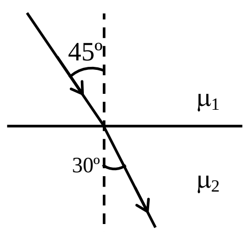
(A) The setting sun appears higher in the sky than it really is
(B) In glass, red light travels faster than violet light
(C) The refractive index of diamond is greater than that of glass
(D) Refractive index of a material is greater for red light than that of violet light **[A,B,C]**

Q.1 In a lake 2m deep, a measuring post of height 3m is fixed vertically. For an angle of incidence of 45º of Sun's radiations, find the length of the shadow of the post at the bottom surface ? $\left[\mu_w = \frac{4}{3}\right]$ [in metre]

Sol.[2] Try yourself.

Q.2 A beam of light propagates through a medium 1 and falls onto another medium 2 at an angle 45º. After that it propagates in medium 2 at an angle 30º. The light's wavelength in medium 1 is 141.4 Å. Wavelength has the light in medium 2 … × 100 Å.

Sol. **[1]**



$\mu_1 \sin 45º = \mu_2 = \sin 30º$

$$\frac{\mu_1}{\sqrt{2}} = \frac{\mu_2}{2}$$

$$\frac{\mu_1}{\mu_2} = \frac{1}{\sqrt{2}}$$

$$\frac{\lambda_2}{\lambda_1} = \frac{1}{\sqrt{2}}$$

$$\lambda_2 = \frac{\lambda_1}{\sqrt{2}}$$

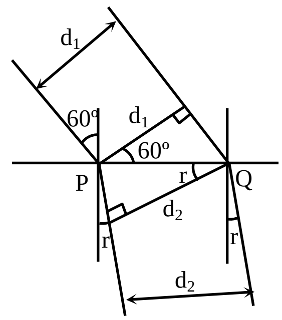
$$= \frac{100\sqrt{2}}{\sqrt{2}} = 100 \text{ Å}$$

Q.3 A circular beam of light of diameter d = 2cm falls on a plane surface of glass. The angle of incidence is 60º and refractive index of glass is $\mu = \frac{3}{2}$. Find the diameter of the refracted beam in cm.

Sol.[3] $d_1 = PQ \cos 60º$

$d_2 = PQ \cos r$

$$\frac{d_1}{d_2} = \frac{1}{2\cos r}$$



$d_2 = 2\, d_1 \cos r$

$1 \times \sin i = \mu \sin r$

$$\sin r = \frac{\sin 60º}{\mu} = \frac{1}{\sqrt{3}} \Rightarrow \cos r = \sqrt{\frac{2}{3}}$$

$$d_2 = 2 \times 2 \times \sqrt{\frac{2}{3}} = 3.26 \text{ cm}$$

Q.4 A light ray in medium (RI = 5/3) enters another medium at an angle 30º. The angle in other medium is $\sin^{-1}$ (5/6). How many minimum degrees the incident angle must be increased such that the ray is completely reflected.

Sol.[7] $\frac{5}{3} \sin 30º = n \,.\, \frac{5}{6} \Rightarrow n = 1$

$$\sin \theta_c = \frac{3}{5} \Rightarrow \theta_c = 37º$$

and so 37 – 30 = 7

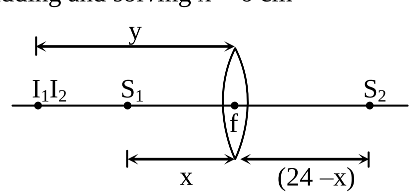
Q.5 There is a point object on the left of an oscillating slab with amplitude 4 cm. The observer is on the right. If RI of slab material is 2 then find oscillating amplitude of image.

Sol.[0] Slab movement doesn't displace object.

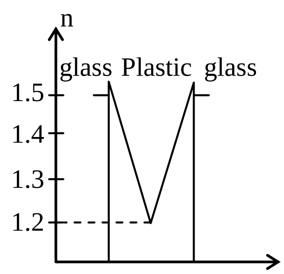
Q.6 The distance between two point source of light is 24 cm. What distance from any of the source a convex lens of focal length 9 cm be placed such that images of both source are formed at the same point. Answer that distance which is less than 10.

Sol.[6] $\frac{1}{y} - \frac{1}{-(24-x)} = \frac{1}{9}$ and $\frac{1}{-y} - \frac{1}{-x} = \frac{1}{9}$

adding and solving x = 6 cm



Q.7 A thin plate of transparent plastic is embedded in a thick slab of glass. The index of refraction of glass is n = 1.5; the index of refraction of the plate changes as shown. A beam of light passing through the glass and strikes the surface of the plastic plate. The maximum angle of incidence θ_{max} enables the beam to pass through the plate is



Sol. $\theta = 53^\circ$

PHYSICS

Q.1 If the critical angle for total internal reflection from a medium to vacuum is 30°, the velocity of light in the medium is -

(A) 3×10^8 m/s (B) 1.5×10^8 m/s

(C) 6×10^8 m/s (D) $\sqrt{3} \times 10^8$ m/s

[B]

Sol. $\text{Sin } i_c = \frac{1}{{}_r\mu_d} = \frac{\mu_r}{\mu_d} = \frac{v_d}{v_r}$

$\sin 30° = \frac{V_d}{3\times10^8} \Rightarrow v_d = 1.5 \times 10^8$ m/s

Q.2 A piece of glass is placed on a wood having letters of different colours. The letters of which colour will appear maximum raised

