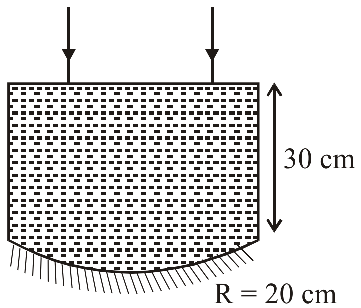
CLASS TEST

SECTION-I

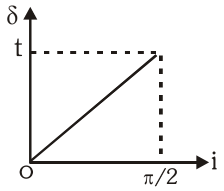
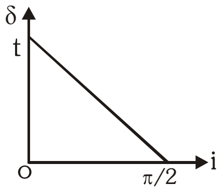
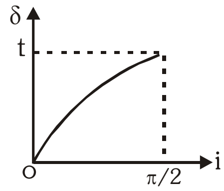
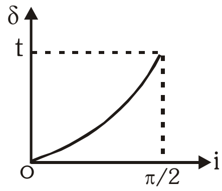
Single Correct Answer Type **7 Q. [3 M (–1)]**

1. A vessel with a silvered concave bottom is filled with water of refractive index 4/3. A parallel beam of light is incident on the water surface as shown in figure. What is position of final image from water surface:-

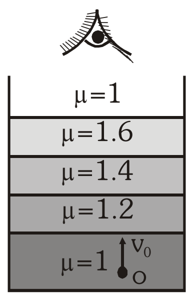


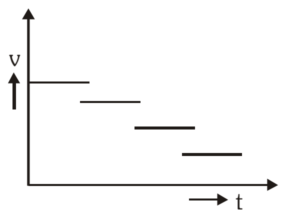
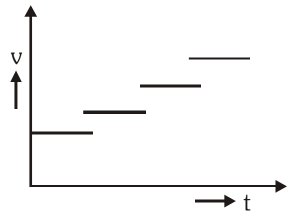
(A) 15 cm (B) 20 cm (C) 10 cm (D) 7.5 cm

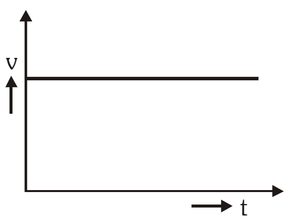
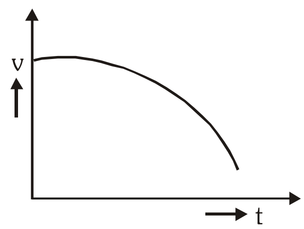
2. A ray of light passes through a rectangular slab of thickness t. The variation of lateral shift (δ) with angle of incidence (i) is

(A) 
(B) 
(C) 
(D) 

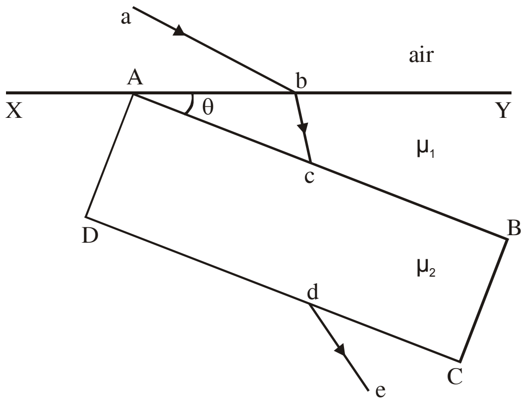
3. An object is moving with a constant velocity in a vessel containing layers of immiscilide liquids of different refractive indices as shown in figure. Variation of velocity with time (until object comes out) is best represented by :



(A) 
(B) 

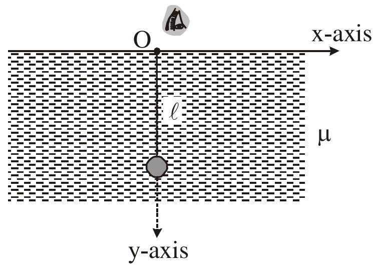
(C) 
(D) 

4. A ray of lgiht ab passing through air, enters a liquid of refractive index μ_1, at the boundary XY. In the liquid, the ray is shown as bc. The angle between ab and bc is δ (angle of deviation). The ray then passes through a rectangular slab ABCD of refractive index μ_2 ($\mu_2 > \mu_1$), and emerges from the slab as ray de. The angle between XY and AB is θ. The angle between ab and de is-



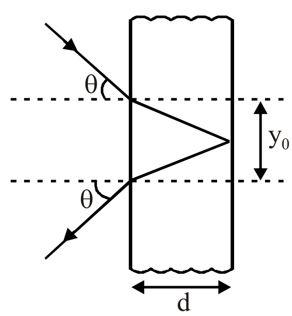
(A) δ (B) $\delta + \theta$ (C) $\delta + \sin^{-1}\left(\frac{\mu_1}{\mu_2}\right)$ (D) $\delta + \theta - \sin^{-1}\left(\frac{\mu_1}{\mu_2}\right)$

5. A pendulum of length ℓ is free to oscillate in vertical plane about point O in a medium of refractive index μ. An observer in air is viewing the bob of the pendulum directly from above. The pendulum is performing small oscillations about its equilibrium position. The equation of trajectory of bob as seen by observer is



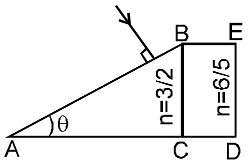
(A) $x^2 + y^2 = \ell^2$ (B) $\frac{x^2}{(\ell/\mu)^2} + \frac{y^2}{\ell^2} = 1$ (C) $\frac{x^2}{\ell^2} + \frac{y^2}{(\ell/\mu)^2} = 1$ (D) $x^2 + y^2 = \left(\frac{\ell}{\mu}\right)^2$

6. A ray of light incident from air on a glass plate of refractive index n is partly reflected and partly refracted at the two surfaces of the glass. The displacement y_0 in the figure is



(A) $\frac{2d\sin\theta}{\sqrt{n^2 - \sin^2\theta}}$ (B) $\frac{2d\sin\theta}{\sqrt{\sin^2\theta - \frac{1}{n^2}}}$ (C) $\frac{2d\sqrt{n^2 - \sin^2\theta}}{\sin\theta}$ (D) None of these

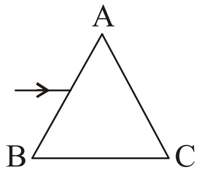
7. In the figure ABC is the cross section of a right angled prism and BCDE is the cross section of a glass slab. The value of θ so that light incident normally on the face AB does not cross the face BC is [Given $\sin^{-1}(3/5) = 37°$]



(A) $\theta \le 37°$ (B) $\theta < 37°$ (C) $\theta \le 53°$ (D) $\theta < 53°$

Multiple Correct Answer Type **4 Q. [4 M (–1)]**

8. A ray of light is incident on a equilateral triangular prism parallel to its base as shown in the figure. The ray just fails to emerge from the face AC. If μ be the refractive index of the prism then the incorrect relation(s) is/are :



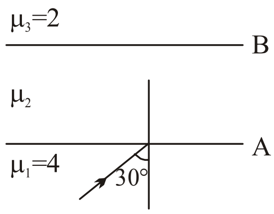
(A) $2\sin^{-1}\left(\frac{1}{\mu}\right) = \frac{\pi}{3}$

(B) $\sin^{-1}\left(\frac{1}{\mu}\right) + \sin^{-1}\left(\frac{1}{2\mu}\right) = \frac{\pi}{6}$

(C) $\sin^{-1}\left(\frac{1}{\mu}\right) + \sin^{-1}\left(\frac{1}{2\mu}\right) = \frac{\pi}{3}$

(D) $\sin^{-1}\left(\frac{\mu}{2}\right) + \sin^{-1}\left(\frac{\mu}{4}\right) = \frac{\pi}{3}$

9. A light ray is incident on lower medium boundary at an angle 30° with the normal. Which of following statement is/are **TRUE**?