(A) Red (B) Green

(C) yellow (D) violet **[D]**

Sol. Raise = $h_{ac}\left(1-\frac{1}{\mu}\right)$

For Raise to be maximum, μ has to maximum

$\mu \propto \frac{1}{\lambda}$

Q.3 Light travels through a glass of thickness t and refractive index n. If c is the velocity of light in vacuum, the time taken by light to travel through the plate is :

(A) t/nc (B) ntc (C) nt/c (D) tc/n

[C]

Q.4 The velocity of light in air is $3\text{x}10^{10}$ cm /sec. If the refractive index of glass with respect to air is 1.5, then velocity of light in glass is :

(A) 2×10^{10} cm/sec

(B) 4.5×10^{10} cm /sec

(C) 3×10^{10} cm/sec

(D) 1×10^{10} cm /sec **[A]**

Q.5 The refractive index of water is (4/3) and that of glass is (3/2) .If the speed of light in glass is 2×10^{8} m/s. The speed of light in water will be :

(A) 1×10^8 m/s (B) $(9/4) \times 10^8$ m/s

(C) $(8/3) \times 10^8$m/s (D) $4 \text{x}10^8$ m/s

[B]

Q.6 Critical angle for total internal reflection of light of a certain frequency at a denser-rarer boundary is 30°. At what angle should the same light be incident on the boundary from the side of denser medium that the reflected and the refracted rays are mutually perpendicular ?

(A) $\tan^{-1}(2)$ (B) $\tan^{-1}\left(\frac{1}{3}\right)$

(C) $\cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ (D) $\cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ **[C]**

Sol. $\frac{1}{\mu} = \sin 30° = \frac{1}{2}$

$\mu = 2$

$2 \sin i = 1. \sin (90° – i)$

$\tan i = \frac{1}{2}$

$\Rightarrow \cos i = \frac{2}{\sqrt{1^2+2^2}} = \frac{2}{\sqrt{5}} \Rightarrow i = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$

Q.7 Green light of wavelength 5460 Å is incident on an air glass interface. If the refractive index of the glass is 1.5, the wavelength of the light in the glass would -

(A) decreases to 3640 Å

(B) remain the same 5460Å

(C) decreases to 4861 Å

(D) increase to 8190 Å **[A]**

Sol. $\lambda_{glass} = \frac{\lambda_{air}}{\mu}$

$\therefore \lambda_{glass} = \frac{5460}{1.5}$ Å = 3640 Å

Q.8 A beam of light composed of red and green rays is incident obliquely at a point on the face of rectangular glass slab. When coming out on the opposite parallel face, the red and green rays emerge from -

(A) Two points propagating in two different non parallel direction

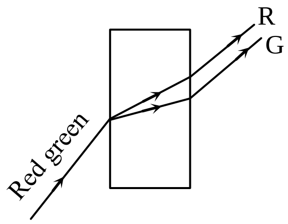
(B) Two points propagating in two different parallel directions

(C) One point propagating in two different directions

(D) One point propagating in the same directions

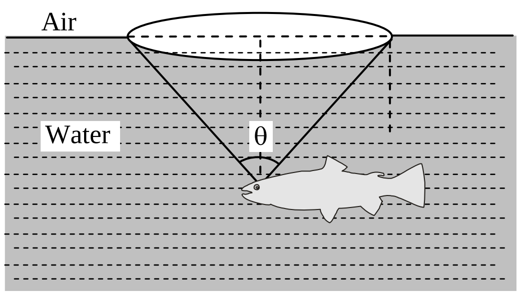
[B]

Sol.



Red and green light will emerge in two different points propagating in two different parallel directions

Q.9 A fish is a little away below the surface of a lake. If the critical angle is 49º, then the fish could see things above the water surface within an angular range of θº where



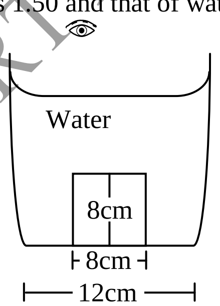
(A) θ = 49º (B) θ = 90º

(C) θ = 98º (D) θ = 24 $\frac{1^o}{2}$ **[C]**

Sol. According to figure in question

$\theta = 2C = 2 \times 49^o = 98^o$

Q.10 A cylindrical vessel of diameter 12 cm contains 800π cm^3 of water. A cylindrical glass piece of diameter 8.0 cm and height 8.0 cm is placed in the vessel. If the bottom of the vessel under the glass piece is seen by the paraxial rays (see figure), locate its image. The index of refraction of glass is 1.50 and that of water is 1.33.



(A) 2.1 cm (B) 7.1 cm

(C) 9.1 cm (D) 11.1 cm **[B]**

Q.11 Critical angle for light going from medium (1) to (2) is 60º. The speed of light in medium (1) is v ; then speed of light in medium (2) is -

(A) v/2 (B) 2v/$\sqrt{3}$ (C) $\frac{\sqrt{3}}{2}$ v (D) 2v

Sol. **[B]**

$\sin i_c = \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$ ∴ $\sin 60^o = \frac{v}{v_2}$

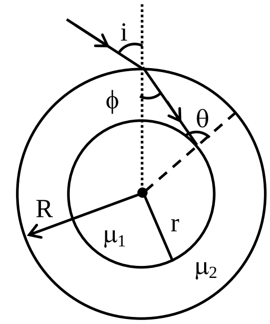
∴ $v_2 = v/\sin 60^o = 2v/\sqrt{3}$

Q.12 A capillary tube is made of glass with the index of refraction 3, outer radius of the tube is 30 cm. The tube is filled with a liquid with the index of refraction 2. What should be the minimum internal radius of the tube r so that any ray that hits the tube would enter the liquid -

(A) 15 cm (B) 10 cm

(C) 20 cm (D) 45 cm

Sol. **[A]**



$\theta < \theta_c$

$\sin\theta < \sin\theta_c$

$\sin\theta < \frac{\mu_1}{\mu_2}$

$\sin\theta < \frac{2}{3}$

when i is maximum θ is also max and if $\sin\theta_{max} < \frac{2}{3}$ light will enter in liquid.