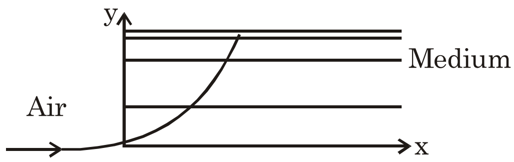
(A) If $\mu_2 > 2$ then total deviation is 60°

(B) If $\mu_2 < 2$ then total deviation is 60°

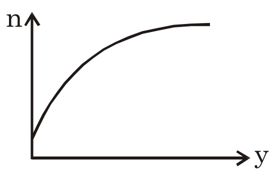
(C) If $\mu_2 > 2$ then total deviation is 120°

(D) If $\mu_2 < 2$ then total deviation is 120°

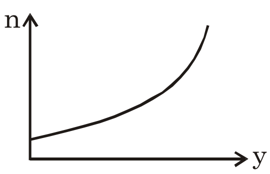
10. The refractive index of the medium within a certain region $x > 0$, $y > 0$, changes continuously with y. A thin light ray travelling in air in the x-direction strikes the medium at right angles and moves through the medium along a circular arc of radius R.



(A) Refractive index of medium varies with y as



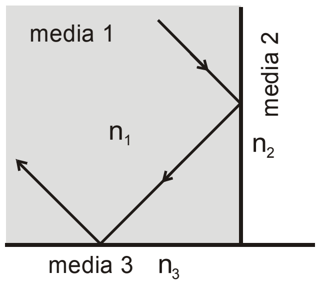
(B) Refractive index of medium varies with y as



(C) If refractive index of medium can increase upto a value $n = 2.5$, the maximum value of y is $\frac{3R}{5}$

(D) If refractive index of medium can increase upto a value $n = 2.5$, the maximum value of y is $5R$

11. In the diagram shown, light is incident on the interface between media 1 (refractive index n_1) and 2 (refractive index n_2) at angle slightly greater than the critical angle, and is totally reflected. The light is then also totally reflected at the interface between media 1 and 3 (refractive index n_3), after which it travels in a direction opposite to its initial direction. The media must have a refractive indices such that



(A) $n_1 < n_2 < n_3$ (B) $n_1^2 - n_3^2 > n_2^2$ (C) $n_1^2 - n_2^2 < n_3^2$ (D) $n_1^2 + n_2^2 > n_3^2$

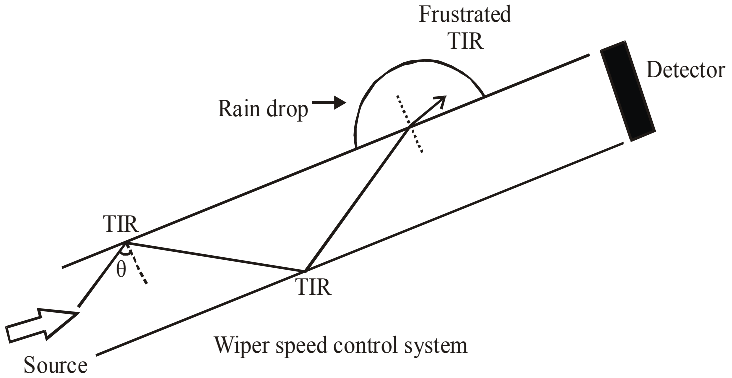
Linked Comprehension Type (2 Para × 3Q.) [3 M (-1)]
(Single Correct Answer Type)

Paragraph for Question No. 12 to 14

Frustrated TIR (F-TIR) : In optics, when light rays traveling in a denser medium strike at medium boundary at an angle greater than critical angle, TIR occurs and a surface wave which is called **Evanescent wave** forms in rarer medium. An evanescent wave is a near-field **standing wave (waves which do not carry energy)** with an intensity that exhibits exponential decay with distance (less than wavelength) from the boundary at which the wave is formed.

Imagine that a beam of light traveling within a block of glass is internally reflected at a boundary. Presumably if you pressed another piece of glass against the first, the air-glass interface would be made to vanish and the beam would then propagate onward undisturbed. Furthermore, this transition from total to no reflection occurs gradually as the air film between them thinned out as explained above, when third medium with a higher refractive index (than the low-index second medium) is placed within less than several wavelengths distance from the interface between the first medium and the second medium, the evanescent wave will be different from the one under "ordinary conditions" and it will pass energy across the second into the third medium (evanescent wave coupling). This process is called "frustrated" total internal reflection (FTIR) and is very similar to quantum tunneling. An example of application of this principle is automatic **Wiper speed control** found in high end cars like Skoda, Audi, BMW etc.

Figure shows an example of an optical system designed to detect the amount of water present on the windshield of a car to adjust the wiper speed. As shown in this figure, we can use the windshield as a waveguide to guide the light from a source located at one end (bottom of the windshield) to a detector located in the opposite end. The light suffers total-internal reflection (TIR) at the glass-air interface. However, when rain drops are present, some of the light will suffer frustrated TIR escaping outside the waveguide. Since we know the power of the light source, a given drop in power can be correlated to the amount of water present and used to adjust the wiper speed.



Wiper speed control system

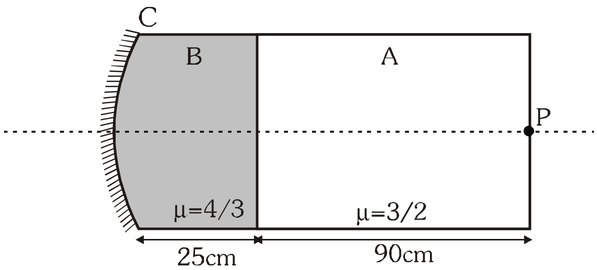
12. Choose the **CORRECT** statement.
(A) The energy carried by evanescent wave is zero in both TIR and FTIR.
(B) The energy carried by evanescent wave is non-zero in both TIR and FTIR.
(C) The energy carried by evanescent wave is zero in TIR and non-zero in FTIR.
(D) The energy carried by evanescent wave is non-zero in TIR and zero in FTIR.

13. In the following systems which should not be based on FTIR?
(A) Allen student card attendance system (B) Thumb attendance system
(C) Finger print scanner (D) Multi touch screen

14. For the wiper speed control system to work, the angle of incidence on the glass air interface is θ, then
(A) $\theta < \sin^{-1}\left(\frac{\mu_{water}}{\mu_{glass}}\right)$ (B) $\theta > \sin^{-1}\left(\frac{\mu_{water}}{\mu_{glass}}\right)$
(C) $\sin^{-1}\left(\frac{\mu_{air}}{\mu_{glass}}\right) < \theta < \sin^{-1}\left(\frac{\mu_{water}}{\mu_{glass}}\right)$ (D) $\theta > \sin^{-1}\left(\frac{\mu_{air}}{\mu_{glass}}\right)$

Paragraph for Questions no. 15 to 17

An object P is placed on the glass slab A, which is 90 cm thick with refractive index 3/2. A container B of thickness 25 cm having water of refractive index 4/3 is sandwiched between glass slab A and a concave mirror C of radius of curvature 70 cm.



15. As a result of first refraction, find the distance of image from glass-water interface
(A) 50 cm (B) 60 cm (C) 75 cm (D) 80 cm

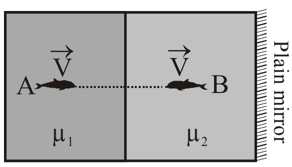
16. Second image will be formed after reflection from the concave mirror, the distance of second image from the mirror will be
(A) 57.50 cm (B) 52.50 cm (C) 27.5 cm (D) 32.5 cm