$i_{max} = \frac{\pi}{2}$ $\sin\phi = \frac{1}{\mu_2} = \frac{1}{3}$

Apply sine rule $\frac{\sin\phi}{r} = \frac{\sin(\pi-\theta)}{R} = \frac{\sin\theta}{R}$

$\frac{\sin\phi}{r} = \frac{\sin\theta}{R}$

$\frac{R}{3r} = \sin\theta$

$\frac{R}{3r} < \frac{2}{3}$

$r > \frac{R}{2}$

$r > \frac{30}{2}$

r > 15 cm

minimum radius = 15 cm

Q.13 The critical angle for total internal reflection of light going from medium I to medium II is given by the relation tan i_C = 5/9. The refractive index of the I medium with respect to the medium II is -

(A) 1.8 (B) 1.6

(C) $\sqrt{156}/5$ (D) $\sqrt{106}/5$ **[D]**

Q.14 Two media I and II are separated by a plane surface having speeds of light 2×10^8 m/s and 2.4×10^8 m/s respectively .What is the critical angle for a ray going from I medium to II ?

(A) $\sin^{-1}\left(\frac{1}{2}\right)$ (B) $\sin^{-1}\left(\frac{5}{6}\right)$

(C) $\sin^{-1}\left(\frac{5}{12}\right)$ (D) $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$ **[B]**

Q.15 If refractive index for water and glass are 4/3 and 5/3 respectively and light is tending to go from glass to water , the critical angle is:

(A) $\sin^{-1}$ (4/3) (B) $\sin^{-1}$ (5/3)

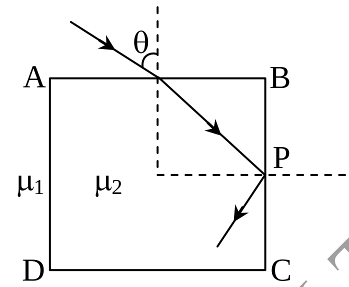
(C) $\sin^{-1}$ (4/5) (D) $\sin^{-1}$ (5/4) **[C]**

Q.16 If the critical angle for total internal reflection from a medium to vacuum is 30° the velocity of light in the medium is :

(A) 3×10^8 m/s (B) 1.5×10^8 m/s

(C) 6×10^8 m/s (D) $\times 10^8$ m/s **[B]**

Q.17 A cube of side a made of a material of refractive index μ_2 is immersed in a liquid of refractive index μ_1. A ray is incident on face A B at an angle θ as shown. Total internal reflection just takes place at point P on face BC. Then find the value of θ.



(A) $\sin\theta = \frac{\mu_2}{\mu_1}$

(B) $\sin\theta = \sqrt{\left[\left(\frac{\mu_2}{\mu_1}\right)^2 + 1\right]}$

(C) $\sin\theta = \sqrt{\left(\frac{\mu_1}{\mu_2}\right)^2 - 1}$

(D) $\sin\theta = \sqrt{\left(\frac{\mu_2}{\mu_1}\right)^2 - 1}$ **[D]**

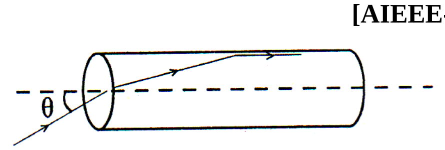
Q.18 A ray of light from a denser medium strikes a rarer medium at an angle of incidence i. If the reflected and refracted rays are mutually perpendicular to each other, what is the value of critical angle?

(A) $\sin^{-1}$ (cot i) (B) $\sin^{-1}$ (tan i)

(C) $\cos^{-1}$ (cot i) (D) $\cos^{-1}$ (tan i) **[B]**

Q.19 A transparent solid cylindrical rod has a refractive index of $\frac{2}{\sqrt{3}}$. It is surrounded by air. A light ray is incident at the midpoint of one end of the rod as shown in the figure.

[AIEEE-2009]

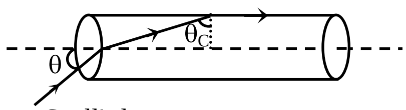


The incident angle θ for which the light ray grazes along the wall of the rod is -

(A) $\sin^{-1}\left(\frac{1}{2}\right)$ (B) $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$

(C) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$ (D) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$ **[D]**

Sol.



From Snell's law

$\mu_{air} \sin\theta = \mu_{cylider}. \sin(90 - \theta_C)$

$\Rightarrow \quad 1.\sin\theta = \frac{2}{\sqrt{3}}.\cos\theta_C$

$\Rightarrow \quad \sin\theta = \frac{2}{\sqrt{3}}\cos\left[\sin^{-1}\frac{1}{\mu_{cy}}\right]$

$= \frac{2}{\sqrt{3}}\cos\left[\sin^{-1}\frac{\sqrt{3}}{2}\right]$

$= \frac{2}{\sqrt{3}}\cos 60° = \frac{1}{\sqrt{3}}$

$\Rightarrow \quad \theta = \sin^{-1}\frac{1}{\sqrt{3}}$.

Q.20 Critical angle for light going from medium (i) to (ii) is θ. The speed of light in medium (i) is v, then speed in medium (ii) is -

(A) v (1– cos θ) (B) v / sin θ

(C) v / cos θ (D) v (1 – sin θ) **[B]**

Sol. $_2\mu_1 = \frac{1}{\sin\theta} = \frac{\mu_1}{\mu_2} = \frac{v_2}{v_1} \Rightarrow v_2 = \frac{v_1}{\sin\theta}$

$\therefore \boxed{v_2 = \frac{v}{\sin\theta}}$

Q.21 A microscope is focused on a mark on a piece of paper and then a slab of glass of thickness 3 cm and refractive index 1.5 is placed over the mark. How should the microscope be moved to get the mark again in focus ?

(A) 2 cm upwards

(B) 1 cm upwards

(C) 4.5 cm upwards

(D) 1 cm downwards **[B]**

Q.22 A bird in air looks at a fish vertically below it and inside water in a tank. If the distances of the fish as estimated by the bird is S_1 and that of bird as estimated by the fish is S_2 then the refractive index of liquid μ is -

(A) $\frac{S_1}{S_2}$ (B) $\frac{S_1+S_2}{S_1-S_2}$

(C) $\frac{S_2}{S_1}$ (D) $\frac{S_1+S_2}{S_1}$ **[C]**

Q.23 A layer of benzene (μ_1 = 1.5) 6 cm deep floats on water (μ_2 = 1.33) 4 cm deep. When viewed vertically through air the apparent distance of the bottom of the vessel below the surface of the benzene will be -

(A) 14 cm (B) 7 cm

(C) 21 cm (D) 3.5 cm **[B]**

Q.24 A mark is made on the bottom of a vessel, over this mark, a glass slab of thickness 3.5 cm and refractive index 7/4 is placed. Now water (refractive index 4/3) is poured into the vessel so that the surface of water is 8 cm above the upper surface of the slab. Looking down normally through the water, the apparent depth of the mark below the surface of water will be -

(A) 6.33 cm (B) 7.5 cm

(C) 8 cm (D) 10 cm **[C]**

Q.25 The refractive index of water is 4/3 and that of glass is 5/3. What will be the critical angle for the ray of light entering water from the glass ?

(A) $\sin^{-1}\frac{4}{5}$ (B) $\sin^{-1}\frac{5}{4}$

(C) $\sin^{-1}\frac{1}{2}$ (D) $\sin^{-1}\frac{2}{1}$ **[A]**

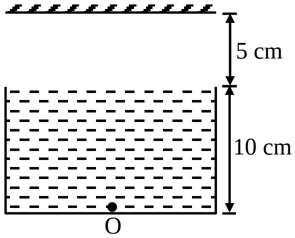
Sol. $\mu_w = \frac{4}{3}$; $\mu_g = \frac{5}{3}$

Ray of light moves from glass to water

$\sin C = \frac{1}{_w\mu_g} = \frac{\mu_w}{\mu_g} = \frac{4/3}{5/3} = \frac{4}{5}$

$\boxed{C = \sin^{-1}\left(\frac{4}{5}\right)}$

Q.26 Consider the situation shown in figure. Water $\left(\mu_w = \frac{4}{3}\right)$ is filled in a beaker upto a height of 10 cm. A plane mirror is fixed at a height of 5 cm from the surface of water. Distance of image from the mirror after reflection from it of an object O at the bottom of the beaker is -



(A) 15 cm (B) 12.5 cm
(C) 7.5 cm (D) 10 cm **[B]**

Sol. Distance of first image (I_1) formed after refraction from the plane surface of water is $\frac{10}{4/3}$ = 7.5 cm

from water surface $\left(d_{app} = \frac{d_{actual}}{\mu}\right)$

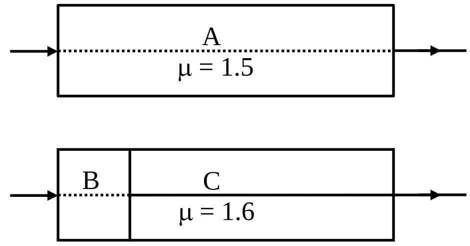
Now distance of image is 5 + 7.5 = 12.5 cm from the plane mirror.

Q.27 A beam of light is converging towards a point 1 on an screen. A parallel plane plate of glass whose thickness in the direction of the beam = t, refractive index = μ, is introduced in the path of the beam. The convergence point is shifted by -

(A) $t\left(1-\frac{1}{\mu}\right)$ away (B) $t\left(1+\frac{1}{\mu}\right)$ away
(C) $t\left(1-\frac{1}{\mu}\right)$ nearer (D) $t\left(1+\frac{1}{\mu}\right)$ nearer

[A]

Q.28 Two transparent slabs are of equal thickness, one is made of material A of refractive index 1.5 and the other is made of two materials B and C the ratio of their thickness being 1:2. The refractive index of C is 1.6 .If monochromatic parallel beams passing through the slabs have the same number of waves; the refractive index of B is -



(A) 1.4 (B) 1.3
(C) 1.1 (D) 1.5 **[B]**

Q.29 If the critical angle for a medium is 60º, then the refractive index of the medium is-

(A) $2/\sqrt{3}$ (B) $\sqrt{3}/2$
(C) $\sqrt{3}$ (D) $\sqrt{2}/3$ **[A]**

Sol. $\sin i_c = \frac{1}{\mu}$ ∴ $\mu = \frac{1}{\sin i_c}$

∴ $\mu = \frac{1}{\sin 60°}$ ∴ $\mu = \frac{2}{\sqrt{3}}$

Q.30 A film of air is enclosed between a pair of thin microscope slides and the combination is then inserted in water. A ray of white light is projected through water and the light reflected by the film of air sandwiched between the two slides is received on a screen. If the angle of incidence of the ray on the film is gradually decreased; from 90°, the reflected light -

(A) will turn red and then vanish
(B) will remain white and then vanish
(C) will remain white at all angle of incidence
(D) will turn blue and then vanish **[D]**

Q.31 A bird in air looks at a fish vertically below it and inside water. x is the height of the bird above the surface of water and y the depth of the fish below the surface of water. If refractive index of water with respect to air is μ. The distance of the bird as observed by the fish is -

(A) x + y (B) $x + \frac{y}{\mu}$
(C) μx + y (D) μx + μy **[C]**

Q.32 A fish rising vertically with speed 3 ms^{-1} to the surface of water sees a bird diving vertically towards it with speed 9 ms^{-1} ?