17. The distance of final image from the object P, is
(A) 70.2 cm (B) 68.25 cm (C) 62.25 cm (D) 39.37 cm

SECTION-III

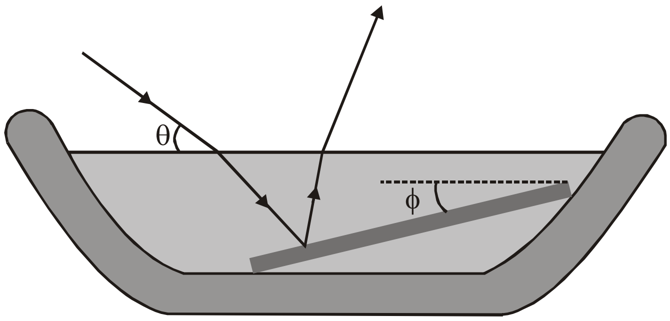
Numerical Grid Type (Ranging from 0 to 9) 2 Q. [4 M (0)]

1. An aquarium is bifurcated by a thin sheet of transparent material as shown in the figure. Each of the two portions contains different kinds of liquid (refractive indices $\mu_1 = 4/3$ and $\mu_2 = 27/20$ respectively). Two fishes A and B swim along each other with their line of approach perpendicular to the interface. One of the side walls is a plane mirror. The velocity of separation of the two images of the fish B that are being observed by the fish 'A' in cm/s is:



[V=4.05 cm/s]

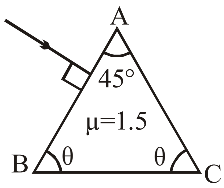
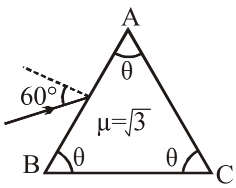
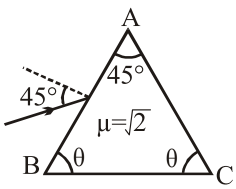
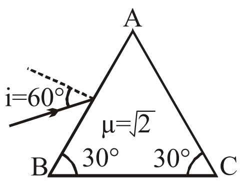
2. A small mirror is placed in a bowl of water, making an angle $\phi = 13.5°$ with the water surface as shown in figure. A beam of light strikes the water at angle $\theta = \cos^{-1}\left(\frac{2}{3}\right)$ from its surface and subsequently reflects from the mirror. At what angle (in degree) from the water surface does the ray emerge from the water?



SECTION-IV

Matrix Match Type (4 × 5) **1 Q. [8 M (for each entry +2(0)]**

1. Match the following :-

Column-I		Column-II
(A)		(P) At surface AC TIR will take place
(B)		(Q) At surface AC light will be refracted
(C)		(R) Ray refracted at AB will be parallel to base BC
(D)		(S) Ray refracted at AB will not be parallel to base BC
		(T) None of these

CLASS TEST # 07 (TNAS) **ANSWER KEY**

SECTION-I

Single Correct Answer Type **7 Q. [3 M (–1)]**

1. Ans. (A)	**2. Ans. (C)**	**3. Ans. (A)**	**4. Ans. (A)**
5. Ans. (C)	**6. Ans. (A)**	**7. Ans. (B)**	

Multiple Correct Answer Type **4 Q. [4 M (–1)]**

8. Ans. (A,B,D)	**9. Ans. (A,D)**	**10. Ans. (B,C)**	**11. Ans. (B,D)**

Linked Comprehension Type **(2 Para × 3Q.) [3 M (-1)]**

(Single Correct Answer Type)

12. Ans. (C)	**13. Ans. (A)**	**14. Ans. (C)**	**15. Ans. (D)**
16. Ans. (B)	**17. Ans. (D)**		

SECTION-III

Numerical Grid Type (Ranging from 0 to 9) **2 Q. [4 M (0)]**

1. Ans. 8 **2. Ans. 4**

SECTION-IV

Matrix Match Type (4 × 5) **1 Q. [8 M (for each entry +2(0)]**

1. Ans. (A) P,S; (B) Q,R; (C) Q,S; (D) P,S