Given ${}_a\mu_W = \frac{4}{3}$. The actual velocity of dive of the bird is -

(A) 6 ms^{-1} (B) 4 ms^{-1}

(C) 8.4 ms^{-1} (D) 4.5 ms^{-1} **[D]**

Q.33 The refractive index of glass is 1.9. If a light through a glass slab of thickness d in time t and takes the same time to travel through a transparent beaker filled with water upto a thickness 1.5d, then the refractive index of water is -

(A) 1.27 (B) 1.33 (C) 1.20 (D) 1.50

[A]

Sol. $\frac{v_{glass}}{v_{water}} = \frac{\mu_{water}}{\mu_{glass}}$

Time = $\frac{\text{Distance}}{\text{speed}}$

$\therefore \frac{d}{v_{glass}} = \frac{1.5d}{v_{water}} \Rightarrow \frac{v_{glass}}{v_{water}} = \frac{1}{1.5}$

$\therefore \frac{\mu_{water}}{\mu_{glass}} = \frac{1}{1.5} \Rightarrow \frac{\mu_{water}}{1.9} = \frac{1}{1.5}$

$\Rightarrow \mu_{water} = 1.27$

Q.34 Just before the time of sun set or shine the sun appears to be oval because -

(A) the sun changes its shape at that time

(B) of the scattering of light

(C) of the effects of refraction

(D) of the effects of diffraction **[C]**

Q.35 The twinkling of stars is due to -

(A) the fact that star do not emit light continuously

(B) frequent absorption of star light by their own atmosphere

(C) the fact that refractive index of the earth's atmosphere fluctuates

(D) intermittent absorption of star light by earth atmosphere **[C]**

Q.36 Which statement is correct ?

(A) When light proceeds from denser to rarer medium and the angle of incidence is greater than critical angle total internal reflection of light takes place

(B) When light proceeds from rarer to denser medium total internal reflection of light takes place

(C) When light proceeds from denser to rarer medium, total internal reflection always takes place

(D) None of the above **[A]**

Q.37 When the surface of the lake is calm, a fish, submerged in water will see the entire outside world within an inverted cone whose apex is situated at the eye of the fish and the cone subtends an angle of : (μ_W = 4/3)

(A) 10º (B) 60º (C) 98º (D) 30º

[C]

Q.38 A ray of light from a denser medium strikes a rarer medium at an angle of incidence i. The reflected and refracted rays make an angle of 90° with each other. The angles of reflection and refraction are r and r′. The critical angle is –

(A) $\sin^{-1}$ (tan r) (B) $\sin^{-1}$ (tan r′)

(C) $\tan^{-1}$ (sin r) (D) $\tan^{-1}$ (sin i)

[A]

Q.39 Mirages are observed in deserts due to phenomenon of -

(A) Interference of light

(B) Total internal reflection

(C) Scattering of light

(D) Double reflection of light

[B]

Q.40 We see the sun a little before it rises on the horizon and a little after it sets below the horizon. This is a consequence of the phenomenon of –

(A) Total internal reflection (B) Refraction

(C) Dispersion (D) Scattering of light

[A]

Q.41 A cut diamond (or air bubble in water) shines brilliantly due to -

(A) Its molecular structure

(B) Absorption of light

(C) Total internal reflection

(D) Some inherent property **[C]**

Q.42 A man, standing on a platform, is aiming at the fish with the help of a bow and an arrow. The arrow will -

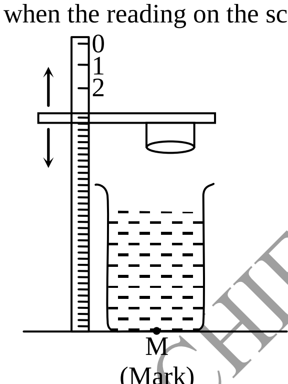
(A) hit the fish if he aims it above the fish

(B) hit the fish if he aims at the fish

(C) not be able to hit the fish

(D) hit the fish if he aims it below the fish **[D]**

Q.43 A beaker containing liquid is placed on a table, underneath a microscope which can be moved along a vertical scale. The microscope is focused, through the liquid onto a mark on the table when the reading on the scale is a.



It is next focused on the upper surface of the liquid and the reading is b. More liquid is added and the observations are repeated, the corresponding readings are c and d. The refractive index of the liquid is -

(A) $\frac{d-b}{d-c-b+a}$ (B) $\frac{b-d}{d-c-b+a}$

(C) $\frac{d-c-b+a}{d-b}$ (D) $\frac{d-b}{a+b-c-d}$ **[A]**

Q.44 The critical angle of light going from medium A to medium B is θ. The speed of light in medium A is V, the speed of light in medium B is:

(A) $\frac{V}{\sin\theta}$ (B) $V\sin\theta$

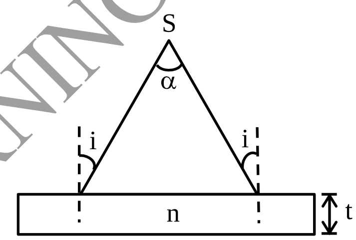
(C) V cot θ (D) V tan θ

Sol. **[A]**

A medium is denser then B medium

$$_B\mu_A = \frac{V_B}{V_A} = \frac{1}{\sin\theta}\ ;\ V_B = \frac{V_A}{\sin\theta} = \frac{V}{\sin\theta}$$

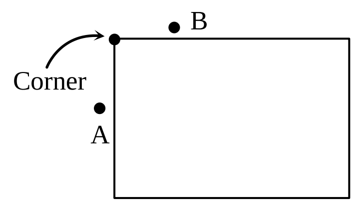
Q.45 A diverging beam of light from a point source S having divergence angle α, falls symmetrically on a glass slab as shown. The angles of incidence of the two extreme rays are equal. If the thickness of the glass slab is t and the refractive index n, then the divergence angle of the emergent beam is – **[IIT-JEE -2000]**



(A) Zero (B) α

(C) $\sin^{-1}(1/n)$ (D) $2\sin^{-1}(1/n)$ **[B]**

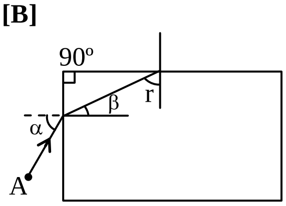
Q.46 A 90º corner is made from a transparent optical material with a refractive index such that A cannot see B when he is standing behind the corner. Minimum value of refractive index is-



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

(C) $\sqrt{5}$ (D) $\sqrt{7}$

Sol. **[B]**



$r_{min} > \theta_c$

r = 90 – B

r is minimum when β is maximum.

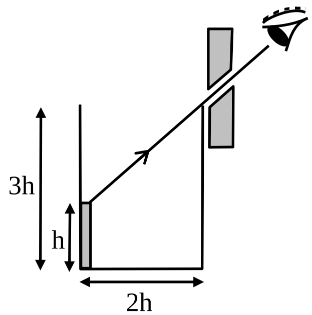
Maximum value of β is θ_c

$\therefore\ 90^\circ - \theta_c > \theta_c$

$$45^\circ > \theta_c \Rightarrow \frac{1}{\sqrt{2}} > \frac{1}{\mu}$$

$$\Rightarrow \mu > \sqrt{2}$$

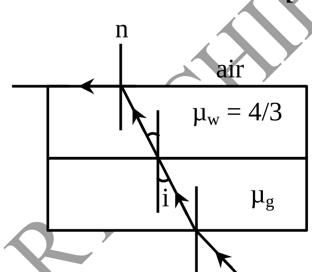
Q.47 An observer can see through a pin-hole the top end of the thin rod of height h, placed as shown in the figure. The beaker height is 3h and its radius h. When the beaker is filled with a liquid up to a height 2h, he can see the lower end of the rod. Then the refractive index of the liquid is – **[IIT-JEE 2002]**



(A) $\frac{5}{2}$ (B) $\sqrt{\frac{5}{2}}$

(C) $\sqrt{\frac{3}{2}}$ (D) $\frac{3}{2}$ **[B]**

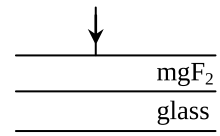
Q.48 In the given figure, at water-air interface, light ray incident at critical angle then the value of μ_g is – **[IIT-JEE 2003]**



(A) $\frac{3}{4\sin i}$ (B) $\frac{1}{\sin i}$

(C) $\frac{4}{3\sin i}$ (D) none of these **[B]**

Q.49 White light is incident normally on a glass surface (n = 1.52) that is coated with a film of mg F_2 (n = 1.38). For what minimum thickness of the film will yellow light of wavelength 550 nm (in air) be missing in the reflected light ?

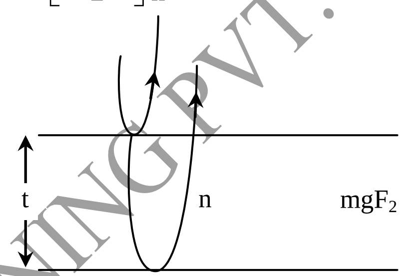


(A) 99.6 nm (B) 49.8 nm

(C) 19.6 nm (D) 10.6 nm

Sol. **[A]**

$$2t = \left[\frac{2m+1}{2}\right]\frac{\lambda}{n}$$



$$t_{min} = \frac{\lambda}{4n} = \frac{5.5\times10^{-7}}{4\times1.38} = 99.6 \text{ nm}$$

Q.50 A small girl of height 1 m can just see her image in a vertical plane mirror 4m away from her. Her eyes are 0.92 m from the floor. In order that she sees her full image in the mirror, the shortest vertical dimension of the mirror is -

(A) 0.50 m (B) 0.70 m

(C) 0.46 m (D) 0.56 m **[A]**

Sol. The minimum size of plane mirror required to see the full image of anyone is half of the height required.

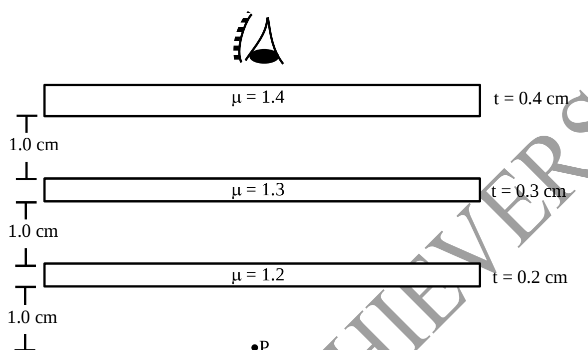
Q.1 A rectangular glass block of thickness 10 cm and refractive index 1.5 is placed over a small coin. A beaker is filled with water of refractive index 4/3 to a height of 10 cm and is placed over the glass block:

(a) Find the apparent position of the object when viewed along near normal direction

(b) Draw a near ray diagram

(c) If the eye is slowly moved away from the normal at a certain position, the object is found to disappear due to total internal reflection. At which surface does this happen and why ? **[(a) 14.17 cm]**

Q.2 Locate the image of the point P as seen by the eye in the figure.

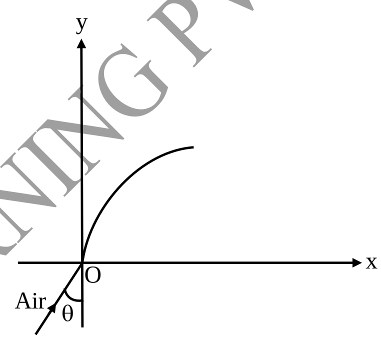


[0.22 cm above P]

Q.3 Two optical media have a plane boundary between them. Suppose θ_{icr} is the critical angle of incidence of a beam and θ_1 is the angle of incidence at which the refracted beam is perpendicular to the reflected one (the beam is assumed to come from an optically denser medium). Find the relative refractive index of these media if $\sin\theta_{icr}/\sin\theta_1 = \eta = 1.28$.

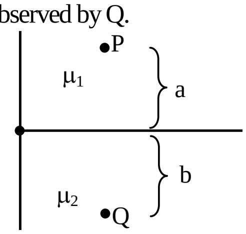
$$\frac{n_1}{n_2} = \frac{1}{\sqrt{\eta^2 - 1}} = 1.25$$

Q.4 A ray of light travelling in air is incident at angle $\theta = 30^o$ on a long rectangular slab of a transparent medium. The point of incidence is origin O of the co-ordinate system shown in figure. The medium has a variable index of refraction μ (y) given by $\mu = (0.25 + ky^{-2})^{1/2}$ where k = 1.0 m^2. Calculate equation for trajectory of the ray in the medium.



[$y^2 = 4x$]

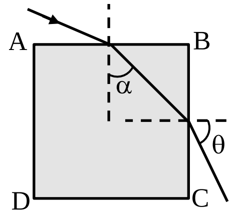
Q.5 P & Q are two point observers in mediums as shown. Find ratio of distances between P & Q as observed by P & as observed by Q.



Sol. $\mu_1 : \mu_2$

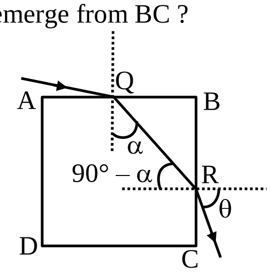
Q.6 ABCD is the plane of glass cube. A horizontal beam of light enters the face AB at the grazing incidence. Show that the angle θ which any ray emerging from BC would make with normal to BC is given by $\sin\theta = \cot\alpha$

where α is the critical angle. What is the greatest value that the refraction index of glass may have if any of the light is to emerge from BC.



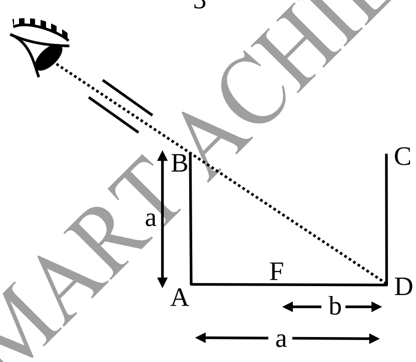
Sol. $\mu \le 2$

Q.7 ABCD is the plane of glass cube. A horizontal beam of light enters the face AB at the grazing incidence. Show that the angle θ which any ray emerging from BC would make with the normal to BC is given by sin θ = cot α where α is the critical angle. What is the greatest value that the refractive index of glass may have if any of the light is to emerge from BC ?



[$\sqrt{2}$]

Q.8 A cubical vessel with opaque walls is so located that the eye of an observer does not see its bottom, but sees all of the wall CD (see fig.). What volume of water should be poured into the vessel for the observer to see an object F fixed on the bottom at a distance of 'b' = 10 cm from the corner D ? The face of the vessel is 'a' = 40 cm. ($\mu_W = \frac{4}{3}$)

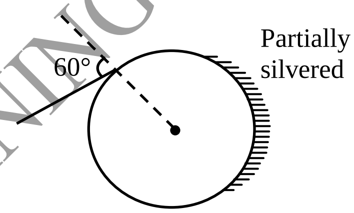


[42.73 litre]

Q.9 A slab of glass of thickness 5 cm and refractive index 1.5 is held a few centimeter in front of a concave mirror of radius of curvature 40 cm. The faces of the slab being perpendicular to the principal axis of the mirror. How far from the mirror must a small object be placed if its reflected image coincides with the object ?

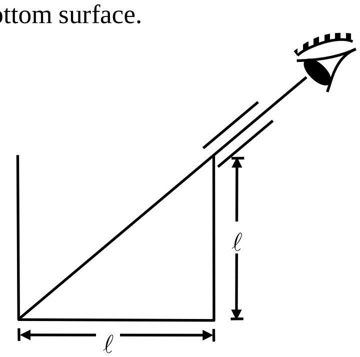
[41.67 cm]

Q.10 A ray is incident on a glass sphere as shown. The opposite surface of the sphere is partially silvered. If the net deviation of the ray transmitted at the partially silvered surface is $\frac{1}{3}$rd of the net deviation suffered by the ray reflected at the partially silvered surface (after emerging out of the sphere), find the refractive index of the sphere.



[$\sqrt{3}$]

Q.11 A cubic tank (of edge ℓ) and position of an observer are shown in the figure. When the tank is empty, edge of the bottom surface of the tank is just visible. An insect is at the centre of its bottom surface.

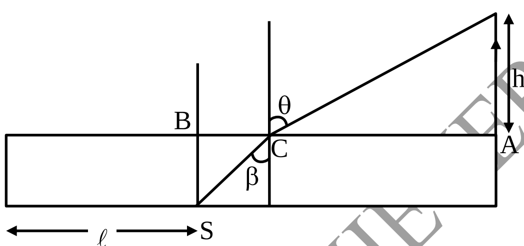


(a) To what height a transparent liquid of refractive index $\mu = \sqrt{5/2}$ must be poured in the tank so that the insect will become visible ?

(b) A small hole of area $a = \frac{\ell^2}{50\sqrt{5}}$ is made in the vertical wall of the tank near its bottom surface at time t = 0, and at the same time the insect starts moving. Find the speed of the insect as a function of time so that it will be just visible at all times. Take the initial height of the liquid as calculated in part (i), while the position of the tank and that of the opening do not change.

[(a) h = l, (b) $\frac{1}{50}\left(\sqrt{\ell}-\frac{t}{50}\right)$]

Q.12 Consider the huge glass slab kept horizontally on top of a point source of light 'S' as shown in the diagram. The slab is of thickness t = 3 m and length '2ℓ' = 9 m. A person whose eyes can be taken at height 'h' above the upper face of glass slab walks over the slab from one edge 'A' to the point 'B' right on top of the point source 'S'. When at 'A' and observing 'S' the line of vision of the person makes 'θ' (= 60º) with the normal to the slab. Refractive index of the slab is $\mu(=\sqrt{3})$. Find

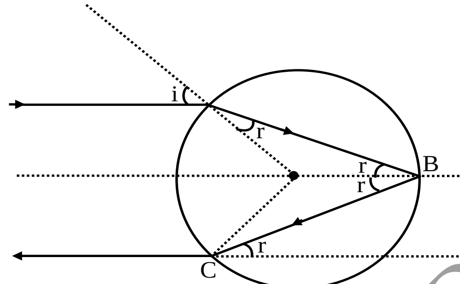


(a) the height 'h'

(b) change in apparent depth of 'S' as observed by the person while moving from A to B.

[(a) 1.6 m, (b) 1.4 m]

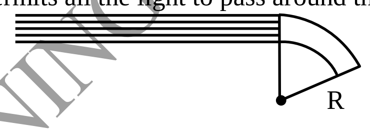
Q.13 A ray of light is incident on the surface of a sphere of refractive index $\frac{\sqrt{7}}{2}$. Other halve of the sphere is silvered. After refraction it is reflected then refracted out of the sphere again such that the total deviation is minimum. Find the



(a) angle of incident i of the ray
(b) total deviation of the ray

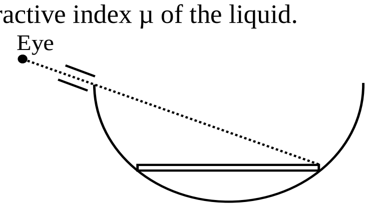
[(a) 60º, (b) 136º]

Q.14 A portion of straight glass rod of diameter 4 cm and refractive index 1.5 is bent into an arc of circle and a parallel beam of light is incident on it as shown in the figure. Find the smallest value of R (the radius of outer arc) which permits all the light to pass around the arc.



[12 cm]

Q.15 A circular disc of diameter 7 cm lies horizontally inside a metallic hemispherical bowl of diameter 25 cm. The disc is just visible to an eye looking over the edge as shown in the figure. The bowl is now filled with a liquid. It is observed that, the whole of the disc is just visible to the eye in the same position. Find the refractive index μ of the liquid.



[μ= 4/3]

Q.16 Light from a point source in air falls on a spherical glass surface (n = 1.5 and radius of curvature = 20 cm).

The distance of the light source from the glass surface is 100 cm. At what position final image is formed.

Sol. $\frac{\mu_2-\mu_1}{R}$

Q.17 A fish rising vertically to the surface of water in a lake uniformly at the rate of 3 m/s observes a kingfisher (bird) diving vertically towards the water at a rate of 9 m/s vertically above it. If the refractive index of water is (4/3), find the actual velocity of the dive of the bird. **[4.5 m/s]**

Q.18 A point source of light is placed a distance h below the surface of a large deep lake.

(a) Show that the fraction f of the light energy that escapes directly from the water surface is independent of h and is given by

$$f = \frac{1}{2} - \frac{1}{2n}\sqrt{n^2 - 1}$$

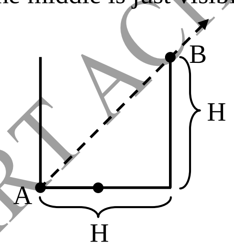
where n is the index of refraction of water. (Note : Absorption within the water and reflection at the surface, except where it is total, have been neglected.)

(b) Evaluate this fraction for n = 1.33.

[(b) 0.17 litre]

Q.19 Light is incident at an angle α on one planar end of a transparent cylindrical rod of refractive index n. Determine the least value of n so that the light entering the rod does not emerge from the curved surface of rod irrespective of the value of α. **[$\sqrt{2}$]**

Q.20 An eye is in the line AB. A liquid of $\mu = \sqrt{1.5}$ is filled in container to a height h such that a small coin in the middle is just visible to eye. Find h.



Sol. $H - \frac{H}{\sqrt{2}}$